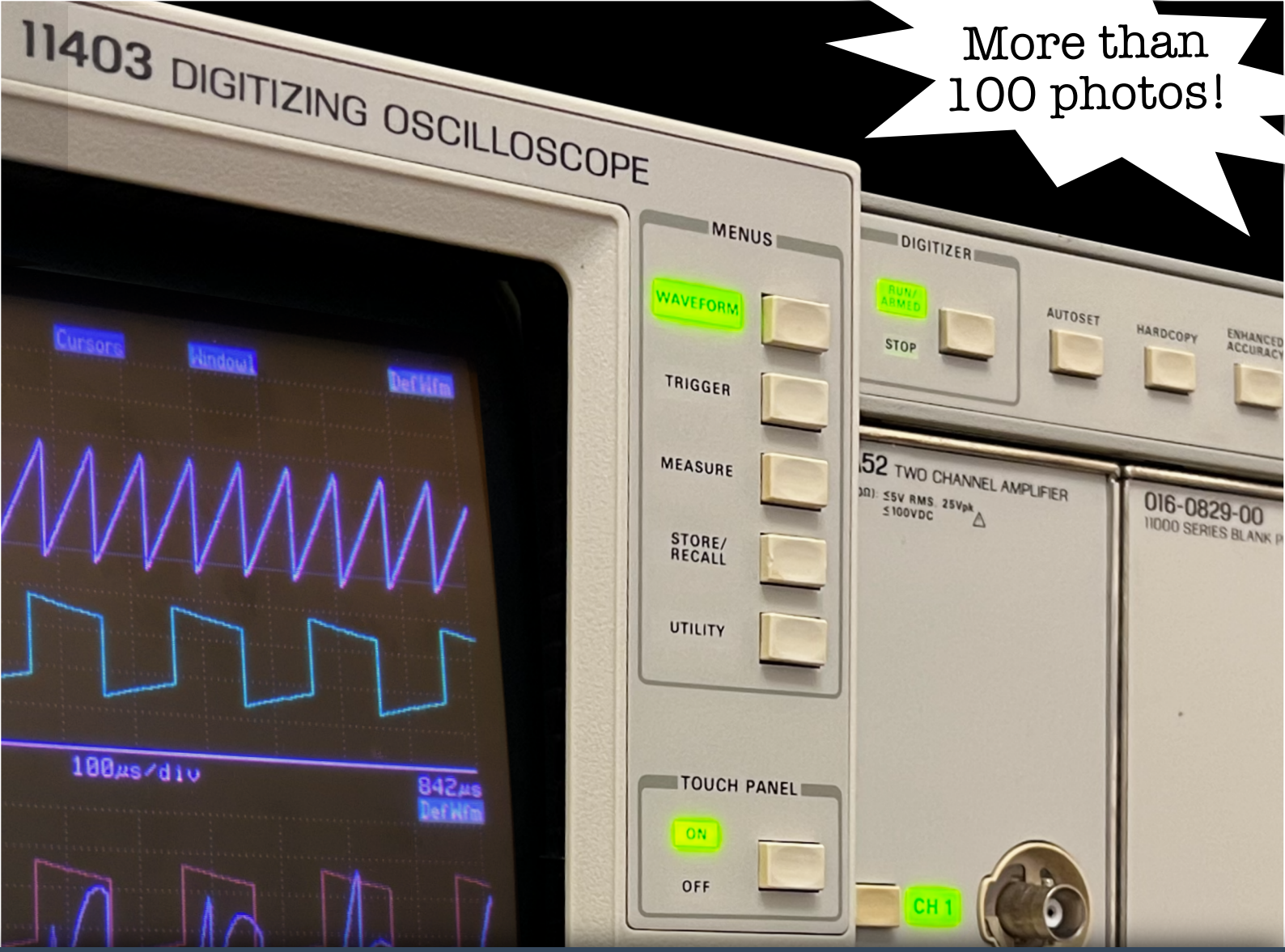
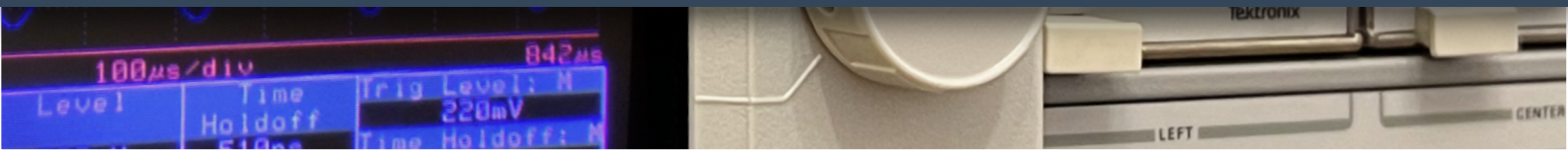


More than 100 photos!

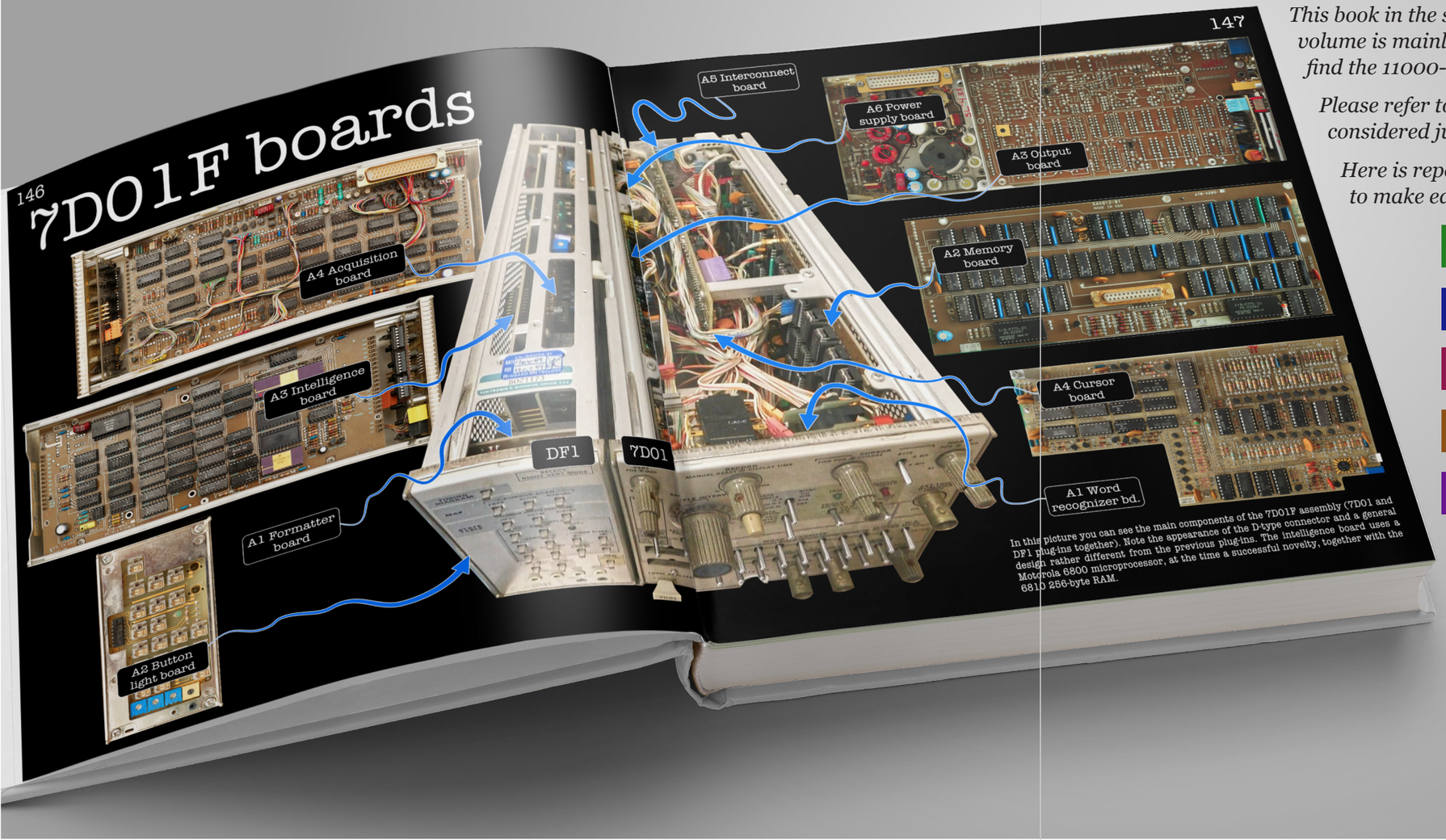
Giovanni Gianni Becattini

Tektronix oscilloscopes

Volume 2: 11000-Series etc.



Organization of this book



This book in the second volume of "Tektronix oscilloscopes" series. The first volume is mainly related to the 7000-Series, in this second volume you will find the 11000-Series and some HP oscilloscope.

Please refer to vol.1 for all the general information, this is to be considered just a continuation of the first.

Here is reported, however, the overall subdivision in colored sections, to make easier the reading:

7000-Series key points	The green section	Vol. 1
7000-Series mainframes	The blue section	Vol. 1
7000-Series plug-ins	The fuchsia section	Vol. 1
7000-Series restoration	The brown section	Vol. 1
11000-Series	The violet section	Vol. 2

NOTICE: I don't claim any historical rigor, I am not an expert of this matter. Even though I am an electronics professional, in this case I work as a simple enthusiast, with limited means and a home laboratory. If I wrote something wrong, or infringed somebody else's rights, please write me and I will amend consequently.

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Tektronix oscilloscopes vol. 1
The 7000-Series

Includes the Tektronix 465

580 pages



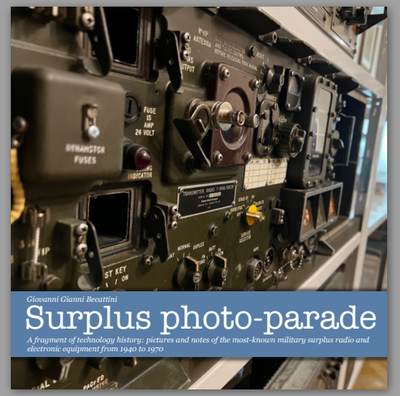


Tektronix oscilloscopes vol. 2
The 11000-Series

Includes the HP 54502A and 54540A

116 pages





Surplus photo-parade
Old military surplus radio equipment and instruments

164 pages



Includes Wireless Set N.19, AN/ART-13 transmitter, BC-348 receiver, R-44/ARR-5 receiver, R-45/ARR-7, R-107 receiver, R-91/ARC-2, Collins 51J receivers, R-390A/URR, R-648 / ARR-41, R-725/URR, AN/GRC-7, RT-70, RT-66, RT-67, RT-68, AN/GRC-19, R-392/URR receiver, T-195 transmitter, Allocchio Bacchini AC-18 receiver, Racal RA17, Siemens E309, Siemens E311, G133F receiver, Geloso G4/216, TV-7/U tube tester, LAEL 755, ZM-3/U, ZM-11/U, TS-505/U, Pantec Major, Chinaglia VTVM 1001. Hewlett Packard HP400H, URM-191, TS-585/U, BC-221, TS-375/U, TS-497/URR

Gianni Becattini free books

All these books are related to vintage electronic equipment that had an important role in building the technological world that we know today: the military radio receivers and transmitters who allowed to keep this world free, and Tektronix instruments which were the base for most of the technical and scientific research in the years from WW2 to the end of 20th century.

I tried to transmit you the look and feel of these wonderful equipment, conjugating the graphic aspect with information about them and their history, technical notes, and some tips for those who wish to restore and preserve them from the wear and tear of the time.

These books are not sponsored and totally free. You can download them from:

- *http://www.k100.biz/parade.htm*
- *https://archive.org (search "Becattini Tektronix" or "Becattini Surplus")*

11000-Series

Subsection
The future of the past

Let's see how the world has evolved after the 7000-Series:

- *The events at its sunset*
- *The competition*
- *The 11000-Series*

The future on the road

Let's see the future

We have seen how the 7000-Series was introduced and many important turning-points of its career. It is now interesting to see what the future will be after its sunset, or just before.

The digital revolution

The 1980 - 1990 decade was a transition period for oscilloscopes. It would take those 10 years, to completely change their concepts and design. In time, there would be no more analog oscilloscopes.

In the first years of that decade, there was not yet a DSO, but the first machines, like the 7854, were fully programmable and system oriented, and were going to open the door to the design of a new world of fully digital oscilloscopes.

By the beginning of the 1980s, a 100 MHz bandwidth was standard for analog oscilloscopes. The nascent "digitizing" technology was not yet fast enough to compete with the 100 MHz analog bandwidth, then considered as a major characteristic for a serious laboratory grade oscilloscope. Even with the limited performance of the first generation of Analog to Digital Converters (ADC), a new set of possibilities were added by this crucial component to the task of waveform recording. As the ADC design strategies advanced, this gave birth to a new generation of instruments.

Kings of the market

The 7000-Series had a very long life. It was presented in October 1969 Tekscopes magazine, and the last presence of its latest members was in the 1990 general catalog: more than 20 years of successes, that made Tektronix the absolute dominator of the oscilloscope market, a dangerous position for any company, because this advantage may suggest that the fat years will never end.

Tektronix dominated the high-end digitizing scope market in 1982 with the 7854 and 7D20. There were a few products with good ideas from small companies, but none of them really posed them many threats.

The HP model 1980

In 1982, HP announced its revolution, with the 1980 model (nobody in Italy would have named 1980 a product presented in 1982, but maybe "1983"...). Not yet a modern digitizing oscilloscope, but fully programmable and system oriented.

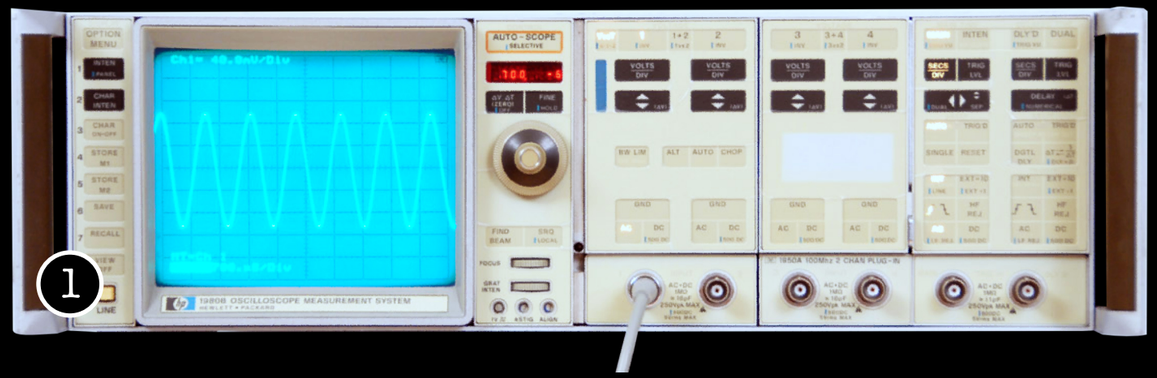
In its basic configuration, the 1980A/B offered two 100 MHz repetitive analog measurement channels with 2 mV/div deflection factors, two independent 5 ns/div sweeps, main or delayed trigger view, delta-time and delta-voltage measurements, and a multitude of automated features including Autoscope, which allowed the user to obtain a display rapidly without adjusting individual controls. With its GPIB interface, the 1980A/B could be combined with other GPIB-compatible instruments to form a completely automated test system. Because the 1980A/B was fully programmable, test routines could be established, stored, and used repeatedly.

This extensive digital control permits such features as an easy-to-use front panel, auto-ranging, complete programmability, digital waveform storage (but limited at 50 kSa/s, one tenth of the 7854), and hardware and firmware expandability. Unlike other oscilloscopes of the time, the 1980A/B's innovative front panel featured a single rotary control.

What would scare me, in the Tektronix's shoes, was the picture here on next page, showing a very well-engineered construction, rational and not very expensive, differently by that electronic monster that Tek was going to design.

1982

❶ The Hewlett Packard 1800, one of the first digitizing oscilloscopes was introduced in 1982.





1

The 1984 that Orwell did not forecast

The HP model 1980 could be an important alarm bell, but Beaverton considered that it could not be a threat to their well accepted products. However, the 7854 was becoming old and big, and probably something new should already have been introduced 1in 1982.

HP took the opportunity of Tektronix apparent inertia and, in 1984, presented the 54100 series of digitizing oscilloscopes, much more modern, smaller and effective units, with a large, low-cost magnetic deflection CRT (the 54100A was described in the April 1986 issue of the Hewlett Packard Journal). The first HP 54100A was already a real DSO, with GHz bandwidth and 40 MSa/s.

Since 1982

In reality, Tektronix hadn't been sitting on his hands, and, in the Fall 1982, launched the Equivalent Time (ET) project. ET took its name from its descriptor, as it was intended to be a general-purpose scope, primarily for repetitive signals. The 1980 7854 was not any longer adequate to the rapidly changing market threats.



2

1984

❶ The HP 1980 interior, clean, rational, very well serviceable.

❷ The HP 54100 is definitely a more modern machine, relatively to the 7000-Series. Note the raster display, typical of a fully digitalized machine, the softkeys on the screen borders and the big knob, that will become the standard for many other subsequent oscilloscopes, included the 11400 series.

The ET project

From 7K-Plus to 11000

*ET (later said “Pioneer”) was the digitizing scope in a new family originally conceived as an extension to the 7000-Series, called "7K-Plus", but in time Tektronix came to realize the significance of the new products and their tremendous power, so adopted the new family nomenclature "11000-Series". I can only suppose that after the 7**6**xx, 7704, 7**8**xx, 7**9**04, and 7**10**4, they decided that the next higher model had to be the **11**000-Series.*

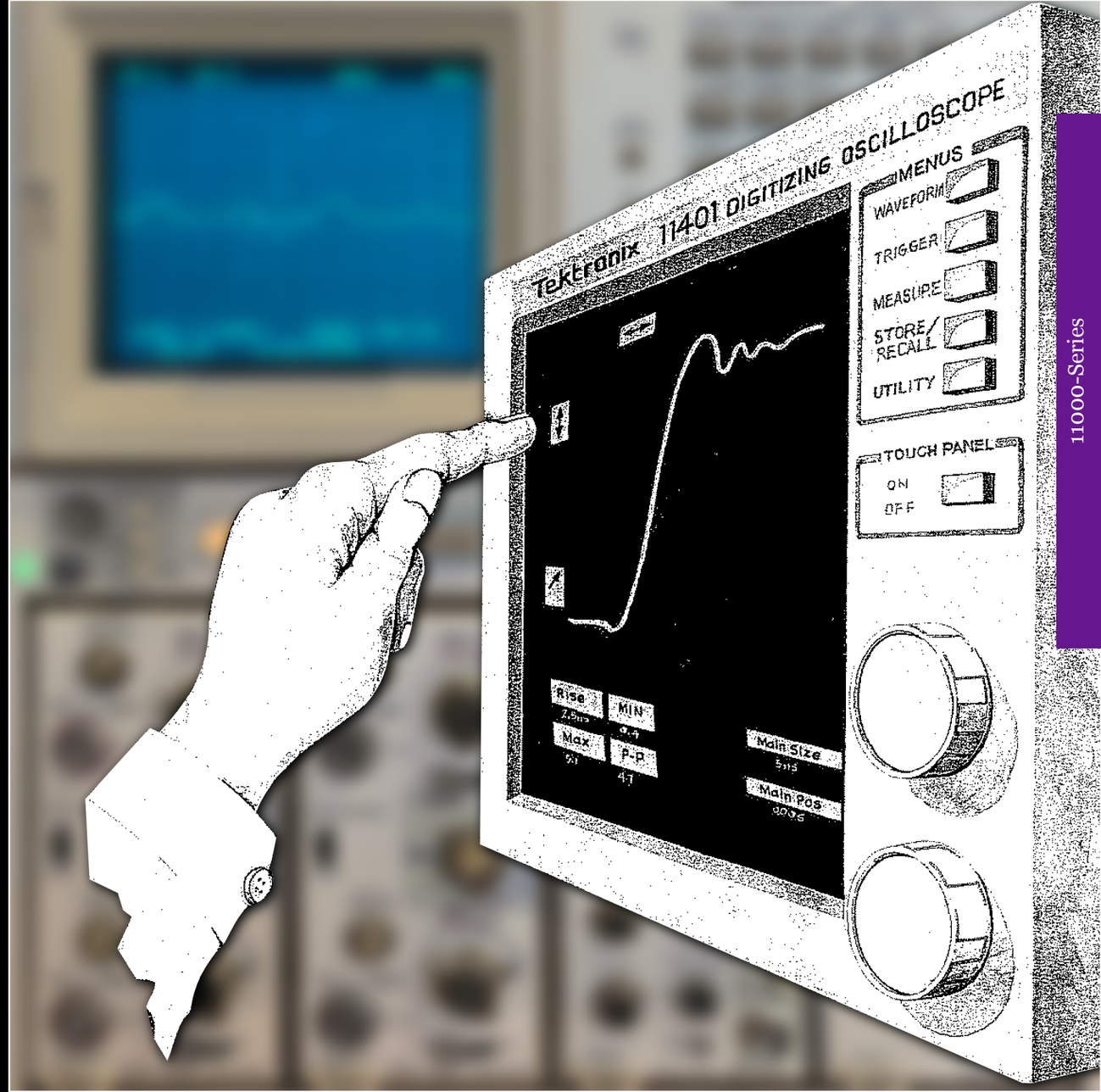
Three instrument clusters were envisioned in 7K-Plus: the low end at 150 MHz, the middle at 300 MHz, and high end at 600 MHz. Each cluster contained analog and digital mainframes and all of them were to share common plug-ins. The first wave was targeted at the 300 MHz cluster, since that would address the largest market. ET was named 7863, 7853DP, and 11331 before finally becoming 11401/11402.

The project, as often happens by the market leaders and not only, was sensibly delayed by the chaos of reorganizations, conflicting visions, market researches and false starts.

The enemy at the doors

The introduction of HP 54100 in 1984 added some panic to the project; they were two years behind and the project had to underwent major changes:

- *the HP had 1 GHz bandwidth vs. ET's 300 MHz, but Tek could however target only 500 MHz, being limited by the sampling hybrid and triggering;*
- *the HP had infinite persistence, so they added point accumulation;*
- *HP had a larger screen and were perceived easier to use; Tek switched to a 9" screen from the 7" of the original design, with a revolutionary human interface.*



We must do it

With only eight months before product announcement, afterwards the HP 54100 presentation, they took a decision that I also in my professional life took sometimes: to say "we must do it, regardless of the difficulties". So they decided to go for 1 GHz bandwidth, because it was the right choice, and under considerable pressure from the field. The program was:

- *to afford a hurried-up work program to soup-up the sampling hybrid;*
- *to port the 7A29 plug-in to ET, already knowing that the instrument would not trigger to bandwidth.*

Uphill struggle

By the time that the ET project materialized, HP had well established their product and added some variations, e.g., a color version and a 1 GS/s version.

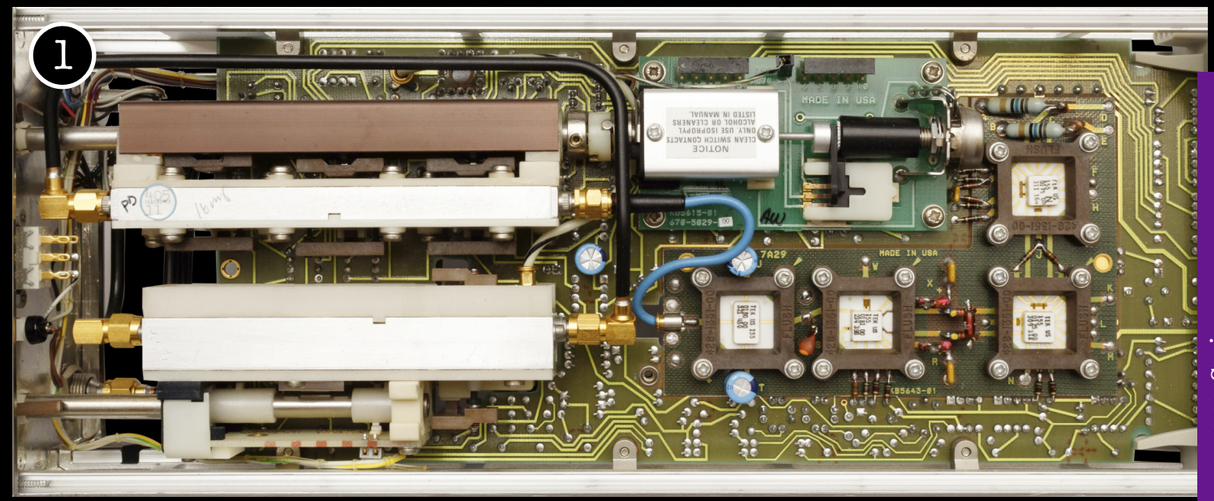
Tek consoled itself with the thought that the marketplace was generally reaffirming that their products were superior, but that is of little consequence when you are running about two years behind. By the time Tek products were available, HP products were established.

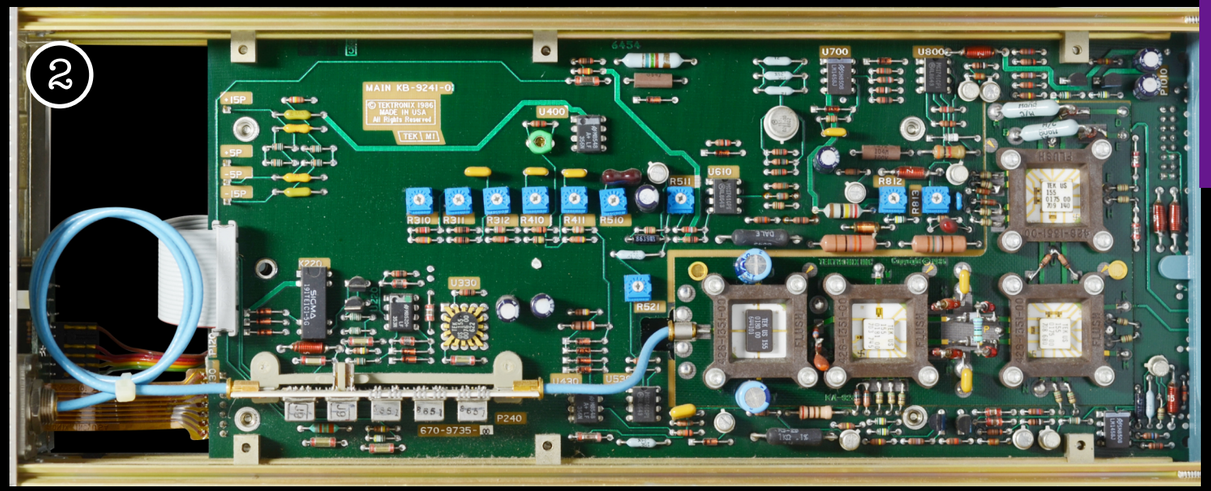
Modifications on the run

Many of ET's features changed little from inception; others changed dramatically. The first idea was for a 300 MHz mainframe with 10 bit 20 MS/s digitizer, ROMpacks for specific application SW, an optional disk drive for user programs and data, an external keyboard for a programming language, probably on the 7854 model, and a color display option. In time, the ROMpacks faded away and disk drive were dropped in favor of PC connection. Color remained in the roadmap, but were postponed due to quality/packaging/cost issues.

Forces and key areas

There were a number of forces and several key areas of development in the ET program. Major forces included a drive for full product programability, easier and more intuitive operation, 7K compatibility, and architectural modularity.





❶ The 7A29 is a 1 GHz single-channel vertical plug-in for 7000-Series, primarily intended for the 7104. Like with the 7A19, a variable signal delay was available as an option.

❷ The 11A71 was derived from the 7A29, ported to the 11000 architecture. All the manual commands have been removed in favor of digital control, managed by an Intel 8031 microcontroller.

Key areas of development were human interfacing, new scope architecture, software, hardware, diagnostics, self-cal, and manufacturability. The requirement for 7K plug-in compatibility placed serious boundary conditions on some aspects of the design, even though it was eventually dropped; one could equally argue both sides of this requirement.

Firmware problems

Tektronix was impacted also by the introduction of firmware, that had been never so relevant before. They had no internal talents and experience, so they had to build up the team from scratch, hiring personnel 100% from outside, many straight from college.

A partially successful attempt to create a common base for both the analog and the digital scopes was tried, but analog and digital scopes were too different. In addition, the firmware group inherited much of a pre-determined architecture, including the microprocessor family, that created further problems because the vendor could not deliver promised development tools.

Self-cal was originally conceived to occur in less than 100 ms every time a new setting was made, but in the end the settled just for capability of the scope to calibrate itself when issued.

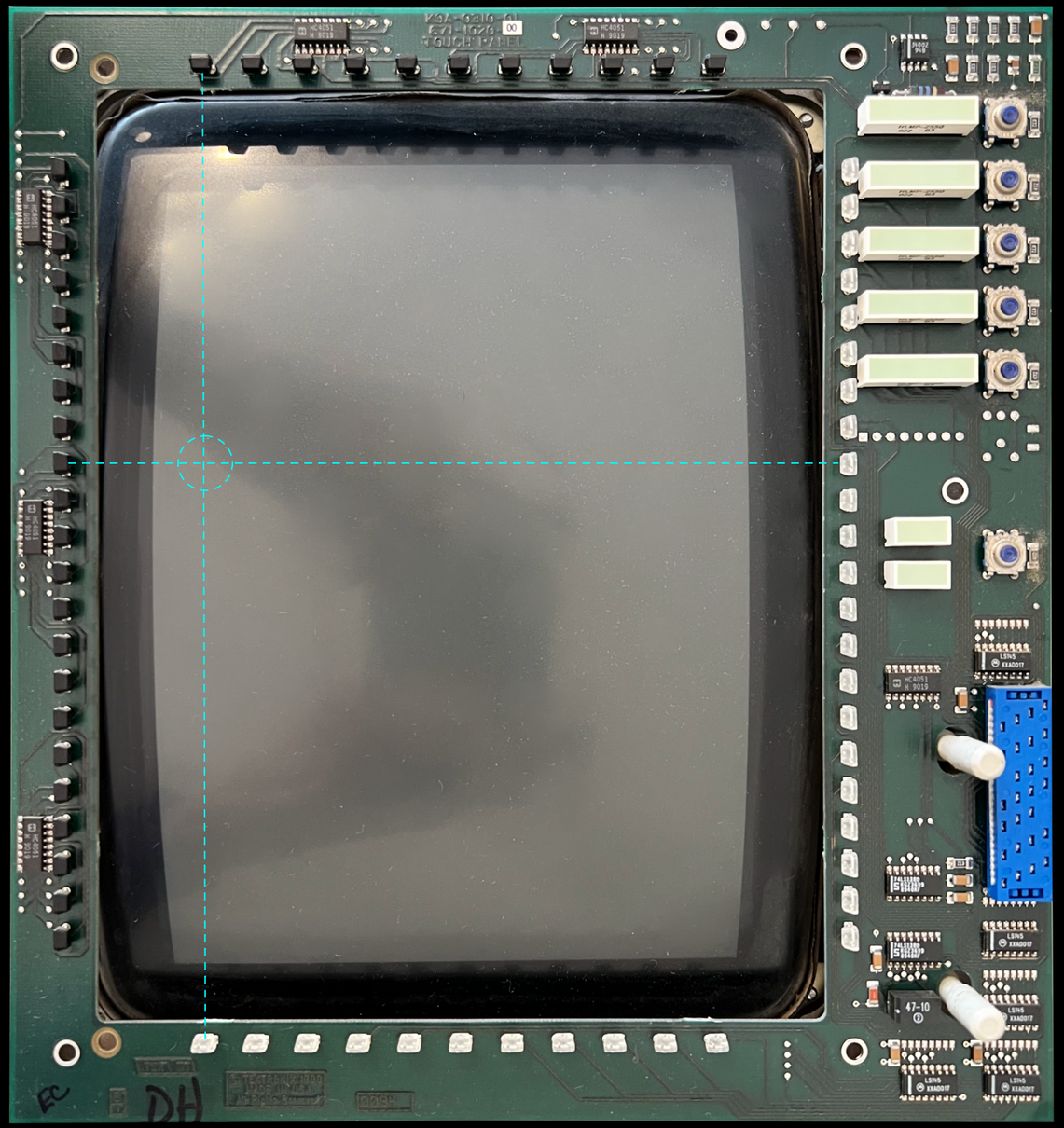
I would say, the normal difficulties that perhaps every first approach had in those years.

We could always come back

Reading the 11400 history documents, I was hit by the phrase "we could always come back", that resumes an important part of the development strategy. The innovation grade of the project made it very risky, so the designers had to administrate the balance between the natural appetite for advanced solutions and the goals to reach in the available time.

This explains the modest 20 MSa/s of the digitizer, the lack of disk drive, the monochrome display etc. when they still had to solve various hardware issues, such dual time bases with versatile functionality and precision timing measurements, multiple access shared memory, and high-resolution vertical raster display system.

As we will see later, a key element on the 11400-Series is the touch screen, still far to arrive in the capacitive/resistive forms that we today know. Its performances are risible with modern eyes: its resolution is only 11 x 22 areas, obtained with an array of infrared emitters and receivers, but reasonably practical and very reliable. The world had begun to change, and the touch screen will be standard in almost every future professional oscilloscope.



1986, the launch

Here it is!

In the end, Tektronix created a totally new digital scope architecture climaxing in a spectacular introduction in the fall of 1986. ET, become the 11000-Series, set many new standards and expectations for digital scopes, such as live operation, high accuracy and resolution, self-cal, multiple channels, and a sexy human interface.

A new family with two main lines

11000 is a new family of Tektronix digital oscilloscopes, introduced in October 1986, intended to be the technology top of its times. At the time of the presentation, it was composed by four new mainframes, five new plug-ins, and three new probes (photo on the right). The mainframes were:

- ***1986, 11300**: 11301 and 11302. They differ only in the CRT type, 11302 has a micro-channel CRT*
- ***1986, 11400**: 11401 (500 MHz), 11402 (1 GHz) - apart the sampler board, they are identical.*

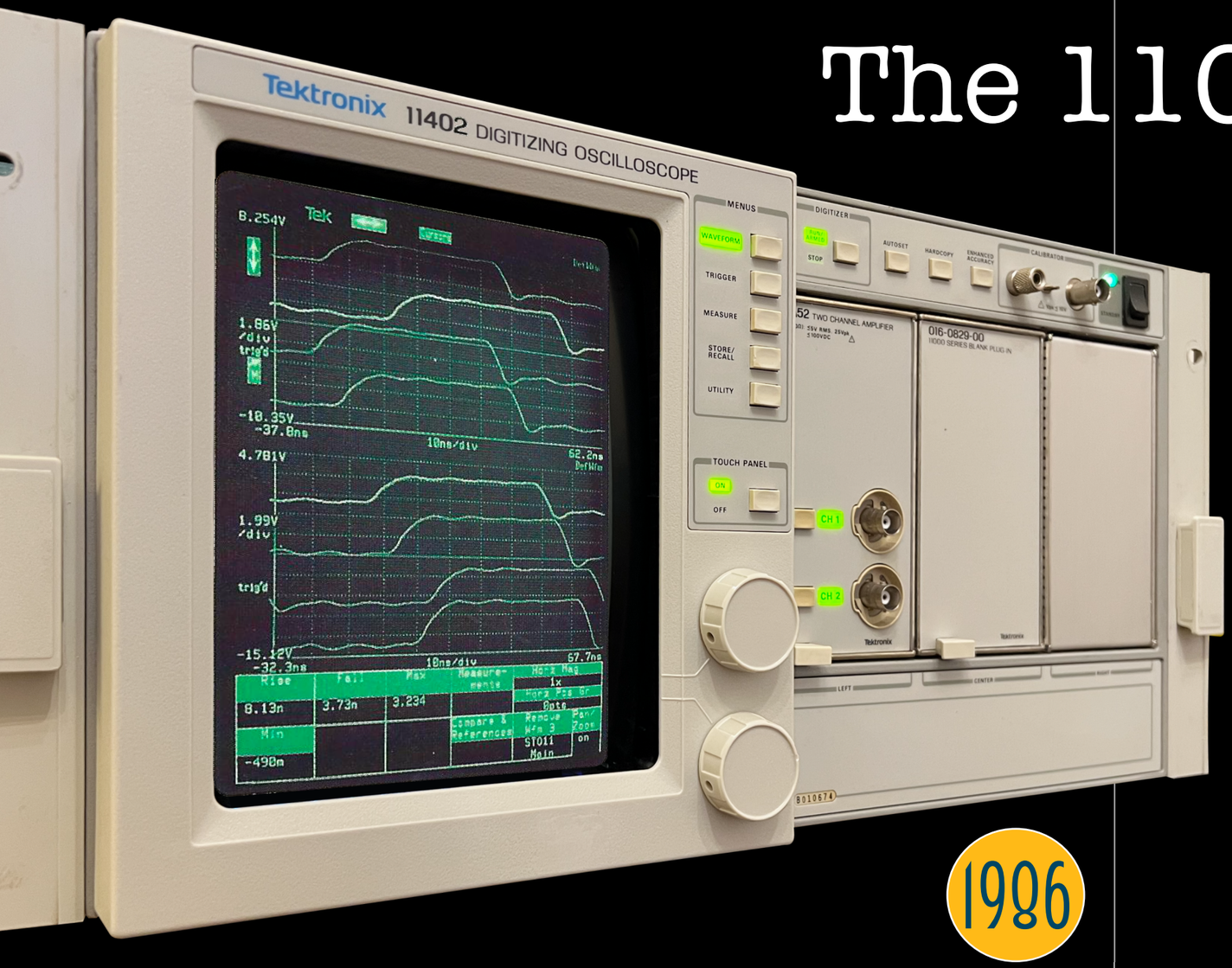
The 11300-Series, defined as "analog", is rather different from the 11400; those units have a relevant digital part, but not capable to acquire data.

Later, new models were added. Remaining about mainframes, they were:

- ***1989, 11201**: 400 MHz, all in one, without plug-in capability;*
- ***1989 catalog: 11301A and 11302A**: updated versions, with 750 MHz counters instead of 500;*
- ***1990 catalog, 11201A, 11402A, 11403**: A = updated versions (most of the boards redesigned); 11403 introduces the color screen.*
- ***1991-1992 supplement, 11403A**: bandwidth extended to 3 GHz, with 11A81 amplifiers.*

The 11000 full-line at the date of the presentation. Years of workmanship to produce a very innovative product system that will last for many years.





The 11000 revolution

1986

Claims

The new oscilloscopes were declared to have the most revolutionary simplification and automation of the entire measurement and analysis process, with unmatched accuracy, high sensitivity, bandwidth, filtering, offset, and overdrive recovery. Tektronix claimed that these machines had higher levels of accuracy than any other oscilloscope system, accomplished using the unique "Enhanced Accuracy" mode providing an automatic self-calibration of the oscilloscope's vertical and horizontal systems against a built-in stable dc source, while the digital architecture provided accuracies in parts per million for timing measurements.

Revolutionary

The Tektronix 11000-Series was for the time a new generation of analysis tools, intended to alter the customers' fundamental expectations of an oscilloscope. The advertisement highlighted many points of the new oscilloscopes, so many that it is not easy to put them in order, but they were really a lot, and somewhat revolutionary indeed.

But revolutionists are the first to be beheaded, and, as we will see, there has been no lack of fierce criticism even today, after so many years.

This in the photo is not a real 11402, but my disguised 11403 (thanks to photo editing).

The 4-traces wall

One of the starting points for the new series, had been the number of traces. Already in the 1980s, four-channel scopes were beginning to be considered no longer adequate for many applications. A new scope, facing the future, ought to offer much more, and there was also the need for a faster way to get more information about each waveform, and their inter-relationship. The 11000-Series allows up to 12 input channels and 8 traces on the screen at the same time, breaking the 4-traces wall of the 7000-Series oscilloscopes.

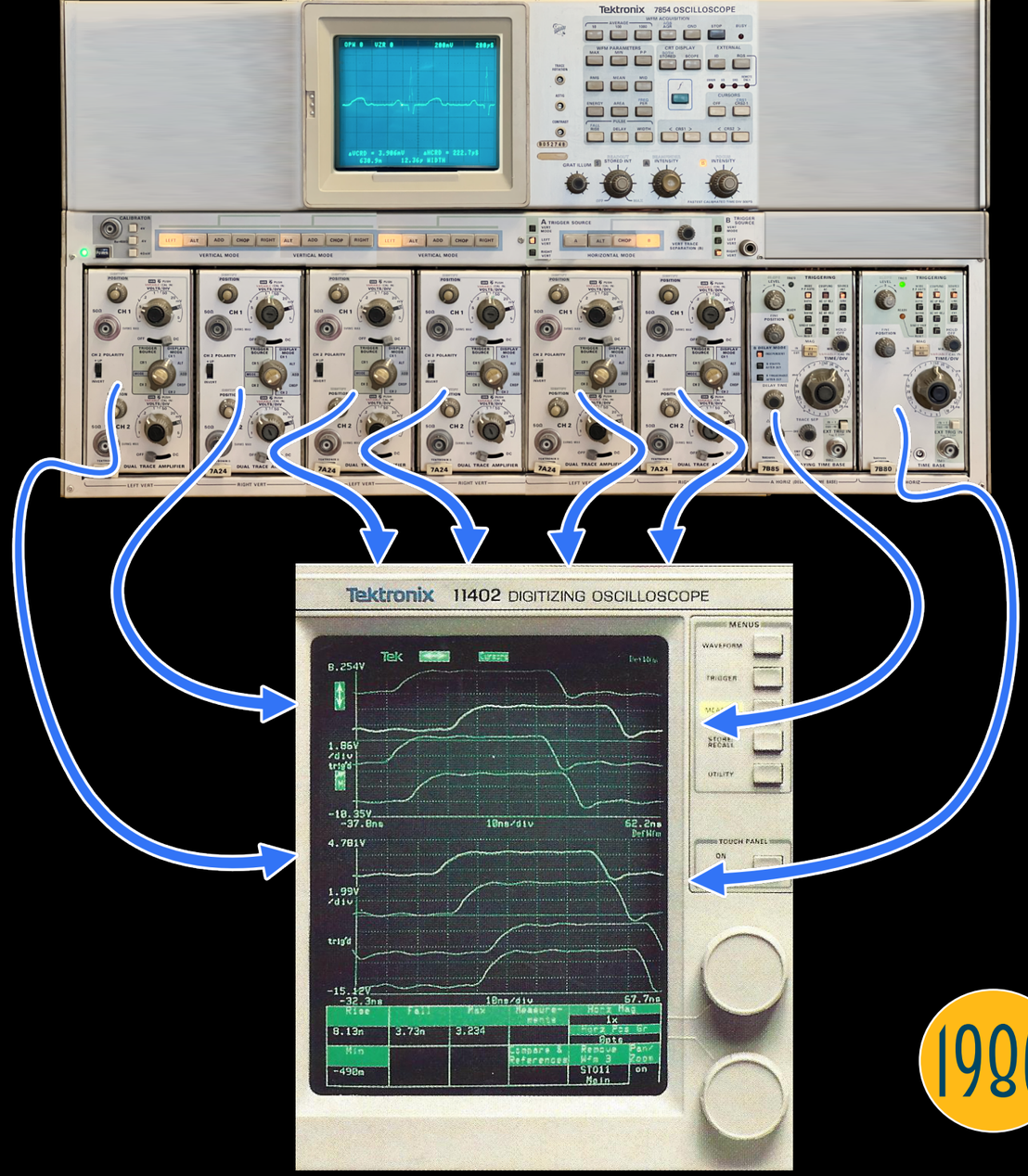
In the traditional way, a monster would be required: think, for example, a 7854 with six 7A24 plug-ins, like the one that ***I tried to imagine on the front page****: only for the verticals, it would have had 48 knobs, 18 sliders and 16 buttons... besides the dimensions, it would be very difficult to use. In any case, a larger screen would be required. Just compare it with the 11402 screen, to understand all the road that had been travelled.*

So, the biggest innovation*: a very simple and clean front panel (eleven buttons only, including the power switch, and two knobs), but with an absolute novelty:* ***a large display with touch screen****, that will acquire colors with the 11403.*

Other emphasized innovations were the ***built-in timer counter*** *and* ***the digital voltmeter;*** *a manner to describe the digital time bases and the possible accurate voltage measurements. In the old language, it was like to say: a 7854 with built-in a 7D15 and a 7D12+M2. In addition, they claimed the* ***cost of ownership reduction****, doubling the recommended time-between-calibrations. When it is time to recalibrate, the process is significantly reduced through the extensive use of on-board diagnostics and calibration aids.*

Another novelty, the ***enhanced accuracy mode****, standard on all 11000-Series scopes, for the most accurate measurements, that we will describe later.*

Providing advanced capabilities, with quick and easy user access, required numerous engineering innovations, including a completely new approach to oscilloscope operation and architecture, as we will see more in details in the following.



1986

Human interface

Many traces, many knobs?

A primary goal of the design had been to make exploitable the many functions offered by the new 11000-family, without a myriad of buttons and knobs. All the user interface was so moved to the screen itself, where the attention of the user is always concentrated. No more "look and decide which knob to move", but "look and touch what you want to change". An added benefit from this approach is that each menu presents only the selections that are currently valid for the measurement at hand.

The big round knobs play an important role as well in interfacing the user. Their function is not fixed, but changes according to the context: for one menu, these knobs may provide vertical positioning and select vertical deflection factor; for another, cursor positioning; and so on.

So Tek described the new UI:

> Clean, consistent, tested, and intuitive, the 11000-Series user interfaces make measurements easy. Parallel menus and touch screens keep the number of buttons and knobs down to a manageable few. All frequently used controls are conveniently grouped around the display where the users' attention is already focused. There is no fumbling around a complicated front panel hunting for the right switch or button. The touch screen is proven and reliable. Fingerprints, grease, dust, and grime are not a problem. The 11000 Series user interfaces provide the closest link possible between an engineer and his scope.

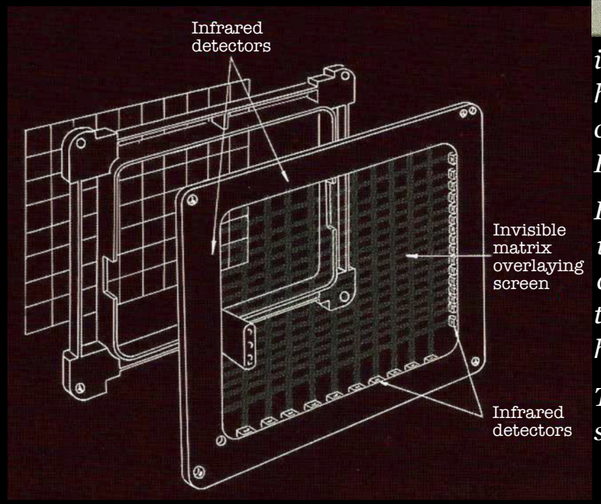
Tektronix also tried a further step, adding the possibility to issue some command from the probe tip, but I don't know how much this feature was really appreciated. A bus structure is even included in the probe leads to handle SRQs (GPIB service requests) and other automatic functions.

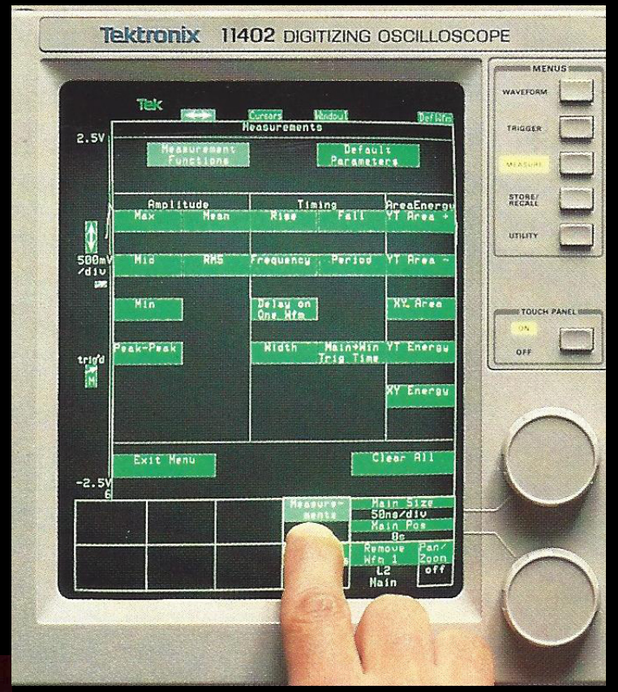
"Will our users understand and accept all that?", asked probably themselves the 11000 designers. They didn't know that, in the years, that will become the logic of any professional oscilloscope (really, manufacturers, including Tektronix, took a few steps back, reintroducing some knobs, but this does not reduce the merit of the vision and of the giant leap of the 11000-Series).

How did they get there?

In the first part of the project, the human interface was more or less the traditional wall of knobs and buttons. In the winter of 1982-83, a group of engineers and marketing people studied the entire concept of human interfacing to suggest new directions. The study hung-up on the "input device" (mouse, track ball, finger, light pen, knobs/buttons, etc.). Eventually, the touch screen approach was chosen. It was software based (flexible, reliable) and direct: a user only had to touch whatever he wanted, without fussing locating something physical. They also conceived a dynamic shallow-depth menu structure to present only valid and meaningful functions when appropriate.

In this approach, the front panel clutter was reduced, and, even more important, the interface was easily reconfigurable without hardware modifications. Two knobs had been considered more convenient than the industry (read HP) trend towards zero or one.





By the summer of 1983, a simulation of the human interface was running on an Apollo workstation, allowing to evaluate the concepts and do some tuning, long before the actual software and hardware would become available.

They were writing the future, but they were not sure how the world would accept their vision.



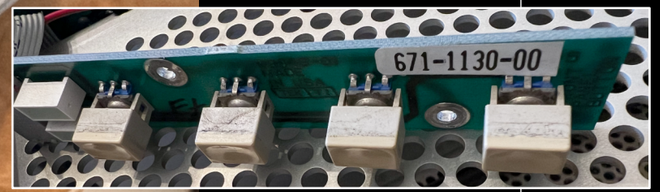
The keys

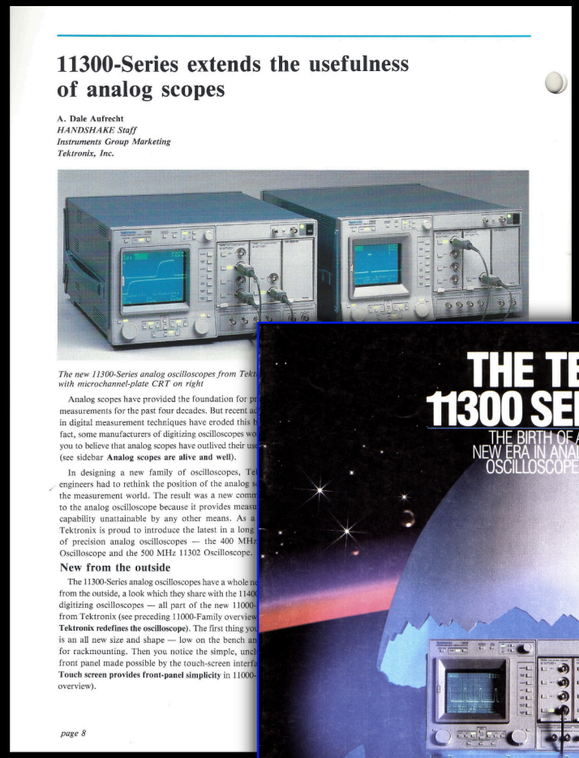
The 11400 keys are not easy to clean when you restore your purchase, but they are not difficult to dismount, so that you can give them a bath.

Dismount the 11400 front bezel is easier that you can think, just remove two screw below it, to access the PCB with the keys and the touch.

Also the other keys have two screw on the interior side of the cabinet.

Here below the keys before cleaning. The caps are easy to remove.





11300-Series extends the usefulness of analog scopes

A. Dale Aufrecht
HANDSHAKE Staff
Instruments Group Marketing
Tektronix, Inc.

The new 11300-Series analog oscilloscopes from Tekt... with microchannel-plate CRT on right

Analog scopes have provided the foundation for pr... measurements for the past four decades. But recent a... in digital measurement techniques have eroded this ... fact, some manufacturers of digitizing oscilloscopes wo... you to believe that analog scopes have outlived their u... (see sidebar **Analog scopes are alive and well**).

In designing a new family of oscilloscopes, Tek... engineers had to rethink the position of the analog ... the measurement world. The result was a new comm... to the analog oscilloscope because it provides measu... capability unattainable by any other means. As a ... Tektronix is proud to introduce the latest in a long ... of precision analog oscilloscopes — the 400 MHz ... Oscilloscope and the 500 MHz 11302 Oscilloscope.

New from the outside

The 11300-Series analog oscilloscopes have a whole n... from the outside, a look which they share with the 1140... digitizing oscilloscopes — all part of the new 11000-... from Tektronix (see preceding 11000-Family overview... **Tektronix redefines the oscilloscope**). The first thing yo... is an all new size and shape — low on the bench an... for rackmounting. Then you notice the simple, unc... front panel made possible by the touch-screen interf... **Touch screen provides front-panel simplicity** in 11000-... overview).

page 8



Tektronix redefines the oscilloscope

A. Dale Aufrecht
HANDSHAKE Staff
Instruments Group Marketing
Tektronix, Inc.

The 11000-Family from Tektronix includes four new mainframes, five new plug-ins, and three new probes.

When you first see a new 11000-Series Oscilloscope from Tektronix, you know this is something different. The simple, clean lines of the front panel, the large display screen, and the new form factor tell you that these are instruments like none you've ever seen before.

But beneath this simple, yet exciting, exterior is more measurement power than ever before designed into a stand-alone oscilloscope. The following article describes the common features and design goals of the new 11000-Family. Companion articles provide details on the new analog oscilloscopes, digital oscilloscopes, amplifier plug-ins, and probes which make up the initial offering in this exciting new oscilloscope family.

HANDSHAKE, WINTER 1986/87 *page 3*

The 11000-Series was presented in the winter 1986/87 issue of "Handshake" Tektronix magazine.

Unfortunately, not many promotional documents have arrived to us. The only I could find is this wonderful 11300 brochure that you can download from TekWiki.

Automatic setup & measurements

Automatic setup

This is a function that I normally hate on any oscilloscope, because when you inadvertently touch it, your setting becomes all messed up. Here the advantage is that there is an undo function to return where you were, and that it is rather widely configurable. At that time it was a novelty, and Tektronix emphasized it:

> Getting a display on the screen has never been easier. Just touch the probe tip to the signal source and press the button on the probe body. The selected signal is automatically scaled both vertically and horizontally, a trigger point is chosen on the selected waveform, and the waveform is positioned on the CRT. You can also push the front panel AUTOSET button to get the same results.

But admitted that

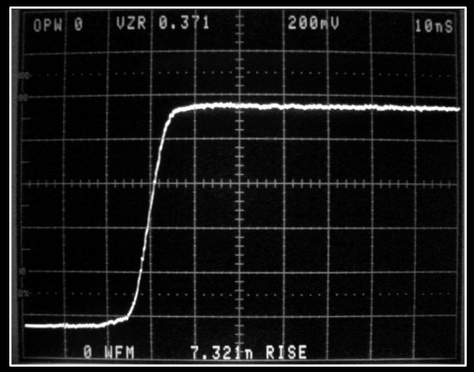
> The autoset display may not be ideal for all measurements. In such cases, just press AUTOSET (or the button on the probe) to get a preliminary setup. Then refine individual settings to provide a display that meets your measurement needs.

Automatic measurements

Through the "measure" menu on the touch screen, up to six pulse-parameter measurements can be selected on the 11400-Series, and up to eight on the 11300-Series. The 11401 and 11402 perform waveform processing functions, pulse parameter analysis, cursor functions and trigger-to-trigger measurements that combine to cover a full range of measurement needs. A special annotation mode shows where measurements are being made on the trace, so users can feel confident that they are on target. Dot cursors can be split between two waveforms to make propagation delay measurements or compare voltages. Measurement zones can be set to limit the automatic measurement to a portion of a displayed trace.

Users can set proximal, distal, and mesial levels to customize timing measurements. Up to six measurement results can be displayed and continuously updated as the data changes (that was not possible with 7854). This lets users make adjustments and see the results quicker than ever before.

A direct hard copy output is provided that includes time and date of the measurement for archiving. The measured values are also available over the GPIB or RS-232C bus.



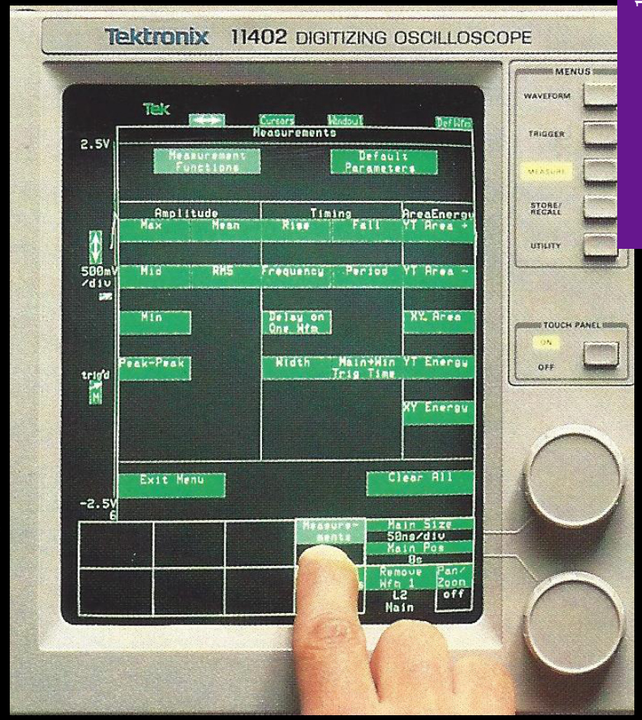
All that was not an absolute innovation: also the previous 7854 could do that, but now the measurement can be performed in real time. However, the appealing programming features of the 7854 are lost. In effect, in the nineties, everyone owns a computer, that offers much more possibilities. Also the presentation is fairly improved. In the photo on the left, you can see how the 7854 could present the measurement results, and just one at a time.

The 7000-Series 7854 screen with a rise time measurement. Just one measurement at a time could be shown, and only on a pre-acquired waveform (not in real time).

Function	11400	7854
Differentiate	●	●
Integrate	●	●
Interpolate	●	●
Smooth	●	●
Average	●	●
Envelope	●	●
+, -, *, /	●	●
Square root	●	●
LOGN/EXP	●	●
ABS/SIGN	●	●
Measure	11400	7854
Rise/fall	●	●
Width	●	●
Delay	●	●
Period/frequency	●	●
Max/min	●	●
P-P	●	●
RMS	●	●
Mean	●	●
MID	●	●

This table shows that the functions offered by the the 11400 are almost the same as the old 7854. They are however much more easily exploitable.

The 11400 measurement menu. A giant step forward in usability.



Automatic comparisons

Many of the 11400 features were very disruptive. We have already seen the possibility to perform automatic measurements on the incoming signals, now we see how to exploit these measurements comparing them with reference values, producing an automatic "pass/fail" result in real time.

Reference values

You can establish reference values for your measurements and have the oscilloscope display the measurement readouts as the amount of variance from the reference value. For example, if you want to see how much a waveform varies from 0.5 V rms, you establish a reference value of 0.5 V rms.

Compare mode

Then you turn on compare mode and the oscilloscope displays the difference between the reference value of 0.5 V rms and the rms value of the waveform being measured.

You can also save the current measurement values as reference values. If you then turn on the compare feature, you can observe how much the signal deviates from those references as you tune the circuit under test.

When the compare mode is on, the measurement readouts show a delta symbol (Δ) in front of them, to remind you that difference values are being displayed. For example, the "rms" measurement indication becomes Δrms when compare mode is turned on.

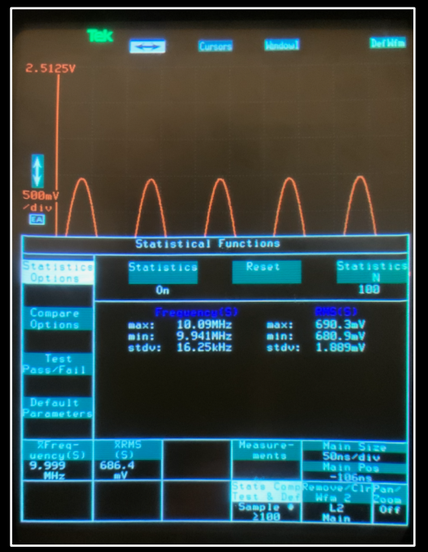
Statistics

The oscilloscope can collect and display mean, standard deviation, maximum, and minimum values for all active measurements.

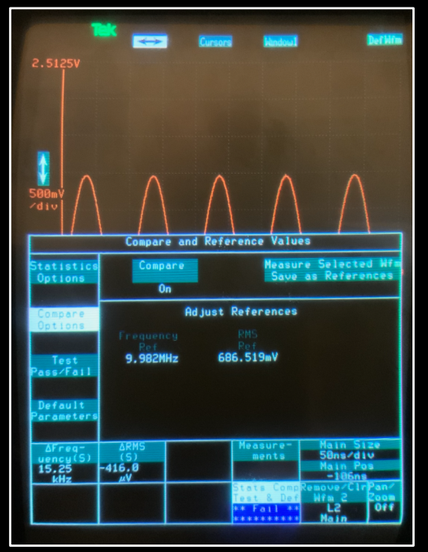
Pass/fail test

You can use the values produced by statistics to perform automatic tests on the incoming signal: if it remains inside those values, the test result is "pass", otherwise is "fail". These limit value can be set or edited also manually, or via the programming interface.

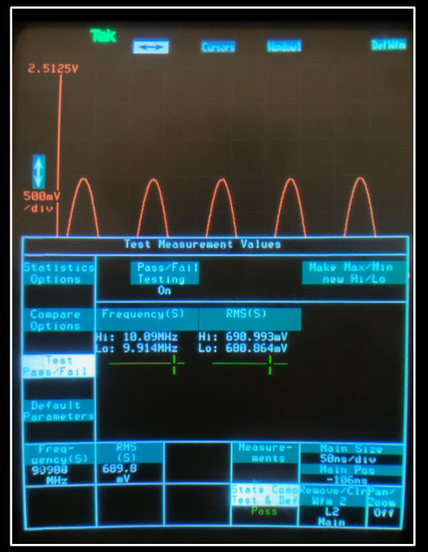
Just to do an example, you can set an upper and lower limit for the frequency and for the rms voltage, and receive an alarm when the analyzed signal exceeds one of these limits. Considering all the other functions offered by the 11000-Series and the capability of being programmed, you can easily understand how this instrument could be the base of the most complex automation systems.



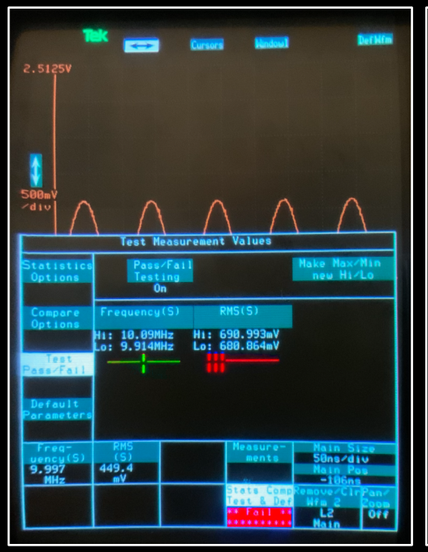
The statistics have been switched on for the two active measurements (frequency and RMS).



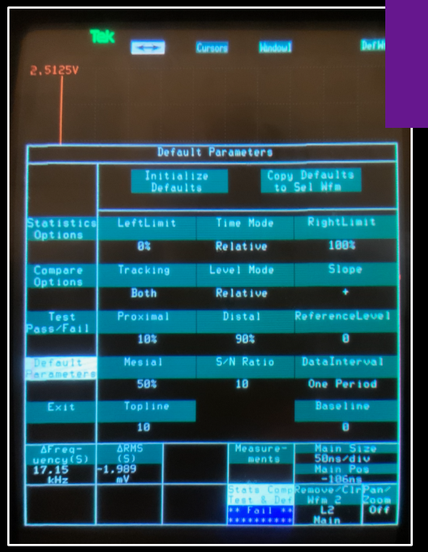
The delta mode. Note the measurement fields changed from MHz to KHz.



The comparison process is currently active and the incoming signal is within the limits.



The RMS value is outside the limits and a "fail" is signaled.



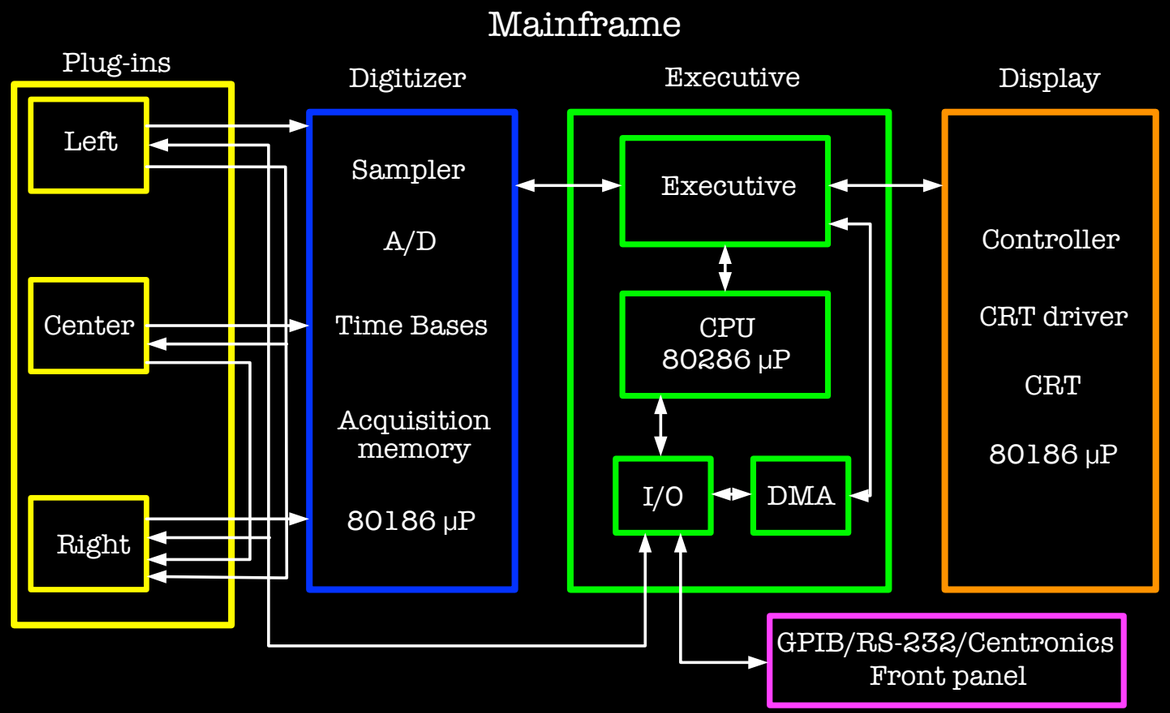
The parameters used for the measurements can be set according to the user's requirements.

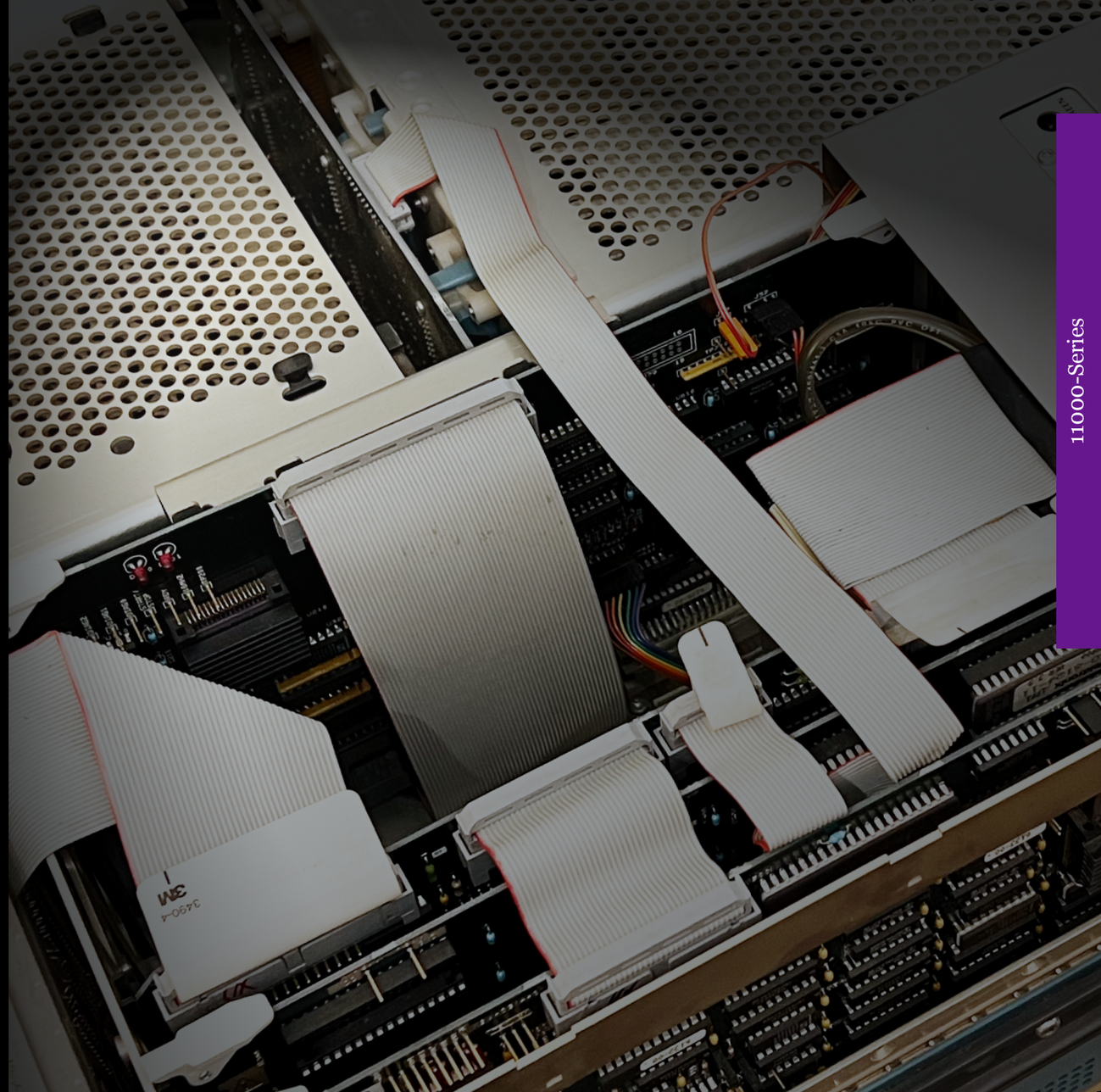
11400 architecture

With reference to the block diagram below, an 11400 oscilloscope is composed by four major modules, each with its own microprocessor:

- *executive: central memory, main processor, with operating system and ROM;*
- *display, driving a vertical scan raster display, monochrome in the beginning, and color later (8 colors). The resolution is 552 x 704 and the display size 9";*
- *digitizer: A/D conversion, time bases;*
- *plug-ins, analog front end signal conditioners.*

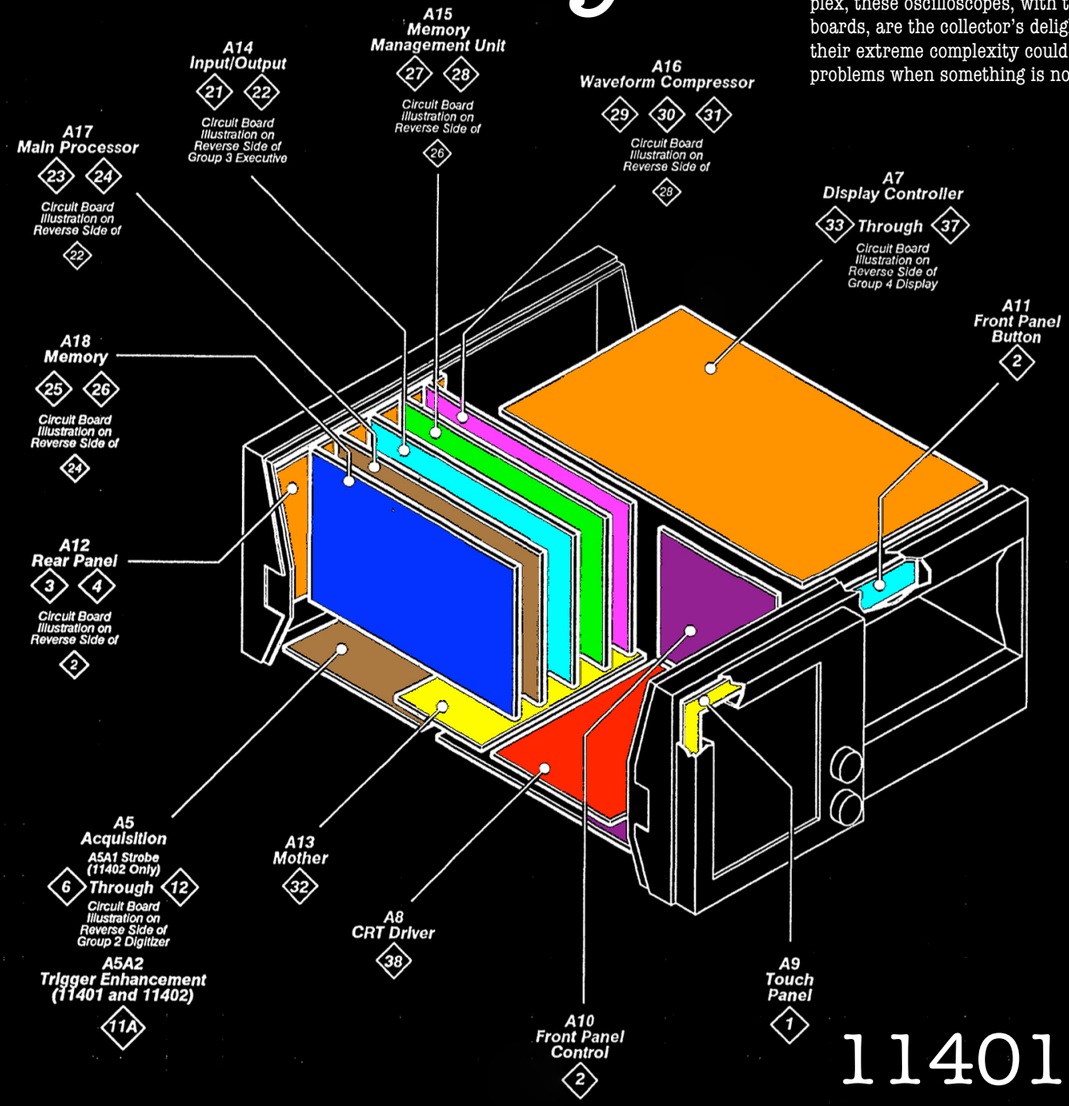
The mainframe uses two 80186 and one 80286, a very impressive architecture for those days.





Modularity

Wonderful, discussed and extremely complex, these oscilloscopes, with their 18 boards, are the collector's delight, even if their extreme complexity could create big problems when something is not OK...

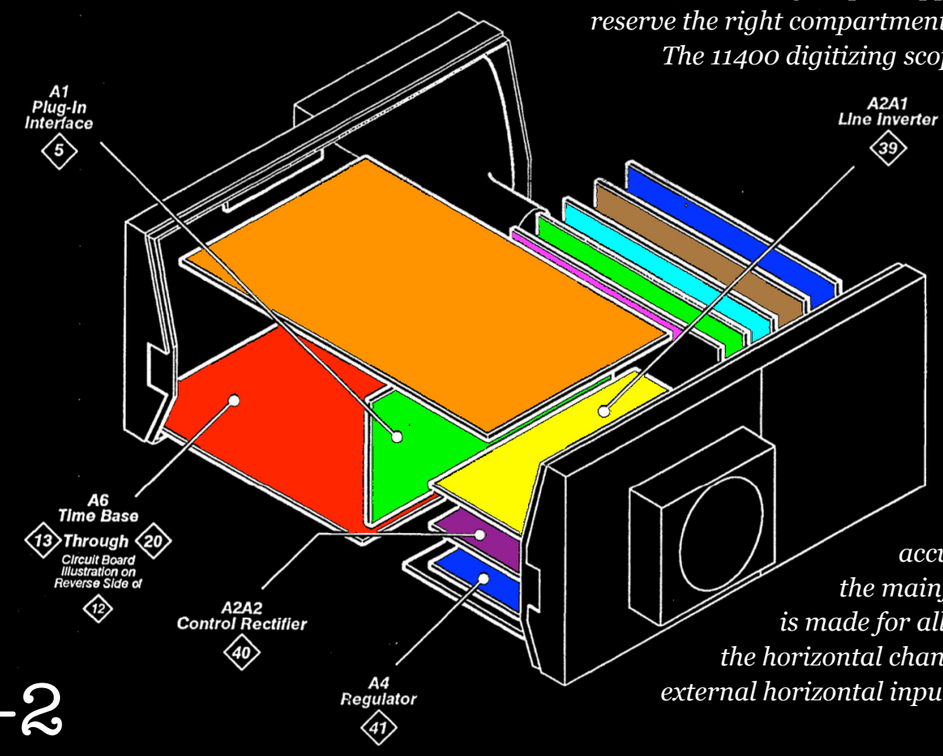


11401-2

The modules are relatively independent in their local operation and were intended to be individually changeable. That allowed reusing them for different products, if required, or to replace them with a different one, extending the product life; for example, other digitizer modules were used to provide higher sampling rates and/or bandwidth, a color display could replace the monochrome; other application software could be added (FFT). As we saw, the first products had been released quite in a hurry; as expected, the market was asking for all these improvements, that arrived with 11402A, 11403, 11403A, DSA 601/602 etc.

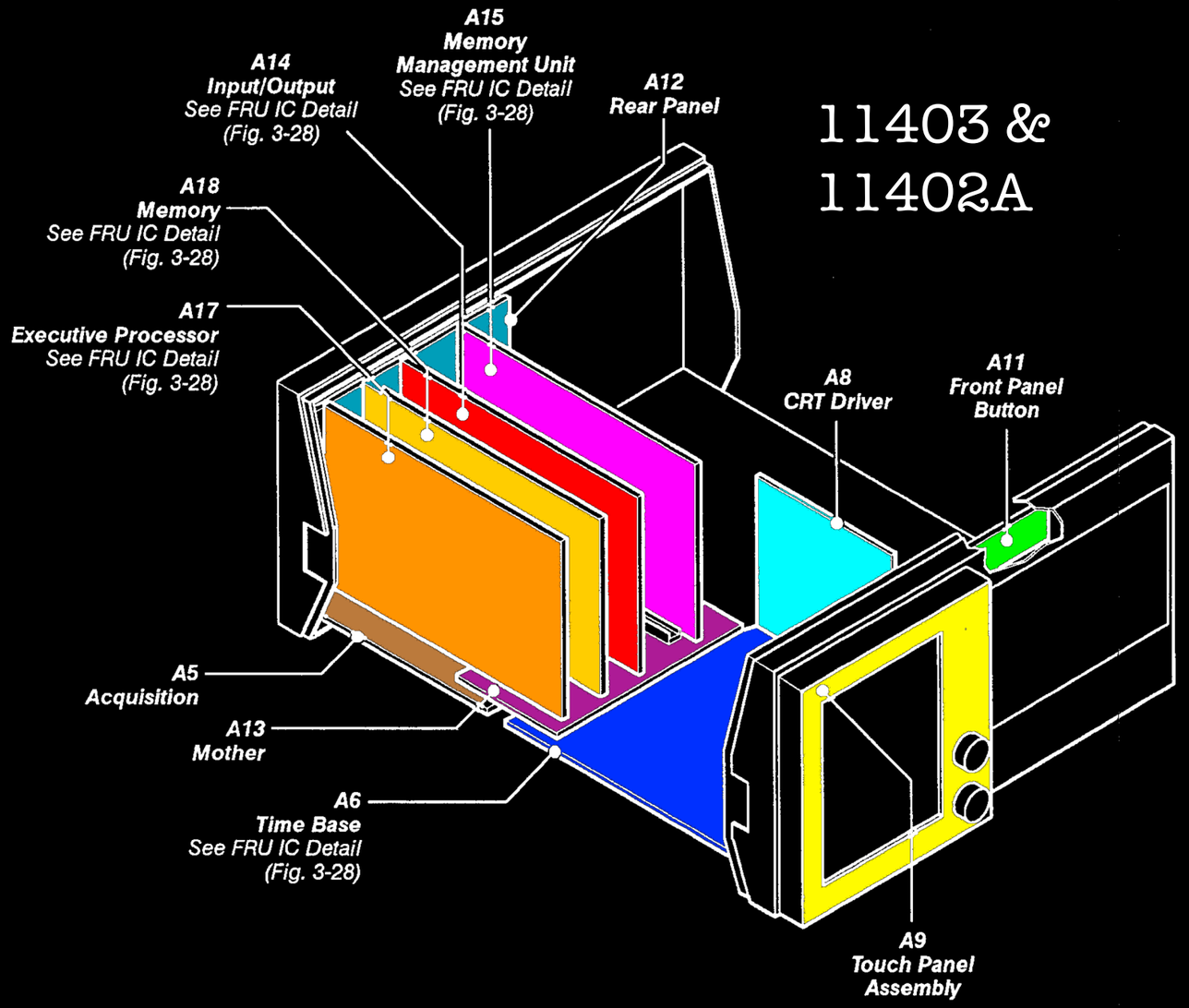
Plug-ins

*For the 11000-Series, Tektronix proposed again the winning **plug-in solution**, so successful on the 7000- and 5000-Series. The plug-ins were physically similar, but not compatible, with those of 7000-Series. The 11300 analog scopes support two vertical amplifiers and reserve the right compartment for triggering and other plug-ins. The 11400 digitizing scopes support up to three vertical amplifiers or combinations of verticals and a trigger plug-in. Each vertical amplifier can have up to 4 channels, reaching so 12 total.*



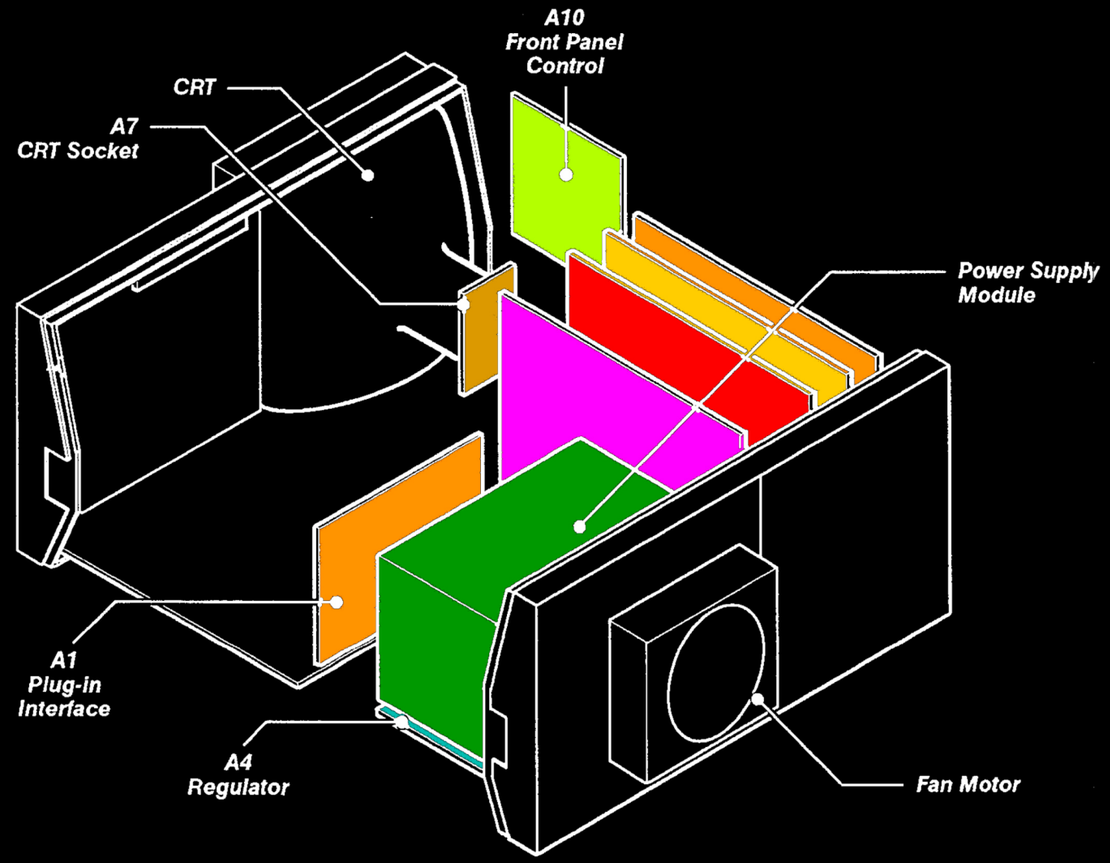
Coming from the 7000-Series, it is surprising that there are no time bases among the plug-ins. Analyzing the use of earlier plug-in instruments, it was discovered that the horizontal plug-ins were rarely, if ever, interchanged. As a result, in the 11000-Family, accurate time bases were designed into the mainframe circuitry. However, provision is made for all functions that need an amplifier in the horizontal channel such as X-Y displays and external horizontal input.

Revised

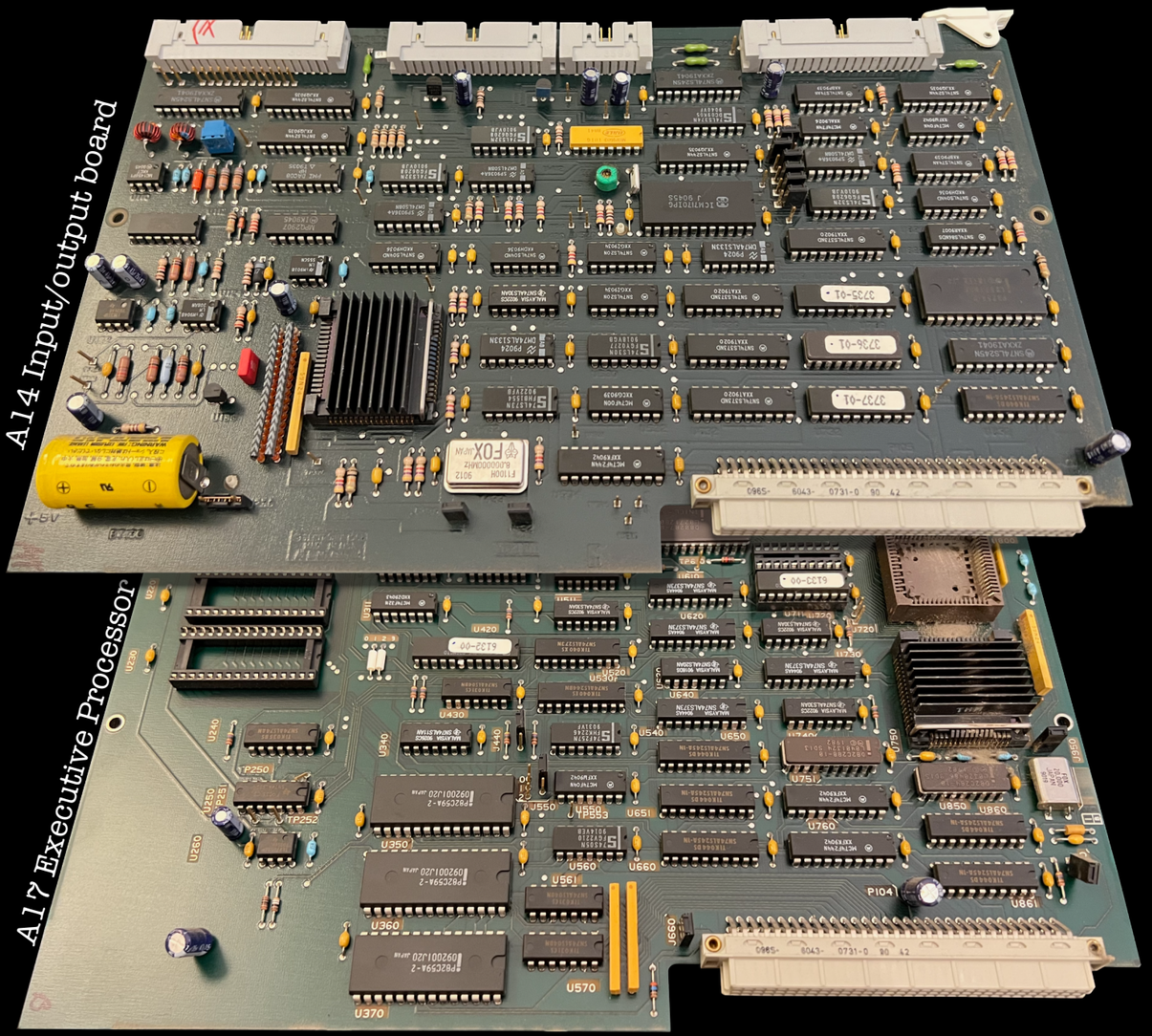


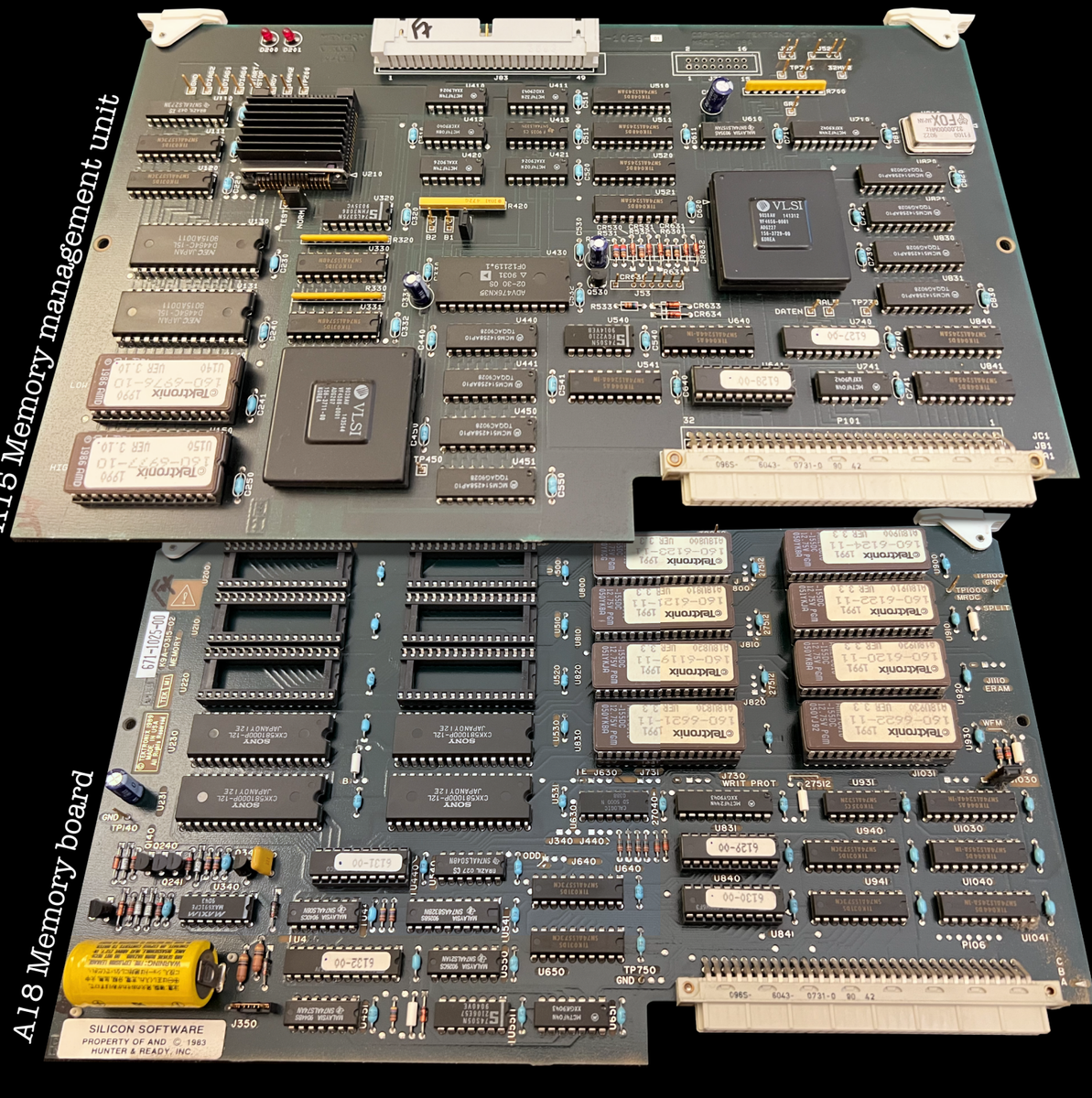
11403 & 11402A

As you can see here, the 403 is rather different compared with the 401/402. I could not find the list with the differences, but certainly one of the most important is the display, that passed to color in the 403. They passed also from a discrete video controller (the large A7 board in previous page, no longer present here) to some LSI video controller, embedded in the Memory Management board A15. One of the vertical boards (A16 Waveform Compressor) has been dropped, and the order of the other changed. Even the digitizer is different.



11403 boards





Complexity

The resulting hardware was excellent: the triple processor made the instrument very fast and responsive, avoiding situations where a single microprocessor was really inadequate, as it happened, for example, on 7854, where occasionally the instrument looks dead for extended periods while the processor is doing something invisible to the user.

But this architecture impacted heavily on the complexity and on the production costs: the 11400s are real electronic monuments. Eighteen boards, and very complex. For example, only in the 11402 A7 Display Controller board, we can count 149 ICs!

I read that toward the end of the project, however, the temptation to return to a single-processor architecture was analyzed, but eventually they preferred the important advantages which the market had proved to appreciate: faster operation, live display, faster throughput rates, and the ability to do several things at one time.

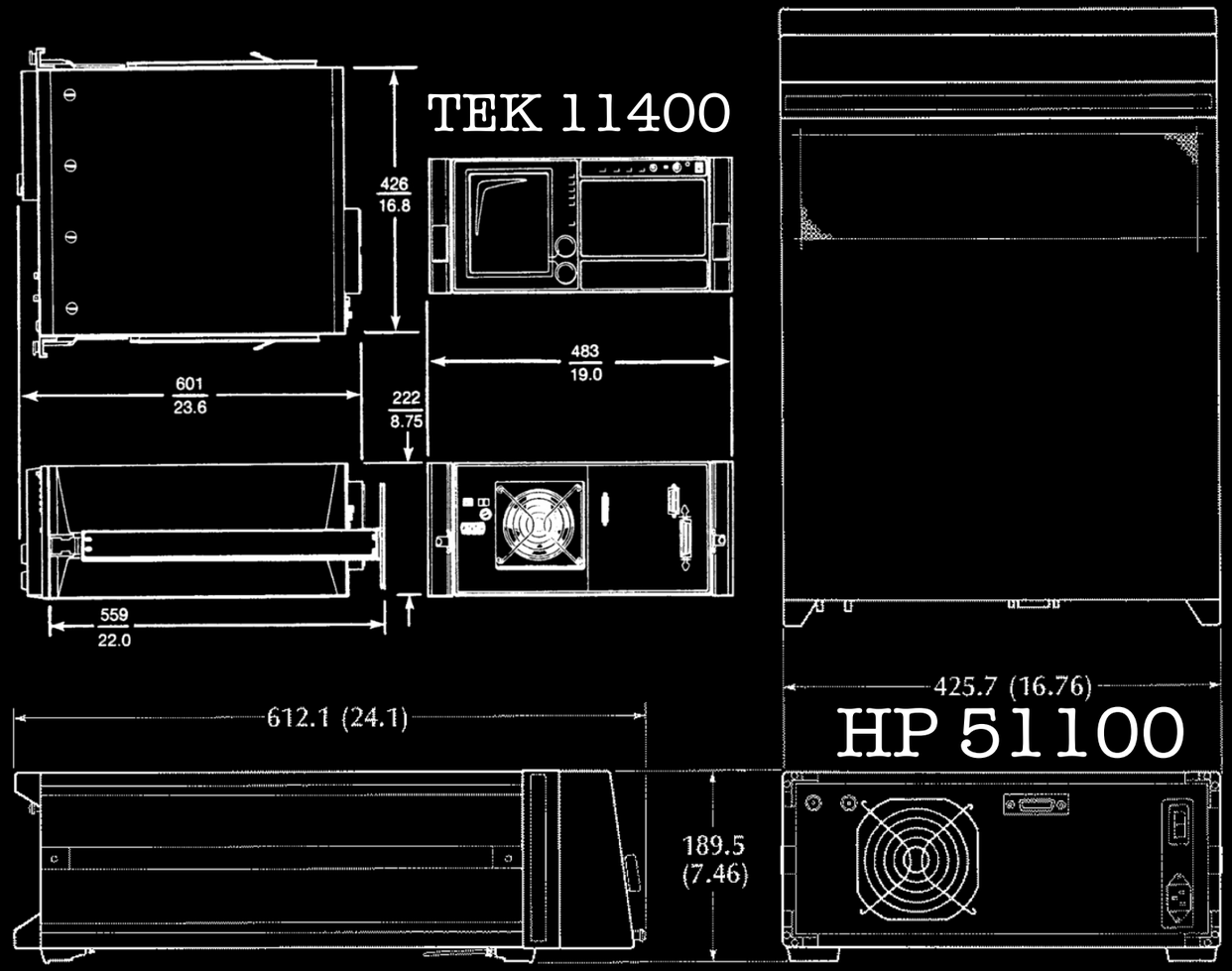
I can imagine that at Tek someone asked: "Was it impossible to make it simpler?".

New ICs

To keep the costs low, to reduce the complexity and to improve the performances, despite a general prudence in creating new battle fronts, Tektronix had to develop a number of new ICs, such as VRS, DAG, Channel Switch, MMUT, TimeBase, TimeInterpolator, and SDI. For the most part, these development succeeded, thanks to the skill and careful execution of each engineer.

Mountable in a rack

A non-evident simplification, was the possibility to easily converted these instruments from bench to rack-mount use. All that is needed for rack-mounting is removal of the feet and replacement of the side panels with rack-mounting hardware. Cable feed-throughs for routing signals from rear to front, an important feature in system applications, were either standard or could be added with a simple option. And without adding specialized models, like in the 7000-Series (e.g., my R7844).



By the way: the new 1400-Series and the HP 54100 had the same horizontal dimension, within few millimeters (the HP is 11 mm deeper). The Beaverton model was however 37 mm taller. I could not reconstruct how the HP could be integrated in the rack, but I suppose that both required 5 rack units (1 RU = 44.45 mm).

The acquisition system

Acquisition

Acquisition is the process of collecting points of data from a signal and assembling them into a waveform record that is shown on the display. Once you create a waveform, the oscilloscope continues to acquire the signal and update the waveform record, and you see a live waveform on the display.

Sampling acquisition

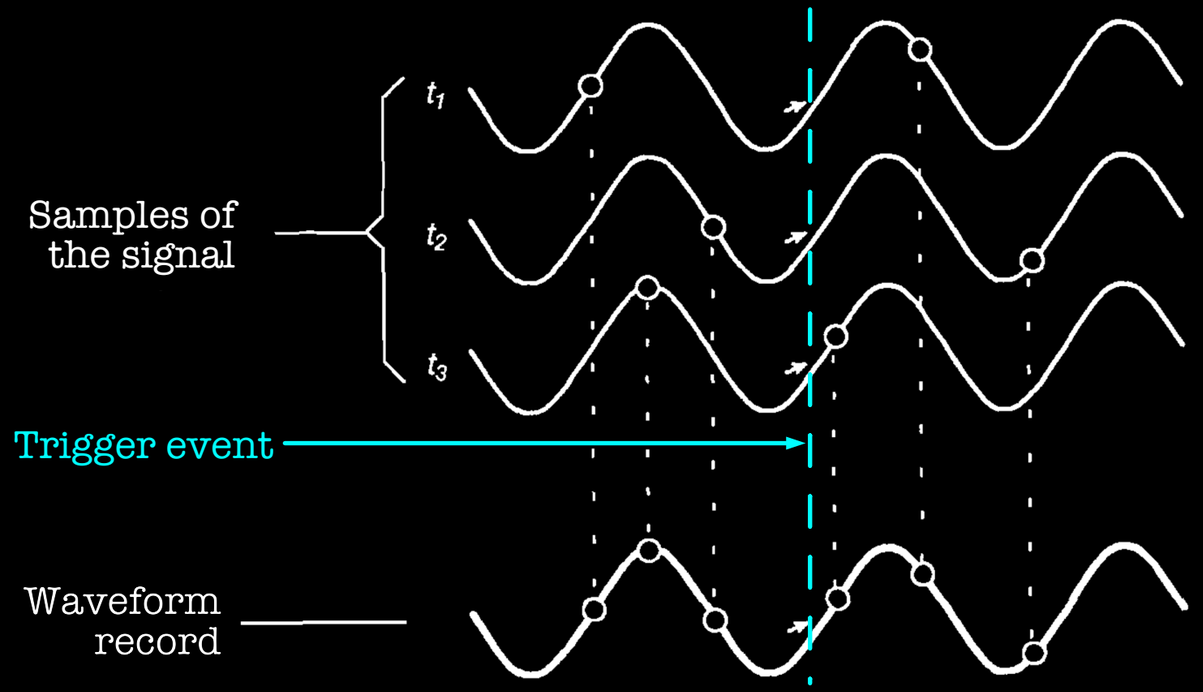
In the so said sampling mode, the oscilloscope does not read the samples in sequence (real time), but collects them from repetitions of the signal. The scope collects just few samples for every trigger event, then reassemble the correct record, determining the position of each sampled point with respect to the trigger event on that repetition, exploiting the repetitiveness of the signal itself.

Samples may be taken both after but also before the trigger event (pre-trigger). This process continues until enough sampled points have been collected to assemble a complete waveform record.

In this way, the acquisition system can be slow as much as you want. You will pay the slowness with the time to wait for having a complete sample (sample interval, see below), and so also for the responsiveness of the displayed waveform respect to variations in the signal.

Sample interval and rate

*The **sample interval** is the time difference between successive points on the waveform record. This is different from the **sample rate**, which is the actual time that it takes to sample and digitize the successive points in the waveform record. To compute the sample interval, divide the time-period that the waveform record displays by the number of points in the waveform record. For example, if you display a waveform at 20 ns per division, a little more than 200 ns of time is displayed. If the waveform has 2048 points, the sample interval is 204.8 ns divided by 2048, or 100 ps.*



Note that:

- *the **Record Length** is the number of points in a waveform record, as we will see just below;*
- *the actual **sample interval** is always a multiple of 50 ns. Equivalent time sampling allows the effective sample intervals to be as small as 10 ps;*
- *the **sample intervals** are automatically determined by the oscilloscope, based upon the number of active plug-in signals, the Record Length, and Record Duration.*

Record length

The record length is set by the user. Standard Record Lengths follow about a 1-2-5 sequence. The "about" is due to the effective size of memory buffers, whose binary round figures are not 500, 1000, 2000, 5000 and 10000, but 512, 1024, 2048, 5120, and 10240 points. In this way, a record fills ~102% of the 10-division display graticule, with the extra points on both sides.

There are also two non-standard Record Lengths with 4096 and 8192 points. These binary Record Lengths fill only~82% of the display graticule area.

Time bases

The time bases (shown in the photo here on the right) determine the duration of each division on the scope screen. The 11000s have two of them, identical, from 500 ps/div to 100 s/div, in 1-2-5 sequence. The time bases are said Main and Window, corresponding to the Delaying and Delayed in the old 7000-Series nomenclature, and stay on a single, large board.

Windows

***Main Record** - The data acquired by the Main time base is called Main Record and, as we saw before, it can be long from 512 to 10,240 point.*

***Window Records** - In addition to the Main Record, either one or two "Window" records may be acquired and displayed. The Window Records may be of a different length (duration) and may have a smaller time/div than the main record. If two Window Records are used, they must have the same duration and time/div settings but can be positioned independently.*

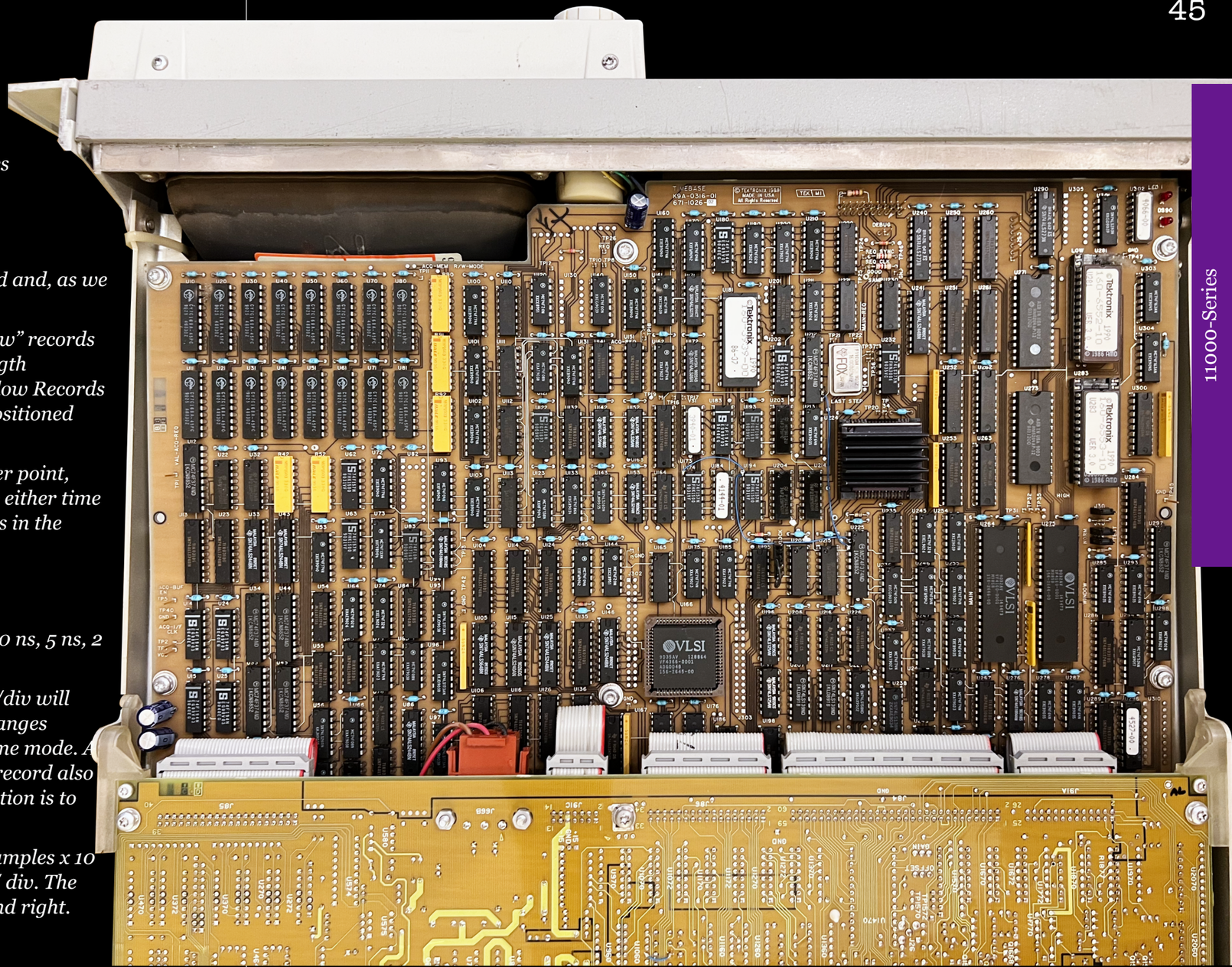
***Positioning** - The Window Records are positioned relative to a window trigger point, which may be positioned relative to the Main Record's trigger point delayed by either time or events. Very similar to what we used to call delaying and delayed time bases in the 7000-Series.*

Limitations

The record length limits the horizontal size range (time/ division) when using 10 ns, 5 ns, 2 ns, 1 ns, and 500 ps per division.

Increasing the Main or Window record length at time/div settings below 10 ns/div will cause an automatic increase in the displayed time/division. The scale factor changes because the minimum time between sample points is 10 ps in the Equivalent Time mode. As the number of points in a waveform record increases, the total duration of the record also increases. The only way to display the complete record with the increased duration is to increase the displayed time per division.

For example, a 512-points record has a minimum duration of 5.120 ns (= 512 samples x 10 ps). With 10 graticule divisions across the screen, the time/ div must be 500 ps/ div. The additional 12 points (120 ps duration) extend beyond the graticule on the left and right.



Increasing the record length to 2048 points increases the duration of the waveform record to 20.480 ns (=2048 x 10 ps). To display the entire record, the horizontal scale factor must be 2 ns/div.

In other words, if you want to go to the fastest speed, you cannot use a record length greater that 512 points, and so on.

The most difficult part

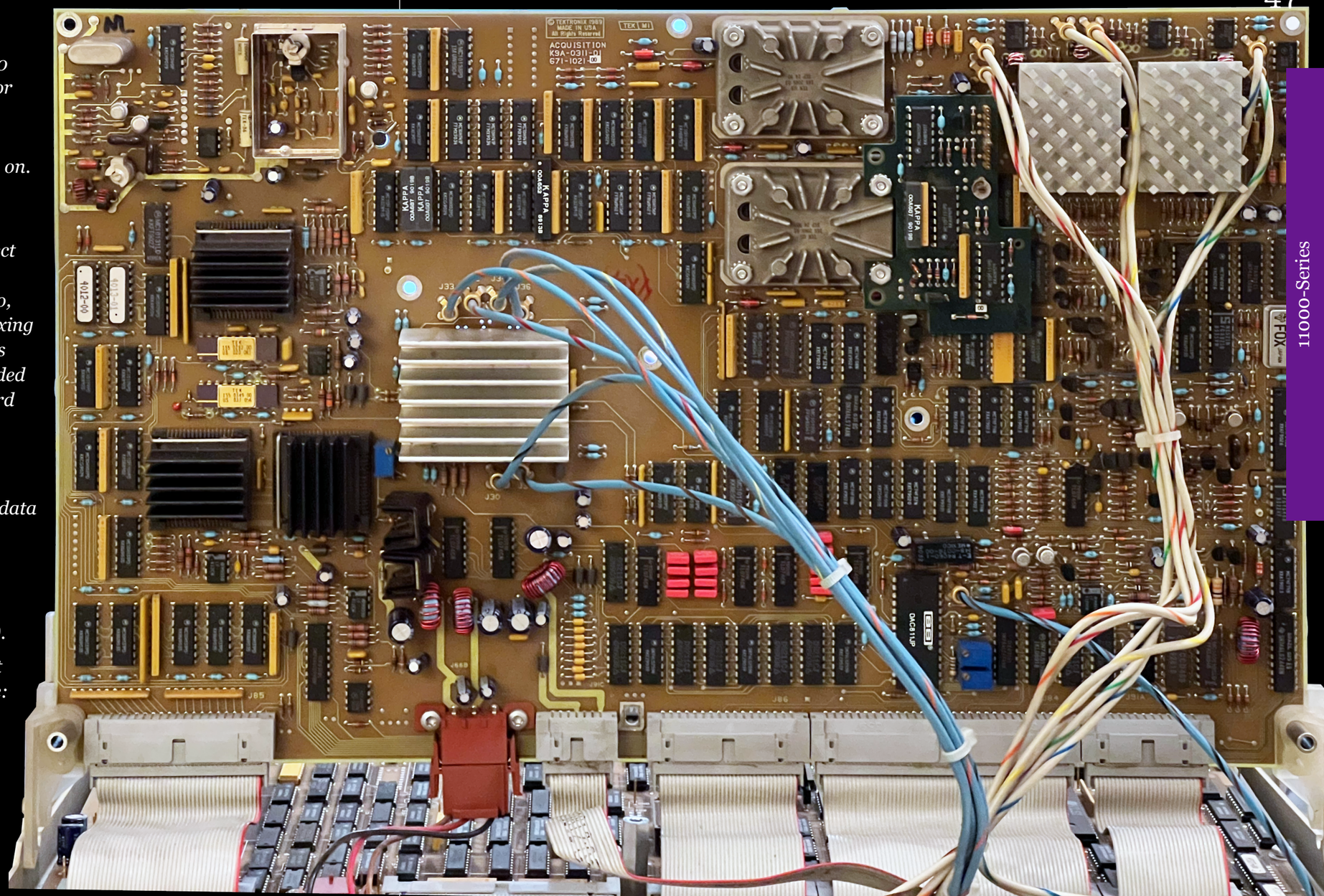
As one could expect, the most difficult area in the ET project had been the acquisition system: fighting with the speed problems, sorting out where all the sampled point must go, which waveform they belong to, and not losing any or mixing them up. These problems tended to manifest themselves as holes or spikes on waveforms. Complicating factors included multiple channels, two time bases, hold-off, variable record lengths, equivalent time vs. real time modes...

Sampling vs. real time

Besides the above said technical difficulties, the sampling data acquisition significantly reduces the oscilloscope's efforts compared with the real time, as confirmed by the performances: the 11402 declare a 1 GHz bandwidth in sampling mode, but in real time can acquire only 1 MHz signals (assuming 20 samples per period, not very many).

The 20 MSa/s sampling rate is probably the weaker point of the 11400-Series. In reality, the things were even worse: simultaneously sampling 2 channels from different plug-ins is at 5 MSa/s each and 3 waveforms from different plug-ins is at 2.5 (three signals, one from each of the three plug-in compartments, are sampled simultaneously). This strong limitation was going to be overcome in subsequent models.

In the photo: the 11403 digitizer board.



The price for 10-bit ADC

The modest speed performances of the 11400-Series were probably the price to pay for the 10-bit vertical resolution (1024 levels). The two years older HP 54100 could sample at 40 MSa/s, but its ADC was only a 7-bit, thus with 128 levels. Probably there were not any 10-bit digitizers of adequate speed available even after the 11K came out, and Tektronix drop back to 8 bit in the 11600 series.

Time accuracy

The Time Base Accuracy is 100 ps +0.002% of measurement interval.

Just to compare, the 7B92A offers an accuracy of 2÷6%, depending on the scan speed and the room temperature. That meant that, for a period of one division, we have:

- *at 500 ps/div and 20°C: 7B92A = 25 ps; 11402 = 110 ps (the 7B92A wins);*
- *at 100 µs/div (100,000,000 ps/div) and 20°C: 7B92A = 2,000,000 ps; 11402: 20,000 ps (the 11402 wins).*

That 100 ps offset ruins the accuracy at high speeds, but it becomes consistently better at all the lower speeds, and on the full temperature range. Digital is digital.

To note that there is no variable control of the scan speed, like in most oscilloscopes have.

Precision time measurement

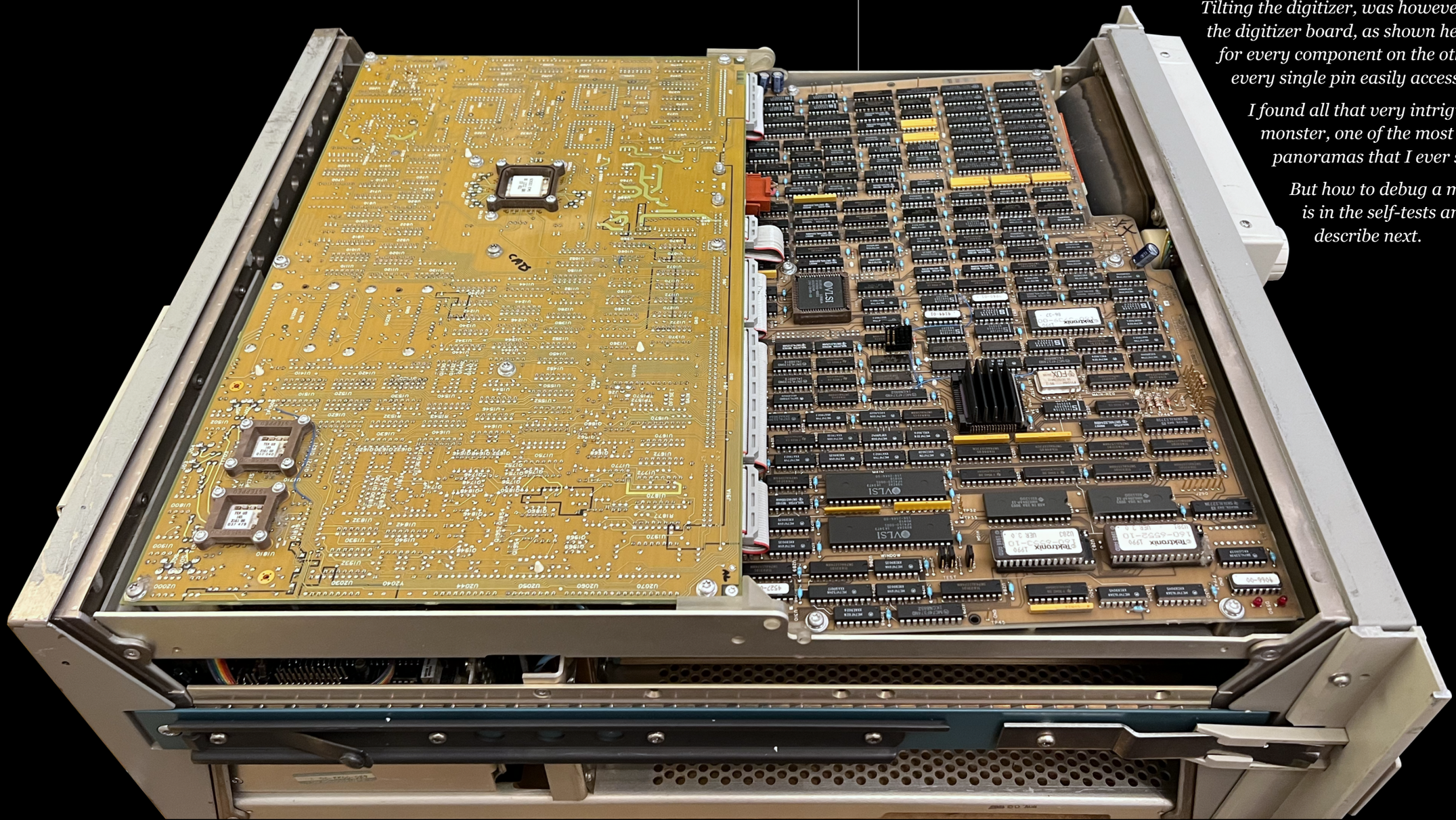
The time between the beginning of the MAIN record trigger and the WINDOW trigger can be measured precisely, even if each trigger only occurs once. Repetitive events allow this measurement to be averaged for better resolution and accuracy. Single Trigger Resolution: 200 ps. Repetitive Resolution: 10ps, after 100 averages. Accuracy: 100 ps +0.002% of record duration (same consideration as the above).

Maintainability

When I started examining the 11403, I was scared catching a glimpse of the large boards underlaying the rack with the vertical boards. "How can one get there?" I thought. But when I removed the bottom cover, I discovered one of the most ingenious solutions. You can access both the Time Bases and the Digitizer boards. The latter can be placed, thanks to a special hinge mechanism, in vertical position, making accessible every IC of the many and many present there, as shown in the photo on the right. That was useful for me to fix some problems.



The intelligent way that Tektronix engineers invented to make accessible all the components of the digitizer and of the time bases. See the hinge detail in the next pages.



Tilting the digitizer, was however not always necessary: the digitizer board, as shown here, reports the silkscreen for every component on the other side, so that you have every single pin easily accessible.

I found all that very intriguing: a real electronic monster, one of the most exciting electronic panoramas that I ever saw…

But how to debug a monster like that? The reply is in the self-tests and diagnostics, that will describe next.

Self-test & diagnostics

Self-test

Tektronix emphasized self-test and diagnostics, and I fully agree with them. Normally it's impossible to check everything, but all the hardware that software can test should be checked, and most of the circuitry added with this purpose is almost always self-paying.

Tektronix, true or false, reports that a comment from a service center was: "The 11400's are boring to fix; they're no fun to troubleshoot because the diagnostics finds the problems so quickly and easily".

Two kind of diagnostic were provided, self-test diagnostics and extended diagnostics.

- ***Self-test diagnostic** - The self-test is a set of internal diagnostic tests executed at power up, that do not require user intervention. These tests can also be invoked by the Utility major menu.*
- ***Extended Diagnostic** - Touching the Extended Diagnostic label in the Utility major menu causes the instrument to enter the Extended Diagnostics test mode. This mode provides qualified service personnel with diagnostic tools to help troubleshoot the instrument.*

Self-test Diagnostics

If the Executive subsystem runs all of its Kernel Diagnostics without failure it will start Self-test Diagnostics (possibly only locally), even though the Display and Digitizer may have failed to establish communication with the Executive subsystem. The Self-test Diagnostics, which are run at power-up and can also be run at other times, help to verify overall instrument functionality in a short period of time.

Extended Diagnostics

Any failures in the Self Test Diagnostics cause the instrument to enter the Extended Diagnostics mode, after the remaining Self Tests have run.

The Extended Diagnostics display shows a test menu with the names of major circuit blocks and the test status of each. The test status will have an indicator string that can be:



The hinge mechanism that allows the digitizer to be 90° tilted, to access every single component.

Clearly, maintainability has been a primary goal in the 11000-Series project.

- *"pass", everything OK;*
- *“*****" for tests that have not run, or which do not have current status information;*
- *"????" indicator for optional hardware which is not present or subsystems whose communication paths are not functional;*
- *a five-digit error index code that refers to a test description in the Extended Service manual (e.g. “G2121”, that means G=digitizer, 2= time bases block, 1=clocks area, 21=specific error routine).*

*Extended Diagnostics consists of all Self-tests several **interactive tests** used to troubleshoot, verify, or calibrate specific circuits.*

In addition, there may be some automatic tests which were excluded from being run in Self-test, such as NVRAM tests or lengthy RAM tests, to protect the instrument from undesirable events or to reduce the Self-test execution time. In the Extended Diagnostics mode, one or more tests can be selected and run with the chosen test loop conditions.

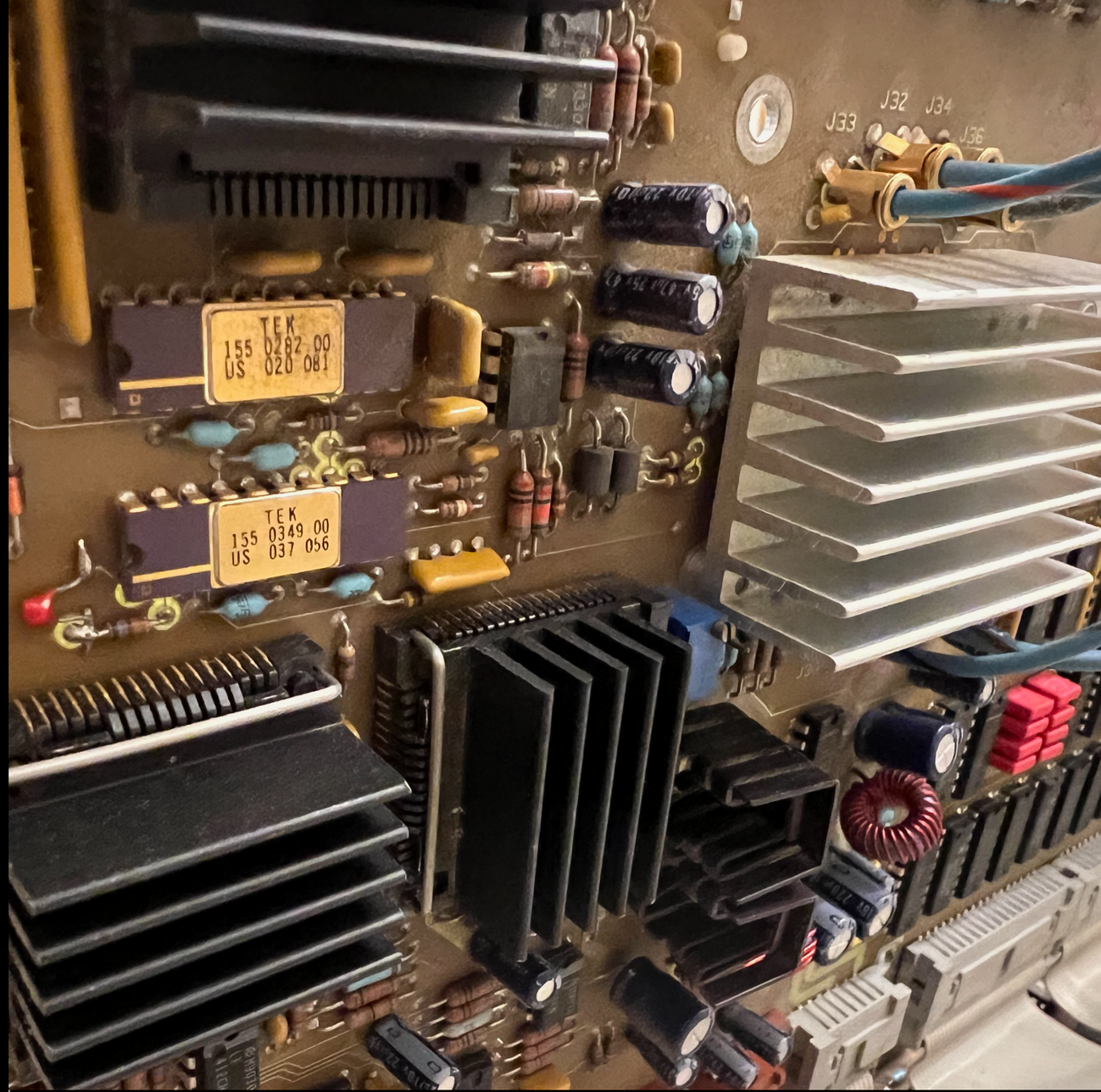
Testing from a TTY console

These tests can also be run remotely with a terminal/controller connected to the RS-232-C or GPIB interface. From it, it’s possible to issue a set of commands that helps troubleshooting, under the instructions of the manual.

Self-calibration

Before the 11000-Series oscilloscopes, special calibration techniques have always been required in order to get oscilloscope measurement accuracies better than the traditional 2 or 3%. But this has all been changed. Each 11000-Series mainframe contains a precision voltage and timing reference for self-calibration. Once the instrument reaches operating temperature, a simple press of a front-panel button (or an instruction via GPIB or RS-232C) invokes a self-calibration of all gain and timing-related functions - from input connector to display screen. A special probe-calibration routine even allows automatic calibration all the way to the probe tip. And his enhanced-accuracy state applies to all measurements until the instrument is turned off, until an internal sensor detects an ambient temperature change of ± 5 degrees C, or a plug-in unit is changed. A warning message is issued to the screen when the instrument can no longer make enhanced-accuracy measurements.

Provision is also made to guide you through probe compensation. One of these probe calibration steps allows you to "deskew" probes as well as the associated channel to match delay through any two channels for precision time-delay measurements.



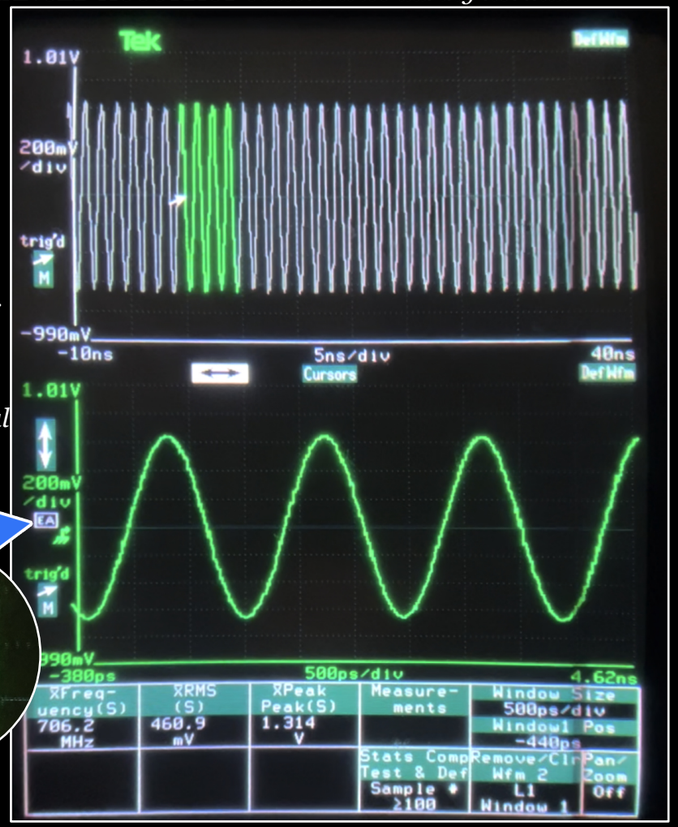
Enhanced accuracy

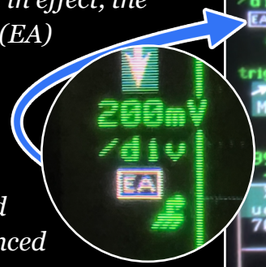
Tektronix defined the 11400s "the most accurate instruments of their kind" present on the market, combining the timing accuracy inherent in digital time bases with 1% vertical accuracy, but all that can be achieved by mean of an automatic procedure called Enhanced Accuracy, that calibrates the system from the channel inputs of the plug-in units through the digitizer.

Enhanced accuracy calibration can be initiated either manually or automatically. To manually run Enhanced Accuracy calibration, press the ENHANCED ACCURACY button twice during normal operation. The second push confirms that you wish to start calibration. A message on the display will prompt you to run Enhanced Accuracy whenever the system reverts to normal accuracy.

Changes of internal oscilloscope temperature greater than +5°C or configuration changes such as installing new plug-in units or probes will require Enhanced Accuracy calibration. If you choose not to run Enhanced Accuracy calibrations, the oscilloscope will return to normal accuracy, which is typically 3% vertical accuracy or better.

When Enhanced Accuracy is in effect, the Enhanced Accuracy symbol (EA) appears to the left of the graticule. This symbol also appears when the selected waveform is a stored waveform that was acquired with the system in the Enhanced Accuracy state.





11403 B-side

The rear panel of the 1140x oscilloscopes shows the variable speed fan, the principal power switch and the interface connectors. An option made available some BNC connectors reported on the front panel, so that the plug-in connectors could be connected inside the rack.

As noted on the configuration table, this unit has the possibility to be mounted on a standard 19" rack.

Choose your interface

The 11401, 11402and 11403 had all IEEE-488 and RS-232C interfaces as standard features, for data transfer and instrument control.

As we are going to see better, the RS-232C port lets you control the instrument with a PC, upload or download waveforms from a workstation or mainframe, or run diagnostics over a modem.



GPIB and RS-232C menus let you match interface parameters with the controller, the modem, or the host.

When the speed was a critical factor, normally the IEEE-488 port was the more favorable choice. A DMA option was available to speed up GPIB data transfers even further.

Whichever bus is chosen, the instruments respond to a logical set of Tektronix Standard Codes and Formats commands that make it rather easy to write the control software.

Talking with it

Part of a system as well

With all the built-in measurement power, Tektronix considered the 11000-Family a system in itself, but it was furthermore designed to be part of a larger measurement system: the 11000-Family was designed with system applications in mind.

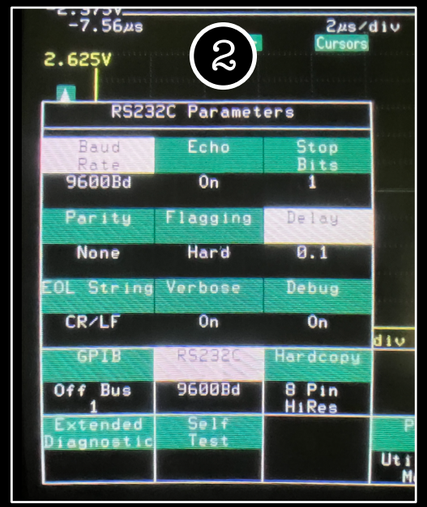
We enthusiasts often underestimate this part, but, behind those interface, there is a world, that certainly required a huge work in the project development.

The most modern interfaces

In those years, the most popular computer interfaces were RS-232 and Centronics, and the 11000s has both. In addition, they have the typical interface for instruments, the GPIB (IEEE-488), created by Hewlett & Packard and widely accepted all over the world.

The 11000 are fully programmable over both RS-232 and GPIB; in the case of the digitizing versions, full bi-directional waveform transfers are supported. This allows complete integration of these scopes into automated test and measurement systems, or into any level of engineering bench automation supported by a personal computer, workstation, or mainframe. GPIB and RS-232 commands are identical and comply with Tek Standard Codes and Formats to allow the ease of programming and compatibility typical of Tektronix programmable instruments.

Device ①	1140x	PC
Connector	DB25M	DB9F
Chassis Ground	1	
Transmit Data (TXD)	2	3
Receive Data (RXD)	3	2
Request to Send (RTS)	4	7
Clear To Send (CTS)	5	8
Data Set Ready (DSR)	6	6
Signal Ground (GND)	7	5
Data Carrier Detect (DCD)	8	1
Data Terminal Ready (DTR)	20	4



Using RS-232

I haven't yet a GPIB controller, so I used the RS-232 to talk with the monster. You can wire yourself the cable according to the table here reported. Note that DCD is not used, there is no connection inside the 1140x for that. You can use a quick 3-wire cable (orange in the table) or a full RS-232 cable, adding the connection depicted in green. This latter solution is the best, because the software handshake is not compatible with binary data transfer that some applications use.

Set the 1140x as shown the picture here and your terminal emulator accordingly (I am using MacWise, that is free and is widely configurable).

Wow, I can talk with it!

Getting the coveted ">" prompt on the terminal was not immediate, but that was not a 11403 fault but was caused by the donkey, that mismatched the wires (when you try to do something quick and dirty you must put in account at least twice the necessary time...). But getting the coveted prompt, was to me of extreme satisfaction, because it allows you a very detailed control of the instrument.

Here in the picture, you can see a sample dialog. First, we ask to identify: the mainframe serial number is B010674 and the plug-in's is B032220. Then we first change the channel 1 trigger coupling to DC and then to AC. The next command asks the current color settings, followed by date and time interrogations. Finally, the current trigger setting is requested.

```
UID?
UID MAIN:"B010674",LEFT:"B032220"
> CHL1 COUPLING:DC
OK
> CHL1 COUPLING:AC
OK
> COL?
COLOR0 HUE:0,LIGHTNESS:0,SATURATION:0;COLOR1 HUE:270,LIGHTNESS:67,SATURATION:36;
COLOR2 HUE:120,LIGHTNESS:60,SATURATION:55;COLOR3 HUE:240,LIGHTNESS:52,SATURATION
:68;COLOR4 HUE:60,LIGHTNESS:60,SATURATION:30;COLOR5 HUE:290,LIGHTNESS:60,SATURAT
ION:65;COLOR6 HUE:0,LIGHTNESS:34,SATURATION:20;COLOR7 HUE:120,LIGHTNESS:40,SATUR
ATION:100
> DATE?
DATE " 7-JAN-23"
> TIME?
TIME "10:28:29"
> TR?
TRMAIN SOURCE:"L1",COUPLING:DC,MODE:NORMAL,SLOPE:PLUS,ALEVEL:5.0E+1,ANLEVEL:3.5E
-1,VOLTS,TIHOLDOFF:7.0E-7,STATUS:NOTRG;TRWIN SOURCE:"L1",COUPLING:DC,MODE:NORMAL
,SLOPE:PLUS,ALEVEL:5.0E+1,NLEVEL:0.0E+0,VOLTS,TIHOLDOFF:2.0E-8,EVHOLDOFF:1,STATU
S:NOTRG
> _
```

③

❶ The RS-232 suggested cable. If you have only to give commands (i.e., not collect waveforms) a 3-wire cable (orange) is enough. For all the functions, use all the wires (green and orange).

❷ The setting on the 11403 (menu accessible via Utility key).

❸ The terminal emulator window. I use to use the free MacWise application.

Just the beginning

But what we have seen is just the beginning. As you can easily understand, you can give the commands and read the answers using a programming language capable of accessing the serial port. For example, you can use a BASIC interpreter in this way:

```
PRINT #1, "CHC1 COUPLING:DC"
PRINT #1, "CHC1? COUPLING"
LINE INPUT #1, RD$
```

to give the two commands that we already saw and get the 11403 answer in a variable RD$. This widely extends the potentialities of this instrument.

Interface software

If your needs are almost standard, you don't need to develop your own applications, but you can buy them ready to be used. These are the applications of which I could get notice:

- ***Docuwave**: maybe this is a software for spies; I could not find any information about it, but only the software itself, with a minimal read me. It was an MS-DOS utility to download waveforms;*
- ***Wavestar**: a long-lived package (070-9785-xx), surely survived until 2012 but no longer supported nor sold.*

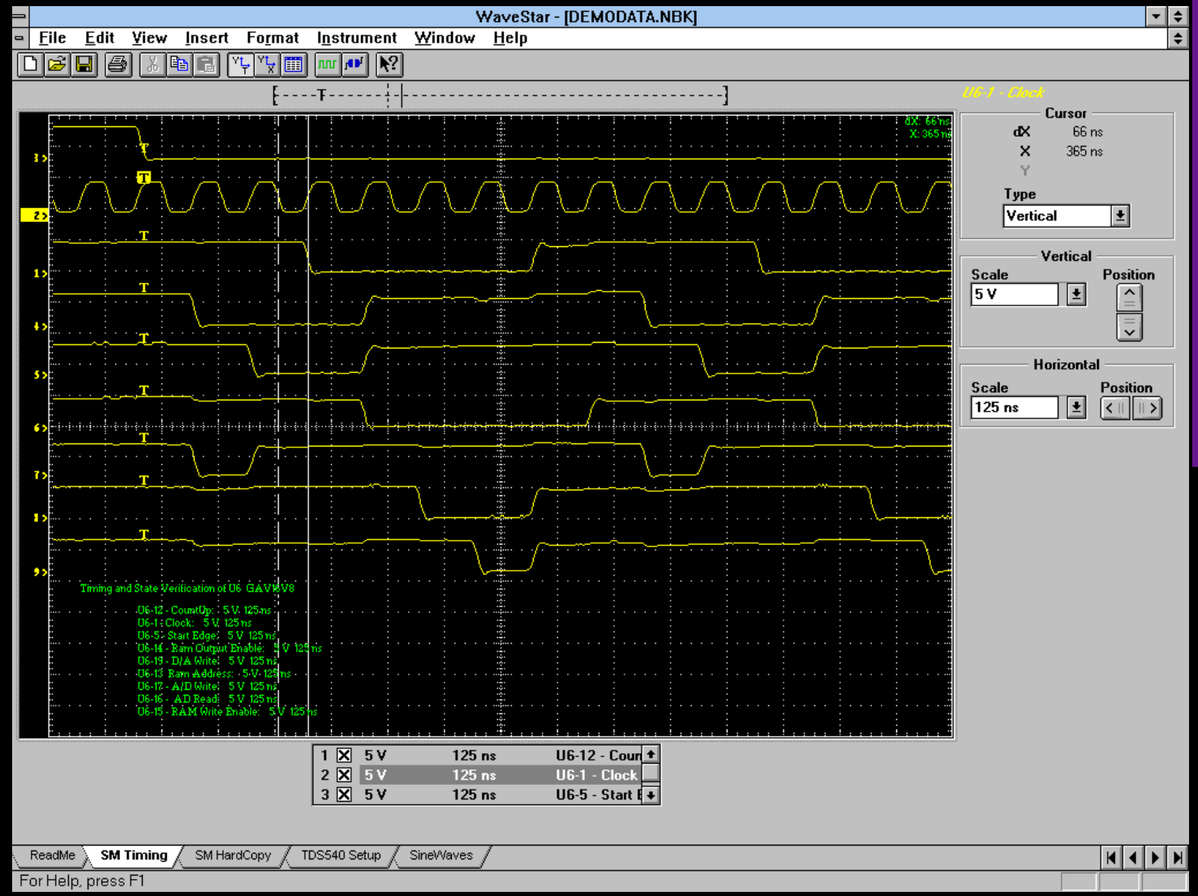
I couldn't yet test them because I don't have any longer an old Window 3.1 or 98/ME computer. I will come back on this in the future.

Wavestar

WaveStar software (see the picture) is a Windows utility application that acquires, displays, prints, and exports waveforms and screen images from digital storage oscilloscopes as graphic images or as data values. It includes tools to collect, organize, annotate, and document measurements taken with Tektronix oscilloscopes.

You can use these tools to perform the following tasks:

- *export waveform images and settings in Excel 4.0 (XLS) and DocuWave (CSV) formats;*
- *import waveform images and settings in TDS waveform (ISF and WFM), 11K series (WFB), and DocuWave (CSV) formats;*
- *copy waveform images and settings to the clipboard for use in spreadsheet and documentation applications;*
- *display waveform data in tabular, measurement, and harmonic views;*
- *create power waveforms.*



On the market

The results

Comparing two complex machines is always very hard, but I tried to synthesize the most commercial parameters in few rows of the table below, where I wrote in red the points where the HP's product is better than Tek's; in orange where they are the same; in green where Tek is definitely better. From it, we can deduce some some idle reflections:

- *Tektronix did their possible, but they couldn't fully overcome the HP 54100 specifications;*
- *part of that is due to the 10-bit choice for the ADC. It was easier to get 40 MSa/s with 7 bit, than 20 with 10 bit. Perhaps they considered it a better critical success factor compared to scan speed, which had not yet risen to today's relevance (legacy of analog scopes mentality?);*
- *among the considered point, there are some heavyweights: the advanced human interface first, but surely also the plug-in architecture and not last the temperature range for the specifications.*

Probably it is correct to consider the 1986 release as a "down payment" for the future releases, the anxiety of coming out quickly with a new product, that would be the base for new future goals. Hard to say that they did not reach their ambitious targets.

Specification	11402	HP54100
Bandwidth	1 GHz	1 GHz
Plug-in architecture	●	No
Advanced human interface	●	No
Max input channels	12	4
Max traces on the screen	8	4
DC resolution	10 (14)	7 (10)
DC accuracy (Tek with 11A52)	0.8%	3%
Scan speed	500ps÷100s	100ps÷1s
Real time sampling rate	20 MSa/s	40 MSa/s
Autoscale	●	●
Automatic measurement functions	●	●
Display resolution	552x704	501x256
Specifications temperature range	0÷+50°C	+15÷+35°C

Was the 11000-Series a success?

I found a document stating that "it was also a successful product in the marketplace, having the highest ramp-up rate of any new Lab Scope ever introduced!". Other sources let us think that the success was not great as described, but certainly many subsequent models derived their architecture from these first unit (DSA600, 11800, CSA800 etc.).

Prices at that time

Tektronix declared that "...prices have been kept extremely low, considering the capabilities provided on a per channel basis".

I tried to do math to understand what it meant. In 1990, the 11403 costed 16,950 USD without any plug-in. In those days, the 7845 costed only 5 USD more, but with it you had to add the time bases as well. So, for example:

- *7454 + 7B80 + 7B85 + 2 x 7A24 = 17,000 + 2,080 + 2,400 + 2 x 3,075 = 27,630 USD*
- *11403 + 2 x 11A52 = 16,950 + 2 x 2800 = 22,550 USD*

The 11403 mainframe has 1 GHz bandwidth against 400 MHz, a color touch screen and a lot of extra features. For example, it can grow up to 12 channels.

If I am not wrong, the above 11403 price corresponds to about 25,000€ today, hard to define it extremely low, but, comparing to previous solutions, maybe it was.

Prices today

Buying today an 11300/11400 on eBay seems to be rather expensive. Today I found the following:

- *11401, with 11A34 and 11A33 Modules, tested, 848$;*
- *11401, with no plug-in, refurbished, 1,495$;*
- *11401, with 11A32 and 11A72, refurbished and calibrated, 2,047.50$;*
- *11401, with 2 x 11A34, used, 500$;*
- *11401, with 2 x 11A32, used, 950$;*
- *11402, with 11A32 and 11A34, used, 450$;*
- *11402, with no plug in, used, 997$;*
- *11402, with 3 x 11A71, used, 999$;*
- *11402, with 11A71 and 11A72, used, 999$;*
- *11403, with 11A72, 11T5H and 11A24V, spare parts only, 1,549,99;*
- *11403, with no plug-in, untested, 1,199,99.*

Most of them are from outside Europe, and the prices don't include shipment and custom. Shipment prices alone are estimated up to 1,200 €. In my modest opinion, they seem exaggerated.

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Home > Test Equipment > Oscilloscope > TEKTRONIX > 11403

11403

Manufactured by **TEKTRONIX**



representative photo
click to zoom

Weight: 14.51 kgs

Estimated Value - €32,180.78

Save as much as 62%

Last Value Update: 31/12/1994

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- OSCILLOSCP NS
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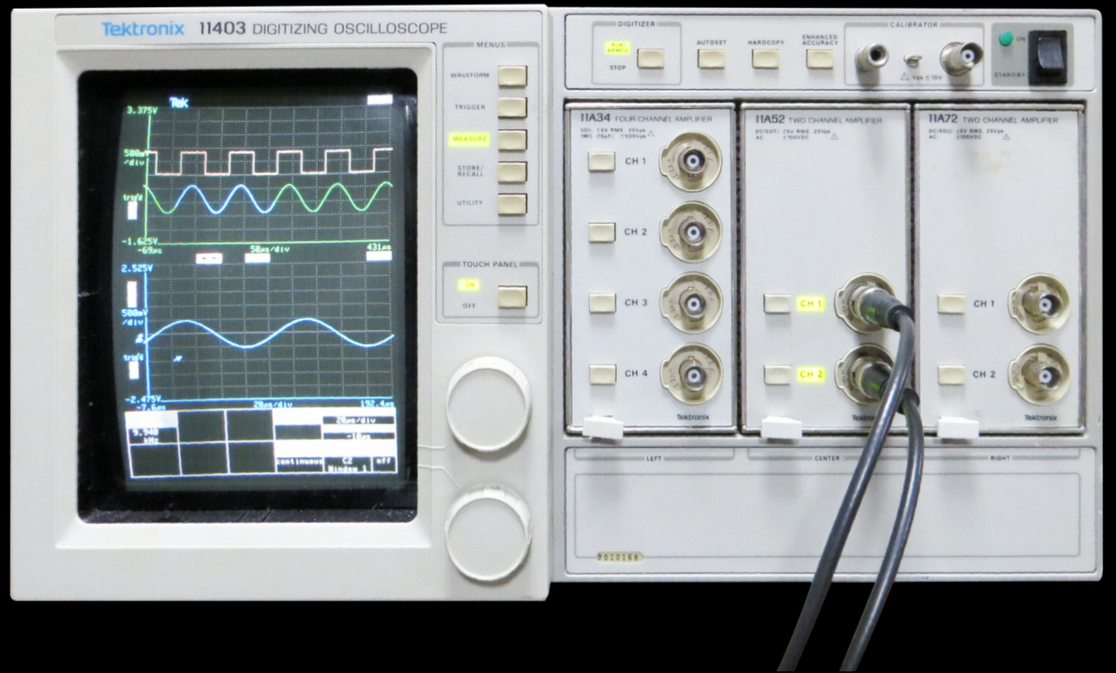
Not always I fully understand what we can find on the Internet. This one was rather incredible and so amusing that I couldn't resist the temptation to show it to you.

Maybe that this book convinced you to buy an 11403... so this is the bargain for you. It seems to be brand new, still in the original packing, and its price is very convenient: only 24,160.34 instead of 32,180€ and 78 cents. But they have other solutions at 18,120.75, 15,704.59 or as low as 14,496.76! For some extra thousand euros, probably they can deliver you also the plug-ins.

If however you find these prices too high, don't worry: they will repair yours for only 12,080.17€. And don't worry: they will beat any competitor price.

I wanted only to joke: perhaps this is something left there by some complex algorithm. Nobody is perfect....

In any case, I am available to sell mine for just 9,999€!



11400 manuals

With the 11403 I had to discover that not for all the Tektronix equipment, plenty of documentation is so easily available as for 7000-Series. Eventually, I found them on Artek Manuals. They are not free but are reasonably priced and of good quality (another opportunity to understand Tekwiki's value. Again a great thanks, Tekwiki!)

The main manuals for the 11403 (the model of my interest) are the following:

- ***11401 & 11402 Introducing** (070-6103-00);*
- ***11403 Tutorial** (070-7418-00) gives step-by-step instructions that demonstrate basic operation of the oscilloscope (not found);*
- ***11403 & 11402A User Reference** (070-7419-01), the front panel reference manual. If you are a new user, first read the 11402A and 11403 Tutorial to become familiar with the oscilloscope. Use this User Reference to answer specific questions about operation of the oscilloscope. The first section "At a Glance" presents quick get-acquainted information and a map of the various menus. Each menu is accompanied by pointers into the detailed second section.*
- ***11403 Programmer Reference** (070-7420-00) describes using a computer to control the oscilloscope through GPIB or RS-232-C interfaces (I found only the 070-8192-00 that is related to 11402A and 11403A, so it should be good also for the 11403);*
- ***11403 Command Reference** (070-7421-00 or -01) describes the commands used to program the oscilloscope (not found);*
- ***11403 Service Reference** (070-7422-00) provides information to repair and replace components of the oscilloscope.*

It existed also:

- *the 11403 QuickStart Package (U.S.A. Tektronix part number 020-1767-00, Europe 020-1768-00) is a complete learning laboratory, including a signal generating board and a workbook. A videotape for the QuickStart Package is included with your oscilloscope. These show you how to use the power of the 11403 Oscilloscope to get the types of measurements you need. The QuickStart Package was available at no charge, but you needed to mail in the postage-paid card included with the oscilloscope.*

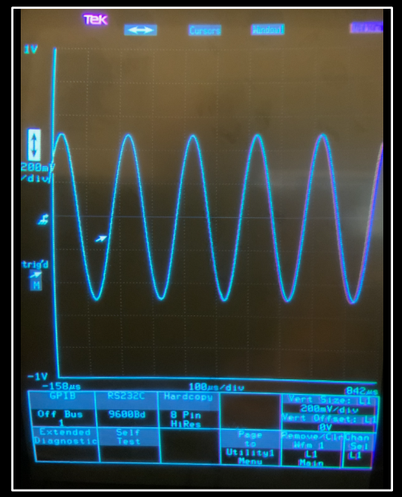
Note that in all the above manuals, neither one schematic diagram is included. For that, there were further manuals. I could find only those for the 11401 & 11402:

- *11401 & 11402 Extended Service Manual, volume 1 (070-0386-99);*
- *11401 & 11402 Extended Service Manual, volume 2 (070-7387-99). This manual contains the schematics.*

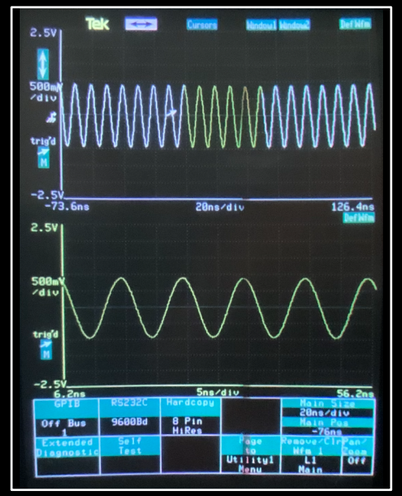
The following table resumes the situation for the manuals' availability. In green the manuals that I could find, in red those that seem not to be available.

P/N	11401	11402	11403	Title	Artek	Tekwiki	Internet
070-7386-99	●	●		Extended service manual vol.1	●		
070-7387-99	●	●		Extended service manual vol.2	●		
070-6779-03	●	●		Service manual	●	●	
070-5791-00	●	●		User's reference manual			●
070-5791-01	●	●		User's reference manual	●		
070-8192-00		●(A)	●(A)	Programmer reference	●		
070-7418-00			●	Tutorial			
070-7419-00			●	User reference	●		
070-7419-01		●(A)	●	User reference		●	
070-7420-00			●	Programmer reference			
070-7421-00			●	Command reference			
070-7422-00			●	Service reference	●	●	
070-8193-00		●(A)	●(A)	Quick reference			●
070-6103-00	●	●		Introducing		●	
070-8194-00			●(A)	Service reference		●	
070-8194-00			●(A)	Service manual	●		
070-7848-99		●(A)		Service manual	●		

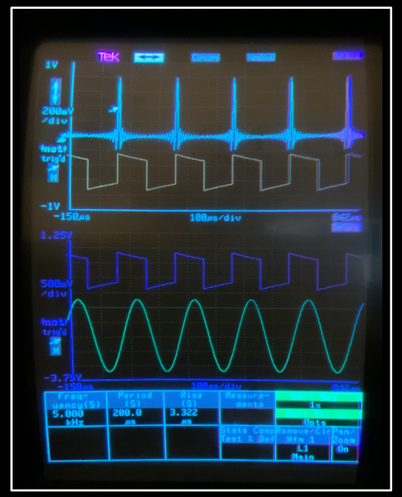
Some 11403 screenshots



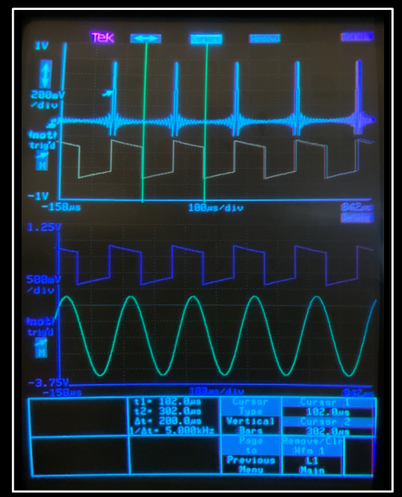
Nothing special, just a single trace.



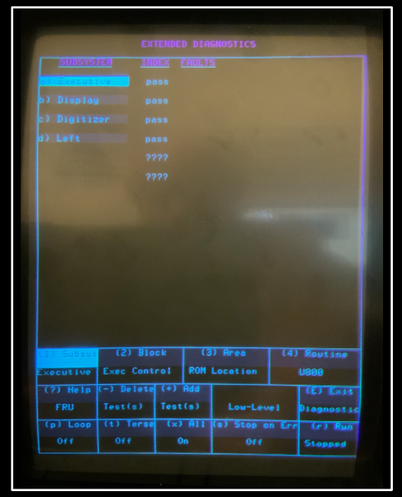
The “window” function, just like the old delaying and delayed time bases of the 7000-Series, with greater precision and control.



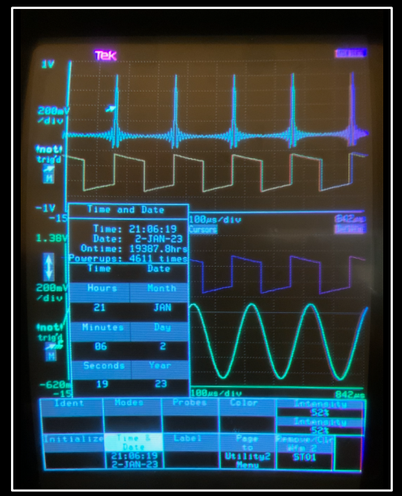
More traces and automatic measurements (below). Up to eight measurements can be done in real-time.



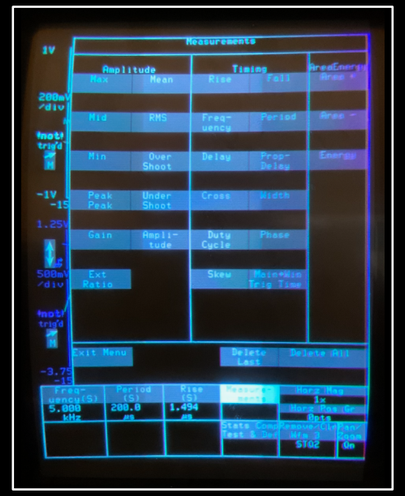
The cursors can be shown as bright dots or, like in this case, as two vertical (or horizontal) bars. Below the position and other information are displayed.



The self test. Each row hides a very high number of different tests, that can be activated individually and used also for repairs.



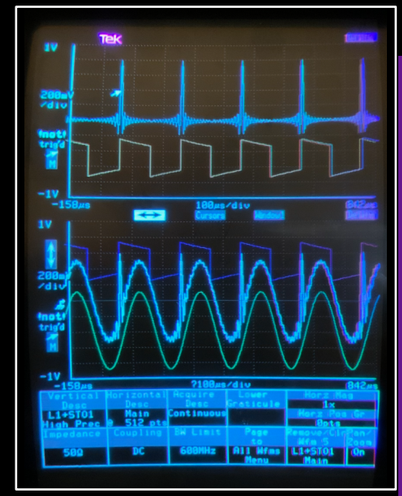
An unknown thing for the old 7000-Series oscilloscope: the date and time, used also to time- stamp the stored traces and setups.



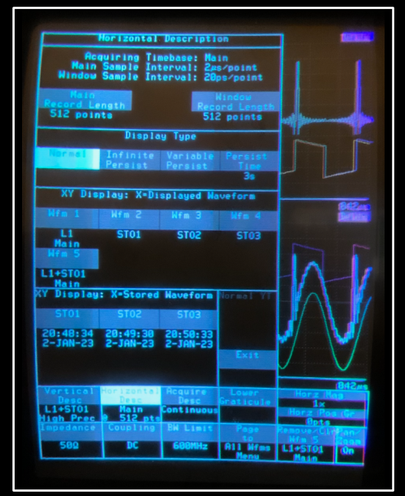
The measurement selection menu, a great innovation at the time and a great improvement over the 7854.



A very interesting function: the trace arithmetics. On the upper row, we are composing an expression that will be evaluated in real-time.



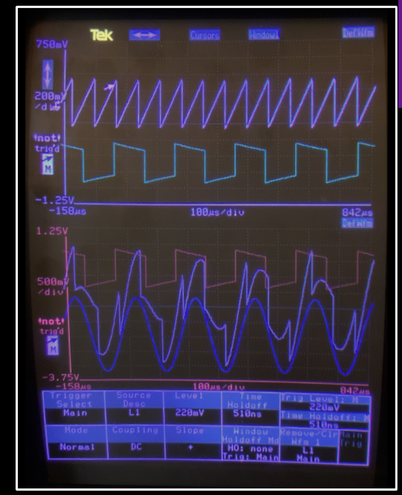
An example of trace arithmetics: the input signal (on top) is added with the stored sinusoidal waveform (green).



The horizontal description menu. Note, among the others, the persistence functions typical of the old CRT storage oscilloscopes.

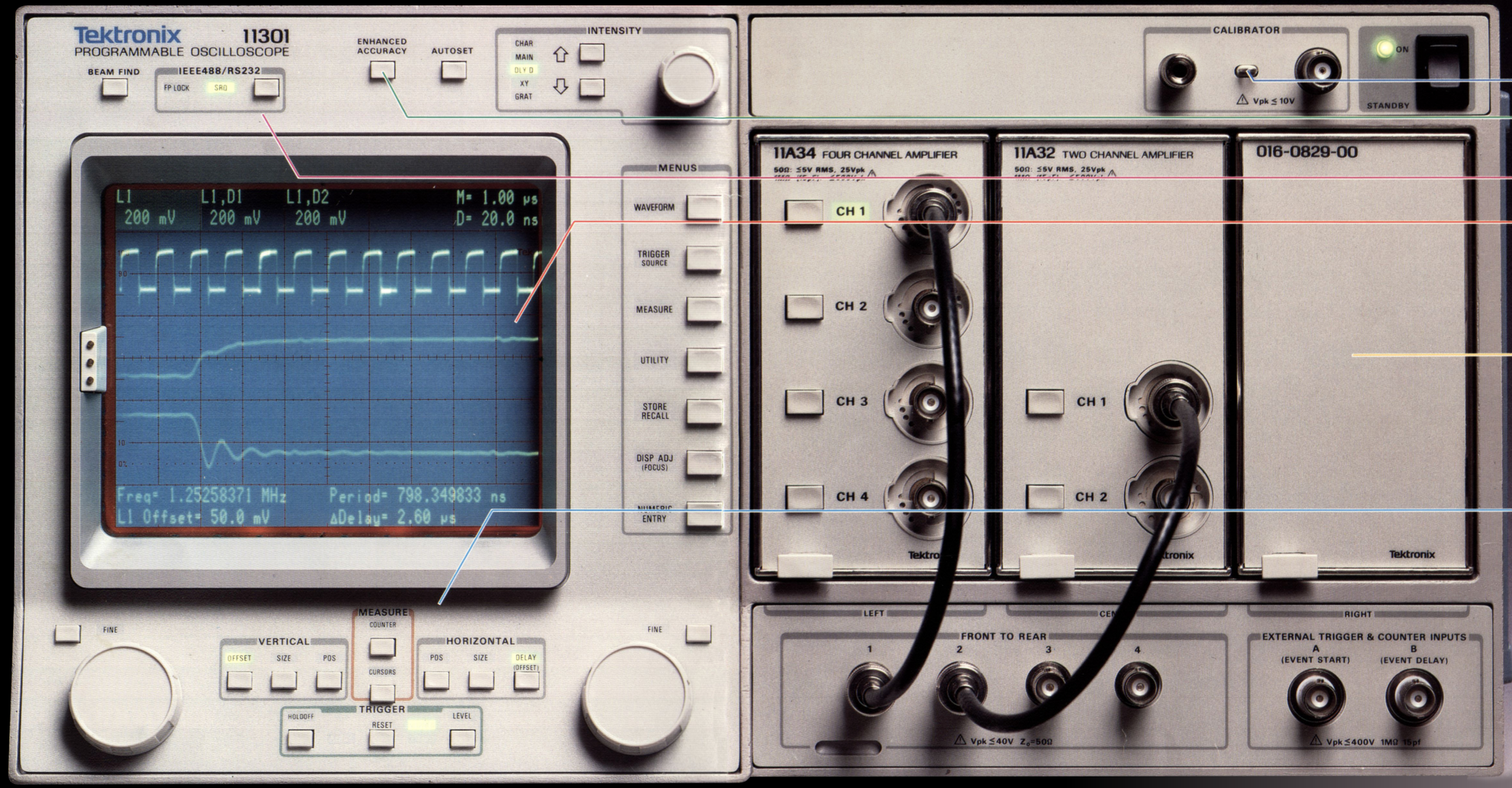


In general, the iPhone 13 can take good photos, but for the 11403 screen maybe it is too fast, as shown here. All the other pictures have been taken thus with the iPad.



Some of the screenshots in this book have significant CRT convergence problem on the right side. That has been corrected here as explained in the next pages.

The beautiful 11301



Counter view trace lets you see what the counter sees when using the integrated counter/timer. No more uncertainty about whe measurement is made.

Built-in calibrator with selecta amplitudes and frequencies.

Push the Enhanced Accurac button to calibrate the scope amplifier input to CRT gratic automatically.

Full programmability via IEE or RS-232C.

Dual delayed sweeps for pre visual comparison of two eve and for accurate propagatio delay measurements.

Touch screen operation pres you only with those controls vant to the task at hand.

Display up to eight traces at

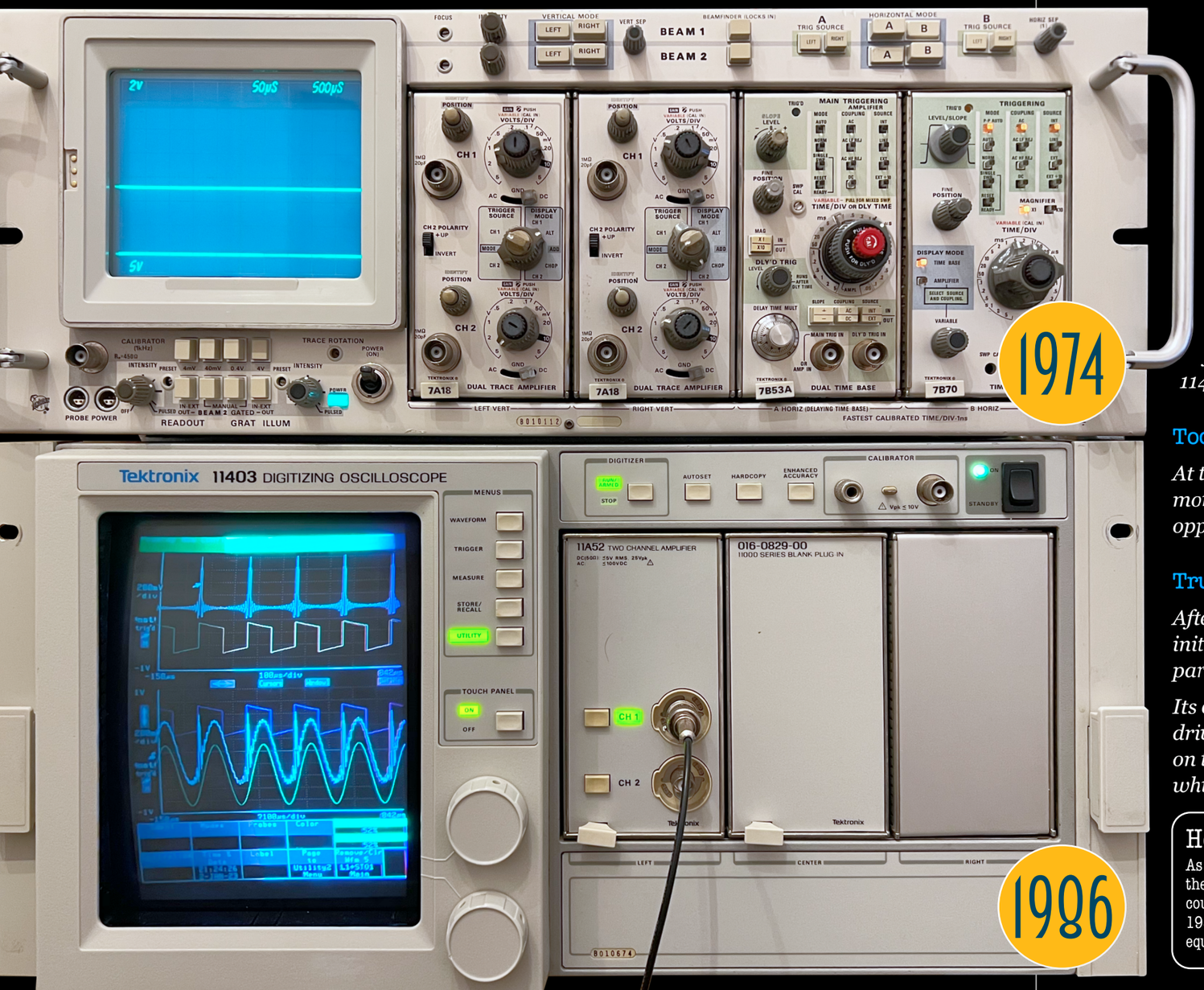
Plug-in modularity assures e lent versatility and promises long, useful future. Five new amplifier plug-ins are immed available.

Use the cursors to make pre measurements on any part displayed waveform. Results be automatically displayed i decibels, percent, degrees, volts or seconds.

Push buttons assign vertical, horizontal and triggering controls to the two knobs. Cursors are also push-button selectable.

11000-Series

We spoke almost only of the 11400-Series, but I find the "half-digital" 11301 one of the most attractive oscillo-scopes ever, so I was happy to spend some moments try-ing to restore this beautiful photograph from the original Tektronix brochure. Th old CRTs are unique!



My monster oscilloscope

As you know, at this point, is that I like these machines, and probably suspect that I wrote all that above just to arrive to this point…to tell you about my new 11403, that you can see here together with the R7844. With the 11000-Series, disappear the "R" versions: two brackets, and the base model goes into a rack.

A wonder machine

I have found the 11403 a wonder machine, with its color touch screen, an lot of functions, and very high performances (1 GHz), even if for repetitive signals only. The 11403, as we have reminded more times, appears for the first time in the 1990 catalog.

Too few knobs and buttons

At the beginning I didn't like it: it had too few knobs and buttons, but when have looked more carefully at these new (in 1986) oscilloscopes, I have been hit, so, when I had the opportunity to buy an 11403 at a fair price, I took it on the fly.

Truelove

After having opened the cabinet and having seen all those wonderful boards full of ICs, the initial attraction suddenly became love. It is the most complex object that I own, or at least on par with the Digital Equipment PDP-8.

Its condition are good: it has some problems in the delayed time base and the monitor was driving me mad to work properly (in the photos you can see a visible convergence problem on the right side). It had still the sealing labels from its last calibration, probably in 1999, while the 11A52 has still the original Tektronix seals.

How old are you?

As we already noted, Tektronix serial numbers cannot help us in detecting the construction year of a gear, but we can rely on the date printed on the ICs. In my unit, I could find ICs of the 40th weeks of 1990. The 11400 have however two non-reversible counters that can be quested by the remote interface, with the commands "UPTime?" and "POWeron?", that in my case report 19397.5 hour and 4671 cycles. In thirty-one years, it worked in mean 625 hours/year. More probably, it was part of a test equipment that worked 2/3 thousand hours per year before passing to other kind of works, and finally to a shelf.

Using it

Not as bad as portrayed

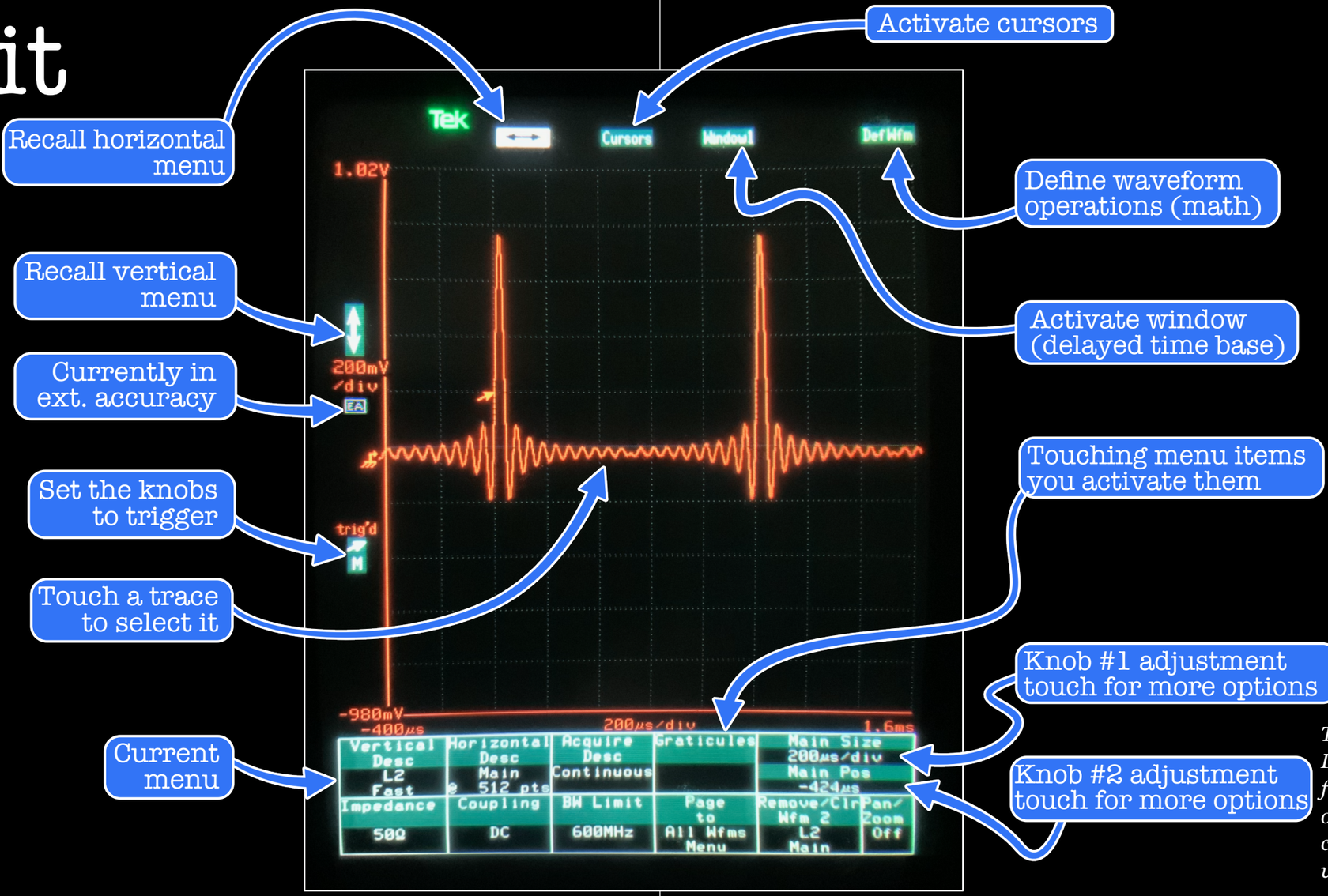
I was in some way prepared: I had read that the 1140x user interface was terrible.

Using it, at first I was a little disoriented, but I got acquainted soon: it has its own logic, but it is not so bad, and also the infrared touch screen, that I expected rather uncomfortable, was more than acceptable, when you learn to touch it.

Touch what you want

Later Tektronix, like others, will add again some knobs but even so the 1140x can get your sympathy rather quickly. The main things to know are summarized in the picture and can be resumed as follows:

- *all the commands stay in the dynamically changing menu;*
- *touch **a menu item** to activate it or to open a submenu; the menu structure is shallow and you never go further this second menu level;*



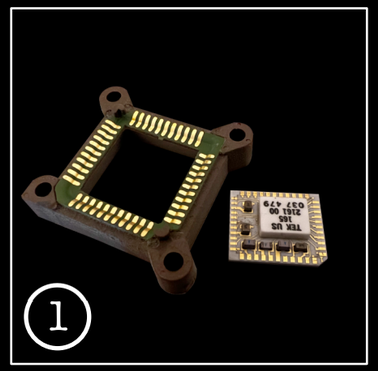
- ***the ⇳ and ⇔ keys** accede the vertical and the horizontal menus (amplitude, position, time base etc.);*
- ***the M key** set the knobs to trigger level and holdoff. For the complete menu, touch the Trigger physical key;*
- *touching **the Cursors button** you can activate various types of cursors.*
- ***the Window button** creates a second graticule and puts there the delayed trace (said window), while the main trace (delaying) gets a portion enhanced, like the 7000;*
- ***the DefWfm key** lets you enter the menu where you can define the trace on the screen, also thru mathematical expressions;*
- *when you have more traces on the screen, select them **just touching them.***

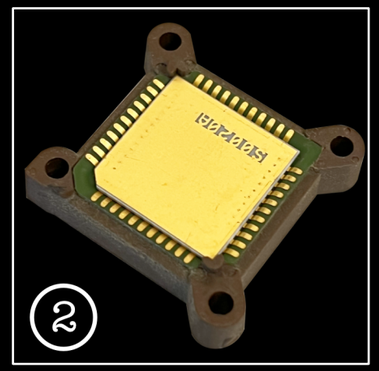
That's almost all you must know. Differently from others, I have found very practical this organization and I believe one can learn rather quickly were the various function reside.

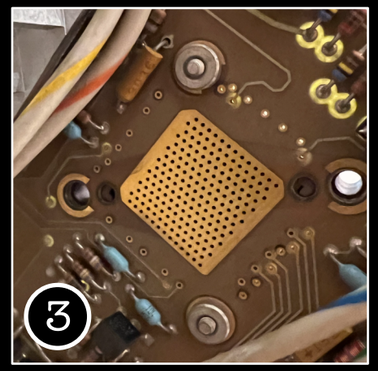
It is a good monster and I like it...

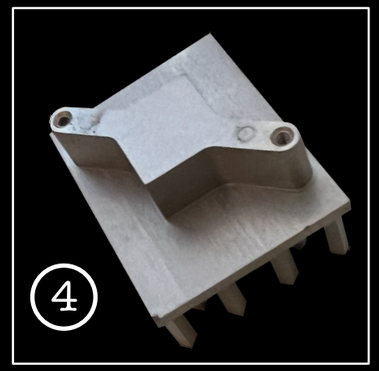
A small repair

Yet it worked... The window function (delayed time base) was the first thing that I tested, but now I was not able to have it working. After having spent a lot of time, I concluded that there was a fault. But today I saw it working again... In a short, it worked only for the few minutes after power up, then it stopped. At the same time, I noted that the trigger was working, but the display said "!not!" triggered. I was resigned to a long study, but without the schematic (the 11403/11402A digitizer is different from the 11401/11402). So I decided an empirical approach: exploiting the 11403's high accessibility, I used an hair dryer to refresh the board and see where is the problem. It was rather easy to find that refreshing U1710 and U1810, the problems flew away: U1810 for the "!not! triggered" and U1710 for the window lock. So I dismounted and cleaned all the surfaces, adding a small amount of thermal paste. Now it pretends to work... I still can't believe I was so lucky!







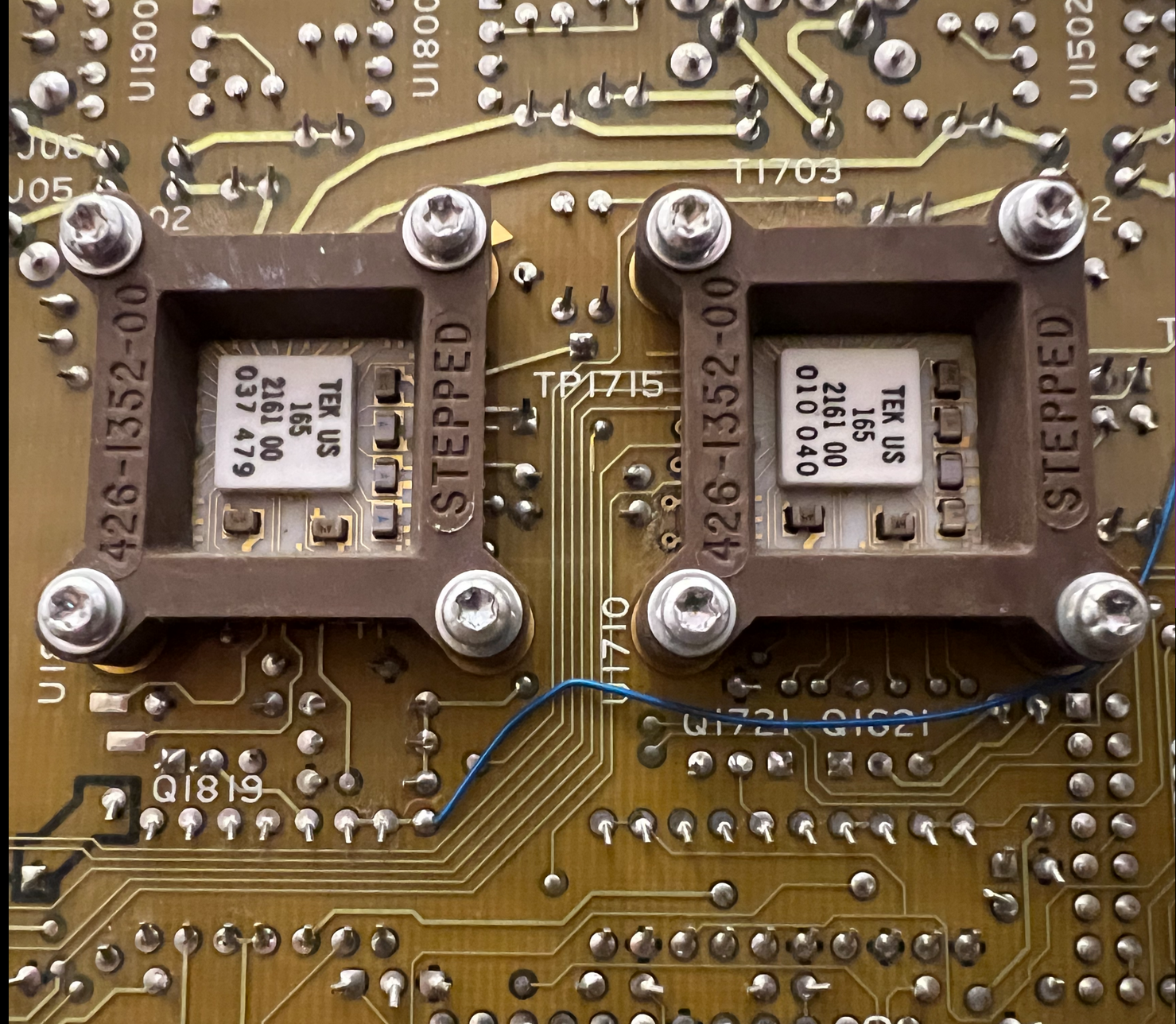


❶ One of the two Tektronix hybrids 165-2161-00 used in the trigger circuit, together its contact bezel, that connect the hybrid itself to the PCB.

❷ The hybrid inserted in the bezel. Pay attention to the positioning corner. The large surface must be spread with a thin layer of thermal conductive paste.

❸ The thermal conductive surfaces on the PCB. The top and front layer are connected with vias to conduce the heath.

❹ The heat sink, on the top side of the PCB (the hybrids stay on the other side). This surface also must receive a very small amount of thermal paste.



Fighting magnetism

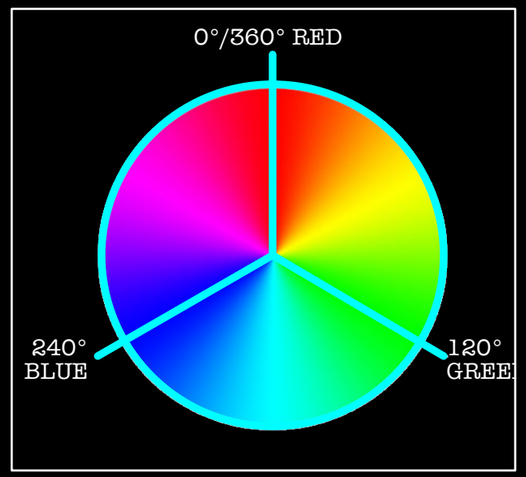
The mystery of bewitched colors

Raster scanned CRTs are something that I never liked, and this case confirms my opinion. When my 11403 arrived, the display was in many cases unreadable and the colors had serious convergence/magnetization problems. I worked a lot on it, obtaining strange results.

Magnetisation

I attributed the bad color problems to CRT magnetization. I discovered that the built-in automatic degausser was faulty. Surely that's the origin, I thought.

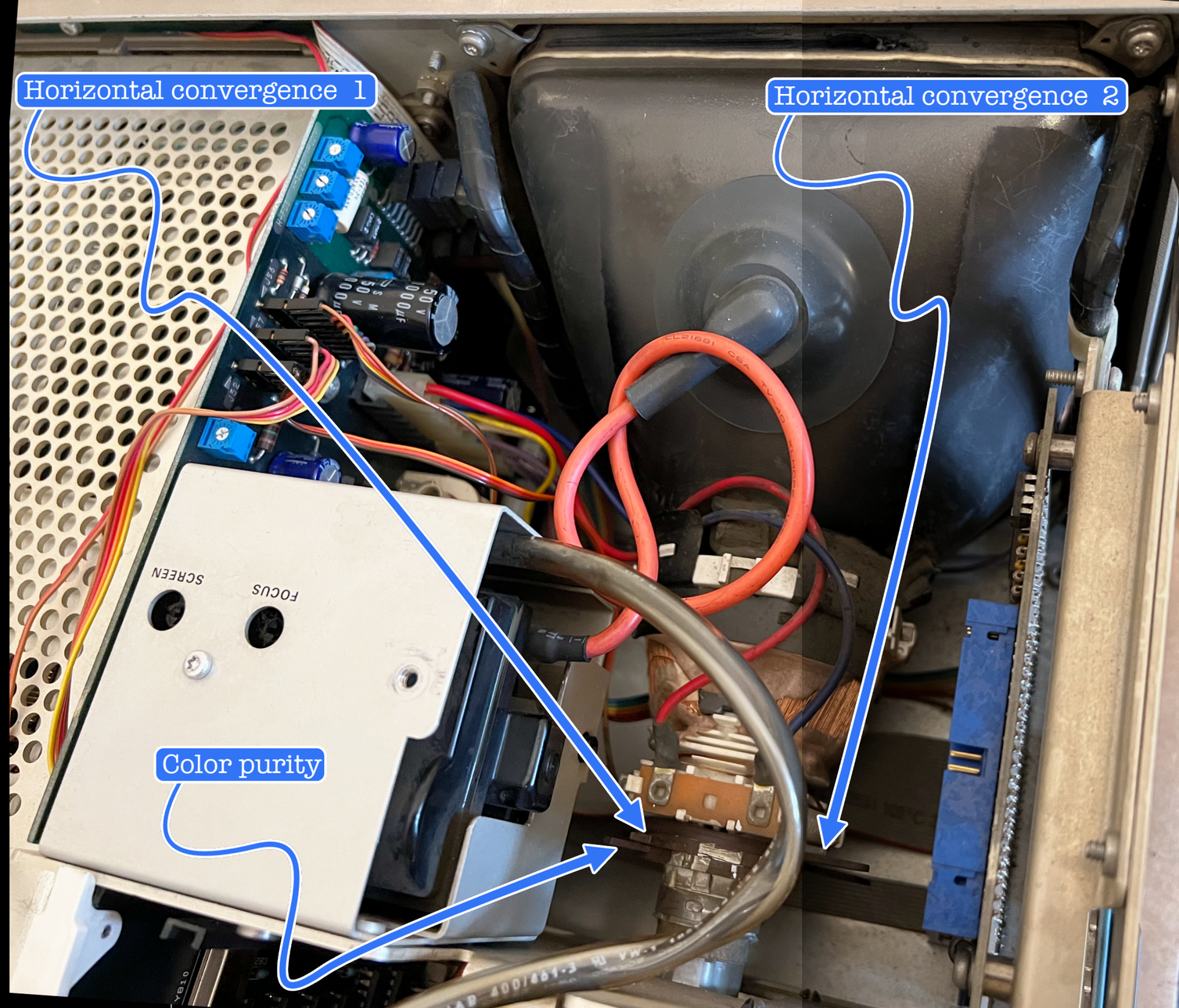
After having repaired the degausser, I discovered that it, albeit electrically working correctly, had almost no effect.



So, it started a sequel of attempts, following the suggestion that I could find on the net, with an electric drill to rotate some magnets and with the transformer of an ancient gun solder.

The results were not good: I never could get a clean page of uniform color and the colors were "rotated" +120° in the HSL color wheel. That means that that which had to be RED came out as GREEN, the BLUE as RED and the GREEN as BLUE.

Then I did something that all suggest to avoid: I switched on/off the solder gun very near to the screen and



changed my goals: instead of trying to remove the red from a blue page, I tried removing the blue from a red page. In that way I could obtain very uniform screens, but the colors were again rotated; not any longer +120° but -120°: the RED gets out BLUE, the GREEN → RED, and the BLUE → GREEN.



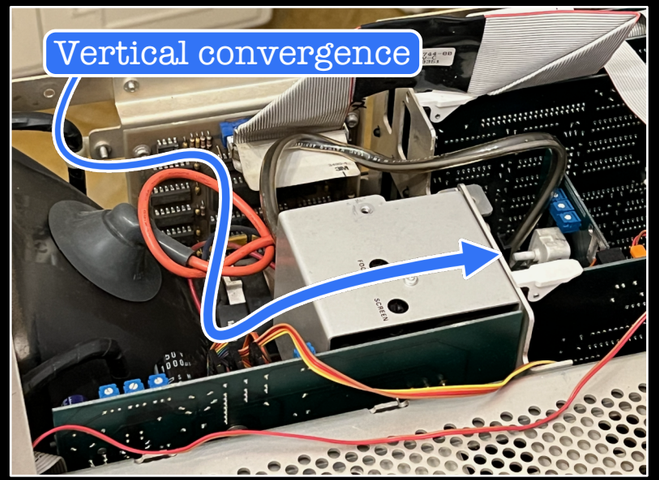
Convergence

Set apart for the moment the magnetization problem, I concentrated on the convergence. The color CRT has three cathodes (guns) and their beams must be focused so that each of them hits the correct one of the three dots that compose a pixel. When the convergence is correct, the three R, G and B beams hit their corresponding dots and the pixel looks white. If that does not happen, a point of a contiguous pixel is hit and you see a doubled pixel in different color, while the first pixel is no longer white.

On a Trinitron CRT like this, you have the following controls for the convergence:

- *the turnable magnets on the CRT neck for vertical convergence;*
- *the R210 trimmer for horizontal convergence.*

In the case of the 11403, the tube is rotated 90° CCW (the scan is vertical), and the magnets act thus on the horizontal and R210 on the vertical convergence (the photos labels report the effective controls).



Operating on these controls, I could obtain a more than decent screen. But the colors remain rotated -120°.

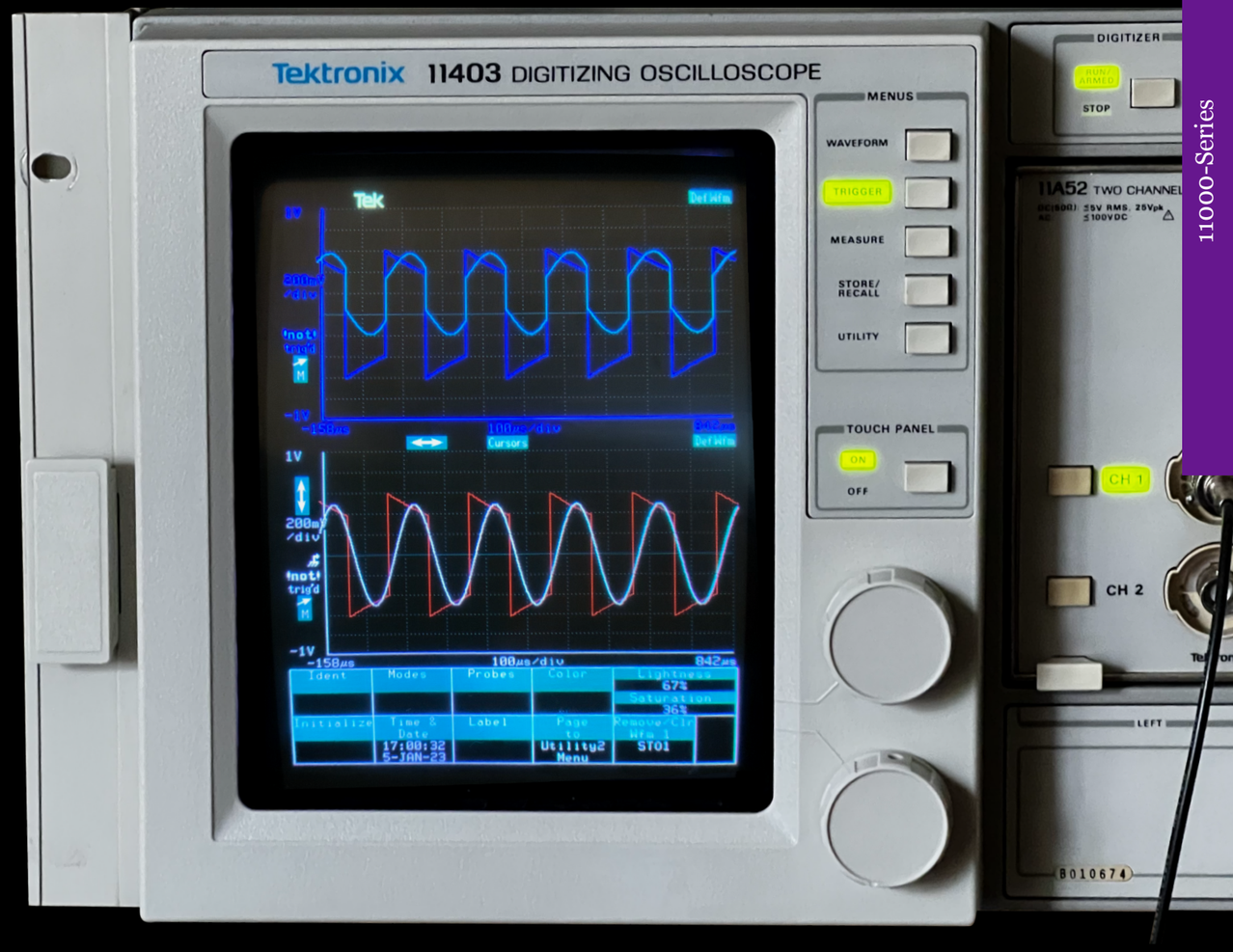
Not a trivial problem

The first things that I thought was a wiring or a software mistake, but it is not so: everything is OK, is actually the CRT that produces the colors rotation.

I asked the help from friend on various forums but we could not decode the cause. Hypotheses have been made about a residual magnetization or that the CRT aperture grill moved due to a strong mechanical shock.

Almost a victory

I decided to surrender to these bewitched colors. Considering that the CRT has been kept on for near 20,000 hours, the current situation is not bad, as you can see in the photos: all the colors are nice enough and furthermore configurable, so the only difference is in the HSL parameter values, not in the results, that I can however control. Sometimes it's better withdraw from roulette until one wins...



CRT degausser

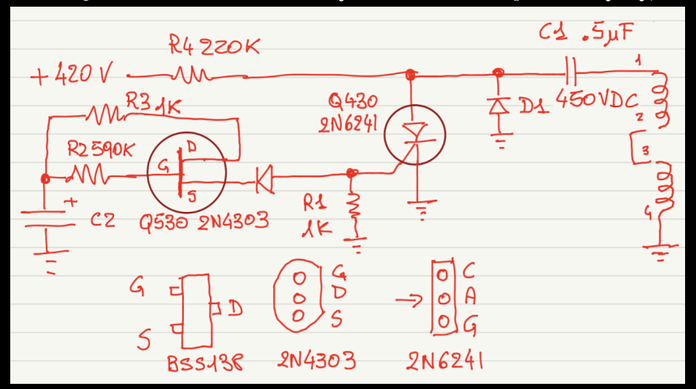
Unfortunately, the 11403 schematics are not available; you can find only those of the 11401/402, but they have a monochrome monitor. So I rebuilt the degausser circuit, should it be useful for you, here is its schematic and some explanation.

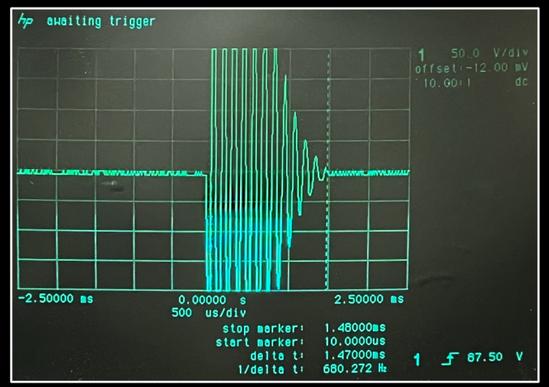
Differently from standard TV that use degaussing coils and a PTC, the 11403 circuit works upon power-up of the CRT, using a thyristor (Q430), that closes a tank circuit to ground powered by the 420V grid potential, allowing it to oscillate and demagnetize the CRT by mean of two inductors set on the CRT's sides.

I could guess that they used an RC circuit to trigger the thyristor, but they preferred instead the circuit shown in the diagram, probably because it doesn't require another voltage. In my case, the FET (Q530) was faulty. I added a wire in parallel to R1, so that I can give a positive voltage from outside to issue a degauss command. In the diagram you can see the voltage across the coils (it goes outside the oscilloscope range).



I didn't have at hand nothing better, so I tried to replace the hard-to-find 2N4303 with an SMD BSS138, creating that horrible mushroom that you see in the round picture. Anyway, it works!







11000-Series

Subsection

The plug-ins

Not so many as for the 7000-Series but very intriguing.

11000 plug-ins

A variety of bandwidths, number of channels, coupling and input choices became available in the years. At the beginning they were just five, but, in the years, they grew, even though not as those of 7000-Series. Nine years after the 11000-Series launch, the Tektronix 1995 catalog reported them for the last time, together with the 11403A: in the 1996, they disappeared. Tekwiki reports 10 total.

The plug-ins in the first wave were:

- *11A32 dual-channel amplifier, 350 MHz;*
- *11A33 single-channel differential comparator amplifier, 150 MHz, 10,000:1 CMR;*
- *11A34 quad-channel amplifier, 350 MHz;*
- *11A52 dual-channel amplifier, 600 MHz, 50 ohm;*
- *11A71 single-channel amplifier, 1GHz.*

Subsequently, the following were added:

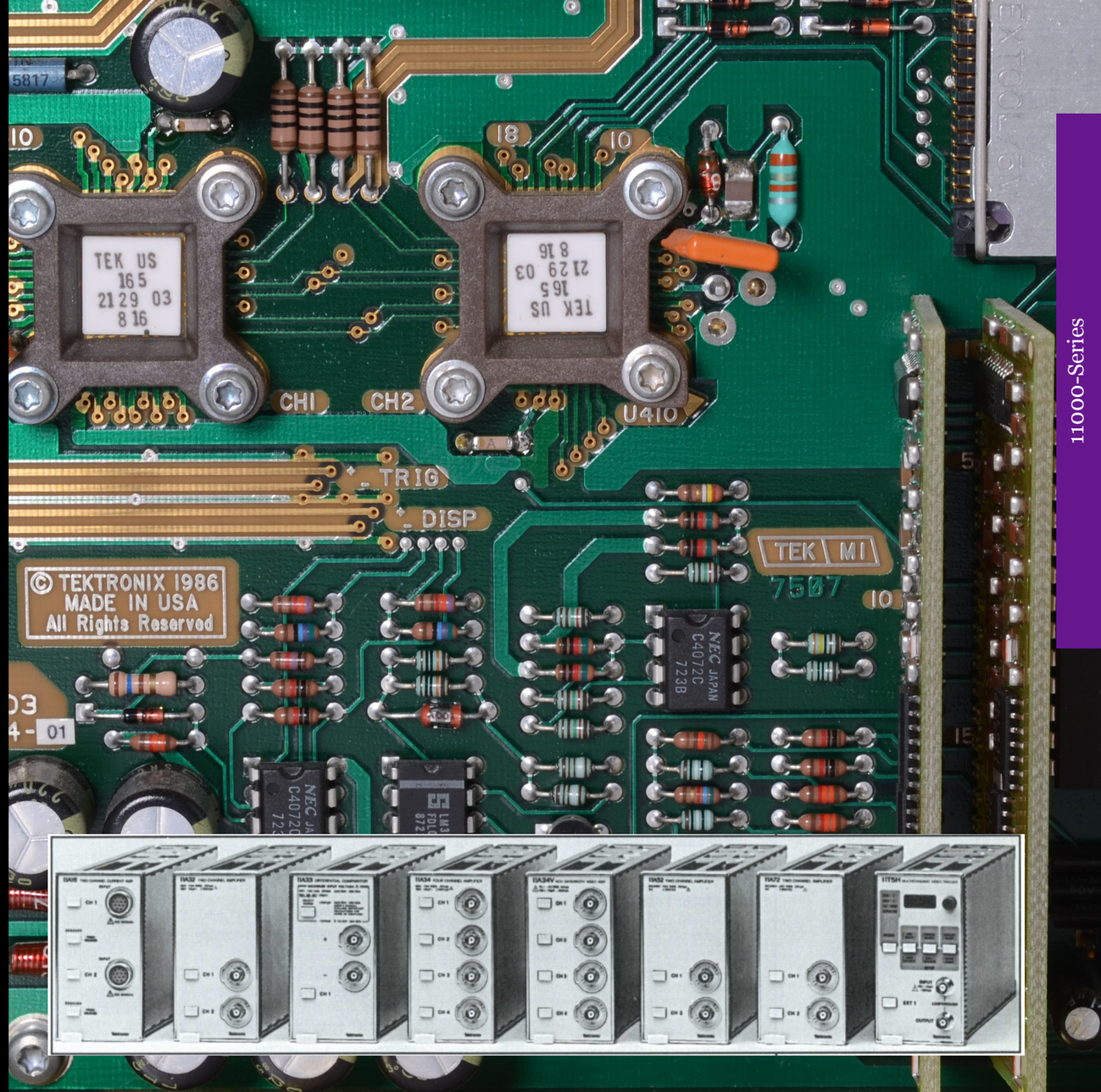
- *11A72 dual-channel amplifier, 1GHz, 50 ohm (1989);*
- *11F10 optical-input plug-in (it appeared only in the 1989 catalog and was not released to the market);*
- *11A16 dual-channel current amplifier, 120 MHz (1991);*
- *11T5H multi standard video trigger and 11A34V high bandwidth video amplifier. They allow triggering and measurements on video signals for HDTV, medical imaging systems, graphics monitors, and other video systems (1991);*
- *11A81 3 GHz single-channel sampler/amplifier (1992).*

Control of the 11000 Series plug-ins is accomplished through the mainframe, either manually or over the IEEE Standard 488 or RS-232C bus. A single pushbutton for each channel is the only control on the amplifier plug-in. This button turns the display of the associated channel on and off.

Each of the input channels on all amplifier plug-ins use the TEKPROBE interface. This interface allows the mainframe to supply power to active probes (such as the P6204 or P6703A), to sense the type (and, with some probes, the serial number) of the probe, to supply offset voltage to probes so equipped, to detect activation of the probe's ID pushbutton, and to provide other communication between the probe and the oscilloscope as appropriate to the type of probe.

It has been existed also a 016-0829-00: just an empty plug-in for building custom interface.

Following the guidelines of this book, I am going to present mostly the equipment that I own, so, until now, you will find in the following just the 11A52.

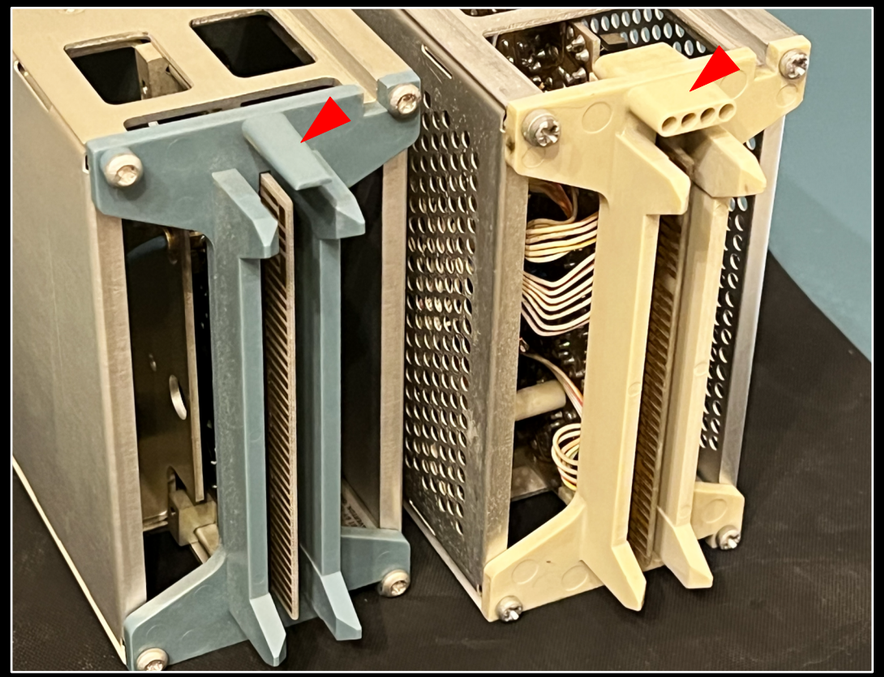


11A52

The 11A52 is a high bandwidth dual-trace amplifier plug-in for the 11000-Series mainframes.

It provides 600 MHz bandwidth in the 11402/11403 digitizing mainframe and 400 MHz bandwidth in the 11302 analog mainframe. Two built-in four-pole bandwidth-limiting filters (100 and 20 MHz) may be activated to reduce unwanted high-frequency noise at 24 dB/octave.

Both coarse and fine deflection-factor steps are fully calibrated. At 1 mV/div, the high-resolution calibrated dc offset has a set ability of 25 µV and a range of ±1 V (equivalent to 16 bits), giving an effective screen height of 2000 divisions and permitting absolute dc measurement accuracies to ±0.3%.



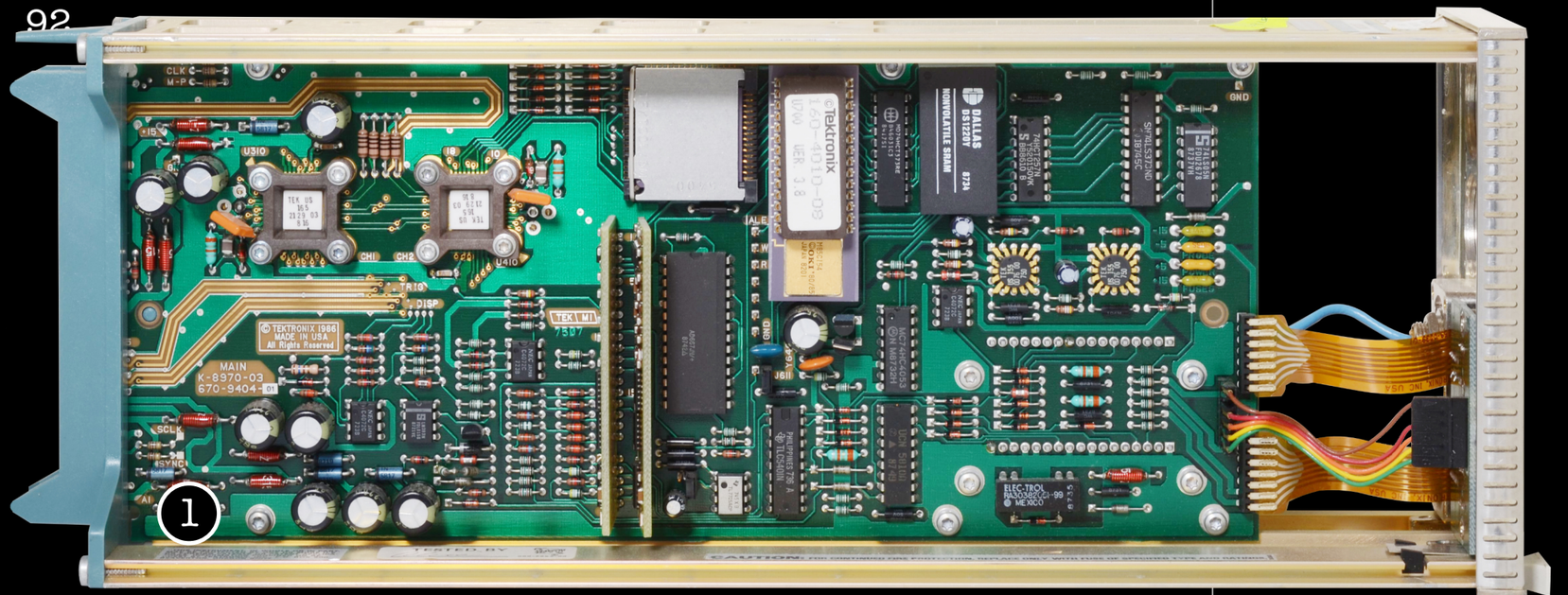
This is the first 11000-Series plug-in that I own. I was curious to understand the compatibility with the 7000-Series.

The plug-in housing is absolutely the same, but willingly Tektronix made impossible to insert a 11000 plug-in on a 7000-Series mainframe or the contrary.

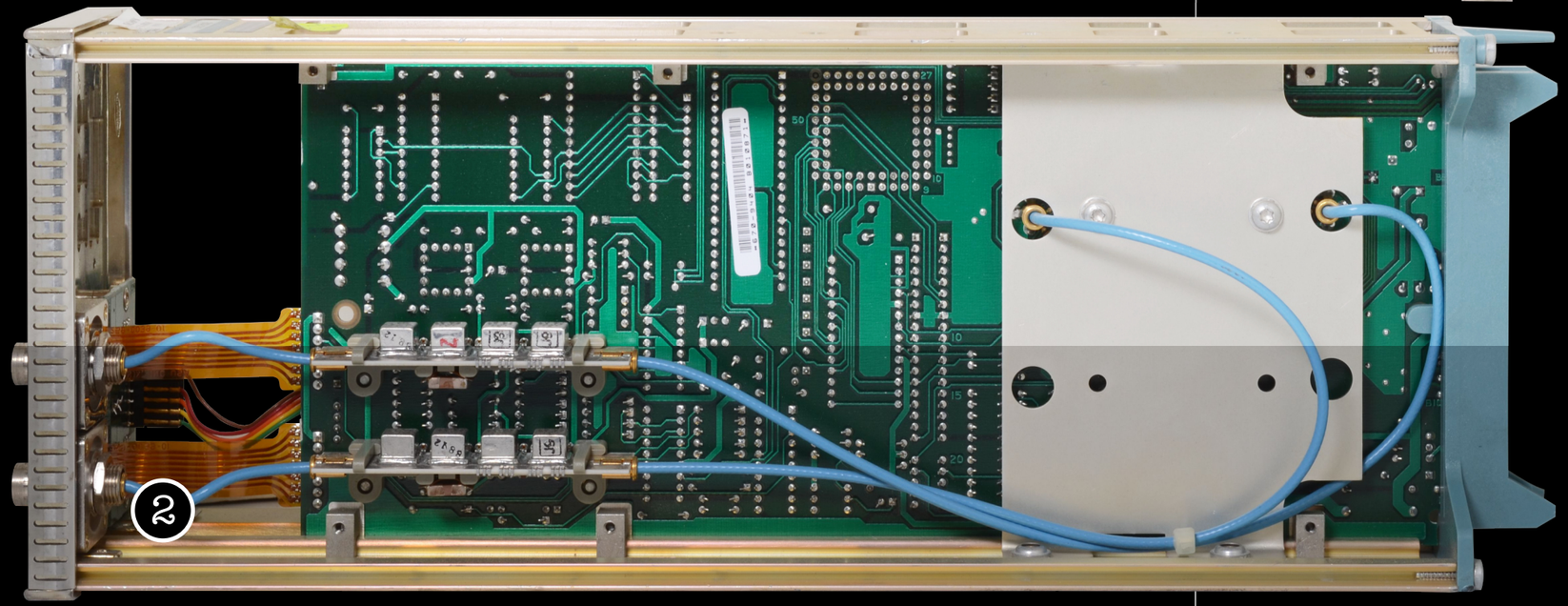
The discrimination is in the protrusion pointed by the red arrows.



1986



1



2



3

11A52 Fast

As we wrote at the beginning of this chapter, the 7A29 was the starting point for designing the new 11000-Series plug-ins.

My 11403 was equipped with just one 11A52, but I stole these picture from TekWiki because mine has still the original Tektronix warranty seals, as you can see here. I couldn't break them…

❶ 11A52 left side view
❷ 11A52 right side view
❸ 11A52 top view



1986

Overdrive recovery time

I had never the opportunity to deal with this parameter before. I found it in the Tektronix specifications and promotional leaflets. Its correct name is ***overload recovery time*** *(Tor), and according to Jeded is:*

The time interval required for an amplifier to recover its ability to perform amplification within stated specification limits after the output voltage amplitude has been distorted by the application of a specified input voltage in excess of rated amplitude or rated rate of change.

I understood that we talk of it because it is in some way important making critical signal integrity measurements with a high-speed digital storage oscilloscope (DSO).

The point is that it is often desirable to measure small aberrations on the top and bottom of high-speed digital signals, like overshoot, undershoot, and overall ripple, and a common technique to increase the effective resolution and accuracy of these types of measurements is to offset the signal under test and then increase the vertical sensitivity around the portion of the waveform of interest (practically: go to high sensitivity and then try to report the interesting part of the trace in the screen).

This practice spreads out the small aberrations of the signal over a larger range of the scope's analog-to-digital converter (ADC). In practice, you enlarge much the vertical amplification, so that the investigated point of the waveform goes outside the screen, then add a DC offset to report it in the visible CRT area.

The very ordered and clean construction of the 11A52 plug-in. Note the two digitizing hybrids, a technology widely used by Tektronix. OK, eventually I opened the seals...

This technique definitely improves the resolution of the measurement of the signal's small aberrations, and you would intuitively believe that it also improves the accuracy. However, offsetting and expanding the signal over a wider range will drive major portions of the signal off-screen and beyond the dynamic range of the oscilloscope's input amplifier and ADC. When this happens, the scope's amplifier can be driven into saturation causing waveform distortions.

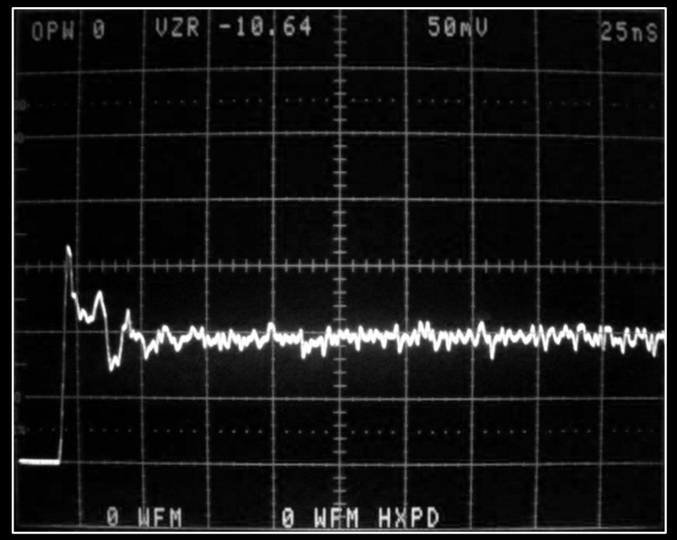
I got this information from [4], and the Author concludes that it doesn't matter how much distortion occurs or what is causing the distortion; any distortion is too much when attempting to improve measurement accuracy and that this measurement technique in reality degrades the measurement accuracy. For example, the Tor of the 11A52 plug-in is declared as follow:

- *1 mV/div to 99.5 mV/div: To within ± (0.2% + 0.1 div) within 20 ns from ± 2 V step.*
- *100 mV/div to 995 mV/div: To within ±(0.2% + 0.1div) within 20 ns from ± 20 V step.*

I could not find a similar specification in the HP 54100 documentation.

As the Author makes evident, 20 ns can seem to be a lifetime when dealing with high-speed signals.

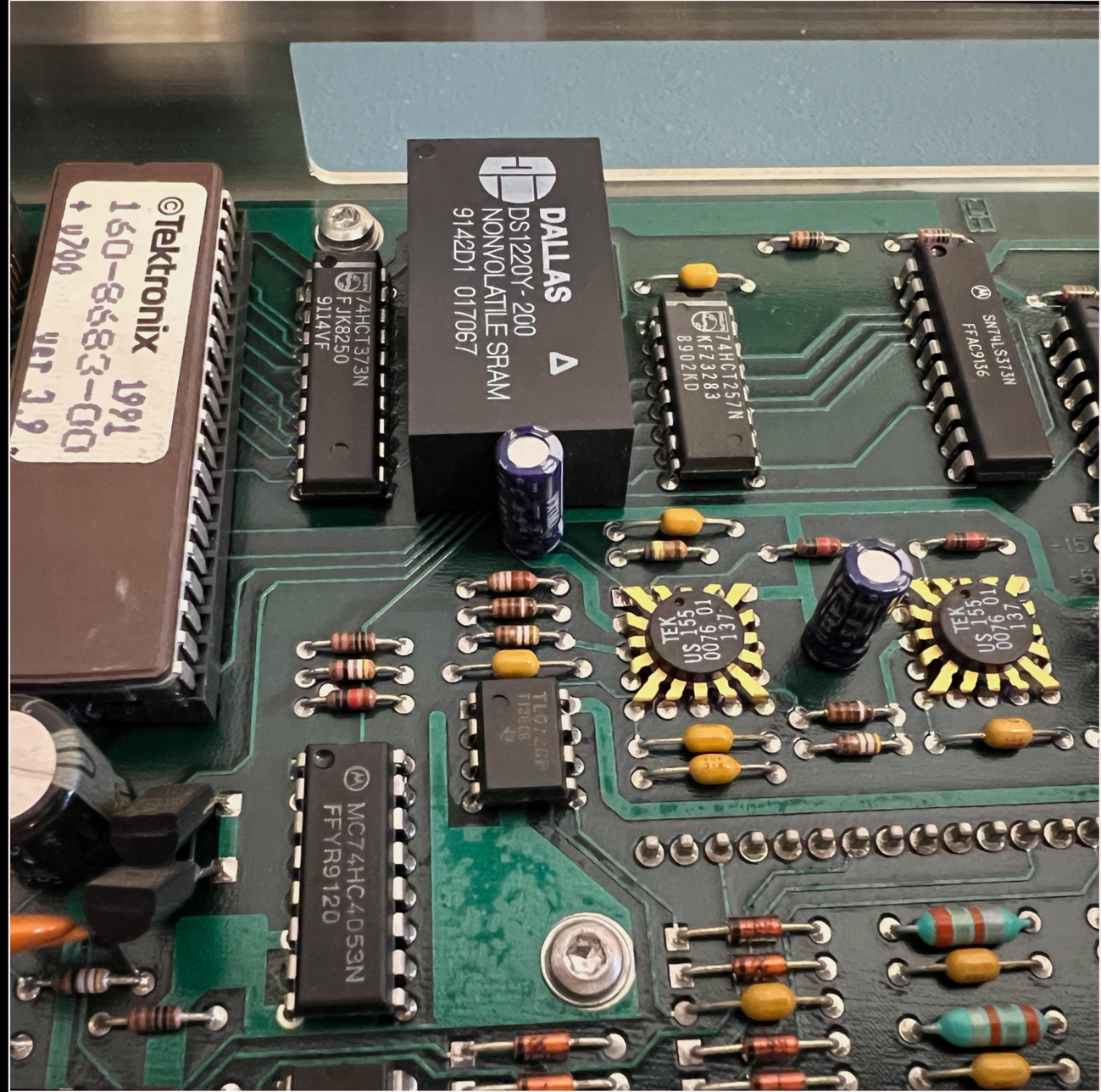
So, the suggestion: never overdrive the input amplifier when making critical vertical and timing measurements, and instead, use the scope's waveform math functions to digitally magnify the waveform around the portions of the signal of interest after averaging.



The patient says to his doctor, "Doctor, it hurts when I bang my head against the wall." The doctor responds, "Well then, don't bang your head against the wall."

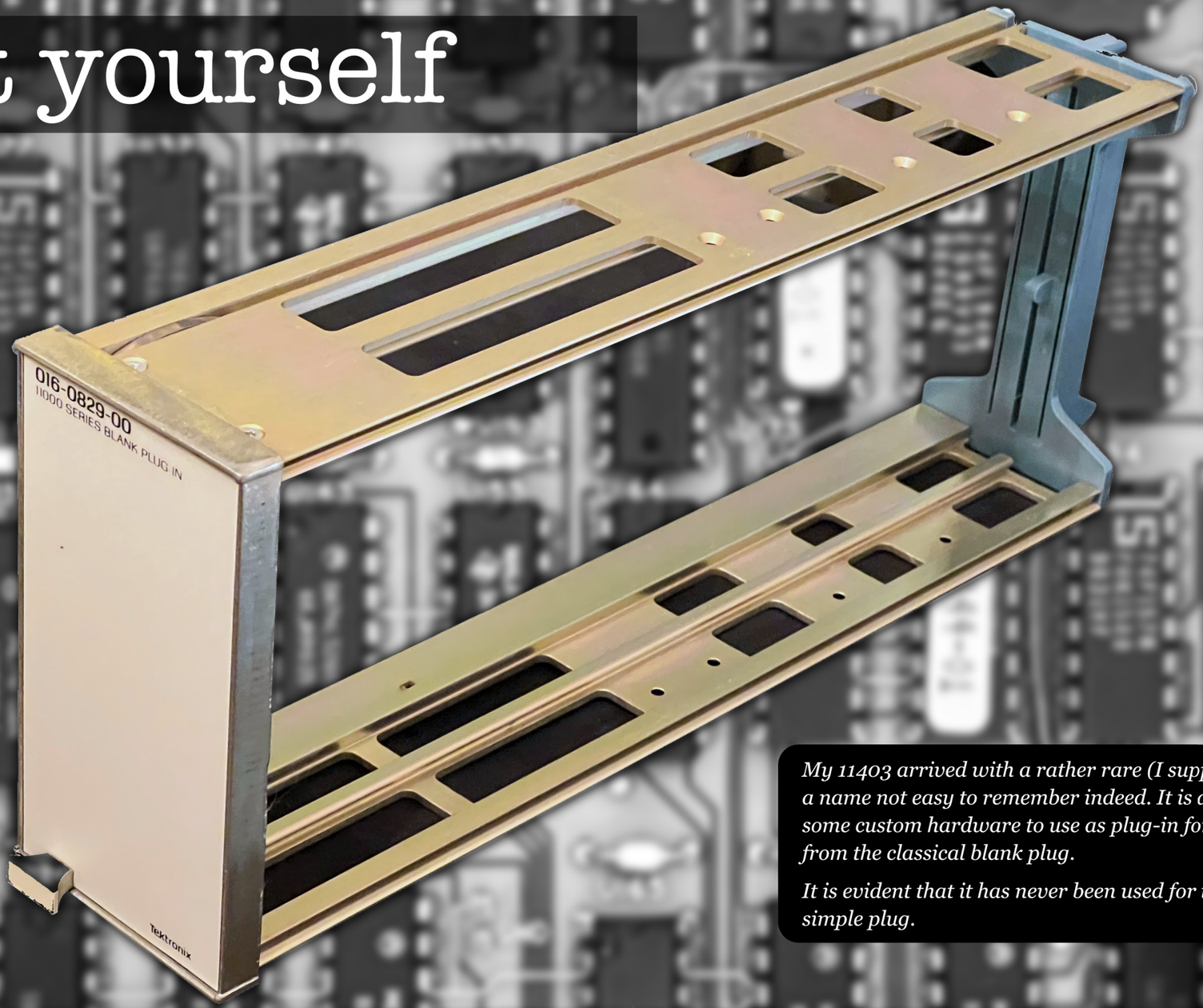
However, there are certainly other situations where this parameter is on the contrary relevant, but I wanted to report it because is very related to our discussion topics.

Example of a 7854 acquired waveform, expanded with the HXPD (expansion horizontal) and VXPD (expansion vertical) commands.



Other 11A52 internal details. Note the widely used by Tektronix Dallas memory. Even at that time I could not understand this choice, it was rather easy to get the same performances and reliability with standard RAMS and a lithium battery

Build it yourself



My 11403 arrived with a rather rare (I suppose) plug-in, called "016-0829-00", a name not easy to remember indeed. It is a "blank" plug-in dedicated to build some custom hardware to use as plug-in for the 11000-Series, thus different from the classical blank plug.

It is evident that it has never been used for that purpose, so remained there as a simple plug.

11400 performances

The old 11403 works still rather well in speed, and I could verify that it acquires correctly repetitive signals exceeding the 600 MHz bandwidth of the 11A52 plug-in (photo ❶)

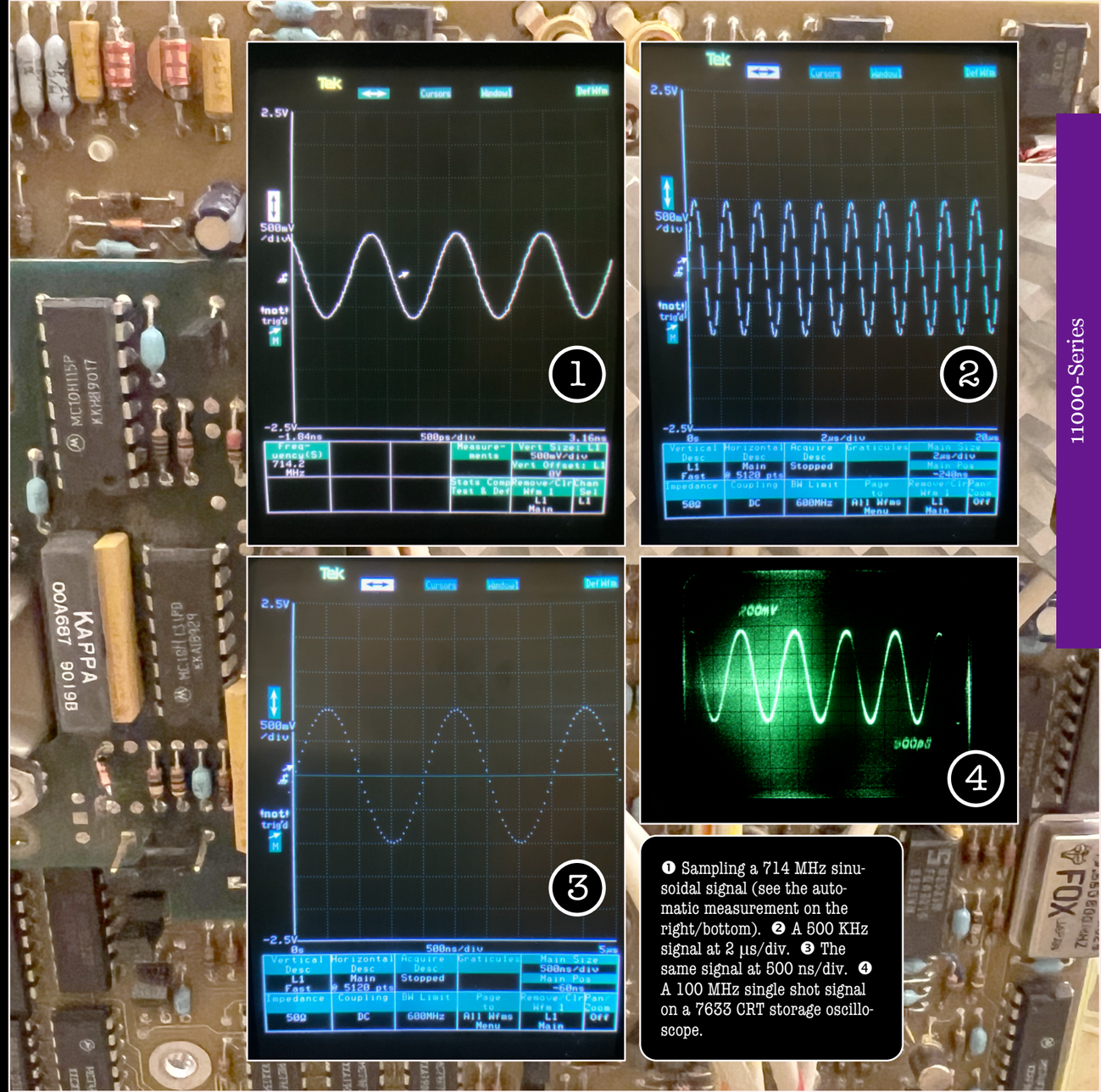
Things become more difficult when we talk about non-repetitive signals, that was the Achille's heel of the first wave of digitizing oscilloscopes. As we know, Tektronix declared only 20 MSa/s for this today top-important parameter.

But how does this traduce practically? I did some tests with sinusoidal waves, in single shot mode. Already at 2 µs/div the trace becomes fragmented (photo ❷), and below this time/div you can see the single dots (connect dots seems not functioning - I don't know if it is a problem of my scope only, but this does not change the reasoning). At 500 ns/div (photo ❸), you can count 10 dots every division, i.e., 20 in one microsecond, that is precisely 20 MSa/s. Hard to use it, thus, for faster than 1 MHz ÷ 500 kHz signals.

The CRT storage 7633 offered far better performances, as you can see in photo ❹ where a single shot 100 MHz sinusoidal wave is perfectly readable in reduced scan mode. We are talking of 100 MHz vs. 500 kHz.

I want to say that in 1986, when the 11400-Series was presented, the CRT storage technology had still good reasons to stay in catalog: the digitizers could not still satisfy the exigences of the non-repetitive signal analysis.

Probably, the broad-bandwidth-repetitive-signals market was however interesting (and in continuity with analog scopes); that explains why they presented in 1990 the 11403, with its color monitor, when new digitizer like DSA601/602 were available, and even the portable 2440 could sample two channels a 500 MSa/s at the same time.



❶ Sampling a 714 MHz sinusoidal signal (see the automatic measurement on the right/bottom). ❷ A 500 KHz signal at 2 µs/div. ❸ The same signal at 500 ns/div. ❹ A 100 MHz single shot signal on a 7633 CRT storage oscilloscope.

Seeking the new world



Gianluigi Coppola (1928-2015) "Le tre caravelle"

Writing this book, I asked myself why I am feeling more and more involved in the Tektronix history. The answer is simple: the situations that I describe are those that I've been through in my long professional life, since when, just over twenty years old, I started designing and producing the first personal computers in Italy. It's not a matter of size: in XXS, M or XXL companies, many problems are definitely the same.

For many reasons, I have been living these situations in different roles, and I think I concluded that assuming a right decision is very easy; you will find lot of people who will tell you how your decision was wrong, and probably they are perfectly right. But often you are required to take not the right decision, but the best combination of decisions; not a single equation, but a system of equations, and that is absolutely not easy. That made me very prudent judging the work of others, or to give hurried opinions.

Coming back to the book's topics, I am trying to just put together the information that I can found and rebuilt the history of our instruments as faithfully as I could (any suggestion or correction is welcome), but I cannot however be always as cold as I would, and this is twice true in the case of the 11000-Series, one of the most discussed projects that I describe in this book.

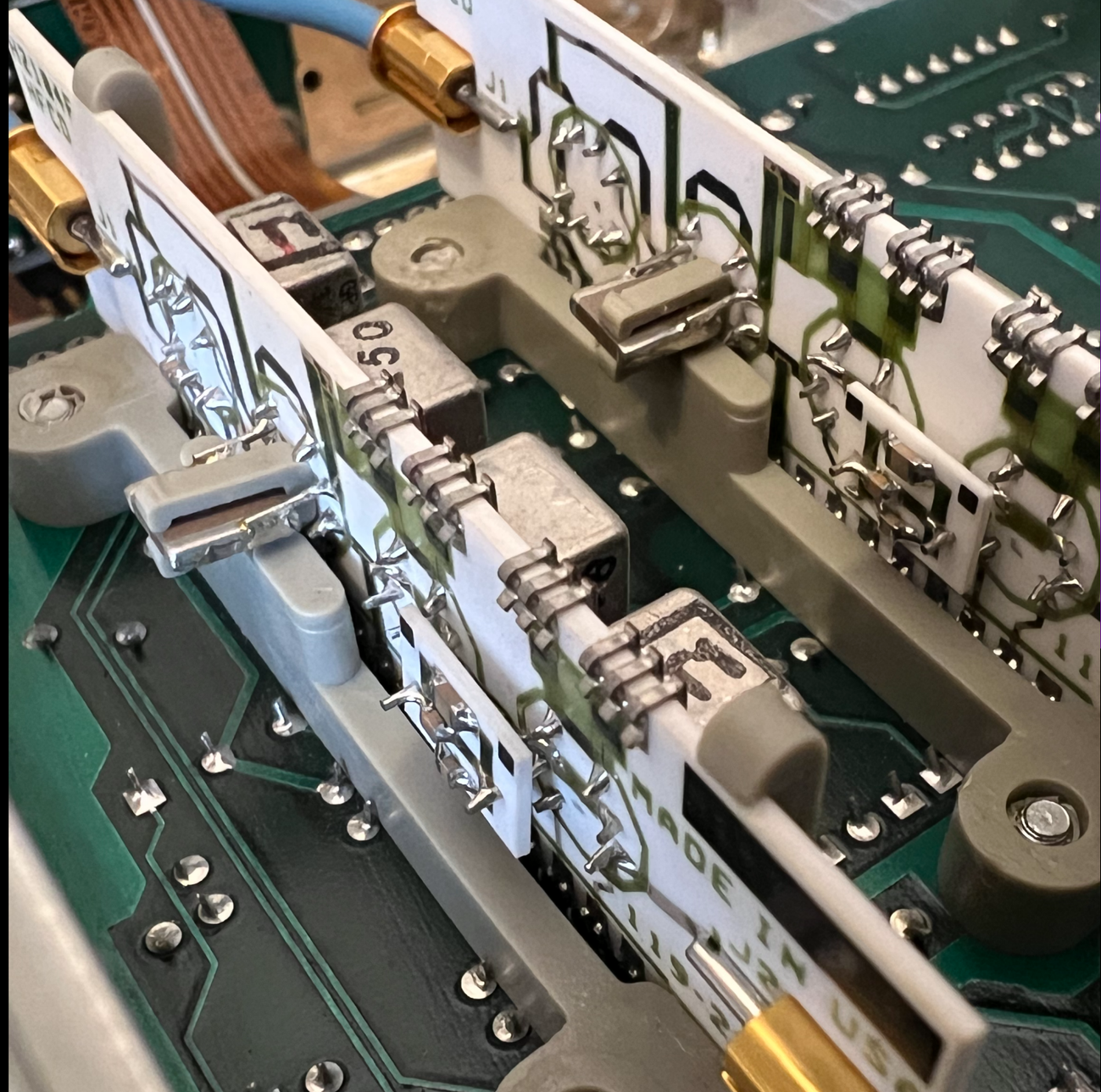
It has been defined ***a controversial project*** *[1], but all the great characters, like Napoleon, are divisive, and arouse discussions even many years after their sunset. The 11000-Series makes no exception: it led Tektronix and the whole oscillography into new dimensions and left his mark on history.*

As we said in the beginning, revolutionists are the first to be beheaded, and it is even too easy finding flaws in a so innovating project, looking backward.

I have found an interesting discussion on Tekscopes@groups.io regarding the possible use today of an 11400 oscilloscope and how compared to the modern ones. That's not very intriguing for me: a Big Boy locomotive is not usable today for regular train service, but that doesn't make it less interesting and valuable. The topic took however a different direction and contains a very interesting discussion between Ditter2 Steve (I could not find his surname) and ***John Addis****, one of the 11400-Series designers (both had been working at Tektronix - I tried to contact Steve, but with no success). Well, I appreciate very much John for its work at the time and for his replies today (almost today), he seems to me a giant in the electronics history. The 11000 team crossed the Pillars of Hercules, without knowing what they will find in those unknown seas, and without knowing that in the future you could fly the Ocean in just few hours.*

References

- *Tekwiki*
- *Wikipedia*
- *Tektronix manuals (see dedicated pages)*
- *[1] Author unknown (1988). The 11400 story. Downloadable from Tekwiki.*
- *[2] A. Dale Aufrecht (1986). Tektronix redefines the oscilloscope. Handshake magazine (Winter 1986/1987), 3-7.*
- *[3] The Oscilloscope Product Line Evolution from 1980 to 2000 (https://hpmemoryproject.org/wc_pages/wall_c_page_01.htm)*
- *[4] J. Hancock (2014). Overcoming Overdrive Recovery. Electronic Design (https://www.researchgate.net/publication/294517947_Overcoming_Overdrive_Recovery)*



In the photo: the 11A52 vertical attenuators.



Extra section

Subsection
The stowaways' hold

They are not 7000-Series... I am not sure how all that could happen...

Maybe I fall in love too easily.

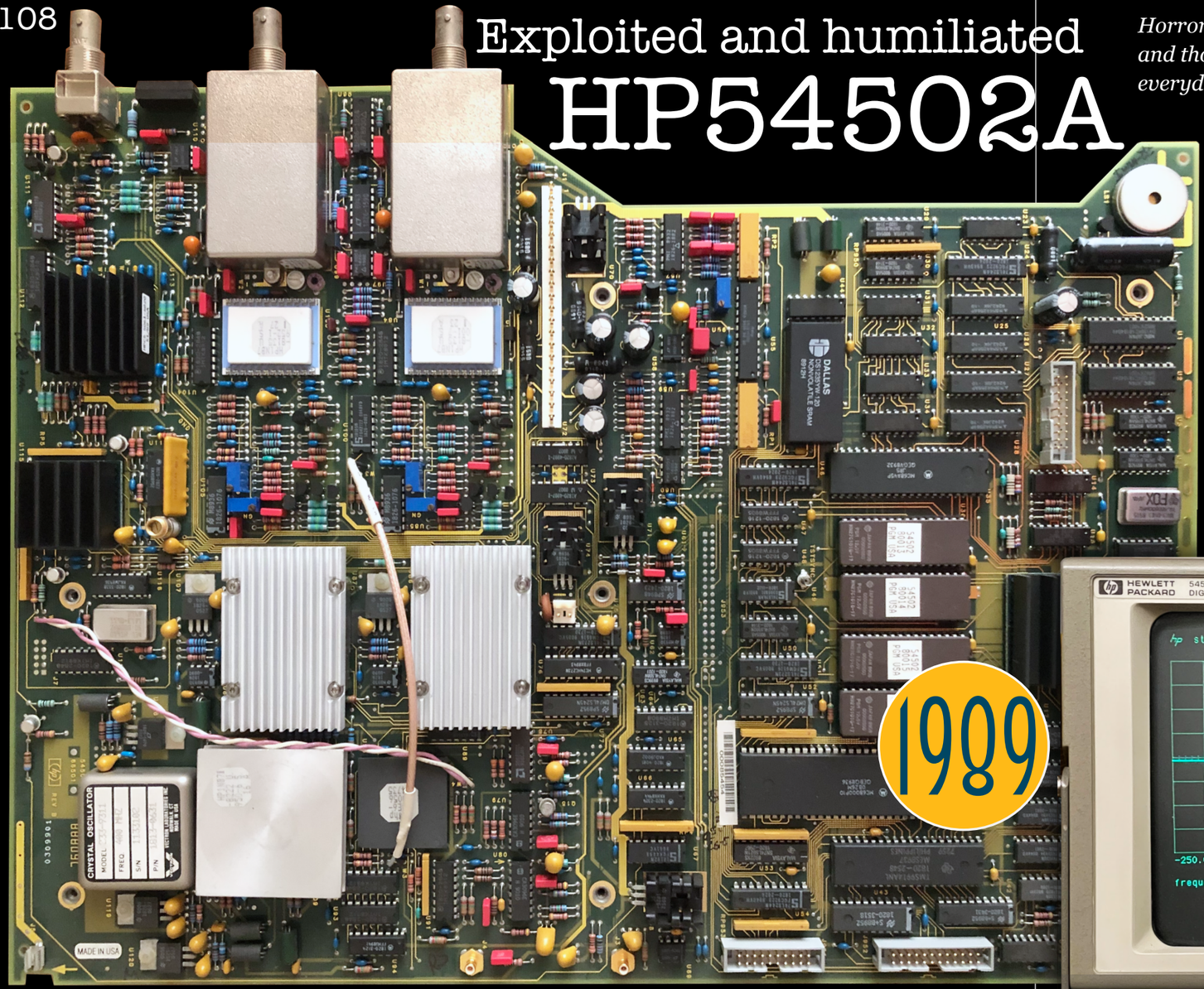
Exploited and humiliated
HP54502A

Horror! The enemy inside! How could an impure HP enter this Tektronix temple? I thought and thought about this addition, but eventually I concluded that it was not fair to exploit it in everyday work and then discriminate it for its origin...

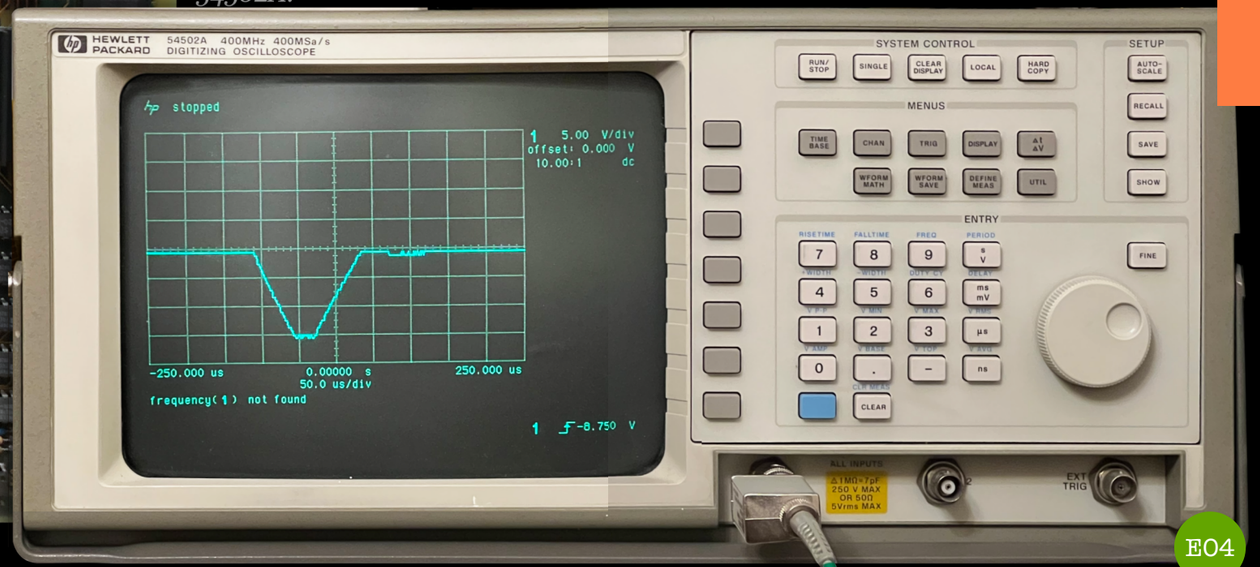
Really, it is not fascinating, but it was essential fixing the first Tektronix scopes, that today I often use in place of it (the CRT storage 7633, particularly, is my preferred for the daily grind - an analog scope gives you more feeling about the incoming signals).



I bought years ago the 1989 54502A, just because it was the less expensive I could find. Years later, it required a repair to replace the NOVRAM chip, which included a lithium battery, now exhausted, and that was the only problem it gave me. It must admit that it is not a bad beast: 400 MHz (repetitive), 400 MSa/s, dual time base, easy to use and a very simple and inexpensive physical architecture, with just one large board (besides the CRT and the power supply). Even if you are not Tek, thanks my old 54502A!



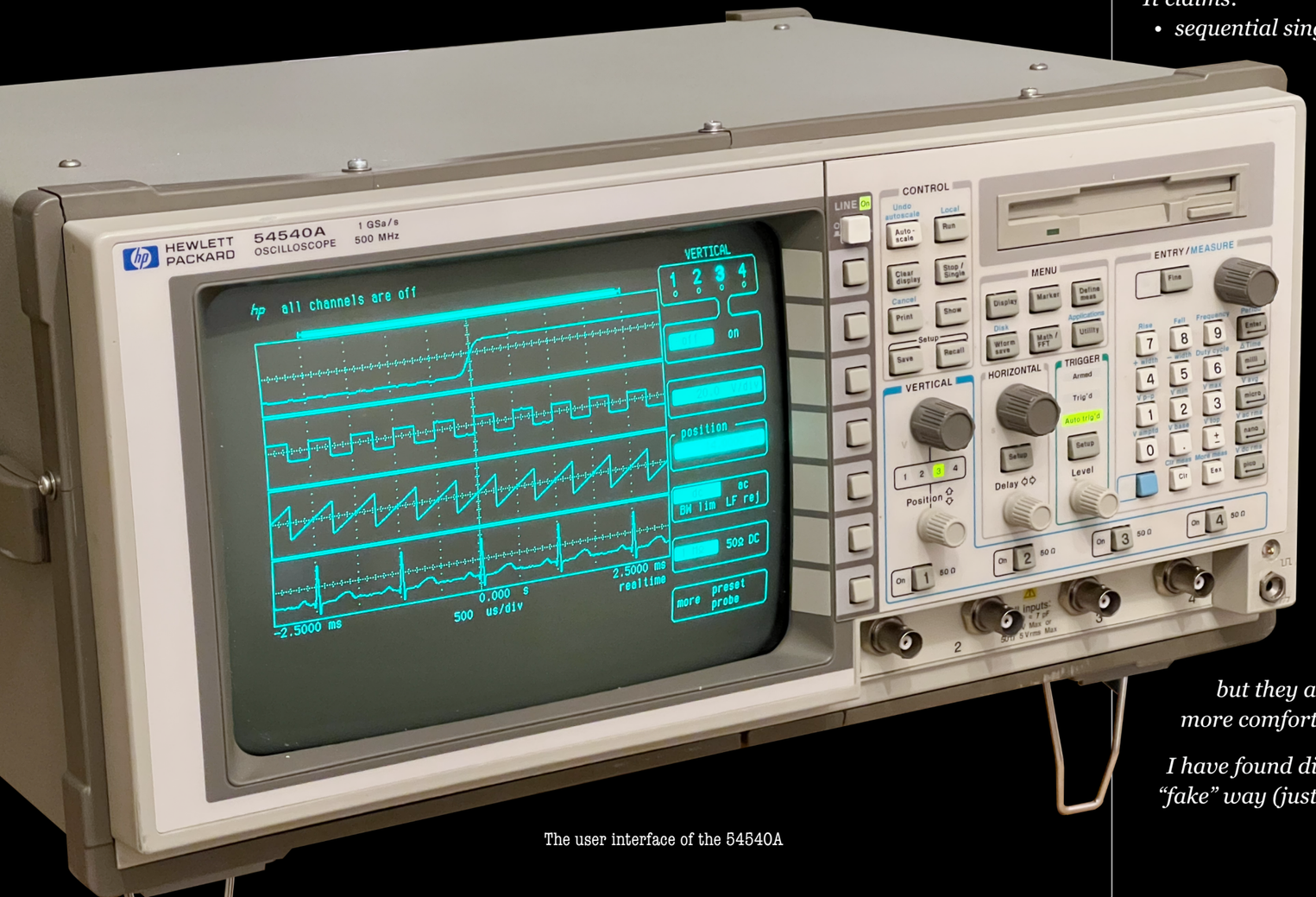
Besides TV like CRT, the 54052 is built on a not too much expensive single board, that resembles the coeval PC motherboards. Note the 68000 CPU, in its typical 64-pin package, and the Dallas memory, with built-in battery, rather common in those years. As told, had to replace it.



An easy winner

HP54540A

1993



The user interface of the 54540A

I bought this oscilloscopes ten years ago and than forgot it. To write this book reminded it to me, so I went to seek it, I found it and I thoroughly cleaned it to photograph it for you.

From a mere technical point of view, it's the best of all here described, but it is not fair. It was presented in 1993 and so it wins easy: 4 channels, 500 MHz, 2 GSa/s (8 bit), 2 mV, 32k points, FFT.

It claims:

- *sequential single-shot to capture successive single-shot events without capturing the dead time in between;*
- *glitch trigger to trigger on glitches down to 1 ns wide;*
- *FFTs to identify signals, determine signal fidelity, or to analyze high-speed transients in the frequency domain;*
- *templates for pass/fail testing;*
- *23 automatic waveform parameter tests. Incoming waveforms are measured with up to three tests at a time and passed or failed according to their limits;*
- *waveforms can be saved and time-stamped upon failure of either waveform compare or limit test. Up to 665 failures of 500 points each can be stored in multiple memory and sent to a printer, plotter, or a computer via HP-IB.*
- *peak detect to avoid missing narrow down to 1 ns events at slow sweep speeds.*
- *3 ½-inch, 1.44 MB, floppy disk drive.*

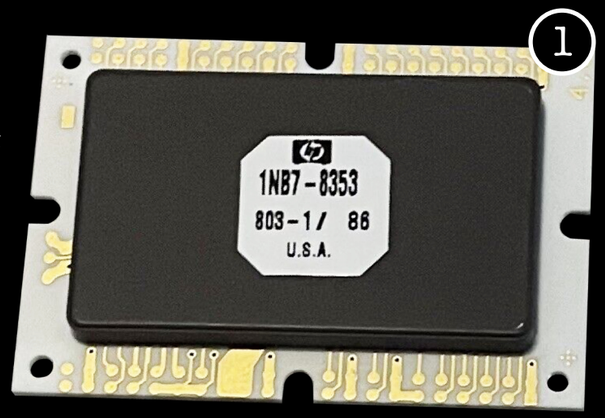
Other features include advanced logic triggering, automatic setup, hardcopy output, full GPIB programmability, pre-trigger viewing, TV triggering, voltage and time markers, pan and zoom, user-controlled sample rate independent of sweep speed, user-controlled record length, fast update rate, fast overdrive recovery, and more.

The 54540 menus look and feel resembles strictly the 54502, but with a big difference: knobs begin to reappear on an oscilloscope panel; just six, in this case, but they announce a trend inversion for the subsequent years, and they make working much more comfortable.

I have found disappointing the lack of the window function, present in the 54502A but only in a "fake" way (just graphic expansion), but the thing I like less in it is the fan noise, ...a small airplane!

HP product system

Used to the first years Tektronix clarity, I find that the HP product system is rather confusing, with lot of models with rather similar identifiers, the differences of which are not always clear, or, willingly or less, hidden it the catalogs folds (for example, the missing window function compared with the 54502).



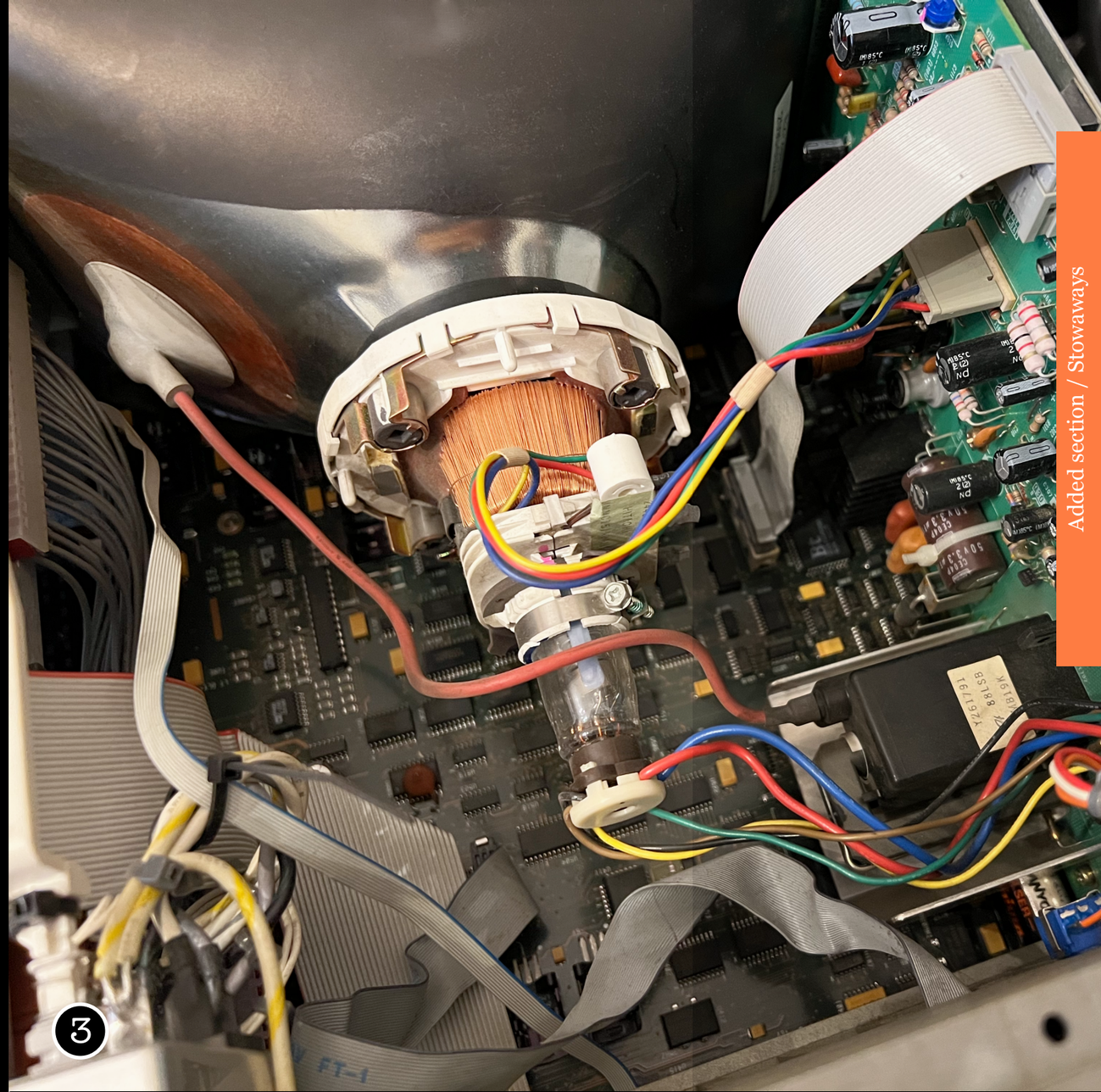
1

For example, in 1997, the 54540A had as many as seven companions: 54540 C, 54542A and C, 54520A and C, 54522A and C, the differences of which I am not able to synthesize shortly.

Besides these small flaws, the great Hewlett & Packard left us many instruments like this, that I find beautiful, easy to use, fast and rich of functions.



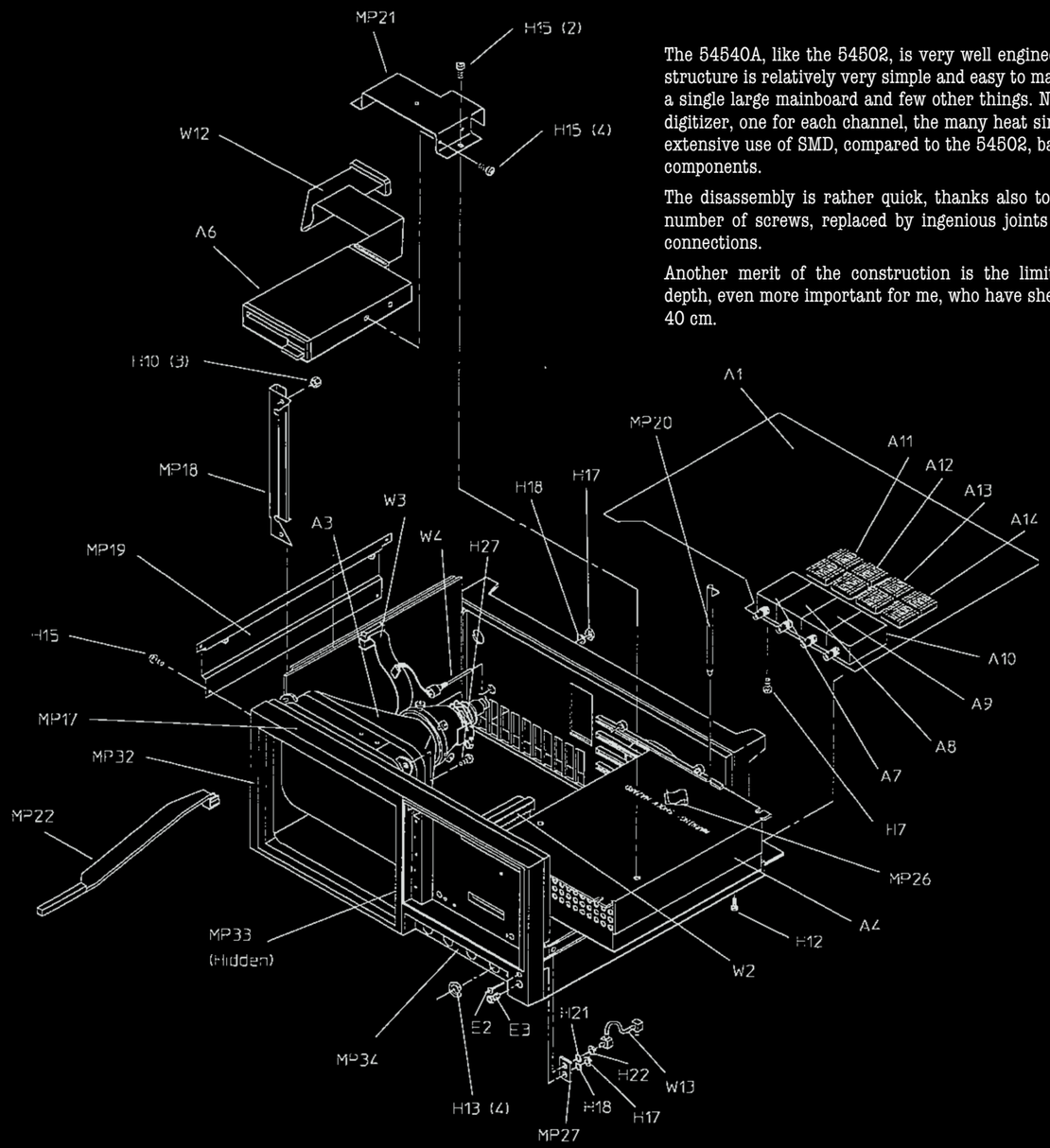
2



3

Added section / Stowaways

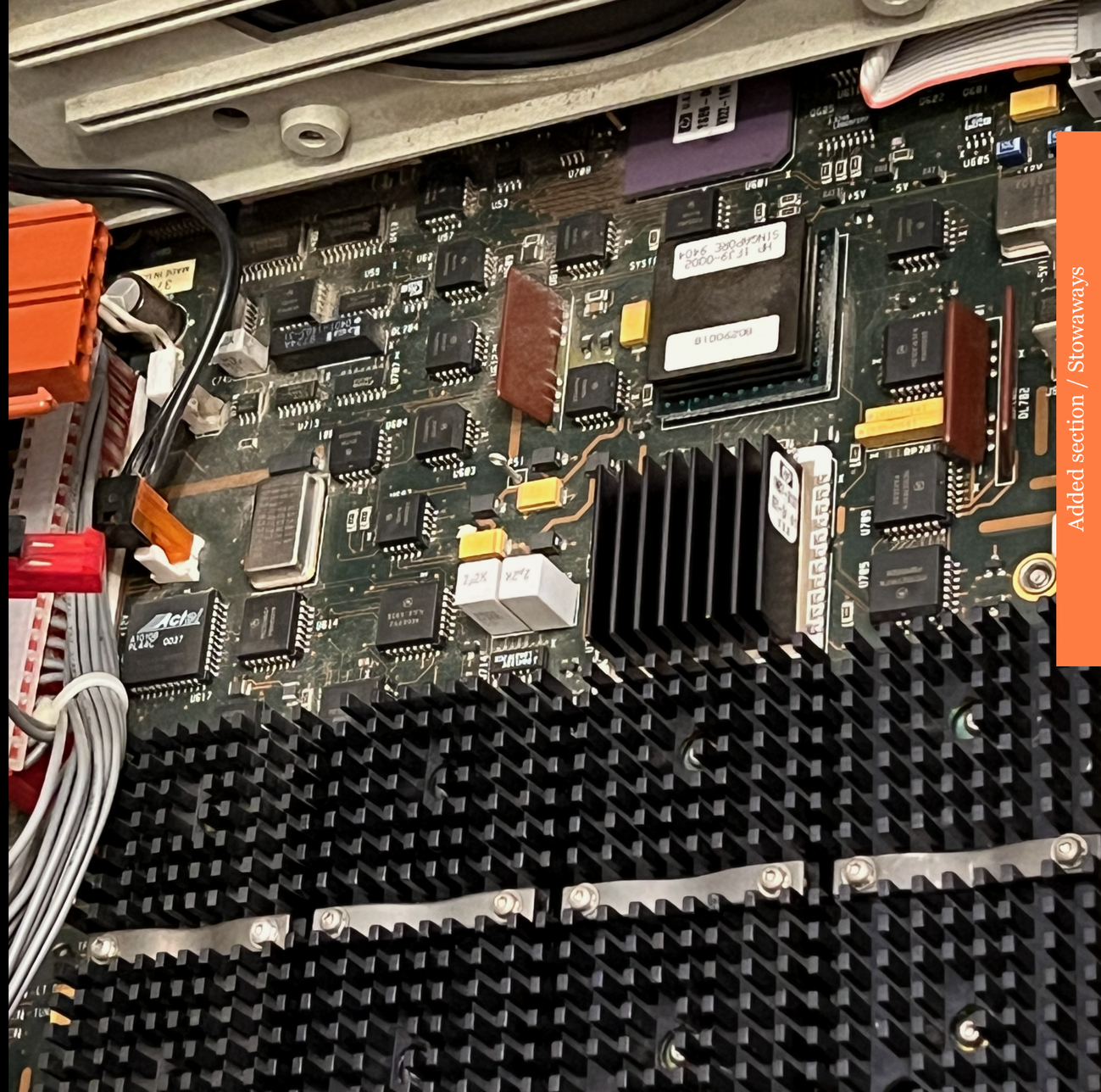
❶ One of the four 54540A hybrid 2 GSa/s digitizers. ❷ The rear of the 54540A is very crowded, as it happens for most oscilloscopes. RS-232, GPIB and Centronics interfaces were a must in those years. ❸ The charm of a magnetic CRT will never be comparable to electrostatic ones. Furthermore, in this case, the (not declared) resolution is not exciting.



The 54540A, like the 54502, is very well engineered and its structure is relatively very simple and easy to maintain, with a single large mainboard and few other things. Note the four digitizer, one for each channel, the many heat sinks, and the extensive use of SMD, compared to the 54502, based on PTH components.

The disassembly is rather quick, thanks also to the limited number of screws, replaced by ingenious joints and sliding connections.

Another merit of the construction is the limited housing depth, even more important for me, who have shelves of only 40 cm.



Added section / Stowaways

The case of the missing window

Too hastily, I wrote something wrong in the previous pages. I said:

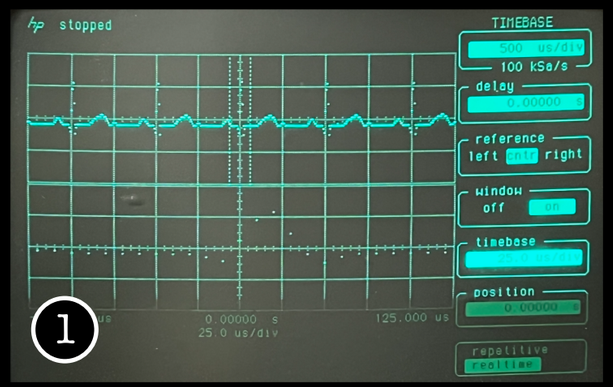
- *the 54502A has the window function, similar to the delaying/delayed function of analog scopes;*
- *the 54540A has not this function.*

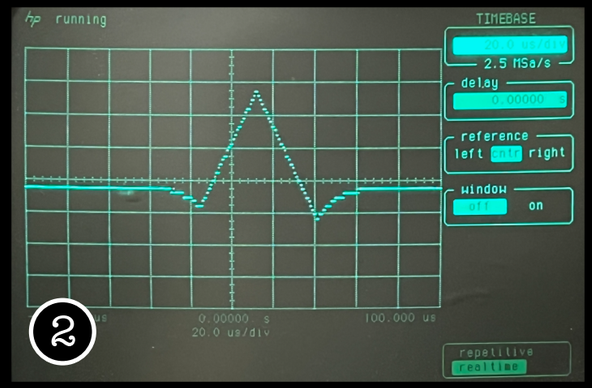
The reality is:

- *to make a real window function, two time bases are required;*
- *neither the 54502A, nor the 54540A has two time bases;*
- *the apparent window function on the 54502A it's a fake. It is just the graphical expansion of the stored points data buffer.*

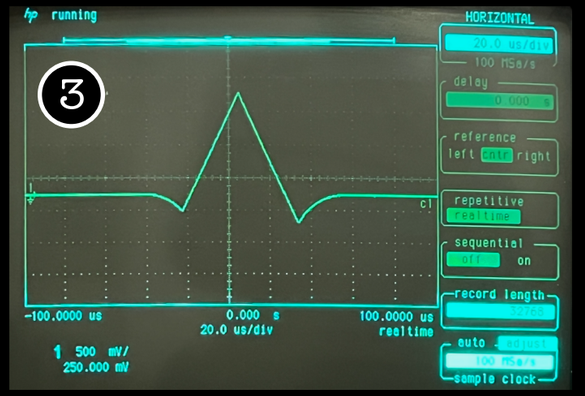
As a confirmation, see the 54502A photos herein reported. Photo ❶ reports the incoming signal, in the upper panel, and the zoomed signal below. Note the intelligent way to show the zoomed portion, that in 7000-Series would have been highlighted, with two dotted vertical bars. I willingly decided to remove the dot join mode, and so you can see that the zoomed trace is composed by very few points.

With a true delayed time base, the zoomed trace should be about like photo ❷, scanned at 20 us/div.





❶ The incoming signal scanned at 500 µs/div with the window function activated, at 25 µs/div. The lower trace, with a low number of points, reveals that it is really only a graphic zoom. ❷ The same pulse how would it be with a true delayed time base. ❷ Same screenshot on the 54540A, with frame buffer at 32,768 and 100 MSa/s sample rate. The chromatic alterations are due to the iPhone photo camera that does not get along with the screen refresh.



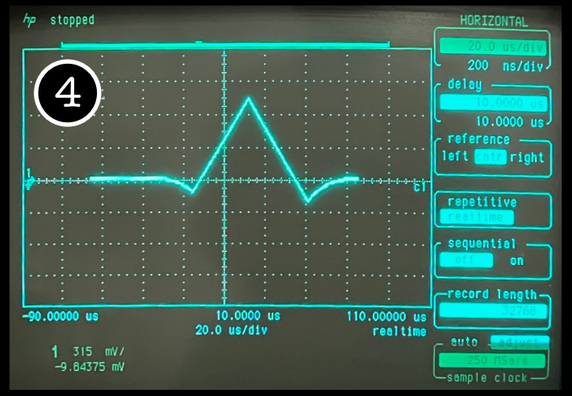
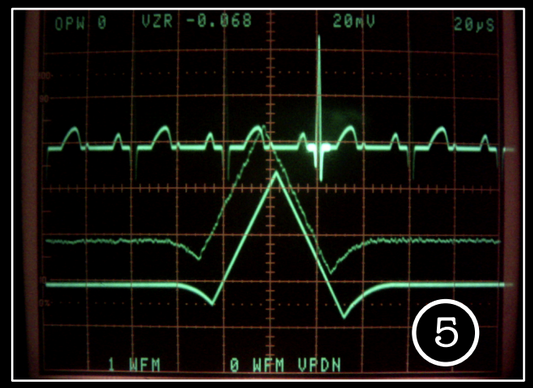
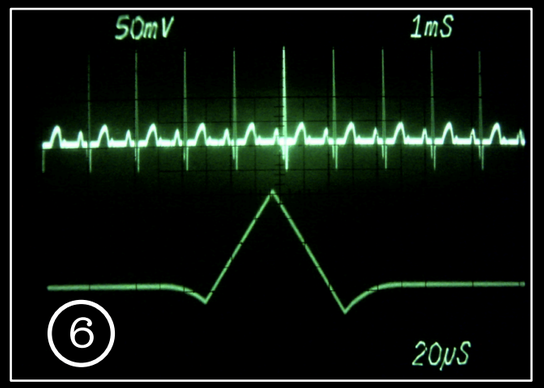


Photo ❸ shows the same pulse on the 54540A, manually setting the buffer size to 32768 and the sample rate to 100 Sa/s (these parameters are automatic and cannot be set on the 54502A). Also here the dot joining has been disabled, but the points are so many that there is no gap between them. As logical, raising the sample rate, the trace does not fill the whole screen (photo ❹), because the memory buffer is not large enough.

To complete the pictures and leave you more historical information, here below the same pulse analyzed on the digital 7854 and on the CRT storage 7633.

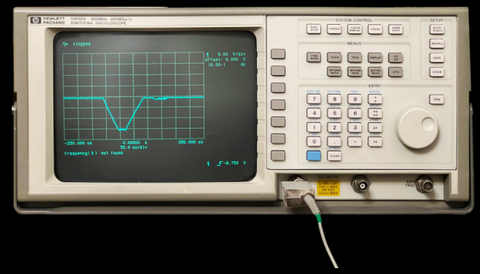




❸ Same screenshot on the 54540A, with frame buffer at 32,768 and 100 MSa/s sample rate. ❹ The 32,768 point long memory buffer is not enough to fill the screen at 250 MSa/s. ❺ The same pulse on the 7854 in analog mode, with superimposed the digitalized one. ❻ The same pulse got on a 7633 CRT storage oscilloscope.

Oscilloscopes history

Some key events



1969-1979
Almost absolute Tektronix dominance ('7000-Series and not only)

1980
Tektronix 7854 first widely distributed digital oscilloscope

1981

1982
Hewlett & Packard introduces Model 1980

1983
Tektronix 2200-Series

1984
Hewlett & Packard introduces Model 54100

1985
Tektronix introduces the 2430 portable DSO

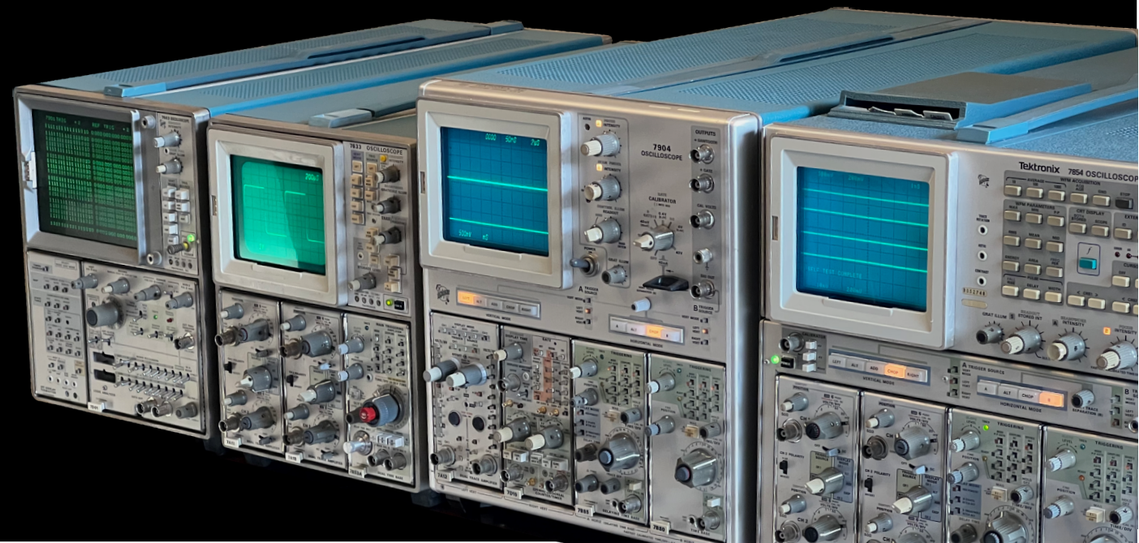
1986
Tektronix introduces the 11000-Series

1987

1988

1989
Tektronix 2440
HP 54502

1993
HP 54540



In this table I included some of those, that, in my imagination, have been important some key events of oscilloscope's history from 1969 to 1993. I don't pretend that that is neither correct, nor complete. To be more clear, it is just the mosaic that I could build to myself with the tiles that I have got and presented in these books. Maybe going to change in the future editions...



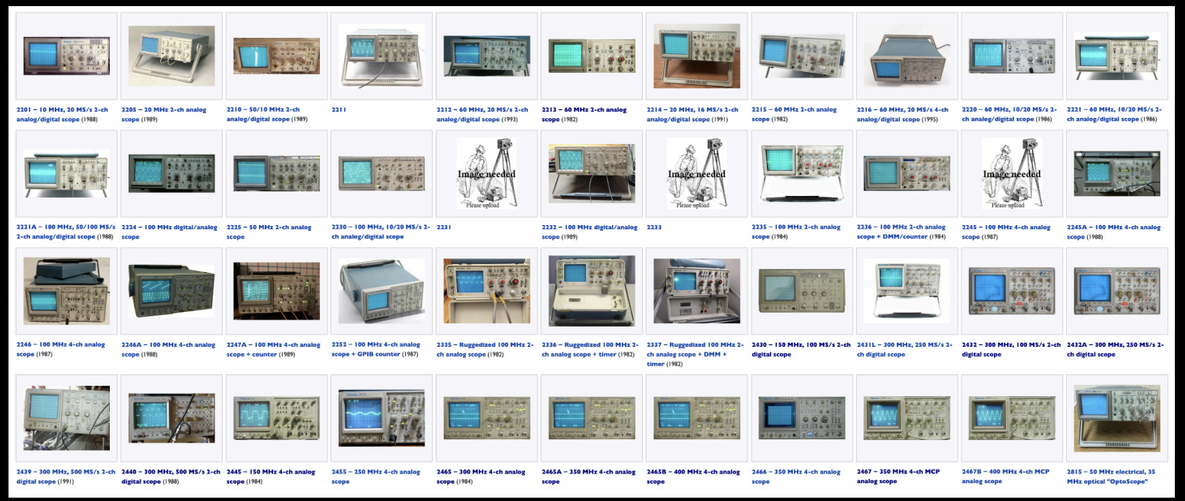
Last minute

I recently convinced myself that I had overlooked some important products that deserve a place of some prominence in the history of our dear oscilloscopes. The reference is to the Tektronix 2000-Series.

This is primarily due to my ignorance, as I repeated, I am just a novice historian, but the model number and nomenclature makes thing less easy to understand. The 2213/2215 were introduced in 1982, and have been followed by a great number of models: the related Tekwiki page reports 44 different base types (see picture below).

Generally speaking, when the range becomes so numerous no model is so significant, but I hope in the future to be able to continue this story talking also of some 2000-Series models.

I will start with the 2430: the first digitizing scope in this series, that will be more deeply described in the future releases of this second volume.




"That's all Folks!"™

Revision history

Rel.	Date	Notes
1.0	*January, 10, 2023*	*First edition*

About me

About me

My name is Giovanni Becattini (but everybody calls me Gianni) and live in Florence, Italy. I started loving electronics when still a boy, and I have been working in professional electronics for more than 50 years, spending my entire life in electronic industry.

All the photos here have been taken with a normal iPhone 13 Pro.

giovanni.becattini@aep-italia.it



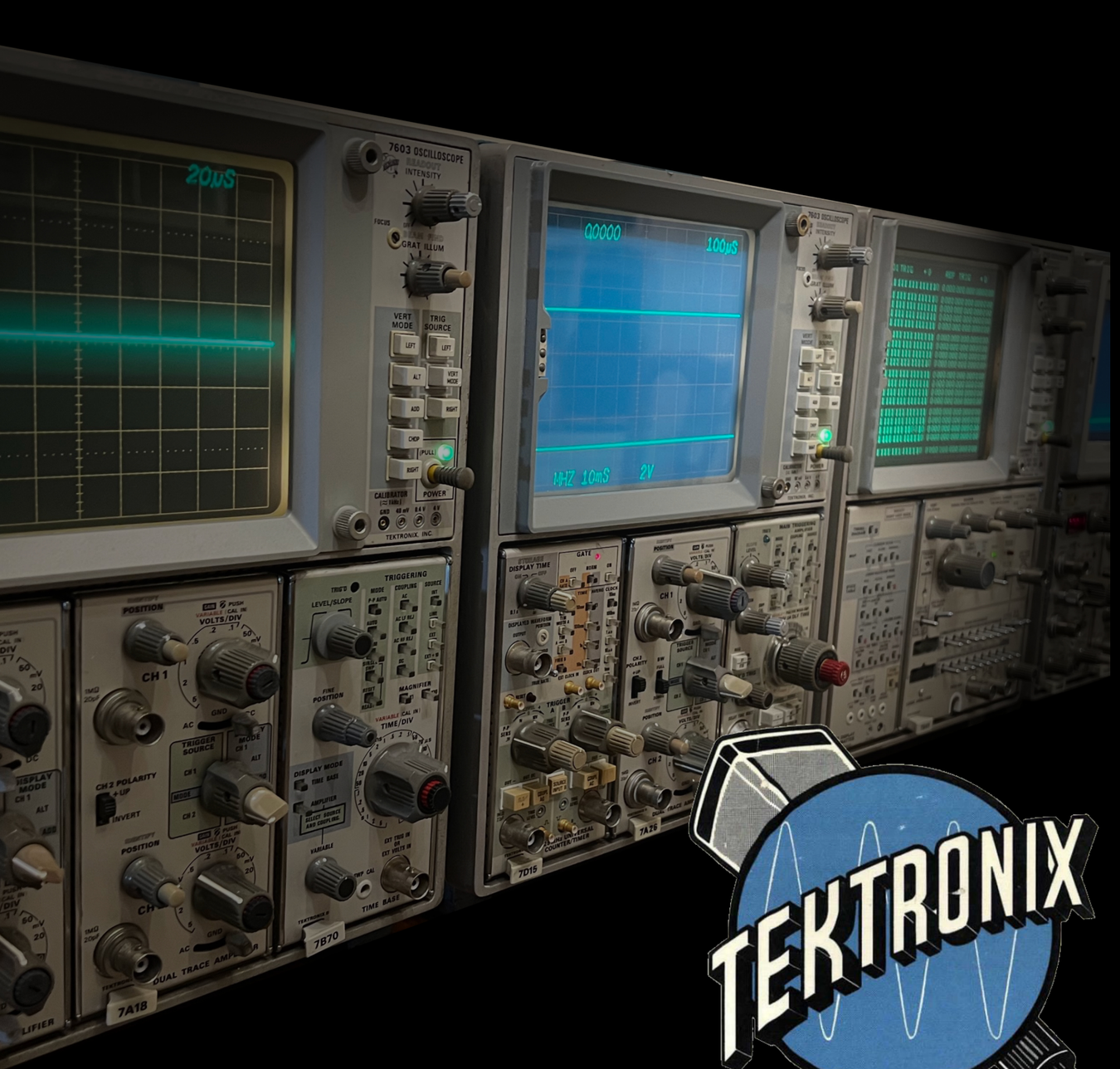
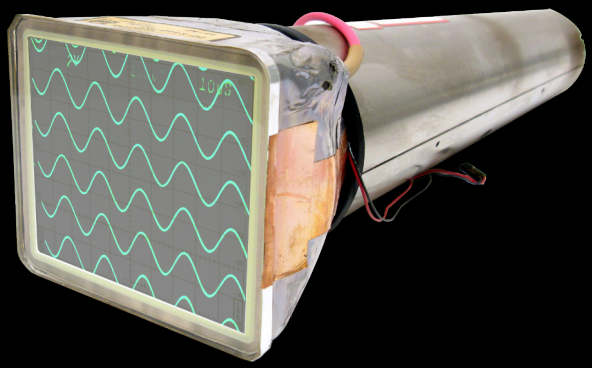


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