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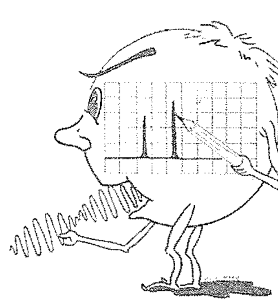


GETTING ACQUAINTED WITH SPECTRUM ANALYZERS

by Russ Myer
Tektronix Advertising Dept.

This is the second and concluding half of an article intended to form a conceptual basis for the understanding of Spectrum Analysis. The first half of the article appeared in the April, 1965 issue of SERVICE SCOPE.

Editors Note:

Part 1 of this article, presented the author's thoughts on Spectrum Analysis to as far as the detector circuit of a spectrum analyzer. Part 1 concluded with a short explanation of two of the detector circuit's three outputs—the linear output and the logarithmic output.

Here in the June, 1965 issue of SERVICE SCOPE, Part 2 begins with a brief review of decibels. This is intended to give the reader a better understanding of the logarithmic output.

We suggest that a refresher reading of Part 1 *before* continuing on to Part 2 will allow the reader to more readily associate himself with the author's thoughts presented here in the second half of the article.

Part II

DECIBELS

To give you a better understanding of the logarithmic output, let's briefly review decibels.

A decibel is one-tenth of a bel. A bel is the same thing as a power of ten. Thus: 50 db is equal to 5 bels. This is the same as 10 to the 5th power, or 10^5.

If we increase the power level of a signal by 60 db, we increase it 10^6 times—a gain of 1,000,000. Increasing a one-watt signal by 60 db increases it to one million watts!

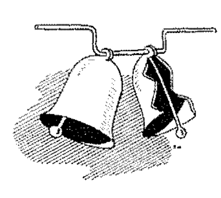
Remember that db merely expresses the difference between two power levels. By itself, it means nothing, nor does it represent any actual quantity of power. If the example above were 1 micro-watt, a 60 db gain would bring the power up to 1 watt. So the same 60 db expressed a difference of almost 1 million watts in the first example and only 1 watt in the second!

Gains of whole bels, 1, 2, 3, etc. . . . can easily be calculated in the head. 1 bel (10 db), for example, means a power gain of 10^1, or ten. 2 bels, (20 db), means a power gain of 10^2, or one hundred. And so on.

EXPONENT	MULTIPLY BY	EXPONENT	MULTIPLY BY
.1	1.25	.6	4.0
.2	1.6	.7	5.0
.3	2.0	.8	6.3
.4	2.5	.9	8.0
.5	3.16		

Figure 5. Fractional Exponent Multipliers.

Unfortunately, gain is not always expressed in even numbers of bels. What about a gain of 33 db? This is a gain of 3.3 bels, or $10^{3.3}$. Reviewing math, this means 10^3 times $10^{.3}$. 10^3 is easy: 1000. What about $10^{.3}$? For this, you'll have to refer to the table of fractional exponents. See Fig. 5. From the table, you'll see that 0.3 corresponds to 2. So 10^3, or 1000, is multiplied by 2. A 33 db gain, therefore, is equal to a gain of two thousand.



Assume that an amplifier has an input of 200 milliwatts. The gain is 33 db. The output, in watts, would be 400 watts. ($0.2 \times 10^{3.3}$)

Db's are also used to express a loss. We can still consider, in the case of our example, that the difference between two signals is 33 db, but as we now desire to express a loss in power, the figure of 2000 must be divided into 1 to obtain its reciprocal. In this second case, our initial power of 200 milliwatts must be multiplied not by 2000, but 1 divided by 2000, or 0.0005. This reduces our 200 milliwatts to 100 microwatts.

To express a difference in voltage levels, more commonly used in oscilloscope work, the number of bels used as exponents, is divided by 2. Example: a voltage gain of 44 db gives an exponent of $10^{4.4}$. Dividing the exponent by 2 gives a new number: $10^{2.2}$. This is $10^2 \times 10^{.2}$, or 100×1.6, or 160. Increasing any voltage level (RMS) by a factor of 160 produces an increase in power of about 25,000 times. This is proved by the relationship $E^2/R(160^2)$.

The power formula, $P = E^2/R$ indicates that power increases as the square of the voltage (resistance remaining the same, of course). The oscilloscope is a voltage-operated device; therefore, increasing a vertical signal by a factor of 2 requires a signal 4 times the power of the original.

So much for decibels. Let us return now to the detector circuit and its 3rd or SQUARE-LAW output.

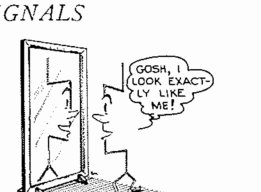
To expand vertical signals, the analyzer's detector is operated in the SQUARE-LAW mode. In this manner, the output voltage is the *square* of the input voltage. Doubling the input causes the output to increase *four* times. Tripling the input causes the output to increase 9-fold!

The advantage of this circuit can easily be seen. Input signals of nearly the same amplitude are expanded and can be measured more accurately on the crt. Also, the crt now measures relative input *power.* Doubling the input power doubles the vertical deflection. Thus, the square-law mode causes the output to behave exactly the opposite of the logarithmic mode.

THE VIDEO AMPLIFIER

The detector circuit is followed by the Video Amplifier. Signals are fed into the amplifier and applied, push-pull, to the crt vertical-deflection plates. To increase the versatility of the spectrum analyzer, video signals can be fed directly into the amplifier, by-passing the i.f. and detector portions of the instrument. This allows an oscilloscope display of ordinary time-based signals.

IMAGES AND OTHER SPURIOUS SIGNALS



Until now, we have assumed that only the signals appearing in the area of the center frequency are presented on the crt display. Unfortunately, this is not always the case. Other signals also sneak through the analyzer and are displayed.

Assume you have set the tuning dial at 300 Mc to observe a signal of that frequency on the crt. Since 300 Mc is the center-frequency signal, it will appear at the center graticule line. Assume further that along with the 300-Mc input, another signal with a frequency of 700 Mc is present at the input.

Since the first L.O. operates 200 Mc higher than the desired input signal, it will be oscillating at 500 Mc. This frequency beats with the 300-Mc input to produce the 200-Mc difference which is allowed to pass through the 1st i.f.

But . . . . the difference between the 500-Mc L.O. and the 700-Mc input is *also* 200 Mc! So, it too is introduced into the 1st i.f. and, as you would expect, appears on the crt — exactly super-imposed on the 300-Mc signal at the center graticule line. Now, set the dial slightly to either side of the 300-Mc center frequency. This causes the signals to move from the center graticule area. However, each signal goes in the *opposite* direction!! A little arithmetic will prove why.

Moving the L.O. to 530 Mc, for example, (tuning dial reading 330 Mc, of course) produces a beat of 230 Mc for the desired input signal of 300 Mc. As the output of the 2nd i.f. is swept through its range of 170 Mc to 230 Mc, it's obvious that the true signal now will appear on the extreme right of the crt. The L.O. frequency of 530 Mc also beats with the 700-Mc input and produces a difference frequency, or beat frequency, of 170 Mc. This causes it to appear to the extreme left of the crt.

This illustrates an important rule: Tuning the L.O. (main tuning dial) to a higher frequency causes the true signal to move to the right of the crt; unwanted signals move to the left. These undesired responses are called "images," or "spurious" responses.

As signals above and below the center frequency of the 1st L.O. can produce beat frequencies, either of the two could be called the "true" signal, depending upon how we labeled the tuning dial. We simply choose to call signals below the frequency of the L.O. *true responses* and all signals above it, the image signals. The i.f., of course, doesn't know the difference.

Another type of spurious response that shows up on the crt is caused by input signals that fall within the bandpass of the first i.f Any input signal falling within the range of 170 Mc to 230 Mc will be displayed. This is called *i.f. feedthrough.* This type of spurious signal is the easiest to identify. Moving the tuning dial either direction does not shift the display on the crt. This is because the 1st L.O. does not beat with any input signal to produce the response.

Figure 6 shows two unknown signals on the crt of the scope. Note their positions on the graticule. The dispersion is set at 50 Mc. Thus, each graticule line represents 5 Mc. First attending to signal A, move it to the center graticule line. This will determine the center frequency of the signal as read on the tuning dial. Assume that

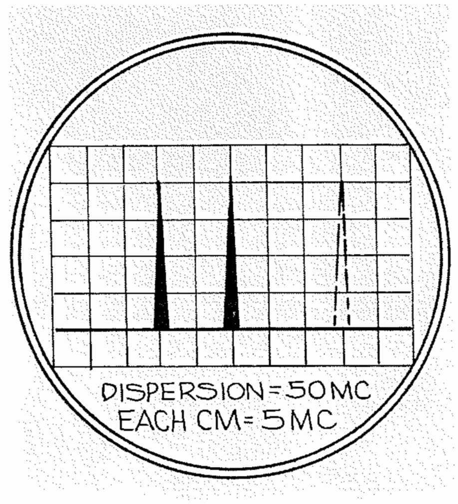
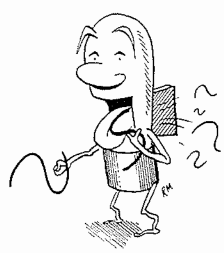


Figure 6. Display after shifting image to center of graticule. This illustrates how two signals, separated by 390 Mc, show up only 10 Mc apart on the crt.

it was necessary to tune the dial higher in frequency. The signal moved higher in frequency, also (towards the left). This identifies signal A as a spurious, or image, response. Reading the tuning dial gives us a figure of 205 Mc. We know the L.O. is operating 200 Mc above the tuning-dial reading, so it must be oscillating at 405 Mc. The image, therefore, is 200 Mc above that, or 605 Mc!

Signal B was moved to the right (down in frequency) to be located at the center graticule line. The tuning dial would now read 215 Mc, which is the frequency of the true input signal.

HARMONIC SPURII



When the operation of the Spectrum Analyzer is considered, remember that any complex waveform is the algebraic sum of a number of pure sine waves. The analyzer permits the display of these individual sine waves on an oscilloscope. The horizontal sweep represents some continuous frequency range.

Any sine wave passed through a non-linear device, such as a tube or a transistor, will be accompained in the output by a new set of frequencies called *harmonics.* These frequencies will be exact multiples of the original, but of decreasing amplitude. The second harmonic, for example, of a 200-Mc signal, is 400 Mc; the 3rd, 600 Mc, etc.

Here is where we can get into trouble with our typical spectrum analyzer. Originally, we spoke of all the signals present at the output of the first mixer: the original L.O. frequency, the original input signal, the sum of the two, and the difference, which was the one selected for i.f. amplification. We also learned that any signal

170-Mc to 230-Mc *higher* than the L.O. frequency would also produce a beat that fell within the bandpass of the first i.f. And, finally, there was i.f. feedthrough.

But, unfortunately, there are other spurii which can show up on the crt screen.

The mixer will produce harmonics of its two input signals, (original signal and L.O.) which are present in the output. Harmonics of the L.O. are of particular interest to us now. For example, assume the L.O. could be set at 300 Mc to show a 100-Mc input signal on the crt. The second harmonic of the L.O. is 600 Mc. If there were a 400-Mc signal of equal strength at the input of the analyzer, it, too, would produce a 200-Mc difference and be displayed on the crt! Because of the decreased amplitude of the harmonic, however, the crt presentation would be less than that of a true-response presentation. (Bear in mind, however, that the 400-Mc signal could have a signal strength several times that of the true signal and show up as a larger amplitude presentation than the true one).

Also, an 800-Mc signal, if present at the input, would beat with the 2nd harmonic of the L.O. and produce the 200-Mc i.f. difference signal. Likewise, the 3rd harmonic of the L.O. — 900 Mc — could beat with a 700-Mc input, or a 1,100-Mc input and produce the 200-Mc i.f. frequency!

Fortunately, these harmonic-caused spurii can be easily recognized. Increasing the L.O. frequency by 100 Mc, for example, increases the 2nd harmonic by 200 Mc, and the 3rd by 300 Mc. Thus, harmonic spurii move across the screen faster than true response or images.

Assume inputs of 700, 400 and 100 Mc. The L.O. is set at 300 Mc to display the 100-Mc signal at the center of the crt. The dispersion is set at 10 Mc, each centimeter representing 1 Mc on the crt. At the center of the crt, only one signal is observed. Actually, three signals are present — the true signal which is L.O. minus the input frequency of 100 Mc, 2 x L.O. minus the input frequency of 400 Mc and 3 x L.O. minus the input frequency of 700 Mc. All these differences are exactly 200 Mc! See Figure 7.

Tuning the L.O. up 1 Mc in frequency will shift the true signal, 100-Mc, exactly 1 division to the right (remember that tuning higher in frequency shifts true signals towards the minus-frequency or right hand side of the crt). The 1-Mc shift upward caused the 2nd harmonic to increase 2 Mc, and this moved the 400-Mc input *two* divisions to the right! The 3rd harmonic increased by 3 Mc, and the 700-Mc signal appeared three divisions to the right of center. Assuming inputs of equal signal strength, the 2nd harmonic signal would be less than the amplitude of the true response and the 3rd harmonic signal amplitude would be less than the second. Observe that, unlike images, moving the L.O. up in frequency causes these harmonic spurii to move in the same direction as true responses.

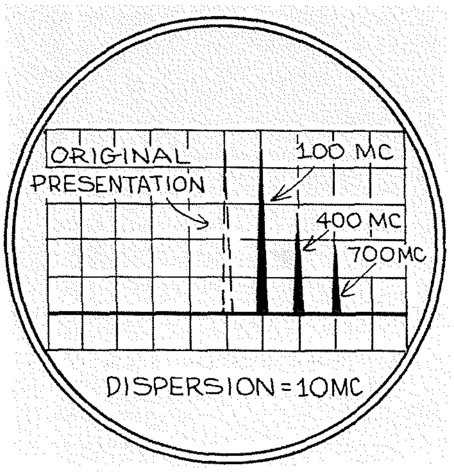


Figure 7. Display showing effects of moving tuning dial up 1 Mc to recognize and separate spurii from true response.

MARKER OSCILLATOR

A feature of the spectrum analyzer is the Marker Oscillator. It generates a 200-Mc signal which is fed into the 1st i.f. of the analyzer. You can use it to determine relative frequency or frequency difference of signals observed on the crt.

You'll remember that the center frequency of the 1st i.f. is 200 Mc. The marker frequency of 200 Mc is injected into the i.f. and will exist at the center of the bandpass of the i.f. You can say, therefore, that the 200-Mc marker indicates the center frequency of the i.f. and is displayed at the center graticule line of the crt. The marker appears as a spike, or "pip", much like the time marks used to calibrate oscilloscopes.

A front-panel control, the "Frequency-Difference Control," allows the marker to be tuned to either side of its 200-Mc mid-range, usually plus or minus 30 Mc (170 Mc to 230 Mc). Figure 8 gives an example of the use of the marker.

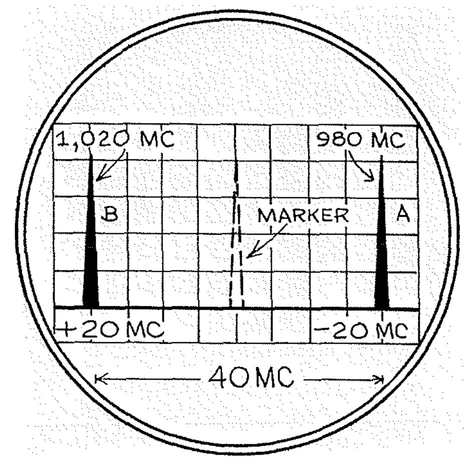
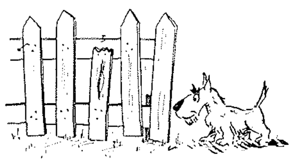


Figure 8. Dispersion is 50 Mc. Each cm = 5 Mc. Marker reads frequency difference.

First, line up the marker "pip" and the signal at "A". The control reads —20 Mc. Moving the marker over to signal "B" and lining them up, the control reads +20 Mc. The frequency difference is 40 Mc and that is the frequency difference between signals "A" and "B". Assume the main-tuning dial is tuned to 1,000 Mc. The dispersion is set at 50 Mc. Each graticule mark now represents 5 Mc. No signal appears at the center graticule line, which represents the center frequency. Therefore, no input at 1000 Mc is present at the input of the analyzer. However, there is a signal 4 graticule lines to the left of the center one. This signal is 20 Mc less than the 200-Mc center frequency, or 180 Mc, and corresponds to an original input of 1,020 Mc. The signal on the right, "B", is 20 Mc greater than 200 Mc and is produced by an input of 980 Mc. Remember to read frequency from right to left!

As we have seen previously, spurious inputs will also produce similar signals on the crt. An input of 1,380 Mc will produce a signal similar to "A" and an input of 1,420 Mc will produce one similar to "B". Note that in the case of these and any images, frequency is read from left to right, in the normal fashion. You can, of course, identify true signals by shifting the main-tuning dial and observing which way the signals move on the crt.



The marker-oscillator output can be frequency - modulated, also. Two modulating frequencies are available on this typical analyzer: 1 Mc and 100 kc. When modulated, the 200-Mc marker signal now becomes a complex waveform which the analyzer will break down into individual sine-wave components (which is what our analyzer does to all complex waveforms!). These are displayed on the crt as pips, spaced equally apart. These pips extend to the right and left of the marker center-frequency displayed on the crt. The separation between the pips is equal to the modulating frequency that caused them. In other words, with a dispersion of 10 Mc and the marker set on 200 Mc, a modulating frequency of 1 Mc will create a "pip" at each graticule line. These pips are called the *"picket fence."*

VERTICAL AMPLITUDE MEASUREMENTS

Look at the graphical view of the bandwidth of the 1st i.f. (Figure 9). The center frequency is 200 Mc. The bandwidth limits are 170 Mc to 230 Mc and is expressed in db variation, usually ±3 db. The figure shows that the flat portion of the curve can vary between minus 3 db and plus 3 db. This is a 6-db variation! Per-

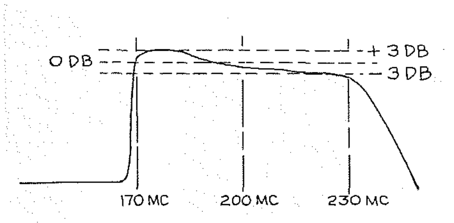


Figure 9. Bandwidth of 1st i.f., reproduced on crt by sweeping constant input signal over 60 Mc range. Note that despite constant input, there is a 6 db variation between 170 Mc and 230 Mc.

haps at the 170-Mc point, the response is +3 db. At the 230-Mc point, it could be —3 db. A single, constant-input signal, swept from 170 to 230 Mc, will produce an output to the detector that varies between +3 db and —3 db. Obviously, this same signal viewed on the crt would assume a varying vertical deflection at different points along the horizontal axis although the input had not changed at all. Therefore, it is important that all measurements using the Spectrum Analyzer be made with the signal under measurement lined up at the center graticule line. Thus, a constant output from the detector is assured.

To measure relative differences in amplitude of signals displayed on the crt, we use the calibrated attenuator of the analyzer.

Assume you have a crt display of two signals of different amplitudes. The detector is in the linear mode. The largest signal is reduced, with the attenuator, to the original amplitude of the second signal. The difference is noted on the attenuator. This is the relative difference. For signals of greatly different amplitude, the log mode of detection may be used. If the input signals were nearly the same amplitude, the square-law detection mode could be used.

This discussion has presented the overall operation of a typical Tektronix Spectrum Analyzer. Although the company's product line features several different models covering other portions of the electromagnetic spectrum, some of which operate a little differently than explained here, they all do one basic thing. They break down complex waveforms and display them on an oscilloscope as individual sine waves on a frequency time base.

The End

The Author wishes to acknowledge the help received from pertinent articles and material supplied by the following Tektronix personnel: Arnold Frisch, Project Manager, and Morris Engelson, Design Engineer of the Spectrum Analyzer group in the Instrument Engineering Department, Fred Davey, Education and Training Program Director, and Fred Beville Field Engineer; also the assistance of others who aided in the editing of this material . . . Russ Myer

About the Author—

Russ Myer received his training in basic electronics at the Venezuela Communication School in Caracas, Venezuela.

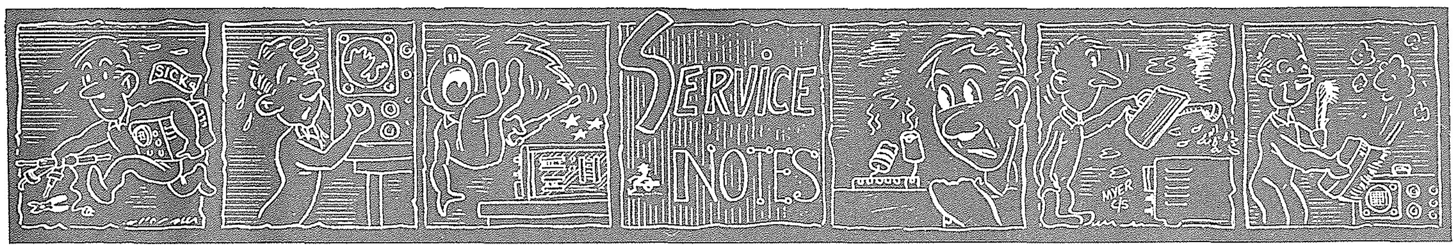
He later took service with the U.S. Federal Aviation Agency and during his tenure studied electronic engineering at their University of the Air in Oklahoma City, Oklahoma.

He followed this with a stint as teacher of electronics at Port Arthur College in Port Arthur, Texas.

Russ has also had five years of experience as a broadcast engineer, holding the position of chief engineer at each of the several stations employing him.

He came to Tektronix, Inc. in April of 1962 and worked in the Test and Calibration and Customers Service departments before transferring, recently, to the Advertising Dept. as a technical writer.

The Editor.



TYPE L-20 PLUG-IN-UNIT SPECTRUM ANALYZER—APPLICATIONS ABOVE ITS SPECIFIED FREQUENCY RANGE

The Type L-20 Spectrum Analyzer's specified upper frequency is 4 Gc. You can, however, use the instrument for applications up to 12 Kmc, at reduced sensitivities. You will need to compute the dial setting for any input frequency from a knowledge of the local oscillator frequency; and, you can compute the local oscillator frequency from the dial setting on Band 2 (fundamental operation) using this equation:

$$\frac{F_{rf} + 200}{n} = F_d + 200$$

Where

F_{rf} = Input signal rf frequency

200 = IF Frequency

n = harmonic number of local oscillator,

Band 2 Dial Reading	n = 5 Kmc	sens —dbm	n = 6 sens —80 dbm Kmc	n = 7 sens —75 dbm Kmc	n = 8 sens —70 dbm Kmc	n = 9 sens —66 dbm Kmc	n = 10 sens —63 dbm Kmc	n = 11 sens —60 dbm Kmc
230	1.95	—85	2.38	2.81	3.24	3.67	4.10	4.53
240	2.00	—85	2.44	2.88	3.32	3.76	4.20	4.64
250	2.05	—85	2.50	2.95	3.40	3.85	4.30	4.75
260	2.10	—85	2.56	3.02	3.48	3.94	4.40	4.86
270	2.15	—85	2.62	3.09	3.56	4.03	4.50	4.97
280	2.20	—85	2.68	3.16	3.64	4.12	4.60	5.08
290	2.25	—85	2.74	3.23	3.72	4.21	4.70	5.19
300	2.30	—85	2.80	3.30	3.80	4.30	4.80	5.30
320	2.40	—85	2.92	3.44	3.96	4.48	5.00	5.52
340	2.50	—85	3.04	3.58	4.12	4.66	5.20	5.74
360	2.60	—85	3.16	3.72	4.28	4.84	5.40	5.96
380	2.70	—85	3.28	3.86	4.44	5.02	5.60	6.18
400	2.80	—85	3.40	4.00	4.60	5.20	5.80	6.40
450	3.05	—85	3.70	4.35	5.00	5.65	6.30	6.95
500	3.30	—85	4.00	4.70	5.40	6.10	6.80	7.50
550	3.55	—85	4.30	5.05	5.80	6.55	7.30	8.05
600	3.80	—85	4.60	5.40	6.20	7.00	7.80	8.60
650	4.05	—85	4.90	5.75	6.60	7.45	8.30	9.15
700	4.30	—85	5.20	6.10	7.00	7.90	8.80	9.70
750	4.55	—85	5.50	6.45	7.40	8.35	9.30	10.25
800	4.80	—85	5.80	6.80	7.80	8.80	9.80	10.80
850	5.05	—85	6.10	7.15	8.20	9.25	10.30	11.35
900	5.30	—85	6.40	7.50	8.60	9.70	10.80	11.90

Chart 1. Chart for determining the value for n in the equation $\frac{F_{rf} + 200}{n} = F_d + 200$.

for F_{rf} between 4 Kmc and 12 Kmc is 5 to 11 (for Type L-20)

F_d = Band 2 dial settings

Sensitivities are estimated—we make no production measurements, *nor do we guarantee performance in this frequency range.* Engineering tests do, however, indicate that the Type L-20 exceeds the estimated sensitivities in most cases.

NOTE: You should always operate at the lowest harmonic possible so as to achieve best sensitivity. Also, on Chart 1 below, those numbers to the right and below the mid-chart line do not appear on the dial of the Type L-20 Spectrum Analyzer. Those numbers above and to the left of the mid-chart line do appear on the dial at a low order of harmonic.

TYPE 545B AND TYPE RM545B OSCILLOSCOPES—IMPROVED VERTICAL AMPLIFIER HF RESPONSE

You can improve the high frequency response of the Type 545B (s/n's 101-1079) and the Type RM545B (s/n's 101-219) Oscilloscopes by replacing C551, a fixed 7.5 pf capacitor, with a 5-25 pf variable capacitor (Tektronix part number 281-0075-00). C551 is located on the lower Vertical Amplifier chassis. You will need to rearrange the components on the ceramic strips to accommodate the larger replacement

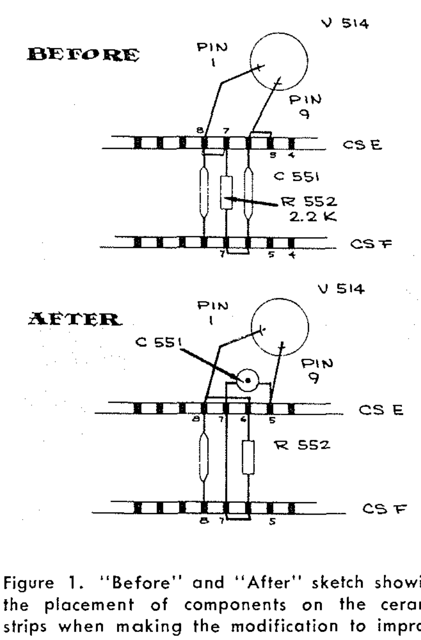


Figure 1. "Before" and "After" sketch showing the placement of components on the ceramic strips when making the modification to improve the vertical amplifier high frequency response in the Type 545B and Type RM545B Oscilloscopes.

capacitor. Figure 1 shows a "BEFORE" and "AFTER" sketch of this modification.

Remove C551 from the ceramic strips, located on the lower Vertical Amplifier, just above the two TA1938 transistors Q513 and Q523. Follow the BEFORE and AFTER drawings and rewire the ceramic strips to accommodate the new C555 capacitor. Refer to your Instruction Manual's Calibration section and recheck the Vertical Adjustment, adding C551 to the procedure as necessary. Don't neglect to change the parts list and schematic values in your Instruction Manual to agree with the new capacitor.

TYPE 2B67 TIME-BASE UNIT—RASTER

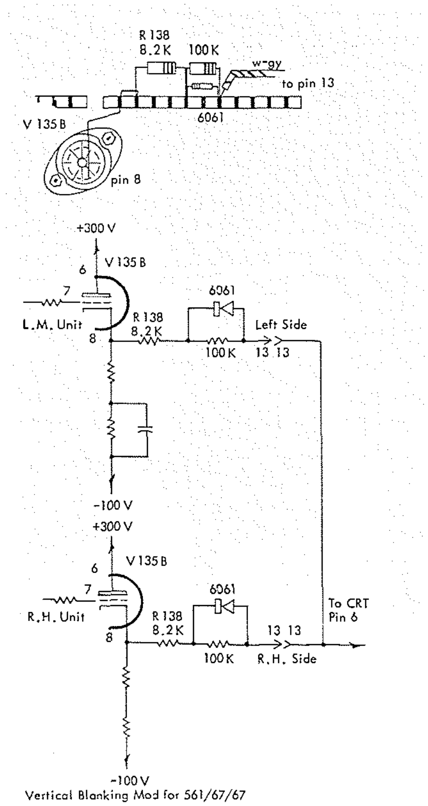


Figure 2. Partial schematic and sketch of component placement on the involved ceramic strips when making the vertical blanking modification to the Type 2B67 Time-Base Unit.

When two Type 2B67 Time-Base Units are used for raster applications in a Type 561A or Type 564 Oscilloscopes the left-hand unit will not blank the vertical retrace. A slight modification to the two Type 2B67's will allow the left-hand 2B67 to blank the vertical retrace. Figure 2 shows the circuit modification in schematic form. With this circuit, if either time base says "off" the beam turns off. That way it's off during each retrace of the horizontal and off during vertical retrace, too. This circuit works well with moderately slow sweeps. It *will not* work at very fast sweeps; there just isn't enough current in the Type 2B67 system to pull these plates around very rapidly.

There are four steps involved in the modification and here they are:

1. On the bottom ceramic strip of each of the two 2B67's, remove the white-grey lead from the end of R138 (8.2 k) resistor and move it two notches to the rear.
2. Connect a 100 k, ½ w resistor (Tektronix part number 302-0104-00) between the 8.2 k resistor (R138) and the white-grey wire moved in Step 1.
3. Shunt the 100 k resistor installed in Step 2 with a 6061 diode (Tektronix part number 152-0061-00). Connect the cathode end of the diode to the junction of the 8.2 k and 100 k resistors.
4. On the Type 561A (or Type 564) Oscilloscope, run a lead from pin 13 of the right-hand interconnecting socket to pin 13 of the left-hand interconnecting socket.

That's all there is to it.

TYPE 545B AND TYPE RM545B OSCILLOSCOPES — ELIMINATING TIME-BASE 'B' TRIGGER JITTER

In some of these instruments, trigger jitter may be apparent when Time-Base 'B' is triggered with the MODE switch in the —EXT position. Should this be objectionable, replacing R92, a 22 k, 1 w, 5% resistor, with a 20 k, 1 w, 5% resistor, (Tektronix part number 303-0203-00) will eliminate the jitter.

R92 is located on the 'B' sweep chassis between the center two ceramic strips, with one end connected to L424, a 225 μh inductor, which is directly over V424, a 6AU6 tube. Be sure to note the changed value for R92 in your Instruction Manual's part list and schematic when you make this modification.

TYPE Q TRANSDUCER & STRAIN GAGE PLUG-IN UNIT—POSSIBLE TEMPERATURE/GAIN PROBLEM

Some Type Q Units within the serial number range of 101 through 1629 will exhibit a temperature/gain problem. The problem manifests itself as a change in gain with a change in temperature and is most likely to occur during warm up of the Q Unit. It can result in a significant measurement error. Two 0.02 μf discaps in the amplifier cause the instability. Replacing these with 0.022 μf, 200 v, PTM capacitors (Tektronix part number 285-0566-00) will assure stable operation during and after warm up.

With the Q unit turned upside down on the bench and the front panel facing you, C5724 and C5755 are located on the four-notch ceramic strips directly behind the front panel and under the μ STRAIN/DIV. switch.

After making this modification, correct the parts list and schematic in your Type Q Unit Instruction Manual to agree with the work you have done.

TYPE 519 OSCILLOSCOPE — POSSIBLE SHORT DAMAGE IN HV SUPPLY

Accidentally grounding the HV supply of the Type 519 Oscilloscope (s/n's below 560) may cause C841, an 0.01 μf-500 v capacitor, to short. This short will, in turn, damage V800, the 6AU5 oscillator tube in the HV circuit.

Replacing C841 with a capacitor having a higher voltage rating will protect against this damage. The replacement should be an 0.01 μf, 1 kv capacitor (Tektronix part number 283-0013-00). C841 is located in the HV supply between pin 7 of V814 (a 12AU7 error-signal-amplifier tube) and ground—consult the CRT CIRCUIT schematic in your Type 519 manual. Be sure to note the changed value for C841 in the schematic and parts list of your manual.

TYPE 519 OSCILLOSCOPE — REPLACEMENT CAPACITOR COVER

Installation of a new type capacitor cover on C655 will offer more protection against arcing of this capacitor in the Type 519 Oscilloscope. C655 is a 2 x 1000 μf, 450 v, EMF capacitor in the 6.3-v crt-heater circuit of the Type 519's power supply. Under the proper atmospheric conditions and at 4000 foot elevations, pins 16, 17 and 26 of T601 and the can of C655 may arc to ground. Should this occur, the two dioodes, D655 and D656 may be destroyed and 601 damaged. Normal age deterioration of the original capacitor cover will enhance the possibilities of this arcing.

The new capacitor cover (Tektronix part number 200-0293-00) is molded of a recently available plastic, highly resistant to age deterioration and with very effective insulating abilities.

TYPE 160A POWER SUPPLY—EXCESSIVE RIPPLE ON +225-SUPPLY

Under conditions of high-load demand at the output and a low-line supply at its power source the Type 160A Power Supply (s/n's 101 through 9049) may exhibit ripple on the +225-v supply that exceeds specifications. Changing R33 from a 1 meg to a 1.5 meg ½ w, 10% resistor will assure that ripple on the +225-v supply remains within specifications. R33 is located on the Type 160A chassis between pin 5 of V33 (a 6AU6 tube) and pin 2 of V35 (a 6080 tube). Tektronix part number for the 1.5 meg resistor is 302-0155-00. After you make the replacement, note the changed value for R33 in the parts list and on the schematic of your Type 160A's Instruction Manual.

REPRINTS AVAILABLE

Reprints of two articles written by Tektronix personnel and which appeared in technical magazines recently are available.

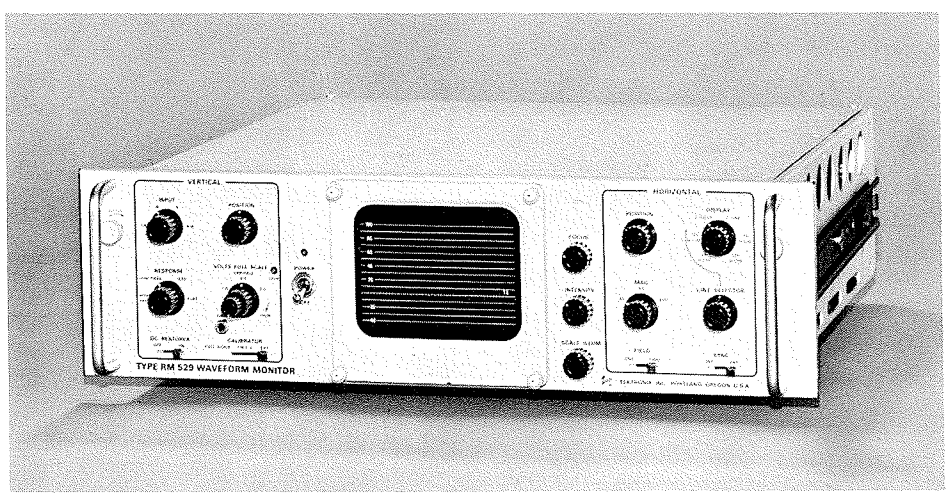
The March, 1965 issue of THE MICROWAVE JOURNAL contained an article on spectrum analyzers. Title of the article is "Oscilloscope Plug-In Spectrum Analyzers". Three Tektronix design engineers, Arnold Frisch, Project Manager, and Larry Weiss and Morris Engelson, Design Engineers with the Spectrum Analyzer group in our Instrument Engineering Department, collaborated to produce this article. It deals primarily with the plug-in type of spectrum analyzers designed for use with the Tektronix Type 530, 540, 550 and 580 Oscilloscopes.

Following a brief rundown on the principles of a spectrum analyzer's performance, the article explains how the plug-in analyzer uses to advantage certain oscilloscope characteristics; such as, the calibrated sweep, the expanded sweep, intensity modulation and (as in the case of the Type 555 Oscilloscope) dual beam presentation.

The January, 1965 issue of ELECTRO-TECHNOLOGY carried an article on sampling oscilloscopes entitled "Nanosecond Measurements with a Sampling Oscilloscope". The author is H. Allen Zimmerman, Project Engineer with the Tektronix, Inc. Instrument Design Department. This article describes the sampling process and discusses the usefulness and versatility of a sampling oscilloscope.

Reprints of either or both of these articles can be obtained from your local Tektronix Field Office, Field Engineer, Field Representative or Distributor.

A NEW TELEVISION WAVEFORM MONITOR THE TEKTRONIX TYPE RM529



The Tektronix Type RM529 is a new television waveform monitor with capabilities for precise measurement of Vertical Interval Test Signals (VIT).

VIT signals have been in use in Europe and Canada for the past ten years. Their use on the North American continent was pioneered by the Canadian Broadcasting Corporation. The United States government authorized the use of VIT signals in that country as far back as 1956. They have, however, only recently come into common use there.

The Type RM529 is designed for use with the 525/50 line scanning rate used in the United States and here in Canada. This instrument can be obtained (on special order) with minor modifications to the sweep and vertical amplifiers that adapt it to other systems currently in use, including 405/50, 819/50 or high-resolution closed circuit systems. Tektronix, Inc. also produces a television waveform monitor, the Type RM529 MOD 158E, that is designed specifically for the CCIR system. This instrument is of interest, primarily to television authorities, engineers and technicians in areas other than the North American continent.

The wide bandwidth of the Type RM529—flat to 8 MHz—assures excellent waveform fidelity and makes the instrument ideally suited for sine-squared testing.

A new highly efficient 12.7 cm aluminized mono-accelerator crt operating at an increased accelerating potential, assures brighter waveform displays in line-selector operation. Viewing area is 7 x 10 cm.

The electrical design of the instruments incorporates the best of both solid state and vacuum tube circuitry, thus assuring extra high reliability and longer component life. Except for the two power transistors all 45 transistors are socket mounted to enhance serviceability. The two power transistors are bolted to the heat sink on the rear panel of the instrument. Vacuum tubes (there are only seven in the instrument) have been used in but a few circuits, and then, only when they offered superior performance or better reliability over presently available semiconductor devices. Total power consumption is only 80 watts and this low power consumption precludes the need for a fan. The result is cleaner operation and complete freedom from mechanical noise.

The design of the Type RM529 is compact. The instrument fits in a standard 19" rack and requires only 5¼" of vertical rack space. It is designed for mounting with the Conrac picture monitor, or other commercial picture monitors in a standard console or relay rack installation.

A positive field selector is incorporated in the Type RM529 and is ideal for monitoring VIT signals.

A video signal is composed of frames (complete pictures) ,occurring at a 30 Hz rate. Each frame is divided into two fields —Field One and Field Two. Each field contains 262½ lines, making up a complete frame of 525 horizontal lines. The two fields interlace; that is, Field One lines occur between those of Field Two. Close inspection shows that a full line of video precedes Field One; while only noe-half line of video precedes Field Two. These two identifying features occur *immediately* before the vertical blanking pulse which precedes the field in question. (See Figure 1, point a and b.) Careful inspection of the vertical-blanking pulse reveals another difference between Field One and Field Two—a difference in the time relationship between the last equalizing pulse and the first horizontal-sync pulse. (See Figure 1, points c and d.) This difference enables electronic circuits to identify individual fields.

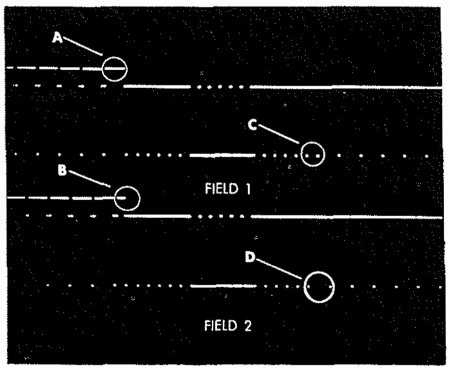


Figure 1. shows the differences between Field One and Field Two. (Double exposure photograph)

A prime feature of the Type RM529 is the ability to distinguish between Field One and Field Two. Through the use of appropriate delay circuitry to interrogate the vertical blanking interval, the Type RM529 can generate a trigger which *positively* locks the Field Trigger Generator to Field One or to Field Two. Hence, triggers initiating a sweep at the start of either Field One or Field Two can be selected with a front-panel switch. *After a noise transient or temporary loss of video, this circuit will always return to the proper field.*

By introducing a delay between these triggers and the start of the sawtooth, *any* line of the TV raster can be inspected individually. Horizontal magnification allows more detailed inspection of the signal on the line selected.

Bright waveform displays are another important feature of the Type RM529. A single line displayed at a frame rate is inherently dim. The Line Selector circuitry in the Type RM529 furnishes a brightening pulse to the crt grid (ac-coupled). This feature makes it unnecessary for the operator to re-adjust the intensity control in line-selector operation. It also limits the normal intensity range, thus preventing accidental burning of the crt phosphor; particularly in the event of sweep circuit failure. The net result is waveforms—exceptionally bright and sharp—that are clearly viewed or photographed.

The Type RM529 has four vertical-amplifier-response positions: high pass, low pass, IEEE and flat.

The high-pass or chroma position is often used to remove low-frequency components from the staircase. With these removed, amplitude of the 3.58 MHz modulation is more easily measured and differential gain determined. Adequate reserve gain exists to expand the subcarrier signal for accurate measurements.

The low-pass position is used to attenuate the high-frequency bursts on the multiburst signal when making axis-shift measurements. It will limit the 0.5 MHz-modulation to approximately 20% of the original amplitude. Modulation is scarcely detectable on the 2-MHz portion of the burst and negligible at the higher frequencies. (This response position is also useful when it is necessary to observe a waveform in the presence of extreme amounts of white noise.)

The IEEE position is the standard response designated by the broadcast industry in Canada and the U.S.A. for making amplitude measurements. It removes the chrominance signal from video containing color information, and eliminates high frequency noise which is often present.

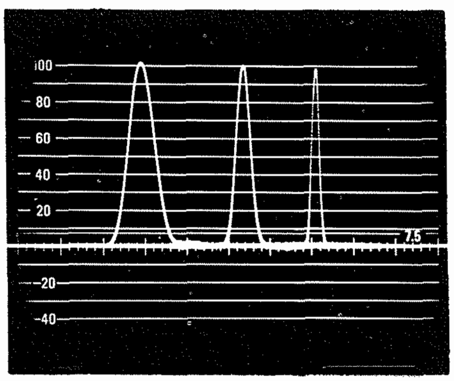


Figure 2. 2T Signal. Multiple exposure. Left: 2T. Center: T. Right: ½T Sine².

The flat response position is usually used when making measurements with multiburst and sine² pulses. It will not significantly attenuate a T pulse and it provides good reproduction of the 50 nsec ½ T pulse, see Figure 2. This position is also useful for making signal-to-noise-ratio measurements because it readily passes all white noise present in the system. A calibrated 14 db increase in sensitivity over the 1.0 v full-scale calibrated sensitivity is provided for such purposes.

DC RESTORATION

A dc restorer on-off switch is incorporated in the Type RM529 to facilitate its use as a modulation monitor. In normal use, the dc restorer serves the function of clamping the video signal to a reference level so that it will not change position with varying average voltage level (brightness). The dc restorer normally clamps to the back porch of the video signal. Black level is usually set to 7.5 IEEE units above the back porch, and the white level to 100 units. The bottom of the sync tip is normally set to —40 IEEE units. Studio signals are usually measured at the 1 v level and 1 v equals 140 IEEE units in normal signal.

When the dc restorer is turned off, the input capacitor of the Type RM529 may be shorted out. All following stages are dc-coupled, making it possible to use the Type RM529 in conjunction with a diode detector for % of modulation measurements. Signals which are not video, such as found in tape recorders, may also be measured. DC coupling is also useful for measuring hum and bounce in the video system. With the dc restorer disabled, and the input of the Type RM529 ac-coupled (normal), the low frequency 3-db down point is approximately 0.32 Hz.

Both the back porch (blanking level) and the sync tip represents stable reference levels in the video signal. Back-porch clamping has in the past been objectionable because it interfered with color burst. Design considerations in the Type RM529 make this objection invalid. Back-porch clamping has the advantage that there is a more direct relationship between the blanking level (back porch) and picture black level than there is to the sync tip level. (A simple modification of the Type RM529 circuitry will adapt the instrument for sync-tip clamping. This modification is described in the Type RM529 Instruction Manual.)

Change in blanking level due to the presence of color burst is well under 1%. No aberrations to the color burst are caused by the clamping circuit.

Service Scope

USEFUL INFORMATION FOR

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