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7L12 SPECTRUM ANALYZER

INSTRUCTION MANUAL

Tektronix, Inc.
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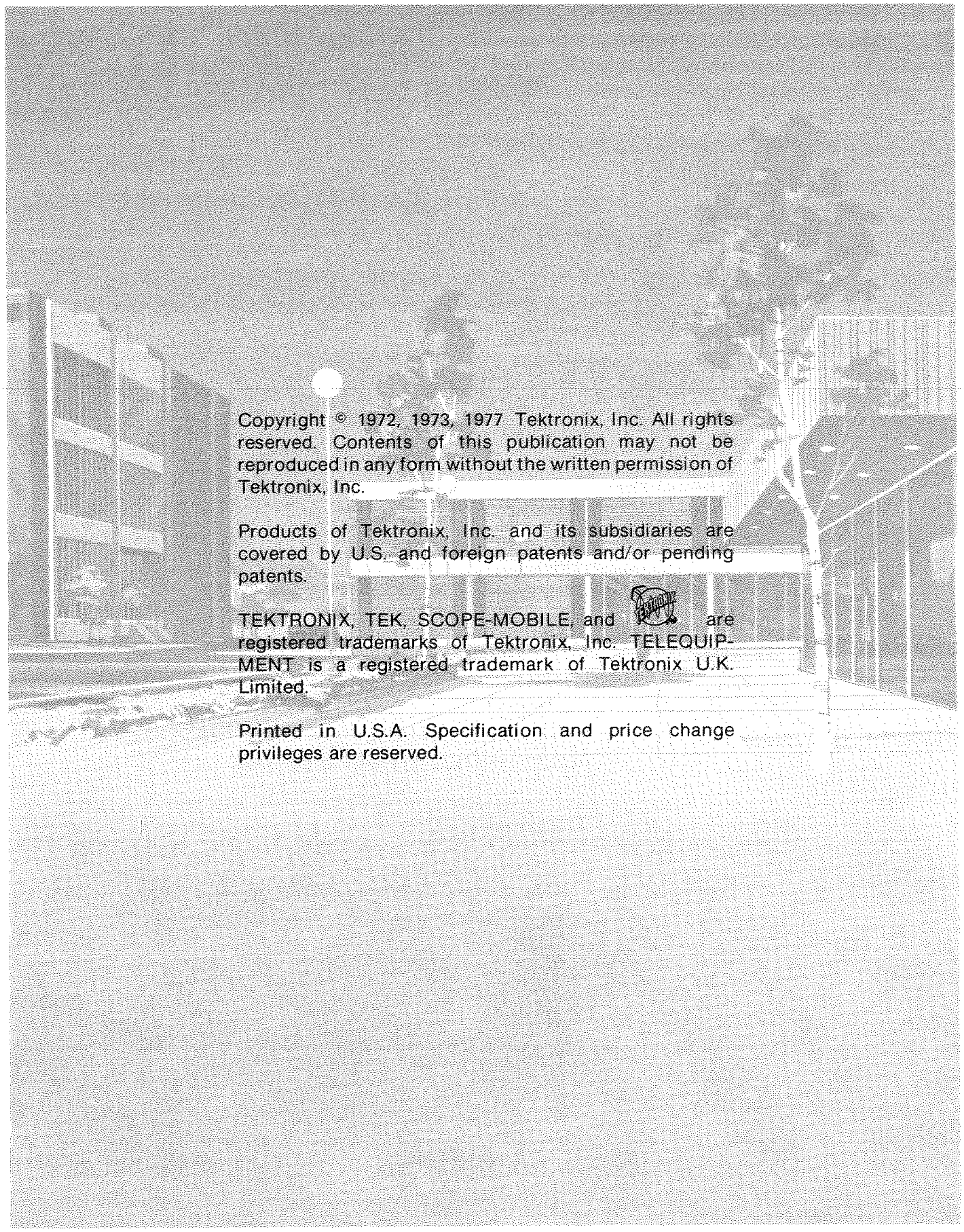

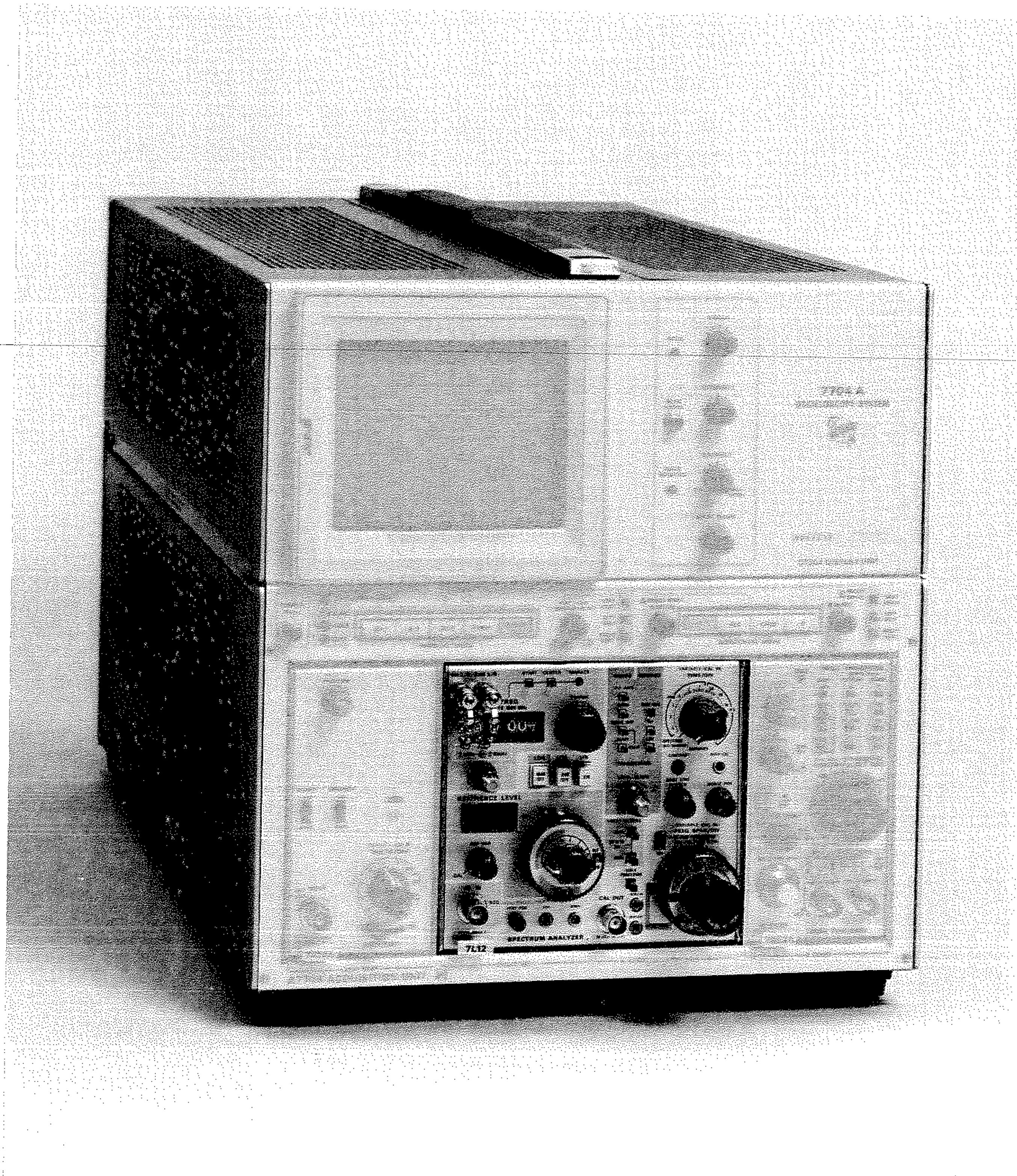

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Fig. 1-1. 7L12 Spectrum Analyzer

SPECIFICATIONS

Introduction

This manual contains information required to operate, test, calibrate, and service the 7L12 Spectrum Analyzer. The manual is divided into nine major sections;

Section 1, General Information and Specifications.

Section 2, Operation Instructions: Information relative to installing and operating the instrument.

Section 3, Performance Check: Provides a complete procedure to check operational performance for an incoming acceptance check, or any additional performance checks that require test equipment to verify instrument specifications.

Section 4, Calibration Procedure: Describes test equipment setup and adjustment procedures required to align the instruments internal adjustments.

Section 5, Circuit Description: Provides basic and general circuit analysis that may be useful when servicing or operating the instrument.

Section 6, Maintenance Instructions: Describes routine and corrective maintenance procedures with detailed instructions for replacing assemblies, sub-assemblies, and individual components. An exploded drawing is part of section 9. Troubleshooting procedures plus general information that may aid in servicing the instruments are also provided.

Section 7, Electrical Parts List: Provides information necessary to order replaceable parts and assemblies.

Section 8, Diagrams: Provides functional block diagram and detailed circuit schematics. Pictorial layout drawings, which show assembly, sub-assembly, and component locations are located adjacent to the diagram (usually on the back of the preceding diagram page). Waveforms and voltage data, for troubleshooting or circuit analysis, are also provided adjacent to or on the diagram.

Section 9, Mechanical Parts List, Exploded drawings and Accessories: Provides information necessary to order replaceable parts. Parts List is cross-referenced to the Electrical Parts List. Exploded drawing shows sequence of assembly and identified assemblies.

Manual Change Information: Provides history and updating information for the manual in the form of inserts. As the manual is updated these inserts are incorporated into the manual text and diagrams.

Description

The 7L12 Spectrum Analyzer is a dual-width plug-in unit, for the 7000-Series Oscilloscopes. When used with any of these oscilloscopes, it displays a spectrum of signal energy within any frequency span to 1.8 GHz. The unit contains horizontal sweep and timing circuits, for frequency and time domain displays, and also means by which an external sweep source can be applied to slave the 7L12 to external devices, such as a recorder.

SPECIFICATIONS
ELECTRICAL CHARACTERISTICS

The following characteristics and features except stability, are applicable after a warm-up period of 40 minutes or more.

Center Frequency Operating Range and Accuracy

From 0.1 MHz to 1.8 GHz. Readout accuracy is within ± (10 MHz + 1% of the dial readout).

Frequency Span

Calibrated steps, in 1-2-5 sequence, from 500 Hz/Div to 100 MHz/Div. Accuracy is within 5% of the span selected and linearity is within 5%, over the center 8 divisions of a 10 division display.

Two additional positions MAX SPAN and 0 provide approximately 1.8 GHz (180 MHz/Div) of span, or fixed frequency operation, for time domain display. Span is continuously variable between steps.

Display Flatness

±1.5 dB over any selected frequency span, with respect to the display level at 50 MHz.

Display Modes

LOG 10 dB/DIV: Provides a calibrated 70 dB dynamic range. Accuracy within 1 dB/10 dB to a maximum of 1.5 dB over the 70 dB dynamic range.

LOG 2 dB/DIV: Provides a calibrated 14 dB dynamic range. Accuracy within ±0.4 dB/2 dB to a maximum of 1.0 dB over the 14 dB range.

LIN: Provides a linear display within 10%, over the graticule height.

Reference Level

Calibrated levels in decade steps, from −100 dBm to +30 dBm, within ±2 dB. (Includes attenuator and gain switching effects when the two are not off-setting each other.) Reference level deviation between display modes is; less than 2 dB from 2 dB/DIV to 10 dB/DIV and less than 0.5 division from 2 dB/DIV to LIN. Note: This deviation is a function of the oscilloscope vertical linearity.

Calibrator

50 MHz ±0.01% with an absolute amplitude level of −30 dBm ±0.3 dB, at 25°C.

RF Attenuator

Calibrated 10 dB steps. Accuracy; ±0.2 dB or 1% of dB reading, whichever is greater.

Gain

Four selector positions, bordered by a blue sector, provide 30 dB of change, in 10 dB steps, for the 10 dB/DIV display mode. These four, plus four additional positions, provide 70 dB of gain change for the 2 dB/DIV and the LIN mode displays.

Accuracy is within ±1 dB/10 dB step to a total of ±1.5 dB when the VARIABLE control is in its CAL detent.

The VARIABLE control, with approximately 10 dB range, provides continuous gain adjustment between each calibrated step.

Resolution

Five resolution bandwidth selections from 300 Hz to 3 MHz, in decade steps, are provided. Bandwidth accuracy, at the 6 dB down level, is within 20% of the resolution selected. Shape factor over the 60 dB to 6 dB level is 4:1 or better (see Fig. 3-4) except 3 MHz. Resolution bandwidth at 60 dB down level is 13 MHz max. Signal level change over the five bandwidths is less than 0.5 dB.

Sensitivity For A CW Signal

Signal + noise = Twice noise in LIN vertical mode (see Fig. 3-2). The following sensitivity characteristics apply at 50 MHz. Sensitivity may decrease gradually to 2 dB at 1.7 GHz and to 4 dB at 1.8 GHz.

Signal Level	Resolution Bandwidth
−115 dBm	300 Hz
−108 dBm	3 kHz
−100 dBm	30 kHz
−90 dBm	.3 MHz
−80 dBm	3 MHz

Intermodulation Distortion (See Fig. 3-6)

Third order is down 70 dB or more from two −30 dBm signals within any frequency span. Second order is down 70 dB or more from two −40 dBm signals.

Spurious Signals From Internal Sources

(Residual Response)

Equal to or less than −100 dBm, referred to the 1st mixer input.

Incidental FM (See Fig. 3-5)

200 Hz (P-P) maximum, when phase locked, or 20 kHz (P-P) maximum in 5 seconds, when out of phase lock mode.

Stability (After a 2 hr warm-up period)

Within 50 kHz, over a 1 hour period at a fixed temperature, when phase locked. Within 100 kHz when not phase locked over a 1 hour period, at a fixed temperature.

Maximum Input Power Level

Linear Operation—RF attenuator at 0 dB; −30 dBm.

Safe Input levels—RF attenuator at 0 dB; +13 dBm. RF attenuator at 60 dB; +30 dBm (1 W average, 100 W peak). NOTE: These are input levels to the 1st mixer and the power rating of the attenuator.

Sweep Rate

Calibrated sweeps, from 10 ms/Div (SPECTRUM position) to 1 μs/Div (within 2%), are provided in 1-2-5 sequence. A VARIABLE control provides continuous variation between steps. When the TIME/DIV selector is in the SPECTRUM position, the range of the VARIABLE control is increased approximately 100X allowing the Time/Div to be increased to about 1 s/Div.

Triggering

Signal source is AC coupled from either the vertical amplifier channels or the power line. Frequency range is approximately 15 Hz to 1 MHz. Sensitivities for the triggered modes are: 1) ⩽0.5 division for the P-P AUTO mode 2) ⩽0.3 division for the NORM mode 3) ⩽1.5 division for the SINGLE SWEEP mode. Sweep automatically recurs at the end of sweep holdoff time in the FREE RUN mode.

Vertical Output Connector

Provides 50 mV ±5% video signal per displayed division, about the CRT vertical center. Source impedance is approximately 1 kΩ. A maximum of 50 mV offset may be introduced by error from the mainframe vertical centering interface.

Horizontal Input Connector

Requires a 10 V ±1 V signal, with a starting reference of 0 V ±1 V from a low impedance (300 Ω or less) source, to normalize the external sweep voltage to the 7L12 frequency span.

OPERATING INSTRUCTIONS

Introduction

This section describes: 1) Installation of the 7L12 into a 7000-Series Oscilloscope. 2) Function of the front panel controls, selectors, indicators and connectors. 3) General operation information, such as; adjustments required to mate the 7L12 to a 7000-Series Oscilloscope, signal application to the RF input, how to use the calibrator for accurate frequency and power level measurements, etc. 4) Some typical applications.

The first steps of the General Operating information calibrate and check the analyzer Frequency Span/Div and the display modes. These steps serve as part of an acceptance check and describe how to obtain a display on the oscilloscope CRT. The Performance Check section of this manual refers to these steps as part of an acceptance checkout procedure.

Performing this Operational Checkout procedure, is recommended to acquaint you with the functions of the controls and selectors and the overall operation of the 7L12.

CAUTION

A safety latch, in addition to the front panel release, must be released before the 7L12 can be pulled from the oscilloscope compartment. The unit will pull out part way when the front panel release is pulled, then the spring safety latch must be pushed up before the unit will pull the rest of the way out. This safety latch is located underneath the right rail near the front corner (see Fig. 2-1).

Do not ship the 7L12 by common carrier when it is installed in the mainframe, unless the 7L12 is bolted into the mainframe. A spectrum analyzer securing kit is available from Tektronix, Inc. for the following instruments: 7313/R, 7603/R, 7613/R, 7623/R, 7623A/R, and 7633/R. Order by Tektronix Part Number 016-0637-00.

FUNCTION OF THE FRONT PANEL CONTROLS AND ADJUSTMENTS

Triggering

SOURCE

Either the vertical channels or the power line may be selected as the trigger source, by the front panel push-buttons. It is AC coupled and has a frequency range from ⩽15 Hz to ⩾1 MHz. The INT push-button, selects the input signal to the 7L12 as the trigger source. The LINE push-button, selects a sample of the power line voltage as the trigger source. A third push-button causes the sweep circuit to free run.

MODE

P-P AUTO: Triggering occurs at the level and slope selected by the LEVEL and SLOPE controls. The peak to peak trigger signal amplitude required for INT triggering must equal or exceed 0.5 division. If trigger signal is absent, or beyond the amplitude and frequency limits specified, the sweep will free run (after hold-off time) at the rate selected by the TIME/DIV selector. The LEVEL control range adapts to changes in the triggering signal amplitude so its range corresponds to the peak to peak signal amplitude.

NORM: Triggering occurs at the level and slope selected by the SLOPE and LEVEL controls. The minimum signal amplitude for triggering must equal or exceed 0.3 division on the display. The LEVEL control selects the signal amplitude level. Triggering does not occur, when the setting of the LEVEL control is beyond the signal amplitude level.

SINGLE SWP: After the READY indicator is lighted, triggering will occur when the signal approaches 1.5 divisions of amplitude. Sweep is initiated as the signal amplitude and slope pass through that selected by the SLOPE and LEVEL controls. The circuit must be reset by pushing the RESET button before another sweep can be triggered.

RESET-READY: A pushbutton that resets the triggering circuit for single sweep operation. RESET-READY button lights when pushed, to indicate that the circuit is ready to be triggered.

LEVEL

A control that selects the amplitude at which triggering occurs for the various triggering modes.

SLOPE

A switch that selects the (+) positive or (—) negative slope of the signal for triggering direction.

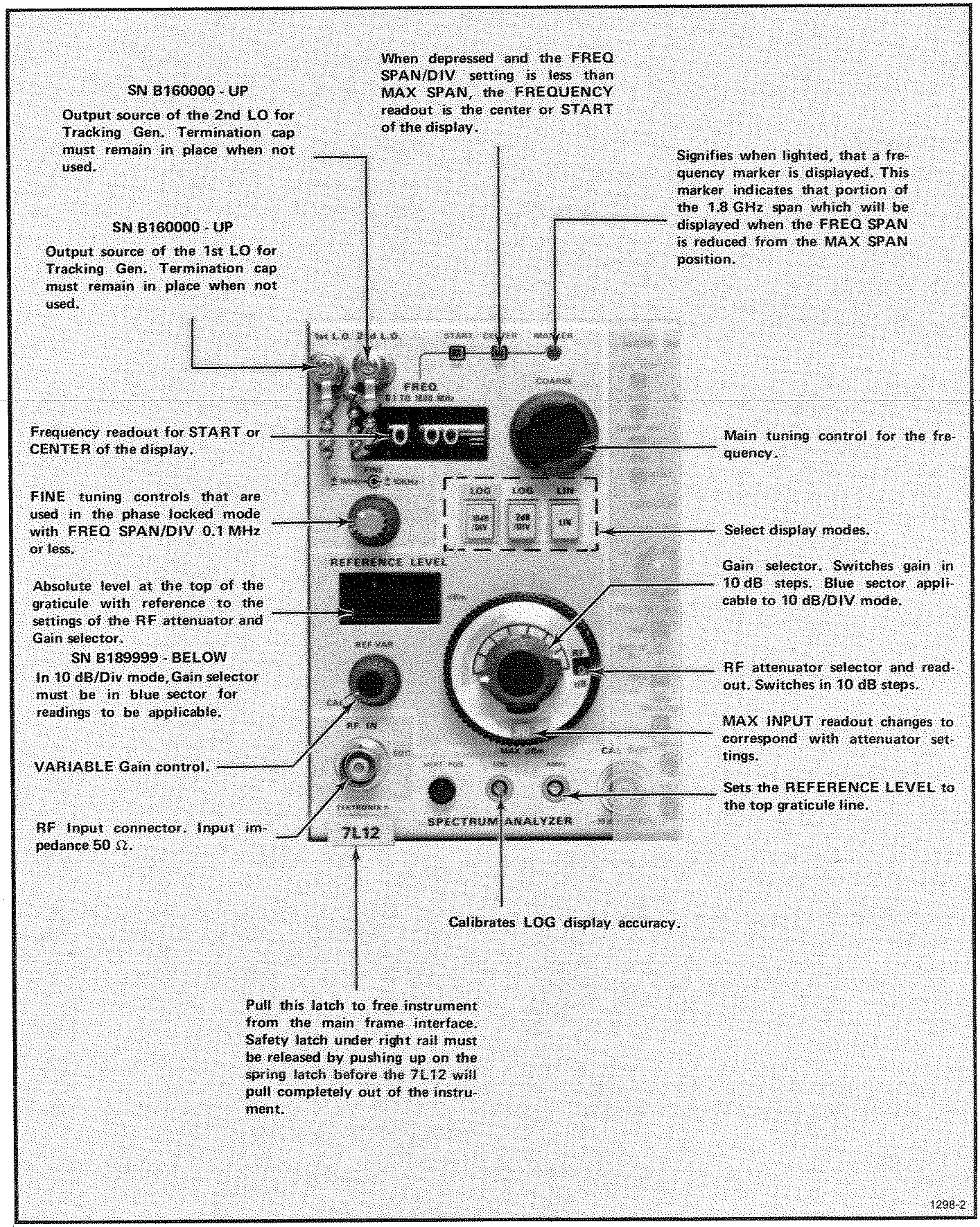


Fig. 2-1A. Controls, selectors and indicators that relate to the display, frequency, dynamic range, and reference levels.

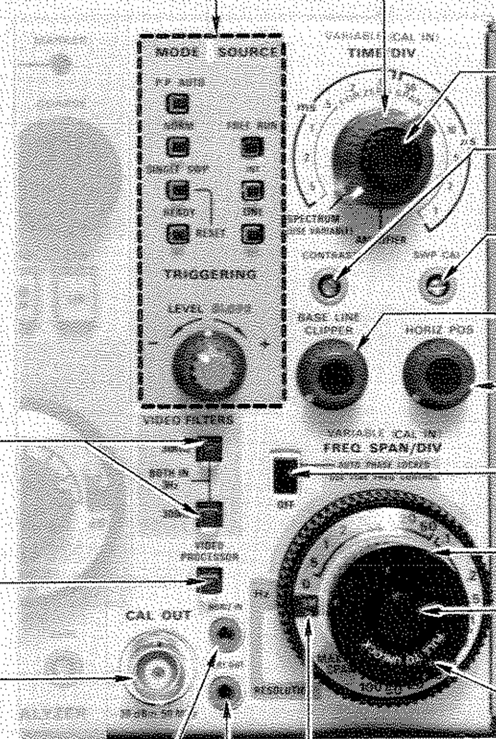


Fig. 2-1B. Controls and selectors that relate to the display; sweep, frequency span, resolution, video processing and phase lock.

Horizontal Sweep

TIME/DIV

Selects calibrated sweep rates (VARIABLE control pushed in) from 10 ms/Div. (SPECTRUM position) to 1 μs/Div, in a 1-2-5 sequence. An AMPLIFIER position allows the analyzer to be swept from an external source.

The SPECTRUM position provides a calibrated 10 ms/Div sweep rate and increases the range of the VARIABLE control to 100X, which allows the Time/Div to be increased to approximately 1 s/Div for spectrum analysis.

The AMPLIFIER position is used to sweep the unit from an external sweep source which can be applied through one of the Vertical Amplifier units or through the HORIZ IN connector on the 7L12. External sweep may be used to slave the spectrum analyzer to a recorder or other external device.

VARIABLE

Provides continuous adjustment over the TIME/DIV range. The VARIABLE control range is increased from 3X to 100X in the SPECTRUM position.

SWEEP CAL

Calibrates the amplitude of the sweep voltage to the FREQ SPAN/DIV circuits and compensates for differences in deflection sensitivities between oscilloscopes.

HORIZ POS

Adjusts the horizontal centering of the display.

HORIZ IN Jack

Used to apply the horizontal (sweep) drive directly, from a chart recorder or other device, to the 7L12 horizontal circuits when the TIME/DIV selector is switched to the AMPLIFIER position. Requires a sweep voltage of 0 V to 10 V ±1 V, from a low impedance source. The ±1.0 V tolerance, at the upper end, is used to calibrate the external voltage ramp, making the frequency span of the 7L12 accurate.

VERTICAL Control and Output Connector

VERT POS

Positions the CRT beam vertically.

VERT OUT Connector

Provides ±50 mV of video signal per displayed division. The amplitude and polarity of this signal is relative to the graticule vertical centerline. Source impedance is about 1 kΩ. The signal can be used to drive an external recorder.

Display Controls and Selectors

BASELINE CLIPPER

Controls the vertical amplitude of that portion (baseline plus signal) of the display that is decreased or subdued in intensity.

CONTRAST

Adjusts the brightness ratio between the clipped (subdued) baseline and the unclipped display. Display intensity is set by the oscilloscope Intensity control.

VIDEO FILTERS

Three filters (30 kHz, 300 Hz and 3 Hz) can be switched in to restrict the video bandwidth and reduce high frequency components. Two push-buttons select 30 kHz or 300 Hz when depressed individually and 3 Hz is selected when both buttons are pushed in.

VIDEO PROCESSOR

Enhances the visibility of pulsed RF signals within wide frequency spans and resolution bandwidths by stretching the fall time of pulsed signals.

FREQ SPAN/DIV

Selects the frequency span (0.5 kHz/Div to 100 MHz/Div in a 1-2-5 sequence) for the display. The VARIABLE control must be pushed in for a calibrated display. Two additional positions, MAX SPAN and 0 are also provided. The MAX SPAN position, increases the frequency span to approximately 1.8 GHz. A frequency marker notch is also displayed to indicate what portion of the spectrum will be displayed when the FREQ SPAN/DIV is reduced. The 0 position converts the analyzer to a tuned receiver, for time domain display. Time analysis of signal characteristics, within the bandwidth capabilities selected by the RESOLUTION setting, can then be analysed.

CAUTION

The FREQ SPAN knob provides ease in switching; however, if excess torque is applied after the switch is in either its full CW or CCW position, the aluminum bushing inside the knob may slip. This will misalign the coupling between the RESOLUTION and FREQ

SPAN selectors. If the coupling is misaligned, the selectors will double detent or switch with a grinding noise. Refer to Knob Removal and Installation instructions in the Maintenance section of the manual for realignment.

VARIABLE (FREQ SPAN/DIV)

Push-push type switch and control. When it is out of its CAL detent, the control provides variable frequency span between each step of the FREQ SPAN/DIV selector. The control must be in the CAL detent for calibrated FREQ SPAN displays.

RESOLUTION

Selects five calibrated resolution bandwidths, from 300 Hz to 3 MHz (within 20%), in decade steps. Shape factor of the response, over the 60 dB to 6 dB amplitude levels, is 4:1 or better.

PULL TO UNLOCK

A concentric sleeve around the VARIABLE control that unlocks the RESOLUTION from the FREQ SPAN/DIV selector, and allows each selector to be independently set.

LOG 10 dB/DIV

Selects a display mode with a calibrated dynamic range of 70 dB (to the 7th graticule line from the top) at 10 dB/DIV. The bottom graticule division is not calibrated.

LOG 2 dB/DIV

When this button is depressed, the dynamic range of the display is a calibrated 14 dB at 2 dB/DIV.

LIN

Selects a linear display, that corresponds to the linear calibration on the left side of the graticule overlay.

REFERENCE LEVEL, RF Attenuation, and MAXimum Power Level Indicators and Selectors

Concentric controls that are connected in an electro-mechanical differential arrangement which select input attenuation and instrument gain.

The Input attenuation (from 0 dB to 60 dB) and Gain (0 dB to 70 dB) are selected in 10 dB steps. An electro-mechanical arrangement and readout windows establish and indicate to the user, MAXimum power input level (in dBm), RF attenuation (in dB), and the REFERENCE LEVEL (in dBm) of the top graticule line. REFERENCE LEVEL is also displayed on CRT's of oscilloscopes with readout feature.

SN B190000 up:

When the gain selector is rotated beyond the blue tint sector, REFERENCE LEVEL readings do not change because the gain is electrically locked out.

In the 2 dB/DIV mode, the full 70 dB range of the gain selector is usable. With the RF Attenuator at 0 dB, switching the gain produces up to an accurate −100 dBm reference level. The dynamic range of the display is now −114 dBm (−100 dBm plus 14 dB display window to the seventh graticule line).

SN B189999 & below:

A blue tint borders the 10 dB/DIV display switch, and four positions of the Gain selector. This is to correlate REFERENCE LEVEL readout to Gain switch settings that are applicable in the 10 dB/DIV display mode. Readings outside the blue sector are erroneous because the gain is electrically locked out. The CRT readout will display the < symbol to signify the readings are erroneous. The dynamic window of the display will not exceed −130 dBm (REFERENCE LEVEL of 60 dBm plus 70 dB dynamic range of the 10 dB/DIV display). In the 2 dB/DIV display mode, the full 70 dB range of the Gain selector is usable. Switching the Gain fully CW with the RF attenuator at 0 dB, produces an accurate −100 dBm reference level. The dynamic range of the display is now −114 dBm (−100 dBm plus 14 dB graticule window, to the 7th graticule line).

VARIABLE (Gain) Control

Provides at least 10 dB of gain variation. The REFERENCE LEVEL readout on the CRT changes to the < symbol to indicate an uncalibrated condition when it is out of its CAL detent. The readout of the REFERENCE LEVEL window on the 7L12 is only applicable when this control is in its CAL detent.

FREQUENCY MHz

Dial reads out the START-CENTER or MARKER frequency of the display. Frequency and dial readout are tuned by the COARSE control.

Depressing the START push-button, selects the start of the display or left (zero) graticule line as the frequency that is indicated by the dial readout. Depressing the CENTER push-button selects the center of the display as the frequency indicated in the readout window. When the FREQ SPAN/DIV is switched to MAX SPAN position, the MARKER indicator is lighted and a notch on the baseline of the display indicates the center of that portion of the span that will be displayed when the FREQ SPAN is reduced.

FINE Frequency Controls

Two concentric controls that provide fine tuning adjustment during phase lock operation or at spans which are 0.1 MHz/Div or less.

LOG and AMP CAL Adjustments

The LOG adjustment calibrates the logarithmic display accuracy and the AMP adjustment sets the REFERENCE LEVEL to the top graticule line.

AUTO PHASE LOCK Switch

Used, in the phase locked modes, to disable the phase lock. The COARSE tuning control will then tune the center frequency without the 1st LO jumping between lock points. This provides a wider tuning range than that of the FINE controls.

CAL OUT Connector

Provides an accurate −30 dBm, 50 MHz signal. This signal provides an absolute reference on the display to check dBm readings and calibrate the REFERENCE LEVEL. Harmonics of the 50 MHz fundamental provide picket fence markers across the frequency span for accurate frequency and span measurements.

RF INput Connector

A 50 Ω input connector for applying the input RF signal to the 7L12. REFERENCE LEVEL indicator refers to the RF level at the RF INput. Refer to General Operating Information in regards to signal applications.

GENERAL OPERATING INFORMATION

This section describes how to mate the 7L12 to a 7000-Series Oscilloscope and how to use the main features of the instrument in making various measurements.

NOTE

External graticules are designed so they will compensate for parallax of the camera. Graticule markings will therefore be correct on photographed displays. Instructions on how to install graticule overlays, will be found in the mainframe manual under the subtitle light filters.

1. Preliminary Front Panel Setup and Calibration Procedure to Match the 7L12 to the Oscilloscope Deflection Sensitivity

a. Plug the 7L12 Spectrum Analyzer into the center two compartments, of a four plug-in 7000-Series Oscilloscope, or into the right two compartments, of a three plug-in 7000-Series Oscilloscope. Ensure that the 7L12 is securely latched in the compartment so it cannot fall out if the oscilloscope is tipped forward.

b. Connect the oscilloscope mainframe to a suitable power source and switch the POWER on. Allow about 20 to 30 minutes for instrument stabilization.

c. Set the front panel controls as illustrated in Fig. 2-2 and connect the CAL OUT signal through a short coaxial cable to the RF INput.

d. Adjust the oscilloscope Intensity, Focus and Astigmatism controls for optimum display definition with normal intensity.

e. Depress the 2 dB/DIV display mode button. Position the baseline of the display to the bottom graticule line with the VERT POSition control and center the display with the HORIZ POSition control.

f. Depress the 10 dB/DIV (LOG) display button. Display should now resemble that shown in Fig. 2-2.

NOTE

When the oscilloscope has a CRT with P7 phosphor, a viewing hood will help shield ambient light and enhance the display information.

2. Calibrate the Sweep Span

a. Switch the FREQ SPAN/DIV to MAX SPAN position, ensure that the VARIABLE (Freq Span) control is pushed in.

b. Position the 0 Hz response on the zero (left) graticule line with the HORIZ POS control.

c. Connect the CAL OUT signal to the RF INput, decrease the FREQ SPAN/DIV to 50 MHz and tune the 5th marker (250 MHz) to the center graticule line (see Fig. 2-3).

d. Calibrate the frequency span to 50 MHz/Div by adjusting the SWP CAL for 1 marker/division. It will be necessary to keep the 250 MHz marker centered with the COARSE FREQUENCY control as the sweep is calibrated. Final display should resemble that illustrated in Fig. 2-3.

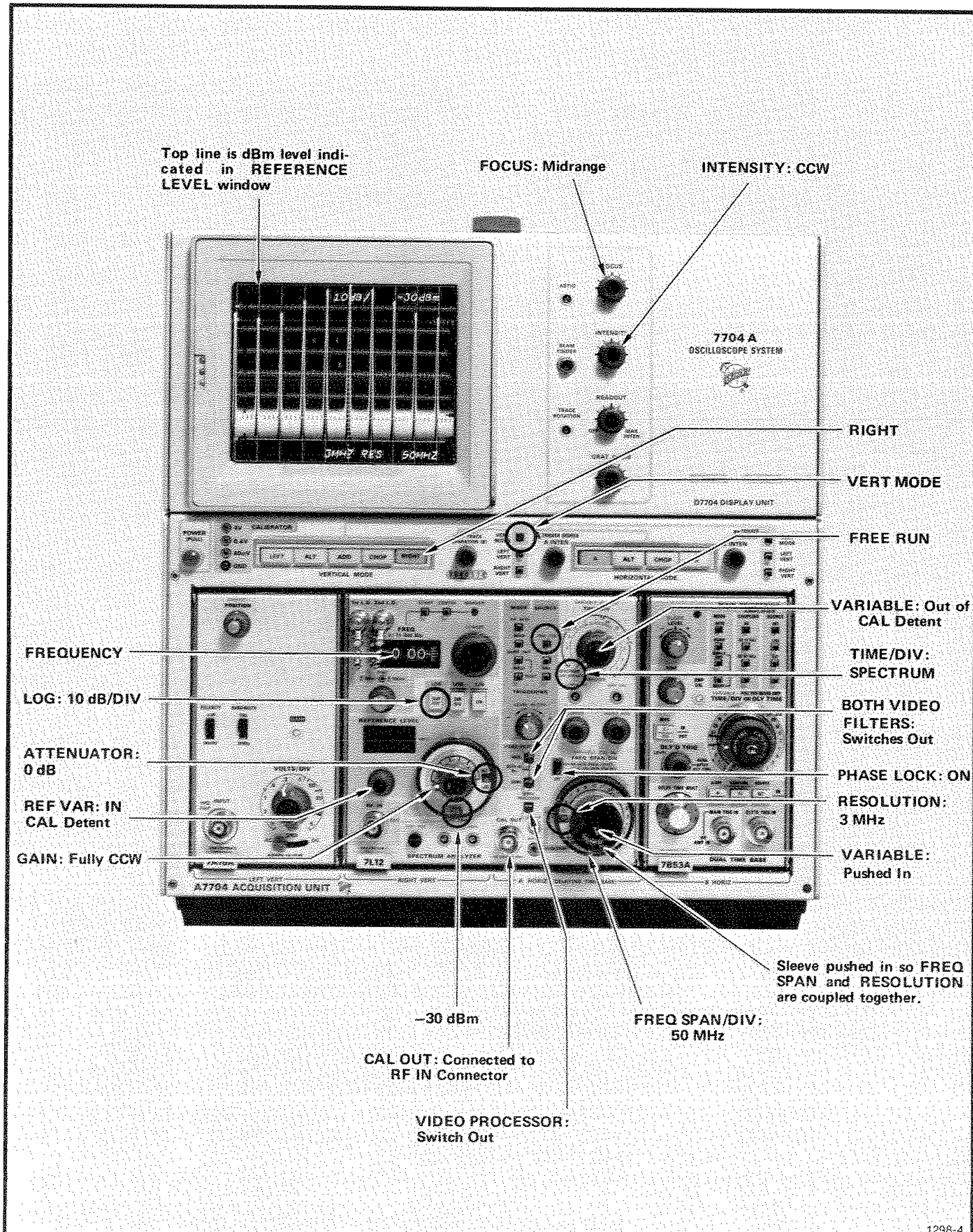


Fig. 2-2. 7L12 Spectrum Analyzer in a 7000-Series Oscilloscope illustrating initial settings of front panel controls and selectors. Circled (O) push-buttons denote button depressed or position of selector.

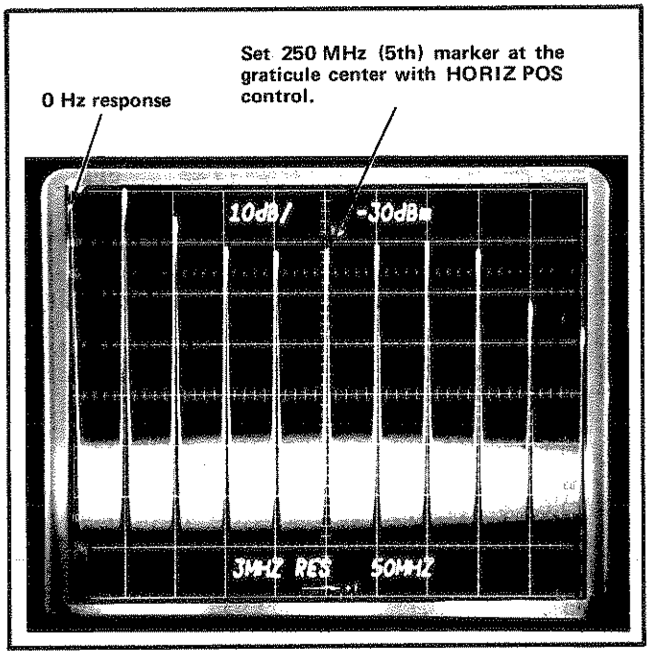


Fig. 2-3. Calibrating the sweep span.

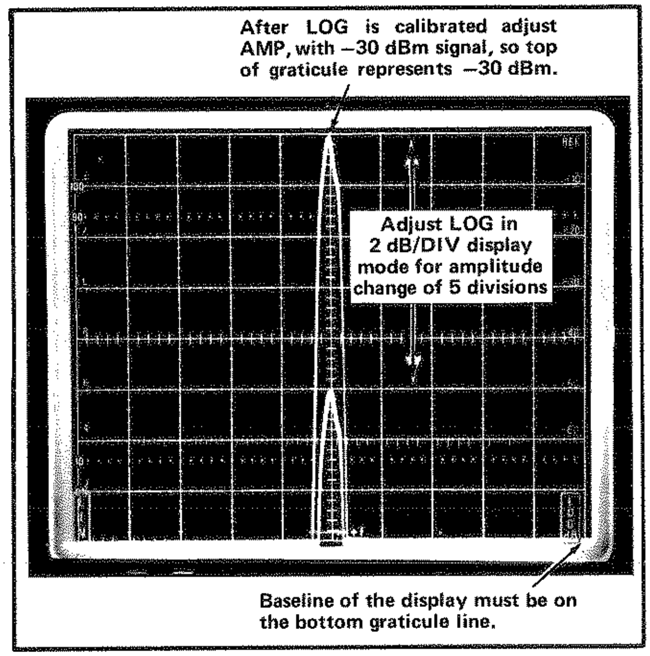


Fig. 2-4. Calibrating the LOG and REFERENCE LEVEL of the display (Double exposure to illustrate the two displays with reference to each other).

3. Check and Adjust LOG-AMP Calibration

The LOG CAL adjustment calibrates the display so it is logarithmic. The AMP CAL adjustment sets the reference level to the top graticule line. There is no interaction between these two adjustments.

a. Set the 7L12 selectors and controls as directed in step 2 and tune the fundamental 50 MHz calibrator signal to the center of the graticule.

b. Uncouple the RESOLUTION selector from the FREQ SPAN/DIV, by pulling out the PULL TO UNLOCK sleeve, then switch the FREQ SPAN/DIV to 5 MHz. The RESOLUTION should remain at 3 MHz. As the FREQ SPAN is decreased, it may be necessary to re-adjust the tuning control to keep the signal centered on screen.

c. Switch the Display Mode to 2 dB/DIV and position the baseline of the display on the bottom graticule line with the VERT POS control.

d. Adjust the AMP CAL and the LOG CAL (if necessary) to bring the 50 MHz signal within the graticule window. Adjust the AMP CAL to establish a signal reference amplitude of 8 divisions (Fig. 2-4 shows a full screen display).

e. Switch in 10 dB of attenuation with the RF Attenuator and note the amplitude change of the signal in graticule divisions. Amplitude change should equal 5 divisions at 2 dB/DIV.

f. If the change is more than 5 divisions (e.g., amplitude decreases from 8 to 2.5 div.), adjust LOG CAL to further decrease the signal amplitude or increase the amplitude change. Conversely if the change is less than 5 divisions (e.g., amplitude changes from 8 to 3.5 div.), adjust the LOG CAL to increase the signal amplitude. NOTE: Correct for approximately 1/2 the total indicated error. This adjustment may seem opposite to what is expected; however, the LOG CAL adjustment shifts the reference level making the net result a correction to the amplitude change.

g. Switch out the 10 dB of RF Attenuation. Adjust the AMP CAL to return the signal level to the reference line. (Ensure that the baseline of the display is still on the bottom graticule line.)

h. Repeat these steps until the 2 dB/DIV LOG display is calibrated (see Fig. 2-4). Return the RF Attenuator to 0 dB (REFERENCE LEVEL −30 dBm), then adjust AMP CAL to position the top of the −30 dBm signal on the reference line. Ensure that the −30 dBm signal is 8 divisions in amplitude.

i. Change the display modes from 2 dB/DIV to 10 dB/DIV, then to LIN. Signal amplitude reference level should not change more than 2 dB from 2 dB/DIV to 10 dB/DIV, or 0.5 division from 2 dB/DIV to LIN mode.

4. Check the 10 dB/DIV and LIN Mode Display Operation

a. After completing the LOG CAL and AMP CAL adjustments, described in step 3, depress the 10 dB/DIV button, ensure that the RF attenuator is at 0 dB and the Gain selector is fully CCW so the REFERENCE LEVEL reads −30 dBm.

b. Switch the FREQ SPAN/DIV to 1 MHz and the RESOLUTION to .3 MHz. Center the 50 MHz marker to the graticule center.

c. Increase the RF attenuator setting in 10 dB steps and note that the signal amplitude decreases 1 division each step.

d. Switch the RF attenuator back to 10 dB, and depress the LIN display mode button.

e. Ensure that the baseline of the display is at the bottom graticule line, and the 50 MHz signal is centered then adjust the VARIABLE Gain control for a signal amplitude of 6.3 divisions.

f. Switch the RF attenuator to 20 dB to add 10 dB of attenuation, and note that the signal amplitude decreases to approximately 2 divisions for a ratio change of 3.16 (this is equivalent to 10 dB in LIN mode).

g. Return the RF attenuator to 0 dB, the VARIABLE Gain control to CAL. The signal amplitude should return to full screen and the REFERENCE LEVEL should indicate −30 dBm.

5. Adjust Contrast and Check Baseline Clipper Operation

The contrast ratio that is set between the clipped portion of the display baseline and the rest of the display depends on sweep rate, FREQ SPAN, RESOLUTION, and ambient light.

a. With the BASELINE CLIPPER set midrange, adjust the CONTRAST for the desired ratio between the clipped or subdued portion and the rest of the display. (Usually the contrast is adjusted so the clipped baseline portion is just visible.)

b. Adjust the BASELINE CLIPPER control so the baseline is subdued. If there is excessive noise it may be desirable to clip this noise level as well.

USING THE ANALYZER

1. Signal Application

The RF INput impedance to the 7L12 is 50 Ω. At high frequencies, impedance mismatches between the RF INput and the signal source can cause reflections in the transmission line which degrades instrument performance. Flat-

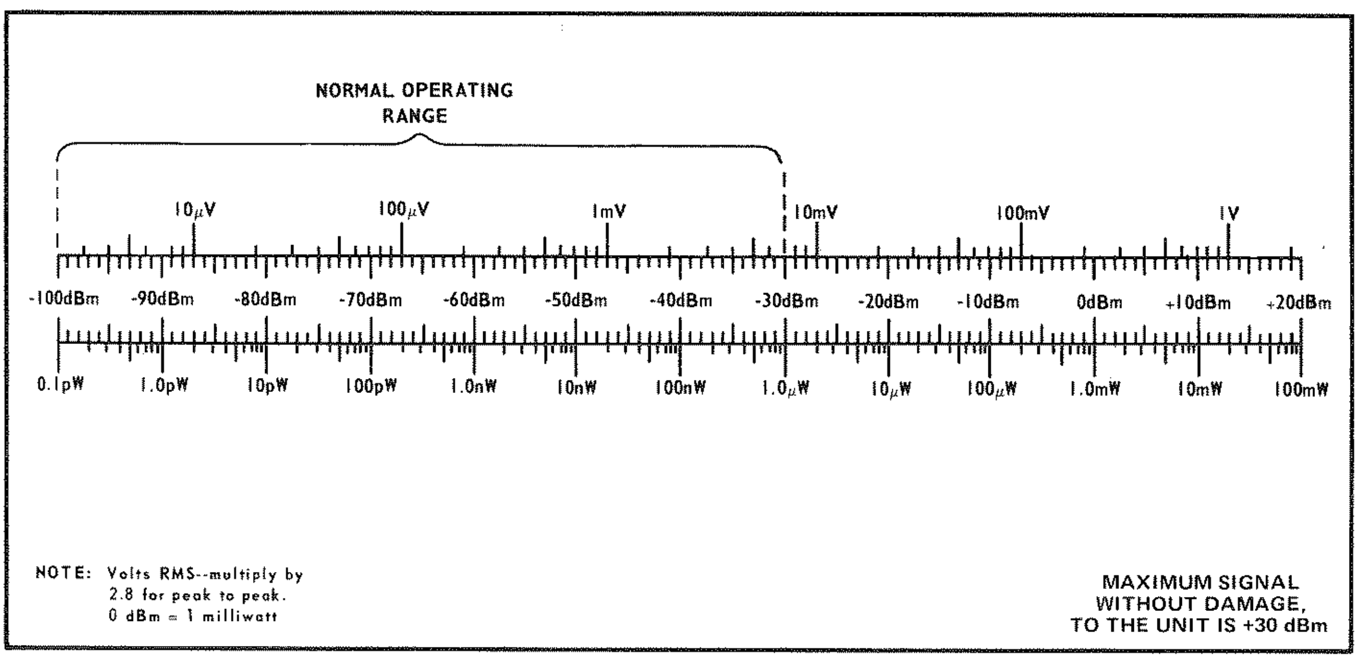


Fig. 2-5. Volts-dBm-Watts conversion chart for 50 Ω impedance.

ness, sensitivity, spurious response, etc. are all affected. To reduce mismatch, use good quality 50 Ω coaxial cable to connect the signal source to the RF INput and keep the cable as short as possible. Cable losses become excessive above frequencies of 1 GHz.

Avoid applying high level signals (above −30 dBm) to the 1st mixer of the 7L12. High level signals overload the mixer and may produce spurious signals. A conversion chart is shown in Fig. 2-5 to aid in determining input signal level, in dBm, μ V, and μ W, from a voltage or power source.

CAUTION

The maximum power input level to the RF attenuator is 1 watt average or 100 watts peak. When the RF input signals are riding on a DC potential, use the DC Block (Part No. 015-0221-00), to prevent the DC from reaching the 1st mixer. When the signal source is 75 Ω and you are using the 75 Ω to 50 Ω minimum loss attenuator, a DC block is not required because one is incorporated in the attenuator.

The 7L12 can be used with a 75 Ω signal source by using a 75 Ω to 50 Ω minimum loss attenuator. This attenuator is available as an optional accessory (refer to the optional accessories list in the catalog or Accessory page in the manual for ordering information). Sensitivity and power levels are often rated in dBm (dB with reference to 1 mW regardless of impedance). Sensitivity and power levels for 75 Ω systems is usually rated in dBmV (dB with reference to 1 mV across 75 Ω). Fig. 2-6 is a circuit diagram of a suitable matching pad for this purpose. The conversion from dBmV to dBm and dBm (75 Ω) to dBm (50 Ω) through matching attenuators is shown in Fig. 2-7 and described as follows:

(dBmV, into 75 Ω) − (dBm, at 50 Ω end) = 54.46 dB

[1] Therefore dBmV = 54.5 + dBm; e.g., −30 dBm (at the 50 Ω input) requires (−30) + (+54.5) or +24.5 dBmV at the 75 Ω input.

[2] dBm (75 Ω input) = dBm +5.72 (50 Ω output); e.g., a −30 dBm input to the RF INput of the 7L12 requires, (−30) + (+5.7) or −24.3 dBm at the 75 Ω input of the pad.

[3] For some applications you may wish to know the relationship between dBm and dBμV. For 50 Ω this is dBμV = (dBm) + 107 dB.

These three relationships are shown in Fig. 2-7 for easy graphical conversion.

Spurious response, caused by signal overload into the 1st mixer, can be minimized if the signal amplitude is kept within the graticule limits. A recommended procedure is to adjust the Gain selector for some baseline noise on the display, then increase the RF Attenuator dB setting until the strongest signals are within the graticule limits. If this does not bring these signals within limits, add additional external attenuators.

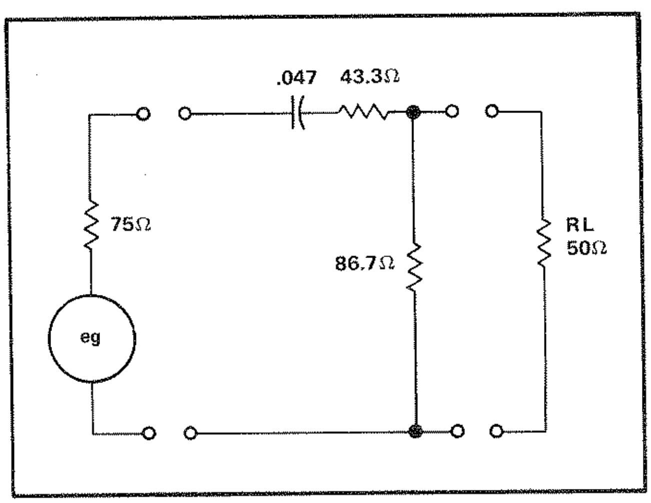


Fig. 2-6. Circuit of a 75 Ω to 50 Ω matching pad (AC coupled).

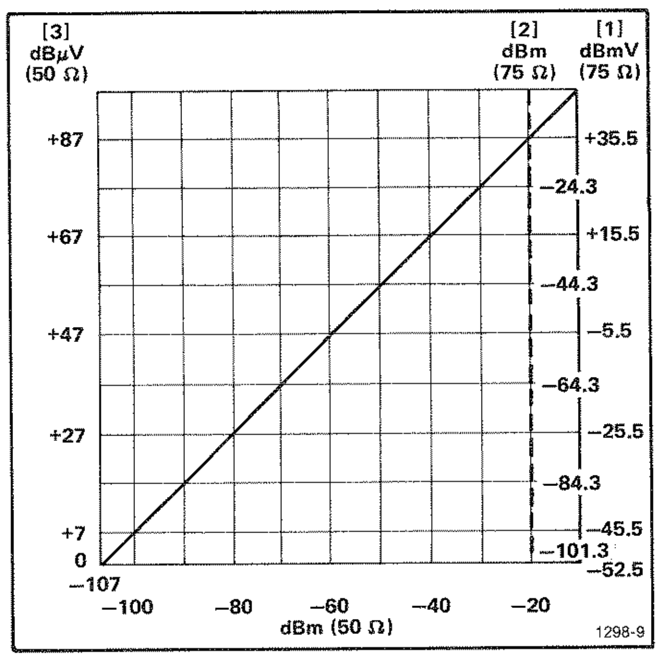


Fig. 2-7. Graph illustrating dBm to dBμV relationship.

2. Resolution, Sensitivity, and Frequency Span

Resolution is the ability of a spectrum analyzer to discretely display adjacent signals within a frequency span. This resolution ability is a function of analyzer bandwidth, sweep speed, frequency span, and incidental FM. The frequency span and sweep time are adjusted for minimum bandwidth to a CW signal. Theoretically, resolution and resolution bandwidth become synonymous at very long sweep times.

Resolution bandwidth is measured and specified for the 7L12, as the bandwidth (separation) at the 6 dB down point on the signal.

As the analyzer sweep speed is increased, the signal amplitude will decrease and bandwidth will increase, signifying that both sensitivity and resolution have been degraded.

The best resolution for a given frequency span and sweep time is expressed as:

$$\sqrt{\frac{\text{Frequency Span (in kHz)}}{\text{Sweep Time (in ms)}}}$$

Bandwidth determines both noise level and resolution capability of the analyzer. As the bandwidth decreases, the signal-to-noise level increases and results in improved sensitivity. Maximum sensitivity therefore, is obtained at the higher resolution settings.

The resolution of the 7L12 Spectrum Analyzer is optimized for most settings of the FREQ SPAN/DIV selector when the RESOLUTION control is in the coupled position. Resolution, however, can be selected independent of the FREQ SPAN by pulling the "PULL TO UNCOUPLE" sleeve around the VARIABLE FREQ SPAN control.

To adequately resolve pulsed spectrum information, the resolution bandwidth of the analyzer should be on the order of 1/10 the side lobe frequency width or the reciprocal of the pulse width. The RESOLUTION selector is usually set, after the sweep rate has been adjusted, for optimum main lobe detail.

3. Gain Desensitization Near 0 Hz

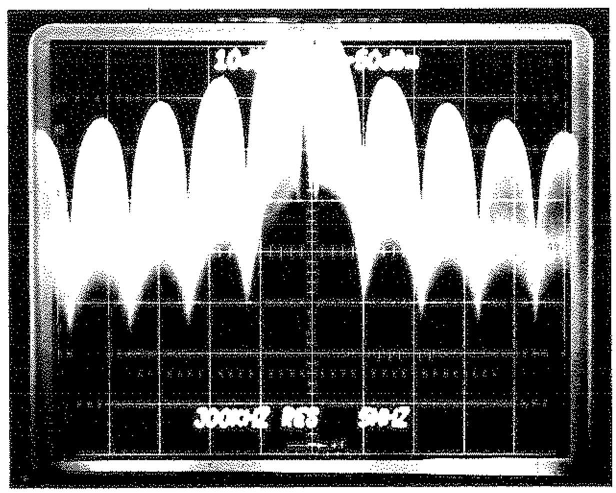
If the Gain selector is set for a REFERENCE LEVEL that is −50 dBm or more (e.g., −60 dBm) with the RF attenuator at 0 dB, a decrease in sensitivity will be noticed below 2 MHz. This effect is caused by the 0 Hz response overdriving the 1st IF amplifier. If you are operating between 0 Hz and 2 MHz do not set the Gain selector in this region.

4. Using the Video Filter

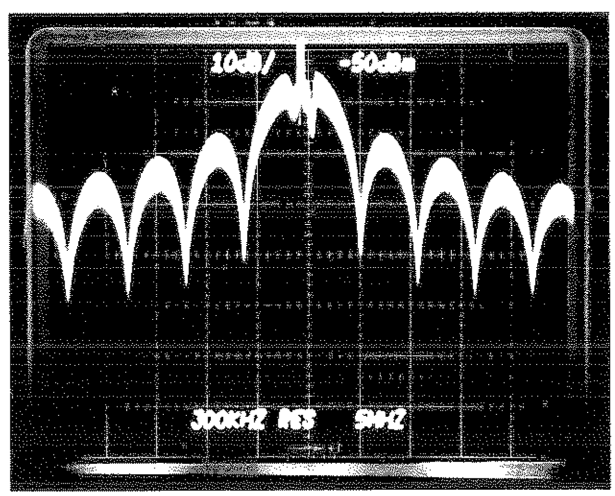
The video filter is used to reduce noise and high frequency components on the display, and when signals are closely spaced the filter will reduce modulation between the two signals. It can also be used to display the envelope of pulsed RF spectra that has a relatively high PRF; however, because the filter is basically an integrating circuit, low PRF signals produce poor results. Fig. 2-8 and Fig. 2-9 illustrate two ways that the VIDEO FILTER can be used.

5. Selecting Sweep Rate

The sweep rate for wide resolution bandwidths is usually set above the visual flicker setting. As the FREQ SPAN is changed it will affect resolution and sensitivity; therefore, as the frequency span is increased, sweep speed should be

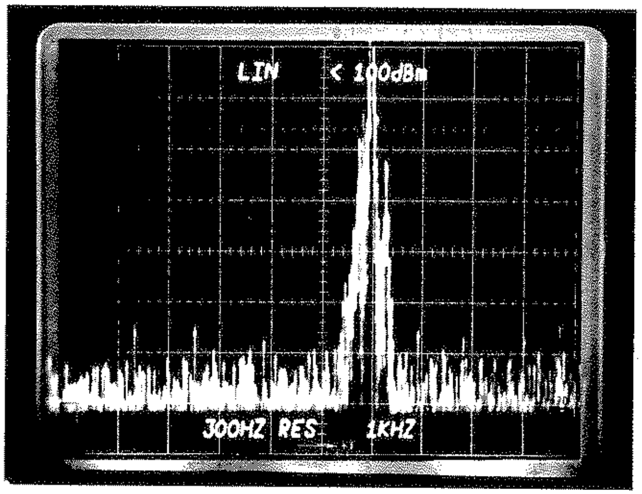


(A) Pulse modulated display without filtering LOG mode.

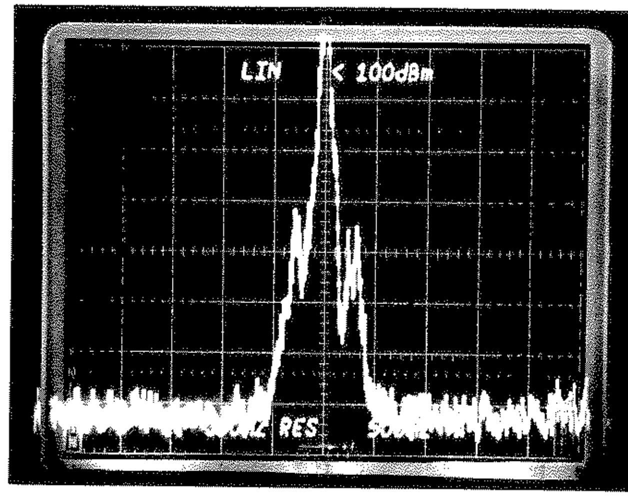


(B) Display with VIDEO FILTER switch on.

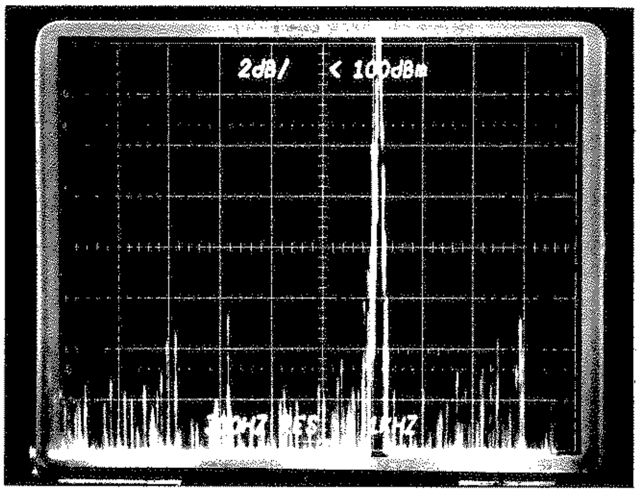
Fig. 2-8. Integrating the display with the VIDEO FILTER.



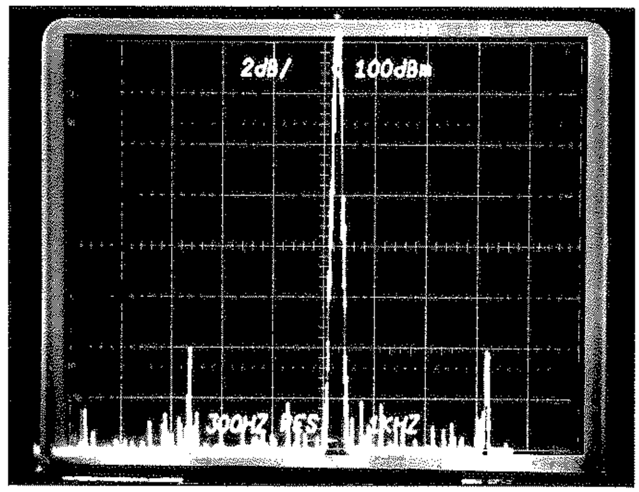
(A) Signal modulated by 200 Hz signal VIDEO FILTER OFF. LIN mode



(B) Same signal as A, VIDEO FILTER ON



(C) Amplitude modulated signal, 2 kHz sidebands.



(D) Same signal as C with VIDEO FILTER ON.

Fig. 2-9. Using the VIDEO FILTER and sweep speed to improve resolution capabilities of the analyzer.

decreased. When the FREQ SPAN is reduced to 0, the analyzer functions as a fixed tuned receiver so the analyzer displays time domain characteristics of the signal within the bandwidth capabilities of the analyzer. Sweep Time/Div can now be used to examine or analyze such characteristics as modulation pattern, pulsed repetition rates, etc.

6. Triggering the Display

The sweep trigger source is usually switched to the FREE RUN mode for spectrum displays; however, it may be desirable or necessary to trigger the display when the event is time related to some source, such as power line frequency; or, when the frequency span has been reduced to zero in order that a time domain analysis can be performed.

The sweep can be triggered, from an internal video signal on the display, or by the power line voltage. Trigger slope for any mode can be + or −, and the triggering level is adjustable over the amplitude range of the triggering signal.

These three triggering modes are provided:

P-P AUTO—which triggers the display through the peak to peak amplitude range of the signal. If the triggering signal is absent, the sweep is automatically recycled to provide a display baseline at all times.

NORM—requires a signal to trigger the display.

SINGLE SWEEP—cycles once after the trigger circuit has been RESET and a triggering signal applied.

The amplitude of triggering signal that is required to trigger the sweep, depends on the mode that is selected. Approximately 0.5 division of signal is required in the P-P AUTO mode, 0.3 division in the NORM mode, and 1.5 division for SINGLE SWEEP operation.

When triggering on pulsed spectra it may be necessary to adjust the FINE tuning, to shift the sweep start away from a null point, as illustrated in Fig. 2-10.

7. How to Sweep the Display Using an External Sweep Source

The 7L12 can be swept by an external voltage which is applied to the front panel HORIZ IN jack, and/or the output voltage of a Vertical Plug-In Unit which is plugged into the Left Vertical compartment of the oscilloscope. When the Time/Div selector is switched to the AMPLIFIER position it connects the input of the 7L12 horizontal sweep circuits to these two external sources. The following procedures describe how the analyzer can be swept from these sources.

a. Sweeping the Analyzer from an External Voltage that is applied to the HORIZ IN jack.

A low impedance (≤300 Ω) voltage source, from 0 V ±1 V to 10 V ±1 V, is required to sweep the analyzer. 0 volts corresponds to 0 Hz and approximately 10 V corresponds to the high frequency end of any selected frequency span. The following procedure describes how to externally sweep the analyzer.

1) Calibrate the sweep span in the SPECTRUM position of the TIME/DIV selector, then switch the TIME/DIV to the AMPLIFIER position. Switch the oscilloscope A Trigger Source to Left Vert. (Remove any plug-in in the left compartment.)

2) Apply the external voltage source to the HORIZ IN jack. Adjust the upper end of the voltage around 10 V until the analyzer sweep span is calibrated. (Use the 7L12 Calibrator to calibrate the FREQ SPAN/DIV.)

NOTE

The frequency deviation across the selected span is a linear function (within 20%) of the input voltage. 5 V-DC should tune the analyzer to the center of the selected span.

b. Manual or Signal Sweeping with the Left Vertical Unit

A vertical amplifier unit, in the left vertical compartment of the oscilloscope, can be used to manually sweep the 7L12; or, an external voltage applied to the amplifier input will produce a vertical output signal that will sweep the analyzer. These procedures are described as follows:

1) Manual Sweeping the Analyzer with the Position Controls

a.) Calibrate the analyzer sweep span in the SPECTRUM position of the TIME/DIV switch as previously described.

b) Switch the TIME/DIV selector to the AMPLIFIER position and switch the oscilloscope Trigger Source to Left Vertical.

c) Use the Left Vertical Amplifier Position control to manually sweep the 7L12 Spectrum Analyzer.

2) Sweeping the Analyzer with a Signal Applied to the Input of the Vertical Amplifier Plug-In Unit

a) Calibrate the sweep span of the analyzer in the SPECTRUM position of the TIME/DIV switch, then switch to the AMPLIFIER position. Switch the oscilloscope Trigger Source to Left Vertical.

b) Apply the sweep signal or sweep voltage to the Input of the Vertical Amplifier. Switch the Input coupling of the amplifier to DC.

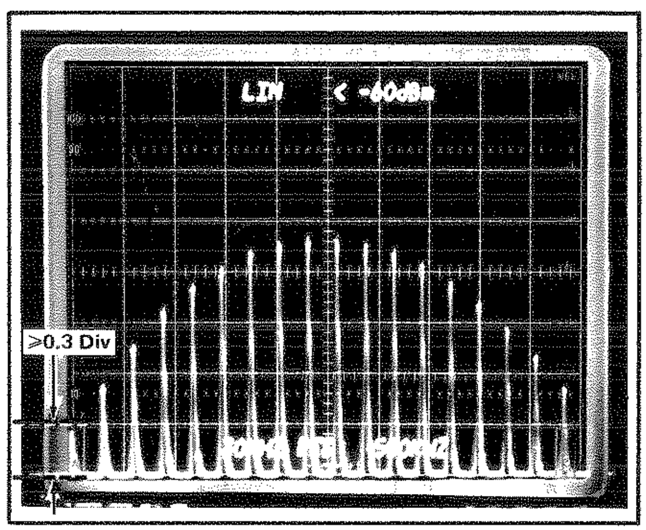


Fig. 2-10. The analyzer requires 0.3 division of signal to trigger the sweep on INT mode. Tune the spectrum null away from the sweep edge with the FINE controls.

c) Use the Vertical Amplifier Position control to set the sweep position and its Volts/Div selector plus Variable control to calibrate the sweep span. (Use the 7L12 Calibrator to provide dispersion markers.)

8. External Triggered Operation Using a Vertical Amplifier Plug-In Unit as the Trigger Source

This procedure is applicable if an external trigger source (e.g., pulse generator) is used to trigger an event and the display of the 7L12 simultaneously.

a. Apply the trigger signal to both the Input of the vertical amplifier unit and the event to be triggered.

b. Switch the oscilloscope Vert Mode to Left and adjust the amplifier Volts/Div selector for a signal amplitude of at least 1.5 division.

c. Switch the Vert Mode to Right and the Trigger Source to Left Vert.

d. Set the 7L12 controls as follows; FREQ SPAN/DIV to MAX, RESOLUTION to 3 MHz, TIME/DIV to SPECTRUM, and Display Mode to 2 dB/DIV. Set TRIGGERING, for NORM Mode, Source to INT, and adjust the TRIGGERING SLOPE and LEVEL controls for the desired triggering point.

e. Position the 0 Hz response of the 7L12 display at the zero (left) graticule line with the HORIZ POS control, and the baseline of the display at the bottom graticule line, with the VERT POS control.

The analyzer is now triggered by an external source. If the event is a single shot, switch the TRIGGERING MODE to SINGLE SWP and arm the circuit by pushing the RESET button to light the READY indicator. Select the desired FREQ SPAN/RESOLUTION and display mode.

9. Using the CAL OUT Signal Reference for Accurate Frequency and Amplitude Measurements

Frequency measurements are enhanced by using the Calibrator frequency comb or picket fence of 50 MHz markers. The Calibrator accuracy is within 0.01%. Absolute frequency measurements within 2 MHz are possible by using either of the two methods described below.

Measuring the Frequency Span Between a Calibrator Marker and the Signal to Obtain an Absolute Frequency Measurement.

1) Tune the signal to the center graticule line, approaching this point from the low frequency side of the display. Couple the FREQ SPAN/DIV and RESOLUTION selectors together and open up the display to obtain an accurate setting, by reducing the FREQ SPAN/DIV to 5 MHz and increasing RESOLUTION to .3 MHz. Adjust SWP CAL, if necessary, to calibrate the display for 10 divisions between the 50 MHz calibration markers. (Remember to approach the center point from the low frequency side.)

2) Connect the CAL OUT signal and the signal source through a BNC 'T' connector to the RF INput so both signal and markers are displayed.

3) Measure the frequency span between the signal and the nearest 50 MHz marker. (Frequency span is 5 MHz/Div.)

4) Add or subtract the frequency span to the respective marker to obtain the signal frequency. Since the maximum frequency span between the signal and marker is 25 MHz ±5%, marker accuracy is 0.01% and human observation error is approximately 1/2 a minor division or 0.5 MHz. The accuracy using this method is within 2 MHz.

Measuring or Reading the Frequency After a Dial Correction Factor Has Been Established.

The dial is marked in 2 MHz increments with an incremental accuracy within 1%.

1) As described for the frequency span method, tune the signal to the graticule center-line, opening the display to 5 MHz/Div to obtain an accurate setting. Tune the signal to the center from the low frequency side.

2) Note the dial reading (i.e., 1002 MHz).

3) Apply the CAL OUT signal to the RF INput and tune the nearest 50 MHz marker to the graticule center-line, again approaching this point from the low frequency side.

4) Note the correction factor required for the dial. For example; a dial reading 1 MHz high requires a correction factor of −1 MHz at this particular point.

5) Add this correction factor to the reading noted in step (2) for an absolute frequency measurement of 1001 MHz (1002 MHz −1 MHz).

Measuring Absolute Signal Levels

Since the top of the graticule is a calibrated REFERENCE LEVEL and the graticule is calibrated in dB/Div, as described in Preliminary Front Panel Calibration procedure, at the beginning of this section, it is easy to measure the absolute level of most signals.

1) Calibrate the graticule as previously described in step 3 of the General Operating Information. Ensure that the VARIABLE Gain control is in its CAL detent.

2) Connect the signal source to the RF INput, as described under Signal Application. Switch to the 10 dB/DIV or 2 dB/DIV display mode.

NOTE

For maximum accuracy use the same cable that was used to calibrate the REFERENCE LEVEL and use the 2 dB/DIV display mode.

3) Select RF attenuator and Gain selector settings that will bring the signal, to be measured, within the screen or graticule window.

NOTE

SN B189999 & below: if you are operating in the 10 dB/DIV mode, the Gain selector must be within the blue sector.

4) Measure the absolute signal level as the number of graticule divisions (in dB) below the top graticule line plus the REFERENCE LEVEL readout in dBm. For example: A signal level 4.5 divisions below the top with a REFERENCE LEVEL readout of −60 dBm, in the 2 dB/DIV display mode, is −60 dBm +(−9 dB) or −69 dBm. This refers to the signal level at the RF INput connector. Add the insertion loss of any external attenuators and cables (if they are used) between the signal source and the RF INput.

NOTE

The maximum input level to the RF INput, for linear operation, is −30 dBm with 0 dB RF attenuation; or +30 dBm with 60 dB of RF attenuation. Signals above this level can only be measured if an external attenuator is used.

Accurate Signal Level Difference Measurements in dB

1) Using the 2 dB/DIV display mode, position the top of the lowest amplitude signal to a reference line within the graticule area with the VARIABLE Gain or VERT POSition controls. If display noise is excessive use the VIDEO FILTER and reduce the sweep speed to maintain signal amplitude, or decrease the RESOLUTION bandwidth.

2) Use the RF attenuator selector to reduce the amplitude of the larger signal until it is within the graticule area, and note the increased attenuator reading.

3) Measure the signal level from the reference line established for the smaller signal (graticule is calibrated in 2 dB/DIV) then add the change in RF attenuator reading to obtain the difference level (in dB) between the two signals.

APPLICATIONS

Applications for the spectrum analyzers, such as the 7L12, include: measuring intermodulation products, cross modulation, radiation interference, modulation percentage, modulation index, absolute and relative signal levels, etc. If you desire assistance for a specific application or current information on additional applications, contact your local TEKTRONIX Field Office or representative.