Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science
6.111 - Introductory Digital Systems Laboratory

Using the MC6847 Video Controller

Brief Description

The 6847 is a video display controller. It reads data from a RAM or PROM, converts this data to a pattern of dots (pixels or pels), and generates the correct video signal to send to a video monitor. The 6847 can provide color or monochrome displays in a variety of resolutions. It can also display text data in some graphics modes. The 6847 also generates synchronization signals for the TV monitor.

MC6847 data sheet: See p. 15, Figure 17a
The selected mode determines the display characteristics. This mode defines the size, number, and sometimes the color of the display elements. It determines the number of memory locations read and how the data is interpreted. The mode is specified by nine inputs to the 6847.

Choose an appropriate mode for your project display requirements, you don't have to use every available feature of the MC 6847!

Text or Graphics

The 6847 can be used for text or graphics. In the text modes, the screen contains 16 rows, each containing 32 characters. Each position corresponds to a location in display memory. Memory addresses 00 - 1F contain the data for the first row, 20 - 3F for the second row, etc. The displayed character is determined by the value stored in memory. You can use an external PROM or the internal ROM to create the character images. In the graphics modes, the display is made up of an array of boxes, each box being off or on. Each box is controlled by one or more bits in display memory. Text and graphics can be mixed by changing the mode ``on the fly''. This is accomplished by defining the G/A input as a logical function of the 6847's address lines.

Resolution

Resolution, the number of boxes on the display, is an issue where people tend to go overboard in their design. The rule here is ``No more than necessary''. Higher resolution means more memory to modify, more address lines to multiplex, and just more headaches in general. 64 x 64 seems like a very low resolution, but it is adequate for many 6.111 projects. High resolution is most useful for line drawing. It is difficult to calculate and draw more than a few lines in the retrace periods when display memory can be accessed. A fast moving, low resolution, color display probably has the greatest aesthetic appeal.

Color

Color is available in a variety of ways with the 6847. In data sheet jargon, ``resolution graphics'' means a box is off (black) or on (white). One bit in memory controls each box's state. In ``color graphics'', two bits control each box providing off or one of three colors. This complicates the bit manipulation of display memory, but not excessively. Semi-graphics modes provide one of eight colors, but the bit manipulation is more complicated. Semi-graphics modes are good when you're moving a lot of predefined patterns from rom to display memory. Certainly four colors are more aesthetic than black and white.

Interfacing to the Monitor

A diagram of a test circuit for the MC6847 is attached. By changing the switch settings, the mode byte can be specified for internal or external character generation or for Semigraphics 4. Measured timing diagrams are given for the character modes.

We recommend that you build this test circuit (or a similar one) first so that you can resolve the interfacing to the MC6847 and verify the control signals that your project will provide. The mode inputs should be configured as they will be for your project.

The test diagram also includes a circuit for an amplifier which will drive either a monochrome monitor or and RGB monitor. Since there is only one output, one can only realize a single color on the RGB monitor. The 3.3K potentiometer should be adjusted so that the lowest point on the output waveform (the sync pulse) is at zero volts. Be sure and leave pins 1, 5, and 8 of the LF357 unconnected.

When using the RGB monitor, one must also wire up the horizontal and vertical sync inputs as shown on the diagram. Unfortunately, the 6847 produces vertical blanking pulses instead of vertical sync. Therefore, we recommend using a one shot to produce a vertical sync pulse which is delayed so that your display will not be shifted on the screen.

It is more difficult to use the Y, PHI A, and PHI B outputs of the MC6847 to actually produce a color display. A ``digital'' approach is outlined with a circuit diagram appended. The basic idea is to use comparators to convert the MC6847 analog outputs to digital signals and then combinational logic to produce RGB.

The levels from the MC6847 are digitized as follows:

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XH = 1 if phiX > 1.75 volts
XL = 1 if phiX < 1.25 volts
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If you are willing to have ORANGE and Yellow appear as the same color, then the digital TTL outputs can be used to drive the RGB monitor directly by selecting that switch position on the RGB monitor. If you really want a separate ORANGE then you should select the analog position and use the extra 1/4 74S38 to diminish the GREEN voltage as shown which should produce an ORANGE. The logic of this has been verified but there may be minor display aberations due to timing problems with the comparator outputs.

After the interface to the monitor is debugged, wire up the address and data lines to the display memory. To debug this memory, substitute an EPROM with a ``test pattern" for the RAM. This allows you to fully test the video display ``module" independent of the circuitry that calculates the pattern to be displayed.

Bits 4, 5, and 6 determine the color for Semigraphics 4 mode. The values given for Y, phiA, and phiB were measured. The * in the column for L means that it may be either 1 or 0 as the Y voltage is close to the threshold.

Input				Measured			Comp. outputs					To the TV Monitor			
D6	D5	D4	Color	Y	phiA	phiB	L	Ah	Al	Bh	Bl	R	G	B	A = 1 if Y < .6
0	0	0	GRN	.58	1	1	*	0	1	0	1	0	1	0	Ah = 1 if
0	0	1	YEL	.48	1.5	1	1	0	0	0	1	1	1	0	phiA > 1.75
0	1	0	BLU	.66	1.5	2	*	0	0	1	0	0	0	1	Al = 1 if
0	1	1	RED	.66	2	1.5	*	1	0	0	0	1	0	0	phiA < 1.25
1	0	0	BUFF	.48	1.5	1.5	1	0	0	0	0	1	1	1	
1	0	1	CYAN	.58	1	1.5	*	0	1	0	0	0	1	1	Bh = 1 if
1	1	0	MAG	.58	2	2	*	1	0	1	0	1	0	1	phiB > 1.75
1	1	1	ORN	.58	2	1	*	1	0	0	1	0	.5	0	Bl = 1 if
			BLK	.72	1.5	1.5	0	0	0	0	0	0	0	0	phiB < 1.25

Application Examples

A block diagram of a bit mapped display using the MC6847 is shown below. The user circuitry is allowed to access the video memory for reads or writes only when /access_enable is asserted low. The mode control consists of the 8 signals G/A, S/A, EXT/INT, GM2-0, CSS, and INV. Functions of these signals are specified in section 5.

Character Oriented Display Generator with an External EPROM

This block diagram allows the construction of a character based display consisting of 16 lines each containing 32 characters. The characters are 8 bits wide by 12 bits high. The character coding is shown to the right.

The ROW counter (LS161) counting 0 thru 11 is used to provide the low 4-bits of the EPROM address. The RAM provides the character code which is used as the EPROM's high address bits. The LS163 is loaded with a 9 at the start of every frame to ensure that the count will start at zero after the top border lines have been skipped. See Figure 13 on the previous page.

	ROW ADDRESS binary	HEX	DATA HEX
---XX---	0000	0	18
--X--X--	0001	1	24
--X--X--	0010	2	24
---XX---	0011	3	18
---XX--X	0100	4	19
--XXXXX-	0101	5	3E
-X-XX---	0110	6	58
-X-XX---	0111	7	58
--XXX---	1000	8	38
--X-X---	1001	9	28
--X--X--	1010	A	24
-XX--XX-	1011	B	66