The size of the data count register of a DMA controller is 16 bits. The processor needs to transfer a file of 29,154 kilobytes from disk to main memory. The memory is byte addressable. The minimum number of times the DMA controller needs to get the control of the system bus from the processor to transfer the file from the disk to main memory is _____.

Solution:

Concept:

A hardware device used for **DMA (Direct memory access)** is DMA controller. DMA controller is a control unit, which can transfer blocks of data between I/O devices and main memory with intervention from the processor.

Data count register provides the number of words DMA can transfer in one cycle.

If memory is byte addressable; 1 word = 1 byte

1 kilobytes = 2^{10} bytes

Calculation:

Size of data counter register of DMA controller = 16 bits

It means, 2^{16} words can be transferred in one cycle.

As, memory is byte addressable.

So, 2^{16} bytes in one cycle. (2^{16} bytes = 2^6 kilobytes)

File size = 29154 kilobytes

Minimum number of times the DMA controller needs to get control of the system bus from the processor to transfer the file from the disk to main memory is = $\left\lceil \frac{File\ size}{bytes\ in\ one\ cycle} \right\rceil = \lceil \frac{29154\ KB}{2^{16}} \rceil = 456$

Q2:

1 Byte = 8 bits
1 KB = 1024 B(ytes) = 2^{10} B
1 MB = 1024 KB = 2^{20} B
1 GB = 1024 MB = 2^{30} B

DMA - Problems

Problem 2:

A hard disk with a transfer rate of 10 Mbytes/second is constantly transferring data to memory using DMA. The processor runs at 600MHz, and takes 300 and 900 clock cycles to initiate and complete DMA transfer respectively. If the size of the transfer is 20 Kbytes, what is the percentage of processor time consumed for the transfer operation?

Solution:

$$Total\ Time = \frac{Total\ Data}{Total\ Transfer\ Rate}$$

Step 1: Find Total Transfer Time

Transfer rate=10 MB per second = 10×2^{20} bytes/sec

Data=20 KB=20×2^{10} bytes

Time=$(20 \times 2^{10})/(10 \times 2^{20}) = 2 \times 2^{-10} = 2 \times 10^{-3} = 2$ ms

$$Processor\ Time = \frac{Cycles\ for\ DMA\ transfer}{Processor\ Speed}$$

$$\%\ Processor\ Time = \frac{Processor\ Time}{Total\ Time} \times 100$$

Step 2 :Find Processor Time

1 MHz = 10^6 cycles/sec

Processor speed= 600 MHz = 600×10^6 Cycles/sec

Cycles required by CPU for DMA Transfer =300+900 =1200 cycles

Time=1200 cycles/(600×10^6) cycles/sec = 2×10^{-6} sec = .002 ms

Step 3 : Find % of Processor Time

% Processor Time = $(.002/2) \times 100 = 0.1\%$

Term	Normal Usage	Usage as Power of 2
K (Kilo)	10^3	$2^{10} = 1,024$
M (Mega)	10^6	$2^{20} = 1,048,576$
G (Giga)	10^9	$2^{30} = 1,073,741,824$
T (Tera)	10^{12}	$2^{40} = 1,099,511,627,776$

Q3:

1 Byte	= 8 bits	
1 KB	= 1024 B(ytes)	= 2^{10} B
1 MB	= 1024 KB	= 2^{20} B
1 GB	= 1024 MB	= 2^{30} B

DMA - Problems

Problem 1:

A hard disk with a transfer rate of 20 Mbytes/second is constantly transferring data to memory using DMA. The processor runs at 300MHz, and takes 300 and 900 clock cycles to initiate and complete DMA transfer respectively. If the size of the transfer is 20 Kbytes, what is the percentage of processor time consumed for the transfer operation?

Solution:

$$Total\ Time = \frac{Total\ Data}{Total\ Transfer\ Rate}$$

$$Processor\ Time = \frac{Cycles\ for\ DMA\ transfer}{Processor\ Speed}$$

$$\%\ Processor\ Time = \frac{Processor\ Time}{Total\ Time} \times 100$$

Step 1: Find Total Transfer Time

Transfer rate=20 MB per second = 20×2^{20} bytes/sec

Data=20 KB=20×2^{10} bytes

Time=$(20 \times 2^{10})/(20 \times 2^{20}) = 1 \times 2^{-10} = 1 \times 10^{-3}$ =1 ms

Step 2 :Find Processor Time

1 MHz = 10^6 cycles/sec

Processor speed= 300 MHz = 300×10^6 Cycles/sec

Cycles required by CPU for DMA Transfer =300+900 =1200 cycles

Time=1200 cycles/(300×10^6) cycles/sec = 4×10^{-6} sec = .004 ms

Step 3 : Find % of Processor Time

% Processor Time = (.004/1) × 100 = 0.4%

Term	Normal Usage	Usage as Power of 2
K (Kilo)	10^3	2^{10} = 1,024
M (Mega)	10^6	2^{20} = 1,048,576
G (Giga)	10^9	2^{30} = 1,073,741,824
T (Tera)	10^{12}	2^{40} = 1,099,511,627,776

Q4. Consider a disk drive with the following specifications. 16 surfaces, 512 tracks/surface, 512 sectors/track, 1 KB/sector, rotation speed 3000 rpm. The disk is operated in cycle stealing mode whereby whenever one 4 byte word is ready it is sent to memory; similarly, for writing, the disk interface reads a 4 byte word from the memory in each DMA cycle. Memory cycle time is 40 nsec. The maximum percentage of time that the CPU gets blocked during DMA operation is

Solution

The correct option is D 25

Revolution Per minute=3000 RPM

Or 3000/60=50 RPS

In one track rotation it can read=512 KB

In 50 RPS it can read=512× 50

For 1 byte read=1/(512× 50)=39.06 ns

⇒ For 4 bytes it takes 156 ns

Percentage of time that the CPU gets
blocked during DMA operation=40156×100

≃25

Question: Which one of the following facilitates transfer of bulk data from hard disk to main memory with the highest throughput?

A. DMA based I/O transfer
B. Interrupt driven I/O transfer
C. Polling based I/O transfer
D. Programmed I/O transfer