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Z86C47-ROM
Z86E47-OTP

CMOS Z8® 8-BIT MICROCONTROLLER

FEATURES

- 8-Bit CMOS Microcontroller for Consumer Television Applications, 64-Pin DIP Package
- Low Cost
- Low Power Consumption
- Fast Instruction Pointer - 1.5 µs @ 4 MHz
- Two Standby Modes-STOP and HALT
- Low Voltage Detection/Voltage Sensitive Reset
- 35 Input/Output Lines
- On-Screen Display Controller
- All Digital CMOS Levels Schmitt-Triggered
- 16 Kbytes of ROM (Z86C47)
- 16 Kbytes OTP ROM (Z86E47)
- 236 Bytes of RAM
- Two Programmable 8-Bit Counter/Timers each with 6-Bit Programmable Prescaler
- Six Vectored, Priority Interrupts from Six Different Sources
- Clock Speed up to 4 MHz
- Permanently Enabled Watch-Dog/Power-On Reset Timer
- 4K x 6-Bit Character Generator ROM
- 160 x 7-Bit Video RAM
- On-Chip Oscillator that Accepts a Crystal, Ceramic Resonator, LC, or External Clock Drive.
- Mask Programmable 128 Character Set Displayed in an 8-Row x 20-Column Format, 12 x 5 Pixel Character Cell, Capable of Supporting English, Korean, Chinese, and Japanese High Resolution Characters.
- Fully Programmable Color Attributes Including Row Character, Row Background/Fringes, Frame Back-Ground/Position, Bar Graph Color Change, and Character Size.
- Programmable Display Position and Character Size Control.
- One Pulse Width Modulator (14-Bit Resolution) for Voltage Synthesis Tuner Control
- Five Pulse Width Modulators (8-Bit Resolution) for Picture Control
- Seven Pulse Width Modulators (6-Bit Resolution) for Audio Control
- Port 2 (8-Bit Programmable I/O) and Port 3 (2-Bit Input, 3-Bit Output) Register Mapped Ports
- Port 4 (8-Bit Output), Port 5 (8-Bit LED Drive Output) and Port 6 (6-Bit Input and Tri-State Comparator AFC Input) Memory Mapped I/O Ports.

GENERAL DESCRIPTION

The Z86C47 and Z86E47 Digital Television Controllers (DTC) introduce a new level of sophistication to single-chip architecture. The Z86C47/E47 are members of the Z8® single-chip microcontroller family with 16 Kbytes of ROM (Z86C47), OTP ROM (Z86E47) and 236 bytes of RAM. Both devices are housed in a 64-pin DIP package, and are CMOS compatible. Having the ROM/OTP ROM selectivity, the DTC offers both external memory and pre-programmed ROM which enables the Z8 microcontroller to be used in a high-volume production application device embedded with a custom program (customer supplied program).

GENERAL DESCRIPTION (Continued)

The Z86E47 offers the use of OTP ROM rather than a preprogrammed mask ROM. This enables the Z8 microcontroller to be used in prototyping, low volume applications, or where code flexibility is required. Zilog's DTC offers fast execution, efficient use of memory, sophisticated interrupts, input/output bit manipulation capabilities, and easy hardware/software system expansion along with low cost and low power consumption. The device provides an ideal performance and reliability solution for consumer and industrial television applications.

The Z86C47/E47 architecture is characterized by utilizing Zilog's advanced Superintegration™ design methodology. The devices have an 8-bit internal data path controlled by a Z8 microcontroller, and On Screen Display (OSD) logic circuits/Pulse Width Modulators (PWM). On-chip peripherals include two register mapped I/O ports (Port 2 and Port 3), Interrupt control logic (1 software, 2 external and 3 internal interrupts), and a standby mode recovery input port (Port 3, P30).

The OSD control circuits support 8 rows x 20 columns for 128 kinds of characters. The character color is specified by row. One of the 8 rows is assigned to show two kinds of colors for bar type displays such as volume control. The OSD is capable of displaying 11 x 15 dot characters.

A 14-bit PWM port provides enough voltage resolution for a voltage synthesizer tuning system. Seven 6-bit PWM ports are used for controlling audio signal level. Five 8-bit PWM ports are used to vary picture levels.

The Z86C47/E47 have 35 I/O pins dedicated to input and output for DTC applications demanding powerful I/O capabilities. These lines are grouped into five ports, and are configurable under software control to provide timing, status signals, parallel I/O, and an address/data bus for interfacing to external memory.

There are three basic address spaces available to support this wide range of configurations: Program Memory, Register File, and Data Memory. The Register File is composed of 236 bytes of general-purpose register, two I/O Port registers and 15 control and status registers.

To unburden the program from coping with the real-time problems such as counting/timing and data communication, the Z86C47/E47 offers two on-chip counter/timers with a large number of user selectable modes (Figure 1).

Notes:
All Signals with a preceding front slash, "/", are active Low, e.g., B/W (WORD is active Low); /B/W (BYTE is active Low, only).

Power connections follow conventional descriptions below:

Connection	Circuit	Device
Power	V_{CC}	V_{DD}
Ground	GND	V_{SS}

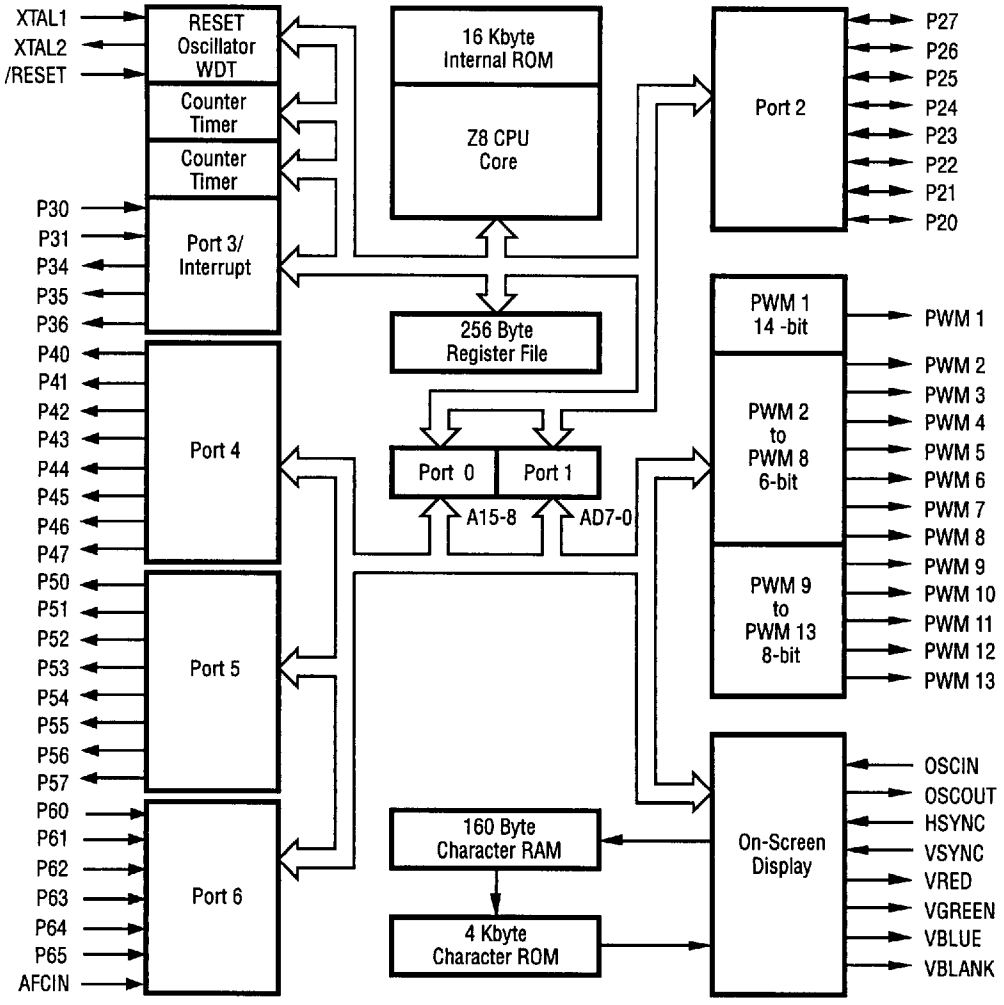


Figure 1. Z86C47/E47 Functional Block Diagram

PIN CONFIGURATION

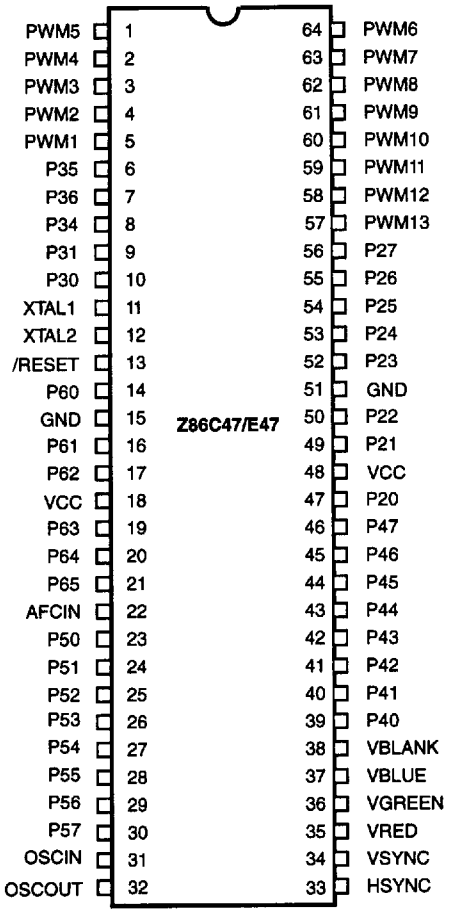


Figure 2. Z86C47/E47 Mask-ROM/OTP-ROM Plastic DIP

PIN IDENTIFICATION

64-pin DIP Z86C47/Z86E47

Pin	Name	Function	Direction
1	PWM5	Pulse Width Modulator 5	Output
2	PWM4	Pulse Width Modulator 4	Output
3	PWM3	Pulse Width Modulator 3	Output
4	PWM2	Pulse Width Modulator 2	Output
5	PWM1	Pulse Width Modulator 1	Output
6, 7	P35-P36	Port 3, Pins 5, 6	Output
8	P34	Port 3, Pin 4	Output
9	P31	Port 3, Pin 1	Input
10	P30	Port 3, Pin 0	Input
11	XTAL1	Crystal Oscillator	Input
12	XTAL2	Crystal Oscillator	Output
13	/RESET	System Reset	Input
14	P60	Port 6, Pin 0	Input
15	GND	Ground	Input
16	P61	Port 6, Pin 1	Input
17	P62	Port 6, Pin 2	Input
18	V_{CC}	Power Supply	Input
19-21	P63-P65	Port 6, Pins 3, 4, 5	Input
22	AFC_{IN}	AFC Voltage Level	Input
23-30	P50-P57	Port 5, Pins 0, 1, 2, 3, 4, 5, 6, 7	Output
31	OSC_{IN}	Video Dot Clock Osc	Input
32	OSC_{OUT}	Video Dot Clock Osc	Output
33	HSYNC	Horizontal Sync	Input
34	VSYNC	Vertical Sync	Input
35	Vred	Video Red	Output
36	Vgreen	Video Green	Output
37	Vblue	Video Blue	Output
38	Vblank	Video Blank	Output
39-46	P40-P47	Port 4, Pins 0, 1, 2, 3, 4, 5, 6, 7	Output
47	P20	Port 2, Pin 0	In/Output
48	V_{CC}	Power Supply	Input
49,50	P21-P22	Port 2, Pins 1, 2	In/Output
51	GND	Ground	Input
52-56	P23-P27	Port 2, Pins 3, 4, 5, 6, 7	In/Output
57	PWM13	Pulse Width Modulator 13	Output
58	PWM12	Pulse Width Modulator 12	Output
59	PWM11	Pulse Width Modulator 11	Output
60	PWM10	Pulse Width Modulator 10	Output
61	PWM9	Pulse Width Modulator 9	Output
62	PWM8	Pulse Width Modulator 8	Output
63	PWM7	Pulse Width Modulator 7	Output
64	PWM6	Pulse Width Modulator 6	Output

PIN IDENTIFICATION

64-pin DIP Z86E47

Pin	Name	Function	Direction
1	PWM5	Pulse Width Modulator 5	Output
2	PWM4	Pulse Width Modulator 4	Output
3	PWM3	Pulse Width Modulator 3	Output
4	PWM2	Pulse Width Modulator 2	Output
5	PWM1	Pulse Width Modulator 1	Output
6-7	P35-P36	Port 3, Pins 5, 6	Output
8	P34	Port 3, Pin 4	Output
9	P31	Port 3, Pin 1	Input
10	P30	Port 3, Pin 0	Input
11	XTAL1	Crystal Oscillator	Input
12	XTAL2	Crystal Oscillator	Output
13	/RESET	System Reset	Input
14	/AS	Address Strobe	Output
15	GND	Ground	Input
16	/DS	Data Strobe	Output
17	R/W	Read/Write	Output
18	V_{CC}	Power Supply	Input
19	SCLK	System Clock	Output
20-21	P66-P67	Port 6, Pins 6, 7	Output
22	AFC_{IN}	AFC Analog	Input
23-30	P00-P07	Port 0, Pins 0,1, 2, 3, 4, 5, 6, 7	Output
31	OSC_{IN}	Video Dot Clock Oscillator	Input
32	OSC_{OUT}	Video Dot Clock Oscillator	Output
33	Hsync	Horizontal Sync	Input
34	Vsync	Vertical Sync	Input
35	Vred	Video Red	Output
36	Vgreen	Video Green	Output
37	Vblue	Video Blue	Output
38	Vblank	Video Blank	Output
39-46	P10-P17	Port 1, Pins 0,1, 2, 3, 4, 5, 6, 7	Output
47	P20	Port 2, Pin 0	In/Output
48	V_{CC}	Power Supply	Input
49-50	P21-P22	Port 2, Pin 1, 2	In/Output
51	GND	Ground	Input
52-56	P23-P27	Port 2, Pins 3, 4, 5, 6, 7	In/Output
57	PWM13	Pulse Width Modulator 13	Output
58	PWM12	Pulse Width Modulator 12	Output
59	PWM11	Pulse Width Modulator 11	Output
60	PWM10	Pulse Width Modulator 10	Output
61	PWM9	Pulse Width Modulator 9	Output
62	PWM8	Pulse Width Modulator 8	Output
63	PWM7	Pulse Width Modulator 7	Output
64	PWM6	Pulse Width Modulator 6	Output

PIN DESCRIPTION

XTAL1, XTAL2 (Time-based input, output, respectively). These pins connect to the internal parallel-resonant clock crystal (4 MHz max) oscillator circuit with 2 capacitors to GND. XTAL1 can also be used as an external clock input.

/AS *Address Strobe* (output, active Low). /AS is pulsed once at the beginning of each machine cycle. Address output is through Port 0 and Port 1 for all external programs. Memory address transfers are valid at the trailing edge of /AS. Under program control, /AS can be placed in the high-impedance state along with Port 0 and Port 1, Data Strobe, and Read/Write.

/DS *Data Strobe* (output, active Low). /DS is active once for each external memory transfer. For READ operations, data must be available prior to the trailing edge of /DS. For WRITE operations, the falling edge of /DS indicates the output data is valid.

R/W *Read/Write* (output, Write active Low). R/W is Low when the DTC is writing to the external program or data memory.

SCLK *System Clock* (output). SCLK is the internal system clock. It can be used to clock external glue logic.

HSYNC (input, Schmitt-triggered, CMOS level). Horizontal Sync is an input pin that accepts an externally generated Horizontal Sync signal of either negative or positive polarity.

VSYNC (input, Schmitt-triggered, CMOS level). Vertical Sync is an input pin that accepts an externally generated Vertical Sync signal of either negative or positive polarity.

OSC_{IN}, OSC_{OUT} (Video Oscillator input, output, respectively). Oscillator input and output pins for on-screen display circuits. These pins connect to an inductor and two capacitors to generate the character dot clock (typically around 6 MHz). The dot clock frequency determines the character pixel width and phase synchronized to HSYNC.

Vblank *Video Blank* (output). CMOS output, programmable polarity. Used as a superimpose control port to display characters from video RAM. The signal controls Y signal output of the CRT and turns off the incoming video display while the characters in video RAM are superimposed on the screen. The red, green, and blue outputs drive the three electron guns on the CRT directly, while the blank output turns off the Y signal.

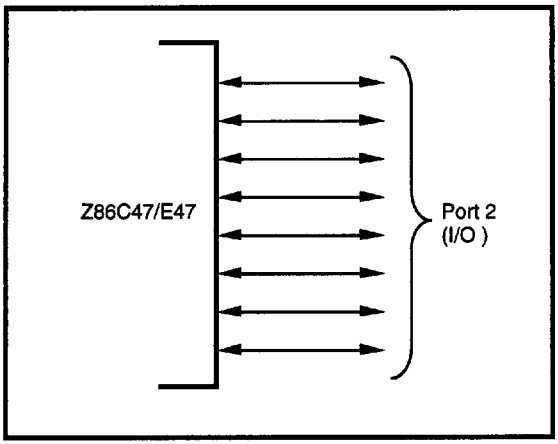
Vblue *Video Blue* (output). CMOS Output of the Blue video signal (B-Y) and is programmable for either polarity.

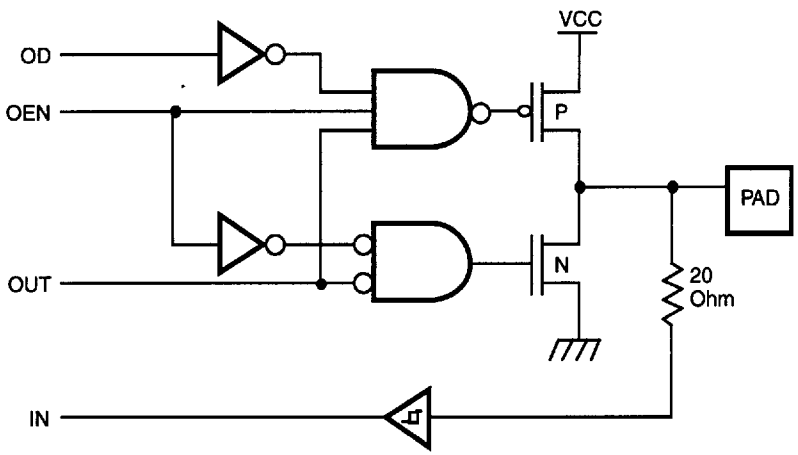
Vgreen *Video Green* (output). CMOS Output of the Green video signal (G-Y) and is programmable for either polarity.

Vred *Video Red* (output). CMOS Output of the Red video signal (R-Y) and is programmable for either polarity.

PIN DESCRIPTION (Continued)

Port 2 (P27-P20). Port 2 is an 8-bit port, CMOS compatible, bit programmable for either input or output. Input buffers are Schmitt-triggered. Bits programmed as outputs may be globally programmed as either push-pull or open-drain (Figure 3).

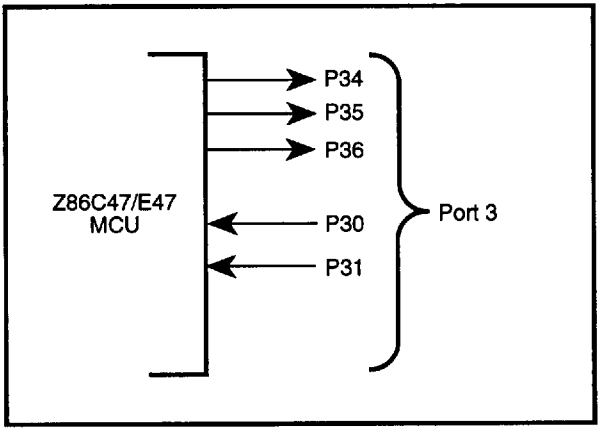


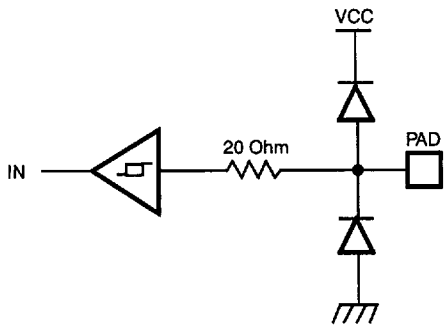


Note: Input/Output, Tri-State, Open-Drain, Pad Type 5

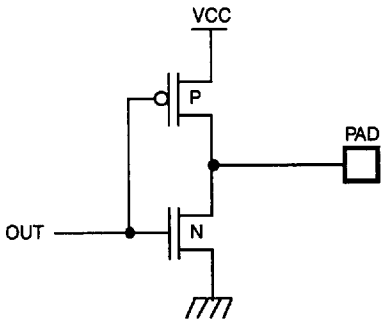
Figure 3. Port 2 Configuration

Port 3 (P30, P31, P34-P36). Port 3, P30 input is read directly. A negative edge event is latched in IRQ3 to initiate an IRQ3 vectored interrupt if appropriately enabled. An application could use the IRQ3 interrupt routine to place the device in STOP mode. A subsequent High on P30 would initiate a Stop-Mode Recovery. Port 3, P31 is read directly. A negative edge event is latched in IRQ2 to initiate an IRQ2 vectored interrupt if appropriately enabled. P31 High is signified as the T_{IN} signal to Timer1. Port 3, P34 and P35 are general-purpose output lines. Port 3, P36 can be used as a general-purpose output or as an output for T_{OUT} (from Timer1 or Timer2) or SCLK (Figure 4).





Note: Input Only, Schmitt-triggered, Pad Type 2



Note: Output Only, Pad Type 3

Figure 4. Port 3 Configuration

PIN DESCRIPTION (Continued)

Port 4 (P47-P40). Port 4 is an 8-bit, CMOS compatible, Output Port (Figure 5).

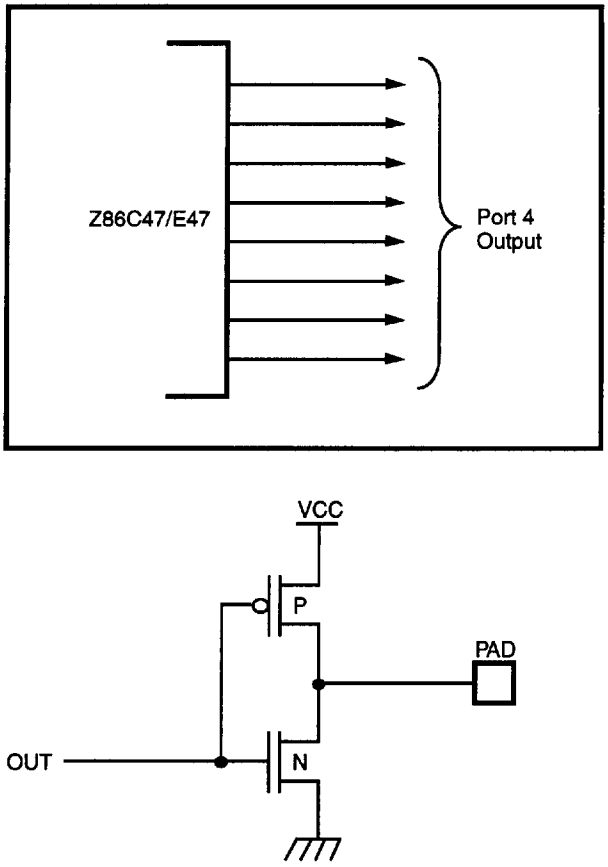
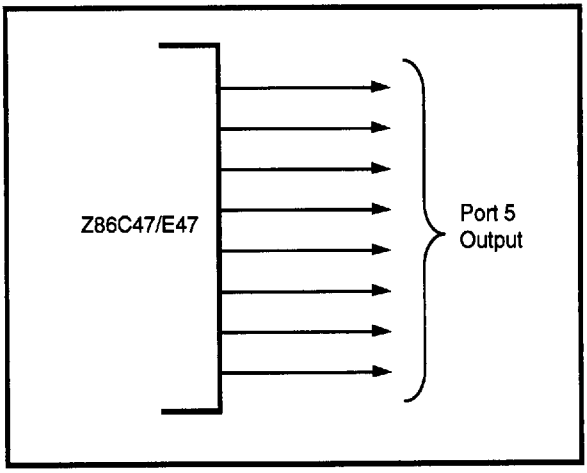


Figure 5. Port 4 Configuration

Port 5 (P57-P50). Port 5 is an 8-bit, CMOS compatible, Output Port. The output ports can directly sink 10 mA at 1.5 Volt V_{OL}. They are typically used to drive multiplexed LED displays (Figure 6).



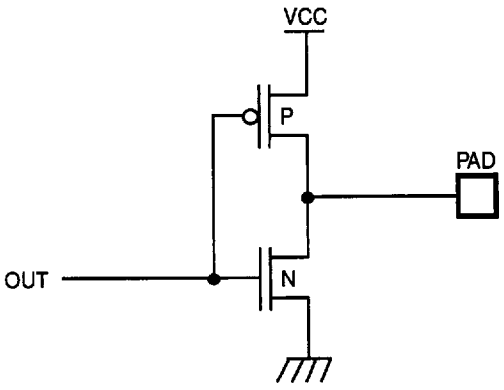


Figure 6. Port 5 Configuration

PIN DESCRIPTION (Continued)

Port 6 (P65-P60). Port 6 is a 6-bit, Schmitt-triggered CMOS compatible, input port. The outputs of the AFC comparators internally feed into the Port 6, P66 and P67 inputs in ROM mode (Figure 7).

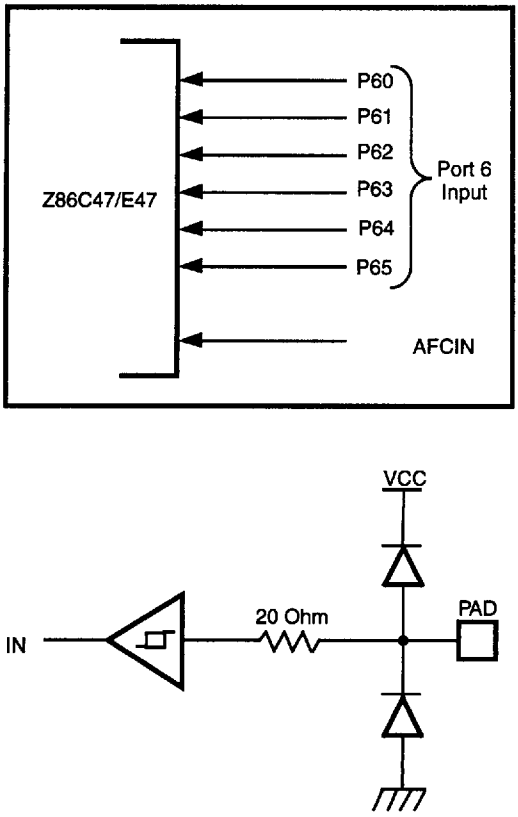


Figure 7. Port 6 Configuration

AFC_{IN} (Comparator input port). The input signal is supplied to two comparators with VTH1=2/5 V_{CC} and VTH2= 3/5 V_{CC} typical threshold voltage. The comparator outputs are internally connected to Port 6, P66 and P67. AFC_{IN} is typically used to detect AFC voltage level to accommodate digital automatic fine tuning functions (Figure 8).

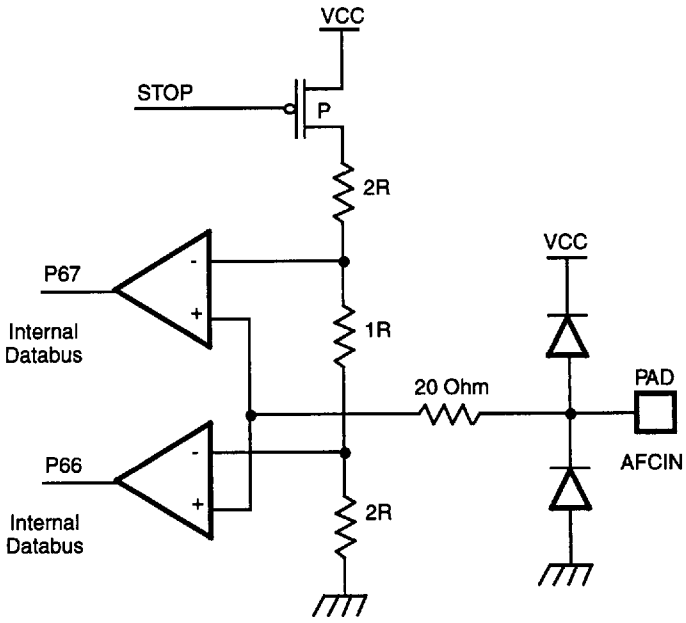


Figure 8. AFC_{IN} Comparator Circuits

PIN DESCRIPTION (Continued)

Pulse Width Modulator 1 (PWM). PWM1 is typically used as the D/A converter for Voltage Synthesis Tuning systems. It is a push-pull output. The PWM maximum value is 0000H and the minimum value is 3FFFH. They are loaded into registers FC12H and FC13H.

Pulse Width Modulator 8-2 (PWM). PWM8-PWM2 are Pulse Width Modulators Circuits with 6-bit resolution.

Pulse Width Modulator 13-9 (PWM). PWM13-PWM9 are Pulse Width Modulator Circuits with 8-bit resolution.

Note: PWM8-PWM1 can also be individually programmed as general-purpose outputs, but the output state of these PWM pins will be inverted from the data loaded into the PWM output register (FC11H). In either case, for PWM8-PWM2, the output drivers are 12V open-drain circuits and PWM1 is push-pull.

/RESET *System Reset.* Code is executed from memory address 000C (HEX) after the /RESET pin is set to a High level. The reset function is also carried out by detecting a V_{CC} transition state (automatic power-on reset) so that the external reset pin can be permanently tied to V_{CC}. A low level on /RESET forces a restart of the device. The /RESET must be Low for a total of 22TpC for the device to reset properly.

FUNCTIONAL DESCRIPTION

The Z8 DTC incorporates special functions to enhance the Z8's application in consumer, industrial, and television control applications.

Pulse Width Modulator (PWM). The DTC has 13 PWM channels (Figure 9). There are three types of PWM circuits: PWM1 (1 channel of 14-bit resolution) typically used for Voltage Synthesis Tuning, PWM8-PWM2 (7 channels of 6-bit resolution) typically used for audio level control, and PWM13-PWM9 (5 channels of 8-bit resolution) typically used for picture level control. PWM8-PWM1 may be used as general-purpose by programming the PWM mode register. The PWM control registers are mapped into external memory and are accessed through LDE and LDEI instructions.

PWM13-PWM2 are at maximum value (on-times) when all 1s are loaded in their PWM Value registers (and minimum value when all 0s are loaded). PWM1 has a maximum value for all 0s and minimum for all 1s.

PWM13-PWM2 have open-drain outputs. PWM1 has a push-pull output.

On-Screen Display (OSD). The OSD has a capability of displaying 8 rows x 20 columns of 128 kinds of characters for either high resolution (11 x 15 dots) pattern (Figure 10).

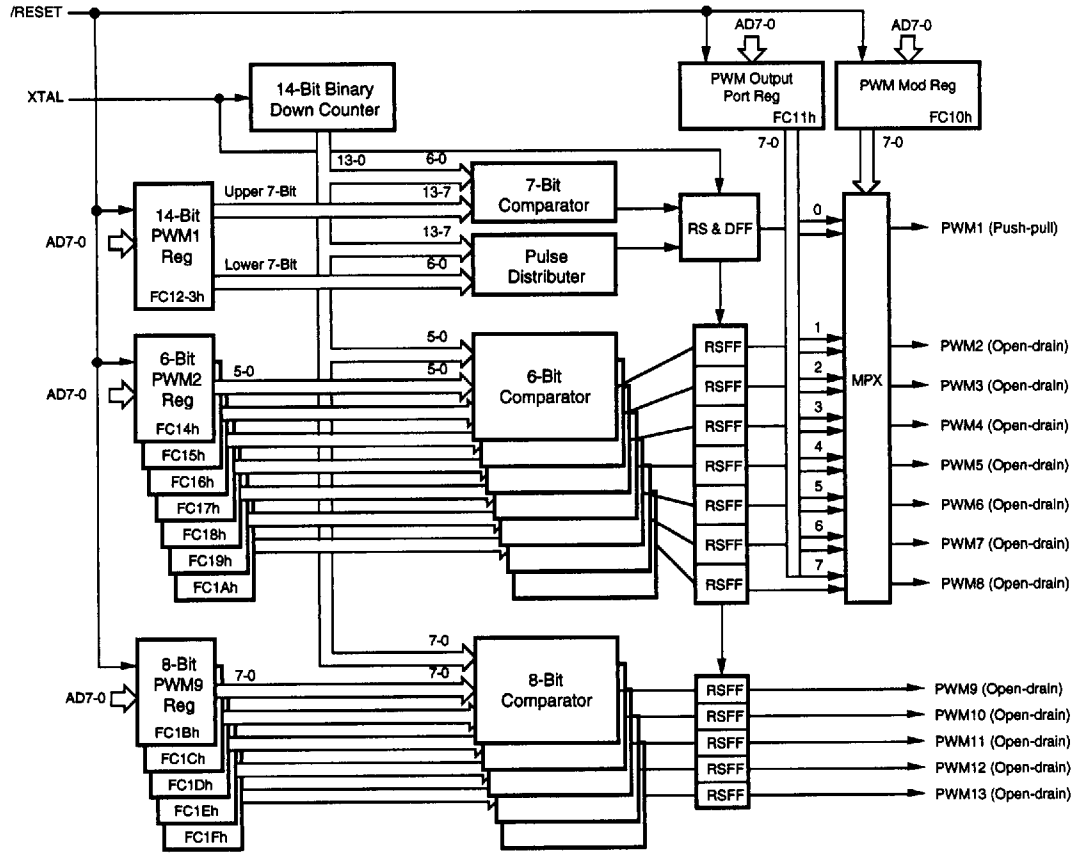


Figure 9. Pulse Width Modulator Block Diagram

FUNCTIONAL DESCRIPTION (Continued)

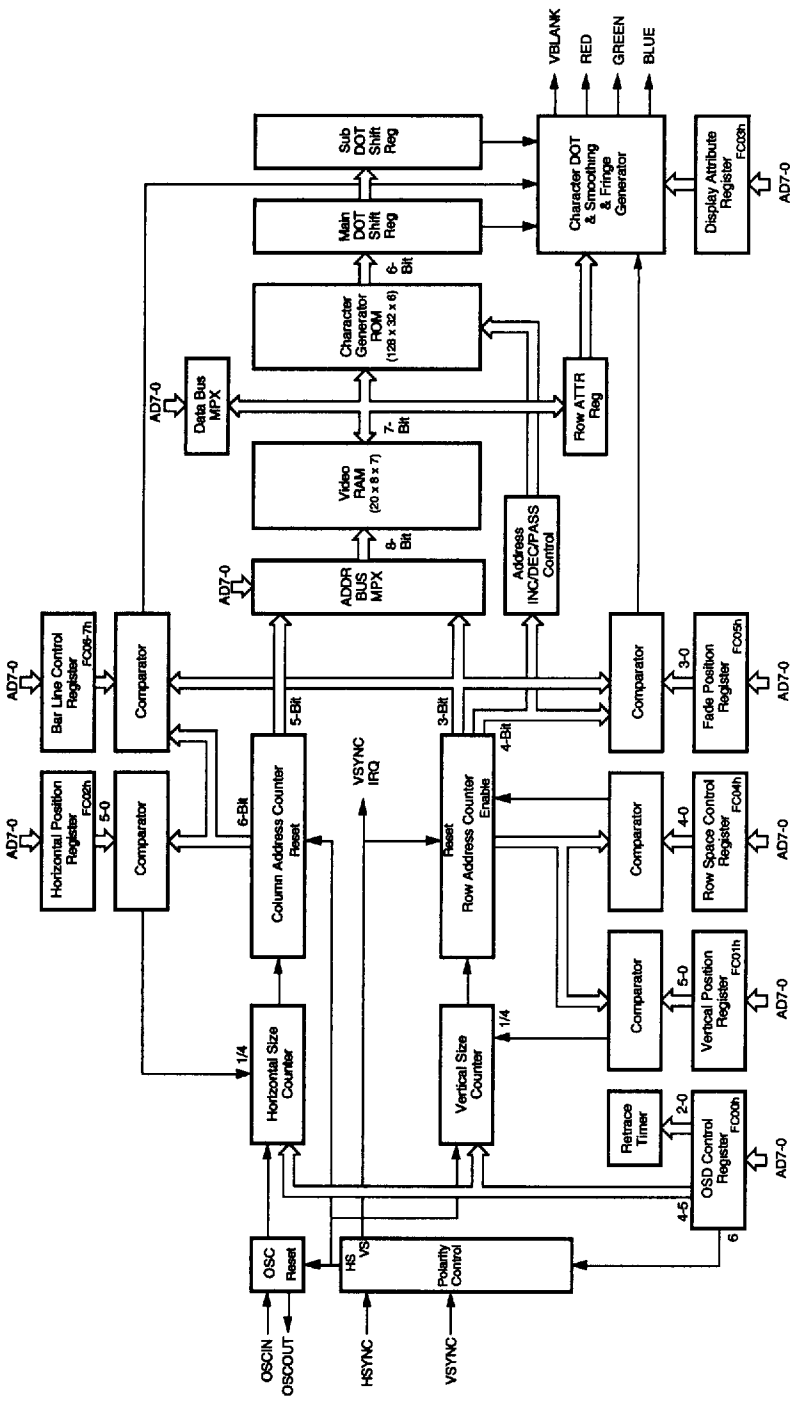


Figure 10. On-Screen Display Block Diagram

The OSD features are as follows:

- **Character Color:** Seven kinds of color are specified on a row basis.
- **Character Pixel Size:** Four character pixel sizes are selected for 1HL, 2HL, 3HL, and 4HL Horizontal Line (HL).
- **Polarity Selections:** Can select active Low or High for horizontal/vertical sync input and RGB outputs.
- **Display Position:** Can display 64 vertical positions by 4HL units and 64 horizontal positions by a 4 dot clock.
- **Inter Row Spacing:** Inter row vertical line spacing is set from 2HL to 17HL.
- **Fade In/Out Control:** Fade position can be determined in vertical direction.
- **Bar Line Type Display:** One of the rows is selected to display an analog bar line every half column by setting second color with proper character set.
- **Fringe Function:** Fringe off/on.
- **Background Color:** Eight kinds of color including black background color.
- **ON/OFF Control:** Character display, backgrounds are turned on and off.
- **Number of Display Characters:** 8 rows x 20 columns.
- **Character Set:** 128, 11 x 15 dots.

Character Generator ROM. The character generator ROM is organized as 4 Kbytes of 6 bits. The ROM defines 11 x 15 dot characters (Figure 11). The Z86E47 is supplied with Zilog's own character Generator ROM.

Video RAM. The Video RAM is organized as 8-row arrays (21 x 7 bits each, Figure 12). The first location of each row array contains the attribute for that row. Row attributes include programmable character color, row background color and control for background off/on. The next 20 bytes contain row character data. Each character byte contains the ASCII code in order to select one of the 128 displayable characters. LDE or LDEI instructions are required to access the Video RAM (Figure 13).

FUNCTIONAL DESCRIPTION (Continued)

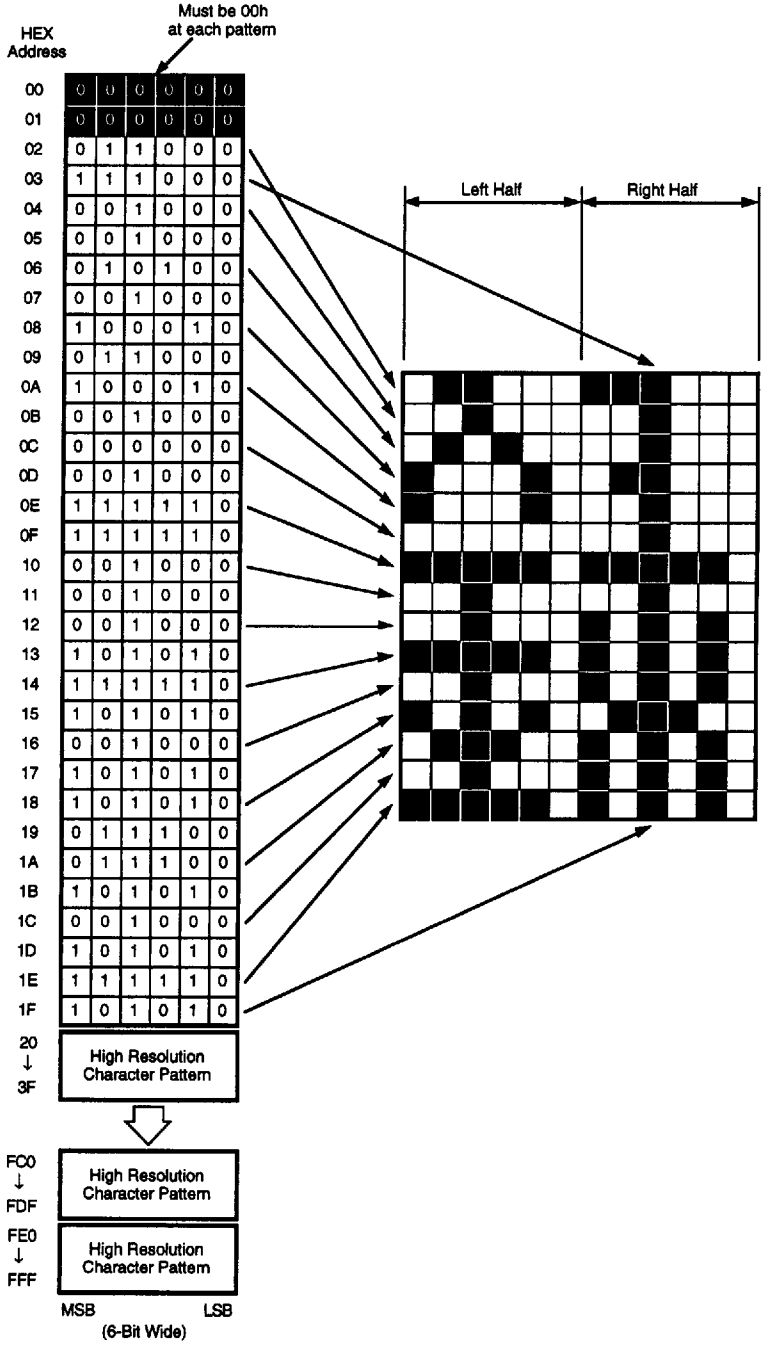


Figure 11. Character ROM Configuration

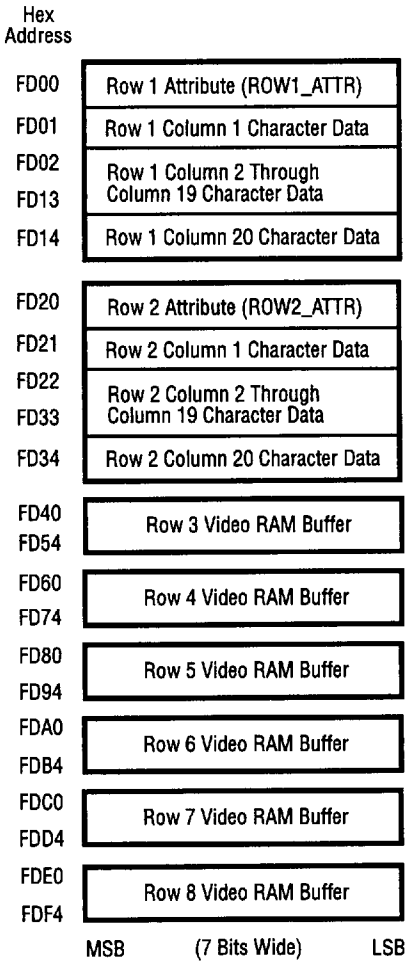


Figure 12. Video RAM Configuration

FUNCTIONAL DESCRIPTION (Continued)

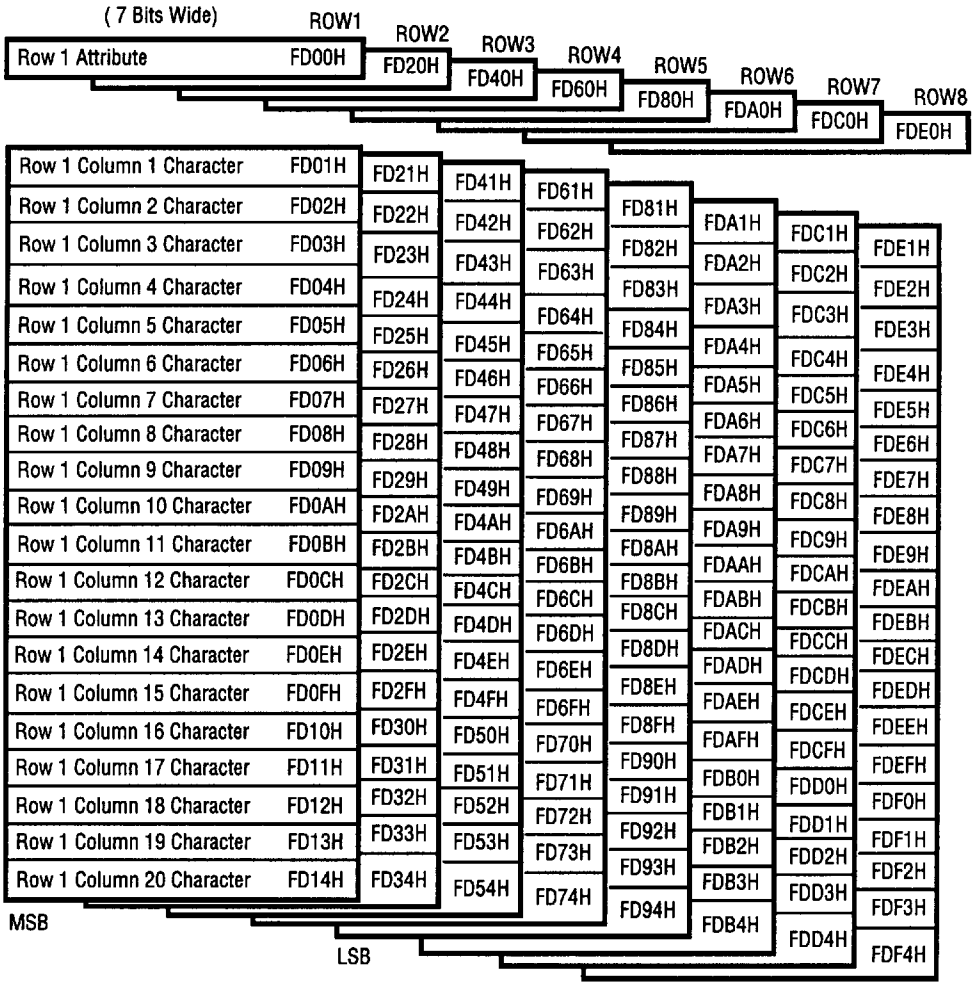


Figure 13. Video RAM Map (Read/Write Registers)

Program Memory. The Z86C47/E47 program ROM size is 16K bytes (Figure 14). The IRQ vector table is located in the lower address space. The vector address is fetched after the corresponding interrupt and program control is passed to the specified vector address. IRQ1 vector is fixed to VSYNC interrupt request and occurs at the leading edge of the filtered VSYNC input. Program memory starts at address 000C (HEX) after reset.

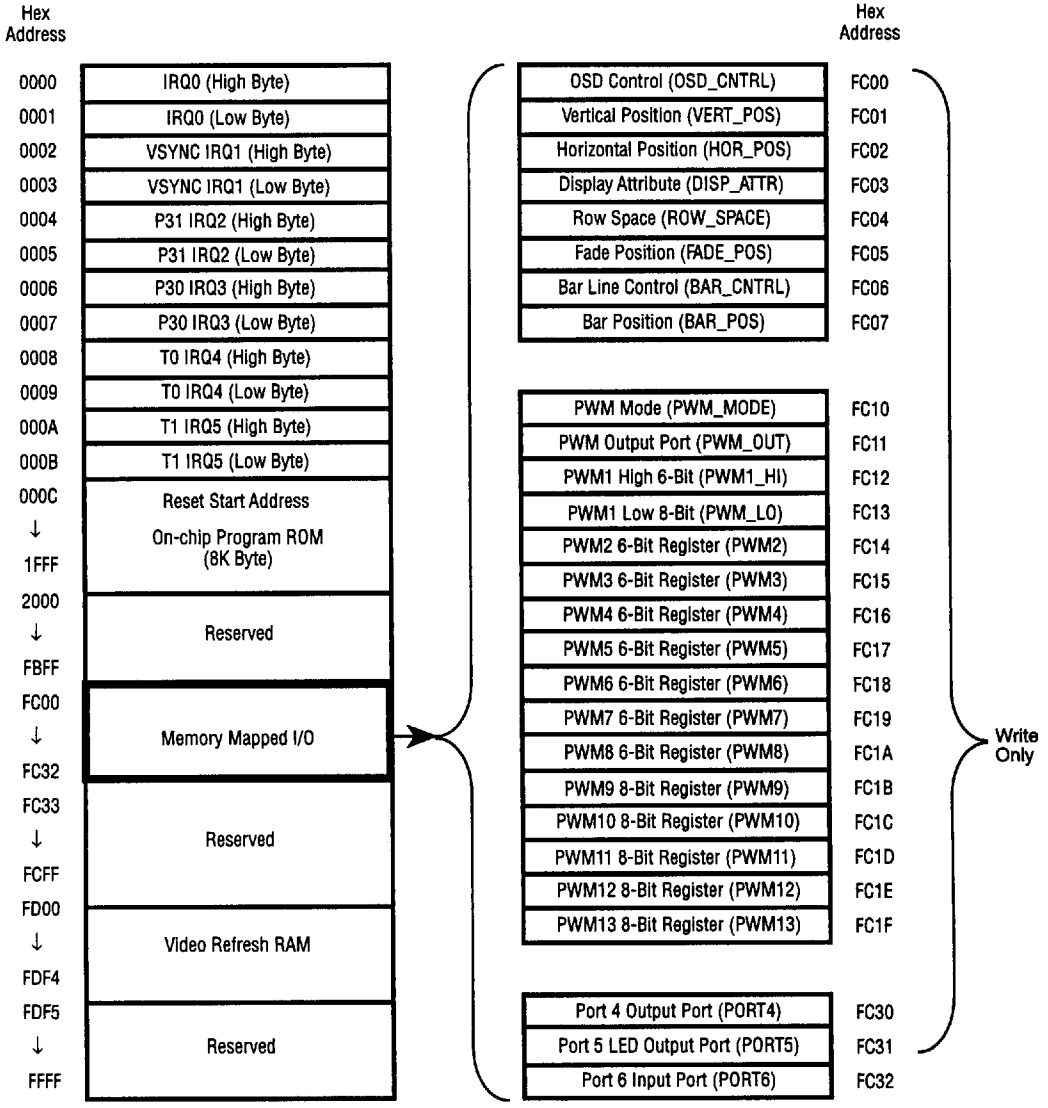


Figure 14. Z86C47/E47 Program Memory

FUNCTIONAL DESCRIPTION (Continued)

Memory Mapped Register. All control registers and I/O ports (except Port 2 and Port 3 and timer, interrupt, flags, and stack pointer control registers are assigned to program memory space. Address space FC00 (HEX) contains OSD control registers, PWM output registers and Ports 4, 5, and 6 I/O registers. Two bits of the decoded AFC_{IN} port are assigned to Port 6 input port. LDE and LDEI instructions are required to transfer data between the Register File and the Memory Mapped Registers.

Register File. A total of 253 byte registers are implemented in the Z8 core. Address 00 (HEX), 01 (HEX) and FO (HEX) are reserved. The Z86C47 register file consists of two I/O Port registers, 236 general-purpose registers and 15 control and status registers (Figure 15). The instructions can access registers directly or indirectly with an 8-bit address field. This also allows short 4-bit register addressing using the Register Pointer. In the 4-bit mode, the register file is divided into sixteen working-register groups, each occupying 16 continuous locations. The Register Pointer addresses the starting location of the active working-register group (Figure 16).

Note: Register Bank E0-EF is only accessed through a working register and indirect addressing modes.

See Figure 17 (Z86C47/E47) for the register file reset conditions.

Hex Address	
00	Port 0 (Internal)
01	Port 1 (Internal)
02	Port 2 (P2)
03	Port 3 (P3)
04	General - Purpose Registers
EF	
F0	Reserved
F1	Timer Mode (TMR)
F2	Timer/Counter1(T1)
F3	T1 Prescaler (PRE1)
F4	Timer/Counter0 (T0)
F5	T0 Prescaler (PRE0)
F6	Port 2 Mode (P2M)
F7	Port 3 Mode (P3M)
F8	Port 0-1 Mode (P01M)
F9	Interrupt Priority Reg (IPR)
FA	Interrupt Request Reg (IRQ)
FB	Interrupt Mask Reg (IMR)
FC	Condition Flag (FLAGS)
FD	Register Pointer (RP)
FE	Stack Pointer High (SPH)
FF	Stack Pointer Low (SPL)

Figure 15. Register File Configuration

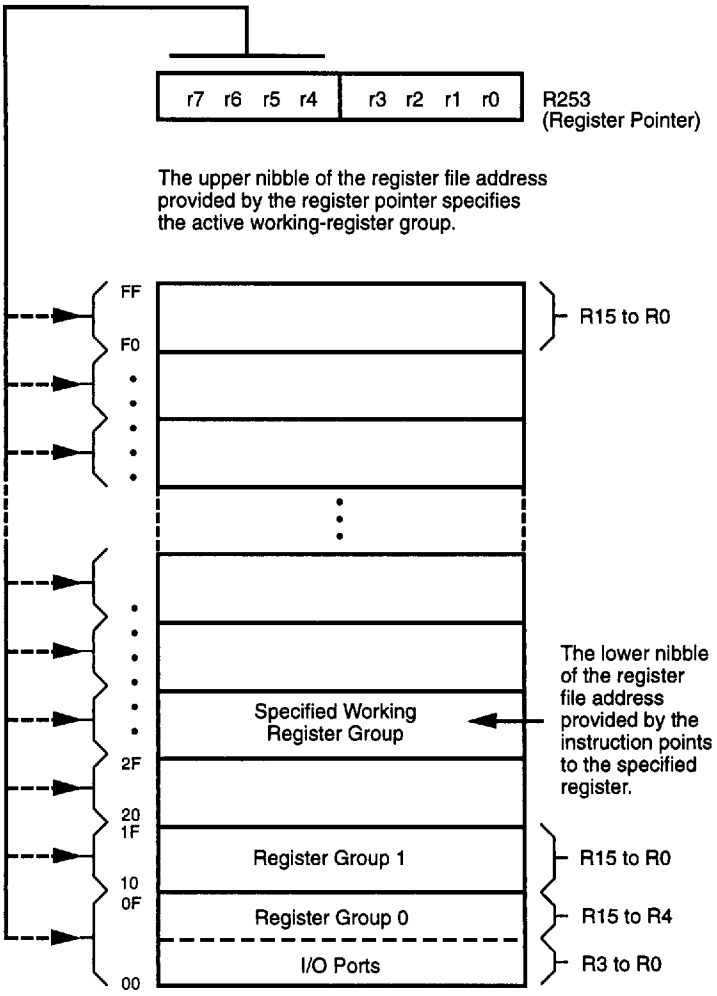


Figure 16. Register Pointer

FUNCTIONAL DESCRIPTION (Continued)

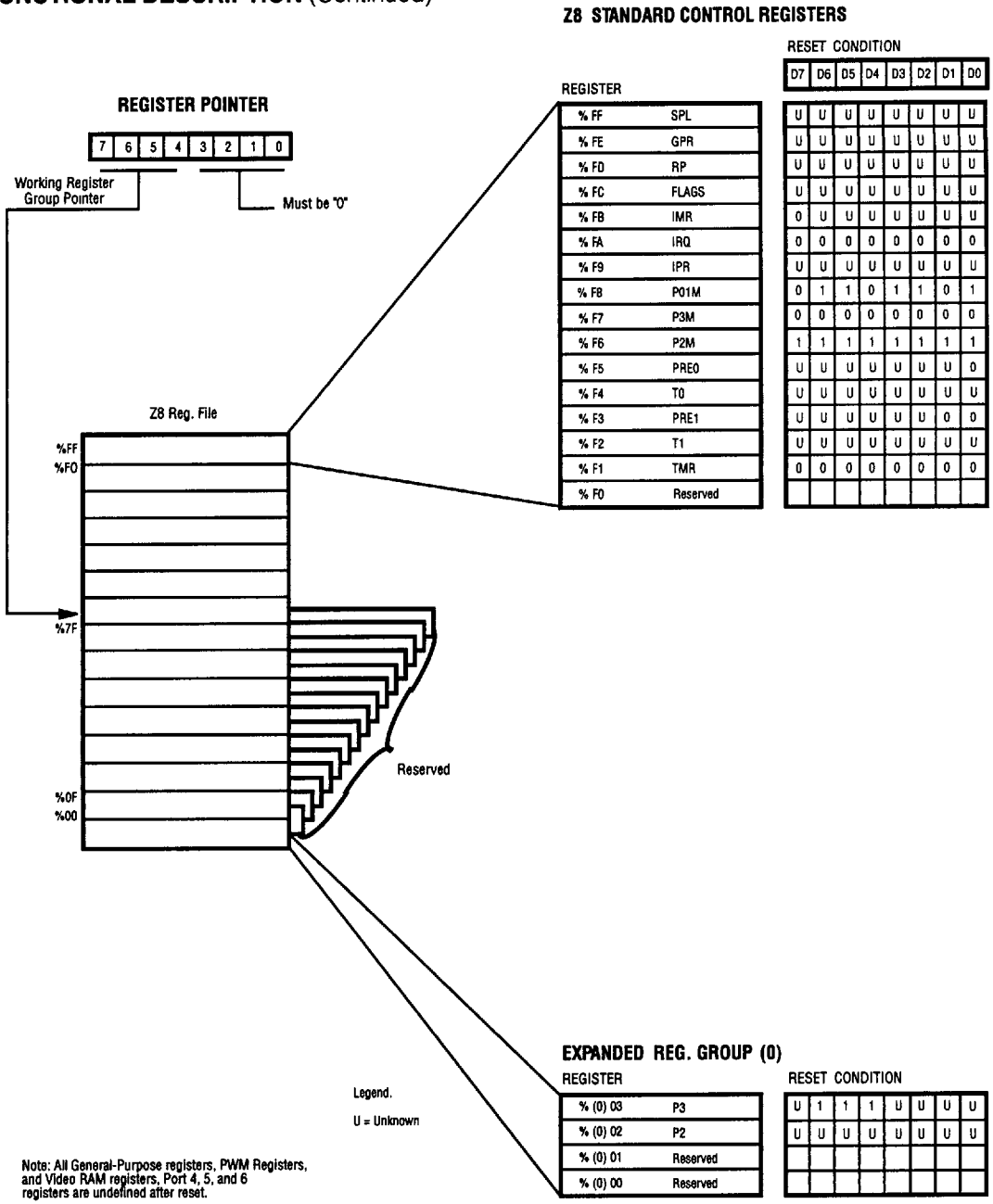


Figure 17. Z86C47/E47 Register File Reset Condition

Stack. Either the internal register file or the external data memory is used for the stack. A 16-bit Stack Pointer is used for the external stack, which can reside anywhere in data memory. An 8-bit Stack Pointer is used for the internal stack that resides within the 236 general-purpose registers.

Counter/Timers. There are two 8-bit programmable counter/timers (T0-T1), each driven by its own 6-bit programmable prescaler (PRE0 and PRE1). The T1 prescaler can be driven by internal or external clock sources; however, the T0 prescaler is driven by the internal clock only (Figure 18).

The counter, but not the prescalers, are read at any time without disturbing their value or count mode. The clock source for T1 is user-definable and is the internal microprocessor clock (XTAL clock/4), or an external signal input through Port 3, P31. The counter/timers are programmably cascaded by connecting the T0 output to the input of T1.

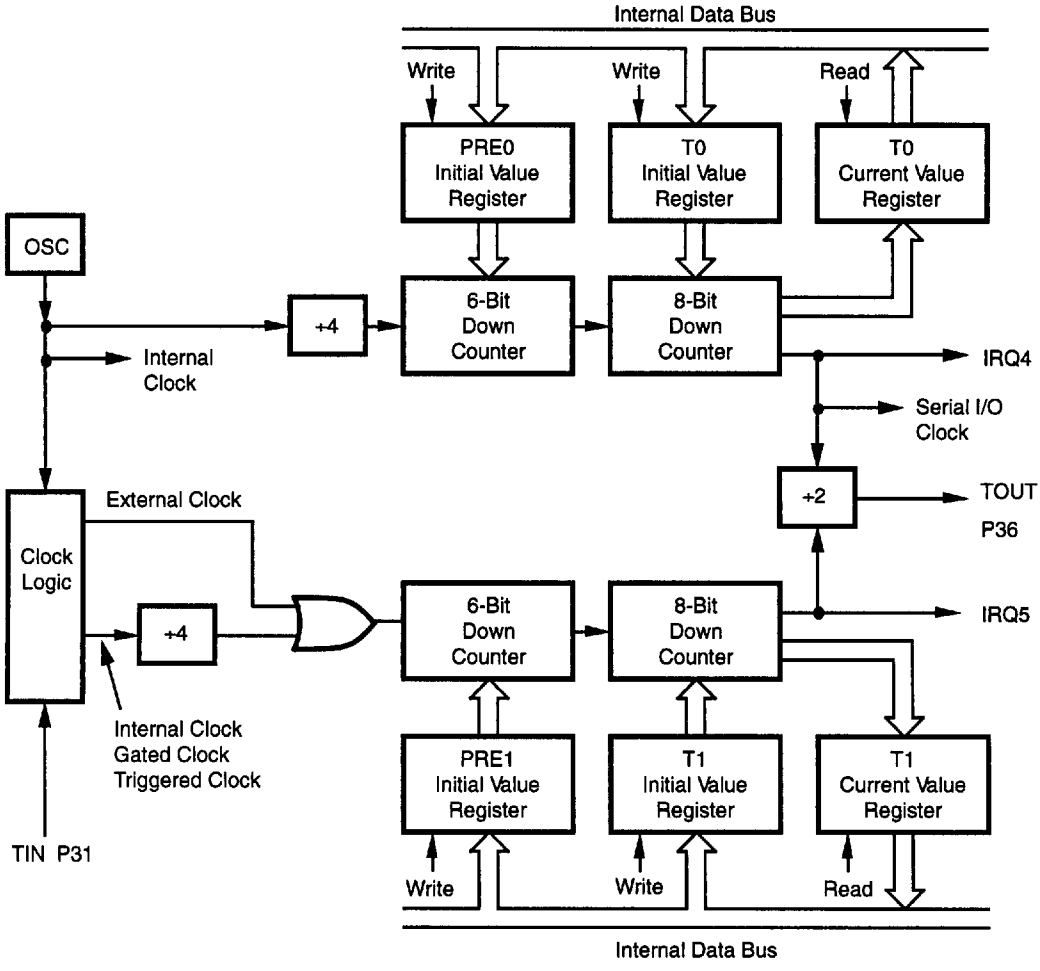


Figure 18. Counter/Timer Block Diagram