Tektronix the 7000 Series

The most iconic oscilloscopes in electronics' history

Volume II
Analog and Digital Plug-ins

Giovanni Becattini

References

The following references are used in this book (from Quacktech Editions unless otherwise noted):

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- [7KS] Tektronix 7000 Series – Mainframes – Elektor Books
- [7KPI] Tektronix 7000 Series – Plug-ins
- [TREG] Tektronix Oscilloscopes Restoration Guide – Elektor Books – Sold Out
- [HP1] Hewlett-Packard and its Voltmeters and Oscilloscopes
- [HP2] Hewlett-Packard Signal Sources
- [HP3] Hewlett-Packard Counters and Spectrum Analyzers
- [HP4] Hewlett-Packard Calculators, Computers and HP-IB
- [VRE] Vintage Radio Equipment – Elektor Book
- [MAC] Apple Macintosh – History, Engineering, and Restoration – Elektor Books
- [QT602] The Good Giant – Tektronix DSA 602A Oscilloscope
- [QT11KP] The Last Plug-ins – Tektronix 11000-Series Plug-ins
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- [QTBYOP] Become Your Own Publisher
- [DAB] Digital but Analog
- [TG7] When Machines Learned to Write
- [PDP-8] DEC PDP-8 – The Minicomputer That Anticipated Microprocessors
- [OTTO] Build Your Own Educational PDP-8 Clone Using an FPGA
- [TUB] The Tubes That Changed the World
- [TRC] Tektronix, The Round Corners – From Vacuum Tubes to Early Solid State
- [HEPS] Tektronix, 7000 Series Power Supplies – History, Design and Restoration

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The Most Iconic

This book is dedicated to the Tektronix 7000 Series oscilloscopes—their technology, their restoration, and the people who conceived and built them with exceptional skill. These instruments represent one of the highest expressions of Tektronix's golden age and remain the best-known oscilloscope family ever produced.

Introduced in October 1969, the 7000 Series marked a major step in electronic instrumentation. Although the plug-in concept was not new, it reached a particularly mature and effective form in this platform. Much of the success and longevity of the series depended on the quality of its modular design and on the intelligence of its implementation.

If the mainframes provided the structure of the system, the plug-ins gave it flexibility. They allowed the same oscilloscope to be adapted to very different tasks and applications, greatly extending its practical value.

This volume is devoted to those plug-ins. It follows Volume 1, dedicated to the mainframes, and examines the units that defined the real capabilities of the system: vertical amplifiers, time bases, samplers, spectrum-analysis plug-ins, and others.

The aim of this book is not simply to list models and specifications, but to examine these plug-ins as technical designs, working instruments, and restoration subjects. Taken together, they document a remarkable family of instruments and an important stage in the evolution of electronic measurement.

Giovanni "Gianni" Becattini
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To my wife
and my family



WARNING!

Very dangerous voltages exist inside every oscilloscope, even after it is switched off.

All the technical information contained in this book is intended for EXPERT TECHNICIANS only, fully aware of the connected risks and their management.

If you are not an expert, don't try even to open them under any circumstance, and always refer to the applicable documentation for their use.

Tektronix
The 7000 Series

Volume 1

Volume 2





Section

Analog Vertical Plug-ins

Plug-ins were arguably the most distinctive and interesting feature of the 7000 Series. In this section, we will examine many of the Series' analog plug-ins, focusing specifically on those designated "7A" (vertical amplifiers). The following section will be devoted to the "7B" plug-ins (time bases), and even after we will cover the digital models—the "7D" plug-ins.

Analog Vertical Plug-ins

The analog vertical plug-ins described in the following pages.

Notice that the 7A13 is present both in analog and digital group, having received in 1976 a new built-in digital voltmeter and the related display.



7A12

110-MHz Dual trace Amplifier

(1969)



7A13

100-MHz Differential Comparator

(1969)



7A18

75-MHz Dual-trace Amplifier

(1971)



7A19

500-MHz Dual-trace Amplifier

(1971)



7A22

1-MHz 10 μV/div Differential Amplifier

(1969)



7A24

400-MHz 50-ohm Dual-trace Amplifier

(1974)



7A26

200-MHz Dual-trace Amplifier

(1974)

Analog Time Base Plug-ins

The analog time bases are basically of two types: dual integrated (delaying/delayed), or separated delaying and delayed.

The 7B70 described here was the companion of the delaying 7B75.



7B53A

5 ns/div to 5 s/div

Dual Time Base

(1973)



7B85

1 ns/div to 5 s/div

Delaying Time Base

(1976)



7B92A

500 ps/div to 0.2 s/div

Dual Time Base

(1976)



7B70

2 ns/div to 5 s/div

Time Base

(1969)



7B80

1 ns/div to 5 s/div

Time Base

(1976)

Plug-ins for Everything

Tektronix (and not only) produced dozens of plug-ins for the 7000 Series.

Each plug-in model is identified by an acronym; the first digit is always “7”, indicating that the plug-in belongs to the 7000 Series. The second letter specifies the function of the plug-in:

- A — Amplifier unit
- B — "Real-time" time-base unit
- C — Curve tracer
- D — Digital unit
- L — Spectrum analyzer
- M — Miscellaneous
- S — Sampling unit
- T — Sampling time-base unit

The third digit (and any following digits) forms the model number.

According to the information I found online, I was able to count about 65 different models. Some of these are remarkably complex — for example, the spectrum analyzers or logic state analyzers (7D01). Even a complete digital storage oscilloscope had been implemented in a three-unit wide plug-in, the 7D20.



Section

Vertical Plug-ins

Subsection

7A12 Dual Amplifier

One of the “first wave” plug-ins, very peculiar for its forty switches.

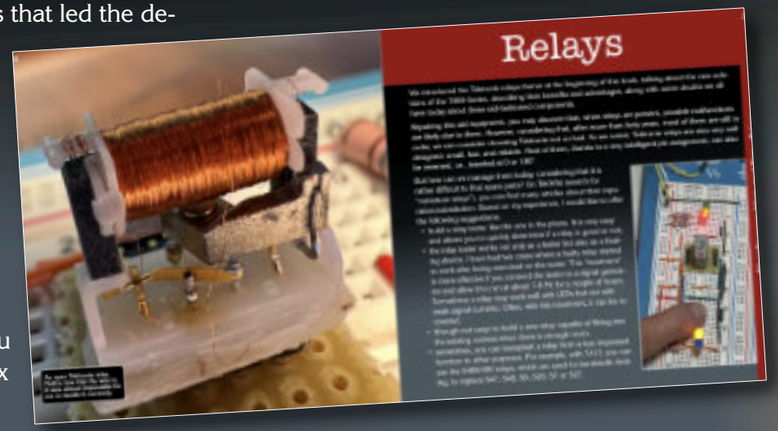
Dual 120-MHz Amplifier

The Tektronix **7A12** is a 120 MHz dual-trace vertical plug-in for the 7000-Series oscilloscopes. It is a rather peculiar device for several reasons.

First, its unique appearance: the front panel features **no fewer than forty** typical Tektronix pushbuttons, twenty of which replace the traditional channel attenuator knobs (ten per channel). It almost feels as if the designers got drunk on the freedom offered by the new miniaturized switches introduced with the 7000-Series.

Another interesting feature of the 7A12 is its ability to **compensate for large DC offset voltages** (±500 divisions), a theme that will be analyzed in depth with the 7A22—and that I do not want to spoil here. Unlike the 250 MHz 7A11 plug-in, however, the offset voltage is not available on the front panel for external measurement.

Yet another noteworthy aspect is **the use of relays** in the signal path to set the attenuation level. We have already discussed this Tektronix solution several times, as it was adopted in many of their products. At first, I instinctively distrusted it—so far removed from today's standards. Over time, however, I came to understand the reasons that led the designers to this choice, and even prompted Tektronix to manufacture an entire line of relays specifically engineered for such applications.


Relays

Occasionally, a relay may fail to operate properly—but quite often it can be restored through the right kind of "exercise," unless it is genuinely damaged. You will find much more on Tektronix relay restoration in [TREG].



Circuit Description

The **7A12** is composed of the four modules: **attenuators**, **input amplifiers**, **main amplifiers** and **switching logic**. The main board contains the interfaces to the mainframe and houses both the attenuators and the amplifiers.

The **attenuator** is the part you are most likely to work on, so I will provide some details here that I hope will be useful. The amplifier is designed for a deflection factor of **10 mV/div**, so if you want to observe a larger signal, it must be attenuated accordingly. The attenuator consists of four stages: ×100, ×10, ×5, and ×1 (×1 = maximum gain). Each stage is switched in or out via a relay. Perhaps to simplify the control logic, the first two attenuator stages (×100 and ×10) use an inverted control — but this does not affect overall operation (the inversion is handled by transistors Q60 and Q70). The table shows which attenuators are inserted at each setting, and which trimmers are used for calibration.But how does the 5 mV/div position work? It does not rely on attenuation (as the 10 mV/div setting does, using a direct link), but instead doubles the sensitivity of the amplifier through a dedicated input on U225, activated by Q205.

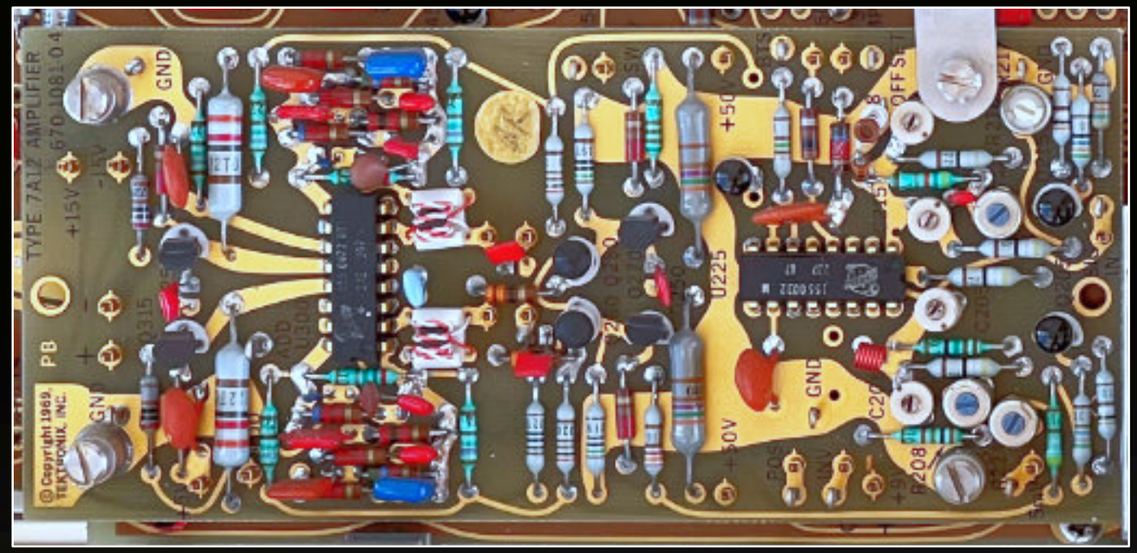
The 7A12 **amplifier circuit** is built almost entirely around a custom IC: U225, the **Tektronix M55** (P/N 155-0032-00), a variable-gain transconductance amplifier, implemented as a monolithic IC in a 16-pin DIP, a very modern architecture for that era. According to TekWiki, even the original chip designers later criticized it:

> *"… This is an undesirable way of doing variable gain control, but neither Roy nor I knew that at the time. It is a noisy configuration. At 0% signal gain, there is lots of noise gain. It has poor thermal balance at anything other than 100%, and the not-very-useful 0% signal gain. In between 0% and 100% gain, the circuit performs poorly in terms of noise and thermal balance…"*

(This habit of regretting earlier designs is, of course, absolutely normal among us electronic designers...)

The IC was later replaced by an improved version (155-0216). But perhaps the original was not so bad after all, considering that it was used in many other projects, including the super-successful **465/475** oscilloscope series.

	X100	X10	X5	X2	Corner	Top
5mV						
10mV						
20mV				X	C19B	C19A
50mV			X		C16B	C16A
0.1V		X			C13B	C13A
0.2V		X		X	Check	Check
0.5V		X	X		Check	Check
1V	X				C10B	C10A
2V	X			X	Check	Check
5V	X		X		Check	Check



Above: The 7A12 main board. Even if turned down, you can see the 155-0032 a variable-gain transconductance amplifier, implemented as a monolithic IC in a 16-pin DIP, a very modern architecture for that era.

Both amplifiers in the 7A12 are mounted on their own separate boards — and the two boards are identical. **A touch of genius**: despite being physically identical, each board carries part of the very interesting switching logic for both vertical DISPLAY MODE and TRIGGER SOURCE — implemented with another custom Tektronix IC, which we will encounter again in many other plug-ins.

The **vertical signal switching stage** responds to the LEFT, ALT, ADD, CHOP, and RIGHT push buttons, and determines which input (CH 1 or CH 2) provides the signal to the oscilloscope display. It consists of another Tek custom IC: U300 (155-0022-00) and its associated components. This IC selects one or mixes two analog signals, based on logic inputs applied to pins 4 and 14. The vertical switch is located on the CH 1 amplifier board.

The **trigger switch** is identical in design to the vertical signal switch described above — but it is located on the CH 2 amplifier board. This stage determines which input signal (CH 1 or CH 2) provides the trigger signal to the oscilloscope's time base unit, depending on whether the LEFT, VERT MODE, or RIGHT button is pressed.

In this way, while the two amplifier boards are physically identical, they can perform different functions.

Dual-trace 75-MHz Amp

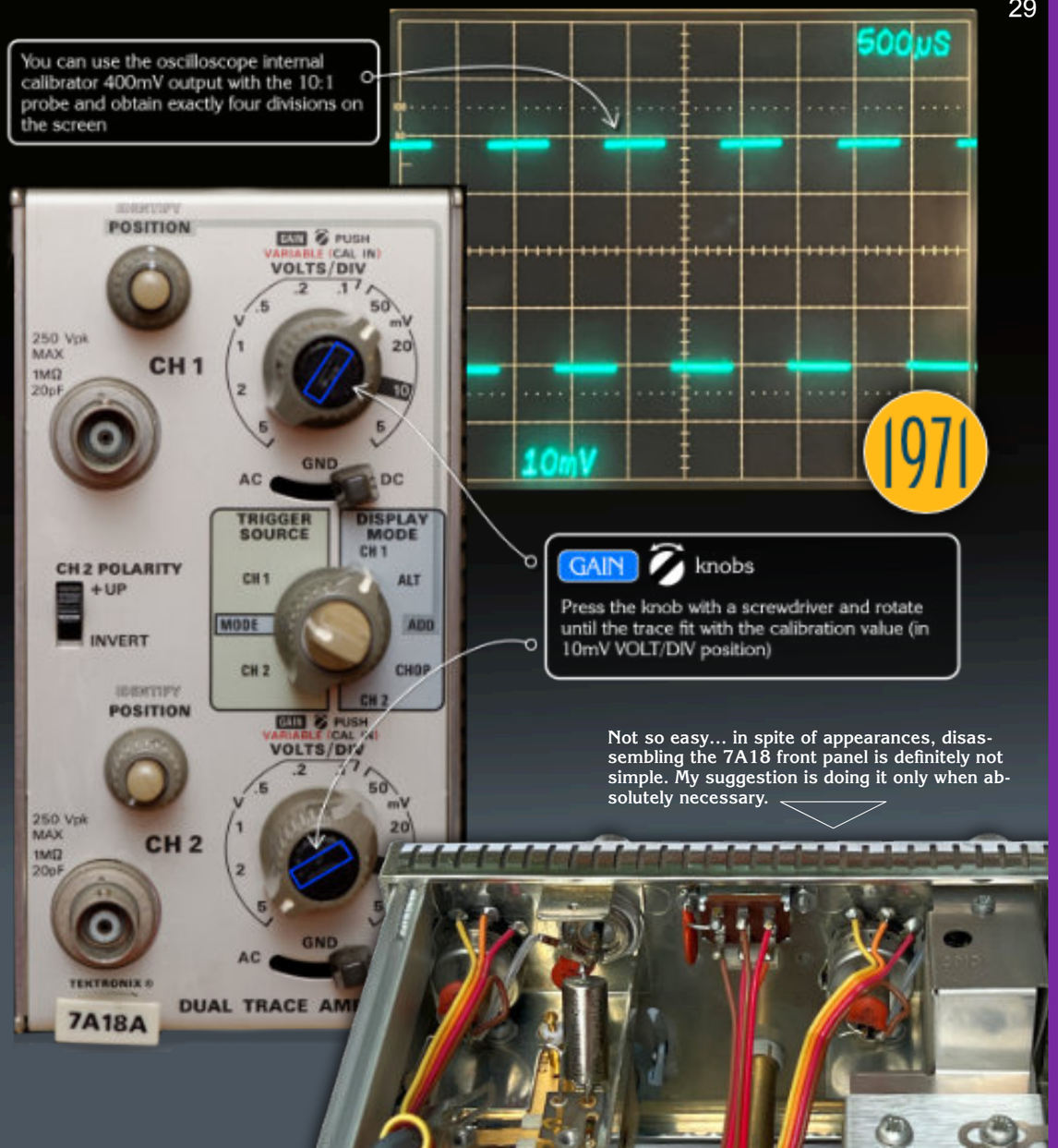
The Tektronix **7A18** is a general-purpose 75 MHz dual-trace vertical plug-in. It is one of the simplest 7000-Series plug-ins — and was probably one of the most popular vertical amplifiers of the series. It's likely that many users wanted to own a 100 MHz scope, such as the 7603, "for the future" — but considered 75 MHz perfectly sufficient for their actual needs. And then there was the price difference: the 7A18 cost $615 in 1976, while its bigger brother, the 200 MHz 7A26, cost about $1,150 — roughly double the price. (In today's terms, about $3,000 vs. $6,000 — not exactly peanuts, especially if you wanted to buy two vertical plug-ins.) In any case, the 7A26 had an extra 100 MHz of bandwidth — but this was not really usable with the 76xx-Series mainframes.

Where is the Gain Control? I must admit that, at first, I didn't understand a fundamental point: all the 7000-Series vertical amplifiers lack an absolute calibration. I initially suspected calibration errors — but in reality, there were none. It was probably not practical for Tektronix to guarantee that all mainframes would have exactly the same gain factor. Instead, Tektronix provided a way to adjust the gain quickly — not as a lab calibration, but as a routine user operation. Some plug-ins offer a front-panel adjustment screw for this purpose. But **where is** it on the 7A18 (and the 7A26)? Once again, Tektronix managed to consolidate more functionality into a single knob. If you press the black knob labeled VARIABLE, it pops out, allowing you to adjust the gain to your liking. This adjustment is, of course, uncalibrated, and the operation is very intuitive. But there's more: I didn't realize at first that this knob has another function. You can adjust the overall calibrated gain of the plug-in by pressing and turning it with a screwdriver (see the drawing). Simple and effective!

Repairs

TekWiki says that… *"The pins of the attenuator modules are connected to conductive traces on the ceramic substrate inside by low-temperature soldering, which can go bad. Re-seating the module can temporarily restore the internal contact but will usually not fix the problem permanently. Repair is possible by opening the click-locked lid and carefully resoldering"*.

I have also had a lot of problems with "noisy" controls in the past, but they all went away with a good cleaning. Furthermore, like other plug-ins, the 7A18's tantalum capacitors have a high risk of bursting. Personally, I am too lazy (or prudent) and avoid unnecessary interventions, but it might be a good idea to replace them with modern ones.

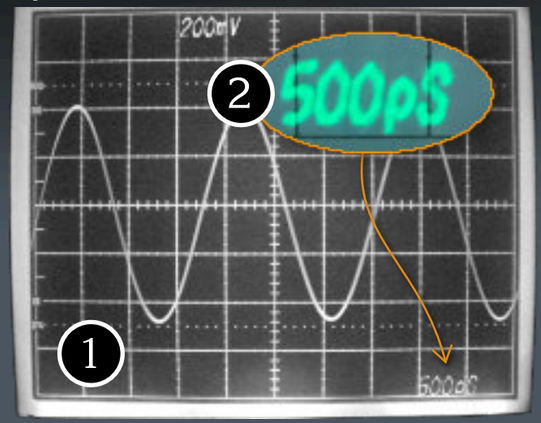


7A19 Super Fast 600 MHz

The **7A19** is a single-channel, 600-MHz vertical amplifier plug-in introduced alongside the 7904 mainframe in late 1971/early 1972. It is obvious that the 7904—rated for 500 MHz—needed a matching amplifier capable of exploiting its full bandwidth. The 7A19 front panel is simple and clean, with no variable gain control. An option (#4) was available that added a variable signal delay (±0.5 ns), implemented with a mechanically adjustable passive delay line, intended to match the timing between multiple channels.

The PRE-CHG setting on the input coupling switch is intended for situations where residual charge on the input coupling capacitor could otherwise overload the amplifier input. To use it, you first set the switch to PRE-CHG before connecting the input signal, then wait about two seconds before switching to AC (the low-frequency cutoff point in AC mode is 1 kHz). The PRE-CHG setting also acts as a ×100 attenuator, with an input impedance of 5 kΩ in series with 2 μF, extending the low-frequency cutoff to about 20 Hz. The AC GND position disconnects the input from the amplifier and terminates it into a capacitively coupled 50 Ω load.

I received my 7A19, sold as "spare parts only," and was resigned to keeping it as a static display model. However, it turned out to be quite easy to repair—the only issue was dirty switch contacts, as is often the case. Inside the case, there is ample space; working on the 7A19 is a dream compared to other plug-ins.



❶ Remarkable that after all these years, its performance is still very good: on my 7904 the bandwidth is near to 600 MHz (±3 dB), as shown here.

❷ The exciting speed of one half nanosecond!

❸ The C30-A photo camera, modified with the USB camera, as described in other part of this book, used to take photo ❶.



Learn to Properly use the 7A22

Special Skills Required

Differential voltage measurements are performed by applying the signals to the –INPUT and +INPUT connectors. In all cases, the AC–GND–DC coupling switches must be set to the same position (AC or DC), according to the desired coupling method.

Unlike single-ended measurements, however, the differential measurement of small signals is not automatic, nor is it forgiving. It is a discipline in its own right, requiring care, method, and experience. The exceptional capabilities of the 7A22 can only be fully exploited by thoroughly studying its operating principles—starting with the manual, and then returning to it again. Like many Tektronix manuals of this era, it condenses a remarkable amount of essential information into a relatively small space.

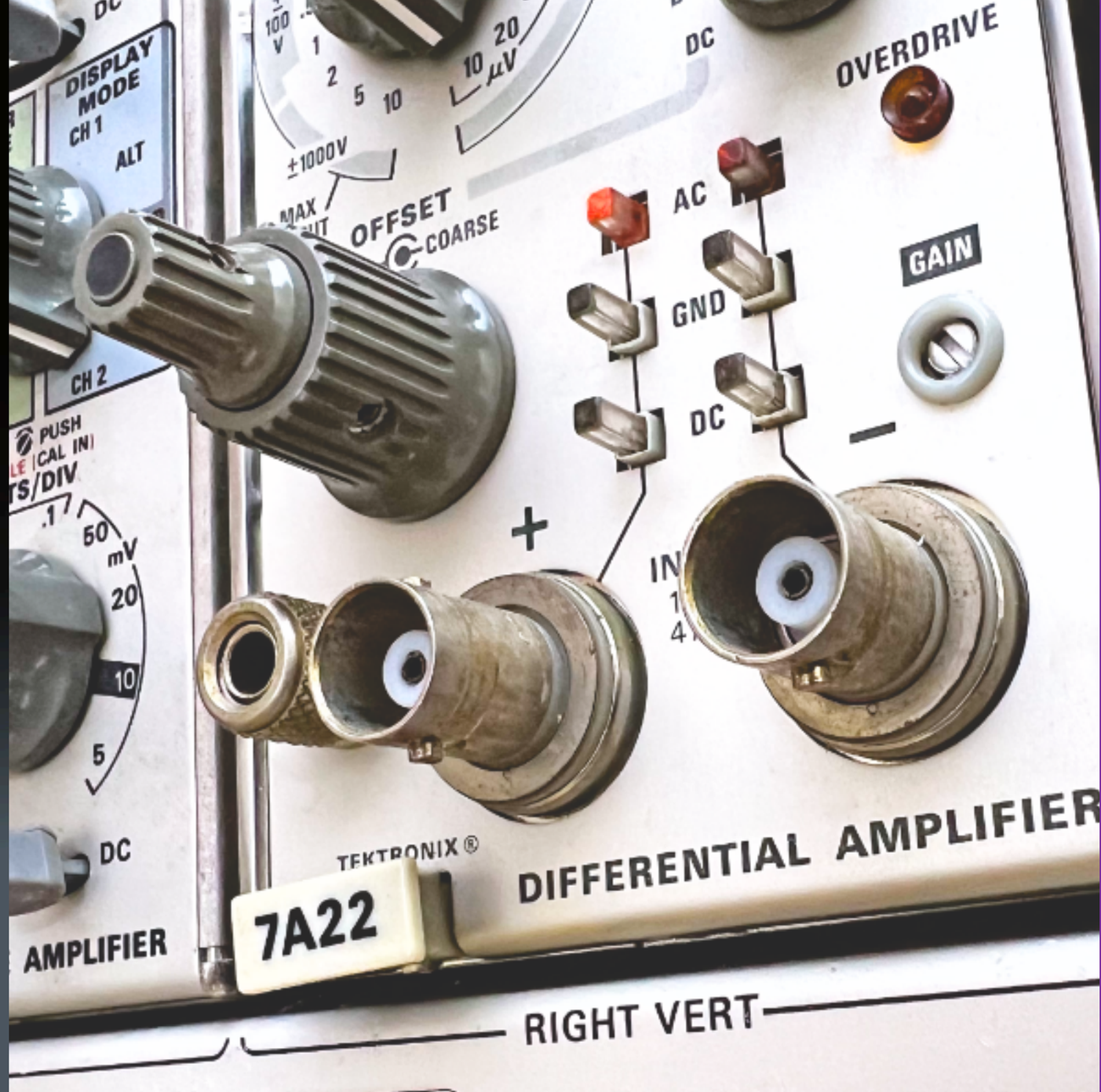
In some situations, internal adjustments may also be required. Access to the relevant trimmers is not restricted to service-only procedures; they are intentionally made accessible from the left side of the plug-in. In the following pages, I will summarize and comment on some key points drawn directly from the manual, highlighting those aspects that are most critical for accurate and reliable differential measurements.

Probes and Readout

Normally, the 7A22 is used in an oscilloscope with readout capabilities. In this case, special probes that adjust the readout deflection factor for probe attenuation may be used.

As in most vertical plug-ins, the –INPUT and +INPUT connectors on the 7A22 feature an outer ring connected to the readout sensing device. This allows the mainframe readout to display the correct deflection factor at the probe tip, regardless of the probe's attenuation.

Attenuating probes without a sensing ring can also be used, but they will not interact with the sensing system. In this case, only the deflection factor of the plug-in itself—as set on the VOLTS/DIV knob—will be displayed.



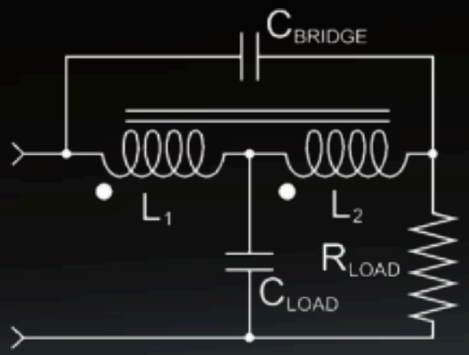
T-Coils

The Circuit

The input attenuators of the 7A24 are similar to those of the 7A19, using replaceable ceramic attenuator modules held to the circuit board by steel springs.

The amplifier itself is built around Tektronix 155-0078-xx differential amplifier ICs (four per channel in early versions; five in later versions, with different grades). In the 5 mV/div range only, the amplifier gain is doubled electronically.

The signal trace layout on the PCB is designed for T-coil peaking. A T-coil (see drawing) is a special type of inductive peaking circuit that extends the bandwidth of an amplifier and improves the rise time of its output signal.



The circuit uses a coupled inductor and a small bypass capacitor. A T-coil can approximately double the bandwidth of an amplifier.

You can think of the inductor as directing the input current into the capacitive part of the load, so that it charges faster. The small bypass capacitor keeps the input impedance of the T-coil constant and resistive.

The 7A24 does not use the ±50 V supplies provided by the mainframe.

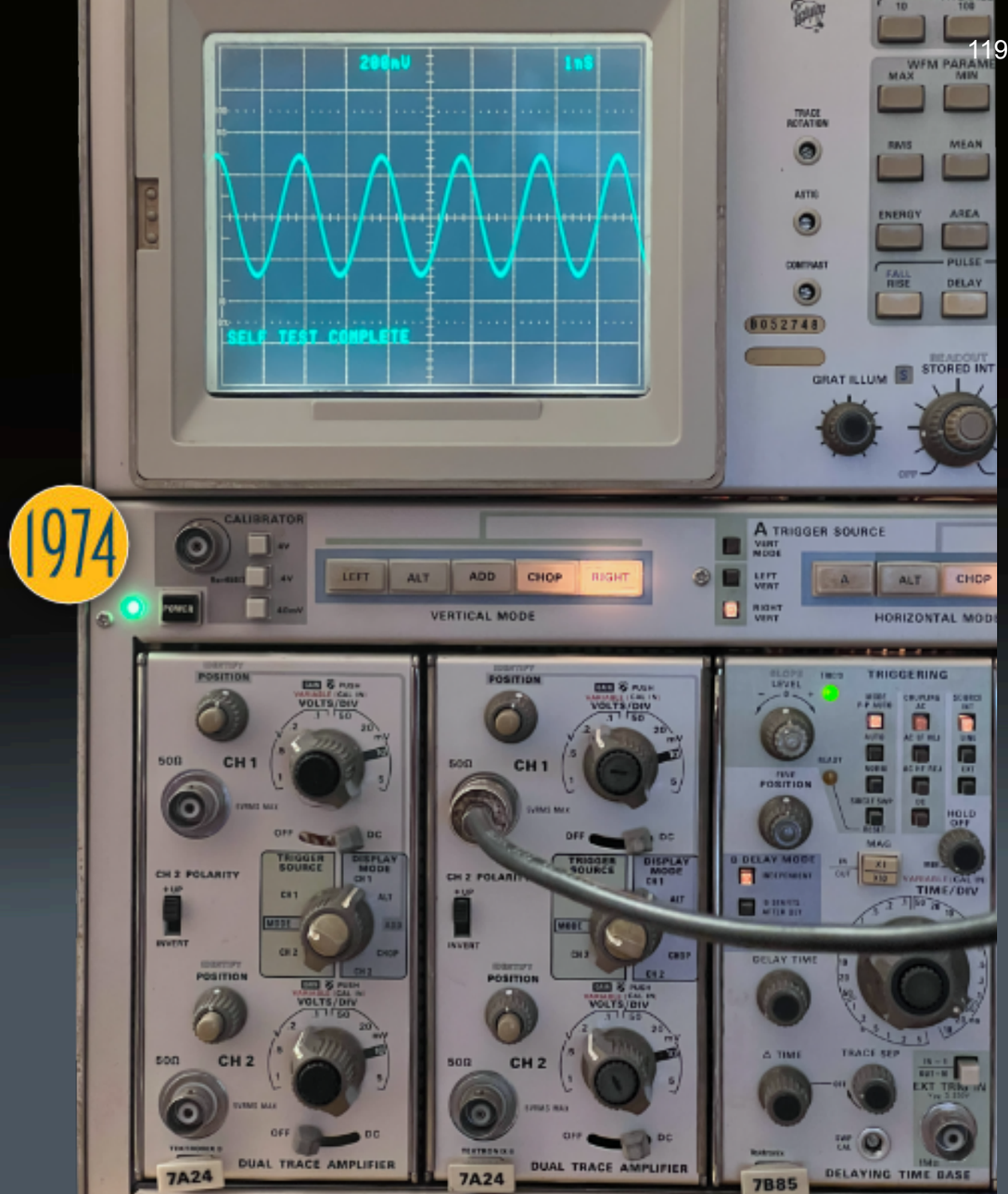
(Adapted from Electronic Design, where you can read the full explanation.)

Photo: You can see the 7854 mainframe with two 7A24 plug-ins, easily recognizable by the input switch, which lacks the AC position. The 7A24 active in the picture arrived non-working. The symptoms were identical to those of a blown input fuse: the trace could be moved with the POSITION control, but no signal was displayed.

In fact, the problem turned out to be nothing more than dirty attenuator contacts—as is common in many plug-ins that have remained dormant for years.

Its performance is still very good: 310 MHz in a 78xx mainframe (–3 dB bandwidth).

In the photo shown here, the input signal is at 550 MHz. The amplitude is reduced to about 50%, but the display remains well triggered, stable, and bright (note the 1 ns/div setting, thanks to the horizontal ×10 expander).



Main Sweep Holdoff. This circuit develops a gate which is used to prevent generation of a trigger signal until the sweep circuits have stabilized after a sweep. Its duration is variable, depending on the setting of the TIME/DIV OR DLY TIME switch, but cannot be adjusted by the user, like with other timebases. Holdoff timing capacitors are separate from sweep timing capacitors. Holdoff is longer for slower sweep rates.

Output from the Main Sweep Holdoff is coupled to the Main Sweep Trigger and the Delayed Sweep Holdoff circuit. A trigger signal cannot be generated during the holdoff interval. The holdoff serves to reset the trigger circuits so that they are ready to receive an input trigger signal after holdoff.

Horiz Output. With the TIME/DIV OR DLY TIME switch set for main sweep, this circuit selects the signal from the Main Sawtooth Generator, amplifies the signal, and converts the single-ended input to a push-pull output signal. DC positioning level is also applied to this block.

Delayed Sweep Mode

To generate the delayed sweep, the Main Sawtooth Generator must first be gated on as sown above.

Delay Pickoff. This circuit, practically a comparator, supplies a positive gate which starts when the main sawtooth signal passes through the level selected by the DELAY TIME MULT control. The gate ends with the main sawtooth signal.

Delayed Sweep Trigger. We have two cases:

- when the DLY'D TRIG LEVEL is set to RUNS AFTER DLY TIME (into knob detent), the output trigger is generated as soon as the delayed gate is applied.
- if the DLY'D TRIG LEVEL control is in the triggerable mode (out of switch detent), the output trigger is initiated by the next input trigger that occurs after the Delay Gate is applied.

The Delayed Sweep Trigger output is a positive gate which is terminated by the Holdoff signal or the positive step from the Delayed Sweep Stop circuit. The positive output gate is coupled to the Delayed Sweep Start Multi.

Delayed Sweep Start Multi. The signal from the Delayed Sweep Trigger causes the Delayed Sweep Start Multi to flip so that a positive gate is coupled to the Delayed Sweep Start Control, and a negative gate is applied to the Mixed Sweep Comparator. The output gates are the same in duration as the positive gate from the Delayed Sweep Trigger.

Delayed Sweep Start Control. For delayed sweep mode of operation the Delayed Sweep Start Control serves to couple the positive gate from the Delayed Sweep Start Multi to the Delayed Sawtooth Generator and the Sweep Gate Out. Input signals from the Main Sweep Start Comparator and the Delayed Sweep Lockout Multi are not effective in this mode.

Delayed Sawtooth Generator. The delayed sweep signal is developed by the Delayed Sawtooth Generator. The sawtooth is generated during the time that a positive gate is applied from the Delayed Sweep Start Control. Rate of change of the sawtooth is set by Ct and Rt, selected by the TIME/DIV (Dly'd) switch. The sawtooth output signal is coupled to the Mixed

Sweep Comparator and the Horizontal Output circuits

Delayed Sweep Stop Circuit. A positive step occurs at the output of the Delayed Sweep Stop circuit when the delayed sawtooth passes through the level selected by the Dly'd Swp Length adjustment. This step is coupled to the Delayed Sweep Trigger and the Delayed Sweep Lockout Multi.

Mixed Sweep Mode

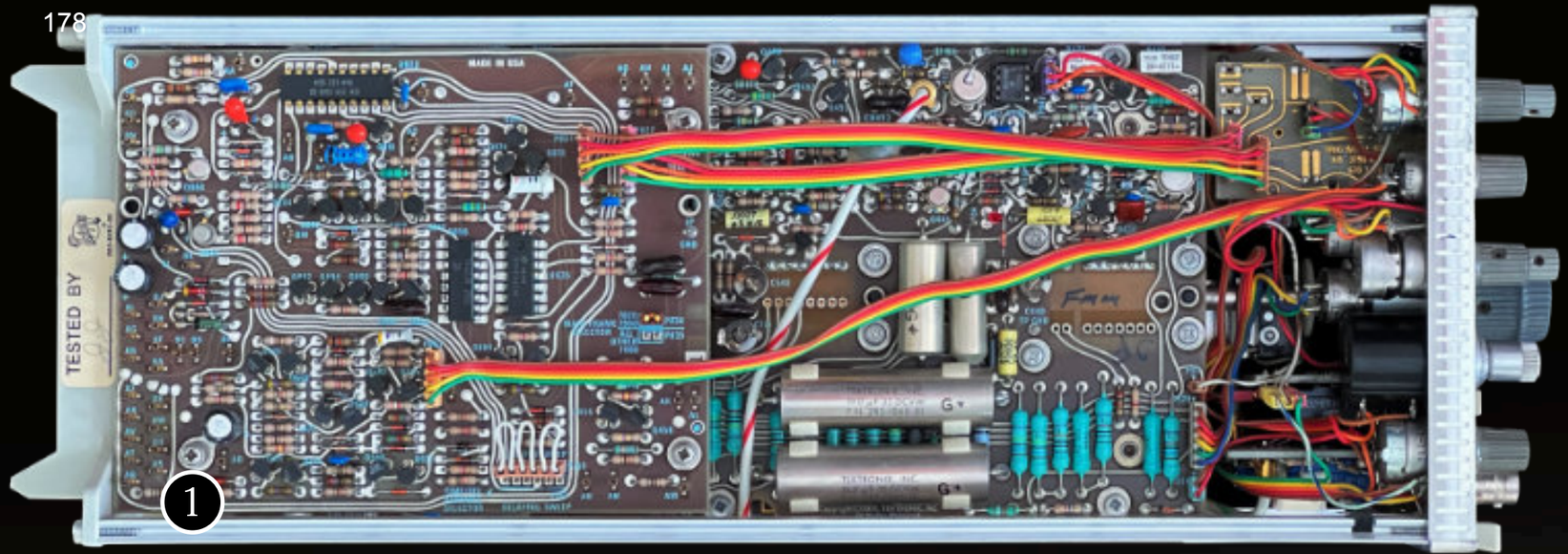
In this mode of operation, the sweep is first running at the main sweep rate and then, after the selected delay interval, runs at the delayed sweep rate. The main sweep and delayed sweep are initiated as previously described.

Operation of Other Circuit Blocks

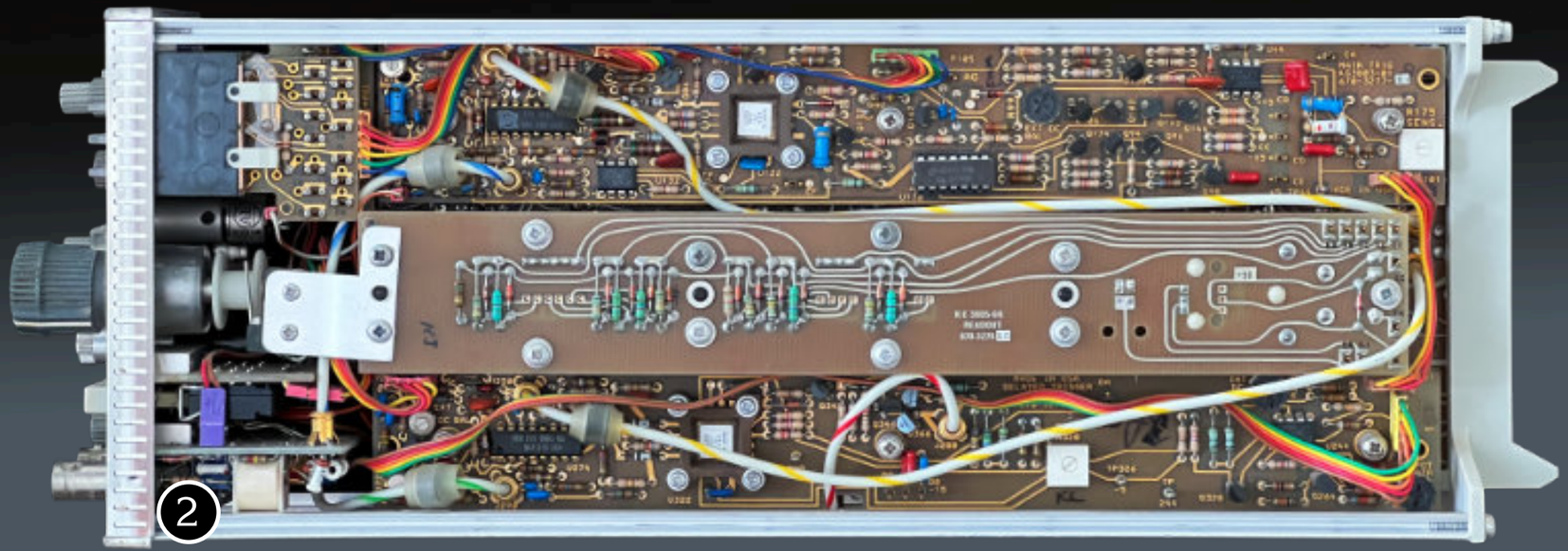
Mixed Sweep Comparator. This circuit determines whether the delayed sweep generator runs at the main sweep rate or at the delayed sweep rate. Before the delay gate is generated (delay gate generated at delay pickoff as determined by the setting of the DELAY TIME MULT dial) the main sweep sawtooth signal is coupled through the Mixed Sweep Comparator, causing the delayed sweep generator to run at the main sweep rate. The resulting sawtooth signal is coupled to the Horizontal Output stage. When a positive gate from the Delayed Sweep Trigger is applied to the Delayed Sweep Start Multi (at Delay Pickoff as determined by the DELAY TIME MULT dial setting) a negative gate is generated and coupled to the Mixed Sweep Comparator. This opens the Mixed Sweep Comparator, preventing the Delayed Sweep Generator from running at the main sweep rate. Simultaneously, the Delayed Sweep Generator is released to run at the delayed sweep rate.

Delayed Sweep Lockout Multi. The positive step from the Delayed Sweep Stop circuit is inverted by the Delayed Sweep Lockout Multi and coupled to the Delayed Sweep Start Control, thus turning off the Delayed Sawtooth Generator.

Sweep Gate Out. Depending on the selection of the TIME/DIV switch, this stage couples the positive gate from either the Main Sweep Start Multi or the Delayed Sweep Start Control to connector A1. The Sweep Gate signal serves to unblank the CRT in the Oscilloscope during the sweep.



1



2



3

Construction

The 7B92A also features a more modern construction compared to the 7B53A. Unfortunately for us restorers, this also means that the traditional component sockets have been eliminated in later production — making repairs more difficult, as sockets are extremely helpful when troubleshooting or replacing components.

A very welcome addition is the long-awaited INTENSITY control for the highlighted portion of the trace — a feature I have always wished to see included everywhere (as discussed on the previous pages).

Finally, note the presence of a convenient pushbutton on the main trigger input, allowing you to select between 1 MΩ and 50 Ω termination — a useful option that further enhances the flexibility of the 7B92A.

❶ 7B92A left side view
❷ 7B92A right side view
❸ 7B92A top view

1971

"A" type

1976

Measure a Burst Frequency

Signal Gating

This is something traditional digital frequency meters **simply cannot do**. The challenge arises when you have a complex waveform and want to measure its frequency in just a portion of the signal. Typical cases include measuring the frequency of a burst, or the instantaneous frequency of a frequency-modulated (FM) wave at a specific moment.

The 7D14 can easily perform its basic counting functions, but achieving this kind of gated measurement requires a bit of additional setup. Tektronix provided two helpful documents—"7000 Series Digital Plug-in Applications" and "7D15 Application Guide 42W-5017"—but I have found them not always as clear as one would hope. Here, then, are a few clarifications.

Time Windows

Like any other digital frequency meter, the 7D14 (photo ❶) operates as a gate and counter. The gate is opened for a fixed time window, during which it counts the pulses of the input signal. The duration of this window—often called gate time—is set using the INTERVAL MEASUREMENT buttons. For example, pressing the 1 ms button will open the gate for 1 millisecond, as illustrated in photo ❷.

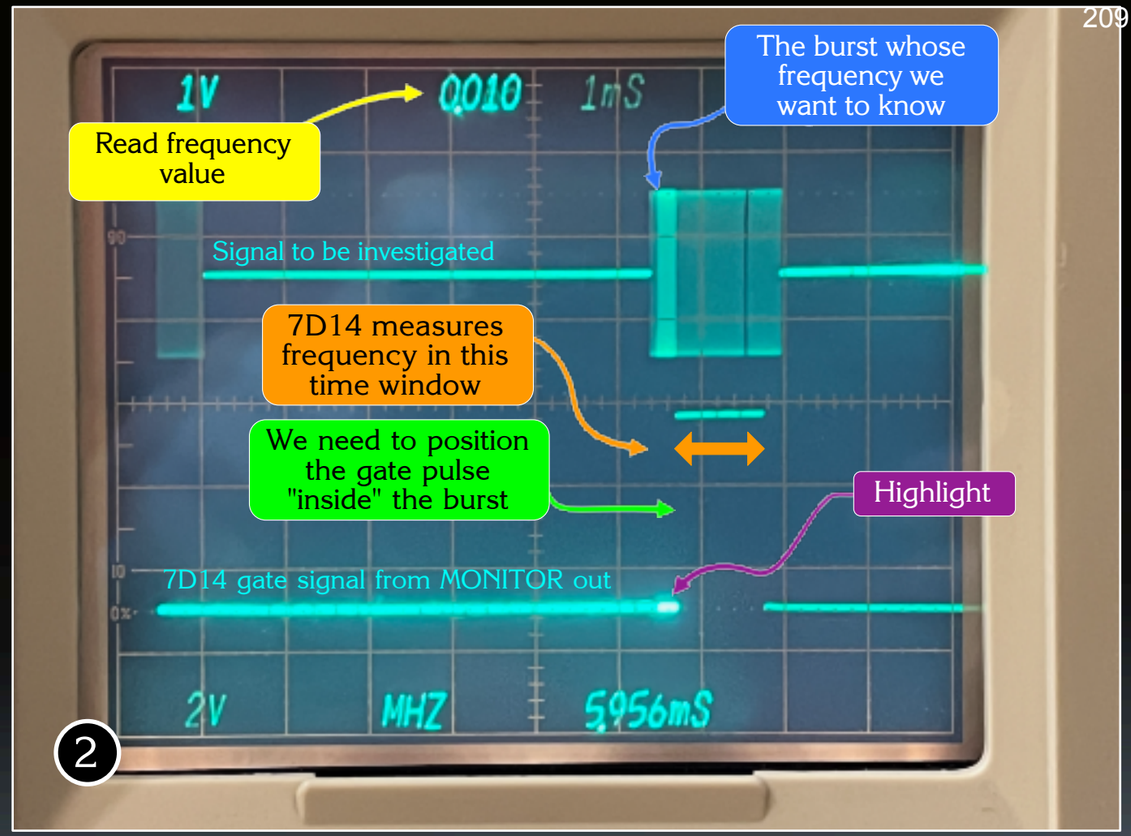
How frequently the measurements are updated depends on the setting of the DISPLAY TIME knob. You can easily verify this behavior by connecting another oscilloscope to the MONITOR OUT on the 7D14's front panel.

Catching All the Pulses

When measuring a continuous wave, the timing of the window is not critical—the oscillations are uniform throughout. But when measuring the frequency of a burst, the window must fall entirely within the burst, or the count will be incorrect.

For example, a 10 kHz signal produces 10 pulses per millisecond. If your 1 ms gate captures only 7 pulses, the meter will display 7 kHz, not 10.





Initial Setup

Let's set up the oscilloscope—a 7904 in this case—to display the screen shown in photo ❶. The procedure is simple:

- Install a dual-channel vertical amplifier (e.g. 7A26) in the left compartment.
- Install a dual time base (e.g. 7B85 → A and 7B80 → B).
- Connect the input signal to both CH1 of the 7A26 and CH A of the 7D14.
- Connect MONITOR OUT from the 7D14 to CH2 of the 7A26.
- Use the A time base to display and synchronize the input signal so it appears stable.

At this point, you will see the time window on CH2, but it will not be synchronized—it will move quickly across the screen.

Measuring Period

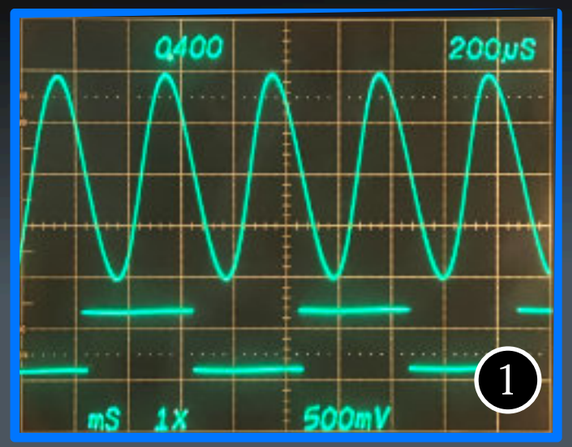
As we know, period is simply the reciprocal of frequency. However, period measurement is typically used for low-frequency signals—often below 50–100 Hz—because it is much more practical to read, say, 475 ms than to interpret a frequency of 2.185263 Hz.

To measure period, the **7D15** gate is opened and closed by the input signal connected to Input A. The number of clock pulses counted during this interval represents the period value.

In this case, it is essential to ensure that the gate signal period matches the exact period of the incoming signal. To achieve this:

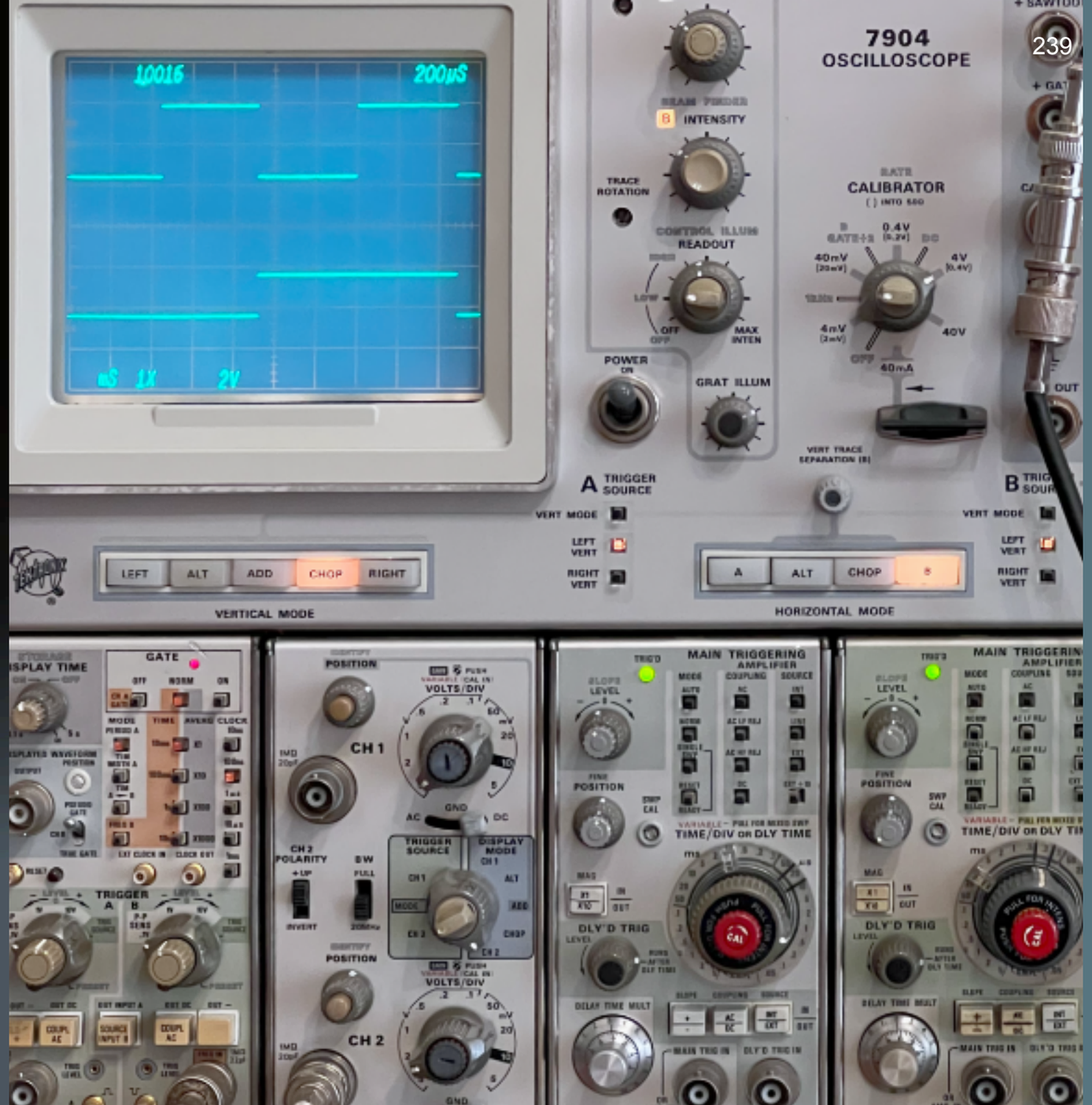
- insert the **7D15** in a vertical compartment;
- send the input signal both to a vertical channel of the oscilloscope and to the A input of the 7D15;
- set the DISPLAYED WAVEFORM switch to either TRUE GATE or PSEUDO GATE;
- the PSEUDO GATE setting increases the refresh rate of the display, making it easier to read.

In the photo ❶ below, you can see a 2.5 kHz signal with a measured period of 0.400 ms. Of course, it is also possible to use the horizontal compartment approach here—just as in frequency measurement.



The setup for test ❶ is:

- GATE: NORMAL
- MODE: PERIOD
- TIME: 10mS
- CLOCK: 100ns
- STORAGE: ON
- DISPL. W.: PSEUDO GATE
- DISPLAY TIME: 0.1 s
- SOURCE INP B: OUT
- SENSIT/LVL: as required





Section

Digital Plug-ins

Subsection

7D12 A/D Converter

An analog-to-digital converter implemented as a kind of “mini sub-mainframe.” Like a Russian doll, it can in turn host three different specialized plug-ins. At the time, an A/D converter was far from inexpensive and had to be fully exploited across multiple functions.







A Different Thing

Inside the 7A16P lives a beautiful, complete MC6800 microcomputer. I would love to one day write software for it — just for the sheer pleasure of bringing it back to life.

It is worth noting that, like several other plug-ins, the 7A16P relies on relays — components I both love and hate. After so many years of service, they surely deserve a peaceful retirement… but instead, here we are, determined to keep them working at all costs.

❶ 7A16P left side view
❷ 7A16P right side view
❸ 7A16P top view

1978

Vexatae Quaestiones

The First DSO?

As you probably understood, I like to get lost in useless musings, typical of an apprentice historian, As As you have probably understood by now, I like to get lost in seemingly useless musings — the typical indulgence of an apprentice historian, which I consider myself to be. After the theological doubt of whether the 7D20 is a mainframe or a plug-in, another *vexata quaestio* arises: what was the first DSO?

With reference to the table below and limiting myself to Tektronix, I had so far regarded the DPO (1972–1981) as the first prehistoric DSO, followed by the 7854 (1980–1990) — still not a true DSO — and then the arrival of the first real DSOs, such as the 2430 of 1986 (and the 11000 Series, although in many ways quite peculiar). But the 7D20 (1982–1992) made me rethink this classification.

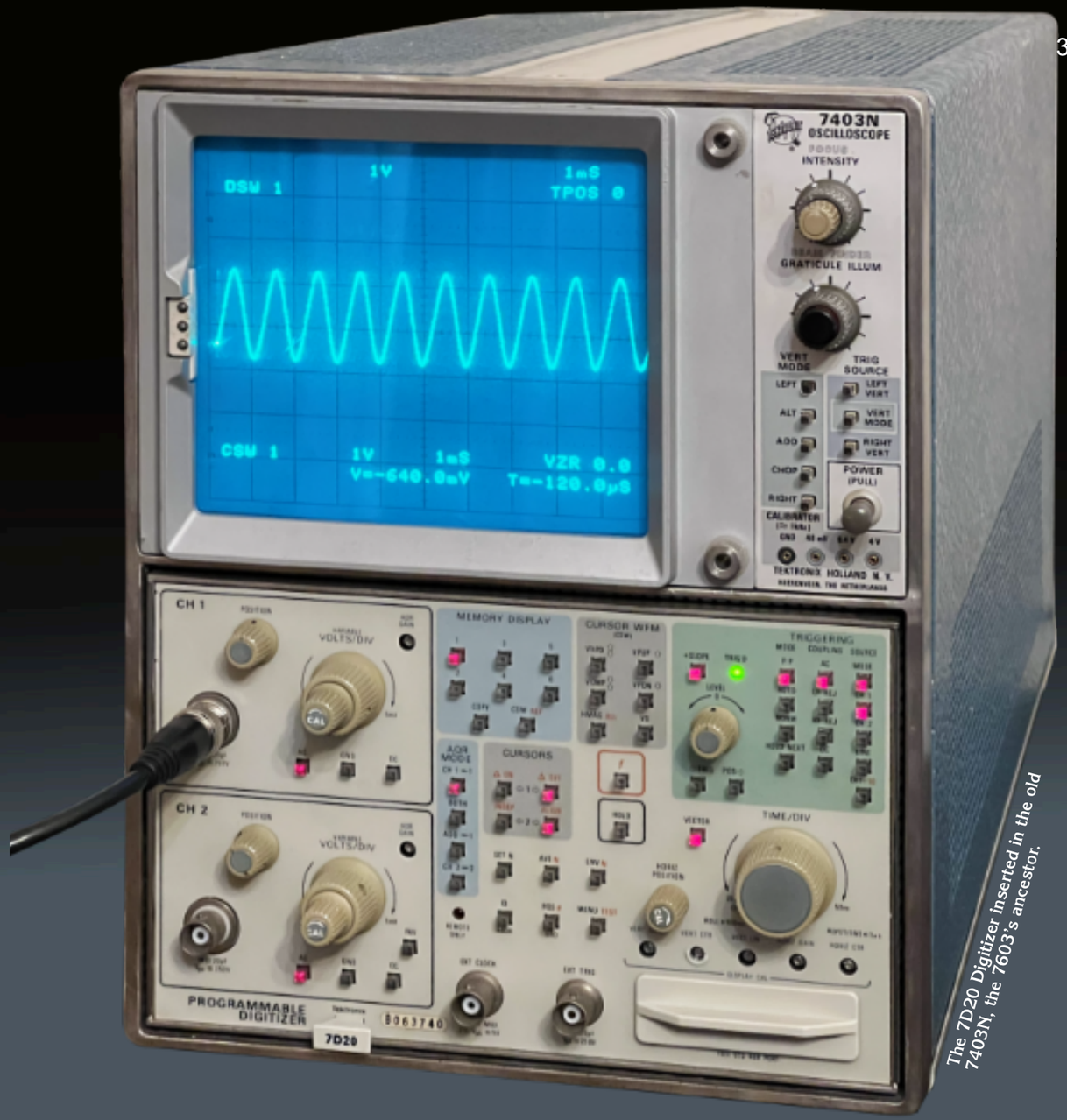
	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
	PREHISTORY										MIDDLE AGES				MODERN				
DPO																			
7854																			
7D20																			
11000																			
2430 etc.																			

A Giant Improvement

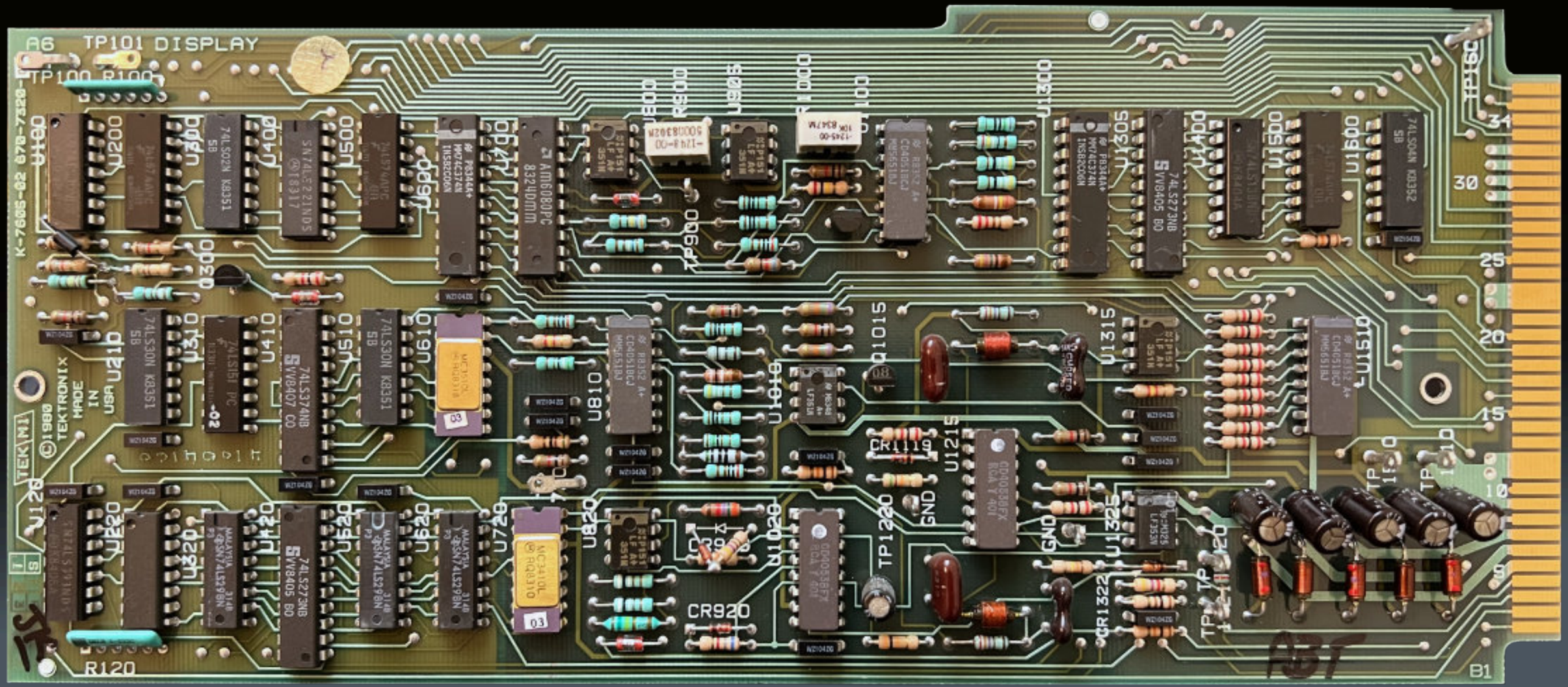
Two years younger than the 7854, the 7D20 represents a huge leap forward:

- **Fully digital**: the 7854 could read knob settings but could not set them. The 7D20, on the other hand, was fully programmable — including vertical sensitivity and sweep speed.
- **Dual channel acquisition**: the 7D20 can continuously acquire two data channels and display them simultaneously.
- **Higher sampling rate**: from the 7854's modest 500 kSa/s to 40 MSa/s, with pre- and post-trigger capability.
- **Automatic ground reference**: no need to acquire the ground level manually.
- **Ease of use**: the 7D20 behaves like an analog oscilloscope but works entirely digitally. It does not require learning the RPN language — which I personally love, but which is admittedly cumbersome and not easy to master.

You could even say that, in technical terms, the 7D20 was a logical dry run for the future 2430. It was not destined to be a great commercial success — partly because of its price (which we will examine) — but it was certainly much closer to the concept of a modern DSO than the 7854 ever was.



The 7D20 Digitizer inserted in the old 7403N, the 7603's ancestor.



A6 Display Board

Measurement examples

Voltage & Frequency

What is shown in this photo is in many ways similar to the previous example, this time arranged in a 7904 mainframe:

- Here too, the measurement of the input signal frequency is performed with the 7D15 plug-in, this time inserted in the horizontal compartment. This avoids the need for an external coaxial cable, a BNC "T" connector, and the associated additional load on the input signal — something that would not have been possible in a 3-compartment mainframe.
- The 7D15 plug-in is performing very well, measuring 250,000.32 kHz, even beyond its official specification of 225 MHz maximum frequency.

In a world where only analog indicators were commonly used, the 7000 Series was among the first to offer the convenience and ease of operation of clearly readable scale factors, test dates, test numbers, and other pertinent test data — all displayed digitally.

The digital plug-ins added the speed, repeatability, and precision of digital measurements, with results shown directly on the CRT.

The 7D15 not only allowed frequency and period measurements — which you could also perform with an external digital counter — but provided the great advantage of displaying results directly on the oscilloscope screen, together with the waveforms, and thus captured in the same hardcopy photo. It also offered many other measurement modes that would have been impossible with a separate instrument — making it a true breakthrough.

