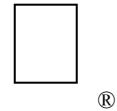


New Technical Notes

Macintosh



Developer Support

Sense Lines

Hardware

M.HW.SenseLines

Written by: Rich "I See Colors" Collyer and Blake Roberts

September 1992

Ever wonder how to set up an Apple video card or an on-board video to support various size monitors? Well, this Technical Note will tell you everything you need to know about what monitors are supported and how.

Sense Lines

The Sense Line Protocol was implemented when Apple recognized the need for a mechanism that would allow a display card to identify the monitor connected to it. For example, the Macintosh IIfx display circuitry and the Macintosh 8•24 and 8•24 GC display cards can now configure themselves according to the monitor that is connected at boot time. The identification scheme works fine, but there is one problem. Three sense lines limit the number of different monitors to seven. To overcome this limitation, newer display cards use an extension to the sense line scheme that allows for 28 new codes.

The extension is based on the following idea: When the display circuitry senses a configuration that in the original scheme signals “no display connected” (in other words, when all three sense lines are not connected), the card pulls down each sense line, one by one, and reads back what the other lines return. To return a unique code, the only requirement is that the sense lines be connected, in the cable or the monitor itself, by wires or diodes. The beauty of this idea is that existing monitors are detected correctly. Newer monitors can have their own encoding, and the circuitry for detecting new monitors is relatively simple. Since there are no active components, adding the encoding to new or existing monitors involves only a few inexpensive diodes and a little wire.

Extended Sense Lines Protocol

The diagram in Figure 1 shows how the extended sense lines are decoded. The idea is for the video card/hardware to hold one line low and read the result of the other two lines. When sense line 0 is held low, sense line 1 and 2 are read.

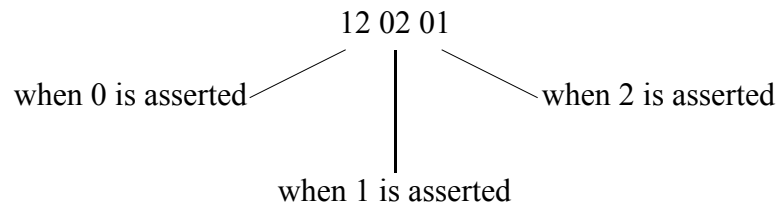
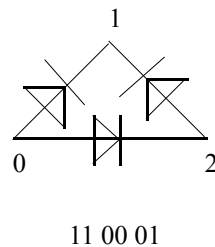


Figure 1 Extended Sense Line Decode Method

To read the chart in Figure 2: The three points of the triangle correspond to the three sense lines. The diodes and wires indicate the interconnect necessary. The six-bit binary number below each diagram (see Figure 3 for all the diagrams) corresponds to the result that will be read when polled. It is read: when 0 is pulled low, 1 and 2 return the first two digits; when 1 is pulled low, 0 and 2 return the second two bits; when 2 is pulled low, 0 and 1 return the last two bits.



The circuitry shown here produces the following code:

SENSE0lowSENSE 1SENSE 2
11
SENSE 1lowSENSE 0SENSE 2
00
SENSE 2 low SENSE 0SENSE 1
01

Figure 2 Extended Sense Line Decode Sample

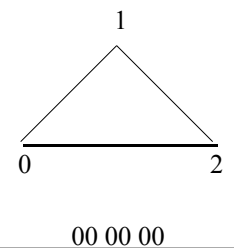
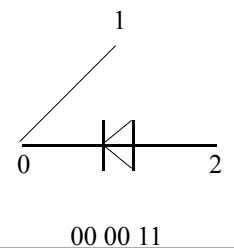
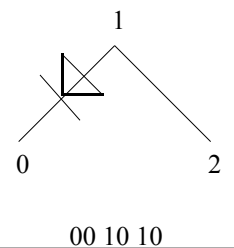
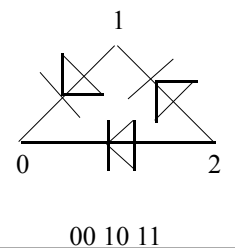
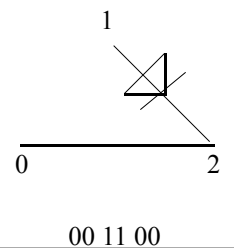
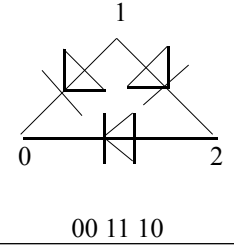
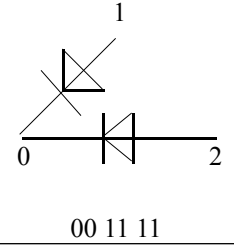
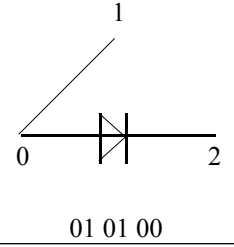
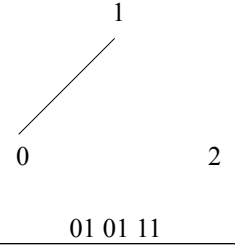
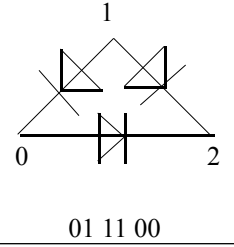
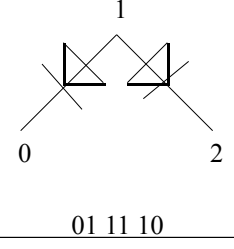
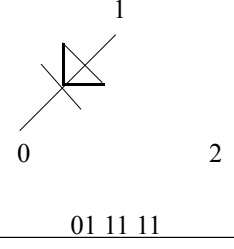
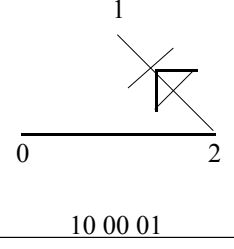
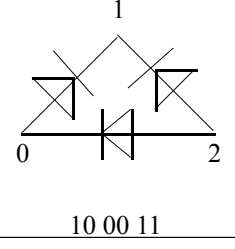
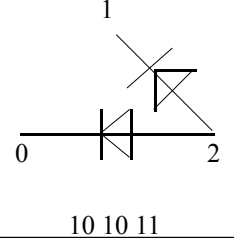
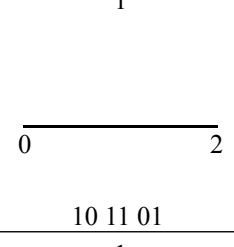
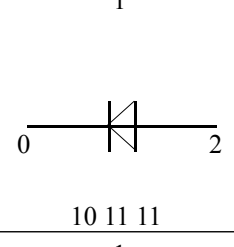
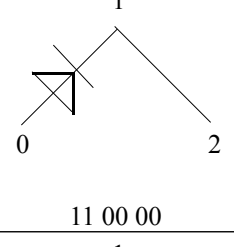
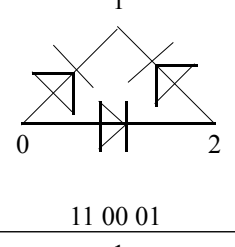
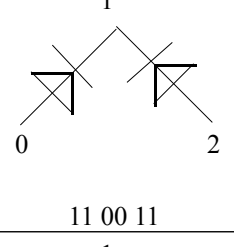
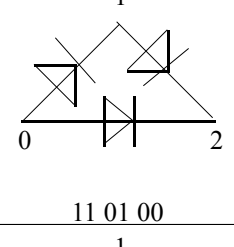
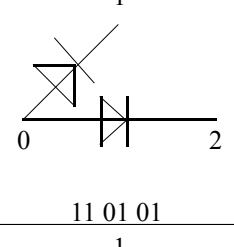
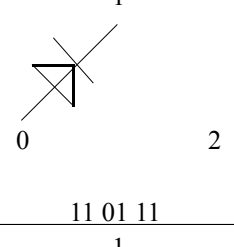
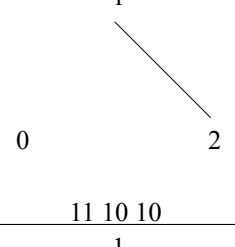
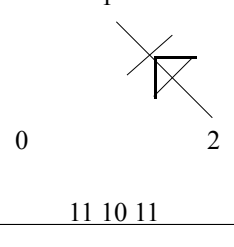
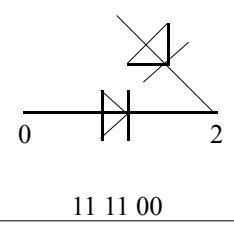
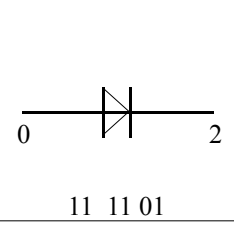
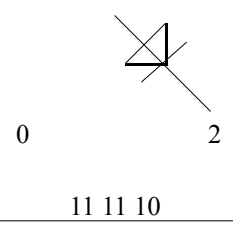
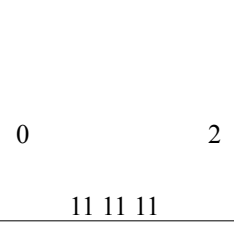
 00 00 00	 00 00 11	 00 10 10	 00 10 11	 00 11 00
 00 11 10	 00 11 11	 01 01 00	 01 01 11	 01 11 00
 01 11 10	 01 11 11	 10 00 01	 10 00 11	 10 10 11
 10 11 01	 10 11 11	 11 00 00	 11 00 01	 11 00 11
 11 01 00	 11 01 01	 11 01 11	 11 10 10	 11 10 11
 11 11 00	 11 11 01	 11 11 10	 11 11 11	

Figure 3 Extended Sense Line Decode Table

Video Connector

Table 1 Signal Assignments for the External Video Connector

<u>Pin</u>	<u>Signal Name</u>	<u>Signal Description</u>
1	RED.GND	Red Ground
2	RED.VID	Red Video Signal
3	/CSYNC	Composite Sync Signal
4	SENSE0	Monitor Sense Line 0
5	GRN.VID	Green Video Signal
6	GRN.GND	Green Ground
7	SENSE1	Monitor Sense Line 1
8	n.c.	Not Connected
9	BLU.VID	Blue Video Signal
10	SENSE2	Monitor Sense Line 2
11	C&VSYNC.GND	Ground for CSYNC & VSYNC
12	/VSYNC	Vertical Sync Signal
13	BLU.GND	Blue Ground
14	HSYNC.GND	HSYNC Ground
15	/HSYNC	Horizontal Sync Signal

Sense Line to Monitors

Table 2 Sense Line Descriptions for Each Monitor

<u>Signal</u>	<u>Sense 0</u>	<u>Sense 1</u>	<u>Sense 2</u>	<u>Frequency (MHz)</u>
RGB 21"	0	0	0	100
NTSC	0	0	1	12.2727 MHz
RGB 12"	0	1	0	15.6672
B&W 12" & RGB 13"	0	1	1	30.24
B&W 15"	1	0	0	57.2834
RGB 15"	1	0	1	57.2834
B&W 21"	1	1	0	100
RGB 16"*	x	1	1	57.2834
RGB 19"*	x	1	1	80
VGA *	x	1	1	25.175
Super VGA *	x	1	1	35.16
NTSC w/Convolution *	x	1	1	12.2727
PAL *	x	1	1	14.75
PAL w/Convolution *	x	1	1	14.75

* Monitors that have an 'x' in the Sense0 column require extended sense line support.

Table 3 Extended Sense Line Descriptions for Each Monitor

<u>SIGNAL</u>	<u>1-2(0 low)</u>	<u>0-2(1 low)</u>	<u>0-1(2 low)</u>
PAL w/Convolution	00	00	00
NTSC w/Convolution	01	01	00
VGA	01	01	11
Super VGA	01	01	11
RGB 16"	10	11	01
PAL	11	00	00
RGB 19"	11	10	10

What Video Hardware Supports What Monitors

** The 16" RGB monitor is supported on this card if the card has a new ROM (see your dealer).

4•8:

<u>Monitor</u>	<u>Max. Bit Depth</u>
NTSC	8
NTSC w/Convolution	8
RGB 13"	8
B&W 15"	4
B&W 21"	4
B&W 12"	8
PAL**	8
PAL w/Convolution**	8
RGB 16"**	4

8•24:

<u>Monitor</u>	<u>Max. Bit Depth</u>
NTSC	Millions
NTSC w/Convolution	Millions
RGB 13"	Millions
B&W 15"	8
B&W 21"	8
B&W 12"	Millions
PAL**	Millions
PAL w/Convolution**	Millions
RGB 16"**	8

8•24GC:

<u>Monitor</u>	<u>Max. Bit Depth</u>
NTSC	Millions
NTSC w/Convolution	Millions
RGB 13"	Millions
B&W 15"	8
B&W 21"	8
B&W 12"	Millions
PAL	Millions
PAL w/Convolution	Millions

RGB 16"***	8
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Macintosh LC/LC II

<u>Monitor</u>	<u>Max. Bit Depth</u>
VGA	8
RGB 13"	8
RGB 12"	Thousands
B&W 12"	8

Macintosh IIci/IIx

<u>Monitor</u>	<u>Max. Bit Depth</u>
RGB 13"	8
RGB 12"	8
B&W 15"	4
B&W 12"	8
RGB 15"	4

Macintosh Quadra 700/900

<u>Monitor</u>	<u>Max. Bit Depth</u>
NTSC	Millions
NTSC w/Convolution	8
VGA	Millions
Super VGA	Millions
PAL	Millions
PAL w/Convolution	8
RGB 13"	Millions
RGB 12"	Millions
B&W 15"	8
RGB 16"	Millions
RGB 21"	8
B&W 21"	8
B&W 12"	Millions

Macintosh Quadra 950

<u>Monitor</u>	<u>Max. Bit Depth</u>
NTSC	Millions
NTSC w/Convolution	8
VGA	Millions
Super VGA	Millions
PAL	Millions
PAL w/Convolution	8
RGB 13"	Millions
RGB 12"	Millions
B&W 15"	Thousands
RGB 16"	Millions
RGB 21"	Thousands
B&W 21"	Thousands

B&W 12"

Millions

Table 4 Monitor Versus Video Hardware Versus Supported Depth

							Super VGA					15" RGB				21" RGB
4•8	H	H					H		H	4					4	
8•24	M	M					M		M	H					H	
8•24GC	M	M					M		M	H					H	
Mac LC					H	H	H	T	H							
Mac LC II					H	H	H	T	H							
Mac IICI							H	H	H	4	4					
Mac IISI							H	H	H	4	4					
Quadra 700	M	H	M	H	M	M	M	M	M	H		M			H	H
Quadra 900	M	H	M	H	M	M	M	M	M	H		M			H	H
Quadra 950	M	H	M	H	M	M	M	M	M	T		M			T	T

LEGEND

H = HUNDREDS
8-BIT depth,
256 colors

T = THOUSANDS
16-BIT depth
32,000 colors

M = MILLIONS
24-BIT depth
16.7 million colors

Hope This Helps™**Further Reference:**

- *Guide to the Macintosh Family Hardware*, Second Edition, Displays
- *develop*, Issue 3, "Macintosh Display Card 8•24GC: The Naked Truth"
- *Developer Notes*, (for each CPU)
- M.HW.ColorMonitors