

INTRODUCING THE NEW GENERATION

The 7504 and 7704 with their array of 13 plug-ins are the vanguard of a new oscilloscope line designed with an unprecedented degree of flexibility in anticipation of future requirements. Each instrument accepts up to four plug-ins and can display its output in a wide variety of ways. Blank plug-in panels are available to cover the unused panels if four plug-ins are not required initially.

The new plug-in oscilloscopes are designed to be the most expandable line of oscilloscopes ever developed. Thought has been given to probable technical developments in both components and instruments, and every effort has been taken to ensure the future compatibility of these designs.

The 13 plug-ins provide an overall measurement capability exceeding that of any other plug-in oscilloscope. 5-mV performance at 150 MHz with a full 8-cm scan, 5-mV four-trace performance at 105 MHz, are just two of the features currently available only in the 7000 Series.

The two plug-in oscilloscopes are identical in front panel appearance. The major differences are in the vertical amplifier, the low voltage power supply, and the cathode ray tubes. The 7504 with appropriate plug-ins provides up to 90 MHz bandwidth performance, while the 7704 has 150 MHz capability.

Possibly the most dramatic feature of the new instruments is the readout capability. Auto scale-factor readout is a standard feature of both oscilloscopes and automatically provides a display of vertical and horizontal sensitivity. By providing the correct scale factors on the face of the CRT, the operator is relieved from simple but bothersome mental calculations. Plug-in knob settings are read out on the CRT screen by means of a unique character generator which time-shares the CRT beam with the normal oscilloscope display.

Magnifier settings and probe attenuation are automatically taken into consideration. Therefore, the operator always reads the value at the probe tip at the correct sweep speed. Should plug-in polarity be inverted, an indication (\downarrow) is given. If any knob becomes uncalibrated, a greater than symbol ($>$) will precede the quantity. A photograph will include both the analog display and alphanumeric data, eliminating the possibility of incorrect labeling.

A new trigger circuit is featured in the new oscilloscopes that greatly simplifies trigger operation. The peak-to-peak auto trigger circuit detects the peak-to-peak excursions of the displayed waveform, stores the value in the peak-to-peak memories, and matches the range of the level control to the range of the displayed signal. With the trigger in the peak-to-peak auto position, the operator can go through the maximum excursions on either slope and never reach an untriggerable position on the control knob.

Switching in the 7000 Series is accomplished in the mainframe of the oscilloscope. Five vertical mode push buttons and four horizontal mode push buttons determine which plug-in outputs will be displayed. Twenty possible combinations of vertical and horizontal operating modes are provided for maximum versatility. This design choice allows comparison between any two vertical channels to enable comparison of signals with significantly different characteristics. For example, sampling (50 Ω) and conventional (1 M Ω); wide bandwidth and high sensitivity; differential comparator and current probe; dual trace and dual trace for four-trace operation are all easily accommodated in the appropriate plug-ins. In addition, as higher performance or special performance plug-ins are developed, they may be used with a more conventional unit.

The center two compartments are designed so they may be devoted to sampling capability, spectrum analysis, or

X-Y display. This allows a signal to be observed in a conventional manner while simultaneously monitoring a sampling display, frequency display, or X-Y display of the identical phenomenon.

Switching is also provided between the two horizontal plug-ins to provide sweep-switching capability. In addition to ALT, a CHOP mode is provided which is convenient when observing two displays of greatly different repetition rates. This mode also provides dual-beam capability up to approximately 20- μ s/div sweep speed.

Placing the plug-in interface before the oscilloscope amplifier provides a number of important advantages. For maximum versatility, we have chosen a plug-in output of 25 mV/div at 0 volts in a 50- Ω environment. This convenient interface will allow us to take the maximum benefit of new developments in components and in signal conditioning. In addition, as future oscilloscopes evolve, changes in display sensitivities are easily accommodated with the buffering vertical amplifier.

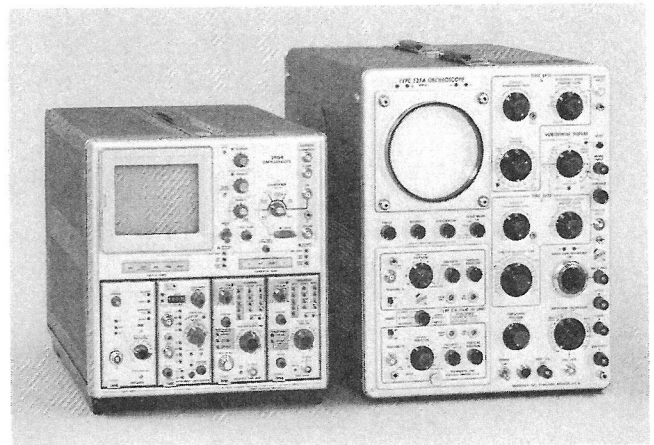
Although this design choice increases the initial price of the oscilloscope, it decreases the price of each plug-in. With the vertical amplifier in the oscilloscope, it is not necessary to build an output amplifier for each plug-in and this saving may be passed along to the customer.

The 150-MHz 7704 utilizes a "high efficiency" power supply which eliminates the bulky iron-core transformer and heat sink and eliminates any necessity for a fan. This new supply dissipates approximately 60 watts com-

7-SERIES PLUG-IN PERFORMANCE

AMPLIFIER	BANDWIDTH		MIN DEFL FACTOR	PERFORMANCE FEATURED
	7704	7504		
7A11	150 MHz	90 MHz	5 mV/div	Low-capacitance FET Probe Amplifier
7A12	105 MHz	75 MHz	5 mV/div	Dual-channel Amplifier
7A13	100 MHz	75 MHz	1 mV/div	Differential DC Offset, High-Freq. CMRR Amplifier
7A14	50 MHz 105 MHz	45 MHz 75 MHz	1 mA/div	AC Current Probe Amplifier (2 current probes)
7A16	150 MHz	90 MHz	5 mV/div	Wide-bandwidth Conventional Input Amplifier
7A22	1 MHz		10 μ V/div	DC-Coupled, High Gain Differential Amplifier
*7S11	350 MHz - 14 GHz depending on Sampling Head		2 mV/div	Sampling Amplifier *Sampling head required
**7M11	2 GHz (175 ps)		X2 atten	**Passive Dual Delay Line Unit

TIME BASE	FUNCTION	MAX SWEEP RATE	TRIGGERING FREQ. RANGE
7B50	Delayed Sweep & Ext. Amp	5 ns/div	DC - 100 MHz
7B51	Delaying Sweep		
7B70	Delayed Sweep & Ext. Amp.	2 ns/div	DC - 200 MHz
7B71	Delaying Sweep		
7T11	Random, Sequential & Real-Time Sampling	10 ps/div	DC - 12.4 GHz



7000 Series and Type 535A. Four plug-in capability and auto scale-factor readout are distinguishing characteristics of the new instrument line.

pared to 140 watts that a conventional supply would dissipate. Use of this new supply removes approximately 12 pounds from the weight of the instrument, providing a 200-W power supply in a 10-lb package.

The instruments make extensive use of color coding to simplify front panel logic for the operator, and improve user interface. In addition, proper front panel component selection has assisted in attaining this goal.

The new R5030 is a dual-beam differential oscilloscope providing 1-MHz, 10- μ V performance in a 6½-inch CRT. The instrument makes use of a fiber-optic readout display adjacent to the CRT area. A separate current mode is provided to accept a current probe (1-mA sensitivity) with no external termination being required.

The instrument is designed for simple operation and uses color coding extensively. Depressing a push button changes the display from a dual beam Y-T to a single beam X-Y display for additional versatility.

Unique to this instrument is a LOCATE function associated with the time-base magnifier. When depressed, the time base is returned to an X1 magnification position and the area which will be magnified is intensified. The magnifier, which is direct reading on the auto scale-factor readout offers five positions of magnification on the time-base switch. The locate feature allows the operator to easily pick out where on the trace he has chosen his magnified sweep.

For further information on all of these new Tektronix instruments, consult your local field engineer. Complete information is given in the August 1969 New Products Catalog Supplement.



READOUT

Since an oscilloscope display is basically a graph, it is logical that the axes be labeled with the scales used, to simplify interpretation of both displays and photographic records. The calibration of this system is accomplished with a coding system that extends to the probe tip and is carried through the plug-in interface. Thus, the oscilloscope takes on the characteristic of a true quantitative instrument.

The 7000 Series introduces a dramatic new system of readout inexpensive enough for oscilloscope use. As oscilloscope displays may present several traces at different sensitivities and sweep speeds, a versatile system is required. A fully integrated electronic character generating system has been developed which timeshares the cathode ray tube with all regular functions. The result is a system which collates within the CRT area all the important parameters of the measurement.

The symbols are 3-mm high and 2-mm wide with spacing 0.3 mm between words. Eight words are possible, four in the upper CRT area and four in the lower CRT area. The intensity of the readout display is adjustable by a front panel control and may be switched off if desired.

The character is written in 9.8 μ s. The display rate is 71.5 Hz, independent of the amount of data. The frac-

tional time taken out of the display is proportional to the number of symbols displayed (0.1% per symbol) and has little effect on the intensity of the normal display.

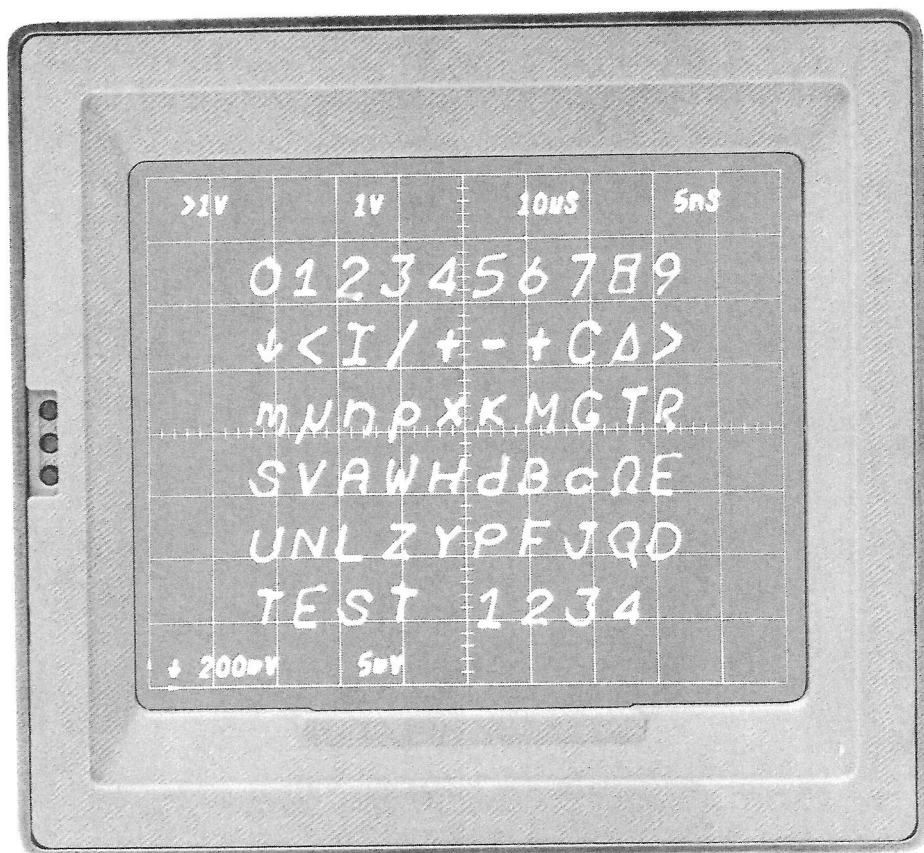
The system uses 14 Tektronix bipolar integrated circuits (the equivalent of some 6000 active devices) and is contained on a 4½ x 5-inch circuit board. The heart of the system is the novel character-generator proper. Utilizing two new circuit principles, ten symbols are packaged in each 65-mil square die, fabricated by the standard planar process. A total of five dice provide a basic 50-character font, but changes in the style of the character (italicization, aspect ratio, size, etc.) are readily made externally. To generate a new set of symbols, it is only necessary to change one mask in the process—the pre-ohmic mask. Since this step is near the end of the process, wafers can be processed in common up to this point.

Each circuit is a complete system, requiring only a power supply and a scanning voltage to produce characters on the CRT. The characters are selected directly by applying a current to one of ten selection pins. The outputs appear from "free" collectors and thus any number of packages may be connected in parallel. The outputs correspond to the scanned X- and Y-values of the complete symbol, and require no further processing. Addressing is performed by currents on column-select lines and row-select lines. The column-select current is in the range 0 to 1 mA, and the character size is directly proportional to it; thus, it is simple matter to generate a display having mixed symbol sizes.

Each symbol is composed of seven strokes, but unlike prevalent seven-stroke generators, the break-points of the strokes may be placed at any one of several hundred locations. In addition, the strokes may have virtually any length and angle, permitting high-quality symbols to be generated by a small number of co-ordinate pairs. Each of the eight break-points consists of an X-co-ordinate and a Y-co-ordinate (no Z-axis information is required to generate the symbol), and these are defined by the number of emitters connected through the pre-ohmic holes in the oxide. A total of 1440 emitters are used in the co-ordinate section of the circuit. This use of multiple emitter-areas as precise current-splitting elements is the first of the features that enabled Tektronix to achieve the high packaging density.

The second feature is found in the method devised for scanning symbols. A simple sequential pulsing of the eight co-ordinates would produce only an eight-dot display. A smooth scanning from one point to the next is required to trace out the character fully. This is achieved by using a resistive ladder network connected to the bases of the co-ordinate-forming transistors.

Multiple exposure. This photograph illustrates a typical auto scale-factor readout at top and bottom. Note the uncalibrated scale of Channel 1 and the polarity inversion of Channel 2. The 50-character font provided is also shown enlarged for clarity, in the center of the photo.



A triangular input waveform smoothly sequences through the co-ordinate pairs, and by proper network biasing produces an X- and Y-current waveform corresponding to the symbol. Scanning rates can be anywhere from DC to a megahertz.

Much of the flexibility of the system stems from the data coding techniques used. Instead of using the usual binary codes, a time-multiplexed multi-level analog current code was adopted, in which the data is divided up into eleven 100- μ A levels at 250- μ s intervals. Since the symbols are stored in a matrix of ten rows (some correspond to the stored instructions, and some are spares) by ten columns, two lines are needed to convey the data out of the plug-in. Data is encoded in the plug-in by switch-closures and resistors. Decoding is accomplished on the readout board by integrated A-D converters (one IC for row and one for column data) which then address the matrix.

Apart from the increased data-handling capacity (some 10^{160} combinations are possible for the readout system), a more subtle advantage results from the use of an analog current code: data can be modified systematically

by the addition or subtraction of levels. For example, one of the instructions controls the number of zeros that follow the first digit of a scaling factor.

Each higher level adds a zero, until two zeros are displayed. The next level causes zeros to be dropped and the prefix (n, μ , m, etc.) to be shifted a factor of 1,000. Consequently, responding to the addition of attenuator probes is a simple matter.

Each word may have up to 10 symbols, although typically there are between 2-5 symbols per word. The symbols are normally written without redundant spaces, but spaces may be called for in the code, if desired. In addition to the scale factor, provision is made for indicating inverted polarity (\downarrow) and not calibrated ($>$ symbol) preceding labeling.

A special "identify" feature is included to determine which scale factor goes with which trace. Depressing the IDENTIFY button replaces the appropriate scale factor with IDENTIFY and deflects the identified trace up a few millimeters. This feature is available on all the new plug-ins and is also present on the new probes introduced.