The Fault Tolerance Modification of Benes Network

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Presented to

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We sincerely welcome comment, suggestions and tactfully stated criticisms from the reader and others that may come into contact with this report.

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ABSTRACT

This project is about the fault tolerant modification of Benes Network. Benes Network is a kind of multistage switching network with no blocking, and it's fault tolerant modification guarantee that when there is a fault occurs in the network, the data can still reach it's destination using an alternate path.

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CHAPTER 1 :

INTRODUCTION

INTRODUCTION

Single instruction stream-multiple data stream (SIMD) multiprocessor computing systems have a significant place among parallel computing system architectures. In these systems, N processors or "processor elements" (PE) execute the same instruction with different operands. SIMD computers are vector machines with speed currently in the range of billions and tens of billions of floating-point arithmetic operations per second; the number of processors in the system may reach several thousands. One of the main difficulties in SIMD computers, as in other parallel systems, is timely delivery of data to all the processors. Efficient choice of switching networks helps to overcome this difficulty.

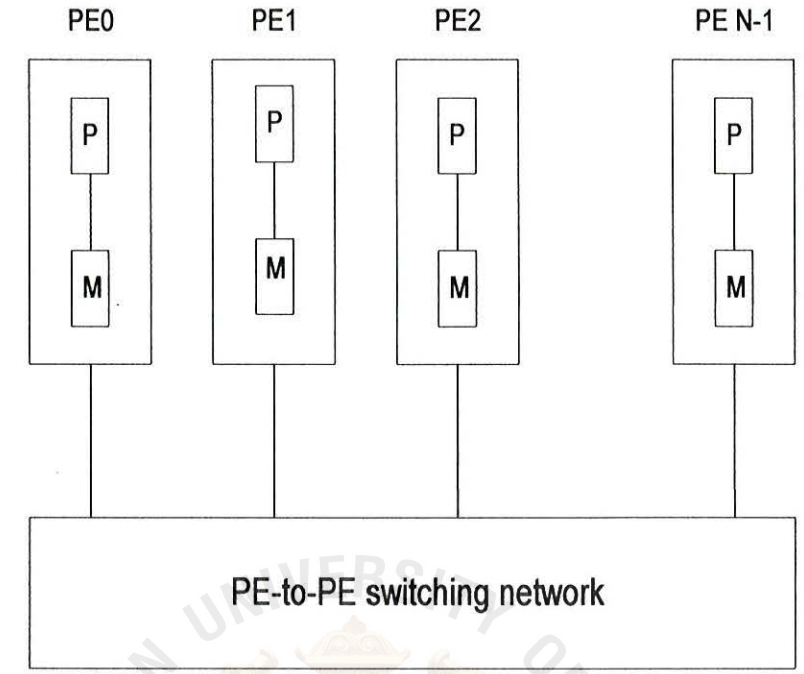
Two basic switching structures are available for SIMD computers. In the first structure (Fig. 1a), each processor has its own individual memory M and is linked by a switching network to other identical processors. In the second structure, the switching network is interposed between the processors and the shared memory modules M of all the processors (Fig. 1b).

The advantage of the second switching structure compared with the first is that each processor has access to the entire addressing space of the shared memory. The main shortcomings are additional delay introduced by the switching network when accessing the memory and the possibility of collision when two or more processors try to access the same memory module.

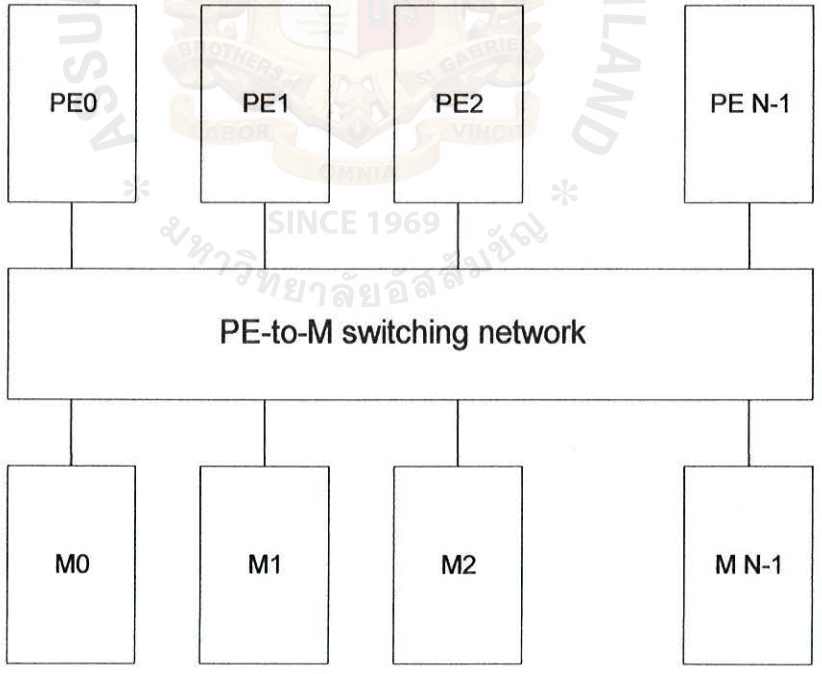
Sequential switching structures originally used in early SIMD computers, e.g., the connection of each PE to four neighbors in Illiac, are an obstacle to increasing the performance of new-generation systems, while the crossbar switch for a system with hundreds and certainly thousands of PEs should be prohibitively costly. Literature analysis shows that the design of switching systems in these architectures largely relied on multistage switching networks (MSN).

MSN are designed for both synchronous and asynchronous parallel systems with a large number of PEs (hundreds and more), where crossbar switching provides the only competitive alternative in performance terms. We will show that MSN have certain advantages compared to crossbar switching systems – the hardware costs are lower and the performance is higher, but the MSN are more difficult to control. In the last two decades, the theory of these networks has made considerable progress and some successful implementations are known.

We consider the main properties and parameter of multistage switching networks and perform a comparative analysis of various MSN types. We consider the techniques for improving their fault-tolerance, and estimate the gain in execution time of some standard procedures with MSN compared to sequential ring type switching systems. Of the enormous variety of multistage switching system configurations, we only consider the basic topologies, which have been implemented or are reportedly being incorporated in future, SIMD supercomputers.



a.



b.

Fig. 1

CHAPTER 2 :

THEORY AND DESIGN

BASIC TYPES OF DATA TRANSFER

The choice of the switching network depends on the frequently used types of messages. The attempts to identify the main types of data transfer in parallel computing systems are of fairly recent origin. The classification of frequently used permutations proposed by Lenfant has become quite popular. According to this classification, the main types of permutations can be grouped into five families. Below we present the main results of the classification of transfers for SIMD computers, based on actual experience with the PS-2000 computers, which supports the validity of this classification.

Frequently used permutations include arbitrary shifts and perfect shuffle. Programming experience on the Illiac IV has shown that these permutations occur so frequently in user programs that to be acceptable, a switching network must ensure efficient implementation of these basic permutations.

Let n be a positive integer, E^n the set of binary vectors $x = (x_n, x_{n-1}, \ldots, x_1)$ representing the integers $:= \Sigma x_i 2^{i-1}$ from 0 to $2^{n-1} - 1$. In application to our case, there are the processor addresses. Then an arbitrary shift by a implies that any z is mapped to $(z + a)\ x\ mod\ 2^n$, where a is an integer.

Of practical interest are also cyclic shifts of amplitude a within the segment 2^{n-j}, i.e., $z \rightarrow (z + a)\ mod\ 2^{n-j}$. Efficient execution of arbitrary shifts primarily requires matrix transposition. Matrix transposition is one of the basic procedures is statistical analysis of large vectors and matrices, in aero and hydrodynamic problems, in linear algebra problems, and in some other problems, and it urgently needs hardware support.

The so-called perfect shuffle permutation is a mapping on the component is mapping on the components of the binary vector x:

$x = (x_n, x_{n-1}, \ldots, x_2, x_1) \rightarrow (x_{n-1}, x_{n-2}, \ldots, x_1, x_0)$.

Perfect shuffle is useful for fast Fourier transform (FFT), for various sorting procedures, for polynomial evaluation, etc.

A fairly popular permutation of the components of the binary vectors x and λ has the form $x \rightarrow x \bullet \lambda$, where $\bullet$ is "sum mod 2." Like ideal shuffle, this permutation is used in FFT. An other useful permutation is "reversal" (reversing the sequence of bits in x) in the entire set E^n and in segments of length $2n\text{-}j$, i.e.,

$$x = (x_n, x_{n-1}, \ldots, x_2, x_1) \rightarrow (x_1, x_2, \ldots, x_{n-1}, x_n).$$

Reversal is also used in FFT. Various segment shuffles are also among the frequently used permutations.

"One-to-many" transfers (with "one-to-all" as a particular case) are common in solving systems of differential equations, both ordinary and partial. Such transfers are usually called nonordinal.

The finite element method (for solving the equations of mathematical physics) and logic circuit modeling use irregular (arbitrary) permutations.

MULTISTAGE SWICTHING NETWORKS WITH BLOCKING

Multistage switching networks for SIMD computers can be provided into two main categories: blocking networks, in which certain permutations may lead to collision, and nonblocking networks. For blocking networks we obviously have $C < 1$, while for nonblocking networks $C = 1$.

Note that blocking networks for SIMD computers usually allow self-routing or distributed control, while nonblocking networking require centralized control, and the setup of such networks is very time consuming. This accounts for the considerable "popularity" of blocking networks in SIMD computers.

Typical representatives of blocking networks are the omega network and the n-cube network. An 8 x 8-omega network is shown in Fig. 2. Each stage in this network implements the interconnections by the perfect shuffle scheme. This network is defined by two functions: the shuffle function and the exchange function. The shuffle function is

$$Shuffle\ (g_{n-1}g_{n-2}\ldots g_1g_0) = g_{n-2}g_{n-3}\ldots g_1g_0g_{n-1}. \quad (1)$$

The exchange function is defined as

$$Exch\ (g_{n-1}g_{n-2}\ldots g_1g_0) = g_{n-1}g_{n-2}\ldots g_1g_0. \quad (2)$$

The N x N omega network consists of $n = \log_2 N$ identical stages. The network may be realized as "one-to-one" or " one-to-many" interconnections. The control is by tags. The binary representation of the address of the output w to which the input v is to be connected is called the destination tag $w = w_{n-1}w_{n-2}\ldots w_1w_0$, and the binary representation of the input $v = v_{n-1}v_{n-2}\ldots v_1v_0$, is called the source tag. When routing the network starting with the input v, the first switch connected with v is switched to the upper output if $w_{n-1} = 0$, and to the lower output if $w_{n-1} = 1$. The same occurs in the subsequent stages, i.e., the switching in stage i is controlled by w_i. Figure 2 shows how the second input is connected with the sixth output by this

algorithm. The omega network does not realize all the permutations without collision. Thus, we see in Fig. 2 that a collision in second-stage interconnections will occur when we attempt to connect simultaneously the zeroth input with the zeroth output and the fourth input with the second output.

There are omega network implementations using elements with more than two switchable channels. To establish the interconnections in this case, a cyclic left shift by one position is applied to the terminal address representation in a system with the base equal to the number of switching element inputs. The network control algorithm is similarly modified, i.e., the switching elements in each stage are controlled by the corresponding digit of the destination tag represented in a system with the chosen base.

The n-cube network belongs to the same class as the omega network. It derives its names from its geometrical interpretation as a n-dimensional cube whose vertices are the processor address in binary representation. In what follows, we will call this network simply a cube. An 8×8 cube network is shown in Fig. 3. The synthesis algorithm for the cube network is quite simple. If the upper and lower outputs for each switch have the same addresses as the upper and lower inputs, then the i-th stage pairs on the switch inputs those input lines whose addresses differ only in the i-th position (in the binary representations if the terminal addressed). Functionally, the cube is equivalent to the omega network, i.e., it realizes without collision the same classes of permutations and has the same control algorithm.

For a network with $N = 2^n$ inputs and binary representation of the input address in the from $g_{n-1}g_{n-2}\cdots g_1g_0$, the cube network may be regarded as consisting of n functions:

$$Cube_i\,(g_{n-1}\cdots g_{i+1}g_i\,g_{i-1}\cdots g_0) = g_{n-1}\cdots g_{i-1}\;\bar{g}_i g_{i-1}\cdots g_0.$$

Cube and omega are essentially topological modifications of the same network. The same class of networks also includes the so-called indirect cube (the full name is "indirect binary n-cube"). In the direct cube network, the sequence of stages is reversed compared to the direct cube (Fig. 4). The indirect cube is functionally equivalent to the direct cube with all the input and output addresses transformed from $g_{n-1} \ldots g_1 g_0$ to $g_0 g_1 \ldots g_{n-1}$.

The indirect cube is useful for PE-to-PE switching (Fig. 1a), because the hardware implementation of a growing processor array and its division into subarrays is simpler here than omega network, say.

From the list of frequently used permutations described above, the cube network and its modifications realize without collisions all the arbitrary shifts, including shifts within segments, and the permutations of the form $x \rightarrow x \bullet \lambda$, but neither ideal shuffle nor reversal can be realized in one pass through the network, i.e., these networks fail, in particular, for permutations that are useful for efficient FFT algorithms.

Banyan networks are topologically equivalent to cube networks. However, Banyan networks differ from the cube and its modifications by their use of the switching elements, which have six, and not four, admissible states (we are referring to 2 × 2 switching elements).

A fundamental property of the different networks considered above is that they all lay a unique path from each input to each output. This produces "intersecting" routes and may cause collisions in the network.

Another type of a blocking network is PM2I (Plus-Minus 2^i) .An example of a PM2I network is the data manipulator. This network consists of n stages with N switches each, and the switch j in stage I is connected to three switches in stage I – 1;specifically: to the switch $(j + 2^i) \bmod N$, to the *switch* $(j - 2^i)$

mod N, and to the switch *j*, where $0 \leq j < N$ and $0 \leq I < n$. Note that in this context a stage is a column of switching elements together with all their outgoing connections (Fig.5). Unlike the networks considered above, PM2I uses 3 x 3 switches, and data can be transmitted at any given time only from one input to any of the three outputs. Different control techniques have been proposed for such a network. A network with individual control of the switching elements has been terms augmented data manipulator (ADM). It can be shown that the ADM is functionally superior to the previously considered networks. Thus, the ADM can realize all the permutations realized by omega plus some additional permutations not realized by omega, such as perfect shuffle. In other words, the ADM will execute without blocking a greater number of permutations than either the cube or the omega, but still it will not execute all N! possible permutations. The price of the greater functional capabilities is higher hardware cost and more complex control than in the omega network.

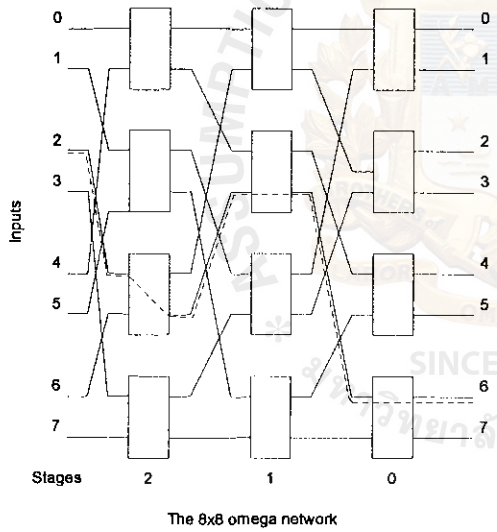
There are also data manipulator modifications using two-input elements, which are topologically equivalent to omega, cube, and other networks.

Switching networks of this class are used in a number of currently available and projected computers, such as STARAN, Ultracomputer, RVAP (Reconfigurable Varistructured Array Processor), PASM (Partitionable SIMD/MIMD – a Purdue University project), the IBM RP3, some military systems, and data flow machines.

An interesting approach to switching was proposed by Burroughs for the NASF system. NASF (Numerical Aerodynamics Simulation Facility) is being developed under contract to NASA, and its main purpose is to solve aerodynamic problems during spacecraft design. Analysis has shown that an average problem in this field requires speeds of an order of 1 billion floating-point operations per second. In the NASF architecture, Burroughs proposes to solve the access problem by means of a certain compromise between Lawrie's system and the BSP solution. (See above) The facility will consist of 512

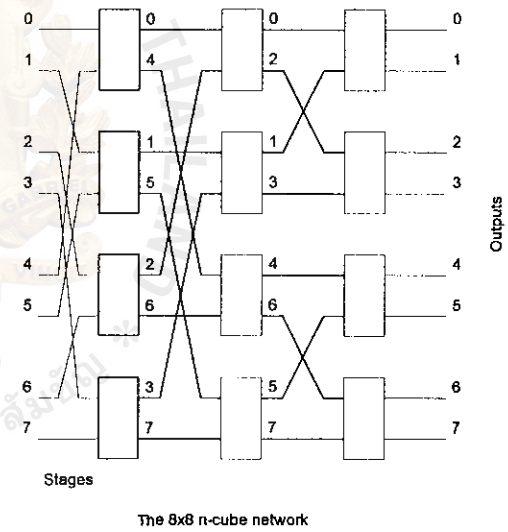
processors, a shared memory field using a prime number of memory modules greater than the number of processors, and a pair of 1024 x 1024 omega switching networks ("upper" and "lower"). Each processor thus can be connected to two ports (one by the upper network and one by the lower network). The access priorities on the upper network are the reverse of the lower-network priorities. If the upper network blocks access to memory, and automatic attempt is made to switch through the lower network.

Thus, the choice of a particular blocking network for SIMD computers is determined by the need to ensure collision-free transfers on some classes of frequently used permutations in the specific problem-oriented multiprocessor system.



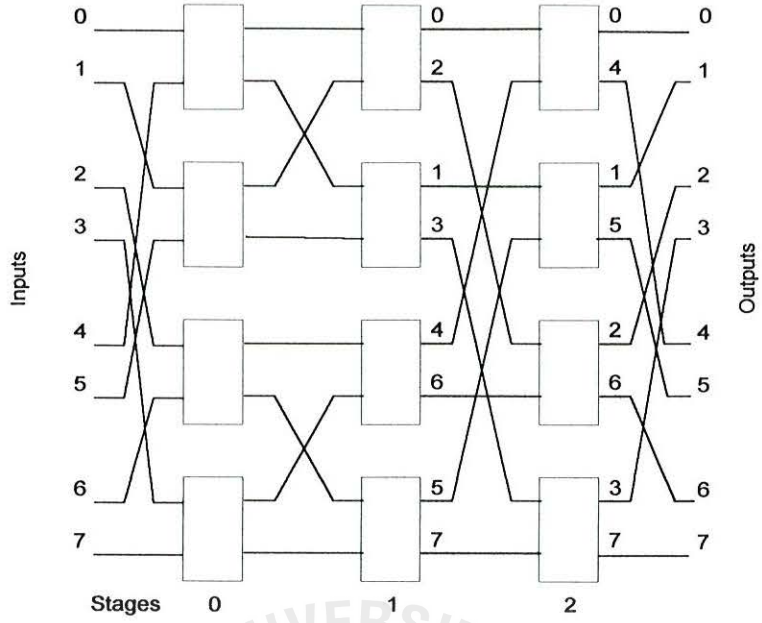
The 8x8 omega network

Fig. 2



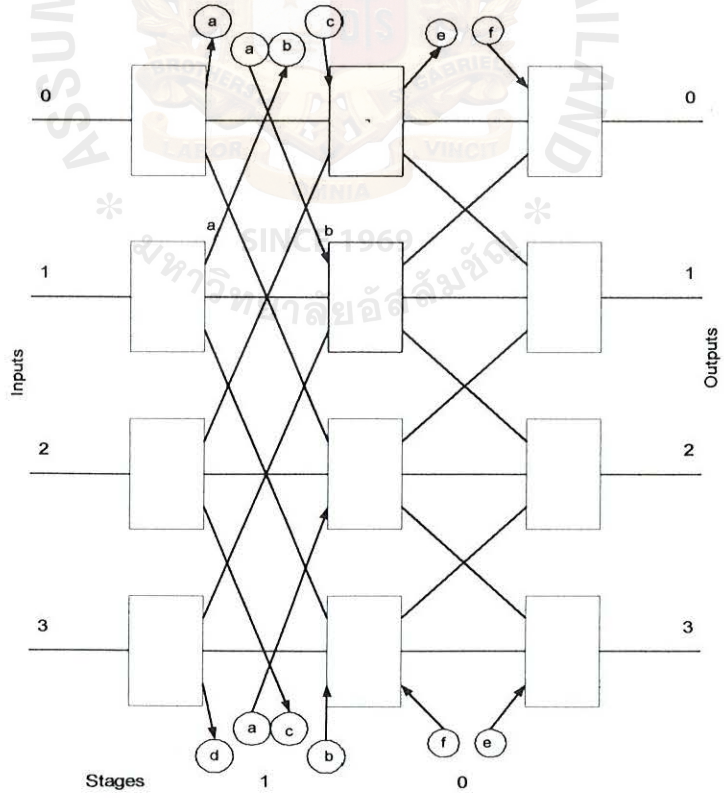
The 8x8 n-cube network

Fig. 3



The 8 x 8 indirect cube network

Fig. 4



The 4 x 4 data manipulator network

Fig. 5

THE BENES NETWORK AND ITS MODIFICATIONS

A second class of multistage switching networks that are of considerable practical interest are the so-called Clos-Benes nonblocking network representing a fairly wide class of network topologies. The objective was to develop a multistage network-realizing crossbar switching functions, i.e., no blocking, yet having fewer connection points than in crossbar networks. We should especially note the considerable contribution of Soviet scientists,in particular, Kharkevich and Neiman, to the theory of nonblocking switching networks.

Below we consider some networks contained in the class of networks studied by C. Clos and V. Benes. These networks consist of square subnetworks, and are thus of particular interest in computer systems.

Let $N = dq$, where d and q are integers. Then the N x N Clos network is representing by three stages (Fig. 6) The input and output stages contain N/d d x d subnetworks each (one of the input stage subnetworks can be eliminated – in Fig. 6 this subnetwork is enclosed in a broken box). The intermediate stage consists of d identical N/d x N/d subnetworks. Such a network is usually termed as a base-d network.

Such networks are fairly efficient in terms of hardware costs and are known in the literature as "rearrangeable," because in case of blocking there is always a possibility of realizing the desired connection by rearranging ("rerouting") some of the previously established connections. For these networks, there are algorithms for collision free realization of arbitrary permutations with simultaneous establishment of all the specified connections in the network. This is typical of the class of synchronous systems, which includes the SIMD computer systems as a particular case. Thus, for rearrangeable networks C = 1.

The network in Fig. 6 has an iterative structure, and for d = 2 successive decomposition of the middle stage into three-stage structures produces a network implemented using only two-input elements. The network constructed in such a way is usually called Benes network. Figure 7 is a base-2 8 x 8 network. With $N = 2^n$ inputs, the Benes network has $2\ log_2 N - 1$ stages. Its main shortcoming as compared with cube networks is the need for centralized control; moreover, it uses a complex and essentially sequential algorithm in order to compute the collection of signals controlling subnetwork switching (the "control vector" in what follows) during the realization of an arbitrary permutation.

We will now describe the so-called looping algorithm, which is basic for intersection control in Benes networks. Assume that the Benes network shown in Fig. 7 is required to realize the permutation p: $0 \rightarrow 3$, $1 \rightarrow 7$, $2 \rightarrow 4$, $3 \rightarrow 0$, $4 \rightarrow 2$, $5 \rightarrow 6$, $6 \rightarrow 1$, $7 \rightarrow 5$, which is usually represented in the compact form the

$$p = \begin{matrix} 0\,1\,2\,3\,4\,5\,6\,7 \\ 3\,7\,4\,0\,2\,6\,1\,5 \end{matrix}$$

First, this permutation should be described as an interconnection map (Fig. 8). The pair of network inputs that belong to the same switching element of the output stage defines the row address and the pair of network inputs that belong to the same switching element of the input stage defines the column address. Crosses in the corresponding positions mark pairs of input-output connections of the given permutation. Then the input into the map is chosen arbitrarily. For example, choosing as the starting point the "cross" (we call it the "input" in what follows) in rows 23 and column 01, we look for the next input in the same row or in the same column so as to form a loop. In Fig. 8, the input row 23 and column 45 is chosen. The process is continued until no loop can be formed because we return to row

23 and column 01. The loop inputs are then alternately named a and b. A second loop is formed similarly. Then the input and output lines names a are assigned to the subnetwork a, while the line name b are assigned to the subnetwork b. The resulting control of the input and output switching elements in shown in Fig. 9.

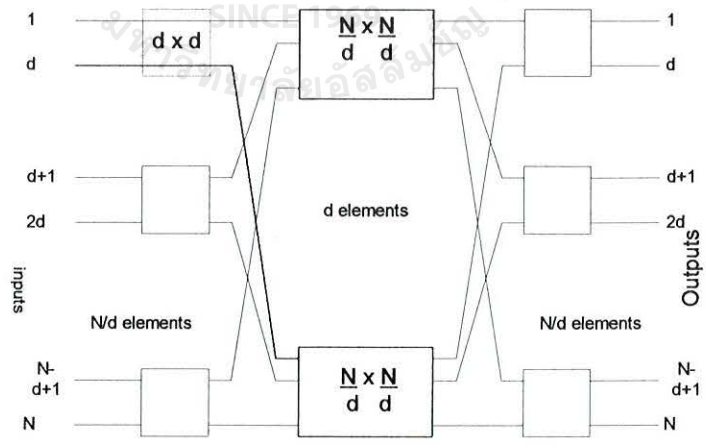
Using the given permutation and the established connections in the input and output stages, we can easily identify the permutations that should be realized by the subnetworks a and b. Then the looping algorithm is recursively applied to both subnetworks.

Such algorithm run in time $O(N \log_2 N)$. These time requirements to compute the control vector are obviously very large and may be totally unacceptable in some cases. To avoid this difficulty, we can compute the control vectors in advance (e.g., in the compiling stage) and store them in a "control vector table." Such tables take up a lot of memory space – not less than $(2 \log_2 N-1)\ N/2$ bits per control vector for one permutation.

Another possibility is to focus on the frequently used permutations in the classification introduced above. The number of frequently used permutations is of order of $2^{2\log_2 N}$, which is quite small compared with the total number of all permutations N!. Therefore, the permutation name can be encoded within the limits of the parameter field of the instruction "Start a frequently used permutation." On-line recursive algorithms have been proposed for such regular permutations, in which the times to compute a control vector does not introduce a noticeable delay into switching network operation. Arbitrary permutations, which are fairly noticeable delay into switching network operation. Arbitrary permutations, which are fairly infrequent in applications, should be realized by one of the general algorithms.

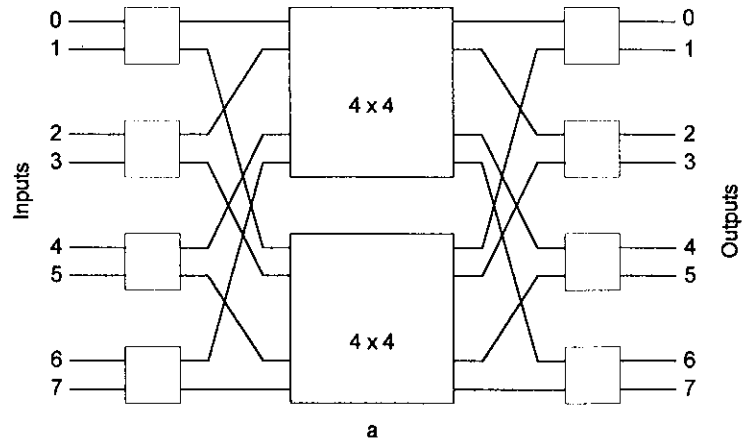
Of considerable interest is the switching network solution adopted in the Phoenix system. The final configuration of this system will consist of 1040 processors combined into groups of 65 (one standby processor in each group), ensuring a maximum speed of over 10 billion floating-point operations per second (GFLOP). One of the major innovations in system architecture adopted in this project is the decision to use a switching network that allows any possible interconnection of processors. A modified Benes network is proposed for this purpose. The advantage of this modification is that the distribution processors can be spatially divided into groups of close processors together with the associated switching network elements interconnected by close links (Fig. 10). If the central stages are connected "straight," the network is partitionable into independent local subnetworks.

Another example of a rearrangeable switching network is used in the GF-11 supercomputer. It consists of 576 processors and ensures speeds of up to 11 GFLOP. A nonblocking rearrangeable three-stage network interconnects the processors. Each stage in this network consists of 24 switching elements of 24 x 24 each.

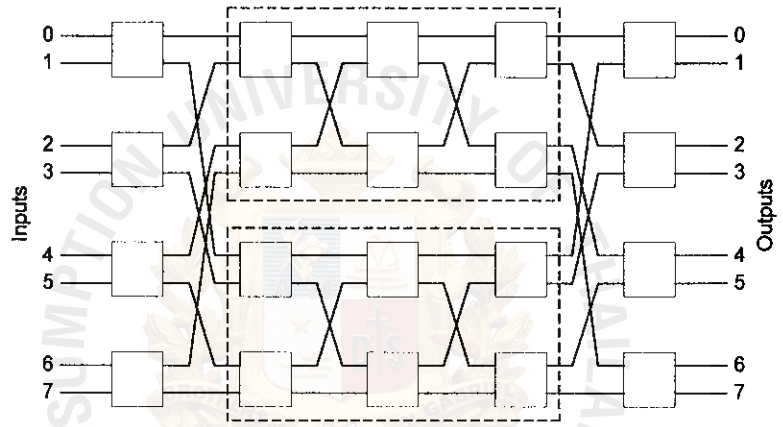


Base-d N x N Clos network.

Fig. 6



a



b.
Base-2 8 x 8 Benes network.

Fig. 7

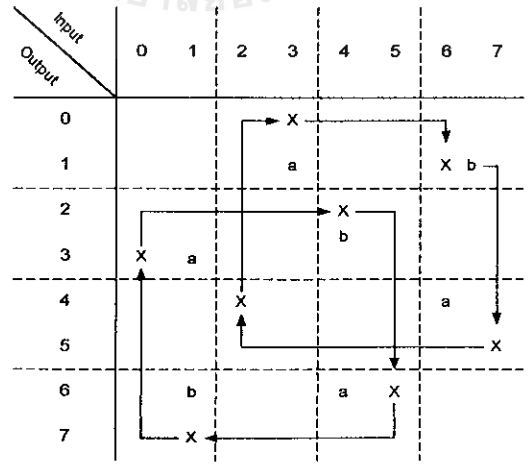


Fig. 8

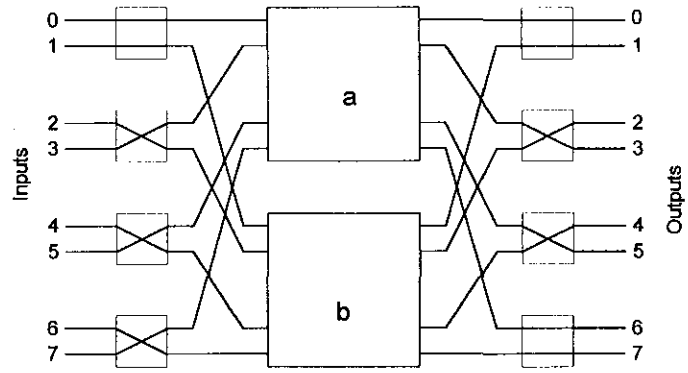
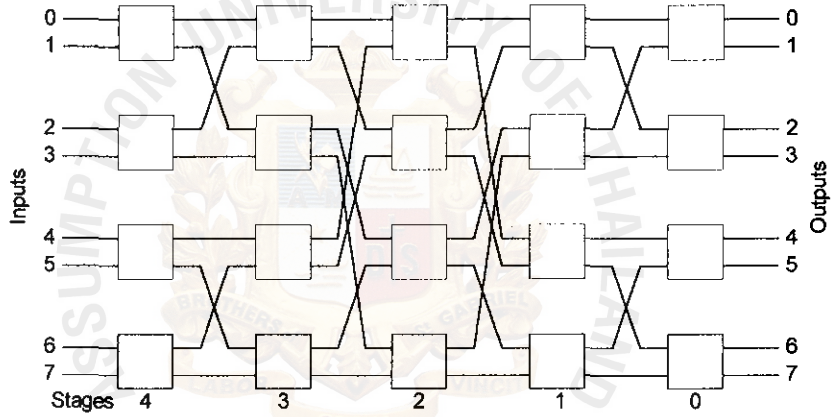


Fig. 9



A modified 8 x 8 Benes network partitionable into local subnetworks.

Fig. 10

FAULT-TOLERANT SWITCHING NETWORKS

The examples of switching networks considered above show that with a large number of processors (hundreds and thousands) these networks are fairly complex devices. The switching control algorithms are also fairly complex, especially for Benes networks. Since the reliability of a switching network has a direct impact on the reliability of the entire system, reliability improvement can be achieved by designing networks that are fault-tolerant with respect to (usually) single faults. The problems of design of a fault-tolerant network are formulated as follows.

1. For single faults in switching elements and their interconnections, the network should realize without collision the original classes of admissible permutations.
2. A fault-tolerant network should have a sufficiently simple algorithm that will rearrange it in case of a fault.
3. Network control should be capable of partitioning the network into subnetworks of equal size, coupled both electrically and structurally. The last requirement makes it possible to disconnect the faulty half of the network for repair, while the nonfaulty half continues functioning, emulating the complete switching network with performance reduced by a factor of 4.

Fault-tolerance implies neutralization of the effect of faults in the network. This is possible only if we provide static redundancy, e.g., masking in a three-fold majority-voting structure, or dynamic redundancy, which pinpoints the fault and reconfigures the network or the data flows. In what follows, we consider dynamic redundancy techniques.

The data transmitted in a single clock cycle through the switching network may be one bit, one byte, or one processor word. In the last two cases, faults may be detected by appending a parity bit or several bits in the Hamming code. However, these methods, while signaling the existence of a fault, do not pinpoint the fault location in the switching network. It is better to use for this purpose special diagnostic tests which are run periodically as part of network testing or after a fault has been detected.

Simple and efficient diagnostic tests are available for the class of single stuck-at faults const $\equiv 1$ (or $\equiv 0$) on one of the information inputs (outputs) or on the control input of the switching element in a base-2 switching network. The main idea of these tests is the following. Apply an input combination to the N network inputs such that each switching element receives the signal 01 or 10 on its two inputs, with the same control signal on all the elements. As all the input values are inverted in a nonfaulty network, each output terminal should successively procedure the two values 01 and 10. If this sequence is not observed on one of the output terminals, there is a fault in the information channel connected with this terminal. Repeating the same test for inverted values of the control signal on each switching element, we may detect another information channel passing through the same faulty component. The fault is in the component, which is common to both information channels.

These tests are similarly applied to check for control signal faults. An error in the output signal is detected by comparing the output values with a reference. A reference signal is needed because if there is a fault in the control signal of the switching elements in the last stage, a 1-out-of-2 code will not be violated on the network output terminals (unlike the case of such a fault in all the other stages), and the output therefore have to be tested by comparison with reference values.

All the above remains valid for cube and omega networks, their generalizations and also for Benes networks.

Thus, a base-2 switching network can be diagnosed by four test combinations, which identify the faulty switching element or the faulty component in the transmission channel.

The diagnostic results make it possible to move to the next stage of recovery in a faulty switching network – neutralizing the effect of the fault. Here two approaches are available. The first relies on the introduction of an extra stage in cube networks. Because of the extra stage, there are now two paths from any source to any destination in the switching network.

The second approach designs a switching network with a given constant number of nonintersecting routes from any source to the destination. For blocking network, the existence of alternative routes is ensured by a special choice of the switching element base in the network. Both approaches are considered in more detail below.

In the Benes network, there are more than one independent path for each input-output pair, so that in principle it is possible to bypass single faults and to realize any given permutation in two passes without extra stages. If the first and the last stages in the Benes network are augmented with multiplexors-demultiplexors (fig. 12), then the modified Benes network will be fault-tolerant to single faults. In this case, fault tolerance is also accomplished in two passes through the network. In the first pass, the data are switched through the nonfaulty paths, while in the second pass alternative paths switch the remaining connections. Because of the perfect symmetry of the two alternative path in the second pass by passing the control signals from the switching elements of one "storey" of intermediate stages to another "storey" (in Fig. 12, the " stories" are enclosed in broken boxes). The control signals are generated in advance for the given interconnection list by one of the known algorithms, assuming a nonfaulty network. The control for the switching elements of the first and the last stages participating in the unrealized connection is reversed, i.e.,

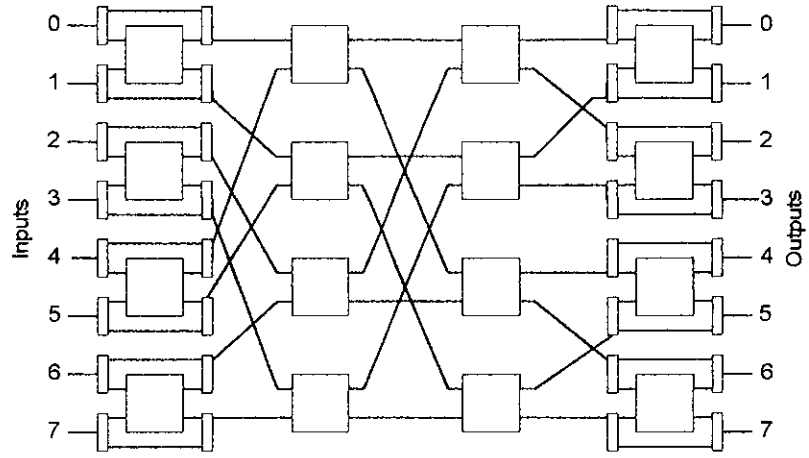
if one element was initially connected "straight", it is now switched to "exchange," and conversely.

If the fault is detected in the first or the last stage, then the network control is somewhat different. Specifically, if the fault is detected in a switching element of the first (last) stage connected "straight," then this element is disconnected, the bypass multiplexors-demultiplexors are activated, and the required switching can be realized even in a single pass, because all the other control signals are not altered. If the faulty element was realizing the exchange function (connected cross-cross), then the fault element, are switched in the first pass, and the bypass multiplexors-demultiplexors of the faulty element are activated in the second pass, when the control signals from the first "storey" of intermediate stages are transferred to the second "storey" and conversely, thus exciting two alternative paths relative to the initial paths in the faulty network.

Note that the modified Benes network (Fig. 10) allows decomposition of the entire network into two subnetworks of equal size, so that the nonfaulty half can emulate the entire network. This decomposition is useful during the recovery of the faulty half of the network.

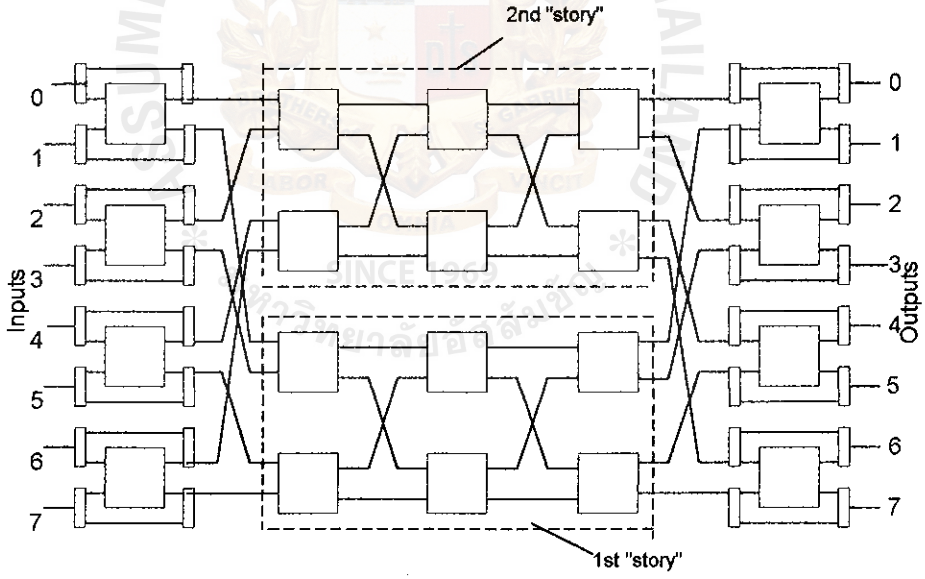
The previously considered approach to fault-tolerance relies on explicitly appending ad extra stage to the cube network in order to produce an additional route between any input-output pair. The alternative approach implicitly uses the redundant switching capabilities of the switching elements in order to achieve fault-tolerance of the network. These capabilities arise when fault-tolerant networks are designed using a base $W = 2^{\gamma}$ omega network, where γ is an integer grater than 1; the number of stages in the network is $[\log_W N]$, where [x] is the nearest integer greater than x. A theorem is proved which claims that for a N x N uniform network of this kind, with $N = 2^n$. The number of different routes R between input-output pair is given by $R = W^{]n/\gamma[}$, where]x[is the difference between the nearest integer

equal to or greater than the real number x and x. Note that N should be divisible by W, but for $N = W^t$ the modified omega reduces to an ordinary omega network, i.e., a network with a unique route for each input-output pair. Figure 15 shows a modified base-8 16 x 16 omega network. The network consists of two stages. In this case, $n = 4$, $\gamma = 3$, $N = 2^4 = 16$, $W = 2^3 = 8$, $]n/\gamma[=]4/3[= 2/3$, and therefore, $R = W^{]n/\gamma[} = 8]^{4/3}[= 8(2/3) = 4$. The existence of four possible routes for each input-output pair essentially improves the fault-tolerance of the network. Thus the network shown in Fig. 5 will realize the initial permutation in two passes in the presence of any two faults in the interconnections between the stages.



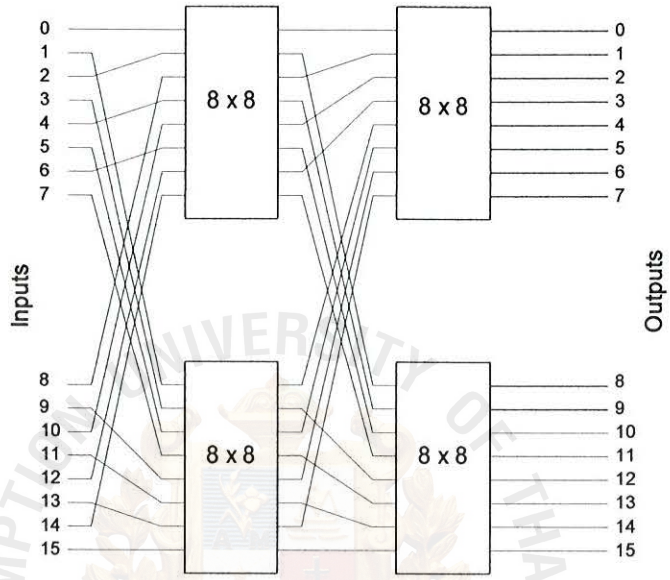
A fault-tolerant modification of the 8 x 8 Benes network.

Fig. 11



A fault-tolerant modification of the 8 x 8 Benes network.

Fig. 12



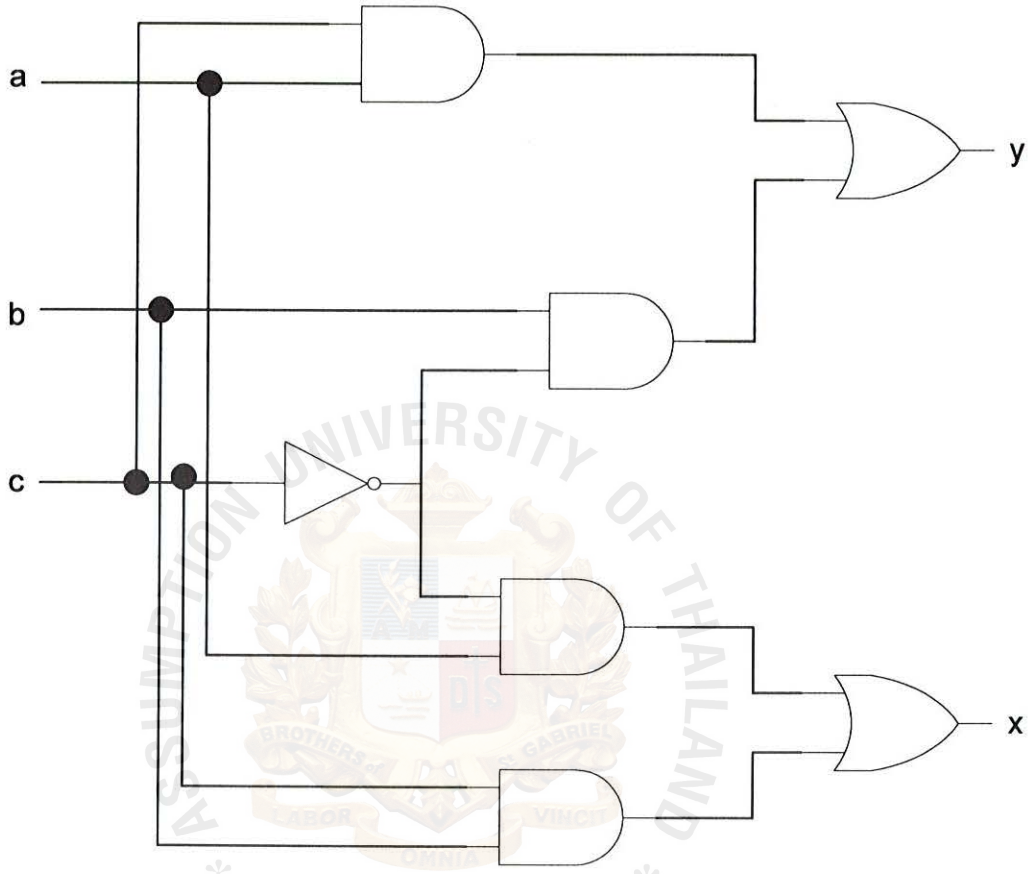
A fault-toleranct modification of the 16 x 16 omega network with four routes of each input-output pair.

Fig. 13

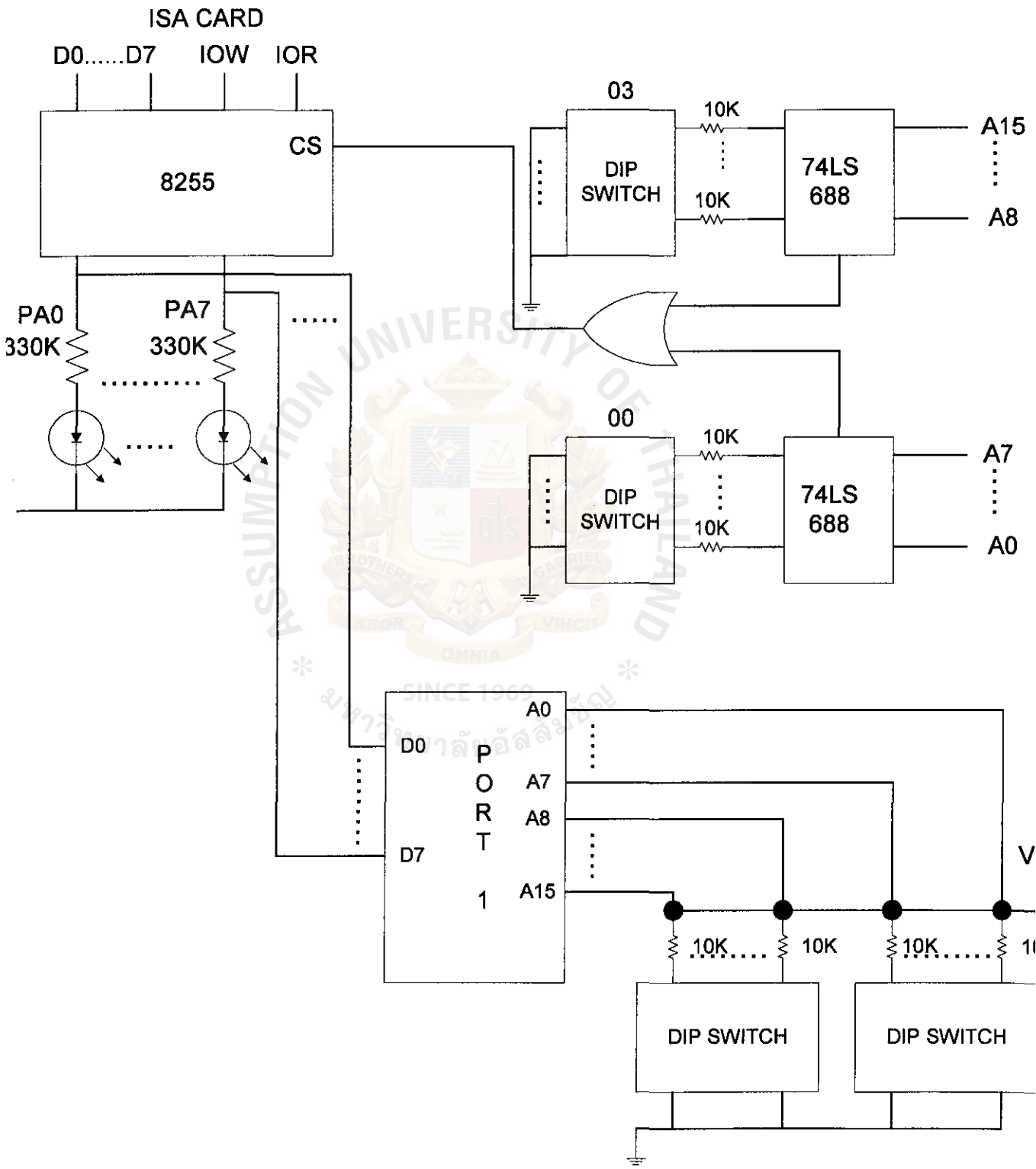
CHAPTER 3 :

FABRICATION AND CONSTRUCTION

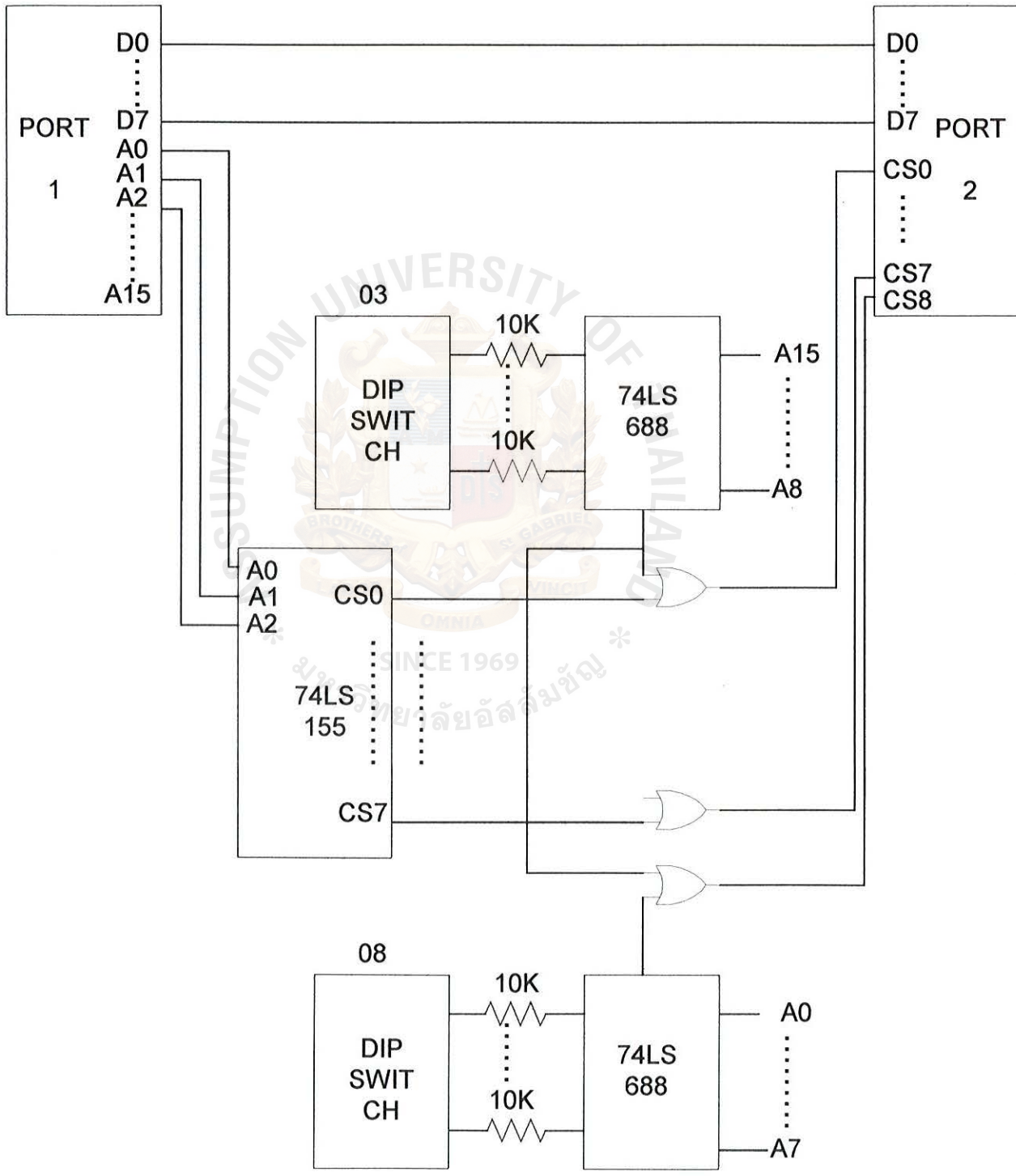
Circuit Diagram of the switch



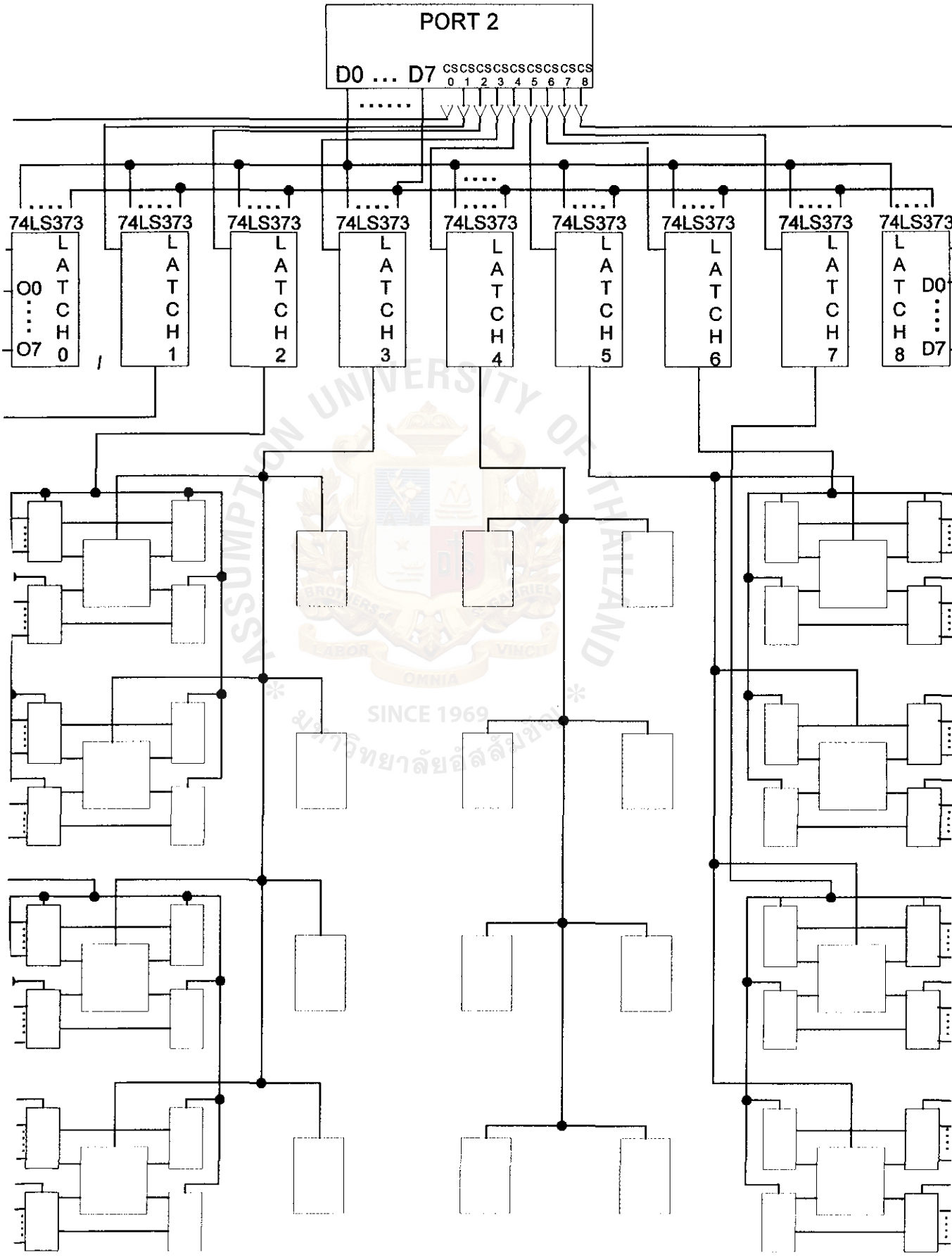
Circuit Diagram of the address decoder



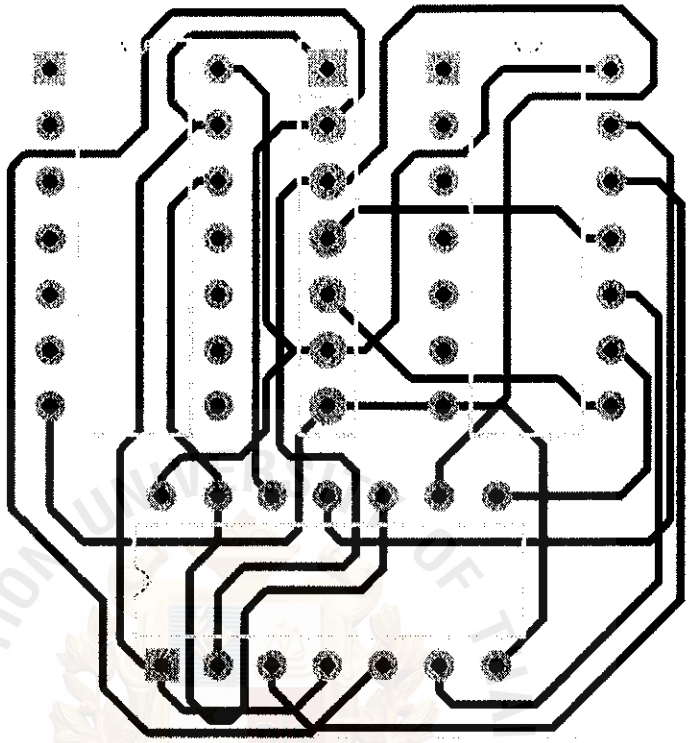
Circuit Diagram of the address decoder 2



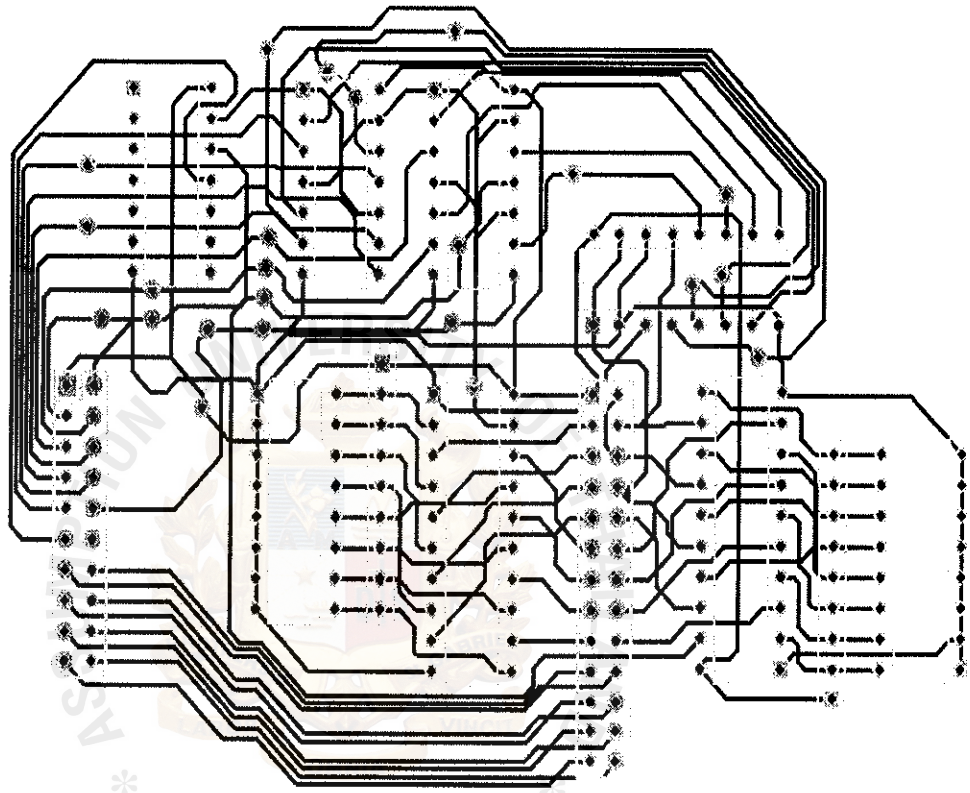
Circuit Diagram of the Benes Network



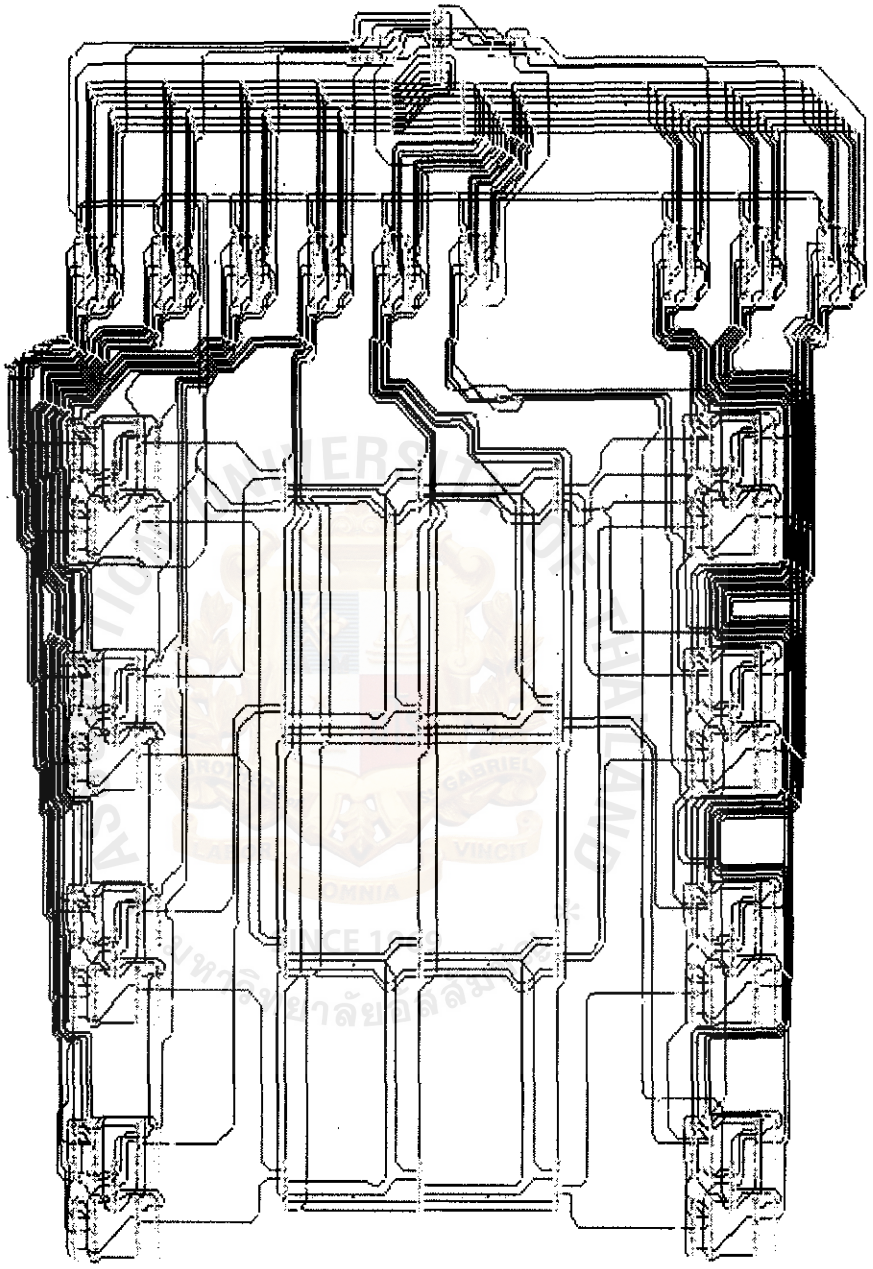
PCB design for switch



PCB design for address decoder



PCB design for Benes Network



Outputs correspondence to inputs with chosen permutation requests

```
#include<stdio.h>
#include<conio.h>
#include<ctype.h>
void main(void)
{
 int m[21];
 int a[8],b[8];
 int a1=0,a2=0,a3=0,a4=0;
 int n;
 char high,low;
 clrscr();
 printf("**********************************\n");
 printf("***     1.Perfect Shuffle     **\n");
 printf("***     2.Bit Reverse         **\n");
 printf("***     3.Flip Permutation    **\n");
 printf("***     4.Cyclic Shift        **\n");
 printf("**********************************\n");
 printf("Please choose a number : ");
 scanf("%d",&n);

 if (n==1)
 { m[1]=0; m[5]=0; m[9]=0; m[13]=0; m[17]=0;
  m[2]=0; m[6]=1; m[10]=1; m[14]=1; m[18]=1;
  m[3]=1; m[7]=0; m[11]=0; m[15]=1; m[19]=0;
  m[4]=1; m[8]=1; m[12]=1; m[16]=0; m[20]=1;
 }
 if (n==2)
 { m[1]=0; m[5]=0; m[9]=0; m[13]=0; m[17]=0;
  m[2]=0; m[6]=0; m[10]=0; m[14]=0; m[18]=0;
  m[3]=1; m[7]=0; m[11]=1; m[15]=1; m[19]=1;
  m[4]=1; m[8]=1; m[12]=1; m[16]=0; m[20]=1;
 }
 if (n==3)
 {
  clrscr();
  printf("**********************************\n");
  printf("***          1. 101       **\n");
  printf("***          2. 011       **\n");
  printf("***          3. 010       **\n");
  printf("***          4. 111       **\n");
  printf("**********************************\n");
  printf("Please choose a number : ");
  scanf("%d",&n);

  if (n==1)
  { m[1]=1; m[5]=0; m[9]=1; m[13]=0; m[17]=0;
   m[2]=1; m[6]=0; m[10]=1; m[14]=0; m[18]=0;
   m[3]=1; m[7]=0; m[11]=1; m[15]=0; m[19]=0;
   m[4]=1; m[8]=0; m[12]=1; m[16]=0; m[20]=0;
  }
  if (n==2)
  { m[1]=0; m[5]=0; m[9]=0; m[13]=1; m[17]=1;
   m[2]=0; m[6]=0; m[10]=0; m[14]=1; m[18]=1;
   m[3]=0; m[7]=0; m[11]=0; m[15]=1; m[19]=1;
   m[4]=0; m[8]=0; m[12]=0; m[16]=1; m[20]=1;
  }
```

```
 if (n==3)
 { m[1]=0; m[5]=0; m[9]=0; m[13]=1; m[17]=0;
   m[2]=0; m[6]=0; m[10]=0; m[14]=1; m[18]=0;
   m[3]=0; m[7]=0; m[11]=0; m[15]=1; m[19]=0;
   m[4]=0; m[8]=0; m[12]=0; m[16]=1; m[20]=0;
 }
 if (n==4)
 { m[1]=0; m[5]=0; m[9]=1; m[13]=1; m[17]=1;
   m[2]=0; m[6]=0; m[10]=1; m[14]=1; m[18]=1;
   m[3]=0; m[7]=0; m[11]=1; m[15]=1; m[19]=1;
   m[4]=0; m[8]=0; m[12]=1; m[16]=1; m[20]=1;
 }
}
if (n==4)
{ clrscr();
 printf("Please enter a number[1 , 2] : ");
 scanf("%d",&n);

 if (n==1)
 { m[1]=0; m[5]=0; m[9]=0; m[13]=0; m[17]=0;
   m[2]=0; m[6]=1; m[10]=1; m[14]=1; m[18]=1;
   m[3]=1; m[7]=0; m[11]=0; m[15]=1; m[19]=0;
   m[4]=1; m[8]=1; m[12]=1; m[16]=0; m[20]=1;
 }
 if (n==2)
 { m[1]=0; m[5]=0; m[9]=0; m[13]=0; m[17]=0;
   m[2]=1; m[6]=1; m[10]=1; m[14]=1; m[18]=0;
   m[3]=0; m[7]=1; m[11]=0; m[15]=0; m[19]=1;
   m[4]=1; m[8]=0; m[12]=1; m[16]=1; m[20]=1;
 }
}
 clrscr();
 printf("The controls are as shown below.\n\n");
 printf(" %d  %d  %d  %d  %d \n",m[1],m[5],m[9],m[13],m[17]);
 printf(" %d  %d  %d  %d  %d \n",m[2],m[6],m[10],m[14],m[18]);
 printf(" %d  %d  %d  %d  %d \n",m[3],m[7],m[11],m[15],m[19]);
 printf(" %d  %d  %d  %d  %d \n",m[4],m[8],m[12],m[16],m[20]);
 printf("\nPlease enter the data.\n");
 printf("\nThe higher 4 bits of data in HEX = ");
 scanf("%c",&high);
 scanf("%c",&high);
 printf("The lower 4 bits of data in HEX = ");
 scanf("%c",&low);
 scanf("%c",&low);

 if (high == '1')
 a1 = 1;
 else if (high == '2')
 a2 = 1;
 else if (high == '3')
 { a2 = 1; a1 = 1; }
 else if (high == '4')
 a3 = 1;
 else if (high == '5')
 { a3 = 1; a1 = 1; }
 else if (high == '6')
 { a2 = 1; a3 = 1; }
 else if (high == '7')
 { a2 = 1; a1 = 1; a3 = 1;}
 else if (high == '8')
```

```
a4 = 1;
else if (high == '9')
{ a1 = 1; a4 = 1; }
else if (high == 'A'|| high == 'a')
{ a2 = 1; a4 = 1; }
else if (high == 'B'|| high == 'b')
{ a2 = 1; a4 = 1; a1 = 1;}
else if (high == 'C'|| high == 'c')
{ a3 = 1; a4 = 1; }
else if (high == 'D'|| high == 'd')
{ a3 = 1; a4 = 1; a1 = 1;}
else if (high == 'E'|| high == 'e')
{ a3 = 1; a4 = 1; a2 = 1;}
else if (high == 'F'|| high == 'f')
{ a3 = 1; a4 = 1; a2 = 1; a1 = 1;}

a[1]=a1; a[2]=a2; a[3]=a3; a[4]=a4; a1 = 0; a2 = 0; a3 = 0; a4 = 0;
if (low == '1')
a1 = 1;
else if (low == '2')
a2 = 1;
else if (low == '3')
{ a2 = 1; a1 = 1; }
else if (low == '4')
a3 = 1;
else if (low == '5')
{ a3 = 1; a1 = 1; }
else if (low == '6')
{ a2 = 1; a3 = 1; }
else if (low == '7')
{ a2 = 1; a1 = 1; a3 = 1;}
else if (low == '8')
a4 = 1;
else if (low == '9')
{ a1 = 1; a4 = 1; }
else if (low == 'A'|| low == 'a')
{ a2 = 1; a4 = 1; }
else if (low == 'B'|| low == 'b')
{ a2 = 1; a4 = 1; a1 = 1;}
else if (low == 'C'|| low == 'c')
{ a3 = 1; a4 = 1; }
else if (low == 'D'|| low == 'd')
{ a3 = 1; a4 = 1; a1 = 1;}
else if (low == 'E'|| low == 'e')
{ a3 = 1; a4 = 1; a2 = 1;}
else if (low == 'F'|| low == 'f')
{ a3 = 1; a4 = 1; a2 = 1; a1 = 1;}

a[5]=a1; a[6]=a2; a[7]=a3; a[8]=a4;
if (m[1]==0)
{ b[1]=a[1];
  b[2]=a[2];
}
else
{ b[1]=a[2];
  b[2]=a[1];
}
if (m[2]==0)
{ b[3]=a[3];
  b[4]=a[4];
```

```
}
else
{ b[3]=a[4];
  b[4]=a[3];
}
if (m[3]==0)
{ b[5]=a[5];
  b[6]=a[6];
}
else
{ b[5]=a[6];
  b[6]=a[5];
}
if (m[4]==0)
{ b[7]=a[7];
  b[8]=a[8];
}
else
{ b[7]=a[8];
  b[8]=a[7];
}
a[1]=b[1];   a[2]=b[3];   a[3]=b[5];   a[4]=b[7];
a[5]=b[2];   a[6]=b[4];   a[7]=b[6];   a[8]=b[8];
m[1]=m[5];   m[2]=m[6];   m[3]=m[7];   m[4]=m[8];
if (m[1]==0)
{ b[1]=a[1];
  b[2]=a[2];
}
else
{ b[1]=a[2];
  b[2]=a[1];
}
if (m[2]==0)
{ b[3]=a[3];
  b[4]=a[4];
}
else
{ b[3]=a[4];
  b[4]=a[3];
}
if (m[3]==0)
{ b[5]=a[5];
  b[6]=a[6];
}
else
{ b[5]=a[6];
  b[6]=a[5];
}
if (m[4]==0)
{ b[7]=a[7];
  b[8]=a[8];
}
else
{ b[7]=a[8];
  b[8]=a[7];
}

a[1]=b[1];   a[2]=b[3];   a[3]=b[2];   a[4]=b[4];
a[5]=b[5];   a[6]=b[7];   a[7]=b[6];   a[8]=b[8];
```

```
m[1]=m[9];   m[2]=m[10];   m[3]=m[11];   m[4]=m[12];
if (m[1]==0)
{ b[1]=a[1];
  b[2]=a[2];
}
else
{ b[1]=a[2];
  b[2]=a[1];
}
if (m[2]==0)
{ b[3]=a[3];
  b[4]=a[4];
}
else
{ b[3]=a[4];
  b[4]=a[3];
}
if (m[3]==0)
{ b[5]=a[5];
  b[6]=a[6];
}
else
{ b[5]=a[6];
  b[6]=a[5];
}
if (m[4]==0)
{ b[7]=a[7];
  b[8]=a[8];
}
else
{ b[7]=a[8];
  b[8]=a[7];
}
a[1]=b[1];   a[2]=b[3];   a[3]=b[2];   a[4]=b[4];
a[5]=b[5];   a[6]=b[7];   a[7]=b[6];   a[8]=b[8];
m[1]=m[13];   m[2]=m[14];   m[3]=m[15];   m[4]=m[16];
if (m[1]==0)
{ b[1]=a[1];
  b[2]=a[2];
}
else
{ b[1]=a[2];
  b[2]=a[1];
}
if (m[2]==0)
{ b[3]=a[3];
  b[4]=a[4];
}
else
{ b[3]=a[4];
  b[4]=a[3];
}
if (m[3]==0)
{ b[5]=a[5];
  b[6]=a[6];
}
else
{ b[5]=a[6];
  b[6]=a[5];
}
```

```
    if (m[4]==0)
    { b[7]=a[7];
      b[8]=a[8];
    }
    else
    { b[7]=a[8];
      b[8]=a[7];
    }
    a[1]=b[1];   a[2]=b[5];   a[3]=b[2];   a[4]=b[6];
    a[5]=b[3];   a[6]=b[7];   a[7]=b[4];   a[8]=b[8];
    m[1]=m[17];   m[2]=m[18];   m[3]=m[19];   m[4]=m[20];
    if (m[1]==0)
    { b[1]=a[1];
      b[2]=a[2];
    }
    else
    { b[1]=a[2];
      b[2]=a[1];
    }
    if (m[2]==0)
    { b[3]=a[3];
      b[4]=a[4];
    }
    else
    { b[3]=a[4];
      b[4]=a[3];
    }
    if (m[3]==0)
    { b[5]=a[5];
      b[6]=a[6];
    }
    else
    { b[5]=a[6];
      b[6]=a[5];
    }
    if (m[4]==0)
    { b[7]=a[7];
      b[8]=a[8];
    }
    else
    { b[7]=a[8];
      b[8]=a[7];
    }
    printf("\nThe output data is %d%d%d%d%d%d%d%d.",b[8],b[7],b[6],b[5],b[4],b[3],b
[2],b[1]);
    getch();
}
```

```
#include<stdio.h>
#include<conio.h>
#include<ctype.h>
void main(void)
{
 int a[9],b[9];
 int i,c,d;
 clrscr();
 printf("The data of the first pass.\n");
 for (i=7;i>-1;i--)
 {
  printf("D%d= ",i);
  scanf("%d",&a[i+1]);
 }
 printf("\nThe data of the second pass.\n");
 for (i=7;i>-1;i--)
 {
  printf("D%d= ",i);
  scanf("%d",&b[i+1]);
 }
 printf("\nThe first error bit = ");
 scanf("%d",&c);
 printf("\nThe second error bit = ");
 scanf("%d",&d);
 c++;
 d++;
 a[c]=b[c];
 a[d]=b[d];

 printf("\nThe correct output is %d%d%d%d%d%d%d%d.",a[8],a[7],a[6],a[5],a[4],a[3],a
[2],a[1]);
 getch();
}
```

Benes Network with no fault

```
DATA SEGMENT
PERF DB '1.Perfect Shuffle$'
BIT DB '2.Bit Reverse$'
FLIP  DB '3.Flip Permutation$'
SHIF DB '4.Cyclic Shift$'
CLRF DB 10,13,'$'
DAT  DB ?
MSG1 DB 'Please choose a number:
$'
MSG2 DB 'Please enter the data: $'
MSG13 DB 'Sending controls to
port....$'
MSG3 DB '0301 , the first set of the
bypass circuits.$'
MSG4 DB '0302 , the second set of
the bypass circuits.$'
MSG5 DB '0303 , the first set of the
switches.$'
MSG6 DB '0304 , the second set of
the switches.$'
MSG7 DB '0305 , the third set of the
switches.$'
MSG8 DB '0306 , the third set of the
bypass circuits.$'
MSG9 DB '0307 , the forth set of the
bypass circuits.$'
MSG10 DB '0300 , the data inputs.$'
MSG11 DB 'Sending the data to
port....$'
MSG12 DB 'Please latch the data
port.$'
MSG14 DB '1.101$'
MSG15 DB '2.011$'
MSG16 DB '3.010$'
MSG17 DB '4.111$'
MSG18 DB '1.Shifted by 1 position.$'
MSG19 DB '2.Shifted by 2
positions.$'
DATA ENDS
CODE SEGMENT
ASSUME CS:CODE , DS:DATA
START: MOV AX,DATA
    MOV DS,AX

    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
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INT 21H
LEA DX,CLRF
MOV AH,9
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INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,PERF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,BIT
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,FLIP
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,SHIF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG1
MOV AH,9
INT 21H

MOV AH,1
INT 21H
MOV BL,AL

LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
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INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG2
MOV AH,9
```

```
      INT 21H

      MOV AH,1
      INT 21H
      CMP AL,40H
      JA  AF
      JMP O_N

AF:   SUB AL,40H
      ADD AL,9
      MOV CL,4
      SHL AL,CL
      MOV CL,AL
      JMP NEXT

O_N:  SUB AL,30H
      MOV CL,4
      SHL AL,CL
      MOV CL,AL

NEXT: MOV AH,1
      INT 21H

      CMP AL,40H
      JA  AF2
      JMP O_N2

AF2:  SUB AL,40H
      ADD AL,9
      MOV CH,AL
      JMP NEXT2

O_N2: SUB AL,30H
      MOV CH,AL

NEXT2: ADD CL,CH
      MOV AL,CL
      MOV DAT,AL

      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
```

```
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
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      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H



      MOV AL,BL
      CMP AL,31H
```

```
     JE  PE
     CMP AL,32H
     JE  BI2
     CMP AL,33H
     JE  FL2
     CMP AL,34H
     JE  CY2
     JMP EXIT

BI2:  JMP BI
FL2:  JMP FL
CY2:  JMP CY
PE:   LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
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     LEA DX,CLRF
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     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H

     LEA DX,MSG13
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,MSG3
     MOV AH,9
     INT 21H
     MOV AH,1
     INT 21H

     MOV AL,89H
     MOV DX,0303H
     OUT DX,AL

     MOV AL,00110011B
     MOV DX,0300H
     OUT DX,AL

     LEA DX,CLRF
     MOV AH,9
     INT 21H

     LEA DX,MSG13
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
```

```
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10101100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,01101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
        INT 21H
        LEA DX,MSG10
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,DAT
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG12
        MOV AH,9
        INT 21H

        MOV AH,1
        INT 21H
        JMP EXIT

BI:     LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG3
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,89H
        MOV DX,0303H
        OUT DX,AL

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG4
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG5
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,10001100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG6
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,01001100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG7
        MOV AH,9
```

```
INT 21H
MOV AH,1
INT 21H

MOV AL,00001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT

FL:  LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG14
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG15
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG16
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG17
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG1
MOV AH,9
INT 21H
MOV AH,1
INT 21H

CMP AL,31H
JE F1
CMP AL,32H
```

```
        JE F22
        CMP AL,33H
        JE F33
        CMP AL,34H
        JE F44
        JMP EXIT

F22:    JMP F2
F33:    JMP F3
F44:    JMP F4

F1:     LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG3
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,89H
        MOV DX,0303H
        OUT DX,AL

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG4
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG5
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00001111B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG6
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00001111B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG7
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00000000B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
```

```
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT

F2:  LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11110000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
```

```
        INT 21H
        JMP EXIT

F3:     LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG3
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,89H
        MOV DX,0303H
        OUT DX,AL

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG4
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG5
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00000000B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG6
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,11110000B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG7
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00000000B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG8
        MOV AH,9
        INT 21H
```

```
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG9
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG11
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG10
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,DAT
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG12
        MOV AH,9
        INT 21H

        MOV AH,1
        INT 21H
        JMP EXIT

F4:     LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG3
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,89H
        MOV DX,0303H
        OUT DX,AL

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG4
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG5
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00000000B
```

```
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11111111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
```

```
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT

CY:  LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG18
MOV AH,9
```

```
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG19
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG1
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        CMP AL,31H
        JE  S1
        CMP AL,32H
        JE  S22
        JMP EXIT

S22:    JMP S2

S1:     LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG3
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,89H
        MOV DX,0303H
        OUT DX,AL

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG4
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG5
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,10101100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG6
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,01101010B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
```

```
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT

S2:  LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
```

```
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,01101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
```

```
MOV AH,1
INT 21H

MOV AL,00001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
```

```
        MOV AH,1
        INT 21H

        MOV AL,DAT
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG12
        MOV AH,9
        INT 21H

        MOV AH,1
        INT 21H
        JMP EXIT

EXIT:   MOV DX,0300H
        MOV AL,00
        OUT DX,AL

        MOV AX,4C00H
        INT 21H

CODE ENDS
END START
```

Benes Network with first or last stage fault

```
DATA SEGMENT
PERF DB '1.Perfect Shuffle$'
BIT DB '2.Bit Reverse$'
FLIP  DB '3.Flip Permutation$'
SHIF DB '4.Cyclic Shift$'
CLRF DB 10,13,'$'
DAT  DB ?
MSG1 DB 'Please choose a number: $'
MSG2 DB 'Please enter the data: $'
MSG13 DB 'Sending controls to port....$'
MSG3 DB '0301 , the first set of the bypass circuits.$'
MSG4 DB '0302 , the second set of the bypass circuits.$'
MSG5 DB '0303 , the first set of the switches.$'
MSG6 DB '0304 , the second set of the switches.$'
MSG7 DB '0305 , the third set of the switches.$'
MSG8 DB '0306 , the third set of the bypass circuits.$'
MSG9 DB '0307 , the forth set of the bypass circuits.$'
MSG10 DB '0300 , the data inputs.$'
MSG11 DB 'Sending the data to port....$'
MSG12 DB 'Please latch the data port.$'
MSG14 DB '1.101$'
MSG15 DB '2.011$'
MSG16 DB '3.010$'
MSG17 DB '4.111$'
MSG18 DB '1.Shifted by 1 position.$'
MSG19 DB '2.Shifted by 2 positions.$'
MSG20 DB 'First or Last Stage Fault$'
MSG22 DB '1.Straight State.$'
MSG23 DB '2.Exchange State.$'
DATA ENDS
CODE SEGMENT
ASSUME CS:CODE , DS:DATA
START: MOV AX,DATA
     MOV DS,AX

FIRST:
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
```

```
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG20
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,PERF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,BIT
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,FLIP
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,SHIF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG1
    MOV AH,9
    INT 21H

    MOV AH,1                ;Get the
controls
    INT 21H
    MOV BL,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
```

```
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H

     LEA DX,MSG2
     MOV AH,9
     INT 21H

     MOV AH,1              ;Get the
data
     INT 21H
     CMP AL,40H
     JA  AF
     JMP O_N

AF:  SUB AL,40H
     ADD AL,9
     MOV CL,4
     SHL AL,CL
     MOV CL,AL
     JMP NEXT

O_N:  SUB AL,30H
     MOV CL,4
     SHL AL,CL
     MOV CL,AL

NEXT: MOV AH,1
     INT 21H

     CMP AL,40H
     JA  AF2
     JMP O_N2

AF2:  SUB AL,40H
     ADD AL,9
     MOV CH,AL
     JMP NEXT2

O_N2: SUB AL,30H
     MOV CH,AL

NEXT2: ADD CL,CH
     MOV AL,CL
     MOV DAT,AL
     MOV AL,BL
     CMP AL,31H
     JE  PE
     CMP AL,32H
     JE  BI2
     CMP AL,33H
     JE  FL2
     CMP AL,34H
     JE  CY2
     JMP EXIT              ;Jump to
controls

BI2:  JMP BI
FL2:  JMP FL
CY2:  JMP CY
PE:
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
```

```
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG22
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG23
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG1
MOV AH,9
INT 21H
MOV AH,1
INT 21H

    CMP AL,31H          ;Straight
or Exchange
    JE PE_S
    JMP PE_X

PE_S: LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG13
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG3
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,89H
    MOV DX,0303H
    OUT DX,AL

    MOV AL,00110011B
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG13
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG4
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,11001100B
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG13
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG5
```

```
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10101100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,01101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
```

```
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00111100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00111100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT
```

```
BI:
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG22
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG23
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG1
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    CMP AL,31H            ;Straight
or Exchange
    JE  BI_S
    JMP BI_X

BI_S: LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG13
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
```

```
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,01001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT


FL: LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
```

```
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG14
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG15
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG16
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG17
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG1
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    CMP AL,31H
    JE  F1
    CMP AL,32H
    JE  F22
    CMP AL,33H
    JE  F33
    CMP AL,34H
    JE  F44
    JMP EXIT

F22:  JMP F2
F33:  JMP F3
F44:  JMP F4

F1:
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
```

```
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG22
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG23
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG1
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    CMP AL,31H          ;Straight
or Exchange
    JE  F1_S
    JMP F1_X

F1_S:  LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
```

```
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H
```

```
        MOV AL,11001100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG9
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,11001100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG11
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG10
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,DAT
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG12
        MOV AH,9
        INT 21H

        MOV AH,1
        INT 21H
        JMP EXIT

F2:
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
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        LEA DX,CLRF
        MOV AH,9
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        LEA DX,CLRF
        MOV AH,9
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        LEA DX,CLRF
        MOV AH,9
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        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
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        LEA DX,CLRF
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        LEA DX,CLRF
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        LEA DX,CLRF
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        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
```

```
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG22
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG23
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG1
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    CMP AL,31H          ;Straight
or Exchange
    JE  F2_S
    JMP F2_X


F2_S:  LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
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    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
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    LEA DX,CLRF
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    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11110000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
```

```
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT

F3:
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
```

```
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG22
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG23
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG1
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    CMP AL,31H          ;Straight
or Exchange
    JE  F3_S
    JMP F3_X

F3_S: LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
```

```
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11110000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
    INT 21H
    LEA DX,MSG8
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,11001100B
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG13
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG9
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,11001100B
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG11
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG10
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,DAT
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG12
    MOV AH,9
    INT 21H

    MOV AH,1
```

```
    INT 21H
    JMP EXIT

F4:
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
```

```
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG22
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG23
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG1
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    CMP AL,31H          ;Straight
or Exchange
    JE  F4_S
    JMP F4_X

F4_S: LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11111111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
```

```
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG8
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG9
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG11
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG10
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,DAT
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG12
        MOV AH,9
        INT 21H
```

```
        MOV AH,1
        INT 21H
        JMP EXIT

CY:
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
```

```
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG18
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG19
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG1
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    CMP AL,31H
    JE  S1
    CMP AL,32H
    JE  S22
    JMP EXIT

S22:  JMP S2

S1:
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
```

```
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG22
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG23
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG1
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    CMP AL,31H              ;Straight
or Exchange
    JE  S1_S
    JMP S2_X

S1_S: LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
```

```
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10101100B

MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,01101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00111100B
```

```
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG13
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG9
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,00111100B
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG11
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG10
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,DAT
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG12
    MOV AH,9
    INT 21H

    MOV AH,1
    INT 21H
    JMP EXIT

S2:
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
```

```
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG22
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG23
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG1
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    CMP AL,31H          ;Straight
or Exchange
    JE  S2_S
    JMP S2_X

S2_S: LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
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    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00111100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00111100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,01101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H
```

```
        MOV AL,11001100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG9
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG11
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG10
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,DAT
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG12
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H
        JMP EXIT


PE_X:   LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG3
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,89H
        MOV DX,0303H
        OUT DX,AL

        MOV AL,11001100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG4
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG5
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,10100011B
        MOV DX,0300H
```

```
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10011010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000101B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11000011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11000011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT


BI_X:  LEA DX,CLRF
       MOV AH,9
       INT 21H

       LEA DX,MSG13
```

```
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00100011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
```

```
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00010011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
```

```
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG9
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,11001100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG11
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG10
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,DAT
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG12
        MOV AH,9
        INT 21H

        MOV AH,1
        INT 21H
        JMP EXIT

F1_X:   LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG3
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,89H
        MOV DX,0303H
        OUT DX,AL

        MOV AL,11001100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG4
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,11001100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG5
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00000000B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
```

```
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
```

```
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT

F2_X: LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
```

```
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11110000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
        INT 21H
        LEA DX,MSG9
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,11001100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG11
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG10
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,DAT
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG12
        MOV AH,9
        INT 21H

        MOV AH,1
        INT 21H
        JMP EXIT

F3_X:   LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG3
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,89H
        MOV DX,0303H
        OUT DX,AL

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG4
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG5
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00001111B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG6
        MOV AH,9
        INT 21H
```

```
MOV AH,1
INT 21H

MOV AL,11110000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
```

```
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT

F4_X: LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
```

```
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11111111B
```

```
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11001100B
```

```
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG11
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG10
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,DAT
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG12
        MOV AH,9
        INT 21H

        MOV AH,1
        INT 21H
        JMP EXIT

S1_X:   LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG3
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,89H
        MOV DX,0303H
        OUT DX,AL

        MOV AL,11001100B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG4
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,00110011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG5
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,10100011B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG13
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG6
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,10011010B
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
```

```
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000101B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11000011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11000011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
```

```
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT

S2_X: LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,11000011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
```

```
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11000011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10010101B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
```

```
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
```

```
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,MSG10
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H

        MOV AL,DAT
        MOV DX,0300H
        OUT DX,AL

        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG12
        MOV AH,9
        INT 21H
        MOV AH,1
        INT 21H
        JMP EXIT

EXIT:   MOV DX,0300H
        MOV AL,00
        OUT DX,AL

        MOV AX,4C00H
        INT 21H

CODE ENDS
END START
```

Benes Network with middle stage fault

```
DATA SEGMENT
PERF DB '1.Perfect Shuffle$'
BIT DB '2.Bit Reverse$'
FLIP  DB '3.Flip Permutation$'
SHIF DB '4.Cyclic Shift$'
CLRF DB 10,13,'$'
DAT  DB ?
MSG1 DB 'Please choose a number: $'
MSG2 DB 'Please enter the data: $'
MSG13 DB 'Sending controls to port....$'
MSG3 DB '0301 , the first set of the bypass circuits.$'
MSG4 DB '0302 , the second set of the bypass circuits.$'
MSG5 DB '0303 , the first set of the switches.$'
MSG6 DB '0304 , the second set of the switches.$'
MSG7 DB '0305 , the third set of the switches.$'
MSG8 DB '0306 , the third set of the bypass circuits.$'
MSG9 DB '0307 , the forth set of the bypass circuits.$'
MSG10 DB '0300 , the data inputs.$'
MSG11 DB 'Sending the data to port....$'
MSG12 DB 'Please latch the data port.$'
MSG14 DB '1.101$'
MSG15 DB '2.011$'
MSG16 DB '3.010$'
MSG17 DB '4.111$'
MSG18 DB '1.Shifted by 1 position.$'
MSG19 DB '2.Shifted by 2 positions.$'
MSG20 DB 'Middle Stages Fault$'
MSG21 DB 'This is the first pass.$'
MSG22 DB 'This is the second pass.$'
DATA ENDS
CODE SEGMENT
ASSUME CS:CODE , DS:DATA
START: MOV AX,DATA
    MOV DS,AX

    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG20
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,PERF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,BIT
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,FLIP
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,SHIF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG1
MOV AH,9
INT 21H

MOV AH,1
INT 21H
MOV BL,AL

LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
```

```
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H

        LEA DX,MSG2
        MOV AH,9
        INT 21H

        MOV AH,1
        INT 21H
        CMP AL,40H
        JA  AF
        JMP O_N

AF:     SUB AL,40H
        ADD AL,9
        MOV CL,4
        SHL AL,CL
        MOV CL,AL
        JMP NEXT

O_N:    SUB AL,30H
        MOV CL,4
        SHL AL,CL
        MOV CL,AL

NEXT:   MOV AH,1
        INT 21H

        CMP AL,40H
        JA  AF2
        JMP O_N2

AF2:    SUB AL,40H
        ADD AL,9
        MOV CH,AL
        JMP NEXT2

O_N2:   SUB AL,30H
        MOV CH,AL

NEXT2:  ADD CL,CH
        MOV AL,CL
        MOV DAT,AL

        MOV AL,BL
        CMP AL,31H
        JE  PE
        CMP AL,32H
        JE  BI2
        CMP AL,33H
        JE  FL2
        CMP AL,34H
        JE  CY2
        JMP EXIT

BI2:    JMP BI
FL2:    JMP FL
CY2:    JMP CY
PE:     LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
        INT 21H
        LEA DX,CLRF
        MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10101100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,01101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
```

```
INT 21H

MOV AL,00001010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
```

```
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG21
MOV AH,9
INT 21H
MOV AH,1
INT 21H

LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10100011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10011010B
MOV DX,0300H
OUT DX,AL
```

```
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000101B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG22
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT

BI: LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
```

```
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,01001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
```

```
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG21
MOV AH,9
INT 21H
MOV AH,1
INT 21H

LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
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LEA DX,CLRF
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LEA DX,CLRF
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LEA DX,CLRF
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LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00100011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00010011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
```

```
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,MSG22
     MOV AH,9
     INT 21H
     MOV AH,1
     INT 21H
     JMP EXIT

FL:  LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
```

```
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H

     LEA DX,MSG14
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,MSG15
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,MSG16
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,MSG17
     MOV AH,9
     INT 21H
     LEA DX,CLRF
     MOV AH,9
     INT 21H
     LEA DX,MSG1
     MOV AH,9
     INT 21H
     MOV AH,1
     INT 21H
```

```
    CMP AL,31H
    JE  F1
    CMP AL,32H
    JE  F22
    CMP AL,33H
    JE  F33
    CMP AL,34H
    JE  F44
    JMP EXIT

F22:  JMP F2
F33:  JMP F3
F44:  JMP F4

F1:   LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
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    LEA DX,CLRF
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    LEA DX,CLRF
    MOV AH,9
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    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG13
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG3
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,89H
    MOV DX,0303H
    OUT DX,AL

    MOV AL,00110011B
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG13
    MOV AH,9
    INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG21
MOV AH,9
INT 21H

MOV AH,1
INT 21H

LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
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LEA DX,CLRF
MOV AH,9
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LEA DX,CLRF
MOV AH,9
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LEA DX,CLRF
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LEA DX,CLRF
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LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
```

```
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
```

```
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
```

```
    LEA DX,MSG9
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,00110011B
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG11
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG10
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,DAT
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG12
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG22
    MOV AH,9
    INT 21H

    MOV AH,1
    INT 21H
    JMP EXIT

F2: LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H

MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11110000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
```

```
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG21
MOV AH,9
INT 21H

MOV AH,1
INT 21H

LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11110000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
```

```
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
```

```
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG22
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT

F3:  LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11110000B
MOV DX,0300H
OUT DX,AL
```

```
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL
```

```
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG21
MOV AH,9
INT 21H

MOV AH,1
INT 21H

LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
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LEA DX,CLRF
MOV AH,9
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LEA DX,CLRF
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LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H
```

```
LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11110000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H
```

```
LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG22
MOV AH,9
INT 21H

MOV AH,1
INT 21H
JMP EXIT

F4:  LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11111111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG21
MOV AH,9
INT 21H

MOV AH,1
INT 21H

LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
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LEA DX,CLRF
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MOV AH,9
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MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
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MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
```

```
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,11111111B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
```

```
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000000B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
```

```
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,DAT
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG12
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG22
    MOV AH,9
    INT 21H

    MOV AH,1
    INT 21H
    JMP EXIT

CY: LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
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    LEA DX,CLRF
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    LEA DX,CLRF
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    LEA DX,CLRF
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    LEA DX,CLRF
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    LEA DX,CLRF
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    LEA DX,CLRF
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    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG18
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG19
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG1
    MOV AH,9
```

```
      INT 21H
      MOV AH,1
      INT 21H

      CMP AL,31H
      JE  S1
      CMP AL,32H
      JE  S22
      JMP EXIT

S22:  JMP S2

S1:   LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H

      LEA DX,MSG13
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
      INT 21H
      LEA DX,MSG3
      MOV AH,9
      INT 21H
      MOV AH,1
      INT 21H

      MOV AL,89H
      MOV DX,0303H
      OUT DX,AL

      MOV AL,00110011B
      MOV DX,0300H
      OUT DX,AL

      LEA DX,CLRF
      MOV AH,9
      INT 21H

      LEA DX,MSG13
      MOV AH,9
      INT 21H
      LEA DX,CLRF
      MOV AH,9
```

```
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10101100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,01101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG21
MOV AH,9
INT 21H

MOV AH,1
INT 21H

LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
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LEA DX,CLRF
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INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
```

```
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10100011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
```

```
MOV AH,1
INT 21H

MOV AL,10011010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000101B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
```

```
    MOV AH,1
    INT 21H

    MOV AL,00110011B
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG11
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG10
    MOV AH,9
    INT 21H
    MOV AH,1
    INT 21H

    MOV AL,DAT
    MOV DX,0300H
    OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG12
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG22
    MOV AH,9
    INT 21H

    MOV AH,1
    INT 21H
    JMP EXIT

S2: LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
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    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
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    LEA DX,CLRF
    MOV AH,9
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    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
```

```
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,01101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00001100B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H
```

```
MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG12
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG21
MOV AH,9
INT 21H

MOV AH,1
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
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MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
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MOV AH,9
INT 21H
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INT 21H
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MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
```

```
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG3
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,89H
MOV DX,0303H
OUT DX,AL

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG4
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL
```

```
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG5
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10010101B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG6
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,10101010B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG7
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00000011B
MOV DX,0300H
OUT DX,AL
```

```
LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG8
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG13
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG9
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,00110011B
MOV DX,0300H
OUT DX,AL

LEA DX,CLRF
MOV AH,9
INT 21H

LEA DX,MSG11
MOV AH,9
INT 21H
LEA DX,CLRF
MOV AH,9
INT 21H
LEA DX,MSG10
MOV AH,9
INT 21H
MOV AH,1
INT 21H

MOV AL,DAT
MOV DX,0300H
OUT DX,AL

    LEA DX,CLRF
    MOV AH,9
    INT 21H

    LEA DX,MSG12
    MOV AH,9
    INT 21H
    LEA DX,CLRF
    MOV AH,9
    INT 21H
    LEA DX,MSG22
    MOV AH,9
    INT 21H

    MOV AH,1
    INT 21H
    JMP EXIT

EXIT: MOV DX,0300H
    MOV AL,00
    OUT DX,AL

    MOV AX,4C00H
    INT 21H

CODE ENDS
END START
```

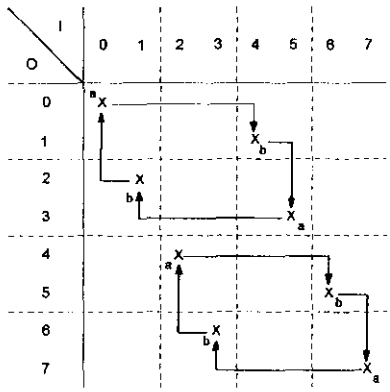
CHAPTER 4 :

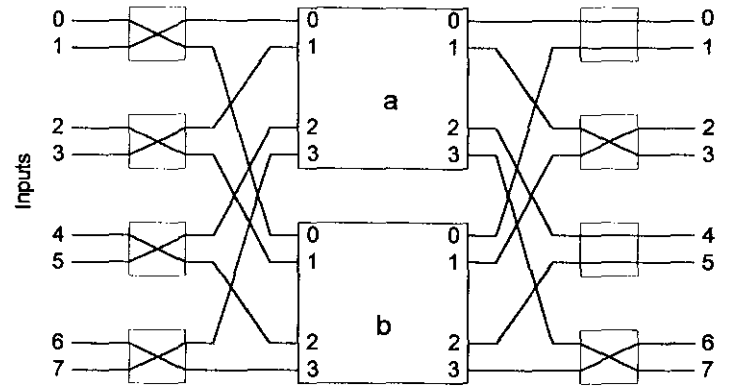
TEST, EXPERIMENTS AND EQUIPMENT

Perfect Shuffle

0 1 2 3 4 5 6 7

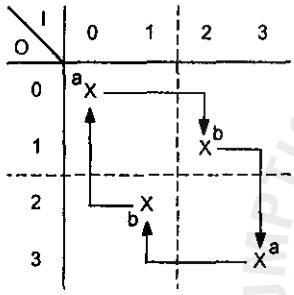
0 2 4 6 1 3 5 7

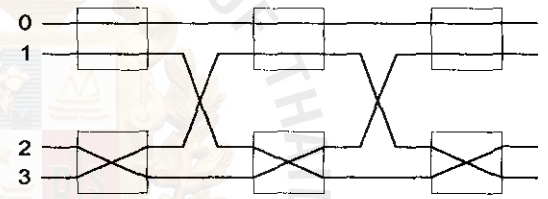




0 1 2 3

0 2 1 3



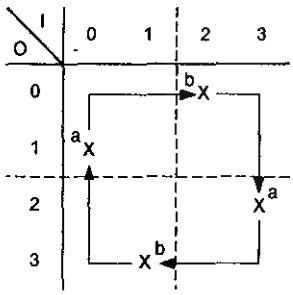


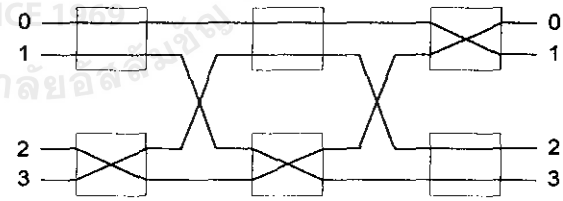
0 1
0 1

0 1
1 0

0 1 2 3

1 3 0 2

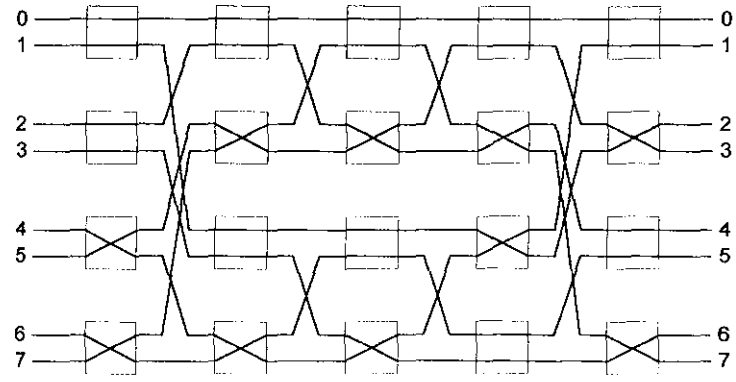




0 1
0 1

0 1
1 0

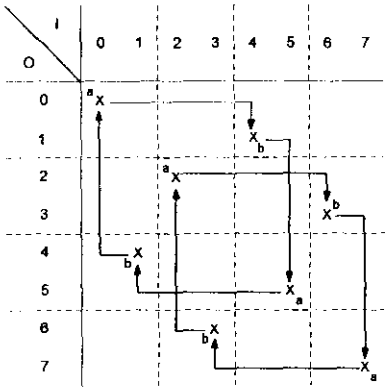
0	0	0	0	0
0	1	1	1	1
1	0	0	1	0
1	1	1	0	1

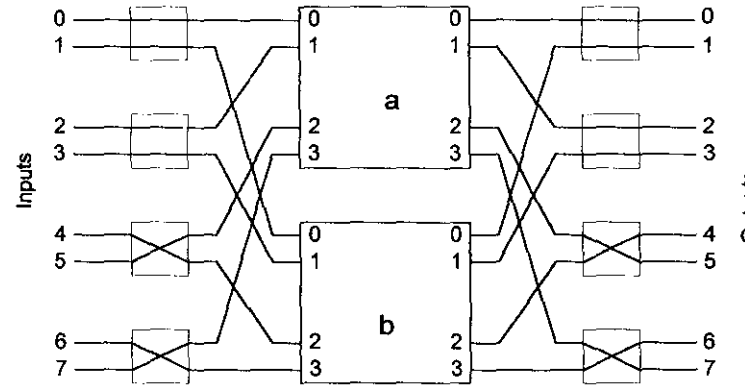


Bit Reversal

0 1 2 3 4 5 6 7

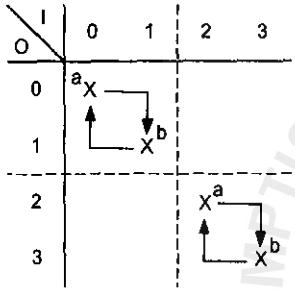
0 4 2 6 1 5 3 7

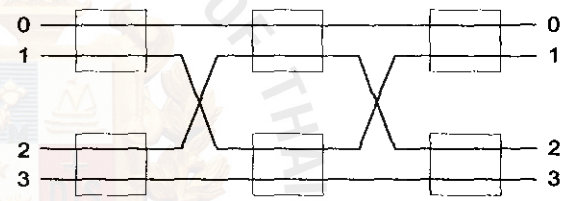




0 1 2 3

0 1 2 3





0 1

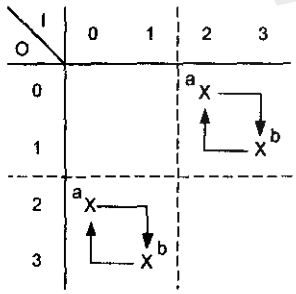
0 1

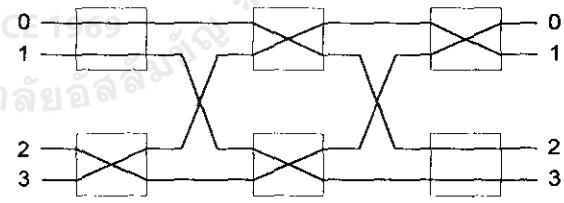
0 1

0 1

0 1 2 3

2 3 01





0 1

1 0

0 1

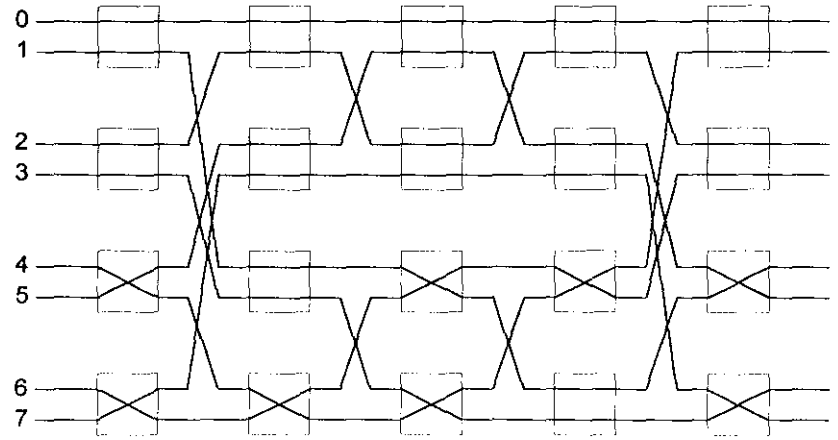
1 0

0 0 0 0 0

0 0 0 0 0

1 0 1 1 1

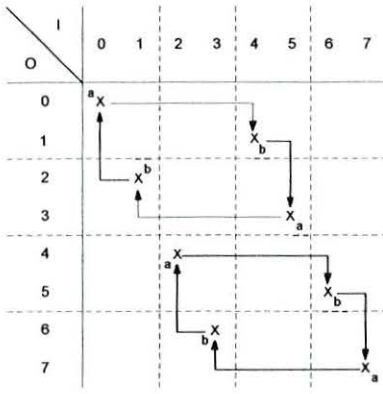
1 1 1 0 1

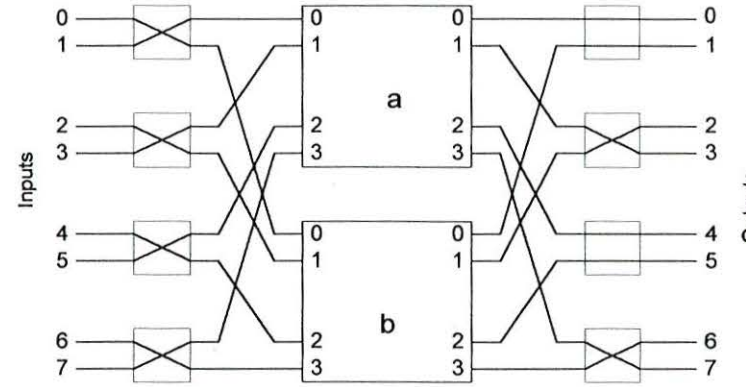


SHIFT 1

0 1 2 3 4 5 6 7

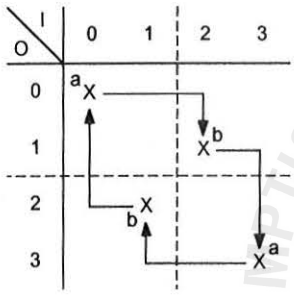
0 2 4 6 1 3 5 7

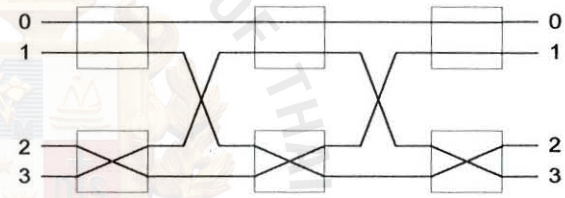




0 1 2 3

0 2 1 3



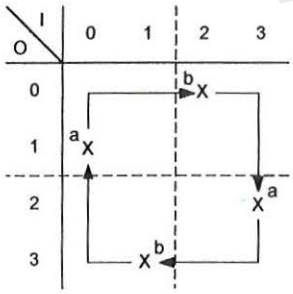


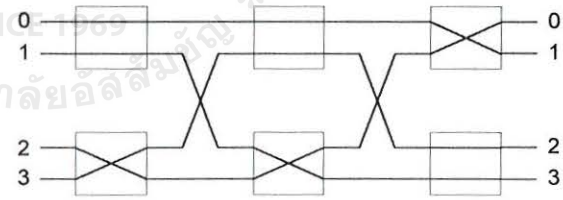
0 1
0 1

0 1
1 0

0 1 2 3

1 3 0 2

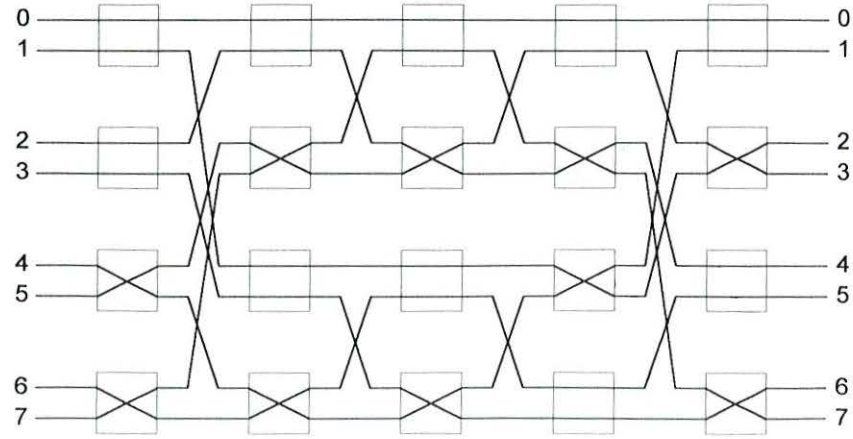




0 1
0 1

0 1
1 0

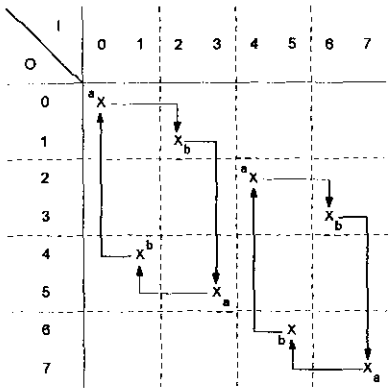
0	0	0	0	0
0	1	1	1	1
1	0	0	1	0
1	1	1	0	1

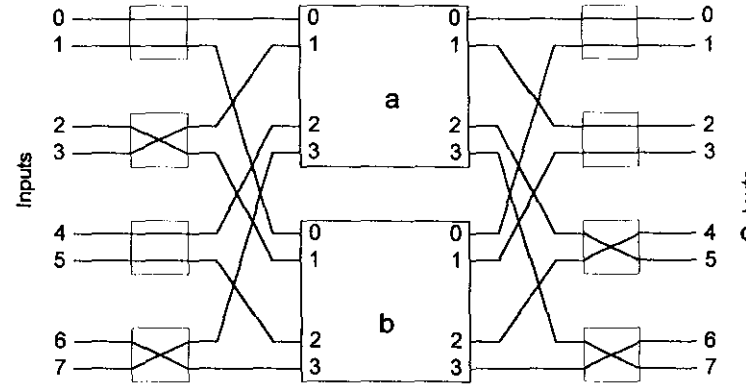


SHIFT 2

0 1 2 3 4 5 6 7

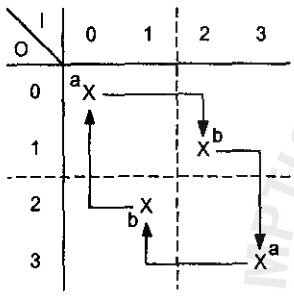
0 4 1 5 2 6 3 7

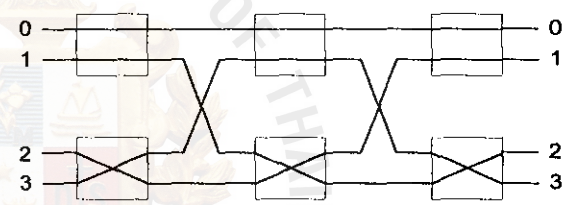




0 1 2 3

0 2 1 3



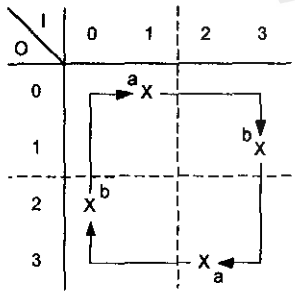


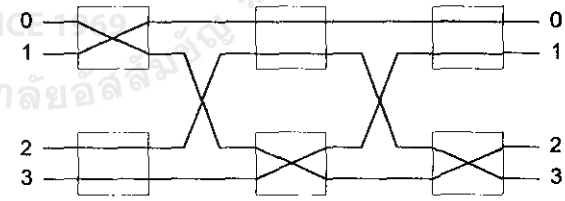
0 1
0 1

0 1
1 0

0 1 2 3

2 0 3 1

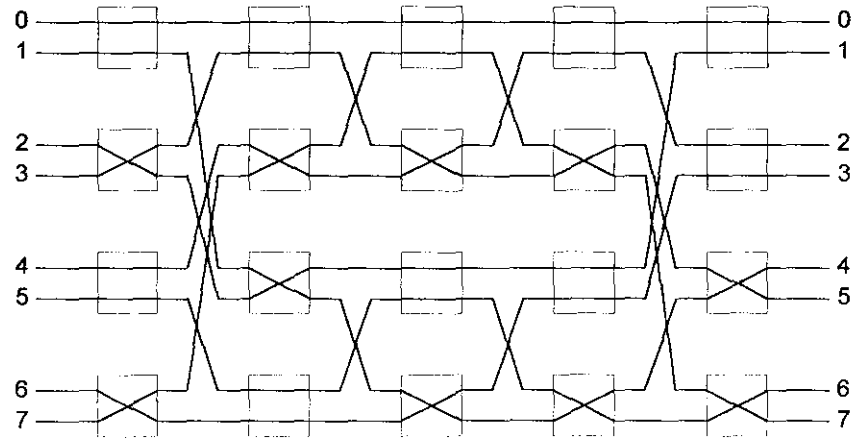




0 1
0 1

0 1
1 0

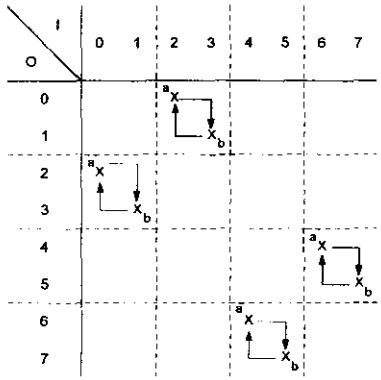
0	0	0	0	0
1	1	1	1	0
0	1	0	0	1
1	0	1	1	1

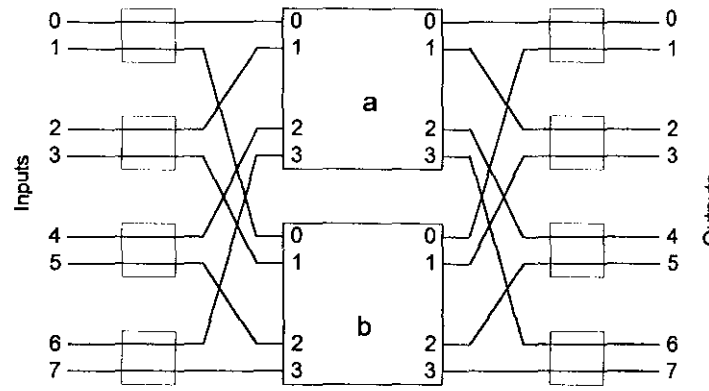


FLIP (010)

0 1 2 3 4 5 6 7

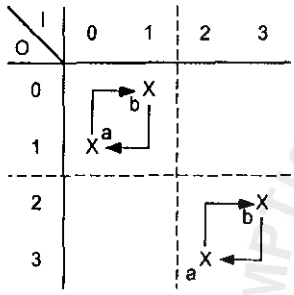
2 3 0 1 6 7 4 5

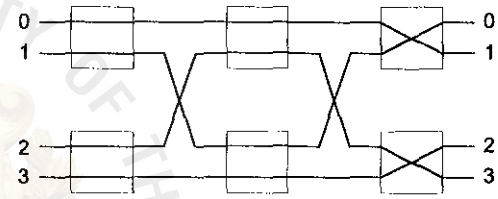




0 1 2 3

1 0 3 2





0 1

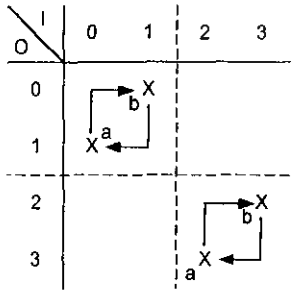
0 1

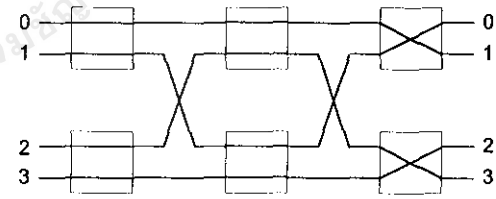
0 1

0 1

0 1 2 3

1 0 3 2





0 1

0 1

0 1

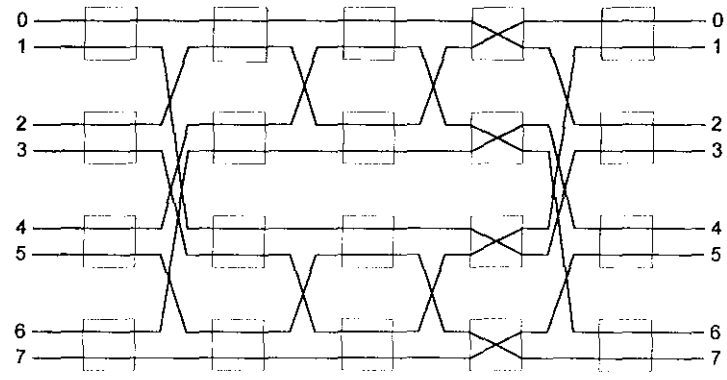
0 1

0 0 0 1 0

0 0 0 1 0

0 0 0 1 0

0 0 0 1 0



FLIP (011)
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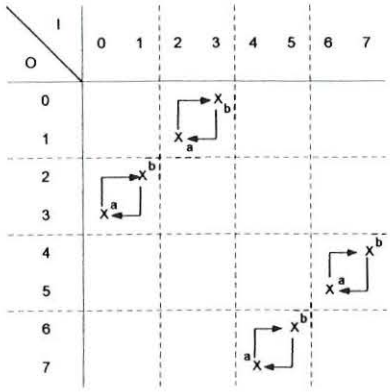
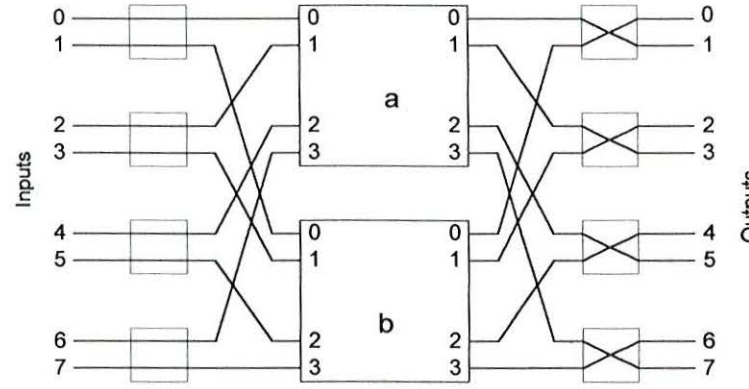
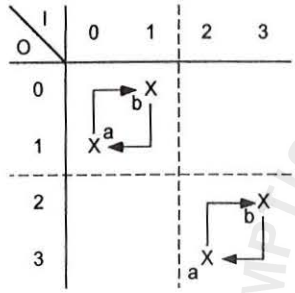
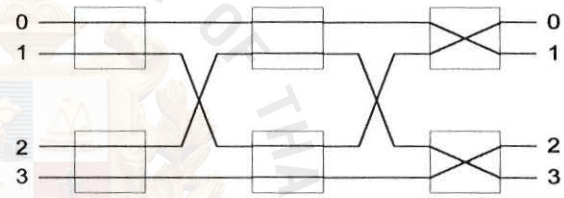
3 2 1 0 7 6 5 4





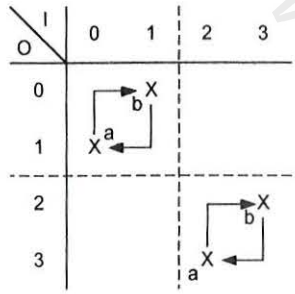
0 1 2 3
1 0 3 2

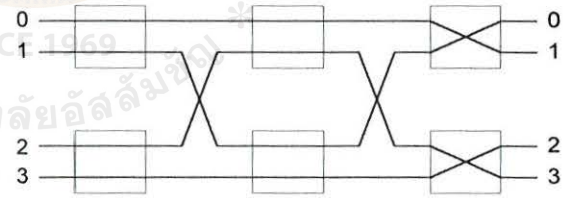




0 1
0 1
0 1
0 1

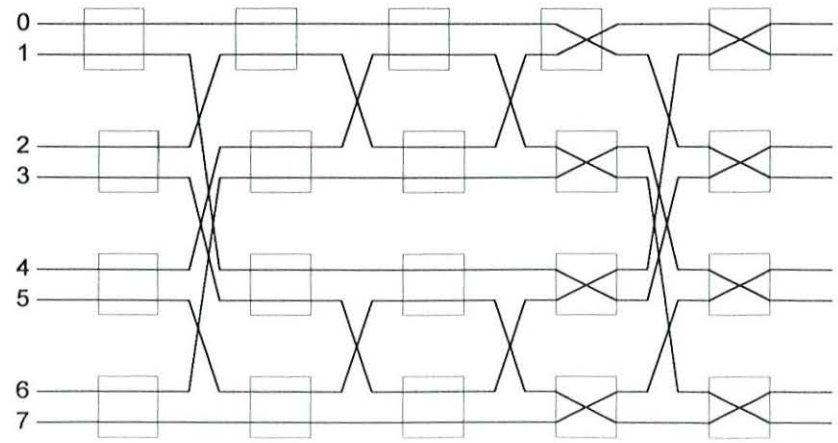
0 1 2 3
1 0 3 2



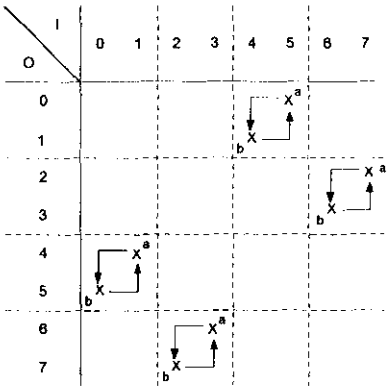


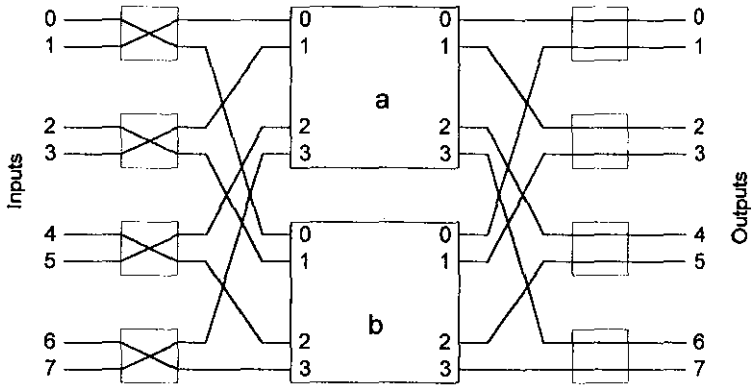
0 1
0 1
0 1
0 1

0 0 0 1 1
0 0 0 1 1
0 0 0 1 1
0 0 0 1 1

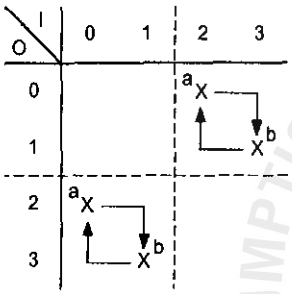


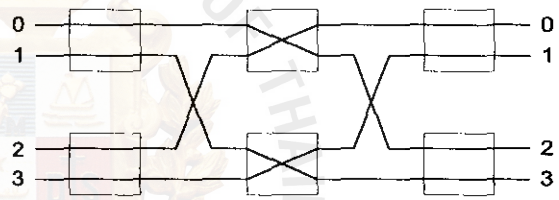
FLIP (101)
0 1 2 3 4 5 6 7
5 4 7 6 1 0 3 2





0 1 2 3
2 3 0 1

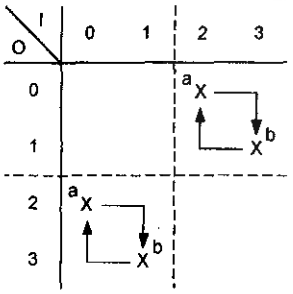


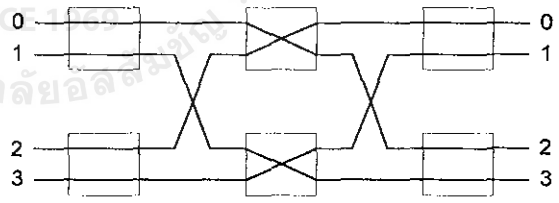


0 1
1 0

0 1
1 0

0 1 2 3
2 3 0 1





0 1
1 0

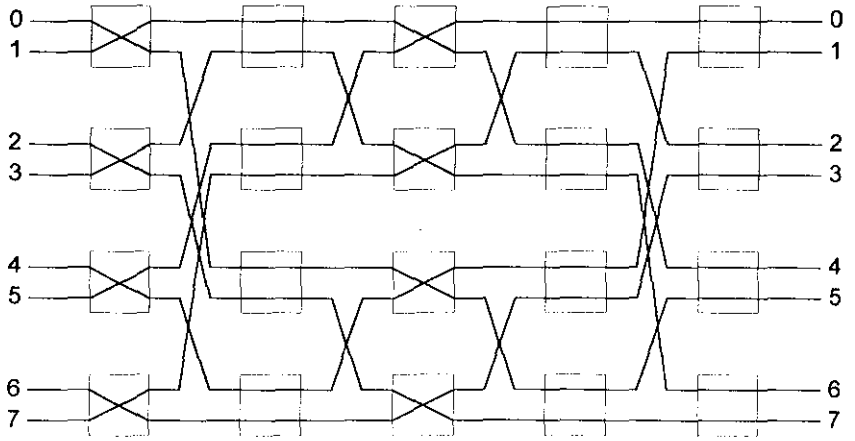
0 1
1 0

1 0 1 0 0

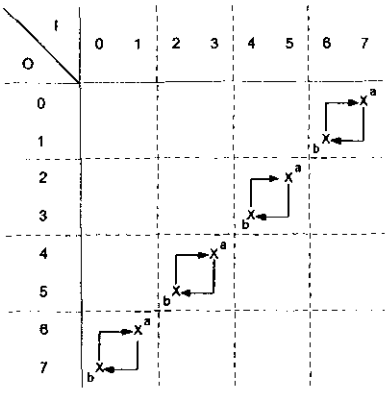
1 0 1 0 0

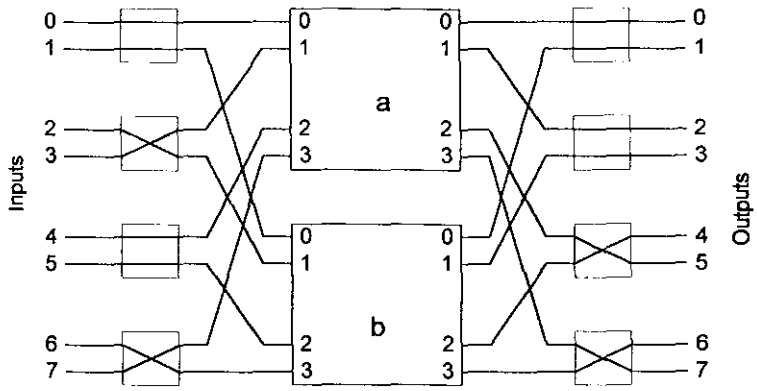
1 0 1 0 0

1 0 1 0 0

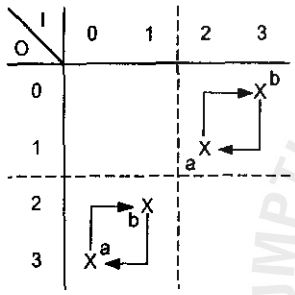


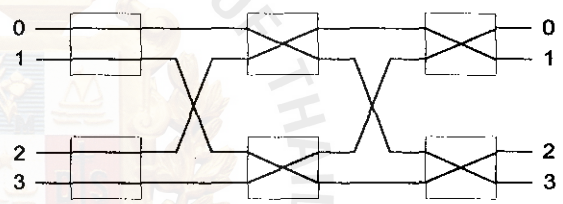
FLIP (111)
0 1 2 3 4 5 6 7
7 6 5 4 3 2 1 0





0 1 2 3
3 2 1 0

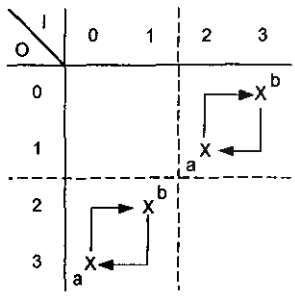


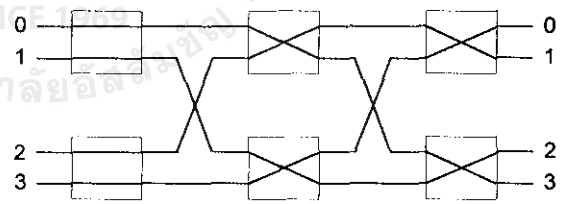


0 1
1 0

0 1
1 0

0 1 2 3
3 2 1 0





0 1
1 0

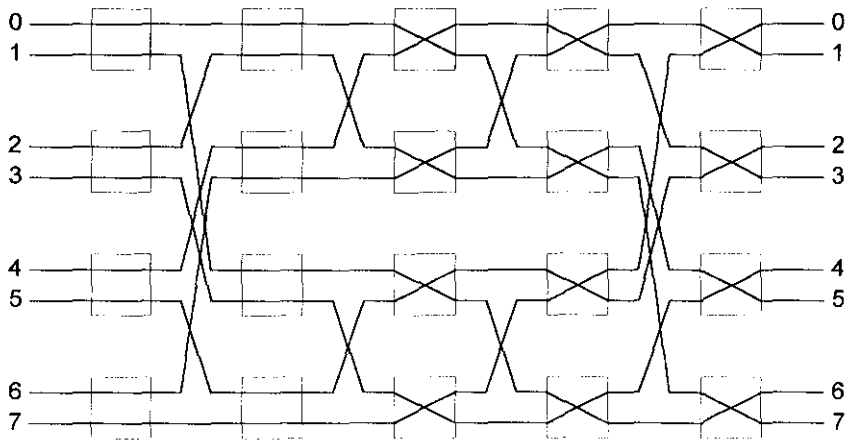
0 1
1 0

0 0 1 1 1

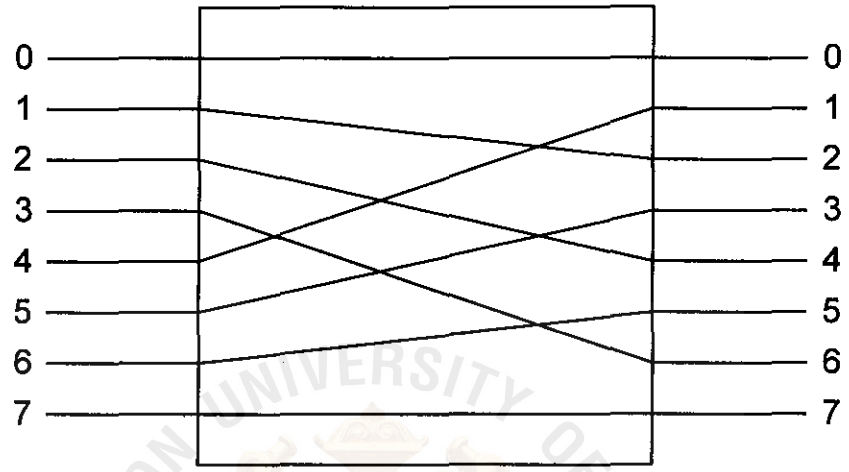
0 0 1 1 1

0 0 1 1 1

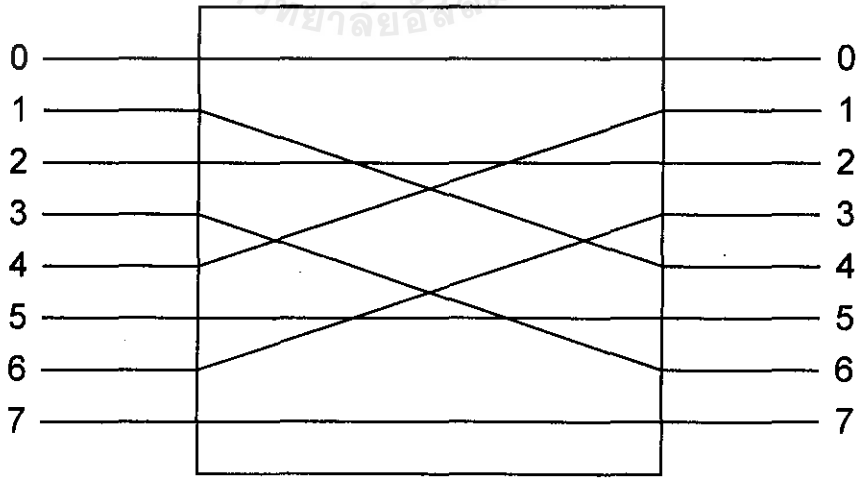
0 0 1 1 1



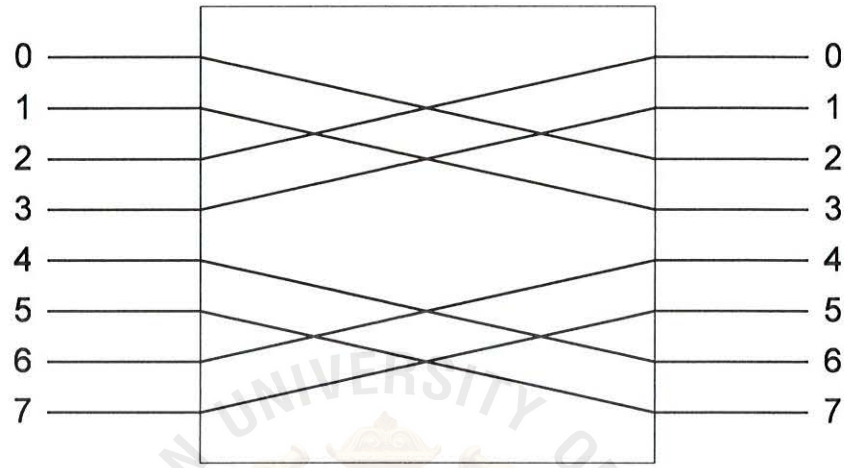
Perfect Shuffle
0 1 2 3 4 5 6 7
0 2 4 6 1 3 5 7



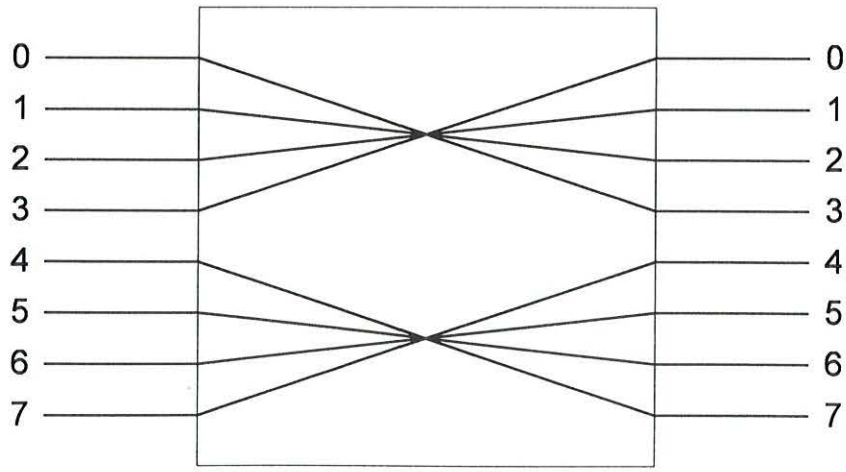
Bit Reversal
0 1 2 3 4 5 6 7
0 4 2 6 1 5 3 7



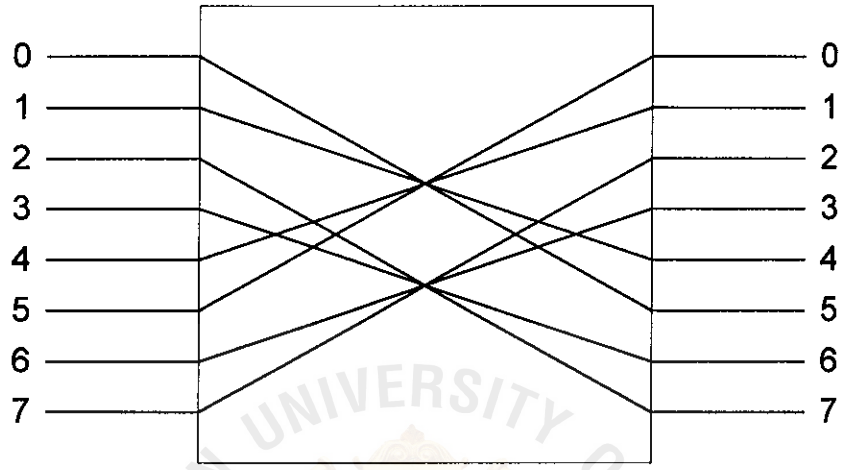
Flip Permutation (010)
0 1 2 3 4 5 6 7
2 3 0 1 6 7 4 5



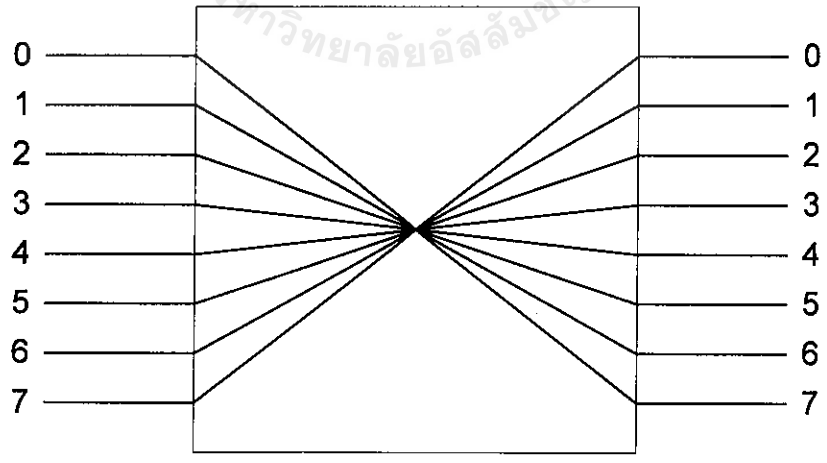
Flip Permutation (011)
0 1 2 3 4 5 6 7
3 2 1 0 7 6 5 4



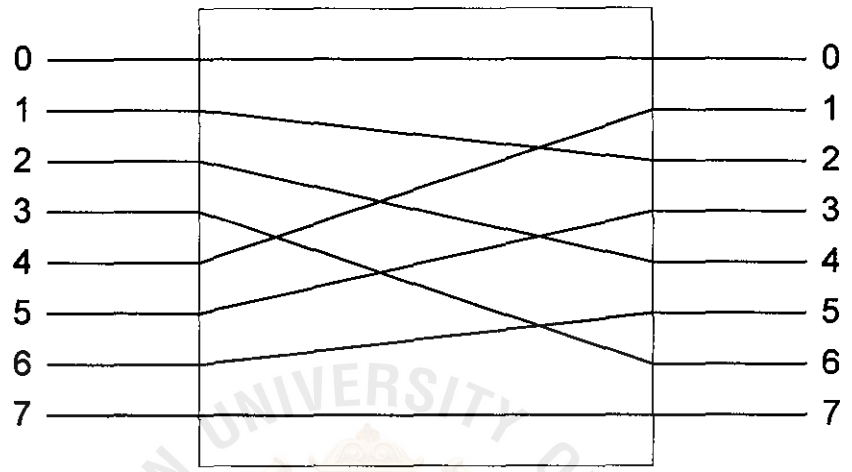
Flip Permutation (101)
0 1 2 3 4 5 6 7
5 4 7 6 1 0 3 2



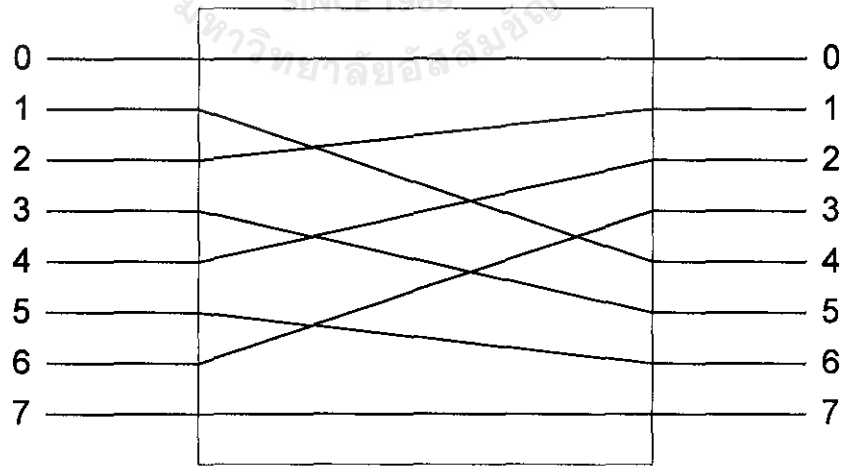
Flip Permutation (111)
0 1 2 3 4 5 6 7
7 6 5 4 3 2 1 0



Cyclic Shift 1
0 1 2 3 4 5 6 7
0 2 4 6 1 3 5 7



Cyclic Shift 2
0 1 2 3 4 5 6 7
0 4 1 5 2 6 3 7

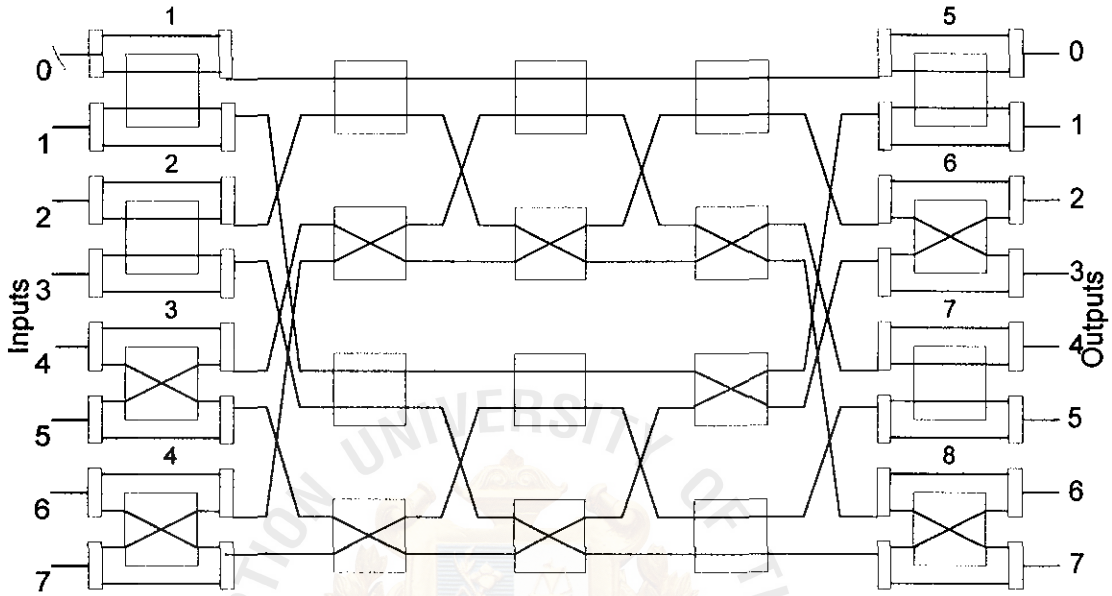


The Equipment

1. 8255a Programmable Parallel Port	1
2. DIP Switches	6
3. 74LS04 Inverter gates	23
4. 74LS08 AND gates	20
5. 74LS32 OR gates	21
6. 74LS688 Comparators	4
7. 74LS373 Data Latches (8 bits)	9
8. 74LS155 Demultiplexers	9
9. 74LS157 Multiplexers	8
10. LEDs	16
11. Resistors 330Ω	16
12. Resistors pack 10kΩ	6
13. ISA Card (for computer interface)	1

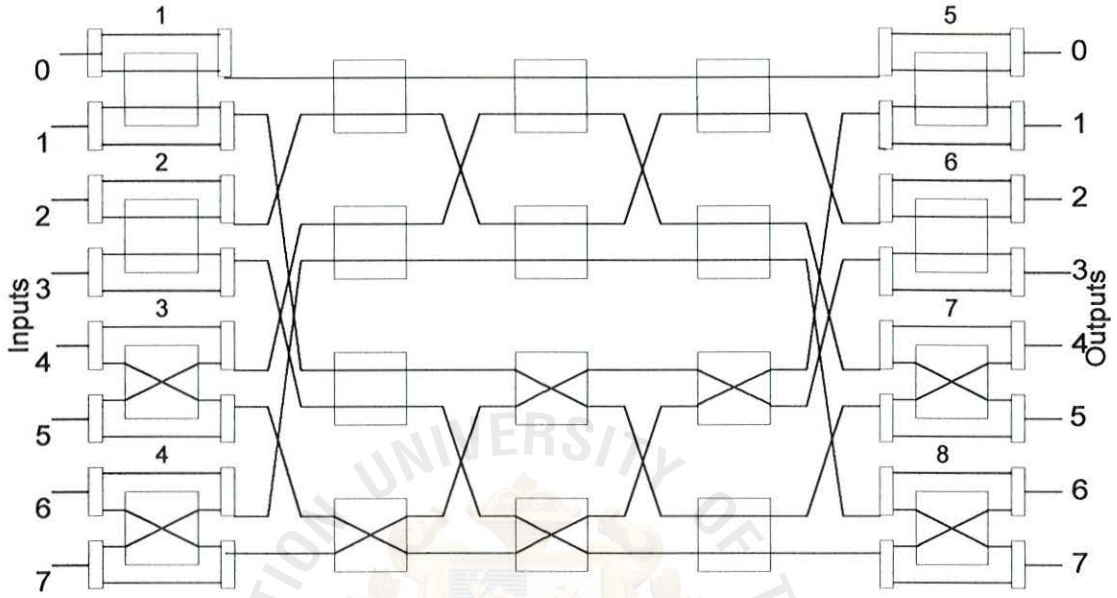
Fault – Tolerant in First and Last Stage

Perfect Shuffle
0 1 2 3 4 5 6 7
0 2 4 6 1 3 5 7



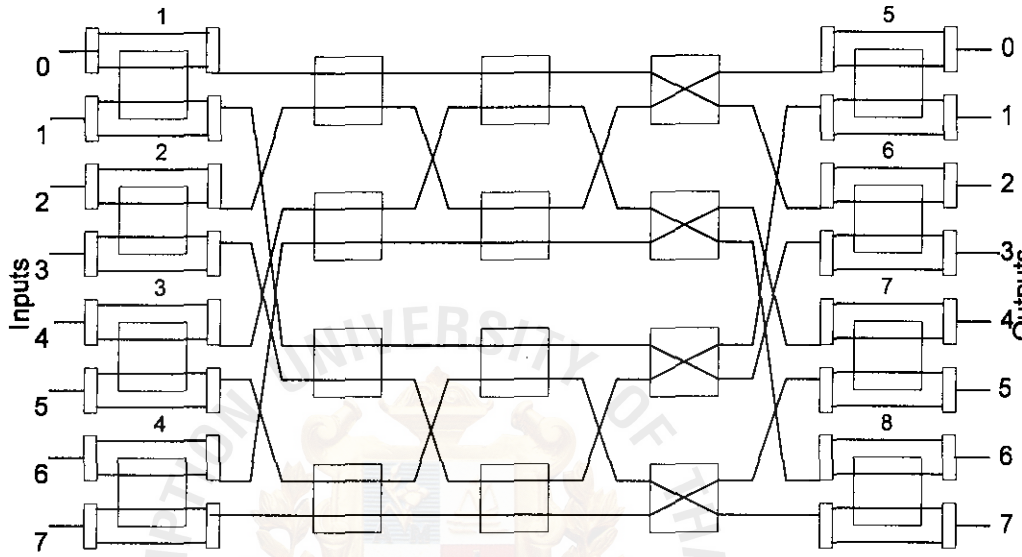
Switch No.	State
1	Straight
2	Straight
3	Exchange
4	Exchange
5	Straight
6	Exchange
7	Straight
8	exchange

Bit Reversal
0 1 2 3 4 5 6 7
0 4 2 6 1 5 3 7



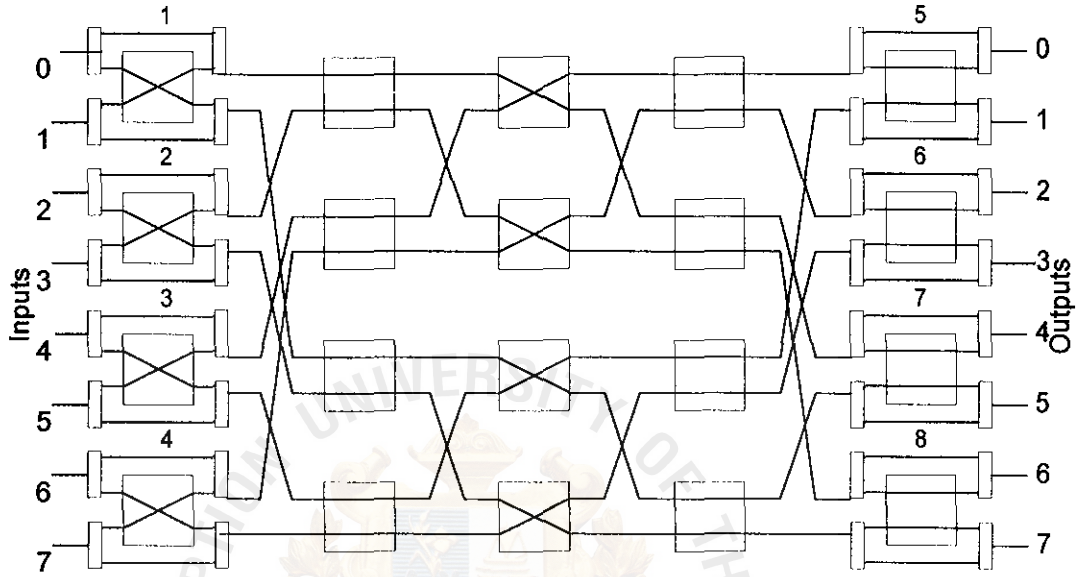
Switch No.	State
1	Straight
2	Straight
3	Exchange
4	Exchange
5	Straight
6	Straight
7	Exchange
8	Exchange

FLIP (010)
0 1 2 3 4 5 6 7
2 3 0 1 6 7 4 5



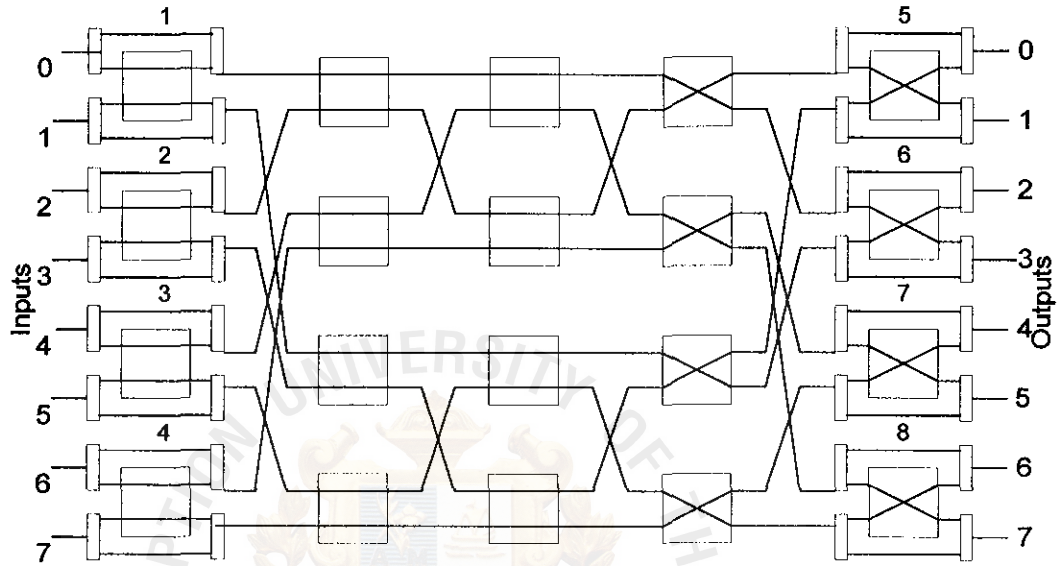
Switch No.	State
1	Straight
2	Straight
3	Straight
4	Straight
5	Straight
6	Straight
7	Straight
8	Straight

FLIP (101)
0 1 2 3 4 5 6 7
5 4 7 6 1 0 3 2



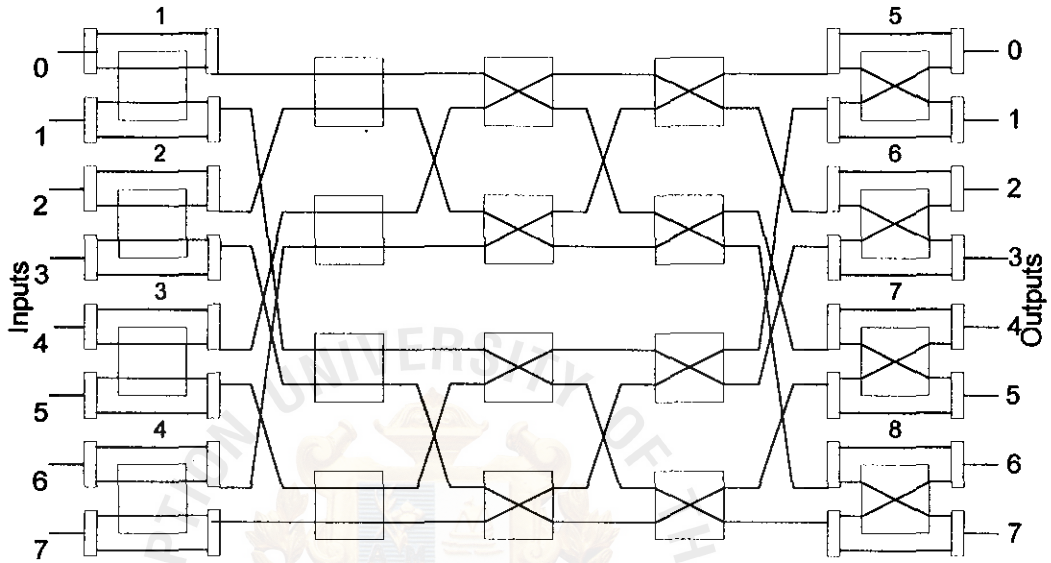
Switch No.	State
1	Exchange
2	Exchange
3	Exchange
4	Exchange
5	Straight
6	Straight
7	Straight
8	Straight

FLIP (011)
0 1 2 3 4 5 6 7
3 2 1 0 7 6 5 4



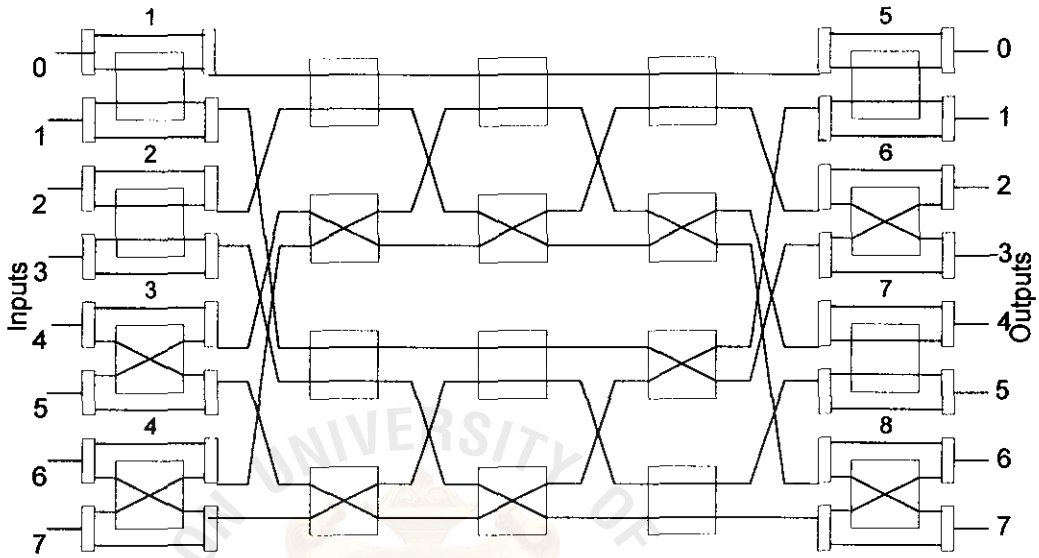
Switch No.	State
1	Straight
2	Straight
3	Straight
4	Straight
5	Exchange
6	Exchange
7	Exchange
8	Exchange

FLIP (111)
0 1 2 3 4 5 6 7
7 6 5 4 3 2 1 0



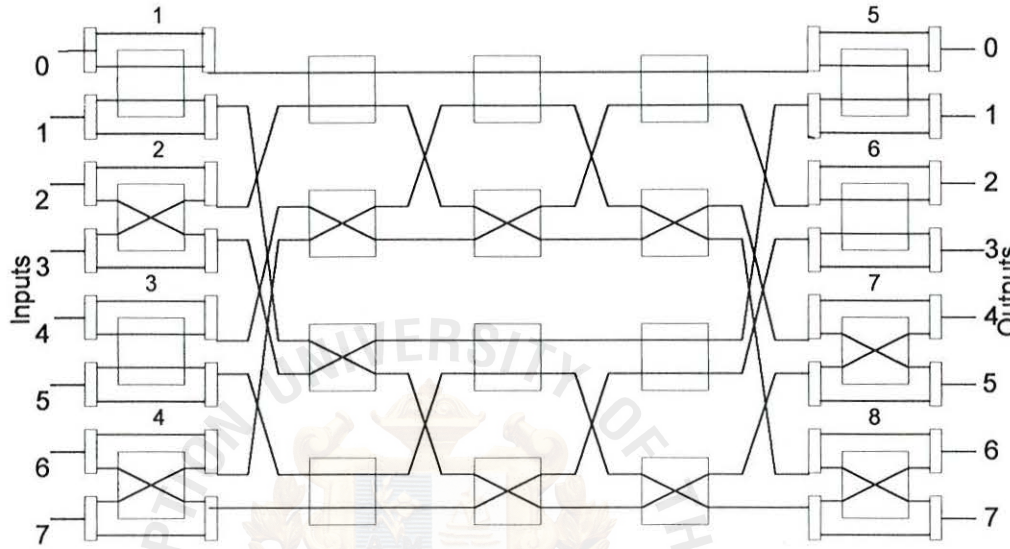
Switch No.	State
1	Straight
2	Straight
3	Straight
4	Straight
5	Exchange
6	Exchange
7	Exchange
8	Exchange

SHIFT 1
0 1 2 3 4 5 6 7
0 2 4 6 1 3 5 7



Switch No.	State
1	Straight
2	Straight
3	Exchange
4	Exchange
5	Straight
6	Exchange
7	Straight
8	Exchange

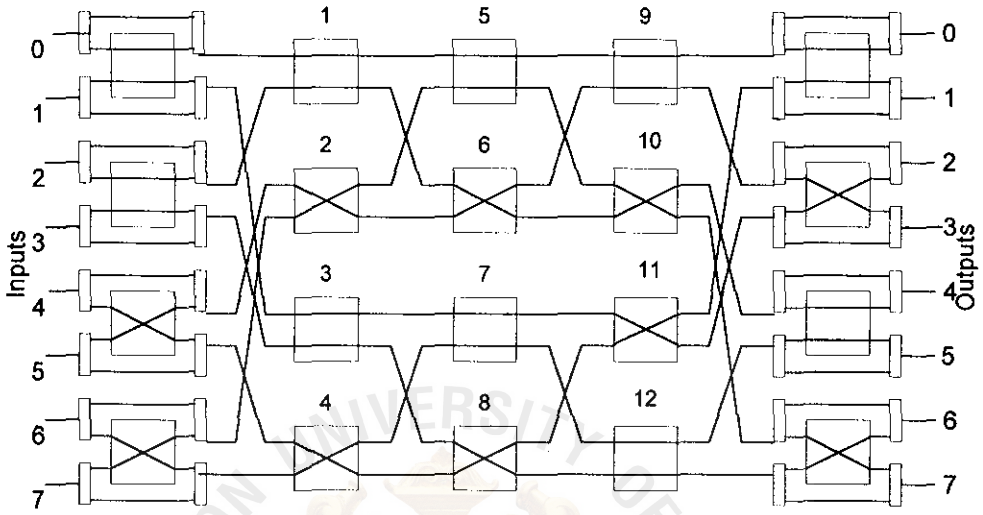
SHIFT 2
0 1 2 3 4 5 6 7
0 4 1 5 2 6 3 7



Switch No.	State
1	Straight
2	Exchange
3	Straight
4	Exchange
5	Straight
6	Straight
7	Exchange
8	Exchange

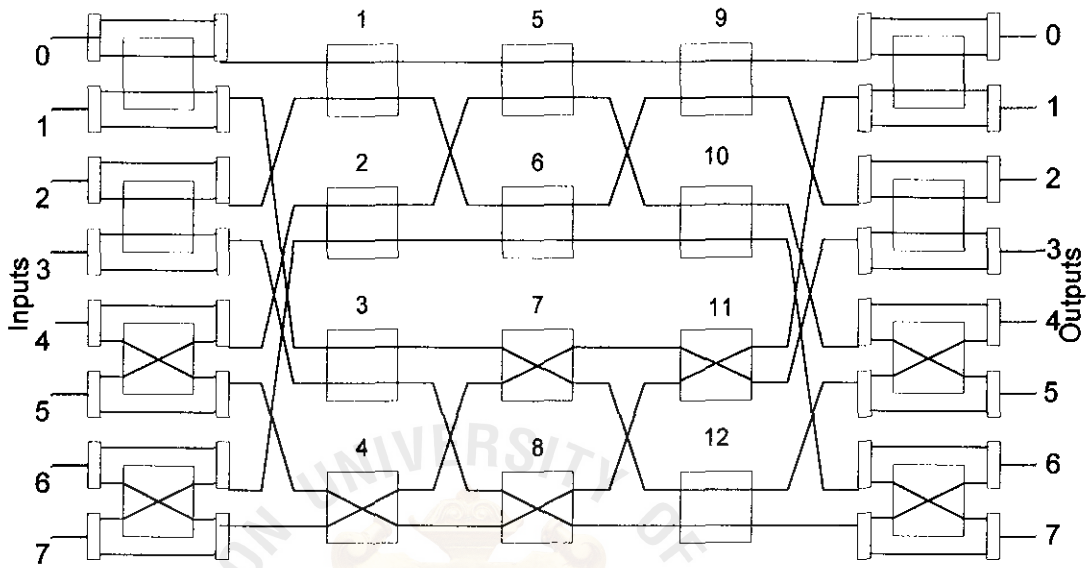
Fault – Tolerant in Middle Stage

Perfect Shuffle
0 1 2 3 4 5 6 7
0 2 4 6 1 3 5 7



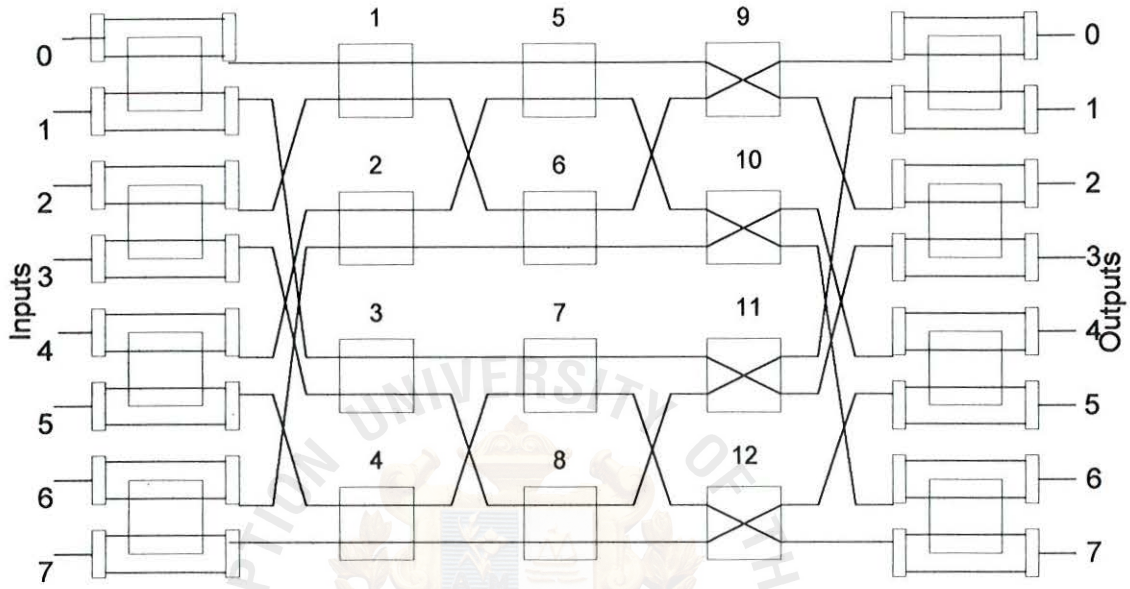
Fault on switch No.	Error on outputs
1	0, 4
2	3, 7
3	2, 6
4	1, 5
5	0 ,7
6	3, 4
7	2, 5
8	6, 1
9	0 ,3
10	4, 7
11	2, 1
12	5 ,6

Bit Reversal
0 1 2 3 4 5 6 7
0 4 2 6 1 5 3 7



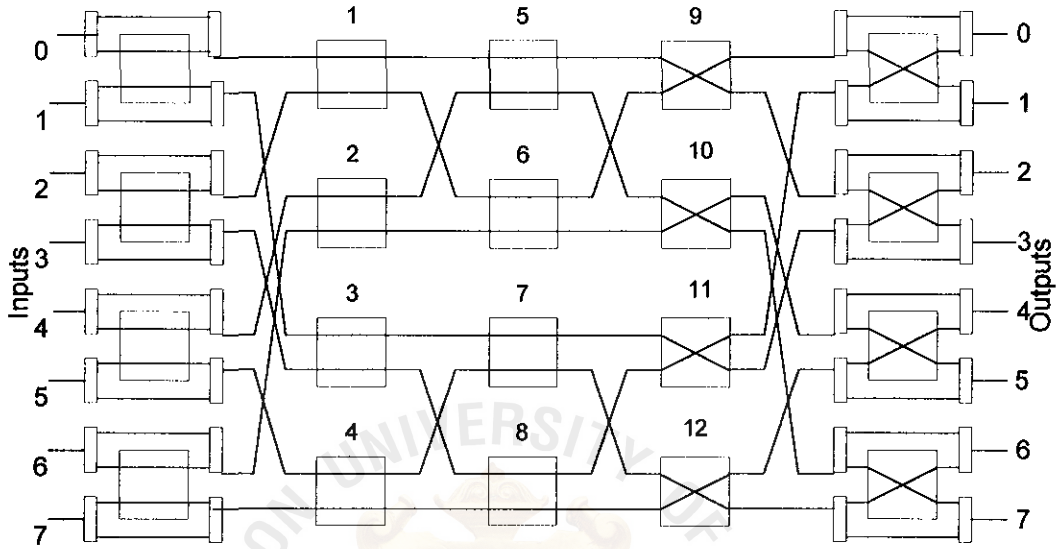
Fault on switch No.	Error on outputs
1	0, 2
2	5, 7
3	4, 6
4	1, 3
5	0, 5
6	2, 7
7	3, 4
8	1, 6
9	0, 2
10	5, 7
11	1, 3
12	4, 6

FLIP (010)
0 1 2 3 4 5 6 7
2 3 0 1 6 7 4 5



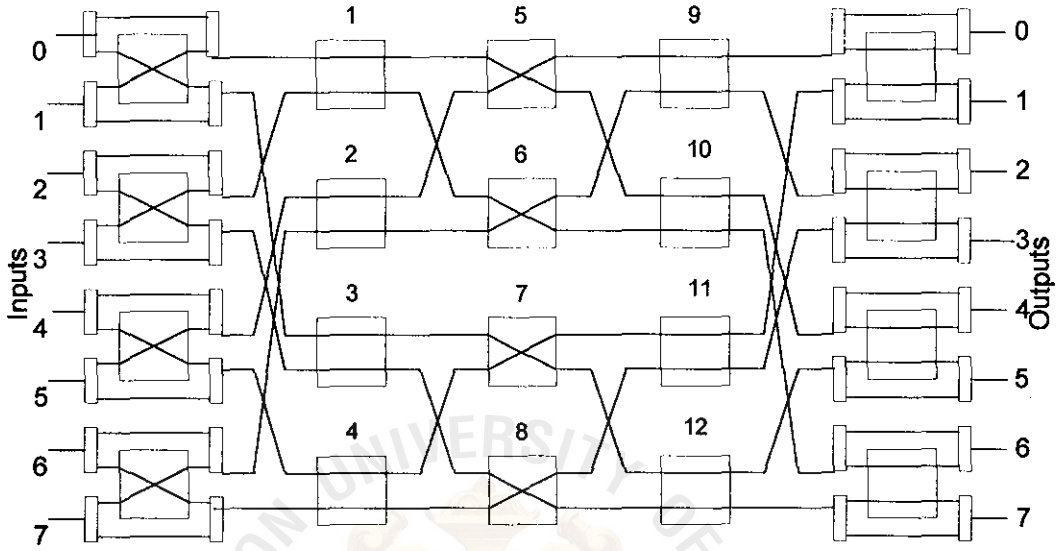
Fault on switch No.	Error on outputs
1	0, 2
2	4, 6
3	1, 3
4	5, 7
5	2, 6
6	0, 4
7	3, 7
8	1, 5
9	0, 2
10	4, 6
11	1, 3
12	5, 7

FLIP (011)
0 1 2 3 4 5 6 7
3 2 1 0 7 6 5 4



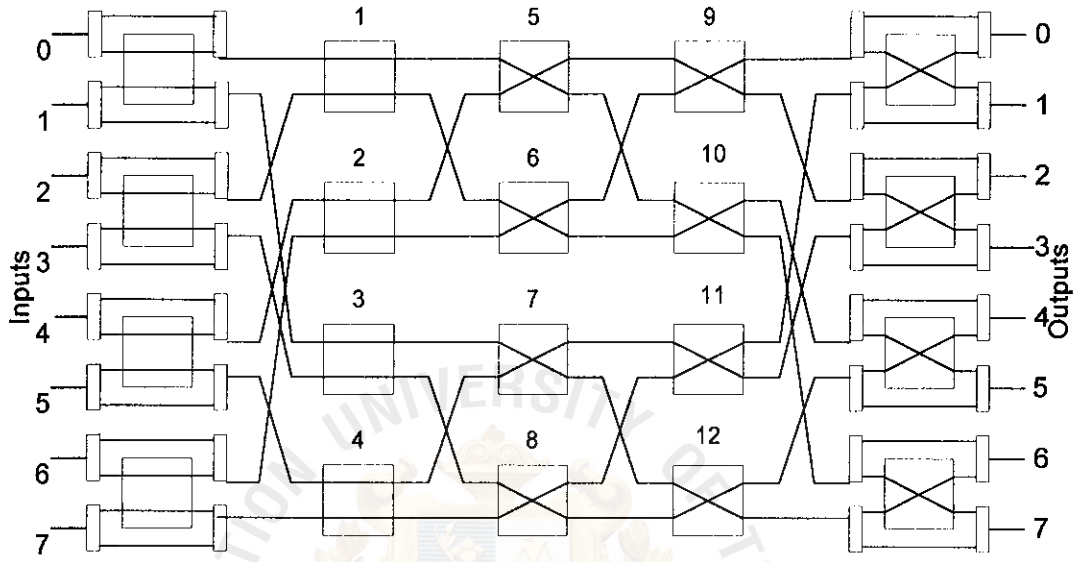
Fault on switch No.	Error on outputs
1	1, 3
2	5, 7
3	0, 2
4	4, 6
5	3, 7
6	1, 5
7	2, 6
8	0, 4
9	1, 3
10	5, 7
11	0, 2
12	4, 6

FLIP (101)
0 1 2 3 4 5 6 7
5 4 7 6 1 0 3 2



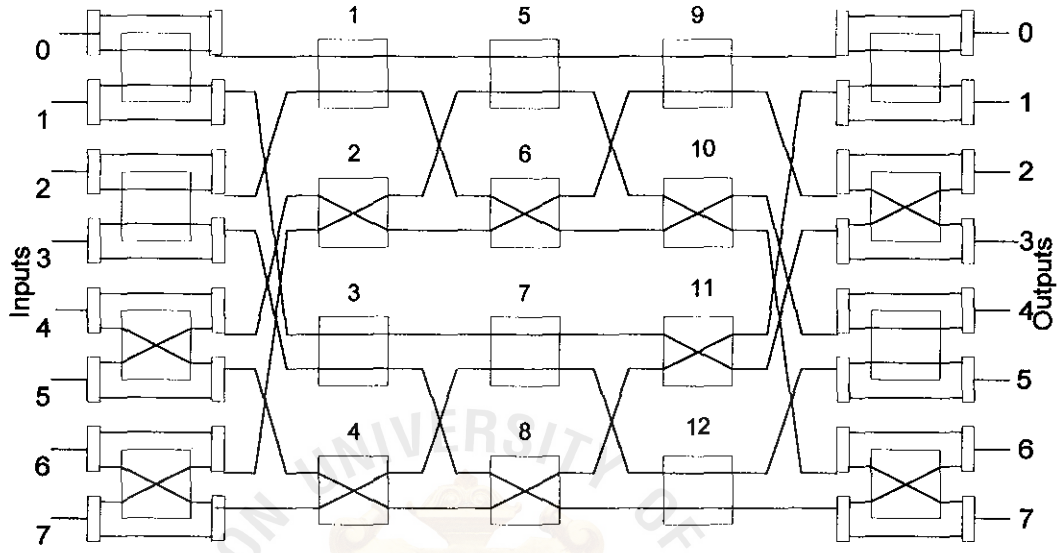
Fault on switch No.	Error on outputs
1	4, 6
2	0, 2
3	5, 7
4	1, 3
5	0, 4
6	2, 6
7	1, 5
8	3, 7
9	0, 2
10	4, 6
11	1, 3
12	5, 7

FLIP (111)
0 1 2 3 4 5 6 7
7 6 5 4 3 2 1 0



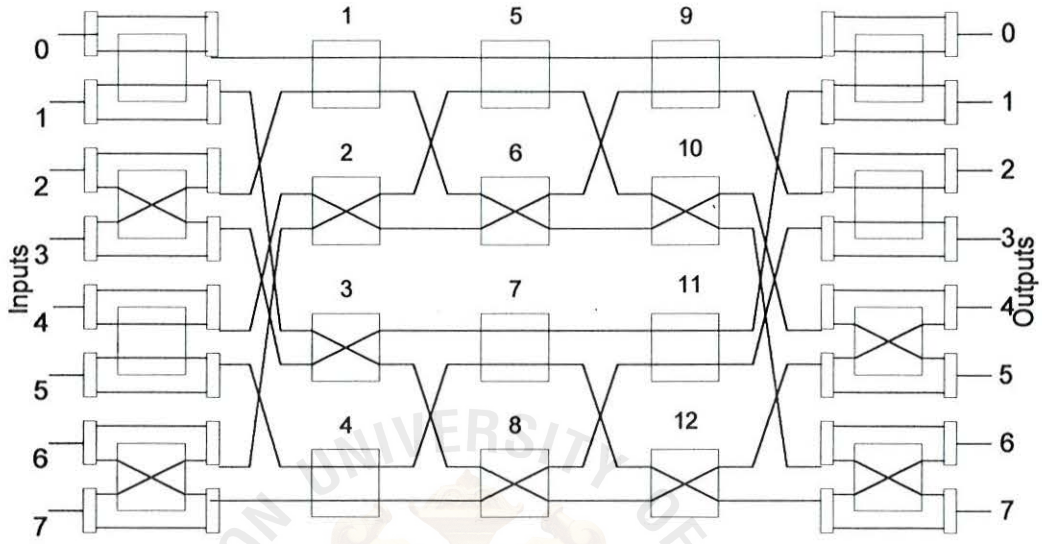
Fault on switch No.	Error on outputs
1	5, 7
2	1, 3
3	4, 6
4	0, 2
5	3, 7
6	1, 5
7	2, 6
8	0, 4
9	1, 3
10	5, 7
11	0, 2
12	4, 6

SHIFT 1
0 1 2 3 4 5 6 7
0 2 4 6 1 3 5 7



Fault on switch No.	Error on outputs
1	0, 4
2	3, 7
3	2, 6
4	1, 5
5	0, 7
6	3, 4
7	2, 5
8	1, 6
9	0, 3
10	4, 7
11	1, 2
12	5, 6

SHIFT 2
0 1 2 3 4 5 6 7
0 4 1 5 2 6 3 7



Fault on switch No.	Error on outputs
1	0, 5
2	2, 7
3	1, 4
4	3, 6
5	0, 7
6	2, 5
7	1, 6
8	3, 4
9	0, 2
10	5, 7
11	1, 3
12	4, 6

CHAPTER 5 :

CONCLUSION AND RECOMMENDATION

Conclusion and Recommendations

Conclusion:

In this project, we have successfully constructed a fault tolerant Benes network. The network is able to recover from not only the faulty switch, but also the wire connection in the network. The input data was able to reach the destination according to the chosen permutation request with and without inserting the fault.

The calculation program was able to function correctly according to the chosen permutation request and also the input data and shown the correct output. Also the programs written in assembly was able to control all the bypassing circuits and the switches which then produce the correct output with and without inserting the fault.

The eight bits of data which we assume that each bit represents a data packet were able to reach their destinations without blocking one another. There is always an alternate path for each data bits in case that one of the switch went down or broken, or there is an error in the link between two switches.

Recommendations:

After constructed the first Benes network (without the circuit on the ISA card) and tested the controls, we find that the latches (74LS373) can't latch the data inputting to it. We knew from A.Voraport that the wires we used to connect the addresses from the ISA card to the address decoder circuit have produced a lot of resistance and delay, so the chip select signal arrived slower than the data inputs which cause the data latches unable to latch the data inputs.

We have solved the problems by design a 8255a Programmable Parallel Port circuit as our data outputs, so the outputs will be latched on the 8255a output port. And we used two DIP Switches as our 16 bits addresses instead of the addresses from the ISA card. So each time we want to send controls to each latch, we have to manually set the DIP Switches to the address corespondent to the latch address.

After we connected the whole circuit to the computer and switch on, the computer hangs and shows the word "Divide overflow". We knew from Dr.Kittiphan that the output latch of the network has something wrong, and it outputs something to the computer and make the computer hang.

We have solved this problem by connected the outputs from the latch to the 8255a Programmable Parallel Port and wish to input the data to the computer via this IC. But for some reasons, the 8255a won't take the data into it's port although the data was there. So, we have to disconnect it from the 8255a and show the output on the Leds.

We have tested our programs and found out that when we use the program of the fault tolerant in the middle stage, we will get two outputs since we have to pass the data for two passes. So the correct output will not appear on the Leds. We have written a program to ask for the two outputs and the error bits, then calculate and show the correct output on the computer screen instead.

In this project, we didn't have time to write another program to check for the faulty switch on it own without asking the user. It is possible to do so, if we send first the testing data through the network with a certain permutation request and then check the output data to find the faulty switch. But in the real world, each switch will have a protocol, and when one switch is broken, the switches connected to it will know that there is a fault, and it will automatically send the data packet through an alternate path.

The program written in assembly is very long since we didn't write it in looped form, but we use copy/paste method instead.

APPENDIX

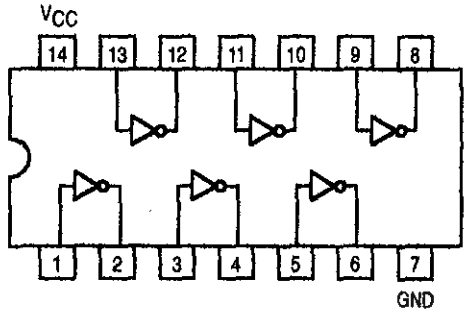
MOTOROLA

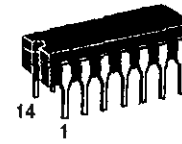
HEX INVERTER

SN54/74LS04

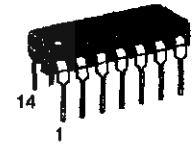
HEX INVERTER

LOW POWER SCHOTTKY

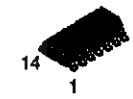




J SUFFIX
CERAMIC
CASE 632-08



N SUFFIX
PLASTIC
CASE 646-06



D SUFFIX
SOIC
CASE 751A-02

ORDERING INFORMATION

SN54LSXXJ	Ceramic
SN74LSXXN	Plastic
SN74LSXXD	SOIC

GUARANTEED OPERATING RANGES

Symbol	Parameter		Min	Typ	Max	Unit
V_{CC}	Supply Voltage	54 74	4.5 4.75	5.0 5.0	5.5 5.25	V
T_A	Operating Ambient Temperature Range	54 74	−55 0	25 25	125 70	°C
I_{OH}	Output Current — High	54, 74			−0.4	mA
I_{OL}	Output Current — Low	54 74			4.0 8.0	mA

DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter		Limits Min	Typ	Max	Unit	Test Conditions	
V_{IH}	Input HIGH Voltage		2.0			V	Guaranteed Input HIGH Voltage for All Inputs	
V_{IL}	Input LOW Voltage	54			0.7	V	Guaranteed Input LOW Voltage for All Inputs	
		74			0.8			
V_{IK}	Input Clamp Diode Voltage			−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA	
V_{OH}	Output HIGH Voltage	54	2.5	3.5		V	V_{CC} = MIN, I_{OH} = MAX, V_{IN} = V_{IH} or V_{IL} per Truth Table	
		74	2.7	3.5		V		
V_{OL}	Output LOW Voltage	54, 74		0.25	0.4	V	I_{OL} = 4.0 mA	V_{CC} = V_{CC} MIN, V_{IN} = V_{IL} or V_{IH} per Truth Table
		74		0.35	0.5	V	I_{OL} = 8.0 mA	
I_{IH}	Input HIGH Current				20	μA	V_{CC} = MAX, V_{IN} = 2.7 V	
					0.1	mA	V_{CC} = MAX, V_{IN} = 7.0 V	
I_{IL}	Input LOW Current				−0.4	mA	V_{CC} = MAX, V_{IN} = 0.4 V	
I_{OS}	Short Circuit Current (Note 1)		−20		−100	mA	V_{CC} = MAX	
I_{CC}	Power Supply Current Total, Output HIGH				2.4	mA	V_{CC} = MAX	
	Total, Output LOW				6.6			

Note 1: Not more than one output should be shorted at a time, nor for more than 1 second.

AC CHARACTERISTICS (T_A = 25°C)

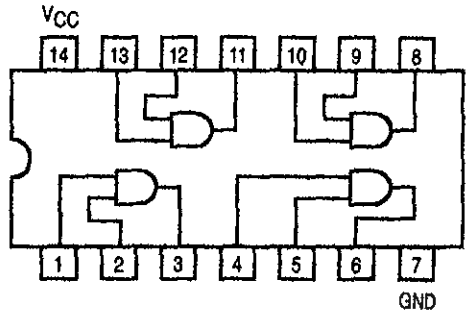
Symbol	Parameter	Limits Min	Typ	Max	Unit	Test Conditions
t_{PLH}	Turn-Off Delay, Input to Output		9.0	15	ns	V_{CC} = 5.0 V, C_L = 15 pF
t_{PHL}	Turn-On Delay, Input to Output		10	15	ns	

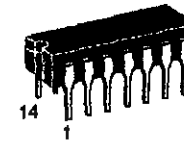
MOTOROLA

QUAD 2-INPUT AND GATE

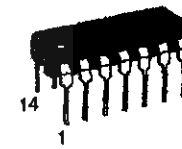
SN54/74LS08

QUAD 2-INPUT AND GATE
LOW POWER SCHOTTKY





J SUFFIX
CERAMIC
CASE 632-08



N SUFFIX
PLASTIC
CASE 646-06

D SUFFIX
SOIC
CASE 751A-02

ORDERING INFORMATION

SN54LSXXJ	Ceramic
SN74LSXXN	Plastic
SN74LSXXD	SOIC

GUARANTEED OPERATING RANGES

Symbol	Parameter		Min	Typ	Max	Unit
V_{CC}	Supply Voltage	54 74	4.5 4.75	5.0 5.0	5.5 5.25	V
T_A	Operating Ambient Temperature Range	54 74	−55 0	25 25	125 70	°C
I_{OH}	Output Current — High	54, 74			−0.4	mA
I_{OL}	Output Current — Low	54 74			4.0 8.0	mA

IC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter		Limits Min	Typ	Max	Unit	Test Conditions	
V_{IH}	Input HIGH Voltage		2.0			V	Guaranteed Input HIGH Voltage for All Inputs	
V_{IL}	Input LOW Voltage	54			0.7	V	Guaranteed Input LOW Voltage for All Inputs	
		74			0.8			
V_{IK}	Input Clamp Diode Voltage			−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA	
V_{OH}	Output HIGH Voltage	54	2.5	3.5		V	V_{CC} = MIN, I_{OH} = MAX, V_{IN} = V_{IH} or V_{IL} per Truth Table	
		74	2.7	3.5		V		
V_{OL}	Output LOW Voltage	54, 74		0.25	0.4	V	I_{OL} = 4.0 mA	V_{CC} = V_{CC} MIN, V_{IN} = V_{IL} or V_{IH} per Truth Table
		74		0.35	0.5	V	I_{OL} = 8.0 mA	
I_{IH}	Input HIGH Current				20	μA	V_{CC} = MAX, V_{IN} = 2.7 V	
					0.1	mA	V_{CC} = MAX, V_{IN} = 7.0 V	
I_{IL}	Input LOW Current				−0.4	mA	V_{CC} = MAX, V_{IN} = 0.4 V	
I_{OS}	Short Circuit Current (Note 1)		−20		−100	mA	V_{CC} = MAX	
I_{CC}	Power Supply Current Total, Output HIGH				4.8	mA	V_{CC} = MAX	
	Total, Output LOW				8.8			

Note 1: Not more than one output should be shorted at a time, nor for more than 1 second.

AC CHARACTERISTICS (T_A = 25°C)

Symbol	Parameter	Limits Min	Typ	Max	Unit	Test Conditions
t_{PLH}	Turn-Off Delay, Input to Output		8.0	15	ns	V_{CC} = 5.0 V C_L = 15 pF
t_{PHL}	Turn-On Delay, Input to Output		10	20	ns	

MOTOROLA

DUAL 1-OF-4 DECODER/ DEMULTIPLEXER

SN54/74LS155
SN54/74LS156

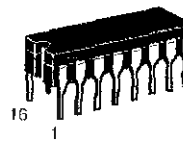
DUAL 1-OF-4 DECODER/ DEMULTIPLEXER

LS156-OPEN-COLLECTOR LOW POWER SCHOTTKY

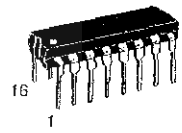
The SN54/74LS155 and SN54/74LS156 are high speed Dual 1-of-4 Decoder/Demultiplexers. These devices have two decoders with common 2-bit Address inputs and separate gated Enable inputs. Decoder "a" has an Enable gate with one active HIGH and one active LOW input. Decoder "b" has two active LOW Enable inputs. If the Enable functions are satisfied, one output of each decoder will be LOW as selected by the address inputs. The LS156 has open collector outputs for wired-OR (DOT-AND) decoding and function generator applications.

The LS155 and LS156 are fabricated with the Schottky barrier diode process for high speed and are completely compatible with all Motorola TTL families.

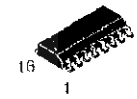
- Schottky Process for High Speed
- Multifunction Capability
- Common Address Inputs
- True or Complement Data Demultiplexing
- Input Clamp Diodes Limit High Speed Termination Effects
- ESD > 3500 Volts



J SUFFIX
CERAMIC
CASE 620-09



N SUFFIX
PLASTIC
CASE 648-08

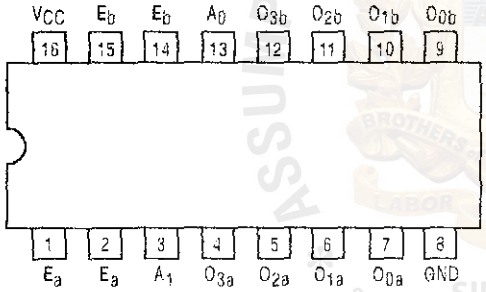


D SUFFIX
SOIC
CASE 751B-03

ORDERING INFORMATION

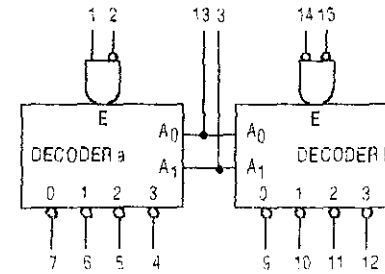
SN54LSXXXJ	Ceramic
SN74LSXXXN	Plastic
SN74LSXXXD	SOIC

CONNECTION DIAGRAM DIP (TOP VIEW)



NOTE:
The Flatpak version has the same pinouts (Connection Diagram) as the Dual In-Line Package.

LOGIC SYMBOL



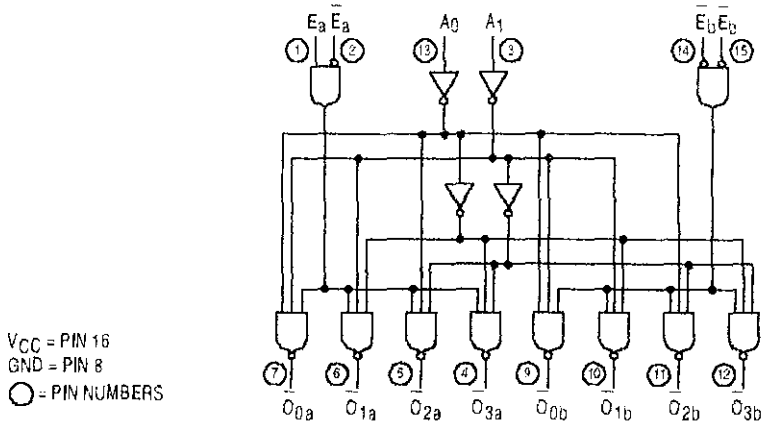
VCC = PIN 16
GND = PIN 8

PIN NAMES

		LOADING (Note a) HIGH	LOW
$\overline{A}_0$, A_1	Address Inputs	0.5 U.L.	0.25 U.L.
$\overline{E}_a$, $\overline{E}_b$	Enable (Active LOW) Inputs	0.5 U.L.	0.25 U.L.
E_a	Enable (Active HIGH) Input	0.5 U.L.	0.25 U.L.
$\overline{O}_0$–$\overline{O}_3$	Active LOW Outputs (Note b)	10 U.L.	5 (2.5) U.L.

NOTES:
a) 1 TTL Unit Load (U.L.) = 40 µA HIGH/1.6 mA LOW.
b) The Output LOW drive factor is 2.5 U.L. for Military (54) and 5 U.L. for Commercial (74) Temperature Ranges. The HIGH level drive for the LS156 must be established by an external resistor.

LOGIC DIAGRAM



V_{CC} = PIN 16
GND = PIN 8
◯ = PIN NUMBERS

FUNCTIONAL DESCRIPTION

The LS155 and LS156 are Dual 1-of-4 Decoder/Demultiplexers with common Address inputs and separate gated Enable inputs. When enabled, each decoder section accepts the binary weighted Address inputs (A_0, A_1) and provides four mutually exclusive active LOW outputs ($\overline{O}_0$–$\overline{O}_3$). If the Enable requirements of each decoder are not met, all outputs of that decoder are HIGH.

Each decoder section has a 2-input enable gate. The enable gate for Decoder "a" requires one active HIGH input and one active LOW input ($E_a \cdot \overline{E}_a$). In demultiplexing applications, Decoder "a" can accept either true or complemented data by using the E_a or $\overline{E}_a$ inputs respectively. The enable gate for Decoder "b" requires two active LOW inputs ($\overline{E}_b \cdot \overline{E}_b$). The LS155 or LS156 can be used as a 1-of-8 Decoder/Demultiplexer by tying E_a to $\overline{E}_b$ and relabeling the common connection as (A_2). The other $\overline{E}_b$ and E_a are connected together to form the common enable.

The LS155 and LS156 can be used to generate all four minterms of two variables. These four minterms are useful in some applications replacing multiple gate functions as shown in Fig. a. The LS156 has the further advantage of being able to AND the minterm functions by tying outputs together. Any number of terms can be wired-AND as shown below.

$f = (\overline{E} + A_0 + A_1) \cdot (E + A_0 + A_1) \cdot (E + A_0 + A_1) \cdot (E + A_0 + A_1)$

where $E = E_a + E_a$; $\overline{E} = \overline{E}_b + \overline{E}_b$

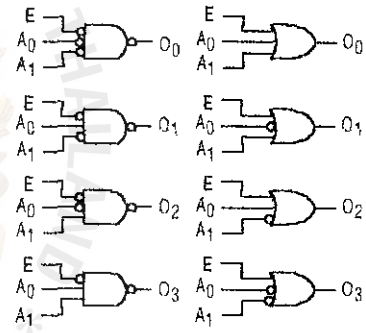


Figure a

TRUTH TABLE

ADDRESS		ENABLE "a"		OUTPUT "a"				ENABLE "b"		OUTPUT "b"			
A_0	A_1	E_a	E_a	O_0	O_1	O_2	O_3	$\overline{E}_b$	$\overline{E}_b$	O_0	O_1	O_2	O_3
X	X	L	X	H	H	H	H	H	X	H	H	H	H
X	X	X	H	H	H	H	H	X	H	H	H	H	H
L	L	H	L	L	H	H	H	L	L	L	H	H	H
H	L	H	L	H	L	H	H	L	L	H	L	H	H
L	H	H	L	H	H	L	H	L	L	H	H	L	H
H	H	H	L	H	H	H	L	L	L	H	H	H	L

H = HIGH Voltage Level
L = LOW Voltage Level
X = Don't Care

GUARANTEED OPERATING RANGES

Symbol	Parameter		Min	Typ	Max	Unit
V_{CC}	Supply Voltage	54 74	4.5 4.75	5.0 5.0	5.5 5.25	V
T_A	Operating Ambient Temperature Range	54 74	−55 0	25 25	125 70	°C
I_{OH}	Output Current — High	54, 74			−0.4	mA
I_{OL}	Output Current — Low	54 74			4.0 8.0	mA

DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter		Limits Min	Limits Typ	Limits Max	Unit	Test Conditions	
V_{IH}	Input HIGH Voltage		2.0			V	Guaranteed Input HIGH Voltage for All Inputs	
V_{IL}	Input LOW Voltage	54			0.7	V	Guaranteed Input LOW Voltage for All Inputs	
		74			0.8			
V_{IK}	Input Clamp Diode Voltage			−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA	
V_{OH}	Output HIGH Voltage	54	2.5	3.5		V	V_{CC} = MIN, I_{OH} = MAX, V_{IN} = V_{IH} or V_{IL} per Truth Table	
		74	2.7	3.5		V		
V_{OL}	Output LOW Voltage	54, 74		0.25	0.4	V	I_{OL} = 4.0 mA	V_{CC} = V_{CC} MIN, V_{IN} = V_{IL} or V_{IH} per Truth Table
		74		0.35	0.5	V	I_{OL} = 8.0 mA	
I_{IH}	Input HIGH Current				20	μA	V_{CC} = MAX, V_{IN} = 2.7 V	
					0.1	mA	V_{CC} = MAX, V_{IN} = 7.0 V	
I_{IL}	Input LOW Current				−0.4	mA	V_{CC} = MAX, V_{IN} = 0.4 V	
I_{OS}	Short Circuit Current (Note 1)		−20		−100	mA	V_{CC} = MAX	
I_{CC}	Power Supply Current				10	mA	V_{CC} = MAX	

Note 1: Not more than one output should be shorted at a time, nor for more than 1 second.

AC CHARACTERISTICS (T_A = 25°C)

Symbol	Parameter	Limits Min	Limits Typ	Limits Max	Unit	Test Conditions	
t_{PLH} t_{PHL}	Propagation Delay Address, E_a or E_b to Output		10 19	15 30	ns	Figure 1	V_{CC} = 5.0 V C_L = 15 pF
t_{PLH} t_{PHL}	Propagation Delay Address to Output		17 19	26 30	ns	Figure 2	
t_{PLH} t_{PHL}	Propagation Delay E_a to Output		18 18	27 27	ns	Figure 1	

AC WAVEFORMS

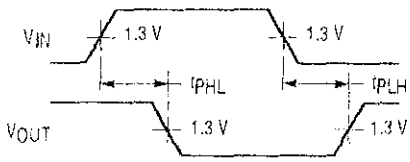


Figure 1

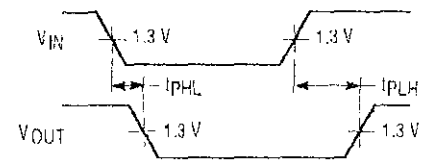


Figure 2

GUARANTEED OPERATING RANGES

Symbol	Parameter		Min	Typ	Max	Unit
V_{CC}	Supply Voltage	54 74	4.5 4.75	5.0 5.0	5.5 5.25	V
T_A	Operating Ambient Temperature Range	54 74	−55 0	25 25	125 70	°C
V_{OH}	Output Voltage — High	54, 74			5.5	V
I_{OL}	Output Current — Low	54 74			4.0 8.0	mA

DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter		Limits Min	Limits Typ	Limits Max	Unit	Test Conditions	
V_{IH}	Input HIGH Voltage		2.0			V	Guaranteed Input HIGH Voltage for All Inputs	
V_{IL}	Input LOW Voltage	54			0.7	V	Guaranteed Input LOW Voltage for All Inputs	
		74			0.8			
V_{IK}	Input Clamp Diode Voltage			−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA	
I_{OH}	Output HIGH Current	54, 74			100	µA	V_{CC} = MIN, V_{OH} = MAX	
V_{OL}	Output LOW Voltage	54, 74		0.25	0.4	V	I_{OL} = 4.0 mA	V_{CC} = V_{CC} MIN, V_{IN} = V_{IL} or V_{IH} per Truth Table
		74		0.35	0.5	V	I_{OL} = 8.0 mA	
I_{IH}	Input HIGH Current				20	µA	V_{CC} = MAX, V_{IN} = 2.7 V	
					0.1	mA	V_{CC} = MAX, V_{IN} = 7.0 V	
I_{IL}	Input LOW Current				−0.4	mA	V_{CC} = MAX, V_{IN} = 0.4 V	
I_{CC}	Power Supply Current				10	mA	V_{CC} = MAX	

AC CHARACTERISTICS (T_A = 25°C)

Symbol	Parameter	Limits Min	Limits Typ	Limits Max	Unit	Test Conditions	
t_{PLH} t_{PHL}	Propagation Delay Address, E_a or E_b to Output		25 34	40 51	ns	Figure 1	V_{CC} = 5.0 V C_L = 15 pF R_L = 2.0 kΩ
t_{PLH} t_{PHL}	Propagation Delay Address to Output		31 34	46 51	ns	Figure 2	
t_{PLH} t_{PHL}	Propagation Delay E_a to Output		32 32	48 48	ns	Figure 1	

AC WAVEFORMS

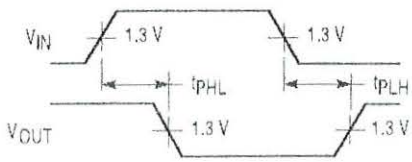


Figure 1

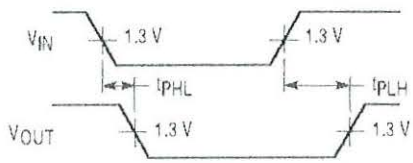


Figure 2

MOTOROLA

QUAD 2-INPUT MULTIPLEXER

SN54/74LS157

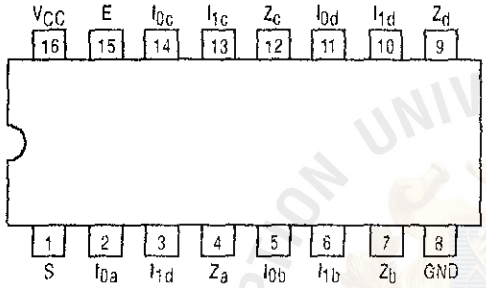
The LSTTL/MSI SN54/74LS157 is a high speed Quad 2-Input Multiplexer. Four bits of data from two sources can be selected using the common Select and Enable inputs. The four buffered outputs present the selected data in the true (non-inverted) form. The LS157 can also be used to generate any four of the 16 different functions of two variables. The LS157 is fabricated with the Schottky barrier diode process for high speed and is completely compatible with all Motorola TTL families.

- Schottky Process for High Speed
- Multifunction Capability
- Non-Inverting Outputs
- Input Clamp Diodes Limit High Speed Termination Effects
- Special Circuitry Ensures Glitch Free Multiplexing
- ESD > 3500 Volts

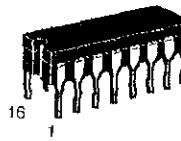
QUAD 2-INPUT MULTIPLEXER

LOW POWER SCHOTTKY

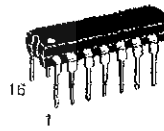
CONNECTION DIAGRAM DIP (TOP VIEW)



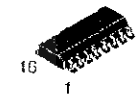
NOTE:
The Flatpak version has the same pinouts (Connection Diagram) as the Dual In-Line Package.



J SUFFIX
CERAMIC
CASE 620-09



N SUFFIX
PLASTIC
CASE 648-08



D SUFFIX
SOIC
CASE 751B-03

PIN NAMES

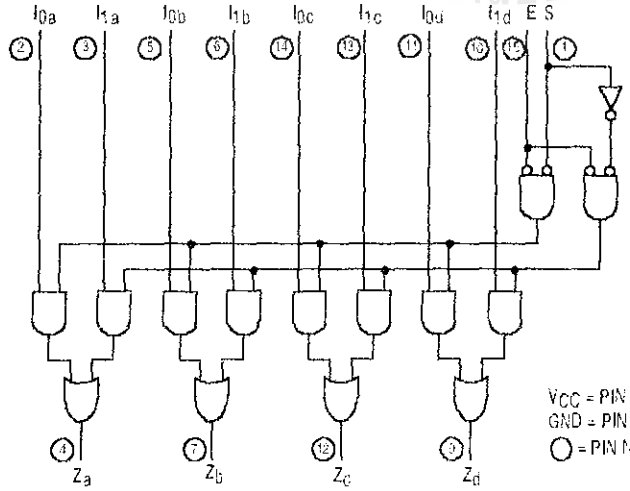
		LOADING (Note a) HIGH	LOW
S	Common Select Input	1.0 U.L.	0.5 U.L.
E	Enable (Active LOW) Input	1.0 U.L.	0.5 U.L.
$I_{0a}-I_{0d}$	Data Inputs from Source 0	0.5 U.L.	0.25 U.L.
$I_{1a}-I_{1d}$	Data Inputs from Source 1	0.5 U.L.	0.25 U.L.
Z_a-Z_d	Multiplexer Outputs (Note b)	10 U.L.	5 (2.5) U.L.

NOTES:
a) 1 TTL Unit Load (U.L.) = 40 µA HIGH/1.6 mA LOW.
b) The Output LOW drive factor is 2.5 U.L. for Military (54) and 5 U.L. for Commercial (74) Temperature Ranges.

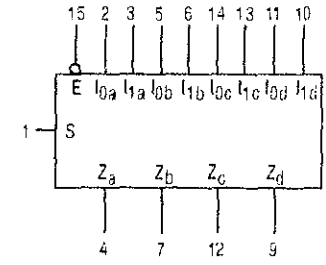
ORDERING INFORMATION

SN54LSXXXJ	Ceramic
SN74LSXXXN	Plastic
SN74LSXXXD	SOIC

LOGIC DIAGRAM



LOGIC SYMBOL



V_{CC} = PIN 16
GND = PIN 8

FUNCTIONAL DESCRIPTION

The LS157 is a Quad 2-Input Multiplexer fabricated with the Schottky barrier diode process for high speed. It selects four bits of data from two sources under the control of a common Select Input (S). The Enable input (E) is active LOW. When E is HIGH, all of the outputs (Z) are forced LOW regardless of all other inputs.

The LS157 is the logic implementation of a 4-pole, 2-position switch where the position of the switch is determined by the logic levels supplied to the Select Input. The logic equations for the outputs are:

$$Z_a = \overline{E} \cdot (I_{1a} \cdot S + I_{0a} \cdot \overline{S}) \qquad Z_b = \overline{E} \cdot (I_{1b} \cdot S + I_{0b} \cdot \overline{S})$$
$$Z_c = \overline{E} \cdot (I_{1c} \cdot S + I_{0c} \cdot \overline{S}) \qquad Z_d = \overline{E} \cdot (I_{1d} \cdot S + I_{0d} \cdot \overline{S})$$

A common use of the LS157 is the moving of data from two groups of registers to four common output busses. The particular register from which the data comes is determined by the state of the Select Input. A less obvious use is as a function generator. The LS157 can generate any four of the 16 different functions of two variables with one variable common. This is useful for implementing highly irregular logic.

TRUTH TABLE

ENABLE	SELECT INPUT	INPUTS		OUTPUT
E	S	I_0	I_1	Z
H	X	X	X	L
L	H	X	L	L
L	H	X	H	H
L	L	L	X	L
L	L	H	X	H

H = HIGH Voltage Level
L = LOW Voltage Level
X = Don't Care

GUARANTEED OPERATING RANGES

Symbol	Parameter		Min	Typ	Max	Unit
V_{CC}	Supply Voltage	54 74	4.5 4.75	5.0 5.0	5.5 5.25	V
T_A	Operating Ambient Temperature Range	54 74	−55 0	25 25	125 70	°C
I_{OH}	Output Current — High	54, 74			−0.4	mA
I_{OL}	Output Current — Low	54 74			4.0 8.0	mA

DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter		Limits Min	Typ	Max	Unit	Test Conditions	
V_{IH}	Input HIGH Voltage		2.0			V	Guaranteed Input HIGH Voltage for All Inputs	
V_{IL}	Input LOW Voltage	54			0.7	V	Guaranteed Input LOW Voltage for All Inputs	
		74			0.8			
V_{IK}	Input Clamp Diode Voltage			−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA	
V_{OH}	Output HIGH Voltage	54	2.5	3.5		V	V_{CC} = MIN, I_{OH} = MAX, V_{IN} = V_{IH} or V_{IL} per Truth Table	
		74	2.7	3.5		V		
V_{OL}	Output LOW Voltage	54, 74		0.25	0.4	V	I_{OL} = 4.0 mA	V_{CC} = V_{CC} MIN, V_{IN} = V_{IL} or V_{IH} per Truth Table
		74		0.35	0.5	V	I_{OL} = 8.0 mA	
I_{IH}	Input HIGH Current $\overline{I_0}$, I_1 E, S				20 40	μA	V_{CC} = MAX, V_{IN} = 2.7 V	
	$\overline{I_0}$, I_1 E, S				0.1 0.2	mA	V_{CC} = MAX, V_{IN} = 7.0 V	
I_{IL}	Input LOW Current $\overline{I_0}$, I_1 E, S				−0.4 −0.8	mA	V_{CC} = MAX, V_{IN} = 0.4 V	
I_{OS}	Short Circuit Current (Note 1)		−20		−100	mA	V_{CC} = MAX	
I_{CC}	Power Supply Current				16	mA	V_{CC} = MAX	

Note 1: Not more than one output should be shorted at a time, nor for more than 1 second.

AC CHARACTERISTICS (T_A = 25°C)

Symbol	Parameter	Limits Min	Typ	Max	Unit	Test Conditions	
t_{PLH} t_{PHL}	Propagation Delay Data to Output		9.0 9.0	14 14	ns	Figure 2	V_{CC} = 5.0 V C_L = 15 pF
t_{PLH} t_{PHL}	Propagation Delay Enable to Output		13 14	20 21	ns	Figure 1	
t_{PLH} t_{PHL}	Propagation Delay Select to Output		15 18	23 27	ns	Figure 2	

AC WAVEFORMS

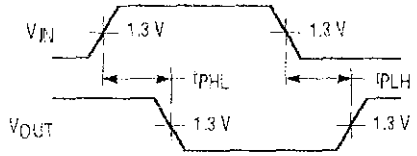


Figure 1

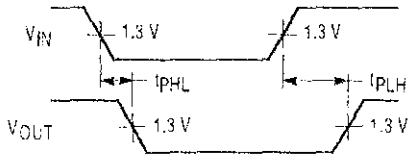


Figure 2

MOTOROLA

SN54/74LS373
SN54/74LS374

OCTAL TRANSPARENT LATCH WITH 3-STATE OUTPUTS; OCTAL D-TYPE FLIP-FLOP WITH 3-STATE OUTPUT

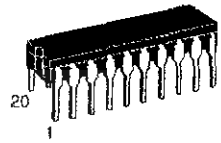
OCTAL TRANSPARENT LATCH WITH 3-STATE OUTPUTS; OCTAL D-TYPE FLIP-FLOP WITH 3-STATE OUTPUT

LOW POWER SCHOTTKY

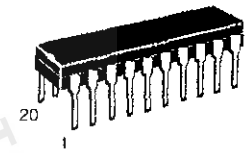
The SN54/74LS373 consists of eight latches with 3-state outputs for bus organized system applications. The flip-flops appear transparent to the data (data changes asynchronously) when Latch Enable (LE) is HIGH. When LE is LOW, the data that meets the setup times is latched. Data appears on the bus when the Output Enable (OE) is LOW. When OE is HIGH the bus output is in the high impedance state.

The SN54/74LS374 is a high-speed, low-power Octal D-type Flip-Flop featuring separate D-type inputs for each flip-flop and 3-state outputs for bus oriented applications. A buffered Clock (CP) and Output Enable (OE) is common to all flip-flops. The SN54/74LS374 is manufactured using advanced Low Power Schottky technology and is compatible with all Motorola TTL families.

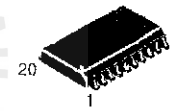
- Eight Latches in a Single Package
- 3-State Outputs for Bus Interfacing
- Hysteresis on Latch Enable
- Edge-Triggered D-Type Inputs
- Buffered Positive Edge-Triggered Clock
- Hysteresis on Clock Input to Improve Noise Margin
- Input Clamp Diodes Limit High Speed Termination Effects



J SUFFIX
CERAMIC
CASE 732-03



N SUFFIX
PLASTIC
CASE 738-03



DW SUFFIX
SOIC
CASE 751D-03

ORDERING INFORMATION

SN54LSXXXJ	Ceramic
SN74LSXXXN	Plastic
SN74LSXXXDW	SOIC

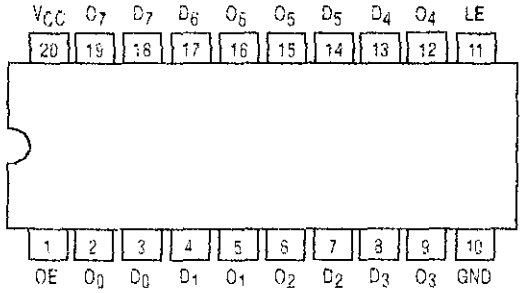
PIN NAMES

		LOADING (Note a) HIGH	LOADING (Note a) LOW
D_0-D_7	Data Inputs	0.5 U.L.	0.25 U.L.
LE	Latch Enable (Active HIGH) Input	0.5 U.L.	0.25 U.L.
CP	Clock (Active HIGH going edge) Input	0.5 U.L.	0.25 U.L.
OE	Output Enable (Active LOW) Input	0.5 U.L.	0.25 U.L.
O_0-O_7	Outputs (Note b)	65 (25) U.L.	15 (7.5) U.L.

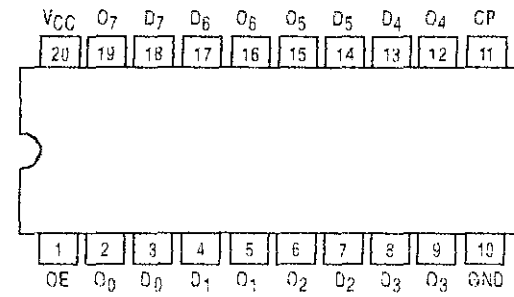
NOTES:
a) 1 TTL Units Load (U.L.) = 40 µA HIGH/1.6 mA LOW.
b) The Output LOW drive factor is 7.5 U.L. for Military (54) and 25 U.L. for Commercial (74) Temperature Ranges. The Output HIGH drive factor is 25 U.L. for Military (54) and 65 U.L. for Commercial (74) Temperature Ranges.

CONNECTION DIAGRAM DIP (TOP VIEW)

SN54/74LS373



SN54/74LS374



NOTE:
The Flatpak version has the same pinouts (Connection Diagram) as the Dual In-Line Package.

TRUTH TABLE

LS373

D_n	LE	$\overline{OE}$	O_n
H	H	L	H
L	H	L	L
X	L	L	Q_0
X	X	H	Z*

H = HIGH Voltage Level
L = LOW Voltage Level
X = Immaterial
Z = High Impedance

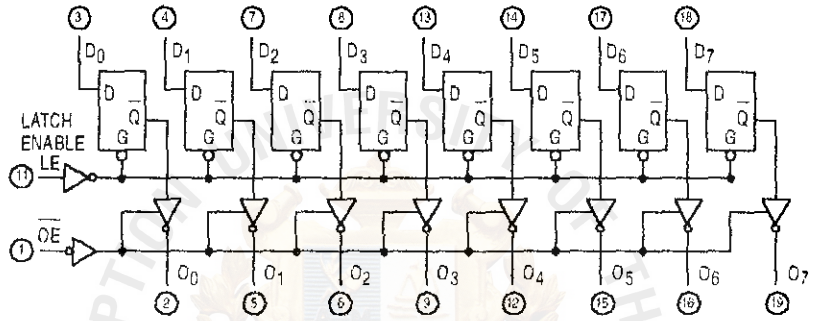
LS374

D_n	LE	$\overline{OE}$	O_n
H	↑	L	H
L	↑	L	L
X	X	H	Z*

* Note: Contents of flip-flops unaffected by the state of the Output Enable input ($\overline{OE}$).

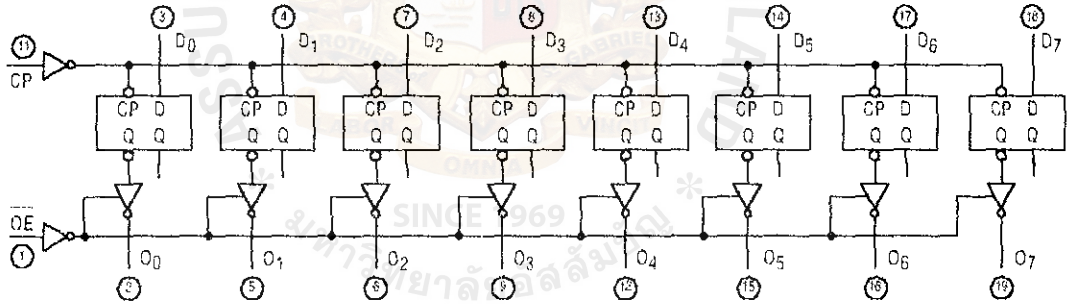
LOGIC DIAGRAMS

SN54LS/74LS373



V_{CC} = PIN 20
GND = PIN 10
○ = PIN NUMBERS

SN54LS/74LS374



GUARANTEED OPERATING RANGES

Symbol	Parameter		Min	Typ	Max	Unit
V_{CC}	Supply Voltage	54 74	4.5 4.75	5.0 5.0	5.5 5.25	V
T_A	Operating Ambient Temperature Range	54 74	−55 0	25 25	125 70	°C
I_{OH}	Output Current — High	54 74			−1.0 −2.6	mA
I_{OL}	Output Current — Low	54 74			12 24	mA

DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (unless otherwise specified)

Symbol	Parameter		Limits Min	Typ	Max	Unit	Test Conditions	
V_{IH}	Input HIGH Voltage		2.0			V	Guaranteed Input HIGH Voltage for All Inputs	
V_{IL}	Input LOW Voltage	54			0.7	V	Guaranteed Input LOW Voltage for All Inputs	
		74			0.8			
V_{IK}	Input Clamp Diode Voltage			−0.65	−1.5	V	V_{CC} = MIN, I_{IN} = −18 mA	
V_{OH}	Output HIGH Voltage	54	2.4	3.4		V	V_{CC} = MIN, I_{OH} = MAX, V_{IN} = V_{IH} or V_{IL} per Truth Table	
		74	2.4	3.1		V		
V_{OL}	Output LOW Voltage	54, 74		0.25	0.4	V	I_{OL} = 12 mA	V_{CC} = V_{CC} MIN, V_{IN} = V_{IL} or V_{IH} per Truth Table
		74		0.35	0.5	V	I_{OL} = 24 mA	
I_{OZH}	Output Off Current HIGH				20	μA	V_{CC} = MAX, V_{OUT} = 2.7 V	
I_{OZL}	Output Off Current LOW				−20	μA	V_{CC} = MAX, V_{OUT} = 0.4 V	
I_{IH}	Input HIGH Current				20	μA	V_{CC} = MAX, V_{IN} = 2.7 V	
					0.1	mA	V_{CC} = MAX, V_{IN} = 7.0 V	
I_{IL}	Input LOW Current				−0.4	mA	V_{CC} = MAX, V_{IN} = 0.4 V	
I_{OS}	Short Circuit Current (Note 1)		−30		−130	mA	V_{CC} = MAX	
I_{CC}	Power Supply Current				40	mA	V_{CC} = MAX	

Note 1: Not more than one output should be shorted at a time, nor for more than 1 second.

AC CHARACTERISTICS (T_A = 25°C, V_{CC} = 5.0 V)

Symbol	Parameter	Limits LS373 Min	LS373 Typ	LS373 Max	LS374 Min	LS374 Typ	LS374 Max	Unit	Test Conditions
f_{MAX}	Maximum Clock Frequency				35	50		MHz	C_L = 45 pF, R_L = 667 Ω
t_{PLH} t_{PHL}	Propagation Delay, Data to Output		12 12	18 18				ns	
t_{PLH} t_{PHL}	Clock or Enable to Output		20 18	30 30		15 19	28 28	ns	
t_{PZH} t_{PZL}	Output Enable Time		15 25	28 36		20 21	28 28	ns	
t_{PHZ} t_{PLZ}	Output Disable Time		12 15	20 25		12 15	20 25	ns	C_L = 5.0 pF

AC SETUP REQUIREMENTS (T_A = 25°C, V_{CC} = 5.0 V)

Symbol	Parameter	Limits LS373 Min	LS373 Max	LS374 Min	LS374 Max	Unit
t_W	Clock Pulse Width	15		15		ns
t_s	Setup Time	5.0		20		ns
t_h	Hold Time	20		0		ns

DEFINITION OF TERMS

SETUP TIME (t_s) — is defined as the minimum time required for the correct logic level to be present at the logic input prior to LE transition from HIGH-to-LOW in order to be recognized and transferred to the outputs.

HOLD TIME (t_h) — is defined as the minimum time following the LE transition from HIGH-to-LOW that the logic level must be maintained at the input in order to ensure continued recognition.

AC WAVEFORMS

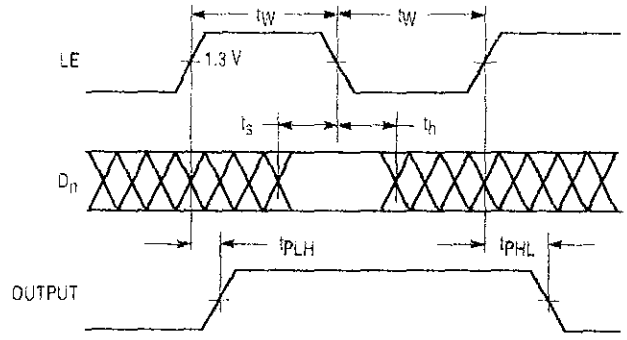


Figure 1

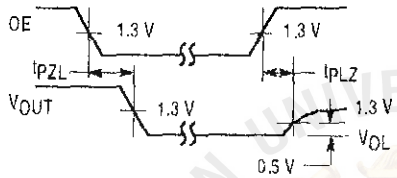


Figure 2

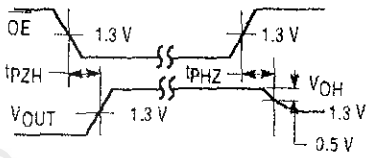
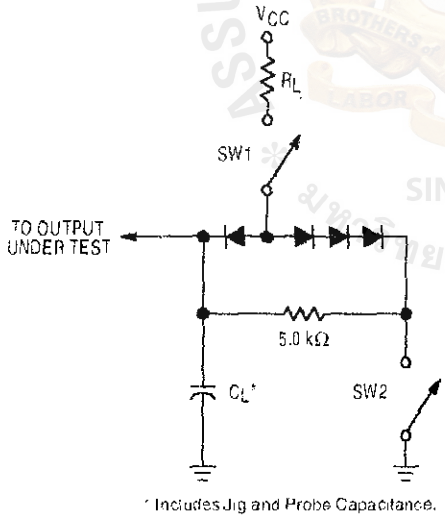


Figure 3

AC LOAD CIRCUIT



SWITCH POSITIONS

SYMBOL	SW1	SW2
t_{PZH}	Open	Closed
t_{PZL}	Closed	Open
t_{PLZ}	Closed	Closed
t_{PHZ}	Closed	Closed

Figure 4

AC WAVEFORMS

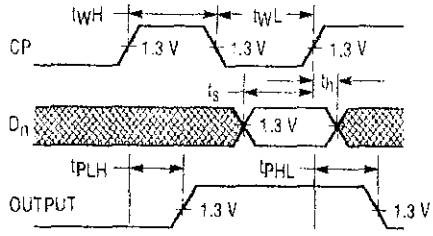


Figure 5

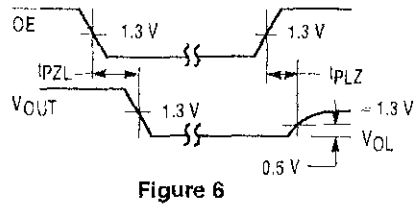


Figure 6

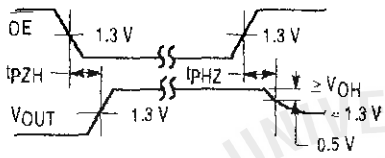


Figure 7

AC LOAD CIRCUIT

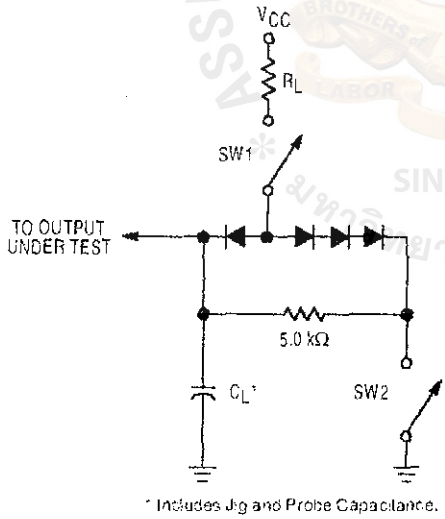


Figure 8

SWITCH POSITIONS

SYMBOL	SW1	SW2
t_{PZH}	Open	Closed
t_{PZL}	Closed	Open
t_{PLZ}	Closed	Closed
t_{PHZ}	Closed	Closed

SDLS008

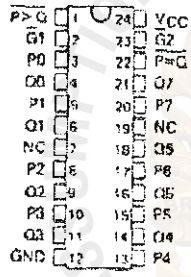
SN54LS682, SN54LS684, SN54LS685, SN54LS687, SN54LS688, SN74LS682, SN74LS684 THRU SN74LS688
8-BIT MAGNITUDE/IDENTITY COMPARATORS

D2617, JANUARY 1981 – REVISED MARCH 1988

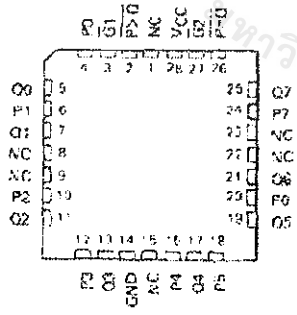
- Compares Two 8-Bit Words
- Choice of Totem-Pole or Open-Collector Outputs
- Hysteresis at P and Q Inputs
- 'LS682 has 20-kΩ Pullup Resistors on the Q Inputs
- SN74LS686 and 'LS687 . . . JT and NT 24-Pin, 300-Mil Packages

TYPE	P = Q	P > Q	OUTPUT ENABLE	OUTPUT CONFIGURATION	20-kΩ PULLUP
'LS682	yes	yes	no	totem-pole	yes
'LS684	yes	yes	no	totem-pole	no
'LS685	yes	yes	no	open-collector	no
SN74LS686	yes	yes	yes	totem-pole	no
'LS687	yes	yes	yes	open-collector	no
'LS688	yes	no	yes	totem-pole	no

SN54LS687 . . . JT PACKAGE
SN74LS686, SN74LS687 . . . DW OR NT PACKAGE
(TOP VIEW)

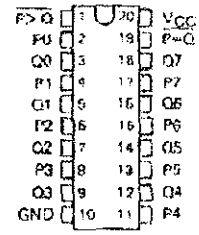


SN54LS687 . . . FK PACKAGE
(TOP VIEW)

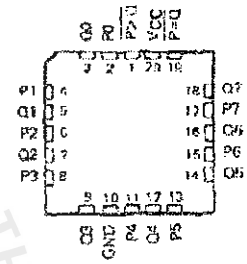


NC—No internal connection

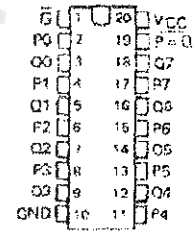
SN54LS682, SN54LS684, SN54LS685 . . . J PACKAGE
SN74LS682, SN74LS684, SN74LS685 . . . DW OR N PACKAGE
(TOP VIEW)



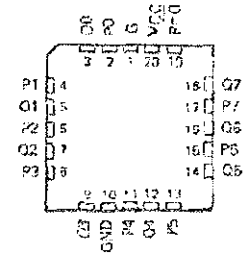
SN54LS682, SN54LS684, SN54LS685 . . . FK PACKAGE
(TOP VIEW)



SN54LS688 . . . J PACKAGE
SN74LS688 . . . DW OR N PACKAGE
(TOP VIEW)



SN54LS688 . . . FK PACKAGE
(TOP VIEW)



TEXAS INSTRUMENTS
POST OFFICE BOX 655012 • DALLAS, TEXAS 75265

SN54LS682, SN54LS684, SN54LS685, SN54LS687, SN54LS688
SN74LS682, SN74LS684 THRU SN74LS688
8-BIT MAGNITUDE/IDENTITY COMPARATORS

description

These magnitude comparators perform comparisons of two eight-bit binary or BCD words. All types provide $\overline{P = Q}$ outputs and all except 'LS688 provide $\overline{P > Q}$ outputs as well. The 'LS682, 'LS684, 'LS686, and 'LS688 have totem-pole outputs, while the 'LS685 and 'LS687 have open-collector outputs. The 'LS682 features 20-kΩ pullup termination resistors on the Q inputs for analog or switch data.

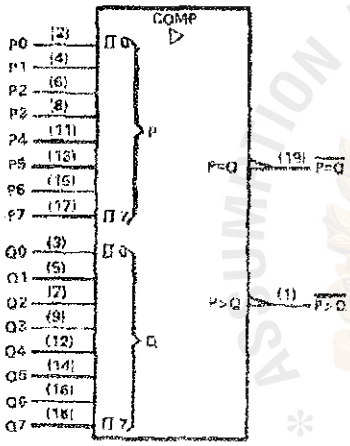
FUNCTION TABLE

INPUTS			OUTPUTS	
DATA	ENABLES		$\overline{P=Q}$	$\overline{P>Q}$
P, Q	$\overline{G}$, $\overline{G1}$	$\overline{G2}$		
P=Q	L	X	L	H
P>Q	X	L	H	L
P<Q	X	X	H	H
P=Q	H	X	H	H
P>Q	X	H	H	H
X	H	H	H	H

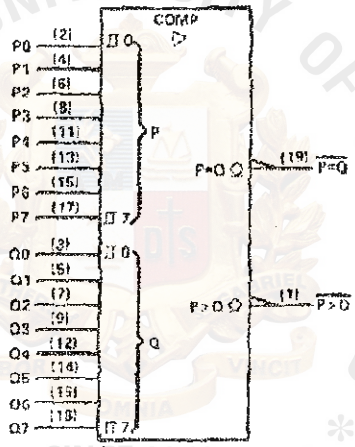
NOTES: 1. The last three lines of the function table applies only to the devices having enable inputs, i.e., 'LS686 thru 'LS688.
2. The $\overline{P \geq Q}$ function can be generated by applying the $\overline{P=Q}$ and $\overline{P>Q}$ outputs to a 2-input NAND gate.
3. For 'LS686 and 'LS687, $\overline{G}1$ enables $\overline{P=Q}$ and $\overline{G}2$ enables $\overline{P>Q}$.

logic symbols†

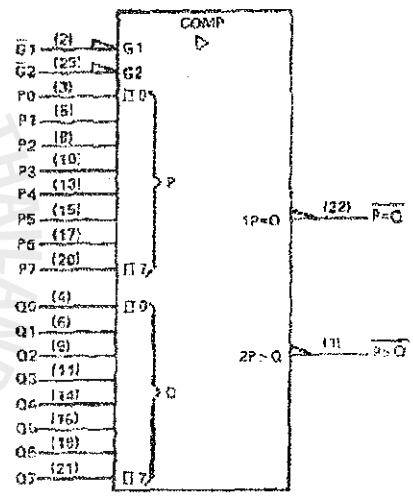
'LS682, 'LS684



'LS685



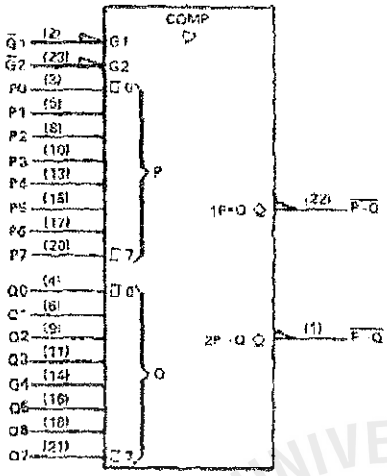
'LS686



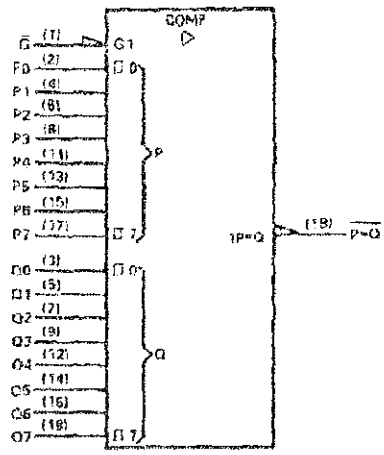
†These symbols are in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.
Pin numbers shown are for DW, J, JT, N, and NT packages.

logic symbols[1] (continued)

'LS687

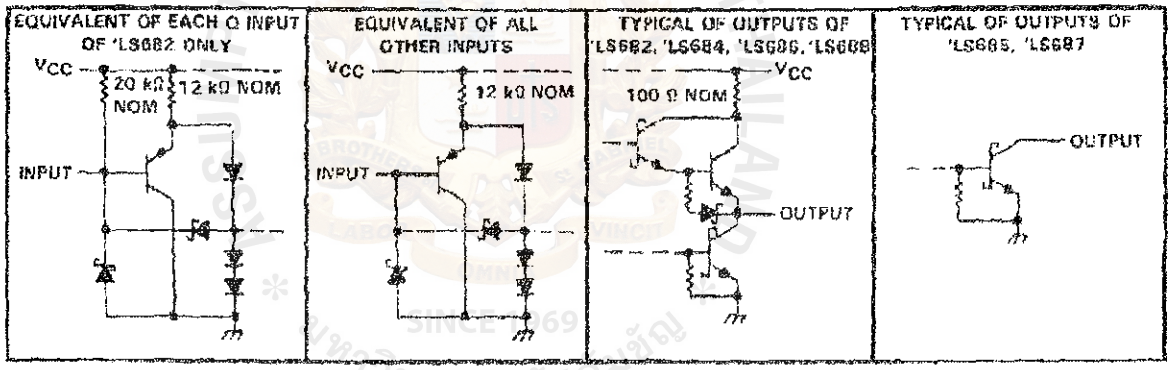


'LS688

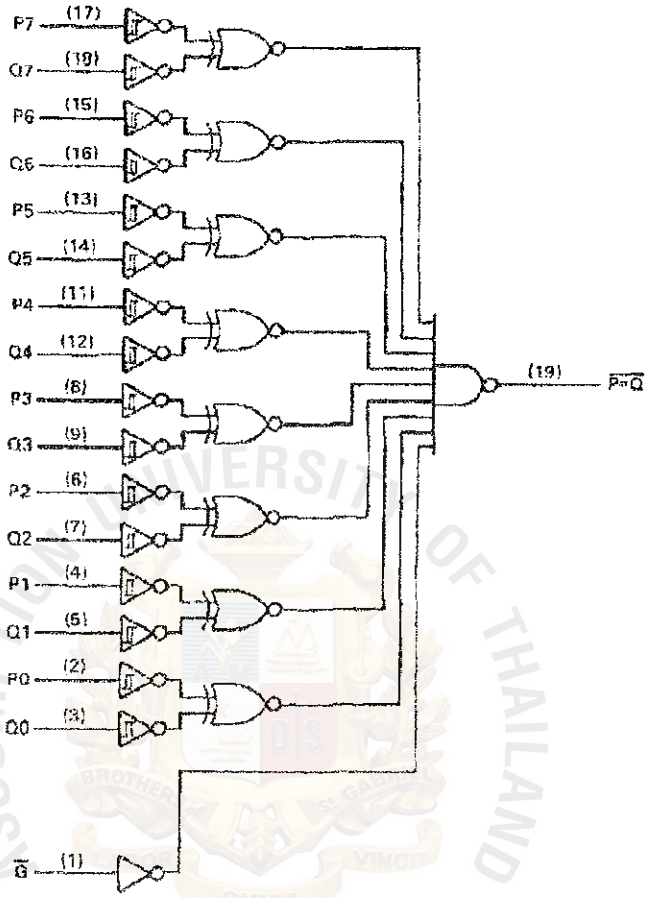


[1]These symbols are in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.
Pin numbers shown are for DW, J, JT, N, and NT packages.

schematics of inputs and outputs



'LS688 logic diagram (positive logic)



Pin numbers shown are for DW, J, and N packages.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{CC} (see Note 1) . . . . . 7 V
Input voltage: Q inputs of 'LS682 . . . . . 5.5 V
All other inputs . . . . . 7 V
Off-state output voltage: 'LS685, 'LS687 . . . . . 7 V
Operating free-air temperature range:
SN54LS682, SN54LS684, SN54LS685, SN54LS687, SN54LS688 . . . . . −55°C to 125°C
SN74LS682, SN74LS684 thru SN74LS688 . . . . . 0°C to 70°C
Storage temperature range . . . . . −65°C to 150°C

NOTE 1: Voltage values are with respect to network ground terminal.

recommended operating conditions

	SN54LS'			SN74LS'			UNIT
	MIN	NOM	MAX	MIN	NOM	MAX	
Supply voltage, V_{CC}	4.5	5	5.5	4.75	5	5.25	V
High-level output current, I_{OH}			−400			−400	μA
Low-level output current, I_{OL}			12			24	mA
Operating free-air temperature, T_A	−55		125	0		70	°C

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER			TEST CONDITIONS[1]		SN54LS'			SN74LS'			UNIT
					MIN	TYP[2]	MAX	MIN	TYP[2]	MAX	
V_{IH}	High-level input voltage				2			2			V
V_{IL}	Low-level input voltage						0.7			0.8	V
$V_{T+} - V_{T-}$	Hysteresis	P or Q inputs	V_{CC} = MIN		0.4			0.4			V
V_{IK}	Input clamp voltage		V_{CC} = MIN,	I_I = −18 mA			−1.5			−1.5	V
V_{OH}	High-level output voltage		V_{CC} = MIN, V_{IH} = 2 V, V_{IL} = V_{IL}max,	I_{OH} = −400 μA	2.5			2.7			V
V_{OL}	Low-level output voltage		V_{CC} = MIN, V_{IH} = 2 V,	I_{OL} = 12 mA		0.25	0.4		0.25	0.4	V
			V_{IL} = V_{IL}max	I_{OL} = 24 mA					0.35	0.5	
I_I	Input current at maximum input voltage	Q inputs, 'LS682	V_{CC} = MAX,	V_I = 8.5 V			0.1			0.1	mA
		All other inputs	V_{CC} = MAX,	V_I = 7 V							
I_{IH}	High-level input current		V_{CC} = MAX,	V_I = 2.7 V			20			20	μA
I_{IL}	Low-level input current	Q inputs, 'LS682	V_{CC} = MAX,	V_I = 0.4 V			−0.4			−0.4	mA
		All other inputs					−0.2			−0.2	
I_{OS}[3]	Short-circuit output current		V_{CC} = MAX,	V_O = 0	−20		−100	−20		−100	mA
I_{CC}	Supply current	'LS682	V_{CC} = MAX,	See Note 1		42	70		42	70	mA
		'LS684				40	65		40	65	
		'LS686				44	75		44	75	
		'LS688				40	65		40	65	

[1] For conditions shown as MIN or MAX, use the appropriate values specified under recommended operating conditions.
[2] All typical values are at V_{CC} = 5 V, T_A = 25°C.
[3] Not more than one output should be shorted at a time, and duration of the short-circuit should not exceed one second.
NOTE 1: I_{CC} is measured with any $\overline{G}$ inputs grounded, all other inputs at 4.5 V, and all outputs open.

switching characteristics, V_{CC} = 5 V, T_A = 25°C

PARAMETER†	FROM (INPUTS)	TO (OUTPUT)	TEST CONDITIONS	'LS682			'LS684			'LS686			'LS688			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t_{PLH}	P	$\overline{P=Q}$	R_L = 667 Ω, C_L = 45 pF, All other inputs low, See Note 2		13	25		15	25		13	25		12	18	ns
t_{PHL}					18	26		17	25		20	30		17	23	
t_{PLH}	Q	$\overline{P=Q}$			14	25		16	25		13	25		12	18	ns
t_{PHL}					15	26		15	25		21	30		17	23	
t_{PLH}	$\overline{G}$, $\overline{G1}$	$\overline{P=Q}$									11	20		12	18	ns
t_{PHL}											19	30		13	20	
t_{PLH}	P	$\overline{P>Q}$			20	30		22	30		19	30				ns
t_{PHL}					15	30		17	30		15	30				
t_{PLH}	Q	$\overline{P>Q}$			21	30		24	30		18	30				ns
t_{PHL}					19	30		20	30		19	30				
t_{PLH}	$\overline{G2}$	$\overline{P>Q}$									21	30				ns
t_{PHL}											18	25				

†t_{PLH} = propagation delay time, low-to-high-level outputs; t_{PHL} = propagation delay time, high-to-low-level output.
NOTE 2: Load circuits and voltage waveforms are shown in Section 1.

recommended operating conditions

	SN54LS'			SN74LS'			UNIT
	MIN	NOM	MAX	MIN	NOM	MAX	
Supply voltage, V_{CC}	4.5	5	5.5	4.75	5	5.25	V
High-level output current, I_{OH}			−1.2			−2.6	mA
Low-level output current, I_{OL}			12			24	mA
Operating free-air temperature, T_A	−55		125	0		70	°C

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER			TEST CONDITIONS†		SN54LS'			SN74LS'			UNIT
					MIN	TYP‡	MAX	MIN	TYP‡	MAX	
V_{IH}	High-level input voltage				2			2			V
V_{IL}	Low-level input voltage						0.7			0.8	V
$V_{T+} - V_{T-}$	Hysteresis	P or Q inputs	V_{CC} = MIN		0.4			0.4			V
V_{IK}	Input clamp voltage		V_{CC} = MIN,	I_I = −18 mA			−1.5			−1.5	V
I_{OH}	High-level output voltage		V_{CC} = MIN, V_{IL} = V_{IL}max,	V_{IH} = 2 V, V_{OH} = 5.5 V			250			100	μA
V_{OL}	Low-level output voltage		V_{CC} = MIN, V_{IH} = 2 V, V_{IL} = V_{IL}max,	I_{OL} = 12 mA		0.25	0.4		0.25	0.4	V
				I_{OL} = 24 mA					0.35	0.5	
I_I			V_{CC} = MAX,	V_I = 7 V			0.1			0.1	mA
I_{IH}	High-level input current		V_{CC} = MAX,	V_I = 2.7 V			20			20	μA
I_{IL}	Low-level input current		V_{CC} = MAX,	V_I = 0.4 V			−0.2			−0.2	mA
I_{CC}	Supply current	'LS685	V_{CC} = MAX,	See Note 1		40	65		40	65	mA
		'LS687				44	75		44	75	

†For conditions shown as MIN or MAX, use the appropriate values specified under recommended operating conditions.
‡All typical values are at V_{CC} = 5 V, T_A = 25°C.
NOTE 1: I_{CC} is measure with any $\overline{G}$ inputs grounded, all other inputs at 4.5 V, and all outputs open.

a8255

Programmable Peripheral Interface Adapter

September 1996, ver. 1

Features

- a8255 MegaCore function implementing a programmable peripheral interface adapter
- Optimized for FLEX® and MAX® architectures
- 24 programmable inputs/outputs
- Static read/write or handshaking modes
- Direct bit set/reset capability
- Synchronous design
- Uses approximately 194 FLEX logic elements (LEs)
- Functionally based on the Intel 8255A and Harris 82C55A devices, except as noted in the "Variations & Clarifications" section on page 50

General Description

The a8255 MegaCore function implements a programmable peripheral interface adapter (see Figure 1). The a8255 has 24 I/O signals that can be programmed in two groups of 12. This MegaCore function operates in the following three modes:

- *Mode 0: Basic Input/Output*—Port A, port B, and port C (upper and lower) can be independently configured as inputs or outputs to read or hold static data. Outputs are registered; inputs are not registered.
- *Mode 1: Strobed Input/Output*—Port A and port B can be independently configured as strobed input or output buses. Signals from port C are dedicated as control signals for data handshaking.
- *Mode 2: Bidirectional Bus*—Port A can be configured as a bidirectional bus with the majority of port C providing the control signals. In this configuration, port B can still implement mode 0 or mode 1.

Figure 1. a8255 Symbol

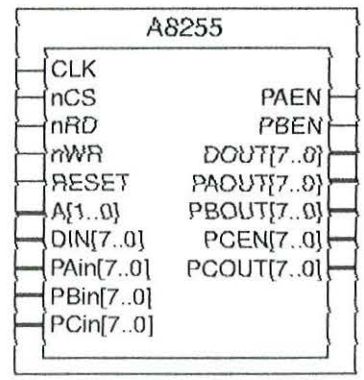


Table 1 describes the input and output ports of the a8255.

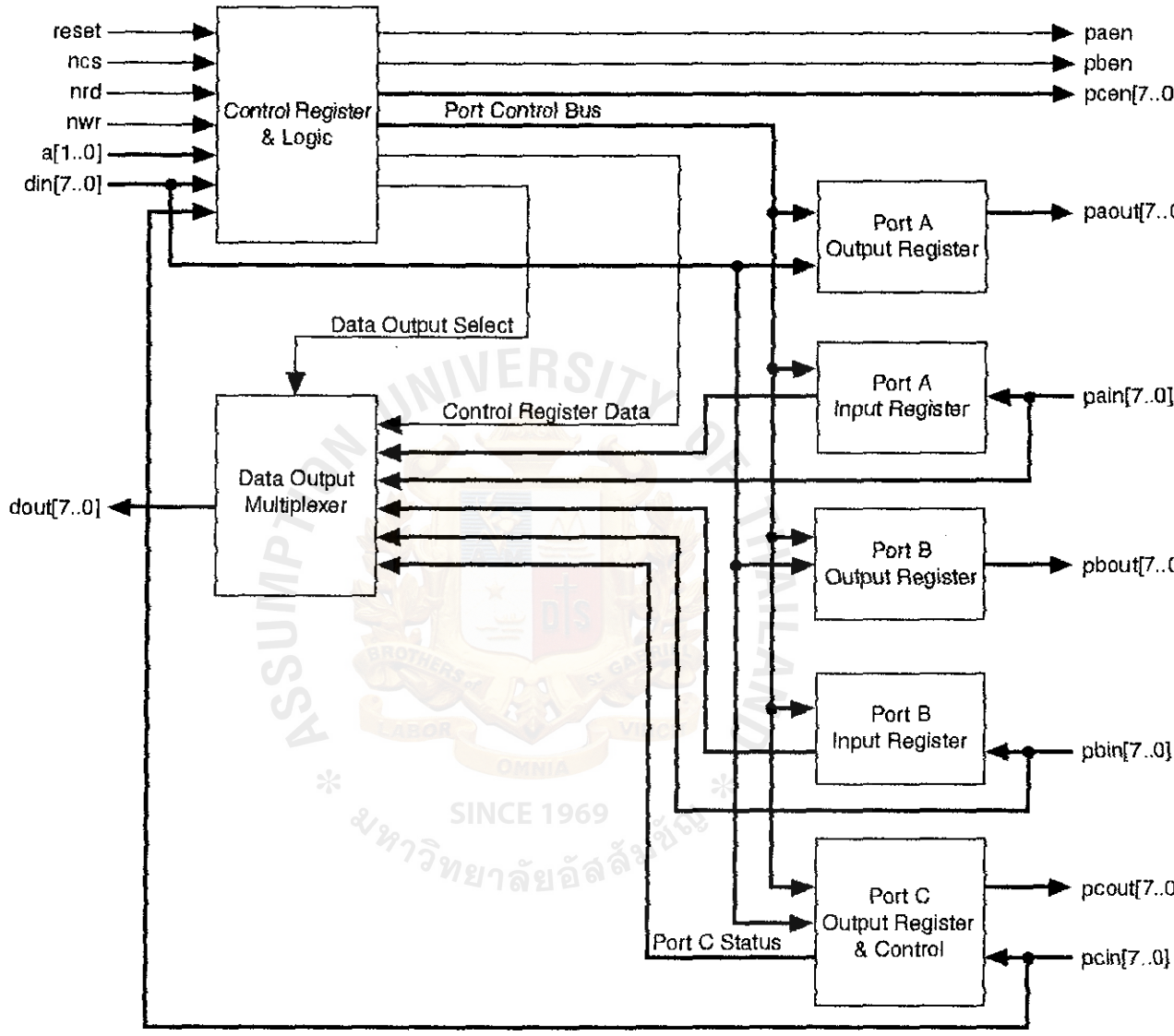
Table 1. a8255 Ports

Name	Type	Polarity	Description
clk	Input	–	Clock.
ncs	Input	Low	Chip select. When ncs is asserted, the a8255 is selected and read and write transactions to internal registers are possible.
nrd	Input	Low	Read control. When nrd is asserted and the a8255 is selected, read transactions from internal registers are possible.
nwr	Input	Low	Write control. When nwr is asserted and the a8255 is selected, write transactions to internal registers are possible.
reset	Input	High	Reset. Initializes the control and port C output registers, and sets the port A, B, and C registers to input mode.
a[1..0]	Input	High	Register address bus. This bus selects one of the internal registers.
din[7..0]	Input	High	Data input bus. The CPU writes data to the internal control, port A, port B, or port C register via the din[7..0] bus.
pain[7..0]	Input	High	Port A input data bus.
pbin[7..0]	Input	High	Port B input data bus.
pcin[7..0]	Input	High	Port C input data bus.
paen	Output	High	Port A data enable. Output enable for the port A output data bus.
pben	Output	High	Port B data enable. Output enable for the port B output data bus.
dout[7..0]	Output	High	Data output bus. The CPU reads data from the internal control, port A, port B, or port C register via the dout[7..0] bus.
paout[7..0]	Output	High	Port A output data bus.
pbout[7..0]	Output	High	Port B output data bus.
pcen[7..0]	Output	High	Port C data enable bus. Output enable for each bit of the port C output data bus.
pcout[7..0]	Output	High	Port C output data bus.

Functional Description

Figure 2 shows a block diagram of the a8255.

Figure 2. a8255 Block Diagram



Register Address Map

Table 2 shows the register address map for the a8255.

Table 2. Register Address Map

a1	a0	Register
0	0	Port A data (all modes)
0	1	Port B data (all modes)
1	0	Port C data (mode 0) and status (modes 1 and 2)
1	1	Control register mode definition and port C bit set/reset

Registers

This section describes the following a8255 registers:

- Control
- Port A, B & C

Control Register

The control register sets the mode and signal direction for the three 8-bit I/O ports. Control of the I/O ports is split into two groups. Group A consists of port A and the upper four bits of port C; group B consists of port B and the lower four bits of port C. Group A can be set to mode 0, mode 1, or mode 2, but group B can be set to only mode 0 or mode 1.

Writing to the control register address with bit 7 set is the mode definition format, which allows control of the mode and direction of the three I/O ports (see Table 3). Writing to the control register address with bit 7 reset is the port C bit set/reset format, which allows single-bit control of port C (see Table 4). The CPU reads the control register using the mode definition format.

Table 3. Control Register Mode Definition Format	
Bit	**Description**
0	Port C (lower) I/O direction: 1 = input 0 = output
1	Port B I/O direction: 1 = input 0 = output
2	Group B mode select: 1 = mode 1 0 = mode 0
3	Port C (upper) I/O direction: 1 = input 0 = output
4	Port A I/O direction: 1 = input 0 = output
6..5	Group A mode select: 00 = mode 0 01 = mode 1 1X = mode 2, *Note (1)*
7	1 when writing = mode definition format Always 1 when reading the control register

Note:
(1) The X indicates "don't care."

Table 4. Port C Bit Set/Reset Format *Note (1)*	
Bit	**Description**
0	Bit set/reset: 1 = set 0 = reset
3..1	Bit select address
6..4	XXX, *Note (2)*
7	0 when writing = port C bit set/reset format

Notes:
(1) For example, to reset bit 3 of port C, bit 7 is reset to indicate that the write is in the port C bit set/reset format. Bits 6 through 4 are "don't care." Bits 3 through 1 are 011 to address bit 3, and bit 0 is 0 to indicate a reset operation. The complete data word is 0XXX0110.
(2) The X indicates "don't care."

Port A, B & C Registers

Depending on the configured input and output directions that are set in the control register, the microprocessor either reads or writes data to/from the port A, B, or C registers. Ports A and B have separate input and output registers.

In mode 0, the port C register functions identically to the port A and B registers. In modes 1 and 2, the port C register has a specialized role; a write to port C has no effect—the register bits must be altered individually using the port C bit set/reset format. Reading the port C status bits in modes 1 or 2 provides the CPU with the status of the control signals and flags, as shown in Tables 5 through 7. However, the modes and port directions can be mixed in more combinations than these tables illustrate.

Table 5. Port C Status Bits with Ports A & B in Mode 1 Input *Note (1)*

Bit	Signal	Description
0	intrb	Port B interrupt request
1	ibfb	Port B input buffer full flag
2	inteb	Port B interrupt enable
3	intra	Port A interrupt request
4	intea	Port A interrupt enable
5	ibfa	Port A input buffer full flag
6	I/O	*Note (2)*
7	I/O	*Note (2)*

Notes:

(1) These bits are defined in Table 9.

(2) Bits 6 and 7 effectively operate in mode 0. The I/O direction is dependent on bit 3 of the control register.

Table 6. Port C Status Bits with Ports A & B in Mode 1 Output *Note (1)*		
Bit	**Signal**	**Description**
0	intrb	Port B interrupt request
1	nobfb	Port B output buffer full flag
2	inteb	Port B interrupt enable
3	intra	Port A interrupt request
4	I/O	*Note (2)*
5	I/O	*Note (2)*
6	intea	Port A interrupt enable
7	nobfa	Port A output buffer full flag

Notes:
(1) These bits are defined in Table 8.
(2) Bits 4 and 5 effectively operate in mode 0. The I/O direction is dependent on bit 3 of the control register.

Table 7. Port C Status Bits with Port A in Mode 2 *Note (1)*		
Bit	**Signal**	**Description**
0	–	*Note (2)*
1	–	*Note (2)*
2	–	*Note (2)*
3	intra	Port A interrupt request
4	inte2	Interrupt enable 2
5	ibfa	Port A input buffer full flag
6	inte1	Interrupt enable 1
7	nobfa	Port A output buffer full flag

Notes:
(1) These bits are defined in Table 8.
(2) Depending on the lower three bits of the control register, bits 0 through 2 either operate in mode 0 or function as status bits for port B in mode 1.

peration

The a8255 operates in the following three modes:

- Mode 0: basic input/output
- Mode 1: strobed input/output
- Mode 2: strobed bidirectional bus

Mode 0: Basic Input/Output

Mode 0 is used to perform simple reads or writes of relatively static signals, such as switches or status displays. Port A, port B, port C (upper), and port C (lower) can be independently configured as inputs or outputs without requiring handshake signals. Data written by the CPU to a port configured as an output is registered; data read by the CPU from a port configured as an input is not registered.

Mode 1: Strobed Input/Output

Mode 1 is used to perform reads or writes of data controlled by handshake signals. Ports A and B are the data ports, configured independently as either inputs or outputs. Port C provides the three handshaking signals for each of the data ports. Both input and output data are registered.

Table 8 shows how the handshaking signals are configured for mode 1 input.

Table 8. Handshaking Signal Configuration (Mode 1 Input)

Name	Signal Type	Description
nstb	Input	Strobe. Enable for input register.
ibf	Output	Input buffer full flag. When set, indicates that data has been loaded into the input register. Set by nstb going low, and reset by the rising edge of the nrd input.
intr	Output	Interrupt request. Can be used as the interrupt signal to the CPU. Set on the rising edge of nstb when inte is high. Reset by the falling edge of nrd.
inte	Internal control bit	Interrupt enable. Set by bit set to PC4 for port A and PC2 for port B.

Table 9 shows how the handshaking signals are configured for mode 1 output.

Table 9. Handshaking Signal Configuration (Mode 1 Output)

Name	Signal Type	Description
nobf	Output	Output buffer full flag. Indicates that data has been written to the port. Goes low on the rising edge of nwr, and returns high when nack is asserted. The rising edge of nobf should be used to latch data into the peripheral.
nack	Input	Acknowledge. Indicates the peripheral is ready to latch the output data.
intr	Output	Interrupt request. Can be used as the interrupt signal to the CPU, which indicates that the peripheral device has latched the data. Reset on the falling edge of nwr; set on the rising edge of nack when inte is high.
inte	Internal control bit	Interrupt enable. Set by bit set to PC6 for port A and PC2 for port B.

Table 10 summarizes the configuration of port C when both port A and port B are configured as mode 1.

Table 10. Port C with Port A & Port B Both Configured as Mode 1 *Note (1)*

Bit	Mode 1 Input	Mode 1 Output	Description
PC0	intrb	intrb	Always output.
PC1	ibfb	nobfb	Always output.
PC2	nstbb	nackb	Always input.
PC3	intra	intra	Always output.
PC4	nstba	I/O	I/O direction configured by bit 3 of the control register in "mode 1 output."
PC5	ibfa	I/O	I/O direction configured by bit 3 of the control register in "mode 1 output."
PC6	I/O	nacka	I/O direction configured by bit 3 of the control register in "mode 1 input."
PC7	I/O	nobfa	I/O direction configured by bit 3 of the control register in "mode 1 input."

te:

The interrupt enable control bits (intea and inteb) are stored in the output register bits PC2, PC4, and PC6.

Mode 2: Strobed Bidirectional Bus

Mode 2 is used to perform reads and writes of data over a bidirectional bus controlled by handshake signals. Port A is the only data port capable of mode 2 operation, while port C provides the five control signals for this data port. Both input and output data are registered. Table 11 shows the configuration for the bidirectional bus.

Table 11. Bidirectional Bus Configuration

Name	Signal Type	Description
nstb	Input	Strobe. Enable for input register.
nack	Input	Acknowledge. Indicates that the peripheral is ready to latch the output data. Acts as the tri-state enable for port A.
ibf	Output	Input buffer full flag. When set, indicates data has been loaded into the input register. Set by nstb going low, and reset by the rising edge of the nrd input.
nobf	Output	Output buffer full flag. Indicates that data has been written to port A. Reset on the rising edge of nwr, and set when nack goes low.
intr	Output	Interrupt request. Can be used as the interrupt signal to the CPU that indicates the peripheral has latched the data. Reset on the falling edge of nwr or falling edge of nrd. Set on the rising edge of nack when inte1 is high, or on the rising edge of nstb when inte2 is high.
inte1	Internal control bit	Interrupt enable 1. Set by bit set to PC6.
inte2	Internal control bit	Interrupt enable 2. Set by bit set to PC4.

Table 12 summarizes the configuration of port C in mode 2.

Table 12. Port C Configuration in Mode 2

I/O	Mode 2	Description
PC0	I/O	Dependent on group B configuration
PC1	I/O	Dependent on group B configuration
PC2	I/O	Dependent on group B configuration
PC3	intra	Output
PC4	nstba	Input
PC5	ibfa	Output
PC6	nacka	Input
PC7	nobfa	Output

Timing Waveforms

Figures 3 and 4 shows the functional timing waveforms for the a8255.

Figure 3. a8255 Mode 0 and Mode 1 Functional Timing Waveforms

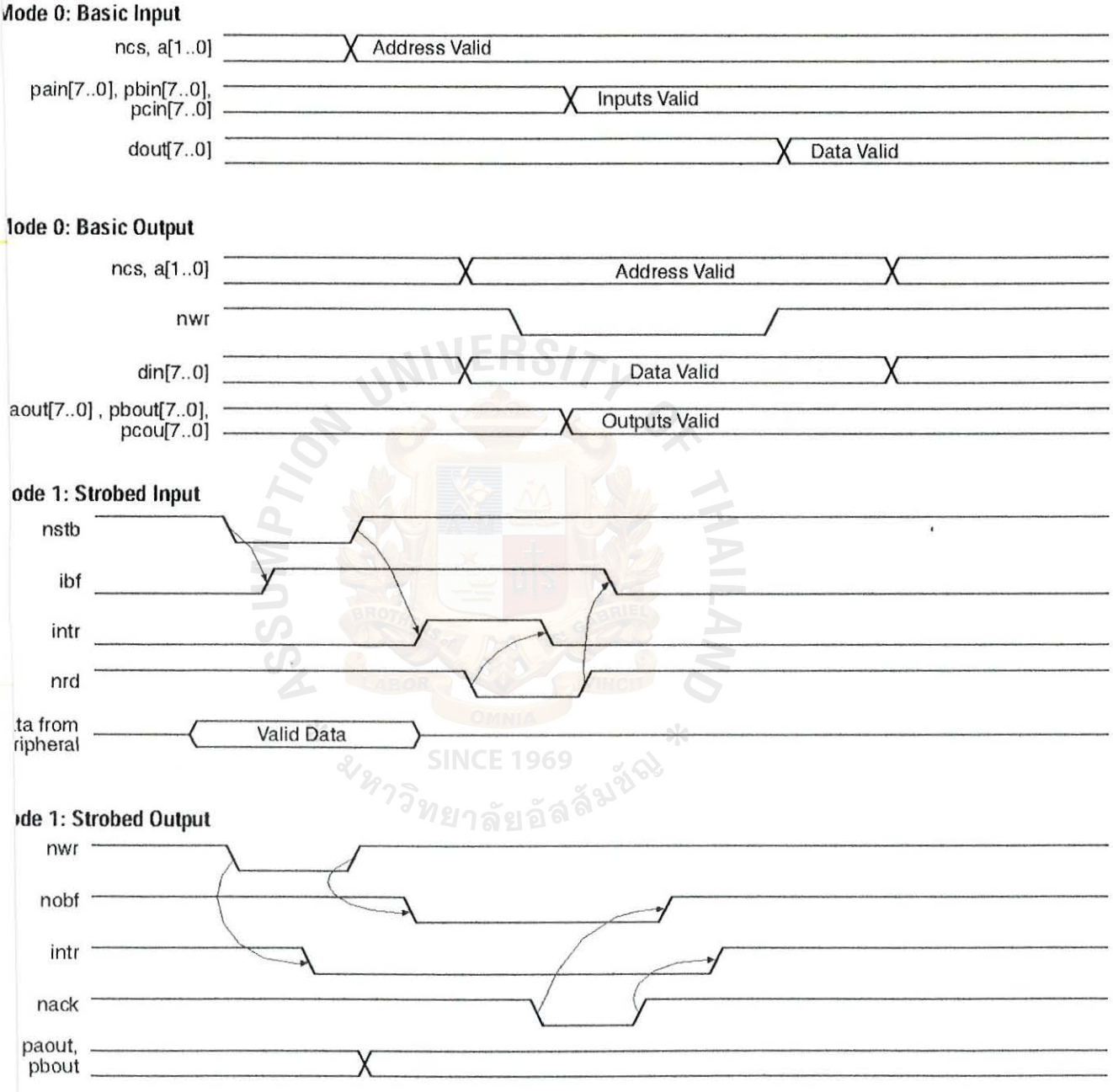
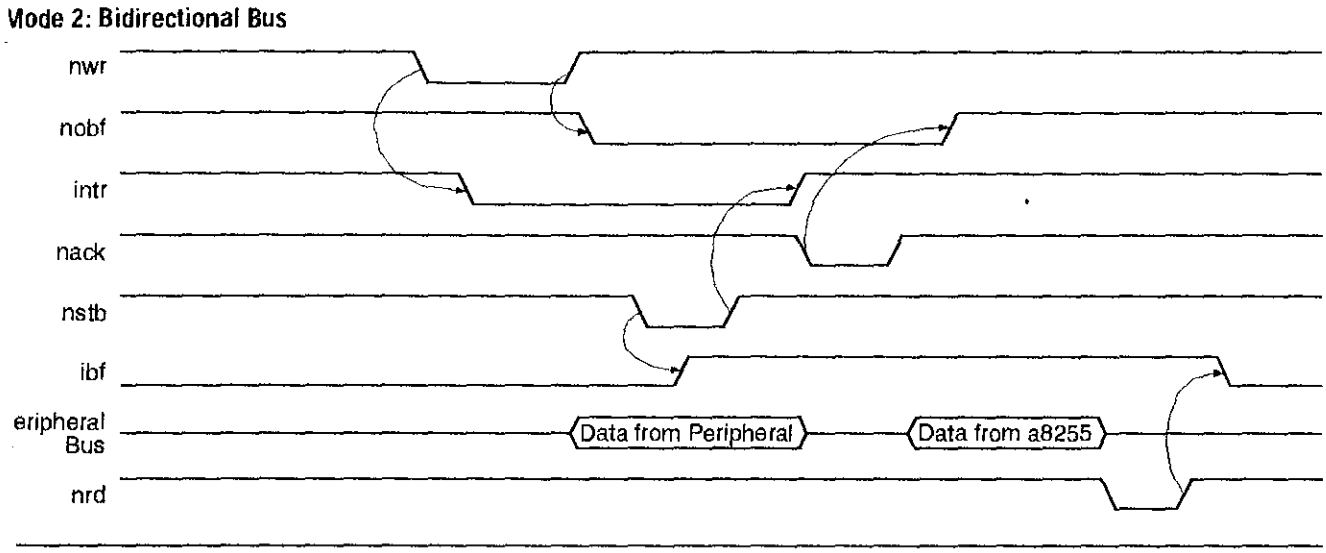


Figure 4. a8255 Mode 2 Functional Timing Waveforms



ariations & larifications

The following characteristics distinguish the Altera a8255 from the Intel 8255A and Harris 82C55A devices:

- To allow synchronous design, a clk input was added as a system clock to the a8255. This capability requires that all strobes (nrd, nwr, nstb, and nack) have a minimum pulse width of one clk cycle.
- In the a8255, the reset input resets the port A, B, and C registers. In the Intel 8255A and Harris 82C55A devices, the port A, B, and C registers are unaffected by the reset input.
- The bidirectional buses in the Intel 8255A and Harris 82C55A devices (d, pa, pb, and pc) are split into input, output, and enable signals in the Altera a8255.
- The a8255 has no "bus hold" passive pull-ups on port signals. Because the port I/O signal is usually tied to the I/O of the Altera device, pull-ups or pull-downs can be added.
- In the a8255, the control register can be read. The control register can be read on the Harris 82C55A device, but the Intel 8255A device does not have this capability.
- In the a8255, the reset signal initializes the control register such that all ports are set to mode 0 inputs. Reading the control register after initialization will return the value of 9B in hexadecimal.
- After initialization in mode 1, the pertinent control signals in the port C register should be configured via the port C bit set/reset commands.
- In mode 2, every read or write of port A resets the intra interrupt signal.
- The Intel and Harris data sheets state that output registers and status flipflops should be reset in the event of a mode change. This feature was not included in the a8255.

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