

# ***Choosing a Lab Scope***



**An article by Jorge Menchu  
that originally appeared in the  
June, 1996 issue of:**

**MOTOR**

# Choosing a Lab Scope

If you plan on investing in a portable lab scope in the near future, don't do a thing until you read this report.

By Jorge Menchu

**W**e've certainly become better versed in the complex technology of today's automotive systems. And as automotive systems become even more complex, our need for more detailed and accurate diagnostic information becomes even more acute. It should come as no surprise, then, that the lab scope has become such an important weapon in our fight against pollution and driveability problems.

Automotive computers use electricity to communicate with the world around them. The lab scope offers us a very detailed view into this "language." Such information as scanner serial data and DVOM readings are very important to diagnosis, too. But this is *interpreted* data. The lab scope, for the most part, displays the *actual* changes going on in a circuit. With it we can determine whether the correct information is being passed through a system and that a signal is behaving as the design engineer intended. More importantly, a scope allows us to see quick-occurring events other tools simply miss. Fi-

nally, a lab scope can also help us to learn faster, because we now have a tangible object—a picture—that represents the actual goings-on in an electrical circuit.

## Purchasing a Scope

There are many things to consider when purchasing a scope, but probably the first thing you should realize is that a scope that's right for one person is not necessarily right for another. For example, many techs live and breathe this stuff. They may prefer to have a scope that's jam-packed with power features but with no automotive-specific presets or functions. These scopes can take a great amount of time to master. A scope that contains built-in presets for automotive testing, on the other hand, offers a much smaller learning curve for the neophyte scope user.

A good way to start your shopping is to examine your needs and determine how the scope fits into your diagnostic approach. Some questions that you might want to consider are: Do you want the scope for ignition analysis or everything but? Will you connect it to a computer to create waveform databas-



Photo: Jorge Menchu



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es or a portfolio or customer printouts? Will you use it every day? Will other people be using it? Do you want automatic waveform measurement or are you interested only in seeing a waveform? How easy is it to learn to use? How much does it cost? etc. Once you evaluate your needs, the next step is to find out how the various scopes address those needs.

### Specifications

This is where the fun begins. Scope specs and sales jargon can be very misleading. Often such words as *bandwidth*, *sample rate* and *A/D converters* are thrown around as if they alone define what's good or bad about scopes. A lab scope that makes you successful is based on a balance of your needs, your understanding of how it behaves and the features it offers. Each scope has strengths and weaknesses; as you become familiar with these characteristics, you'll be able to overcome the weaknesses and take advantage of the strengths.

Most of the scopes offered for automotive use today—and the most popular—are digital storage oscilloscopes (DSOs) that utilize a liquid crystal display (LCD). These characteristics do present some limitations that can have a direct effect on a scope's performance.

A digital scope samples a signal by taking individual voltage measurements. These samples are converted into numbers and then plotted to the display in connect-the-dots fashion. In the middle of a tough battle, we need to know what our scope is capable of showing us and what it's missing. A scope should answer two important questions when it takes a picture of a signal: How detailed is that picture, and how fast is each new picture being displayed—in other words, what's the update rate?

The detail of each picture is based on screen resolution and the time and voltage settings. The volts/division set-

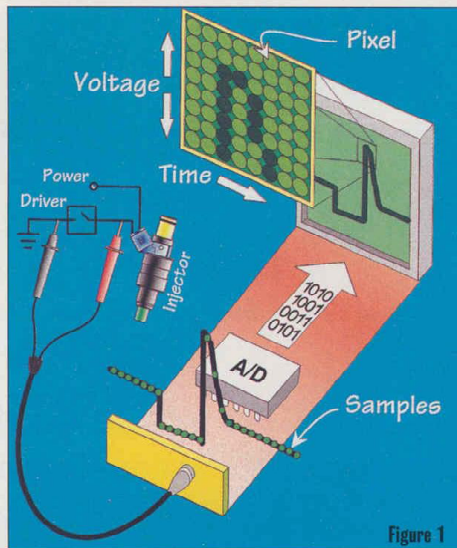


Figure 1

A scope's LCD screen is made up of several columns and rows of lights, called pixels. When a pixel is turned on, the row it's in indicates a voltage level, the columns represent time.

ting determines how tall the waveform will be, while the time/division setting determines how much of the signal will be displayed over time. As we continue, you'll see how screen resolution and the time/division setting can have a major impact on what we actually see.

Let's start by defining the LCD screen. It is essentially a simple grid of lights. These lights are called *pixels* and are arranged in rows and columns, the rows indicating a voltage level, the columns representing time (see Fig. 1). Screen resolution is determined by how many rows and columns are present.

Most of the scopes evaluated for this article have about 250 columns of pixels. Remember, the number of columns represent time. So, we can say that if we wish to display 1 second worth of a signal, it will have to be sampled at least 250 times—once for each column. This also holds true if we wish to display 10mS worth of that signal. It would still have to sample 250 times. As you'd expect, the slower the time/division setting used, the more time that passes between each sample point.

This can create a problem because it increases the chance of fast-occurring signal changes being missed. This might not be so critical on a signal from, say, an O<sub>2</sub> sensor, where we're more interested in the *trend* of the signal. But what about the time/division setting when testing an injector? Fig. 2 illustrates what can happen when the time/division setting

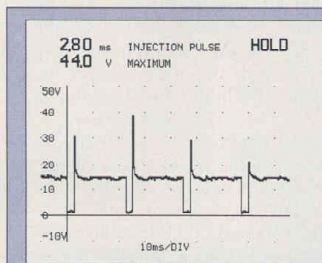


Figure 2

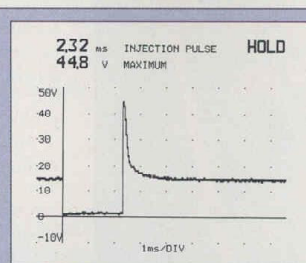


Figure 3

Fig. 2: Is this injector spike intermittently low or is the scope simply not displaying it correctly? In this case, the car ran fine, so the scope setting (10mS/div) must have been too slow. Fig. 3: This is the same injector with the scope setting speeded up to 1mS/div. Note the clarity and detail of the signal. The general rule is: The faster the time/division setting, the less likely it is that you'll miss the high-frequency components of a signal.

Screen captures: Jorge Menchu



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This is a signal from a pulse-modulated injector. The part of the signal after the spike is a very high-frequency digital wave. The distorted pulses are caused by aliasing. Here the injector appears to be bad, but it's actually good!

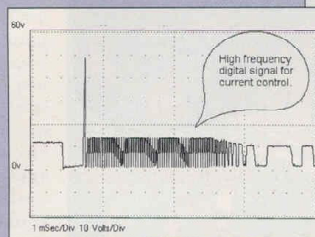


Figure 4

of the scope is set too slow.

To battle this display problem, instead of spreading the 250 samples across multiple instances of the injector signal, try speeding up the 250 samples so the signal will be spread across only one instance (see Fig. 3).

Another problem that a faster time/division setting can help alleviate is *aliasing*. Aliasing occurs when the sample rate is not fast enough to recreate the signal accurately (see Fig. 4). Some scopes offer something that allows us a little more flexibility when dealing with aliasing and missed high-frequency changes. That something is called Glitch Capture (a.k.a. Min/Max or Peak Detect). This feature causes the scope to sample at a very high speed regardless of the time/division setting or screen resolution (see Fig. 5). It will store in memory the highest and lowest values encountered, then display these values when plotting to the display. I consider this a scope *power feature*!

Now that we've covered the resolution question, let's move on to screen refresh rate. Most digital scopes with LCDs update only 2 to 7 times per

second. This is important to know. For example, when looking for an intermittent glitch, we try to relate the occurrence of a problem to a change in the displayed waveform.

But what happens if the problem occurs and the display shows no related changes in the signal? Is the signal good, or did the scope not take the picture at the right time because of a slow update rate? Try to test any scope you plan to purchase. Some scopes slow down the update rate when you view more than one channel at a time. Others analyze the waveform and display numeric values, which can also slow down the update rate. Auto Ranging (not to be confused with a static auto setup) can be another culprit. The object is to make sure the scope is configured the best way possible to give the most reliable results for any given situation. Most of the scopes reviewed for this article offer preset automotive setups. Although these presets save you lots of time, they won't always give you the optimum configuration for each situation. So, to take advantage of everything a scope has to offer, learn to control it yourself.

Some manufacturers are battling the update problem by introducing a Flight Recorder mode. This feature

has in the past been found only on large computer-based engine analyzers, but now can be found in some hand-held scopes, as well. In the record mode, the scope will continuously capture a signal into memory (length limited to size of the buffer), which can be scrolled through at a later time for evaluation. A true flight record misses no information within its capture length.

As you can see, most scopes have some limitations. But their advantages far outweigh their disadvantages, given the amount and quality of the information they can provide. And fortunately, most automotive problems are repetitive enough that even with a slow display update rate, a scope will usually capture a problem and display it.

### The Lineup

Unless otherwise noted, all of the scopes listed below can be connected to a computer, have some sort of Help system, are dual-channel units and have preset automotive setups. I have tried to focus on the things that make each scope stand out. I have also included one analog scope and one that's both analog and digital.

#### Fluke 98

Many techs view the Fluke line of multimeters as the industry benchmark. The 98 seems to continue this tradition by being a very high-quality DSO that's made to last.

**Accessories.** Boy, does this scope come equipped! It has one of the best test lead kits in the industry, which includes silicone shielded leads, a low-pass filter, extensions and many types of test probes and clips. Also included is a secondary pickup and trigger...all in a nice carrying case. A handful of dedicated accessories are available for diesel engine testing and to perform current and temperature measurements, all designed specifically for the 98.

**User Interface.** The user interface on the 98 has been greatly simplified over its predecessor, the 97/Auto. This scope utilizes a simple menu system. It has amazingly few selections

Here is an injector test done at 10ms/div with Glitch Capture on. Notice how even the injector spikes are, even though the time/division setting is relatively slow. Glitch Capture can also prevent aliasing.

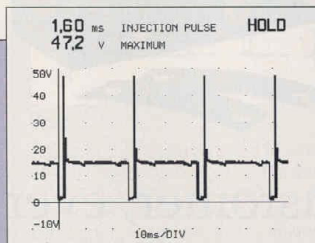
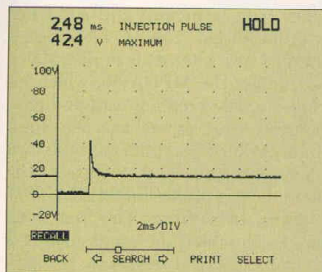


Figure 5





The Fluke 98's image area measures a perfectly square 3.6x3.6 inches. Note how well the screen is laid out. The vertical line by the initial injector drop is the trigger horizontal position.

to cover all of the different sensors, actuators, and other components found on a vehicle. It can do this because of the unique Continuous Autoset function that automatically and continuously sets the voltage and time settings for the signal under test. Things can't get much easier! The Autoset function, by the way, can be bypassed when screen update rate is an issue.

Fluke has also included lots of on-line help for the 98. There's a dedicated button to call up the context-sensitive Help function, and there's even a setting that displays information about instrument-to-vehicle lead connections for any given test.

**Power Features.** The Fluke 98 can be set up as a regular single-channel or dual-channel lab scope or multimeter, bypassing the Autoset functions. It has a single-channel Clitch Capture capable of nailing a 40nS glitch. The scope software includes three record modes: Plot Readings that chart out measurements of a signal; a Min/Max trend plot with time stamp; and, most importantly, a true Flight Recorder. The Flight Recorder will operate from the slowest time/division setting up to 20ms/div via a unique, patented technique. Ideally, it could be faster, but this is still fast enough to view ignition or injector signals when looking for a major failure. Remember, you don't miss anything during the length of the

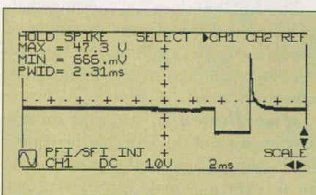
record. The display is well organized and easy to read.

**Miscellaneous.** Other things that make this scope popular are the long-life rechargeable Ni-Cads and a built-in RS-232 port, which allows for quick computer/printer connections.

#### ET-2020 Series 2/KALScope 575

Both of these scopes are manufactured by Tektronix, a precision test equipment company that entered the automotive repair arena several years ago. The ET-2020 Series 2 is sold by Mac Tools, the KALScope 575 by industry stalwart Kal-Equip. Both scopes are identical in operation and functionality.

It's interesting to note that both companies have sold different flavors of this tool in the past. The original Kal-Equip offering did not have pre-programmed automotive setups. The Mac Tools version did, but many improvements have been made since it



The ET-2020 Series 2/KALScope 575 has one of the widest LCD screens available, at 4.72 inches. This waveform was captured using the scope's PFI/SFI INJ preset.

was first introduced two years ago. Buyers of the original ET-2020 can upgrade to the new Series 2.

**Accessories.** The test lead kit supplied with this scope is very complete. It even includes two secondary pickups and all the clips and probes you'd expect to find. The scope also has a very complete operator's manual, and the training video is a must-see!

Other extras include an RS-232 adapter, AC charger and Ni-Cad power pack. The scope comes standard with alkaline batteries. And, as with most scopes, you can connect amp probes and other transducers.

**User Interface.** This scope's user interface is a bit different from the others, largely due to its small size and the fact that the screen takes up most of the front panel. The controls are lined up single-file around the bottom and right side of the display. At first it can be a bit awkward finding the control you need but, like anything, you soon get used to it.

This scope has the most preprogrammed automotive setups in the industry—over 70! These include dual-signal setups for dual O<sub>2</sub> or cam/crank sensors. It also has a special ignition test for DIS using dual secondary pickups. Anytime a preset-up is used, relevant measurement values are displayed automatically. After a presetup is selected, an optional help screen appears offering instruction and other options.

**Power Features.** The LCD of this scope is the widest of those I tested, yet still has only 256 columns of pixels. This kind of stretches the waveform. The large pixel size makes the waveform especially easy to see.

This scope sports Glitch Capture, which can be turned on or off as needed. Dual A/D converters allow for a 40nS capture on both channels. Tektronix also includes its Dynamic Display, a power feature for use when viewing signals that do not change much, such as ignition signals. For signals that do change, you can use the scope's Flight Recorder, which is set to 200mS all the time. This is ideal in many situations, but really not fast enough to view ignition or injector signals.

Another neat feature of this scope is that you can mount a camera tripod right to the back of it. Sure beats laying it around in the engine compartment.

**Miscellaneous.** Like most of the units evaluated for this article, this scope performs full DVOM functions. It can measure AC/DC voltage, resistance and continuity, and perform a diode check. Each test screen is filled with as many measurement values as possible. The scope can be connected to a computer, but to do so

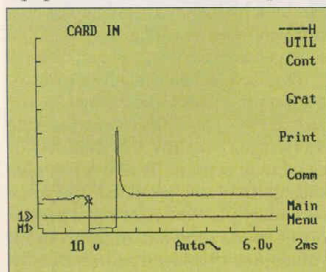


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you must remove the batteries, connect the RS-232 adapter and plug into an AC outlet.

### Sun LS2000

The LS2000 is a rugged piece of equipment that has a rubber protec-



This injector signal was captured by recalling a known-good pattern from the LS2000's on-board library. Doing this displayed the healthy pattern along with the live signal.

tive holster similar to the Fluke 98's. It should be able to take lots of abuse.

**Accessories.** This scope comes with multimeter-type test leads, but it would be better to have a good set of shielded leads. If you buy this scope, make sure you set aside some extra dough for an upgraded lead set.

**User Interface.** This scope has a nice user interface, with a good balance of menus and buttons, and the result is a scope that can be adjusted very quickly. As lab scopes go, the LS2000 has all the functions and most of the flexibility you'd expect. It comes with preloaded waveform examples that can easily be viewed on-screen. These previews are also used to auto-setup the scope for testing. For example, if you wish to test an injector, simply recall the known-good example from memory and hit the Run option. The "known-good" pattern will remain on the display along with the live signal!

**Power Features.** The display is one thing that really makes this scope stand out. It has the highest resolution and a 320x512-pixel LCD. Since the viewing area is not much different in size than the other scopes' dis-

plays, the pixels are smaller, resulting in very sharp text and graphics. It also causes the waveform to be thinner. For those with poorer eyesight, this could be a drawback.

More important is the display update rate. It's faster than that of any of the other scopes tested—up to about seven times per second! When set up properly, this is certainly a power feature.

Another unique feature is that this scope has Glitch Capture on all the time. This means it's sampling the signal at its maximum sample rate regardless of the time/division settings. This helps prevent aliasing and ensures that high-frequency events such as spikes are properly displayed. This is great for most tests but can be too sensitive for testing O<sub>2</sub> sensors or alternator AC ripple. To control this, make sure you use a good set of shielded test leads or, better yet, a low-pass filter.

The LS2000 does not automatically measure the waveform like some of the other scopes do, but you can invoke the cursor function to measure voltage and time.

**Miscellaneous.** Another unique characteristic of this scope is the trigger level setting. There's a dedicated button for this setting, making it very quick and easy to adjust. The trigger source, by the way, is also dedicated to channel 1, which actually simplifies scope use—one less thing to worry about.

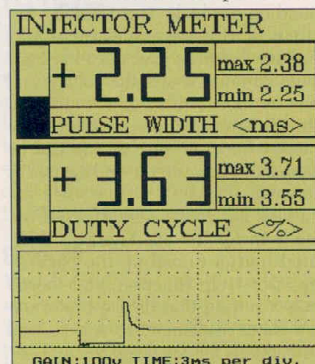
### OTC Vision/Matco inSight

The Vision and the inSight are identical scopes designed by Interro Systems. Unlike the inSight, the Vision utilizes a positive-action membrane keypad. When you install the AC charger and the RS-232 cable to these scopes, you open up a rubber boot that also exposes some of the PC board. Be careful! You don't want metal shavings or liquids entering here.

**Accessories.** These scopes come with a handful of shielded test leads and 5-way clips. They also include a 10:1 probe for testing O<sub>2</sub> sensors. OTC now ships a secondary ignition

lead, trigger pickup and AC filter with the Vision. The AC filter lead is used to view alternator ripple. Matco now offers the MPDA 50, which includes a new program card and ignition test leads, as well as a waveform library. Matco also offers a full-blown ignition analyzer kit that upgrades the 50 to the top-of-the-line MPDA100.

**User Interface.** The first thing you notice about the scope menus is the large, easy-to-read text. Navigating the menus is straightforward as well. You use the arrow keys to go from option to option and hit the Enter key to act. For every level of menu you go into, you simply hit the Exit key to back out. On certain screens it can be somewhat confusing as to which arrow key to push. There's access to a Help menu for



The Vision/inSight provides loads of diagnostic information. Here is the Auto Meter's injector preset. Note the six different values (live and min/max) for each parameter. And yes, those are bar graphs on the left portion of the scope's screen.

each screen via a Function key (F1).

These scopes offer five of the most popular preprogrammed auto setups—injector, O<sub>2</sub>, analog (MAF/MAP), digital (MAF/MAP) and TPS. The AUTO METERS setups will display a waveform as well as helpful measurement values. In some cases, they'll include a chart recorder display along with the numeric values.

**Power Features.** There are



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many things that make these scopes interesting. The first thing is that they're actually a PC. They become a lab scope when you add the appropriate program card and lab scope module. This strategy allows for lots of flexibility. Matco currently offers an ignition analyzer kit that will work with both the Vision and the inSight. It's capable of displaying DIS as well as conventional ignition patterns. It wouldn't be surprising to see these scopes evolve into a scan tool, 5-gas display or other dedicated tester in the future.

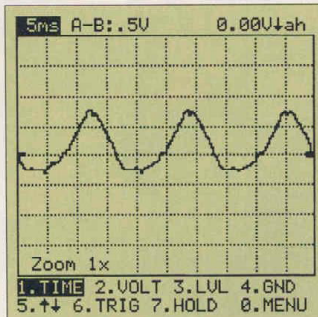
These scopes have four input channels; all others covered in this article have only two. You can test four individual circuits and display all four as waveforms or, when in the DVOM mode, six different measurement windows such as voltage, frequency, duty cycle, etc. Imagine testing all four wheel speed sensors at the same time! When viewing the four channels, each waveform is in time sync with the others. Sending these screens to a printer or computer can certainly produce some impressive handouts for training.

These scopes sport a unique Record function that automatically records up to 50 screens of data that can be played back. Yes, played back, as if it were live! Imagine capturing a problem in the record buffer and playing it back for the customer to show what went wrong with his or her car! The Record function is not a continuous record, however. It's based on the regular update of the screen, which is saved to memory.

**Miscellaneous.** The OTC and Matco scopes offer a few different report formats for dumping the screen to a serial printer. They can be connected to a PC with a low-cost serial cable. The screen backlight is especially bright.

### Mastertech

The Mastertech is made by Vetronix and sold by Mac Tools. It's a well-built unit that comes with a protective holster to handle the rigors of everyday shop use. An easy-to-use thumbwheel makes changing screen



Using the Mastertech's Auto Setup feature made easy work of capturing this waveform from a magnetic pickup. Note the Zoom option (lower left), which allows for closer examination of the signal.

contrast on this scope a cinch.

**Accessories.** The Mastertech comes with basic shielded leads and test clips. They're enough to get to work, but your measurements are limited to signals up to  $\pm 20$  volts DC. For the more serious scope user, an Enhanced Diagnostic Lead Set (EDLS) is available, which includes everything needed to view injector, secondary and primary ignition and other high-voltage signals.

**User Interface.** You'll find the user interface especially easy on this scope. It uses the Exit key to back out of menus. The text for most menus is in large, bold letters. There's also a special menu when at the lab scope screen for waveform-related actions.

**Power Features.** This tool currently epitomizes the word *multifunction*. At present it's a scope, DVOM and, most important, a full-function scanner. Despite its multifaceted chores, it still does a good job getting waveforms on the display.

The Mastertech features an Auto Setup, measurement cursors, single- or dual-channel displays, up to a 5X zoom and a built-in waveform library. It might not have some of the power features that other scopes offer, but it can get you what you need to view signals. All this from a tool whose

roots are a scanner!

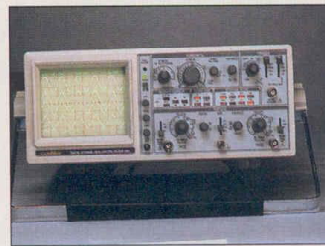
But wait, there's more. As a DVOM, it offers a full-screen display of voltage, frequency and duty cycle measurements. Displayed along with the live readings are Min/Max values. And, according to Vetronix, you can now view OBD II serial data and multimeter data on the same screen (although I did not test this).

**Miscellaneous.** The Mastertech's scanner data as well as the screens from the meter and lab scope can be captured to a PC or printer.

### Goldstar OS-3040

The OS-3040 is a traditional bench-style electronics lab scope. It uses a CRT that updates in microseconds! This scope is a true analog/digital job in one package.

**Accessories.** The scope comes with 10:1 probes from the electronics industry. These are not suitable for au-



tomotive work, so if the OS-3040 piques your interest, plan on investing in a good automotive test lead kit, such as my AES C-286.

**User Interface.** The OS-3040 has a traditional analog lab scope front panel, so it takes some getting used to. There are no preprogrammed automotive setups. Along with the standard controls is an extra set of buttons to access the DSO functions. All controls are laid out logically.

**Power Features.** It's hard to beat the confidence of an analog scope that can update in microseconds. And it's hard to beat the charting ability of a digital scope when viewing, say,  $O_2$  sensor signals. With this scope you can do both!



The OS-3040 has cursors for measurement in both analog and digital modes. Even time and voltage settings can be displayed. At 40mHz, the screen is bright, although you'd want to shade it in high-light situations. Want to take the OS-3040 on a road test? No problem. Just connect a voltage inverter and off you go.

**Miscellaneous.** This scope can save waveforms to memory, which can then be downloaded to a PC. The waveform memory is not battery-backed, though, so you can't unplug the scope until you've saved your work.

#### BK 2120

The 2120 is an analog job all the way—a traditional bench-top electronics lab scope.

**Accessories.** BK has created an automotive scope by including a good




automotive test lead kit with ignition pickup and more. Also included is a nice operator's manual with instructions for automotive work.

**User Interface.** This scope has a standard analog scope front panel, which takes some practice to get comfortable with. There are no pre-programmed automotive setups, either. But using the operator's manual and noting how each control is logi-

cally laid out should shorten the learning curve.

**Power Features.** Analog! And that means a fast screen update. What's at the probe tip is what's displayed on-screen.

**Miscellaneous.** The 2120 has a 20mHz bandwidth and dual-channel capabilities. And it's low in cost. If you can't afford a digital scope but want to get started viewing waveforms, this scope may be the ticket. 

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**More information**

While this article was written in 1996, it is still very relevant. Most of the scopes and accessories mentioned are still available and some have even been improved. To see what scopes are available as well as find accessories for your existing scope, visit our online store at [www.aeswave.com/products](http://www.aeswave.com/products).