

### Description

The  $\mu$ PD71059 is a low-power CMOS programmable interrupt control unit for microcomputer systems. It can process eight interrupt request inputs, allocating a priority level to each one. It transfers the interrupt with the highest priority to the CPU, along with interrupt address information. By cascading up to eight slave  $\mu$ PD71059s to a master  $\mu$ PD71059, a system can process up to 64 interrupt requests. System scale, interrupt routine address, interrupt request priority, and masking are all under complete program control.

### Features

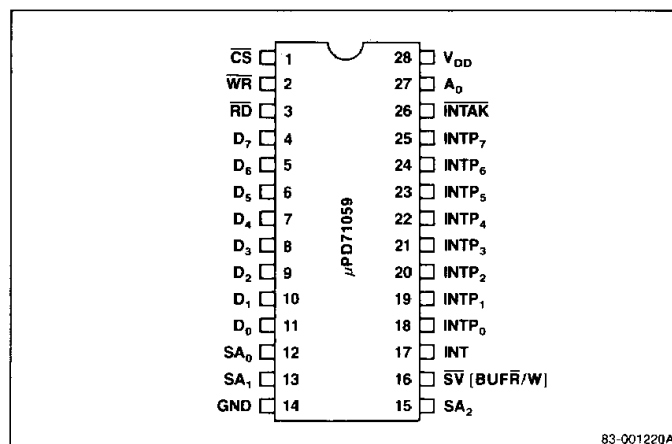
- ☐  $\mu$ PD8085A compatible (CALL mode)
- ☐  $\mu$ PD70108/70116 compatible (vector mode)
- ☐ Eight interrupt request inputs per chip
- ☐ Up to 64 interrupt request inputs per system (extended mode)
- ☐ Edge- or level-triggered interrupt request inputs
- ☐ Each interrupt maskable
- ☐ Programmable priority level
- ☐ Polling operation
- ☐ Single +5 V  $\pm 10\%$  power supply
- ☐ Industrial temperature range:  $-40$  to  $+85^\circ\text{C}$
- ☐ CMOS technology
- ☐ 8 MHz and 10 MHz

### Ordering Information

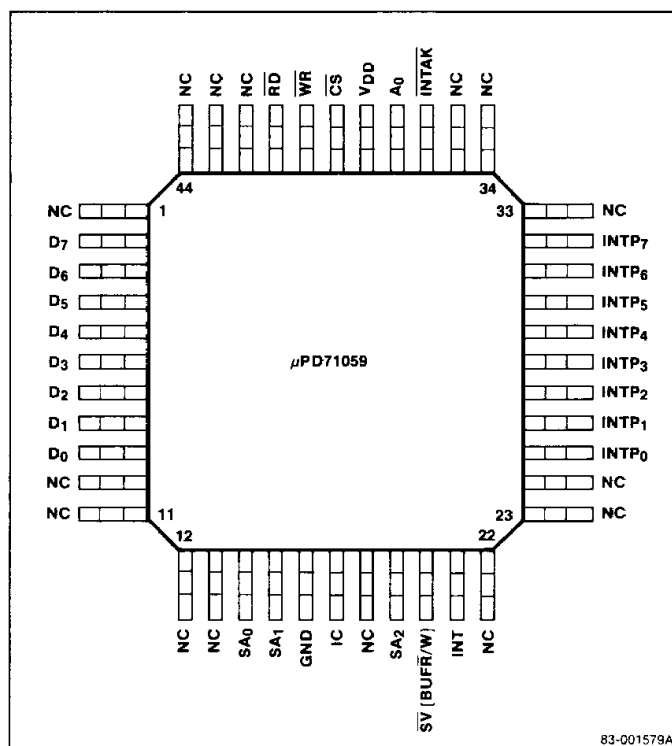
Part Number	Package
$\mu$ PD71059C-8	28-pin plastic DIP (600 mil)
C-10	
G-8	44-pin plastic QFP (P44G-80-22)
GB-8	44-pin plastic QFP (P44GB-80-3B4)
GB-10	
L-8	28-pin PLCC
L-10	

### Pin Configurations

#### 28-Pin Plastic DIP



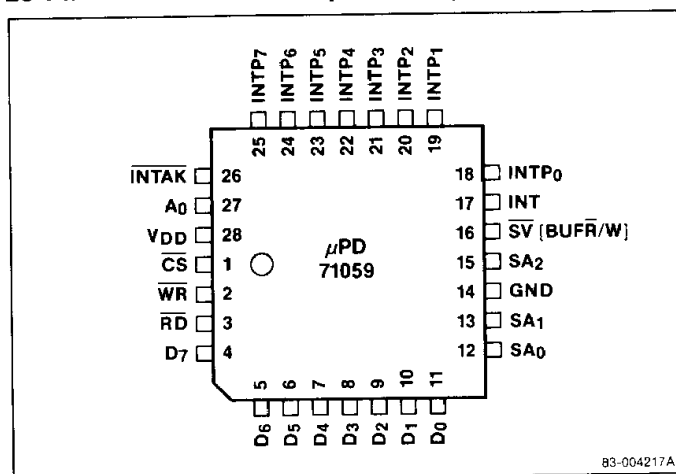
#### 44-Pin Plastic QFP



## μPD71059

### Pin Configurations (cont)

#### 28-Pin Plastic Leaded Chip Carrier (PLCC)



### Pin Identification

Symbol	Function
D <sub>7</sub> -D <sub>0</sub>	Data bus I/O
SA <sub>2</sub> -SA <sub>0</sub>	Slave address I/O, bits 2, 1, 0
GND	Ground potential
IC	Internally connected
SV (BUFR/W)	Slave (Buffer read write) I/O
INT	Interrupt output
INTP <sub>0</sub> -INTP <sub>7</sub>	Interrupt inputs
INTAK	Interrupt acknowledge input
A <sub>0</sub>	Address input
V <sub>DD</sub>	Power supply
CS	Chip select input
WR	Write strobe input
RD	Read strobe input
NC	Not connected

### Pin Functions

#### D<sub>7</sub>-D<sub>0</sub> [Data Bus]

The 8-bit 3-state bidirectional bus transfers data to and from the CPU through the system bus. The data bus becomes active when data is sent to the CPU in the  $\overline{\text{INTAK}}$  sequence. Otherwise, the data bus is high impedance.

#### $\overline{\text{CS}}$ [Chip Select]

The CPU uses the μPD71059's  $\overline{\text{CS}}$  input to select a μPD71059 to read from (IN instructions) or write to (OUT instructions). The  $\overline{\text{RD}}$  and  $\overline{\text{WR}}$  signals to the μPD71059 are enabled when  $\overline{\text{CS}}$  is low.  $\overline{\text{CS}}$  is not used for the INTAK sequence.

#### $\overline{\text{RD}}$ [Read Strobe]

The CPU sets the  $\overline{\text{RD}}$  input to 0 when reading the internal registers IMR, IRR and ISR, and during polling operations to read polling data.

#### $\overline{\text{WR}}$ [Write Strobe]

The CPU sets the  $\overline{\text{WR}}$  input to 0 when writing initializing words IW1-IW4 and command words IMW, PFCW and MCW.

#### A<sub>0</sub> [Address]

The A<sub>0</sub> input is used with  $\overline{\text{CS}}$ ,  $\overline{\text{RD}}$ , and  $\overline{\text{WR}}$  to read or write to the μPD71059. Normally, A<sub>0</sub> is connected to A<sub>0</sub> of the address bus. Table 1 shows the relationship between read/write operations and the control signals ( $\overline{\text{CS}}$ ,  $\overline{\text{WR}}$ ,  $\overline{\text{RD}}$ , and A<sub>0</sub>).

#### INTP<sub>7</sub>-INTP<sub>0</sub> [Interrupt Request from Peripheral]

INTP<sub>7</sub>-INTP<sub>0</sub> are eight asynchronous interrupt request inputs. They can be set to be either edge- or level-triggered. These pins are pulled up by an internal resistance. Their power consumption is lower at high-level input than at low-level input.

#### INT [Interrupt]

INT is the interrupt request output from a μPD71059 to the CPU or master μPD71059. When an interrupt from a peripheral is input to an INTP pin and acknowledged, the μPD71059 asserts INT high to generate an interrupt request at the CPU or master μPD71059.

## **$\overline{\text{INTAK}}$ [Interrupt Acknowledge]**

The  $\overline{\text{INTAK}}$  input from the CPU acknowledges an interrupt from the μPD71059. After acknowledging the interrupt request, the CPU returns three low-level pulses (μPD8085) or two low-level pulses (μPD70108/70116). Synchronizing to these pulses, the μPD71059 sends a CALL instruction in three bytes, or an interrupt vector number in one byte through the data bus.

## **$\overline{\text{SV}}$ [BUFR/W] [Slave, Buffer Read/Write]**

This pin has two functions. When no external buffer is used in the data bus, it is the  $\overline{\text{SV}}$  input. When  $\overline{\text{SV}}$  is low, the μPD71059 acts as a slave. It operates as a master when  $\overline{\text{SV}}$  is high.  $\overline{\text{SV}}$  has no master/slave meaning when the μPD71059 is set to single mode.

As the BUFR/W output, this pin can allow a bus transceiver to be controlled by the μPD71059, if one is required. When the μPD71059 changes its data bus to output, it sets BUFR/W low. It sets BUFR/W high when the data bus changes to input.

## **SA<sub>2</sub>-SA<sub>0</sub> [Slave Address]**

These pins are only used in systems with cascaded μPD71059s. The master μPD71059 uses these pins to address up to eight slave μPD71059s. These pins are output pins for masters, and input pins for slaves.

**Note:** In the single mode, SA<sub>2</sub>-SA<sub>0</sub> are output pins, but the output data has no meaning.

## **V<sub>DD</sub> [Power Supply]**

This is the positive power supply.

## **GND [Ground]**

This is the ground potential.

## **IC [Internally Connected]**

This pin must be left unconnected.

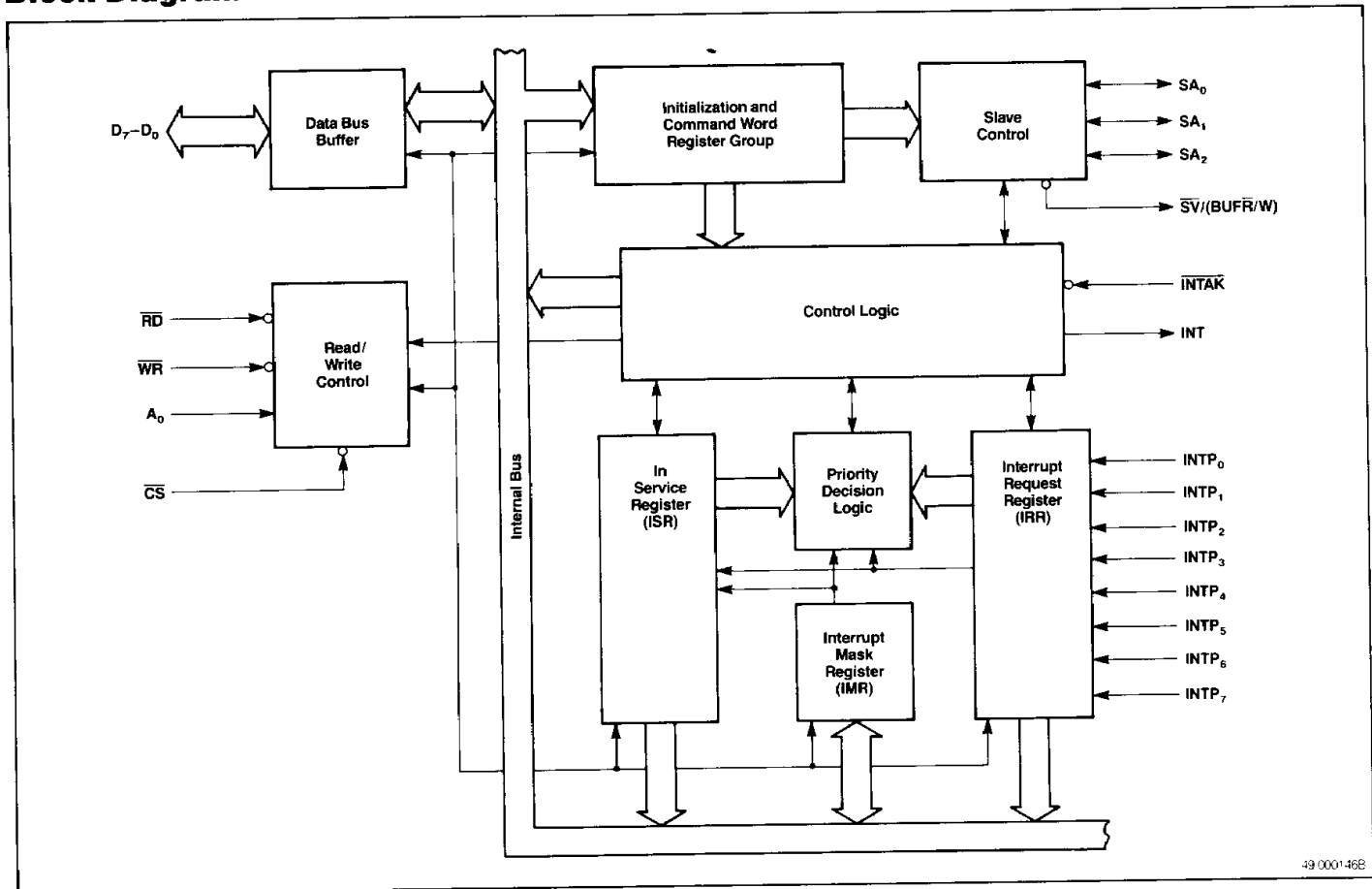
**Table 1. Read/Write Operations**

$\overline{\text{CS}}$	$\overline{\text{RD}}$	$\overline{\text{WR}}$	A <sub>0</sub>	Other Conditions	μPD71059 Operation	CPU Operation
0	0	1	0	IRR set by MCW	IRR to Data bus	IRR read
				ISR set by MCW	ISR to Data bus	ISR read
				Polling phase (Note 1)	Polling data to Data bus	Polling
0	0	1	1		IMR to Data bus	IMR read
0	1	0	0	D <sub>4</sub> = 1	Data bus to IW1 register	IW1 write
				D <sub>4</sub> , D <sub>3</sub> = 0	Data bus to PFCW register	PFCW write
				D <sub>4</sub> = 0, D <sub>3</sub> = 1	Data bus to MCW register	MCW write
0	1	0	1	(Note 2)	Data bus to IW2 register	IW2 write
					Data bus to IW3 register	IW3 write
					Data bus to IW4 register	IW4 write
				After initializing	Data bus to IMR	IMW write
0	1	1	x		Data bus high impedance	
1	x	x	x			
0	0	0	x		Illegal	

**Note:**

(1) In the polling phase, polling data is read instead of IRR and ISR.

(2) Refer to Control Words section for IW2-IW4 writing procedure.

**Block Diagram****Block Diagram Functions****Data Bus Buffer**

The data bus buffer is a buffer between D<sub>7</sub>-D<sub>0</sub> and the μPD71059's internal bus.

**Read/Write Control**

The read/write control controls the CPU's reading and writing to and from the μPD71059 registers.

**Initialization and Command Word Registers**

These registers store initializing words IW1-IW4 and command words PFCW (priority and finish control word) and MCW (mode control word). The CPU cannot read these registers.

**Interrupt Mask Register [IMR]**

The interrupt mask register stores the interrupt mask word (IMW) command word. Each bit masks an interrupt. If bit *n* of this register is 1, the interrupt request INTP<sub>*n*</sub> is masked and cannot be accepted by the μPD71059. The CPU can read this register by performing an IN instruction with A<sub>0</sub> = 1.

**Interrupt Request Register [IRR]**

The interrupt request register shows which interrupt levels are currently being requested. If bit *n* of the IRR is 1, INTP<sub>*n*</sub> is requesting an interrupt. The CPU can read this register.

**In-Service Register [ISR]**

The in-service register shows all interrupt levels currently in service. If bit *n* of this register is 1, the interrupt routine corresponding to INTP<sub>*n*</sub> is currently being executed. The CPU can read this register.

**Slave Control**

Slave control is used in systems with cascaded μPD71059s. A master μPD71059 uses it to control slave μPD71059s, and a slave uses it to interface with the master μPD71059.

**Control Logic**

The control logic receives and generates the signals that control the sequence of events in an interrupt.

## Priority Decision Logic

The priority decision logic determines which interrupt request from the IRR will be serviced next. The decision is made based upon the current interrupt mask, interrupt service status, mode status, and current priority.

## Absolute Maximum Ratings

$T_A = 25^\circ\text{C}$

Power supply voltage, $V_{DD}$	-0.5 to +7.0 V
Input voltage, $V_I$	-0.5 to $V_{DD} + 0.3$ V
Output voltage, $V_O$	-0.5 to $V_{DD} + 0.3$ V
Power dissipation, $PD_{MAX}$	500 mW
Operating temperature, $T_{opt}$	-40 to +85°C
Storage temperature, $T_{stg}$	-65 to +150°C

**Comment:** Exposing the device to stresses above those listed in the absolute maximum ratings could cause permanent damage. The device is not meant to be operated under conditions outside the limits described in the operational section of this specification. Exposure to absolute maximum ratings for extended periods may affect device reliability.

## Capacitance

$T_A = 25^\circ\text{C}$ ;  $V_{DD} = \text{GND} = 0$  V

Parameter	Symbol	Limits			Unit	Test Conditions
		Min	Typ	Max		
Input capacitance	$C_I$			10	pF	$f_c = 1$ MHz
I/O capacitance	$C_{IO}$			20	pF	Unmeasured pins returned to 0 V

## DC Characteristics

$T_A = -40$  to  $+85^\circ\text{C}$ ;  $V_{DD} = 5$  V  $\pm 10\%$

Parameter	Symbol	Limits			Unit	Test Conditions
		Min	Typ	Max		
Input voltage, high	$V_{IH}$	2.2		$V_{DD} + 0.3$	V	
Input voltage, low	$V_{IL}$	-0.5		0.8	V	
Output voltage, high	$V_{OH}$	$0.7 \times V_{DD}$			V	$I_{OH} = -400 \mu\text{A}$
Output voltage, low	$V_{OL}$		0.4		V	$I_{OL} = 2.5$ mA
Input leakage current, high	$I_{LH}$			10	$\mu\text{A}$	$V_I = V_{DD}$
Input leakage current, low	$I_{LL}$			-10	$\mu\text{A}$	$V_I = 0$ V
Output leakage current, high	$I_{LOH}$			10	$\mu\text{A}$	$V_O = V_{DD}$
Output leakage current, low	$I_{LOL}$			-10	$\mu\text{A}$	$V_O = 0$ V
INTP input leakage current, high	$I_{LIPH}$			10	$\mu\text{A}$	$V_I = V_{DD}$
INTP input leakage current, low	$I_{LIPL}$			-300	$\mu\text{A}$	$V_I = 0$ V
Supply current (dynamic)						
	$\mu\text{PD71059}$		$I_{DD1}$	3.5	9	mA
	$\mu\text{PD71059-10}$		$I_{DD1}$	4	9	mA
Supply current (power down mode)			$I_{DD2}$	2	50	$\mu\text{A}$
						Input pins: $V_{IH} = V_{DD} - 0.1$ V $V_{IL} = 0.1$ V Output pins: open (Note 1)

### Notes:

(1) In power down mode,  $\text{INTP}_0$ - $\text{INTP}_7$ ,  $\overline{\text{INTAK}}$ , and  $\overline{\text{CS}}$  must be at high level ( $V_{IH} = V_{DD} - 0.1$  V).

### AC Characteristics

$T_A = -40$  to  $+85$  °C;  $V_{DD} \pm 5$  V  $\pm 10\%$

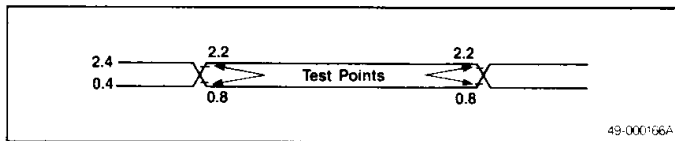
TA = -40 to +85 °C, VDD ± 0.5 V ± 10 %							
Parameter	Symbol	8 MHz Limits ~		10 MHz Limits		Unit	Test Conditions
		Min	Max	Min	Max		
Read Timing							
A0, CS setup to RD ↓	tSAR	0		0		ns	
A0, CS hold from RD ↑	tHRA	0		0		ns	
RD pulse width low	tRRL	160		120		ns	
RD pulse width high	tRRH	120		90		ns	
Data delay from RD ↓	tDRD		120		95	ns	CL = 150 pF
Data float from RD ↑	tFRD	10	85	10	60	ns	CL = 100 pF
Data delay from A0, CS	tDAD		200		120	ns	CL = 150 pF
BUFR/W delay from RD ↓	tDRBL		100		80	ns	
BUFR/W delay from RD ↑	tDRBH		150		100	ns	
Write Timing							
A0, CS setup to WR ↓	tSAW	0		0		ns	
A0, CS hold from WR ↑	tHWA	0		0		ns	
WR pulse width low	tWWL	120		100		ns	
WR pulse width high	tWWH	120		90		ns	
Data setup from WR ↑	tSDW	120		100		ns	
Data hold from WR ↑	tHWD	0		0		ns	
Interrupt Timing							
INTP pulse width	tIPIPL	100		80		ns	(Note 1)
SA setup to second, third INTAK ↓	tSSIA	40		40		ns	Slave
INTAK pulse width low	tIAIAL	160		120		ns	
INTAK pulse width high	tIAIAH	120		90		ns	INTAK Sequence
INT delay from INTP ↑	tDIPI		300		200	ns	CL = 150 pF
SA delay from first INTAK ↓	tDIAS		360		250	ns	Master, CL = 150 pF
Data delay from INTAK ↓	tDIAD		120		95	ns	CL = 150 pF
Data float from INTAK ↑	tFIAD	10	85	10	60	ns	
Data delay from SA	tDSD		200		150	ns	Slave, CL = 150 pF
BUFR/W delay from INTAK ↓	tDIABL		100		80	ns	CL = 150 pF
BUFR/W delay from INTAK ↑	tDIABH		150		100	ns	
Other Timing							
Command recovery time	tRV1	120		90		ns	(Note 2)
INTAK recovery time	tRV2	250		90		ns	(Note 3)
INTAK/command recovery time	tRV3	250		90		ns	(Note 4)

#### Notes:

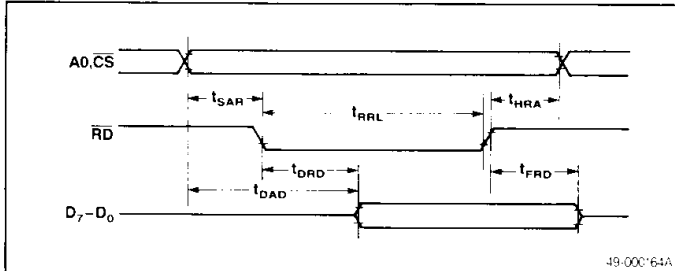
- (1) The time to clear the input latch in edge-trigger mode.
- (2) The time to move from read to write operation.
- (3) The time to move to the next  $\overline{INTAK}$  operation.
- (4) The time to move  $\overline{INTAK}$  to/from command (read/write).

## Timing Waveforms

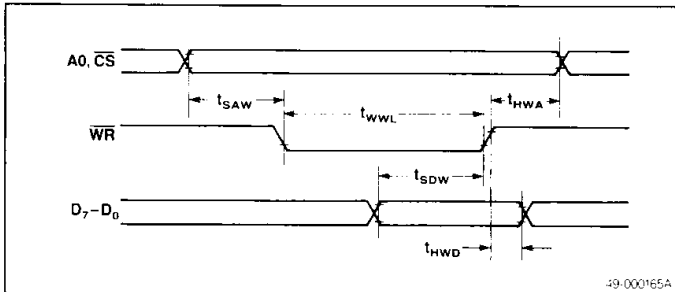
### AC Test Input/Output Waveform



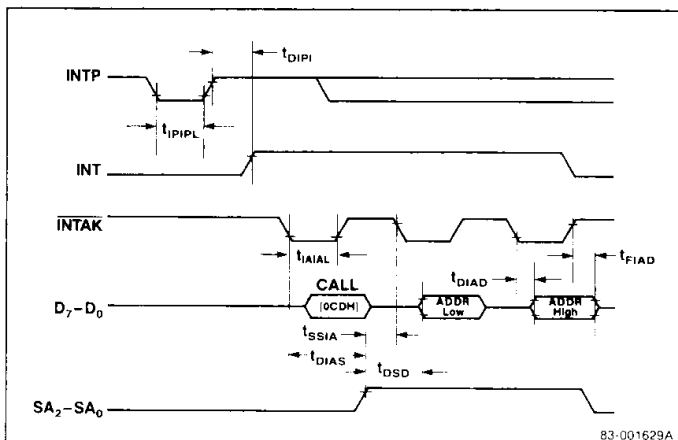
### Read Cycle



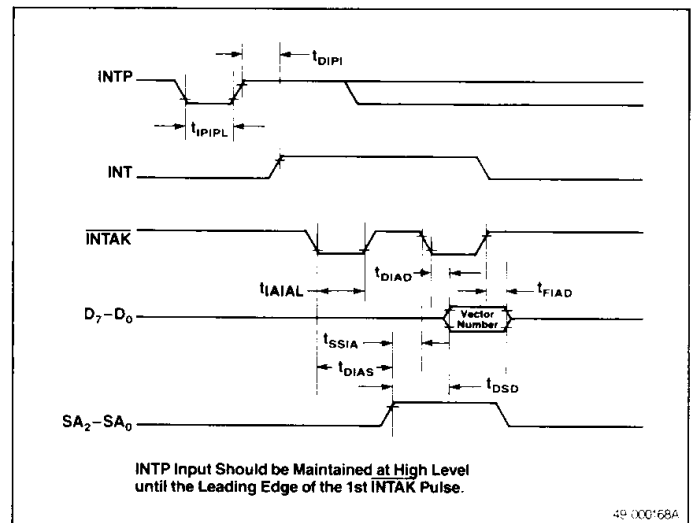
### Write Cycle



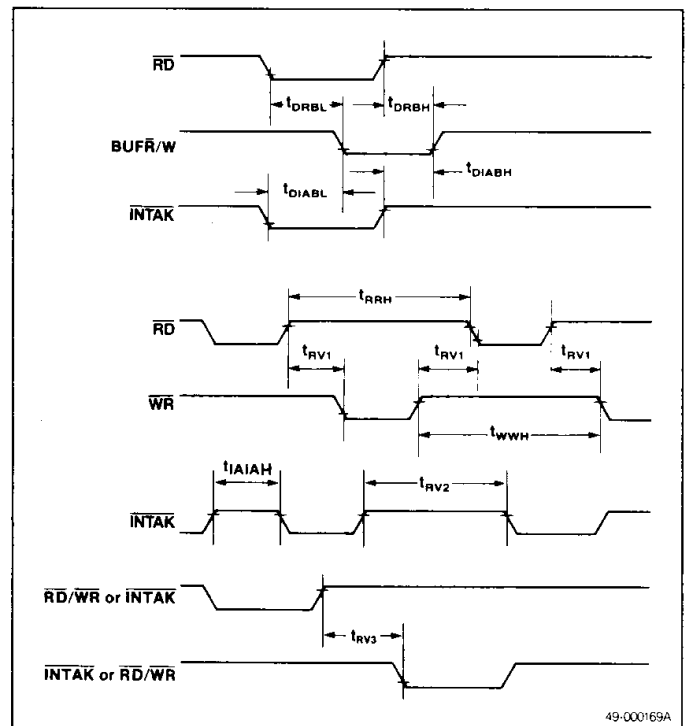
### INTAK Sequence (CALL Mode)



### INTAK Sequence (Vector Mode)



### Other Timing



### Interrupt Operation

Almost all microcomputer systems use interrupts to reduce software overhead when controlling peripherals. However, the number of interrupt pins on a CPU is limited. When the number of interrupt lines increases beyond that limit, external circuits like the μPD71059 become necessary.

The μPD71059 can process eight interrupt request according to an allocated priority order and transmit the signal with the highest priority to the CPU. It also supplies the CPU with information to ascertain the interrupt routine start address. Cascading μPD71059s by connecting up to eight "slave" μPD71059s to a single "master" μPD71059 permits expansion to up to a maximum of 64 interrupt request signals.

Interrupt system scale (master/slave), interrupt routine addresses, interrupt request priority, and interrupt request masking are all programmable, and can be set by the CPU.

Normal interrupt operation for a single μPD71059 is as follows. First, the initialization registers are set with a sequence of initialization words. When the μPD71059 detects an interrupt request from a peripheral to an INT<sub>P</sub> pin it sets the corresponding bit of the interrupt request register (IRR). The interrupt is checked against the interrupt mask register (IMR) and the interrupt service register (ISR). If the interrupt is not masked and there is no other interrupt with a higher priority in service or requesting service, it generates an INT signal to the CPU.

The CPU acknowledges the interrupt by bringing the INT<sub>AK</sub> line low. The μPD71059 then outputs interrupt CALL or vector data onto the data bus in response to INT<sub>AK</sub> pulses. During the last INT<sub>AK</sub> pulse, the μPD71059 sets the corresponding bit in its ISR to indicate that this interrupt is in service and to disable interrupts with lower priority. It resets the bit in the IRR at this point. When the CPU has finished processing the interrupt, it will inform the μPD71059 by sending a finish interrupt (FI) command. This resets the bit in the ISR and allows the μPD71059 to accept interrupts with lower priorities. If the μPD71059 is in the self-FI mode, the ISR bit is reset automatically and this step is not necessary.

### Software Features

The μPD71059 has the following software features:

- Interrupt types: CALL/vector
- Interrupt masking: Normal/extended nesting
- End of interrupt: Self-FI/normal FI/  
specific FI
- Priority rotation: Normal nested/extended  
nested/exceptional nested  
Automatic priority rotation  
Rotate to specific priority
- Polled mode
- CPU-readable registers

### Hardware Configurations

The μPD71059 has the following hardware configurations:

- Interrupt input: Edge/level sensitive
- Cascading μPD71059s: Single/extended  
(master/slave)
- Output driver control: Buffered/non-buffered

### Mode Control

These features and configurations are selected and controlled by the four initialization words (IW1-IW4) and the three command words (IMW, PFCW, and MCW). The format of these words are shown in figures 2 and 3, respectively.

### Control Words

There are two types of μPD71059 control words: initialization words and command words.

There are four initialization words: IW1-IW4. These words must be written to the μPD71059 at least once to initialize it. They must be written in sequence.

There are three types of command words: interrupt mask word (IMW), priority and finish control word (PFCW), and the mode control word (MCW). These words can be written freely after initialization.



## Initialization Words

**Initialization sequence.** When data is written to a μPD71059 after setting  $A_0 = 0$  and  $D_4 = 1$ , data is always accepted as IW1. This results in a default initialization as shown below. See figure 1.

- (1) The edge-trigger circuit of the INTP input is reset. IRR is cleared in the edge-trigger mode.
- (2) ISR and IMR are cleared.
- (3) INTP<sub>7</sub> receives the lowest priority; INTP<sub>0</sub> receives the highest.
- (4) The exceptional nesting mode is released. IRR is set as the register to be read.
- (5) Register IW4 is cleared. The normal nesting mode, non-buffer mode, FI command mode, and CALL mode are set.

**Initialization Words.** The initialization words are written consecutively, and in order. The first two, IW1 and IW2, set the interrupt address or vector. IW3 specifies which interrupts are slaves for master systems, and defines the slave number of a slave system. Therefore, IW3 is only required in extended systems. The μPD71059 will only expect it if bit D<sub>1</sub> of IW1, SNGL = 0. IW4 is only written if bit D<sub>0</sub> of IW1, I4 = 1. See figure 2 for the format of the initialization words.

## Command Words

The command words give various commands to a μPD71059 during its operation to change interrupt masks and priorities, to end interrupt processing, etc. See figure 3.

**IMW [Interrupt Mask Word].** This word masks the IRR and disables the corresponding INTP interrupt requests. It also masks the ISR in the exceptional nesting mode. Bits M<sub>7</sub>-M<sub>0</sub> correspond to the interrupt levels of INTP<sub>7</sub>-INTP<sub>0</sub>, respectively.

In the exceptional nesting mode, interrupts corresponding to the bits of IRR and ISR are masked if the M<sub>n</sub> bit is set to 1.

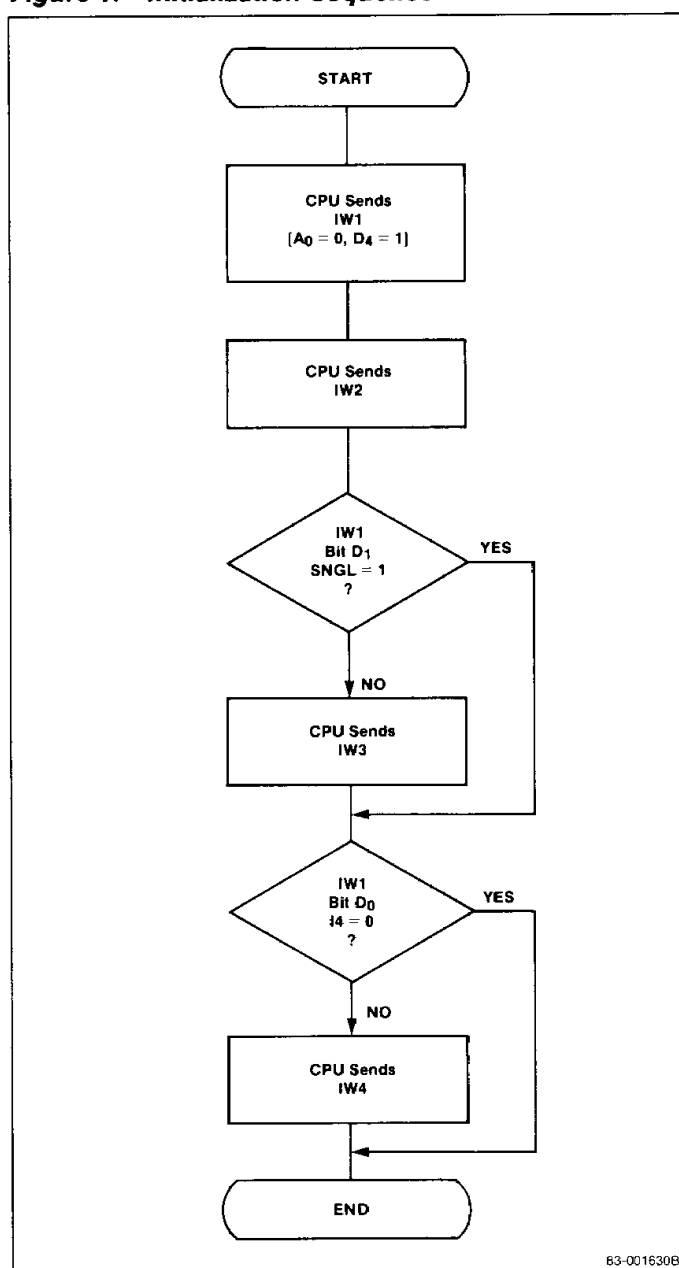
**PFCW [Priority and Finish Control Word].** This word sets the FI (finish interrupt) command that defines the way that interrupts are ended, and the commands that change interrupt request priorities.

When RP (rotate priority) is set to 1, the priorities of the interrupt requests change (rotate). The priority order of the 8 INTP pins is as shown in figure 4. Setting a level as the lowest priority sets all the other levels correspondingly. For example, if INTP<sub>3</sub> is the lowest priority, INTP<sub>4</sub> will be the highest. (INTP<sub>7</sub> has the lowest priority after initialization).

SIL (specify interrupt level) is set to 1 to change the priority order or designate an interrupt level. It is used with the RP and FI bits (bits D<sub>7</sub> and D<sub>5</sub>). When SIL = 1 and RP or FI = 1, the level identified by IL<sub>2</sub>-IL<sub>0</sub> is designated as the lowest priority level. The other priorities will be set correspondingly. When used with FI = 1, it resets the ISR bit corresponding to the interrupt level IL<sub>2</sub>-IL<sub>0</sub>.

**MCW [Mode Control Word].** This word is used to set the exceptional nesting mode, to poll the μPD71059, and to read the ISR and IRR registers.

**Figure 1. Initialization Sequence**



Bits SR and IS/ $\overline{IR}$  are used to read the contents of the IRR and ISR registers. When SR = 0, no operation is performed. To read IRR or ISR, set  $A_0 = 0$  and select the IRR or ISR register by writing to MCW. To select the IRR register, write MCW with SR = 1 and IS/ $\overline{IR}$  = 0. To select the ISR, write MCW with SR = 1 and IS/ $\overline{IR}$  = 1. The selection is retained, and MCW does not have to be rewritten to read the same register again. IRR and ISR are not masked by the IMR.

Figure 2. Initialization Word Formats (Sheet 1 of 2)

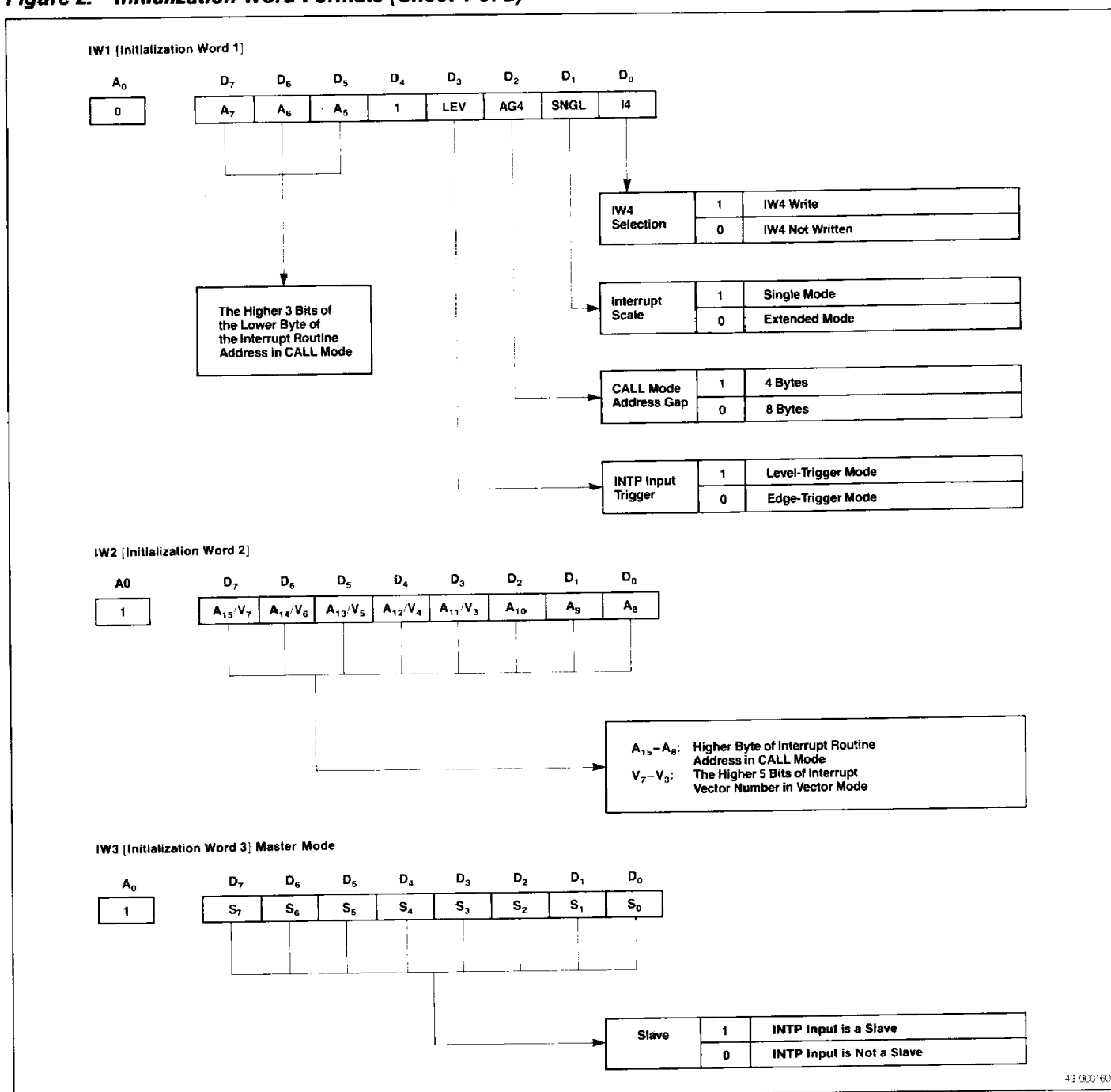


Figure 2. Initialization Word Formats (Sheet 2 of 2)

IW3 [Initialization Word 3] Slave Mode

A <sub>0</sub>	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
1	0	0	0	0	0	SN <sub>2</sub>	SN <sub>1</sub>	SN <sub>0</sub>

Slave Number	0	0	0	0
	0	0	1	1
	0	1	0	2
	0	1	1	3
	1	0	0	4
	1	0	1	5
	1	1	0	6
	1	1	1	7

IW4 [Initialization Word 4]

A <sub>0</sub>	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
1	0	0	0	EXTN	BUF	BSV	SFI	V/C

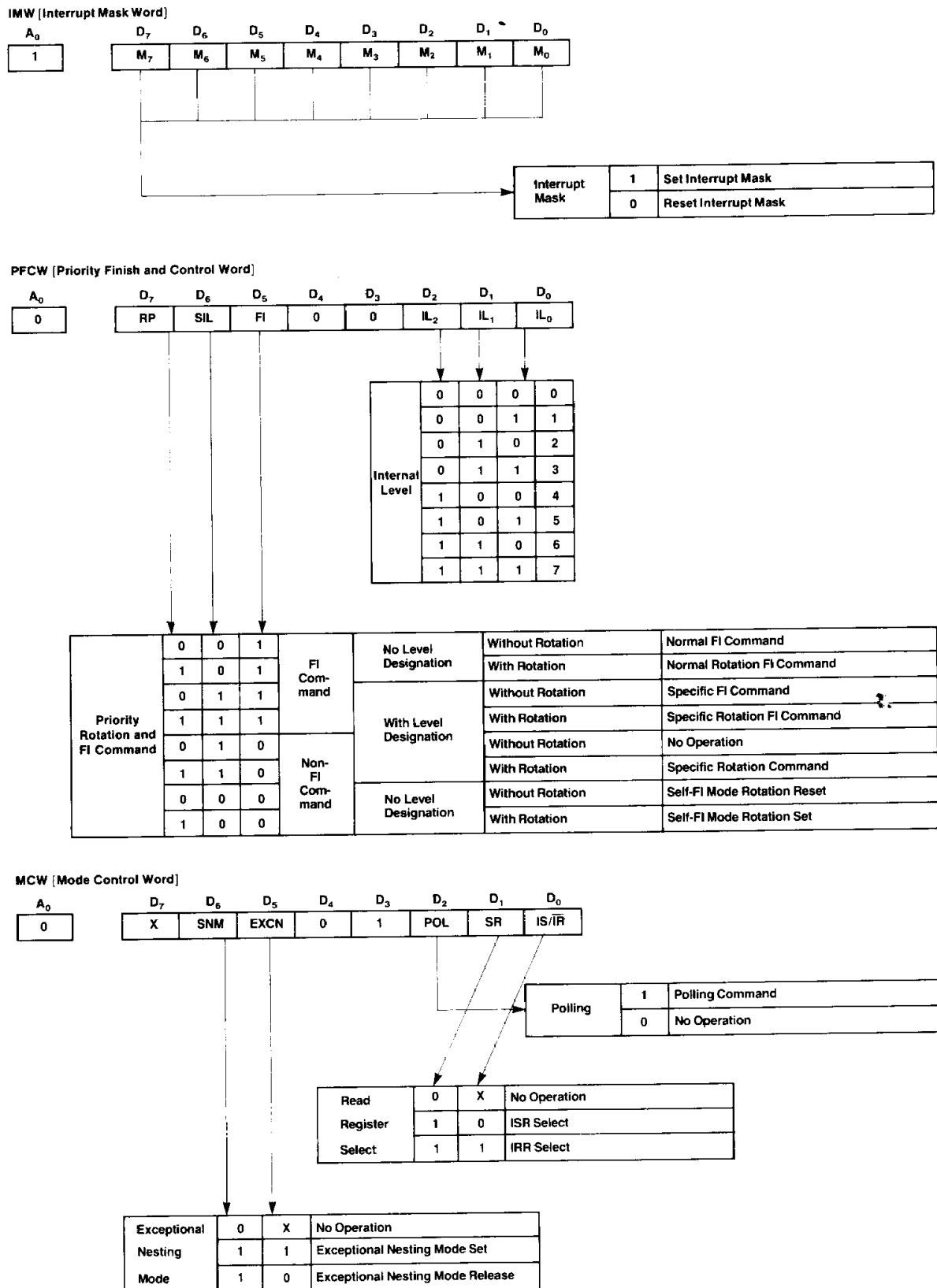
Interrupt Mode Select	1	Vector Mode
	0	CALL Mode

FI Mode	1	Self-FI Mode
	0	FI Command Mode

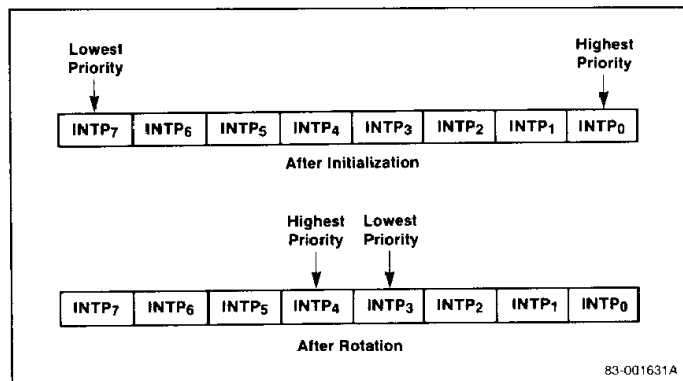
Buffer Mode Select	BUF	BSV	
	0	X	Non-Buffer Mode
	1	1	Buffer Mode Master
	1	0	Buffer Mode Slave

Extended Nest	1	Extended Nest Mode
	0	Normal Nest Mode

Figure 3. Command Word Format



**Figure 4. INTP Priority Order**



## CALL or Vector Modes

The μPD71059 passes interrupt routine address data to the CPU in two modes, depending on the CPU type. This mode is set by bit  $V/\overline{C}$  in initialization word IW4.  $V/\overline{C}$  is set to one to select the vector mode for μPD70108/70116 CPUs, and reset to zero to select the CALL mode for μPD8085A CPUs.

### CALL Mode [μPD8085A CPUs]

In this mode, when an interrupt is acknowledged by the CPU, the μPD71059 outputs three bytes of interrupt data to the data bus in its  $\overline{INTAK}$  sequence. During the first  $\overline{INTAK}$  pulse from the CPU, the μPD71059 outputs the CALL opcode 0CDH. During the next  $\overline{INTAK}$  pulse, it outputs the lower byte of a two-byte interrupt routine address. During the third  $\overline{INTAK}$  pulse, it outputs the upper byte of the address. The CPU interprets these three bytes as a CALL instruction and executes the CALL interrupt routine. See figure 5 and the  $\overline{INTAK}$  sequence (CALL mode) μPD8085 diagram in the AC Timing Waveforms.

Interrupt routine addresses are set using words IW1 and IW2 during initialization. However, only the higher ten or eleven bits of the interrupt addresses are set, A<sub>15</sub>-A<sub>6</sub> or A<sub>15</sub>-A<sub>5</sub>. The μPD71059 sets the remaining low bits (D<sub>5</sub>-D<sub>0</sub> or D<sub>4</sub>-D<sub>0</sub>) to get the address of INTP<sub>n</sub>'s interrupt routine. The addresses for INTP<sub>1</sub>-INTP<sub>7</sub> are set in order of interrupt level. The space between interrupt addresses is determined by setting the AG4 bit (address gap 4 bytes) of IW1. When AG4 = 1, the interrupt routine starting addresses are 4 bytes apart. Therefore, the starting address for INTP<sub>n</sub> is the starting address for INTP<sub>0</sub> plus four times n. When AG4 = 0, starting addresses are eight bytes apart, so the starting address for INTP<sub>n</sub> is the starting address for INTP<sub>0</sub> plus eight times n. See figure 6.

### Vector Mode [μPD70108/70116 CPUs]

In the vector mode, the μPD71059 outputs a one-byte interrupt vector number to the data bus in the  $\overline{INTAK}$  sequence. The CPU uses that vector number to generate an interrupt routine address. See figure 7.

The higher five bits of the vector number, V<sub>7</sub>-V<sub>3</sub>, are set by IW2 during initialization. The μPD71059 sets the remaining three bits to the number of the interrupt input (0 for INTP<sub>0</sub>, 1 for INTP<sub>1</sub>, etc). See figure 8.

The CPU generates an interrupt vector by multiplying the vector number by four, and using the result as the address of a location in an interrupt vector table located at addresses 000H-3FFH. See figure 9.

## System Scale Modes

The μPD71059 can operate in either single mode, with up to eight interrupt lines or extended mode, with more than one μPD71059 and more than eight interrupt lines. In extended mode a μPD71059 is in either master or slave mode.

Bit D<sub>1</sub>, SNGL (single mode), of the first initialization word IW1 designates the scale of the interrupt system. SNGL = 1 designates that only one μPD71059 is being used (single mode system). SNGL = 0 designates an extended mode system with a master and slave μPD71059s. In the single mode (SNGL = 1), the SV input and IW4 buffer mode bits D<sub>3</sub> and D<sub>2</sub> do not indicate a master/slave relation for the μPD71059.

5f

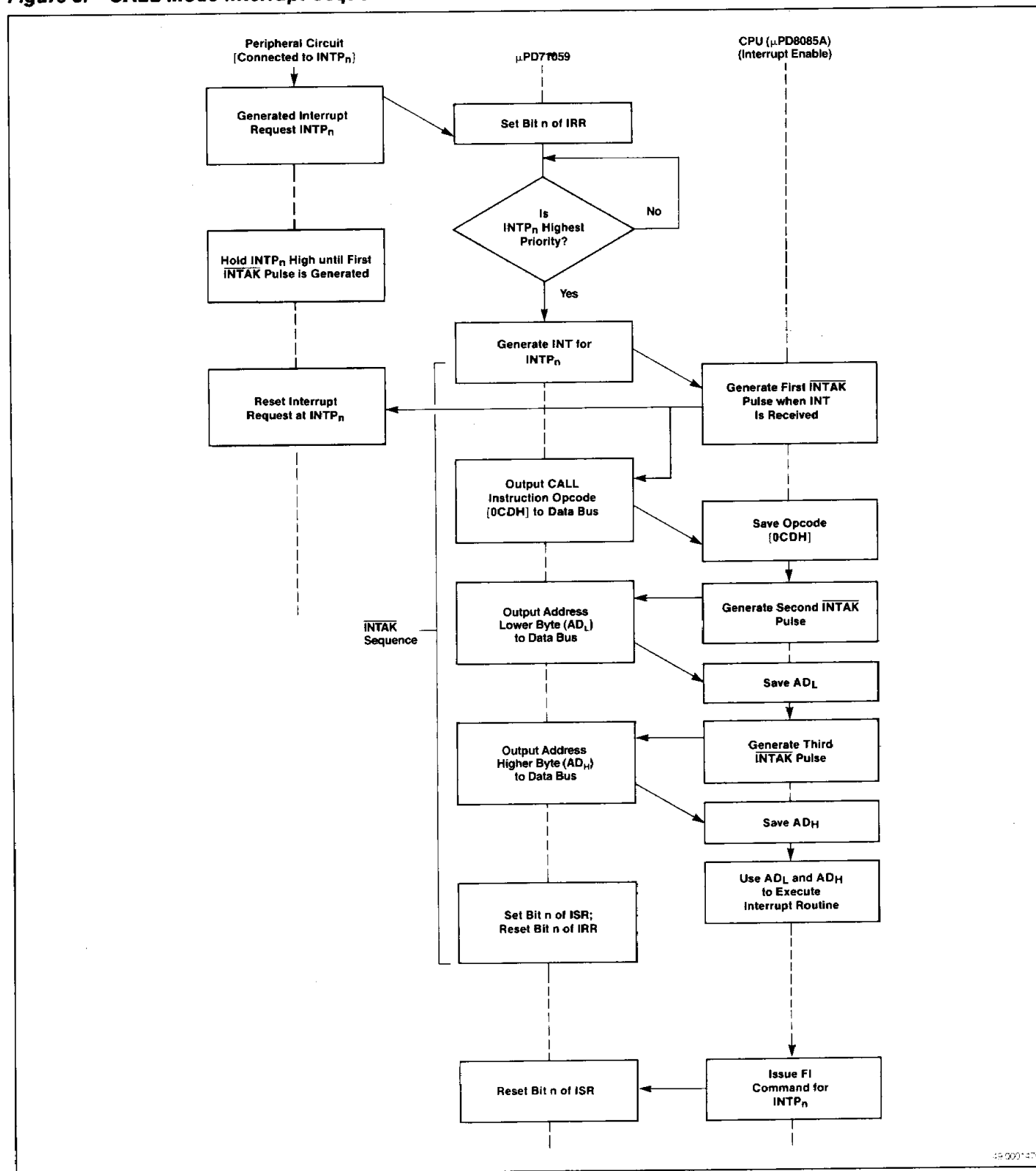
### Single Mode

This mode is the normal mode of μPD71059 operation. It has been described in the Interrupt Operation description. See figure 10 for a system example.

### Extended Mode

In this mode, up to 64 interrupt requests can be processed using a master (μPD71059 in master mode) connected to a maximum of eight slaves (μPD71059s in slave mode). See figure 11 for a system example.

Figure 5. CALL Mode Interrupt Sequence



**Figure 6. CALL Mode Interrupt Address Sequence**

• Address Lower Byte [AD<sub>L</sub>] During Second INTAK

AG4 = 1 (4-Byte Spacing Address)

Interrupt Level	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
INTP <sub>0</sub>	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	0	0	0	0	0
INTP <sub>1</sub>	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	0	0	1	0	0
INTP <sub>2</sub>	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	0	1	0	0	0
INTP <sub>3</sub>	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	0	1	1	0	0
INTP <sub>4</sub>	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	1	0	0	0	0
INTP <sub>5</sub>	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	1	0	1	0	0
INTP <sub>6</sub>	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	1	1	0	0	0
INTP <sub>7</sub>	A <sub>7</sub>	A <sub>6</sub>	A <sub>5</sub>	1	1	1	0	0

AG4 = 0 (8-Byte Spacing Address)

Interrupt Level	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
INTP <sub>0</sub>	A <sub>7</sub>	A <sub>6</sub>	0	0	0	0	0	0
INTP <sub>1</sub>	A <sub>7</sub>	A <sub>6</sub>	0	0	1	0	0	0
INTP <sub>2</sub>	A <sub>7</sub>	A <sub>6</sub>	0	1	0	0	0	0
INTP <sub>3</sub>	A <sub>7</sub>	A <sub>6</sub>	0	1	1	0	0	0
INTP <sub>4</sub>	A <sub>7</sub>	A <sub>6</sub>	1	0	0	0	0	0
INTP <sub>5</sub>	A <sub>7</sub>	A <sub>6</sub>	1	0	1	0	0	0
INTP <sub>6</sub>	A <sub>7</sub>	A <sub>6</sub>	1	1	0	0	0	0
INTP <sub>7</sub>	A <sub>7</sub>	A <sub>6</sub>	1	1	1	0	0	0

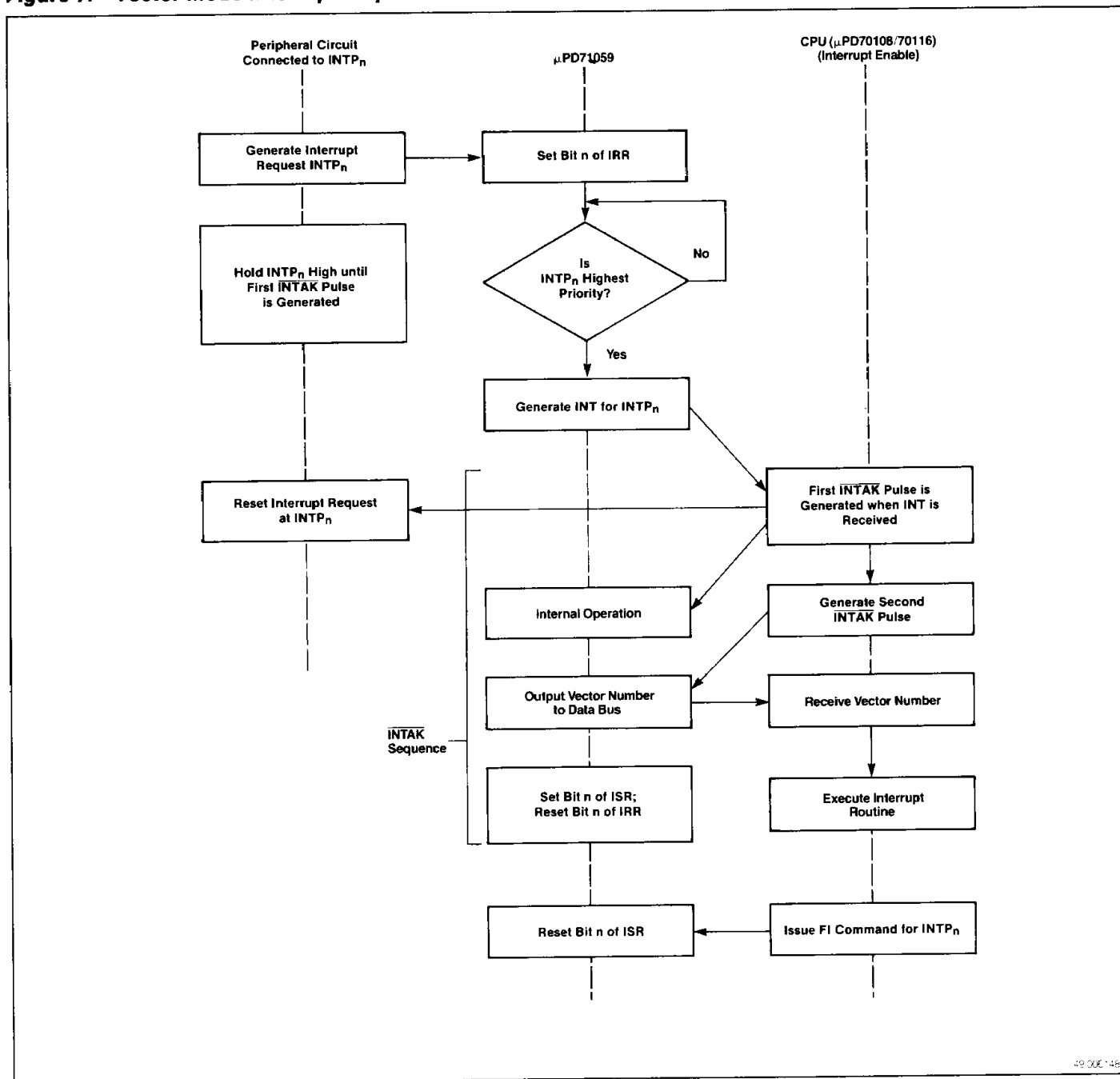
Note: When AG4 = 0, bit A<sub>5</sub> is ignored.

• Address Higher Byte [AD<sub>H</sub>] During Third INTAK

D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
A <sub>15</sub>	A <sub>14</sub>	A <sub>13</sub>	A <sub>12</sub>	A <sub>11</sub>	A <sub>10</sub>	A <sub>9</sub>	A <sub>8</sub>

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Figure 7. Vector Mode Interrupt Sequence



99-0061-1460

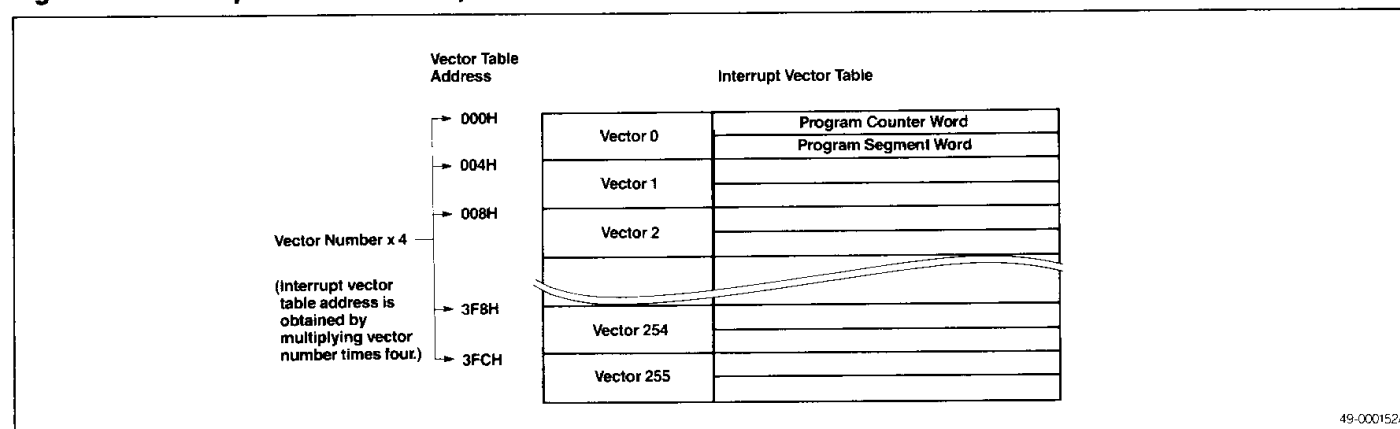


**Figure 8. Vector Numbers Output in Vector Mode**

Output During the Second INTAK								
Interrupt Levels	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
INTP <sub>0</sub>	V <sub>7</sub>	V <sub>6</sub>	V <sub>5</sub>	V <sub>4</sub>	V <sub>3</sub>	0	0	0
INTP <sub>1</sub>	V <sub>7</sub>	V <sub>6</sub>	V <sub>5</sub>	V <sub>4</sub>	V <sub>3</sub>	0	0	1
INTP <sub>2</sub>	V <sub>7</sub>	V <sub>6</sub>	V <sub>5</sub>	V <sub>4</sub>	V <sub>3</sub>	0	1	0
INTP <sub>3</sub>	V <sub>7</sub>	V <sub>6</sub>	V <sub>5</sub>	V <sub>4</sub>	V <sub>3</sub>	0	1	1
INTP <sub>4</sub>	V <sub>7</sub>	V <sub>6</sub>	V <sub>5</sub>	V <sub>4</sub>	V <sub>3</sub>	1	0	0
INTP <sub>5</sub>	V <sub>7</sub>	V <sub>6</sub>	V <sub>5</sub>	V <sub>4</sub>	V <sub>3</sub>	1	0	1
INTP <sub>6</sub>	V <sub>7</sub>	V <sub>6</sub>	V <sub>5</sub>	V <sub>4</sub>	V <sub>3</sub>	1	1	0
INTP <sub>7</sub>	V <sub>7</sub>	V <sub>6</sub>	V <sub>5</sub>	V <sub>4</sub>	V <sub>3</sub>	1	1	1

83-001633B

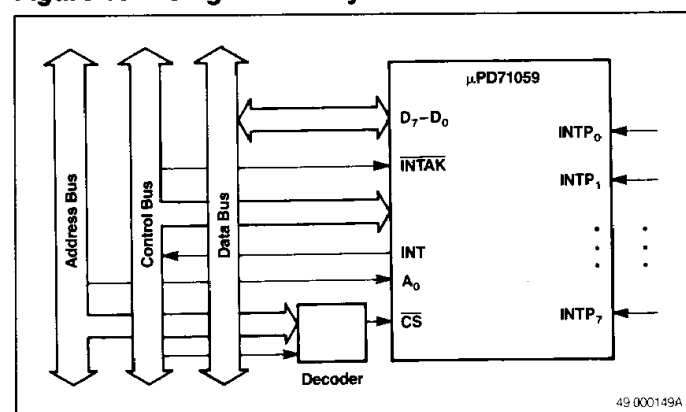
**Figure 9. Interrupt Vectors for the μPD70108/70116**



49-000152A

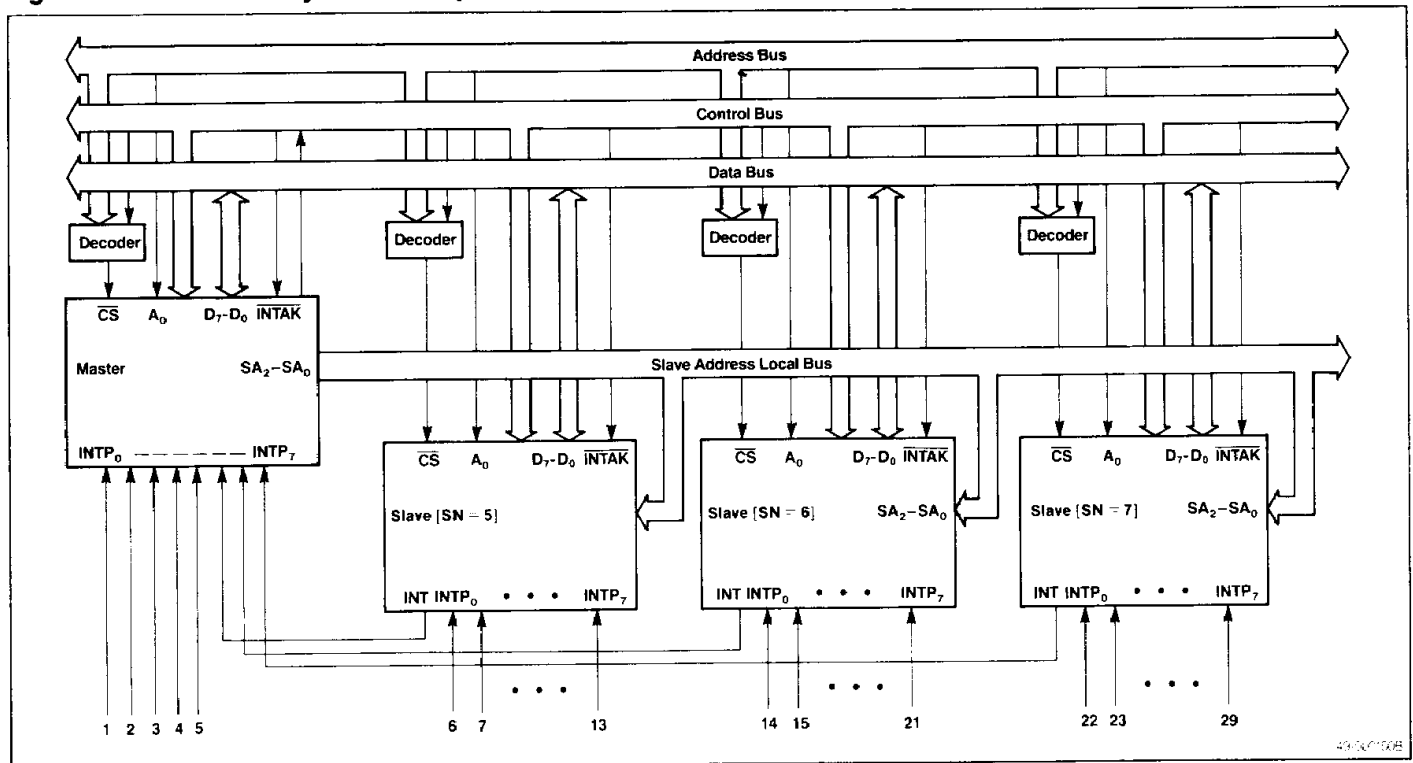
5f

**Figure 10. Single Mode System**



49-000149A

Figure 11. Extended System Example with Three Slaves



## Master Mode

When a μPD71059 is a master in an extended mode system,  $S_7-S_0$  of IW3 (master mode) define which of  $INTP_7-INTP_0$  are inputs from slave μPD71059s or peripheral interrupts.

Consider an interrupt request from  $INTP_n$ . If  $S_n = 0$ , the interrupt is from a peripheral (for example,  $INTP_0$  of the master μPD71059 in Figure 11), and the μPD71059 treats it the same way it would if it were in the single mode.  $SA_2-SA_0$  outputs are low level and the master provides the interrupt address or vector number.

If  $S_n = 1$ , the interrupt is from a slave (for example,  $INTP_7$  of the master). The master sends an interrupt to the CPU if the slave requesting the interrupt has priority. The master then outputs slave address  $n$  to pins  $SA_2-SA_0$  on the first  $\overline{INTAK}$  pulse by the CPU. It lets slave  $n$  perform the rest of the  $\overline{INTAK}$  sequence.

## Slave Mode

When a slave receives an interrupt request from a peripheral, and the slave has no interrupts with higher priority in service, it sends an interrupt request to the master through its INT output. When the interrupt is accepted by the CPU through the master, the master outputs the slave's address on pins  $SA_2-SA_0$ . Each slave compares the address on  $SA_2-SA_0$  to its own address. The slave that sent the interrupt will find a match. It completes the  $\overline{INTAK}$  sequence the same way as a single μPD71059 would.

The master outputs slave address 0 when it is processing a non-slave interrupt. Therefore, do not use 0 as a slave address if there are less than eight slaves connected to the master.

Figures 12 and 13 show the interrupt operating sequences for slaves in the extended mode.

The flowchart illustrates the INTAK Sequence, which is a protocol for interrupt handling between a Slave  $\mu$ PD71059 ( $S_m = 0$ ), a Master  $\mu$ PD71059 ( $S_n = 1$ ), and a CPU ( $\mu$ PD8085A) with interrupts enabled.

**Slave  $\mu$ PD71059 ( $S_m = 0$ ) Path:**

- Peripheral Circuit (Connected to  $INTP_m$  in Slave) triggers an **Interrupt Request is Made to  $INTP_m$** .
- The Slave  $\mu$ PD71059 **Set Bit m of IRR**.
- Decision: **Is  $INTP_m$  Highest Priority?**
  - If **No**, the path proceeds to the Master  $\mu$ PD71059.
  - If **Yes**, the Slave  $\mu$ PD71059 **Generate INT for  $INTP_m$** .
- The Slave  $\mu$ PD71059 **Output Address Lower Byte ( $AD_L$ ) to Data Bus**.
- The Slave  $\mu$ PD71059 **Output Address Higher Byte ( $AD_H$ ) to Data Bus**.
- The Slave  $\mu$ PD71059 **Set Bit m of ISR; Reset Bit m of IRR**.
- The Slave  $\mu$ PD71059 **Reset Bit m of ISR**.

**Master  $\mu$ PD71059 ( $S_n = 1$ ) Path:**

- The Master  $\mu$ PD71059 **Set Bit n of IRR**.
- Decision: **Is  $INTP_n$  Highest Priority?**
  - If **No**, the path proceeds to the CPU.
  - If **Yes**, the Master  $\mu$ PD71059 **Generate INT for  $INTP_n$** .
- The Master  $\mu$ PD71059 **Output Address Lower Byte ( $AD_L$ ) to Data Bus**.
- The Master  $\mu$ PD71059 **Output Address Higher Byte ( $AD_H$ ) to Data Bus**.
- The Master  $\mu$ PD71059 **Set Bit n of ISR; Reset Bit n of IRR**.
- The Master  $\mu$ PD71059 **Reset Bit n of ISR**.

**CPU ( $\mu$ PD8085A) Path:**

- The CPU **Generate First INTAK Pulse After Accepting INT**.
- The CPU **Save Opcode [0CDH]**.
- The CPU **Generate Second INTAK Pulse**.
- The CPU **Save  $AD_L$** .
- The CPU **Generate Third INTAK Pulse**.
- The CPU **Save  $AD_H$** .
- The CPU **Use  $AD_L$  and  $AD_H$  to Execute Interrupt Routine**.
- The CPU **Issue FI Command to  $INTP_m$  of Slave**.
- The CPU **Issue FI Command to Master  $INTP_n$** .

**INTAK Sequence:**

- The **INTAK Sequence** is initiated by the CPU's first pulse.
- The Slave  $\mu$ PD71059 and Master  $\mu$ PD71059 both output their address bytes ( $AD_L$  and  $AD_H$ ) to the data bus.
- The CPU saves the opcode and address bytes.
- The CPU issues the FI (Finish Interrupt) command to the Slave and Master  $\mu$ PD71059.
- The Slave and Master  $\mu$ PD71059 reset their respective ISR bits.

[illegible]

## Buffer and Non-Buffer Modes

In a large system, a buffer may be needed by the μPD71059 to drive the data bus. A buffer mode is supplied, with a signal to specify the buffer direction. In the buffer mode,  $\overline{SV}$  (BUFR/W) is used to select the buffer direction and  $\overline{SV}$  cannot be used to specify the master/slave mode. The master/slave selection must be set by IW4. IW4 bit D<sub>3</sub>, BUF (buffer) and D<sub>2</sub>, BSV (buffered slave) are used together to set the buffer mode and master/slave relation. When BUF = 0, the non-buffer mode is set and BSV has no meaning. When BUF = 1, the buffer mode is set. In buffer mode, the μPD71059 is a master when BSV = 1, a slave when BSV = 0. See figure 14.

## Nesting Modes

The way a μPD71059 handles interrupts when there is already an interrupt in service depends on the nesting mode.

### Normal Nesting Mode

This mode is set when IW4 is not written or when IW4 has EXTN = 0. It is the most common nesting mode. See figure 15.

When an interrupt is being executed in this mode (corresponding bit of ISR = 1), only interrupt requests with higher priority can be accepted.

### Extended Nesting Mode

This mode is only applicable to a master in the extended mode. A slave's eight interrupt priority levels become only one priority level when viewed by the master. Therefore, a request made by a slave with a higher priority than a previous request from the same slave will not be accepted. This cannot be called complete nesting since priority ranking within slaves loses its significance.

The extended nesting mode is set by setting bit D4 of IW4 in both the master and the slave. Interrupt requests of a higher level than the one currently being serviced can be accepted in the master from the same slave in the extended nesting mode.

Care should be exercised when issuing an FI (finish interrupt) command in the extended nesting mode. In an interrupt by a slave, the CPU first issues an FI command to the slave. Then, the CPU reads the slave's in-service register (ISR) to see if that slave still has interrupts in service. If there are no interrupts in service, (ISR = 00H) an FI command is issued to the master, as in the single mode when an interrupt is made by a peripheral.

Figure 14. Buffer Mode

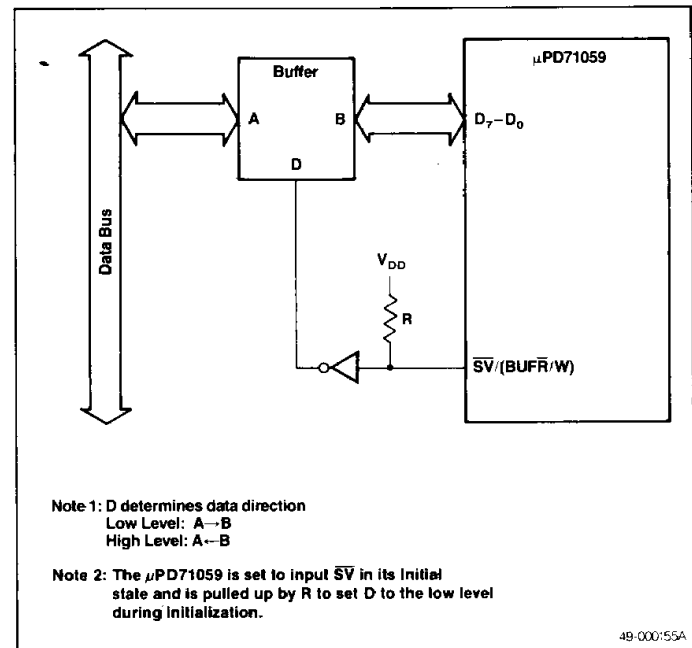
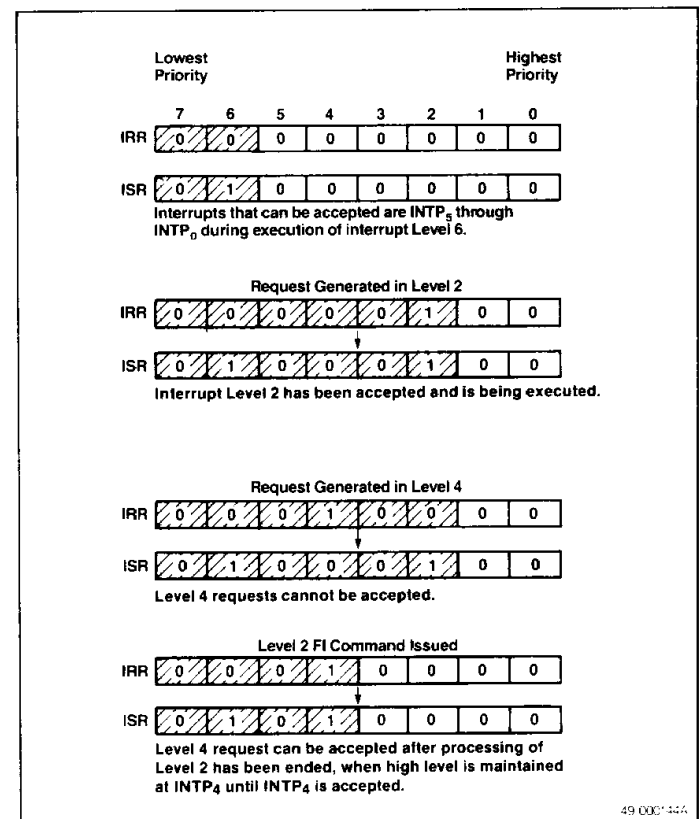


Figure 15. Normal Nesting Mode



## Exceptional Nesting Mode

A μPD71059 in the normal or extended nesting mode cannot accept interrupts of a lower priority than the interrupts in service. Sometimes, however, it is desirable that requests with lower priority be accepted while higher-priority interrupts are being serviced. Setting the exceptional nesting mode allows this. After releasing the exceptional mode, the previous mode is resumed.

The exceptional nesting mode is controlled by the SNM (set nesting mode) and EXCN (exceptional nesting mode) bits (D<sub>6</sub> and D<sub>5</sub>) of MCW. They set and release the exceptional nesting mode. The mode doesn't change when SNM = 0. Exceptional nesting is set if SNM and EXCN = 1 and released when SNM = 1 and EXCN = 0.

Setting a bit in the IMW in the exceptional nesting mode, inhibits interrupts of that level and allows unmasked interrupts to all other levels, higher or lower priority.

The procedure for setting the exceptional nesting (EN) mode is as follows:

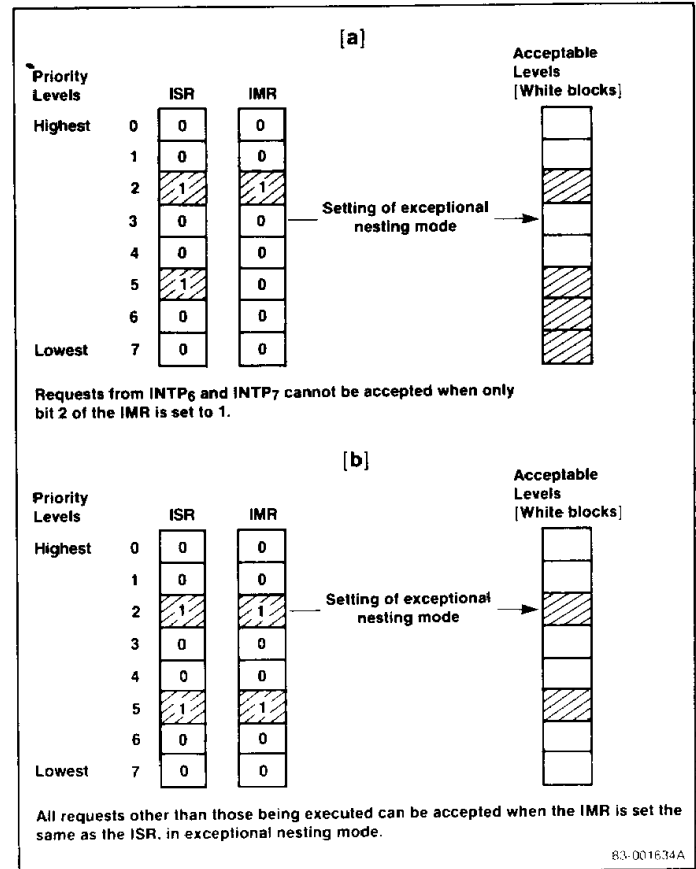
- (1) Read the ISR.
- (2) Write the ISR data to the IMR.
- (3) Set the exceptional nesting mode.

In this way, all interrupt requests not currently in service will be enabled.

Figure 16 (a) shows what happens if IMR is not set to ISR. When the exceptional nesting is set, bit 2 of ISR will be ignored, and bit 5 will be serviced. Servicing bit 5 will mask the lower priority interrupts 6 and 7. When the ISR is set equal to the IMR as in (b), all interrupts except 2 and 5 can be serviced when the exceptional nesting mode is set.

Issuing an FI command to a level masked by the exceptional nesting mode requires caution. Since the ISR bit is masked, the normal FI command will not work. For this reason, a specific FI command specifying the ISR bit must be issued. After the exceptional mode is released, the normal FI command may be used.

Figure 16. Exceptional Nesting Mode



## Finishing Interrupts (FI) and Changing the Priority Levels

The priority and finish control word (PFCW) issues FI commands and changes interrupt priorities.

### Normal FI Command

	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
PFCW =	0	0	1	0	0	X	X	X

When a normal FI command is issued, the μPD71059 resets the ISR bit corresponding to the highest priority level selected from the interrupts in service. This operation assumes that the interrupt accepted last has ended.

When an interrupt routine changes the priority level or the exceptional nesting mode is set, this command will not operate correctly because the highest priority interrupt is not necessarily the last interrupt in service.

## Specific FI Command

	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
PFCW =	0	1	1	0	0	IL <sub>2</sub>	IL <sub>1</sub>	IL <sub>0</sub>

When the specific FI command is issued, the μPD71059 resets the ISR bit designated by bits IL<sub>2</sub>-IL<sub>0</sub> of the PFCW. This command is used when the normal nesting mode isn't being used.

## Self-FI Mode

When SFI of IW4 = 1, the μPD71059 is set to the self-FI mode. In this mode, the ISR bit corresponding to the interrupt is set and reset during the third INTAK pulse. Therefore, the CPU does not have to issue an FI command when the interrupt routine ends. In this mode, however, the ISR does not store the routine in service. Unless interrupts are disabled by the interrupt routine, newly generated interrupt requests are generated without priority limitation by the ISR. This can cause a stack overflow when frequent interrupt requests occur, or when the interrupt is level triggered.

## Self-FI Rotation

Rotation of interrupt priorities can be added to the self-FI mode. In this case, the corresponding interrupt is set to the lowest priority level when a bit is reset in the ISR at the end of the INTAK sequence.

Self-FI Rotation Set:

	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
PFCW =	1	0	0	0	0	X	X	X

Self-FI Rotation Reset:

	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
PFCW =	0	0	0	0	0	X	X	X

## Normal Rotation FI Command

	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
PFCW =	1	0	1	0	0	X	X	X

When the normal rotation FI command is issued, the μPD71059 resets the ISR bit corresponding to the highest priority level selected from the interrupts in service, then rotates the priority levels so that the interrupt just completed has the lowest priority.

## Specific Rotation FI Command

	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
PFCW =	1	1	1	0	0	IL <sub>2</sub>	IL <sub>1</sub>	IL <sub>0</sub>

When the specific rotation FI command is issued, the μPD71059 resets the ISR bit designated by bits IL<sub>2</sub>-IL<sub>0</sub> of the PFCW and rotates the interrupt priorities so that the interrupt just reset becomes the lowest priority. This change in priority levels is different from the normal nesting mode, therefore, it is the user's responsibility to manage nesting.

## Specific Rotation Command

	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
PFCW =	1	1	0	0	0	IL <sub>2</sub>	IL <sub>1</sub>	IL <sub>0</sub>

When the specific rotation command is issued, the μPD71059 sets the interrupt priority specified by IL<sub>2</sub>-IL<sub>0</sub> to the lowest priority. In this case also, the user must manage nesting.

## Triggering Mode

Bit D<sub>3</sub> of the first initialization word, IW1, is LEV (level-trigger mode bit). LEV sets the trigger mode of the INTP inputs. The level-trigger mode is set when LEV = 1. The rising-edge-triggered mode is set when LEV = 0.

## Edge-Trigger Mode

In the edge-trigger mode, an interrupt is detected by the rising edge of the signal on an INTP input. Although an IRR bit goes high when INTP is high, the IRR bit is not latched until the CPU returns an INTAK pulse. Therefore, the INTP input should be maintained high until INTAK is received. This filters out noise spikes on the INT lines. To send the next interrupt request, temporarily lower the INTP input, then raise it.

## Level-Trigger Mode

In the level-trigger mode, an IRR bit is set by the INTP input being at a high level. As in the edge-trigger mode, the INTP must be maintained high until the INTAK is received. Interrupts are requested as long as the INTP input remains high. Care should be taken so as not to cause a stack overflow in the CPU. See figure 17.

**Note:** The μPD71059 operates as if the INTP<sub>7</sub> interrupt had occurred if the INTAK pulse is sent to the μPD71059 by the CPU when the μPD71059 INT output level is low. Bit 7 of ISR is not set. Accordingly, if it is expected that this will occur, the INTP<sub>7</sub> interrupt should be reserved for servicing incomplete interrupts. The FI should not be issued for incomplete interrupts. See figure 18.

Figure 17. INTP Input

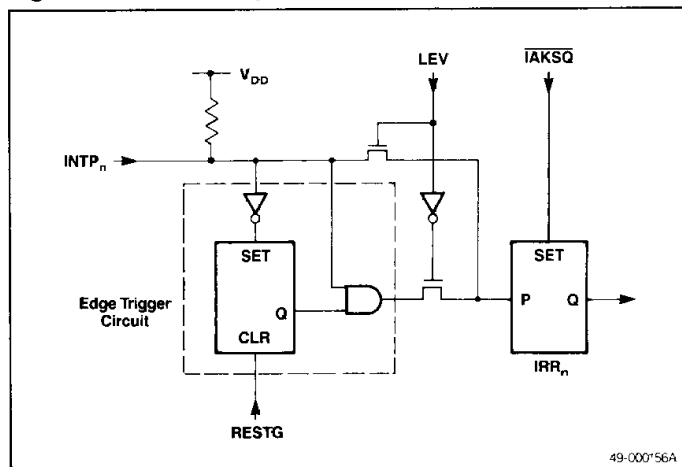
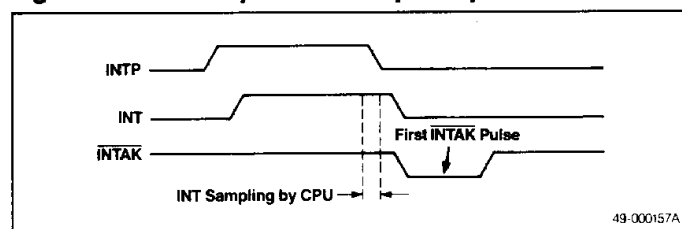


Figure 18. Incomplete Interrupt Request



## Polling Operation

When polling, the CPU should disable its INT input. Next, it issues a polling command to the μPD71059 using MCW with POL = 1. This command sets the μPD71059 in polling mode until the CPU reads one of the μPD71059's registers.

When the CPU performs a read operation with A<sub>0</sub> = 0 in the polling mode, polling data as shown in figure 19 is read instead of ISR or IRR. The μPD71059 then ends the polling mode.

Figure 19. Polling Data

	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
MCW =	INT	0	0	0	0	PL <sub>2</sub>	PL <sub>1</sub>	PL <sub>0</sub>

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The INT bit has the same meaning as the INT pin. When it is set to 1, it means that the μPD71059 has accepted an INTP input.

The PL<sub>2</sub>-PL<sub>0</sub> (permitted level) bits show which INTP input requested an interrupt when INT = 1.

If INT in the polling data is 1, the μPD71059 sets the ISR bit corresponding to the interrupt level shown by bits PL<sub>2</sub>-PL<sub>0</sub> of the polling data and considers that interrupt as being executed. The CPU then processes the interrupt accordingly, based on the polling data read. An FI command should be issued when this processing ends.

**Note:** When a read is performed with A<sub>0</sub> = 1 after the polling command is sent to the μPD71059, the IMR will be read instead of polling data. However, when the polling command is sent, the μPD71059 operates in the same manner when A<sub>0</sub> = 0 as it does when A<sub>0</sub> = 1. This means that although A<sub>0</sub> was set to 1, the μPD71059 will send the contents of the IMR, but it will also set an ISR bit just as it would if A<sub>0</sub> had been set to zero. This may disturb the nesting. Therefore, performing a read operation with A<sub>0</sub> = 1 immediately after sending the polling command should be avoided.