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tech tips

Using The CM2000's Multiburst Pattern To Test A Computer Monitor's Bandwidth

Resolution on computer monitors has been improving steadily since the late seventies. While early computer monitors produced fuzzy images, today's mainstream monitors produce a very sharp, clear picture.

This Tech Tip defines a number of key terms related to bandwidth, shows a bandwidth calculation, and tells how to use the CM2000's Multiburst pattern for testing a computer monitor's bandwidth.

Key Definitions

Pixel – the smallest picture element possible. One of the dots that makes up the displayed image.

Horizontal frequency – the number of times per second the electron beam scans horizontally across the screen and back.

Horizontal pixels – the number of dots that can be displayed horizontally across the screen.

Vertical pixels – the number of dots that can be displayed vertically on the CRT. The number of vertical pixels is similar to the number of scan lines in television terminology.

Vertical frequency – the number of times per second the electron beam scans from the top of the screen to the bottom and back.

Resolution – the number of transitions made between a pixel being on (light) and a pixel being off (dark) on the display.

Bandwidth – the fastest transition between a pixel being on and off, that the monitor circuits are capable of passing and displaying. The higher the bandwidth, the more resolution and clarity in the picture.

Calculating Bandwidth

Vast improvements in computer monitor picture resolution have been made by increasing the horizontal scanning frequency and increasing the number of pixels displayed in one horizontal scan. In other words, more pixels are displayed in less time.

A computer monitor's bandwidth is best checked with a pattern that produces vertical lines that are a single pixel wide (see Figure 1). If the monitor can display a crisp, distinct line, the video circuits have the bandwidth needed to turn on a single pixel at a time. A fuzzy, nondistinct line means the video amplifiers do not have the bandwidth needed to pass the test signal. The signal isn't amplified adequately as it travels through the video circuits (see Figure 2).

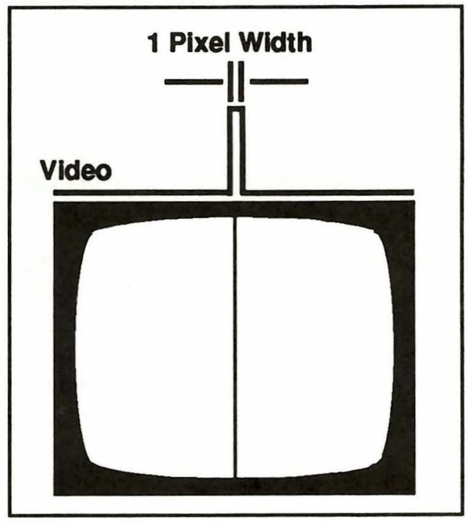


Fig. 1: A one pixel wide line is best suited for testing a monitor's maximum bandwidth.

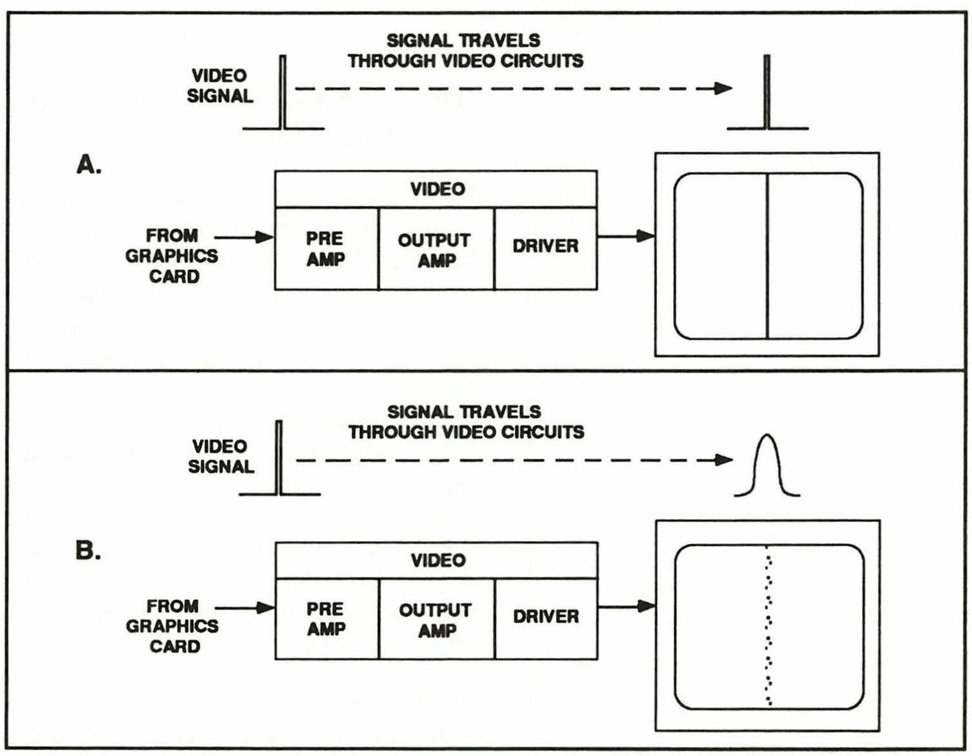


Fig. 2: A.) A crisp, distinct line shows that the monitor has the bandwidth needed to turn on a single pixel at a time. B.) A fuzzy line means the monitor does not have the bandwidth needed to pass the signal.

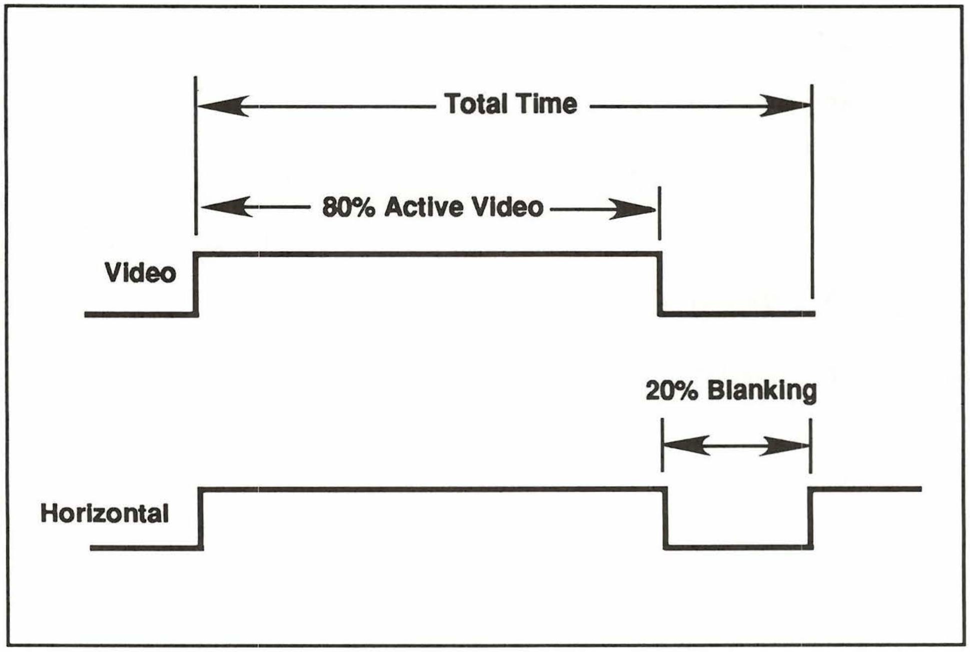


Fig. 3: One scan line is made up of active video and blanking.

The area of concern in a bandwidth test is the area across the display that is seen by the user. This area is called active video. Active video uses about eighty percent of the total horizontal scan time. The rest of the time is spent in blanking – the electron beam is shut off and is moving back across the display (see Figure 3).

For example, let's calculate the required bandwidth of a VGA computer monitor (see Figure 4). The VGA standard has 640 horizontal pixels and the horizontal scanning frequency is 31.5 kHz.

Inverting the horizontal scanning frequency gives a total horizontal scan time of 31.7 microseconds. About 80% of this time is active video (what's seen on the monitor) and about 20% is blanking. So 25.4 microseconds is active video and 6.3 microseconds is blanking.

Horizontal Scan = 31.5 kHz

Total Scan Time = 1/31.5 kHz = 31.7 µsec.

Active Video Time = (80%) (31.7 µsec.) = 25.4 µsec. ***Note: 640 pixels will be displayed in 25.4 µsec.***

Display Time Per Pixel = 25.4 µsec./ 640 pixels = 39.7 nanosec.

Bandwidth required to turn on a single pixel = 1/39.7 x 10^{-9} = 25.2 MHz

Fig. 4: Bandwidth calculation for a VGA monitor.

If 640 pixels must be fit into the 25.4 microsecond active display time, we can find the amount of time it takes to turn on one pixel by dividing 25.4 microseconds by 640 pixels. This shows that each pixel is on for 39.7 nanoseconds (39.7 X 10^{-9} seconds). If we invert 39.7 nanoseconds we get a frequency of 25.2 MHz. So in order to see a crisp, distinct line of one pixel width at the VGA resolution of 640 horizontal pixels, the bandwidth of the video amplifiers must be 25.2 MHz or greater.

Using The Multiburst Pattern For Testing Bandwidth

The CM2000's Multiburst pattern is used for testing a computer monitor's resolution and bandwidth because it has a series of horizontal and vertical lines of varying pixel widths. The sets of vertical lines test horizontal pixel resolution and the sets of horizontal lines test vertical pixel resolution. The lines in each set are grouped according to pixel width. The lines in the first group are one pixel wide, the second group two pixels wide, the third group three pixels wide, etc. The groups of lines that are one pixel wide test the computer monitor to its maximum bandwidth. Each of the lines should be individually discernible on a properly operating monitor.

Because bandwidth is a product of the horizontal scanning frequency, active video time, and the number of horizontal pixels; the bandwidths of the groups of vertical lines in the Multiburst pattern are different for each computer monitor format. Chart 1 (see opposite page) shows the bandwidths for a number of different computer monitor formats. For example, the bandwidth of the "1 pixel on, 1 pixel off" group of vertical lines for a Super VGA computer monitor is 36 MHz.

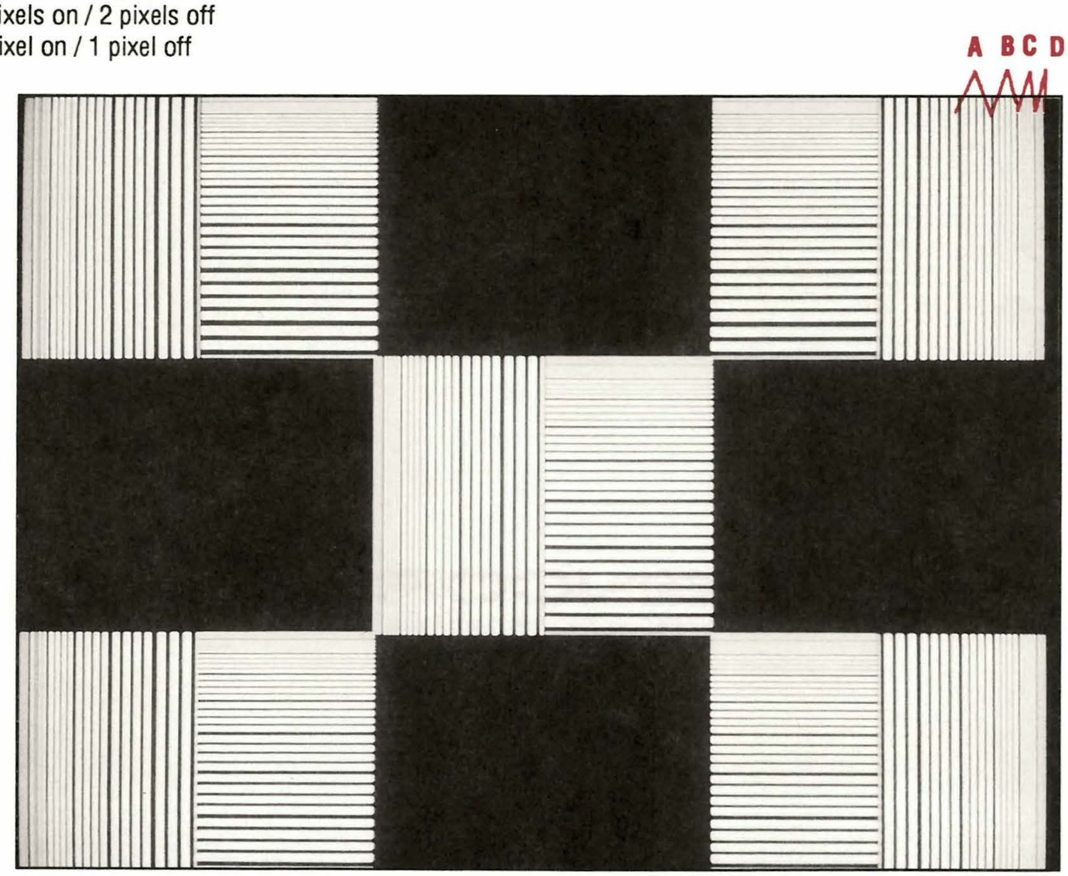
The Multiburst pattern also tests vertical resolution. With vertical resolution we are not concerned with the bandwidth of the signals because these signals are of a much lower frequency. We are instead concerned that we can see each of the sets of lines of 1, 2, 3, and 4 pixel widths.

There are a number of circuits that will keep a computer monitor from being able to display a clear, focused, Multiburst pattern. The monitor may have a problem in the focus or high voltage circuitry, the video circuits, or the CRT.

CHART 1

Computer Monitor Format	H Freq	H Pix	Horizontal Active Vid %	HORIZONTAL FREQUENCY RESPONSE A (MHz)	B (MHz)	C (MHz)	D (MHz)
CGA	15.8	640	71.2%	1.8	3.5	7.1	14.2
Hercules	18.4	720	81.4%	2.0	4.1	8.1	16.3
MDA	18.4	720	81.4%	2.0	4.1	8.1	16.3
EGA	22.0	640	85.7%	2.1	4.1	8.2	16.4
MCGA 2/VGA3	31.5	640	80.1%	3.1	6.3	12.6	25.2
VGA1	31.5	640	80.1%	3.1	6.3	12.6	25.2
PCG	30.5	640	76.6%	3.2	6.4	12.7	25.5
MCGA 1	31.5	720	80.1%	3.5	7.1	14.2	28.3
VGA 2	31.5	720	80.1%	3.5	7.1	14.2	28.3
MAC II	35.0	640	74.1%	3.8	7.6	15.1	30.2
SVGA	35.2	800	78.2%	4.5	9.0	18.0	36.0
8514	35.6	1024	80.9%	5.6	11.2	22.5	44.9
1024x768	48.4	1024	79.0%	7.8	15.7	31.4	62.7
Micro Vax	54.9	1024	80.1%	8.8	17.5	35.1	70.2
Sun	61.8	1024	75.3%	10.5	21.0	42.0	84.0
1280x1024	64.0	1024	76.0%	10.8	21.5	43.1	86.2
Apollo 2500, 3000, 3500, 4500	64.0	1024	75.3%	10.9	21.8	43.5	87.0
IBM RS6000 Color	63.4	1024	72.3%	11.2	22.4	44.9	89.7
Radius	66.0	1024	74.6%	11.3	22.6	45.3	90.5
IBM RS6000 Mono	70.8	1024	74.3%	12.2	24.4	48.08	97.5
Apollo 19" Color	75.1	997	76.5%	12.2	24.5	49.0	97.9

A = 4 pixels on / 4 pixels off
B = 3 pixels on / 3 pixels off
C = 2 pixels on / 2 pixels off
D = 1 pixel on / 1 pixel off



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