8254 PROGRAMMABLE INTERVAL TIMER

8254 PROGRAMMABLE INTERVAL TIMER

- **Consists of three independent 16-bit programmable counters (timers).**

- **Each counter is capable of counting in binary or binary-coded decimal (BCD).**
  - maximum allowable input frequency to any counter is 10 MHz

- **Useful where the microprocessor must control real-time events.**
  - Usage includes real-time clocks, event counters, and motor speed/direction control.

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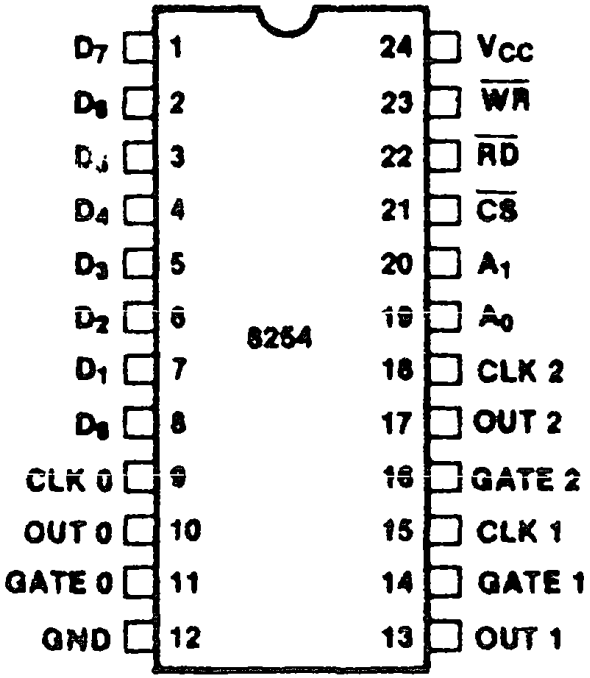
- **Timer appears in the PC decoded at ports 40H–43H to do the following:**
  - Generate a basic timer interrupt that occurs at approximately 18.2 Hz
  - Cause the DRAM memory system to be refreshed
  - Provide a timing source to the internal speaker and other devices.
- **Timer in the PC is an 8253 instead of 8254. The 8254, a higher-speed version of the 8253**



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- **Pin Definitions for 8254**
  - **A0, A1:** The address inputs select one of four internal registers within the 8254.

A_1	A_0	*Function*
0	0	Counter 0
0	1	Counter 1
1	0	Counter 2
1	1	Control word

  - **CLK:** The clock input is the timing source for each of the internal counters. This input is often connected to the PCLK signal from the microprocessor system bus controller.
  - **CS:** Chip select enables 8254 for programming and reading or writing a counter.
  - **G:** The gate input controls the operation of the counter in some modes of operation

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- **Pin Definitions for 8254**
  - **OUT:** A counter output is where the waveform generated by the timer is available.
  - **RD:** Read causes data to be read from the 8254 and often connects to the IORC signal.
  - **VCC:** Power connects to the +5.0 V power supply.
  - **GND:** Ground connects to the system ground bus.
  - **WR:** Write causes data to be written to the 8254 and often connects to write strobe IOWC.

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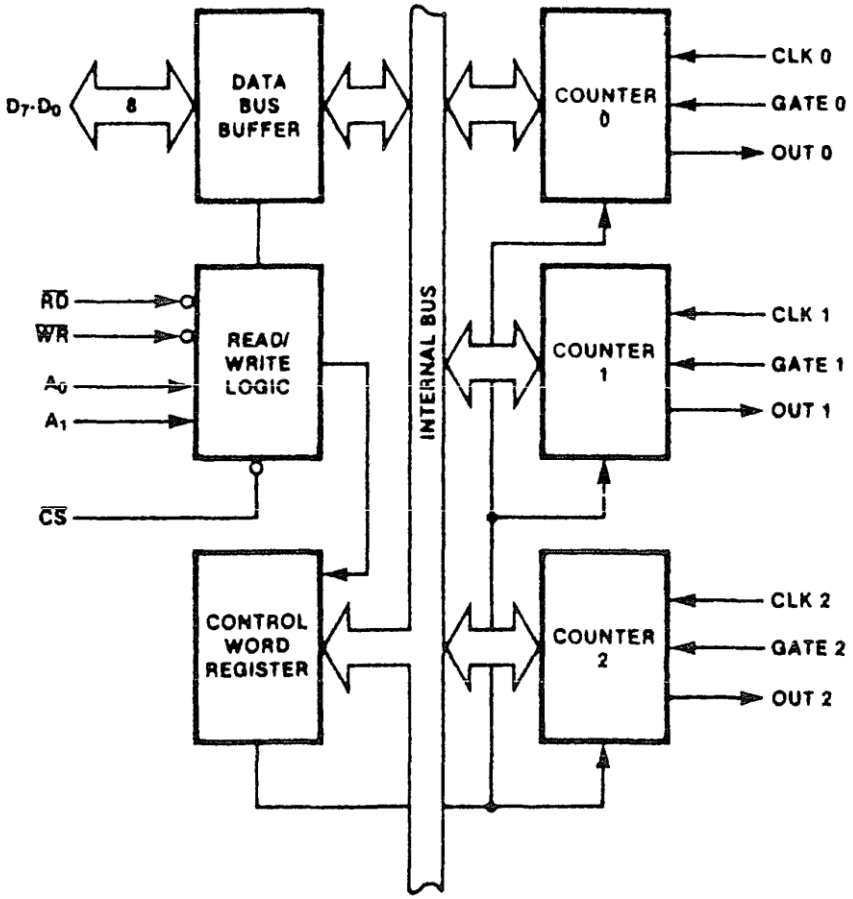
- **Each timer contains:**
  - a CLK input which provides the basic operating frequency to the timer
  - a gate input pin which controls the timer in some modes
  - an output (OUT) connection to obtain the output of the timer



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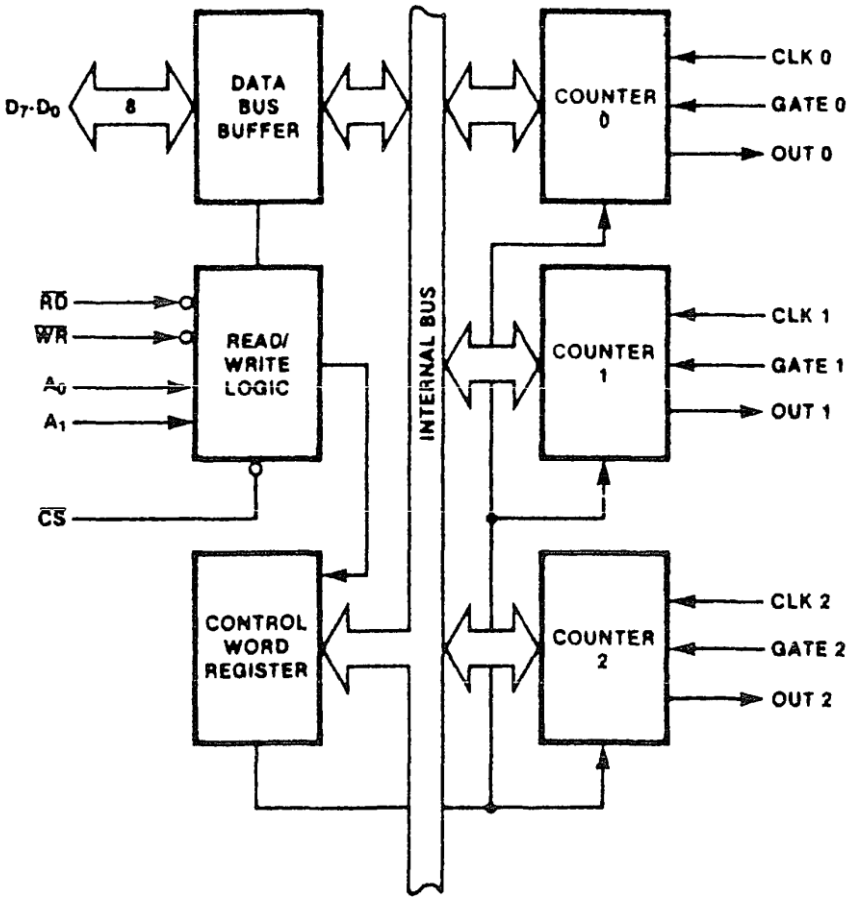
- **The signals that connect to the processor are**
  - the data bus pins (D7–D0),
  - RD, WR, CS, and
  - address inputs A1 and A0.
- **Address inputs are present to select any of the four internal registers.**
  - used for programming, reading, or writing to a counter



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- **Timer zero generates an 18.2 Hz signal that interrupts the microprocessor at interrupt vector 8 for a clock tick.**
  - often used to time programs and events in DOS
- **Timer 1 is programmed for 15 µs, used on the PC to request a DMA action used to refresh the dynamic RAM.**
- **Timer 2 is programmed to generate a tone on the PC speaker.**

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- **Programming the 8254**
  - Each counter is programmed by writing a control word, followed by the initial count.
  - The control word allows the programmer to select the counter, mode of operation, and type of operation (read/write).
  - also selects either a binary or BCD count

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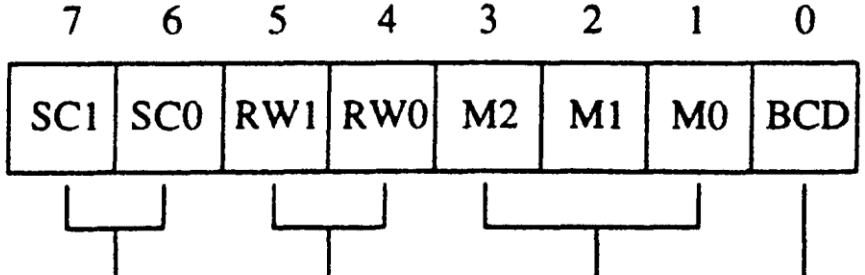
- **Programming the 8254**



Selects a BCD when a logic 1

Selects the mode (mode 0 - - mode 5)

Read/write control
- 00 = counter latch command
- 01 = read/write least-significant byte only
- 10 = read/write most-significant byte only
- 11 = read/write least-significant byte first, followed by the most-significant byte

Selects counter
- 00 = counter 0
- 01 = counter 1
- 10 = counter 2
- 11 = read-back command

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- **Programming the 8254**
  - Each counter may be programmed with a count of 1 to FFFFH; A count of 0 is equal to FFFFH+1 (65,536) or 10,000 in BCD.
  - Timer 0 is used in the PC with a divide-by count of 64K (FFFFH) to generate the 18.2 Hz (18.196 Hz) interrupt clock tick.
    - timer 0 has a clock input frequency of 4.77 MHz + 4 or 1.1925 MHz
  - The order of programming is important for each counter, but programming of different counters may be interleaved for better control.

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- **Programming the 8254**

Example - 1

Write code to set up three counters located at I/O address 40h as follows:

- Counter 0: Binary counter operating in mode 0 with a value of 1234h
- Counter 1: BCD counter operating in mode 2 with a value of 0100h
- Counter 2: Binary counter operating in mode 4 with a value of 1FFFh

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- **Programming the 8254**

Example – 1, cont'd

Mode word for counter 0 = 00 11 000 0 = 30h
Mode word for counter 1 = 01 11 010 1 = 75h
Mode word for counter 2 = 10 11 100 0 = B8h

```
MOV     AL,30H      ;SET UP COUNTER 0 MODE
OUT     43H,AL
MOV     AL,75H      ;SET UP COUNTER 1 MODE
OUT     43H,AL
MOV     AL,0B8H     ;SET UP COUNTER 2 MODE
OUT     43H,AL
MOV     AL,34H      ;LOAD COUNTER 0
OUT     40H,AL
MOV     AL,12H
OUT     40H,AL
MOV     AL,00H      ;LOAD COUNTER 1
OUT     41H,AL
MOV     AL,01H
OUT     41H,AL
MOV     AL,0FFH     ;LOAD COUNTER 2
OUT     42H,AL
MOV     AL,1FH
OUT     42H,AL
```

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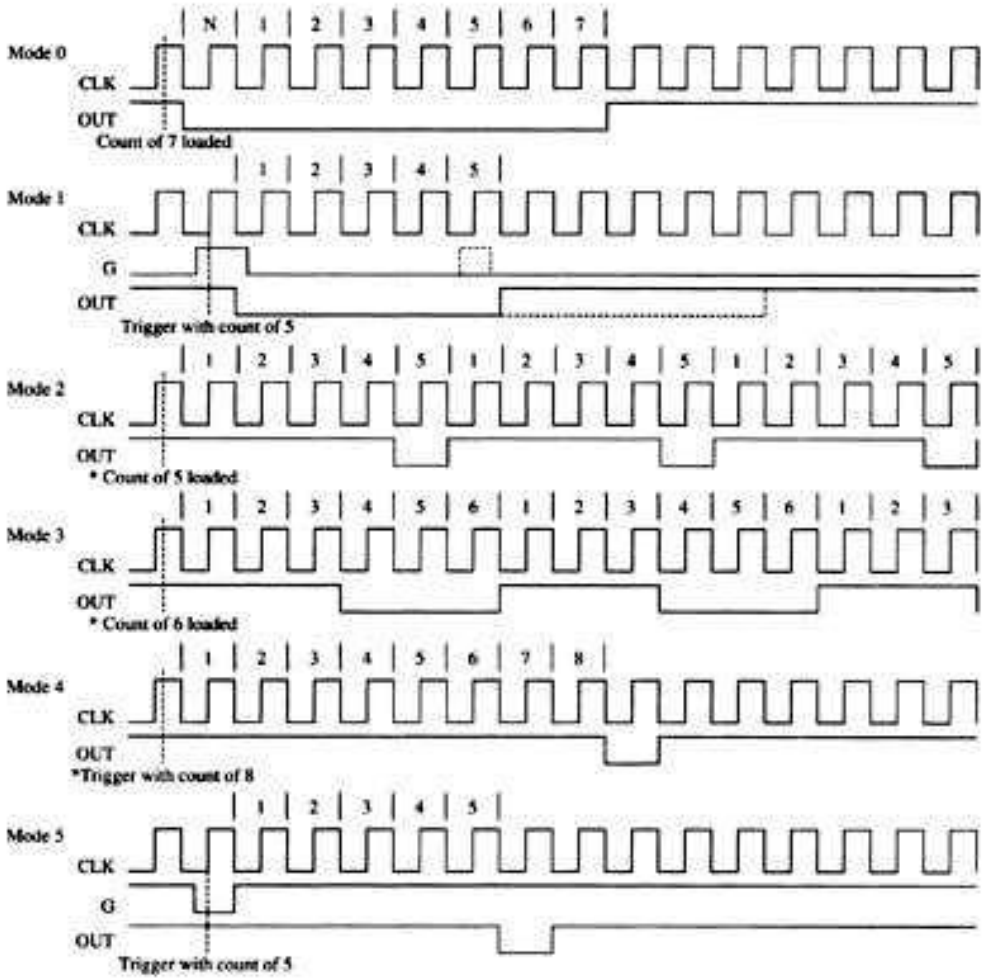
- **Programming the 8254: Modes of Operation**
  - six modes (0–5) of available to each of the 8254 counters
  - each mode functions with the CLK input, the gate (G) control signal, and OUT signal



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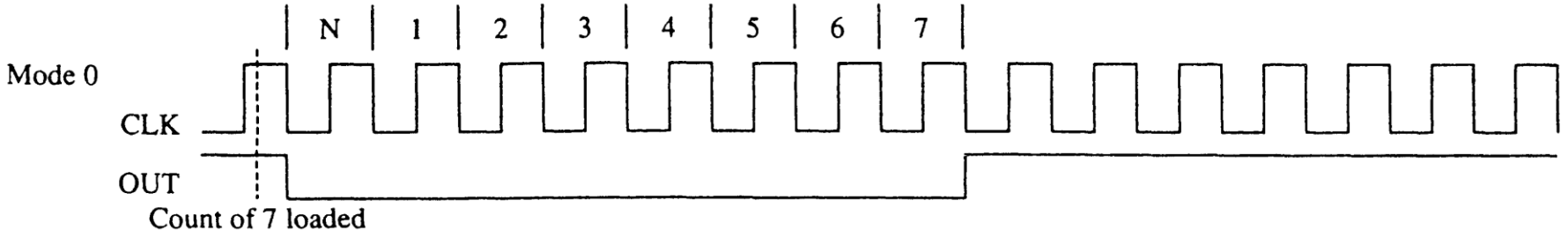
- **Programming the 8254: Modes of Operation, MODE 0**
  - Allows 8254 to be used as an events counter.
  - Output becomes logic 0 when the control word is written and remains until N plus the number of programmed counts.
  - Note that gate (G) input must be logic 1 to allow the counter to count.
  - If G becomes logic 0 in the middle of the count, the counter will stop until G again becomes logic 1.



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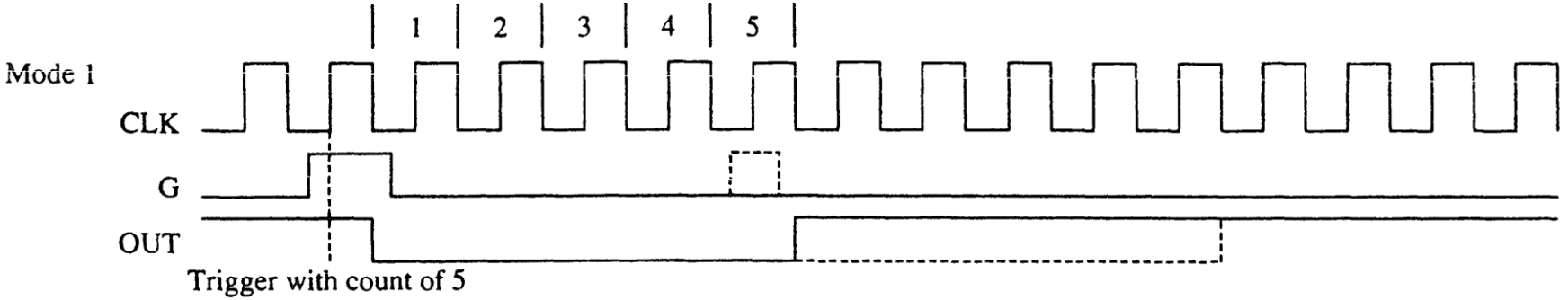
- **Programming the 8254: Modes of Operation, MODE 1**
  - Causes function as a retriggerable, monostable multivibrator (one-shot).
  - G input triggers the counter so it develops a pulse at the OUT connection that becomes logic 0 for the duration of the count.
    - if the count is 10, the OUT connection goes low for 10 clocking periods when triggered
  - If G input occurs within the output pulse, the counter is reloaded and the OUT connection continues for the total length of the count.



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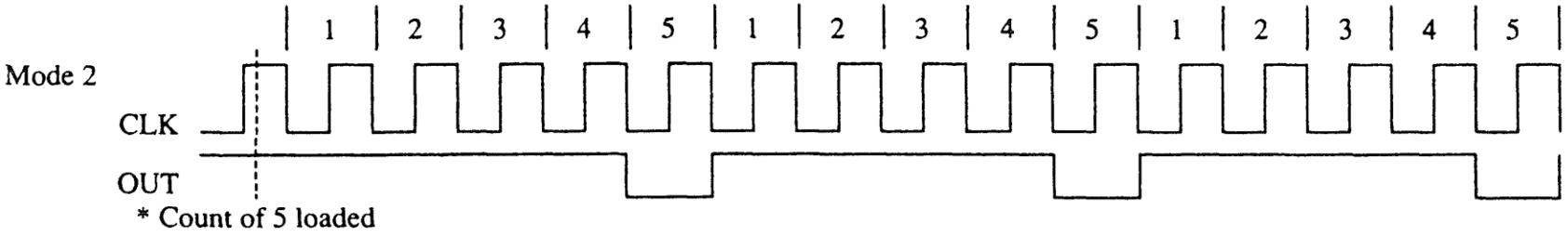
- **Programming the 8254: Modes of Operation, MODE 2**
  - Allows the counter to generate a series of continuous pulses one clock pulse wide.
    - pulse separation is determined by the count
  - For a count of 10, output is logic 1 for nine clock periods and low for one clock period.
  - The cycle is repeated until the counter is programmed with a new count or until the G pin is placed at logic 0.
    - G input must be logic 1 for this mode to generate a continuous series of pulses



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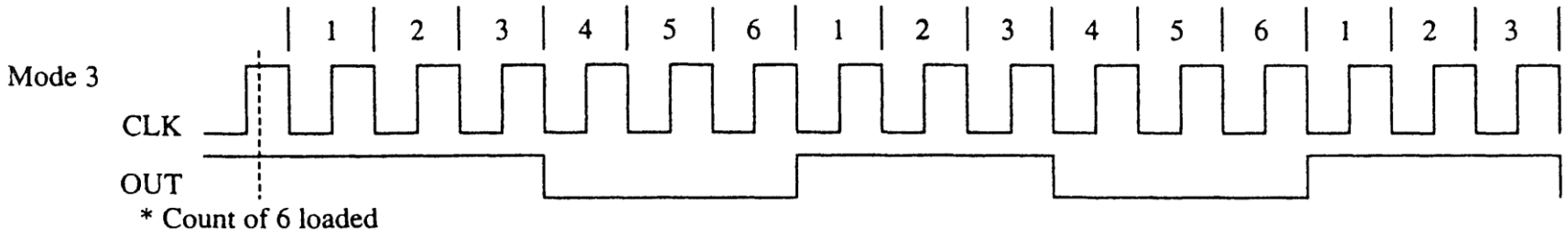
- **Programming the 8254: Modes of Operation, MODE 3**
  - Generates a continuous square wave at the OUT connection, provided the G pin is logic 1.
  - If the count is even, output is high for one half of the count and low for one half of the count.
  - If the count is odd, output is high for one clocking period longer than it is low.
    - if the counter is programmed for a count of 5, the output is high for three clocks and low for two clocks



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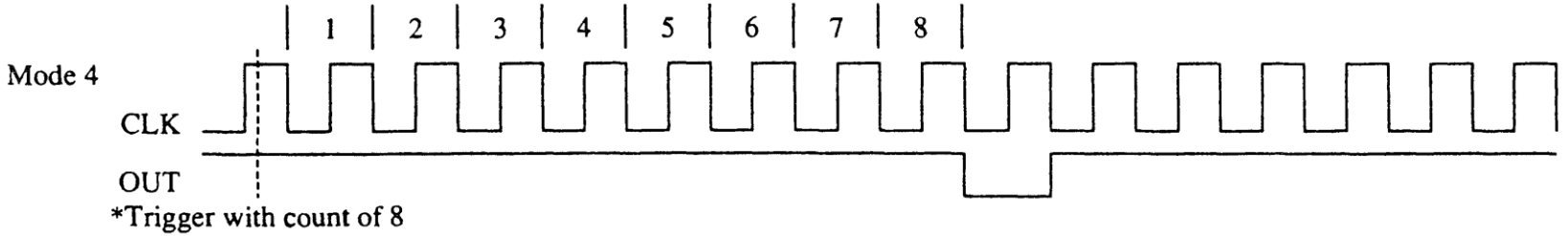
- **Programming the 8254: Modes of Operation, MODE 4**
  - Allows a single pulse at the output.
  - If count is programmed as 10, output is high for 10 clocking periods and low for one period.
    - the cycle does not begin until the counter is loaded with its complete count
  - Operates as a software triggered one-shot.
  - As with modes 2 and 3, this mode also uses the G input to enable the counter.
    - G input must be logic 1 for the counter to operate for these three modes



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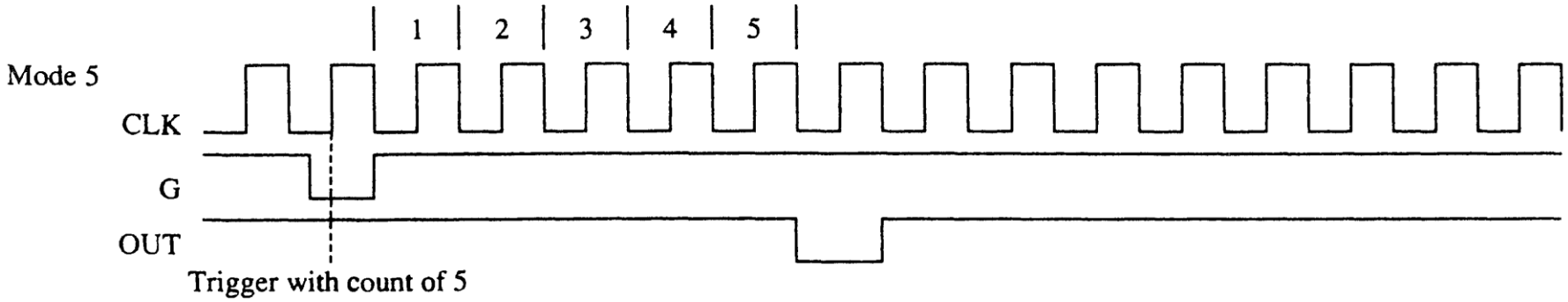
- **Programming the 8254: Modes of Operation, MODE 5**
  - A hardware triggered one-shot that functions as mode 4.
  - except it is started by a trigger pulse on the G pin instead of by software
  - This mode is also similar to mode 1 because it is retriggerable.



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- **Programming the 8254**

Recall example 1…

Counter 0: Binary counter operating in mode 0 with a value of 1234h

- Counter triggered by control word write
- Output goes high after 1234h (4660d) clock cycles

Counter 1: BCD counter operating in mode 2 with a value of 0100h

- Counter triggered by control word write
- Output pulses low (for one clock cycle) every 0100h (translated to BCD is 4 decimal,) clock cycles

Counter 2: Binary counter operating in mode 4 with a value of 1FFFh

- Counter triggered by control word write
- One shot produced after a delay of 1FFFh (=8191d) cycles

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- **Example**

Write a program to initialize counter 2 in mode 0 with a count of C030H. Assume address for control register = 0BH, counter 0 = 08H, counter 1 = 09H and counter 2 = 0AH.

Sol. : Control word

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0		
SC_1	SC_2	RW_1	RW_0	M_2	M_1	M_0	BCD		
1	0	1	1	0	0	0	0	=	B0H

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- **Example**

Source Program

```
    MOV  AL,B0H
    OUT  0BH,AL        ;  Loads  control  word  (B0H)  in  the  control
                       ;  register.
    MOV  AL,30H
    OUT  0AH,AL        ;  Loads  lower  byte  of  (30H)the  count.
    MOV  AL,0C0H
    OUT  0AH,AL        ;  Loads  higher  byte  (C0H)  of  the  count.
```

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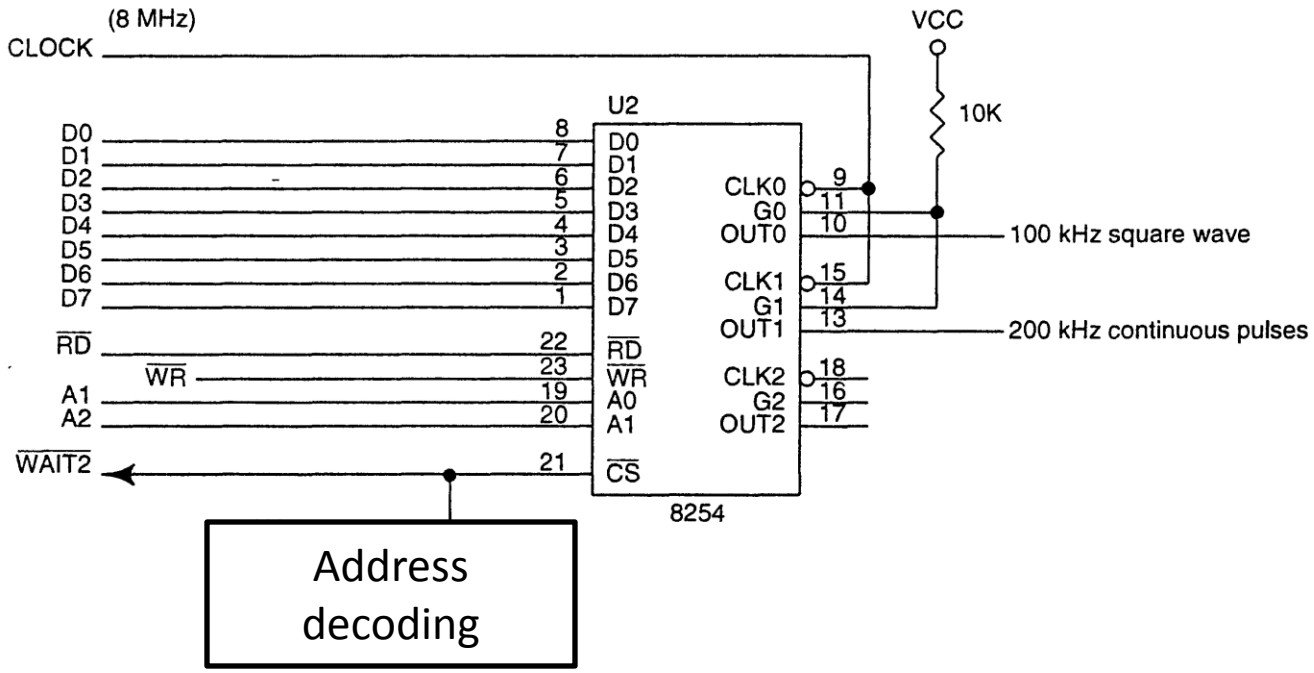
- **Programming the 8254**
  - An 8254 connected to I/O ports 0700H, 0702H, 0704H, and 0706H.



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- **Programming the 8254**
  - To program 100Khz Square wave in out 0 and 200Khz continuous pulse in out 1
    - Input clock is 8 Mhz;
    - G input is pulled up
    - 700H, 702H, 704H and 706H are the four registers for control
  - Find out the counter values for loading
    - 8Mhz/ 100Khz= 80 decimal for counter 0
    - 8Mhz/ 200Khz= 40 decimal for counter 1
  - Find the control words for counters
    - 00110110 for counter 0
    - 0111 0100 for counter 1

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- **Programming the 8254**

```
PUSH   AX                ;save registers
PUSH   DX

MOV    DX,706H           ;address control word
MOV    AL,00110110B      ;program counter 0
OUT    DX,AL             ;for mode 3

MOV    AL,01110100B      ;program counter 1
OUT    DX,AL             ;for mode 2

MOV    DX,700H           ;address counter 0
MOV    AL,80             ;load count of 80
OUT    DX,AL
XOR    AL,AL
OUT    DX,AL

MOV    DX,702H           ;address counter 1
MOV    AL,40             ;load count of 40
OUT    DX,AL
XOR    AL,AL
OUT    DX,AL

POP    DX                ;restore registers
POP    AX
RET
```

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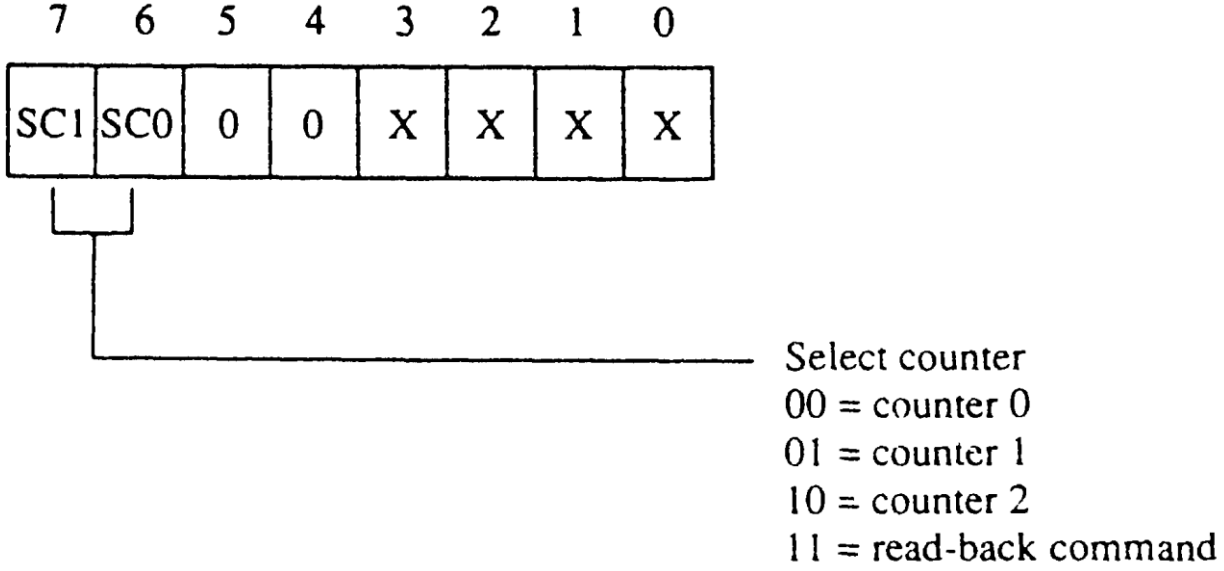
- **Programming the 8254: *Reading a Counter***
  - Each counter has an internal latch read with the read counter port operation.
    - the latches will normally follow the count
  - If counter contents are needed, the latch can remember the count by programming the counter latch control word.
  - counter contents are held in a latch until read



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- **Programming the 8254**

Example - 2

Say we want to read the contents of counter 2 on the fly. The count is to be loaded into the AX register. Assume that the 8254 is located at I/O address 40h

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- **Programming the 8254**

Example – 2, cont'd

First, latch the contents of counter 2, and then its value can be read from a temporary storage register.

```
MOV  AL,10000000b    ;Latch counter 2
OUT  43h,AL
IN   AL,42h          ;Read the lower byte
MOV  BL,AL           ;Store it temporarily
IN   AL,42h
MOV  AH,AL
MOV  AL,BL           ;Counter contents now
                     ;resides in AX
```

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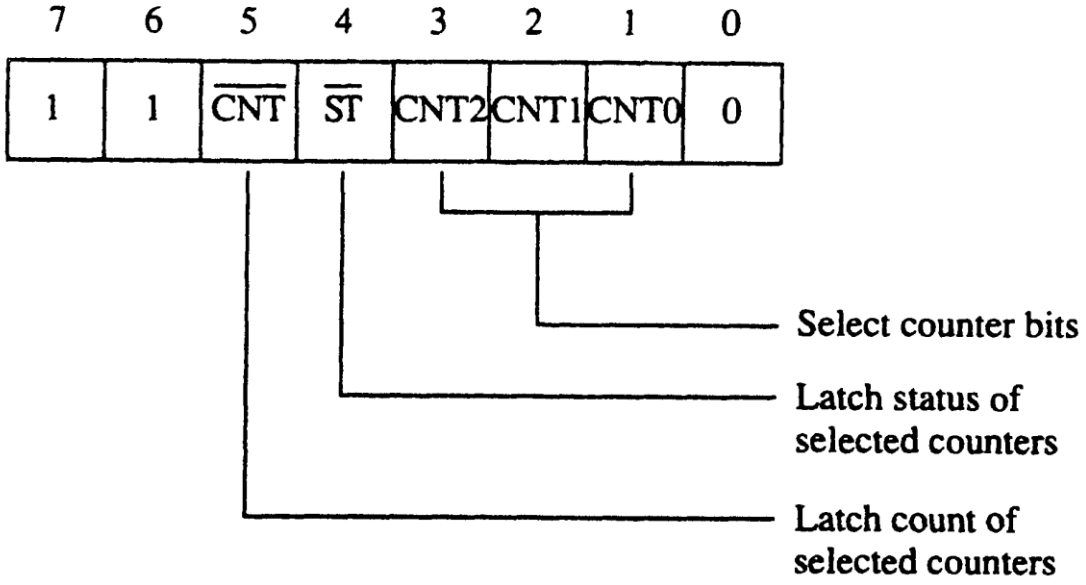
- **Programming the 8254: *Reading a Counter***
  - When a read from the latch or counter is programmed, the latch tracks the contents.
  - When necessary for contents of more than one counter to be read at the same time, the read-back control word is used



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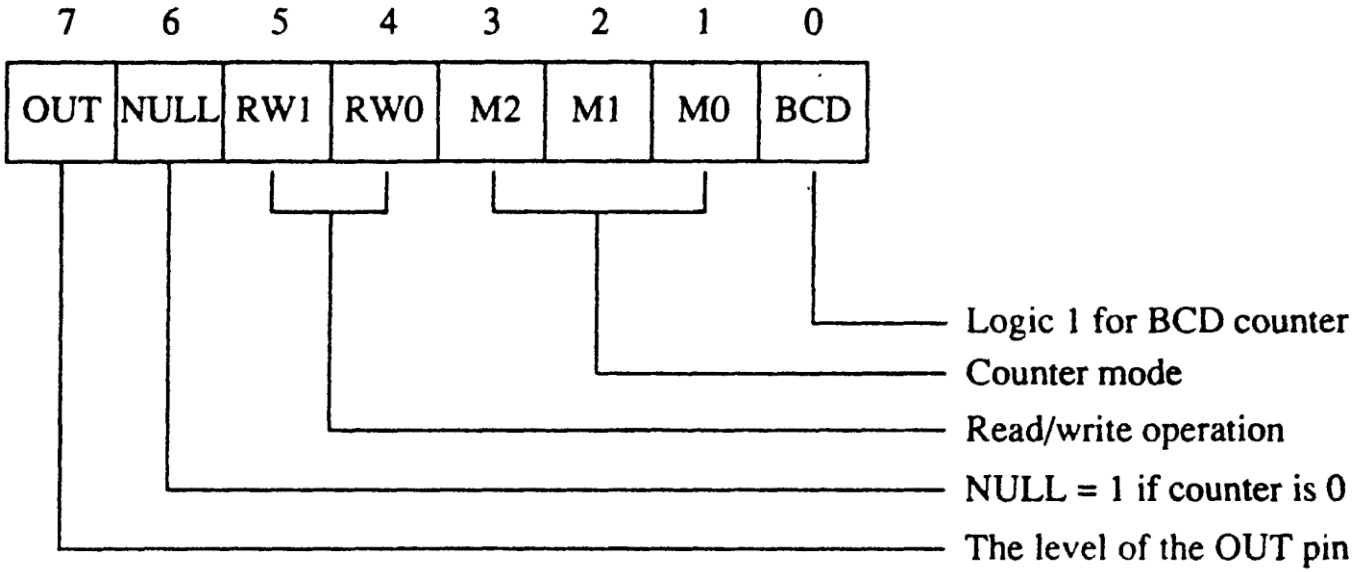
- **Programming the 8254: *Reading a Counter***
  - With the read-back control word, the CNT bit is logic 0 to cause the counters selected by CNT0, CNT1, and CNT2 to be latched.
  - If the status register is to be latched, then the ST bit is placed at logic 0.
  - the status register, which shows: