SPECTRUM BANDWIDTH MEASUREMENT

5.5.11 SPECTRUM BANDWIDTH MEASUREMENT.

Each RADAR has a license to operate a fixed frequency (two for redundant sites) and we have limits to the range of frequencies that we can occupy. This procedure verifies that we are within our limits.

This is done after the klystron tune. Tuning the klystron changes the frequencies that it transmits.

This procedure measures the bandwidth on ether side of the transmit frequency (half bandwidth)

The transmitted frequency spectrum must meet the requirements of RSEC *(Radar Spectrum Engineering Criteria)*.

The RSEC requirements for the WSR-88D transmitter are based upon short pulse operation, a pulse rise time of 0.15 μsec, and a 6 dB down pulse width of 1.57 μsec. (These are fixed values and are not based on actual measured values).

This results in a maximum allowed **-40 dB half bandwidth** of 7.26 MHz and a **-80 dB down half bandwidths** of 72.6 MHz (22.94 MHz if transmitter is equipped with a spectrum filter).

These requirements apply to both short pulse and long pulse operation. The following procedure is written for a HP8563A Spectrum Analyzer. If a different analyzer is used, refer to the manufacturer's handbook data for equivalent step by step instructions.

NWSTC note:

This procedure is mostly pushing buttons and this lesson will skip the button pushing and focus on the measurements.
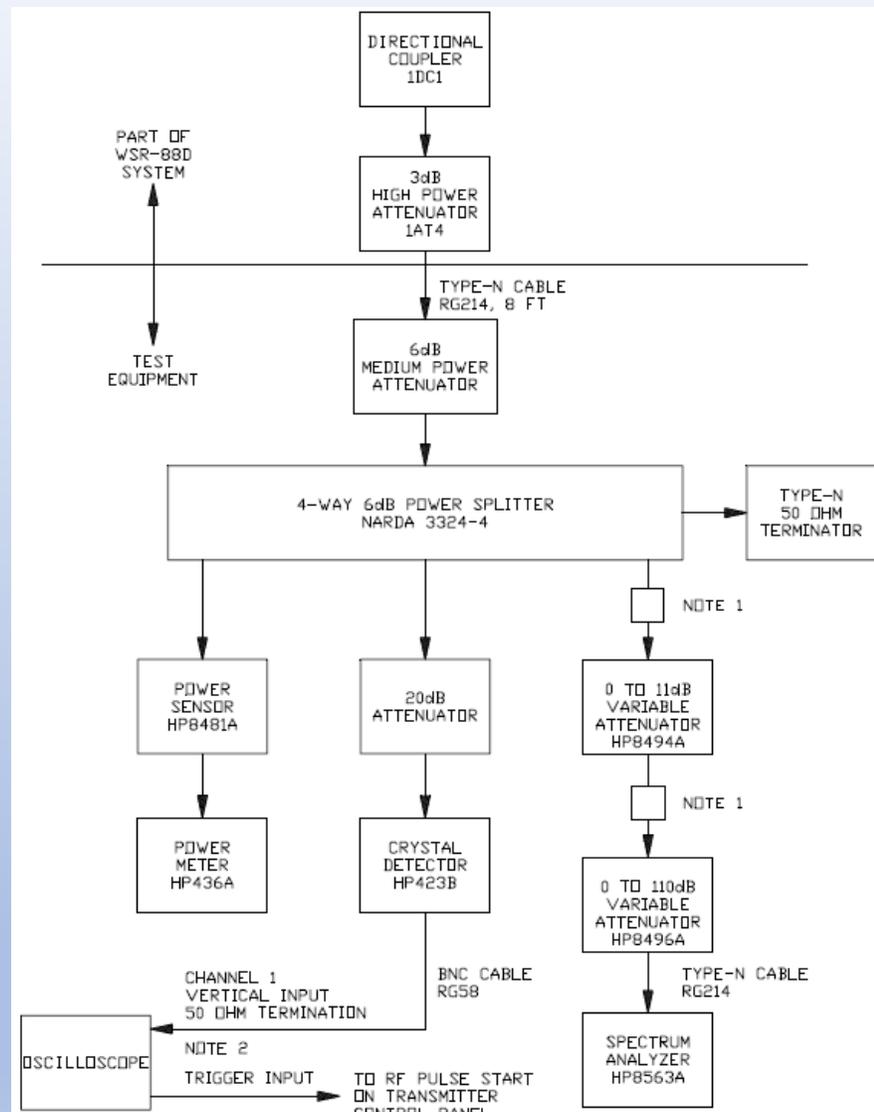
5.5.11.2 Initial Conditions/Preliminary Setup.

> **CAUTION**
>
> If in MAINT mode, always make sure HV OFF is illuminated before selecting a new PRF or pulse width. Failure to do so will cause damage to the PFN switch. However, when in SYSTEM mode, entry into STS Pulsewidth/PRF Selection menus will turn off high voltage.

1. Gain control and place the system in standby by performing procedures in paragraph 3.4.1.2, steps 1 and 2.

2. Connect all test equipment according to the RF test equipment configuration shown in Figure 5-15.


DIRECTIONAL
COUPLER
1DC1

PART OF
WSR-88D
SYSTEM

3dB
HIGH POWER
ATTENUATOR
1AT4

TEST
EQUIPMENT

TYPE-N CABLE
RG214, 8 FT

6dB
MEDIUM POWER
ATTENUATOR

4-WAY 6dB POWER SPLITTER
NARDA 3324-4

TYPE-N
50 OHM
TERMINATOR

NOTE 1

POWER
SENSOR
HP8481A

20dB
ATTENUATOR

0 TO 11dB
VARIABLE
ATTENUATOR
HP8494A

POWER
METER
HP436A

CRYSTAL
DETECTOR
HP423B

NOTE 1

0 TO 110dB
VARIABLE
ATTENUATOR
HP8496A

CHANNEL 1
VERTICAL INPUT
50 OHM TERMINATION

BNC CABLE
RG58

TYPE-N CABLE
RG214

OSCILLOSCOPE

NOTE 2

TRIGGER INPUT

TO RF PULSE START
ON TRANSMITTER
CONTROL PANEL

SPECTRUM
ANALYZER
HP8563A

NOTES:

1. TYPE-N (M-TO-M) ADAPTER
OR SHORT TYPE-N RG214
CABLE (2 TO 3 FT).

2. IF USING AN ANALOG
OSCILLOSCOPE, CONNECT A
50 OHM TERMINATOR USING
A BNC TEE ADAPTER.
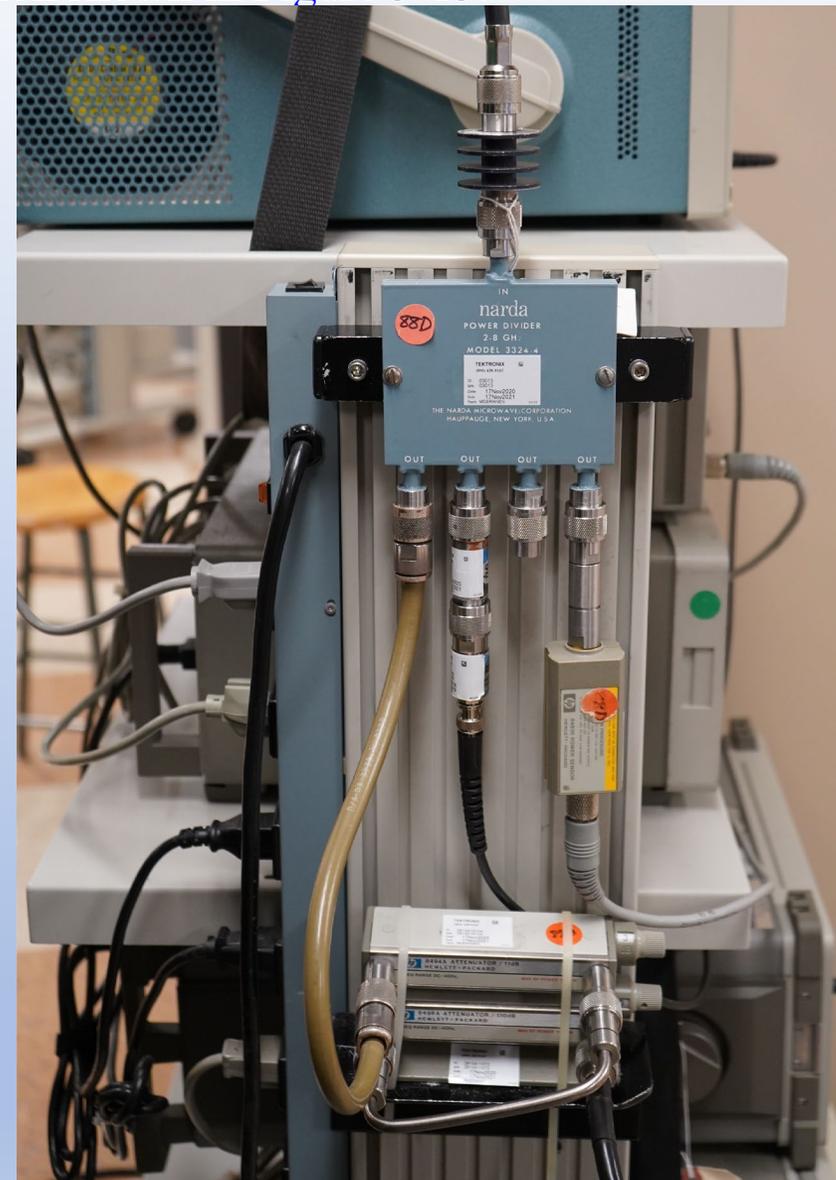
3. Press **POWER ON** pushbutton switch to turn on spectrum analyzer. Spectrum analyzer will automatically conduct a 45 second self-test when power is applied.

5.5.11.2 Initial Conditions/Preliminary Setup.
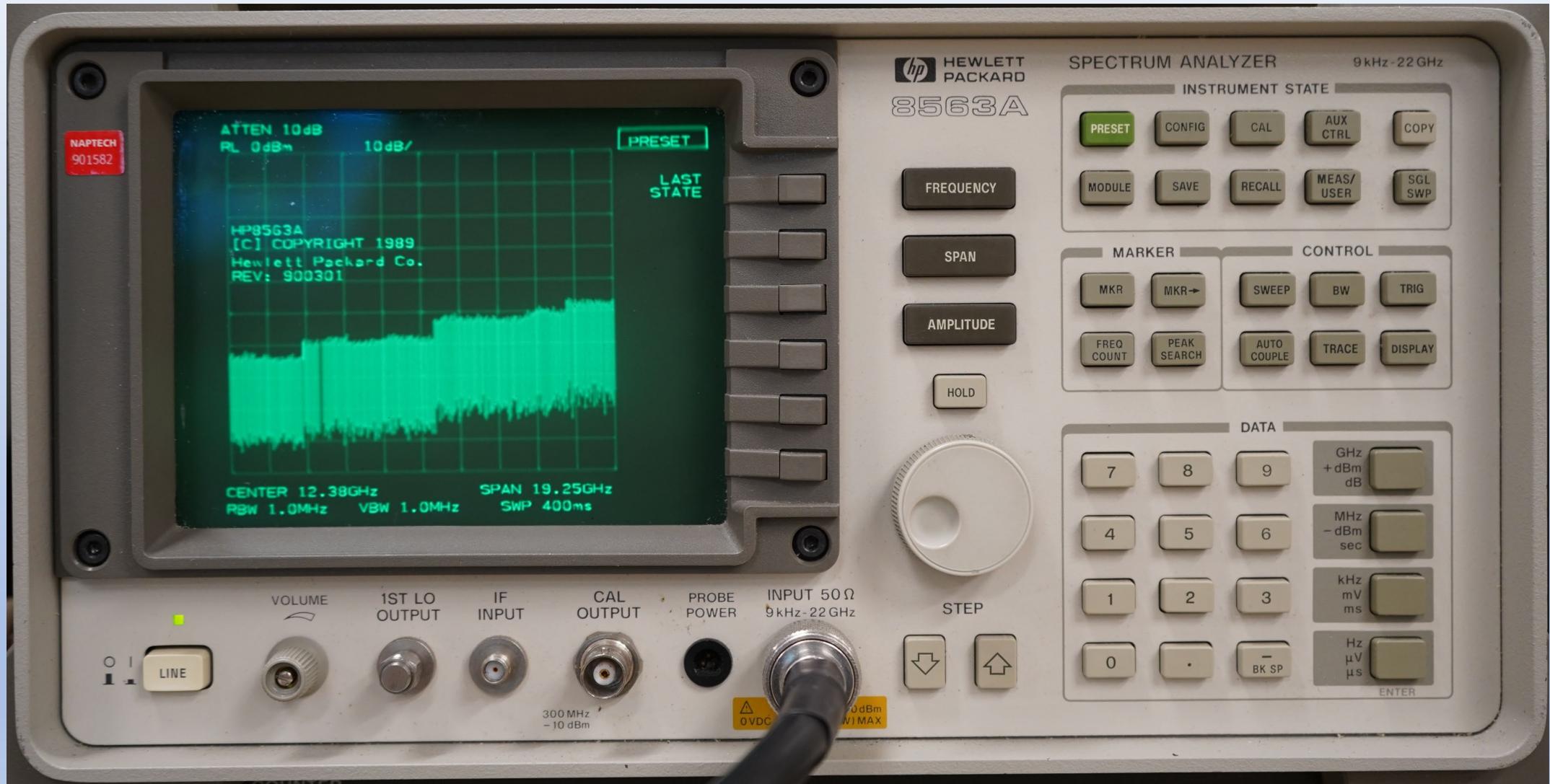
5.5.11.3 Center Frequency Selection.

1. Press **FREQUENCY** pushbutton switch. Spectrum analyzer CRT screen will display frequency selection.

NOTE

The actual parameters are displayed on the left side of the CRT screen. The associated menu selection pushbutton switches are located to the right of the menu.

2. Press menu selection **CENTER FREQUENCY** pushbutton switch. `CENTER FREQUENCY` label on CRT intensifies.

3. Using the spectrum analyzer data entry keyboard, enter numerical value for site frequency and end entry by pressing either **MHz** or **GHz** pushbutton switch (whichever is appropriate). Selected center frequency is displayed on CRT screen.
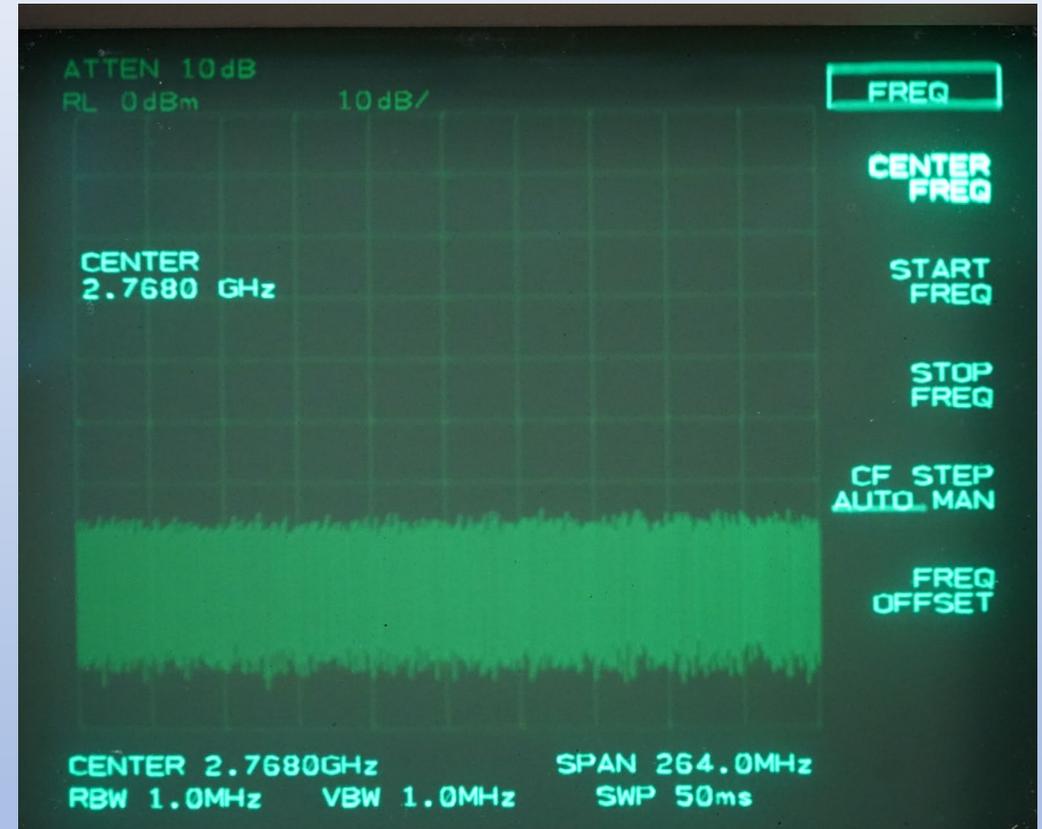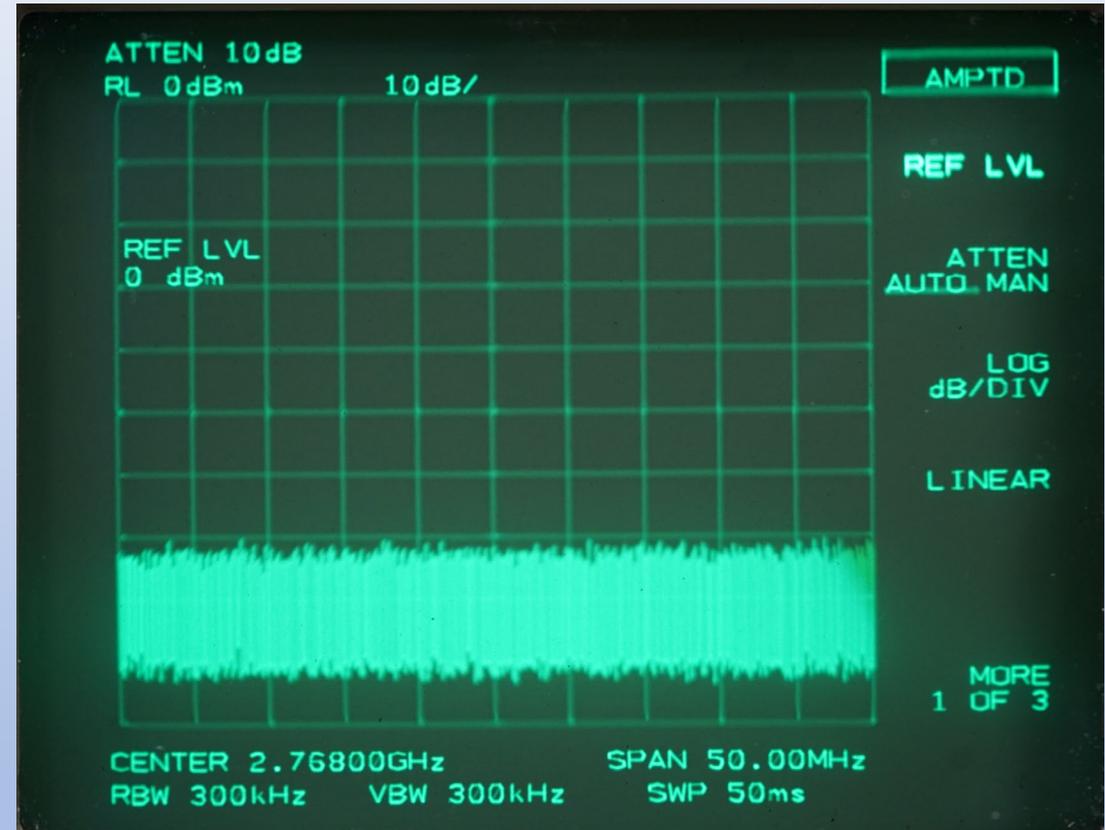
5.5.11.4 Span Selection.

1. Press **SPAN** pushbutton switch. `Span` selection screen is
   displayed on CRT screen.

2. Using spectrum analyzer data entry keyboard, enter **5Ø** and
end selection by pressing **MHz** pushbutton switch. Selected
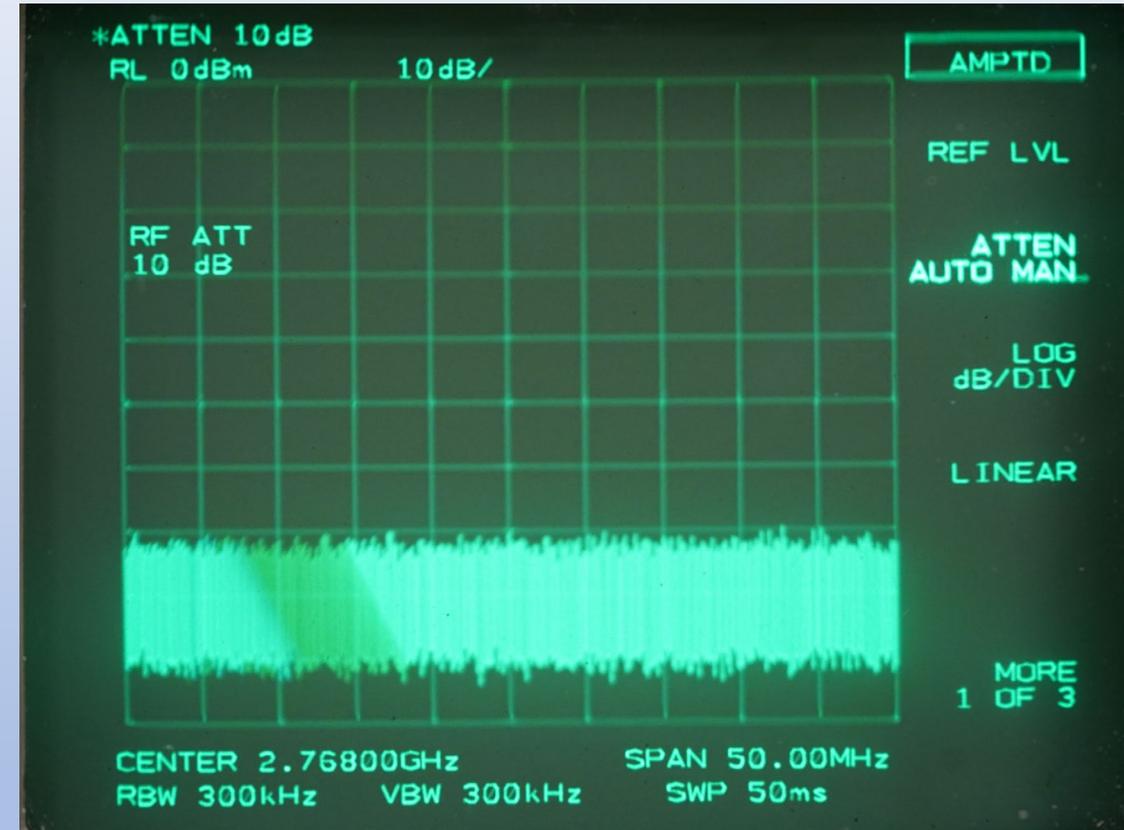span is displayed on CRT screen.
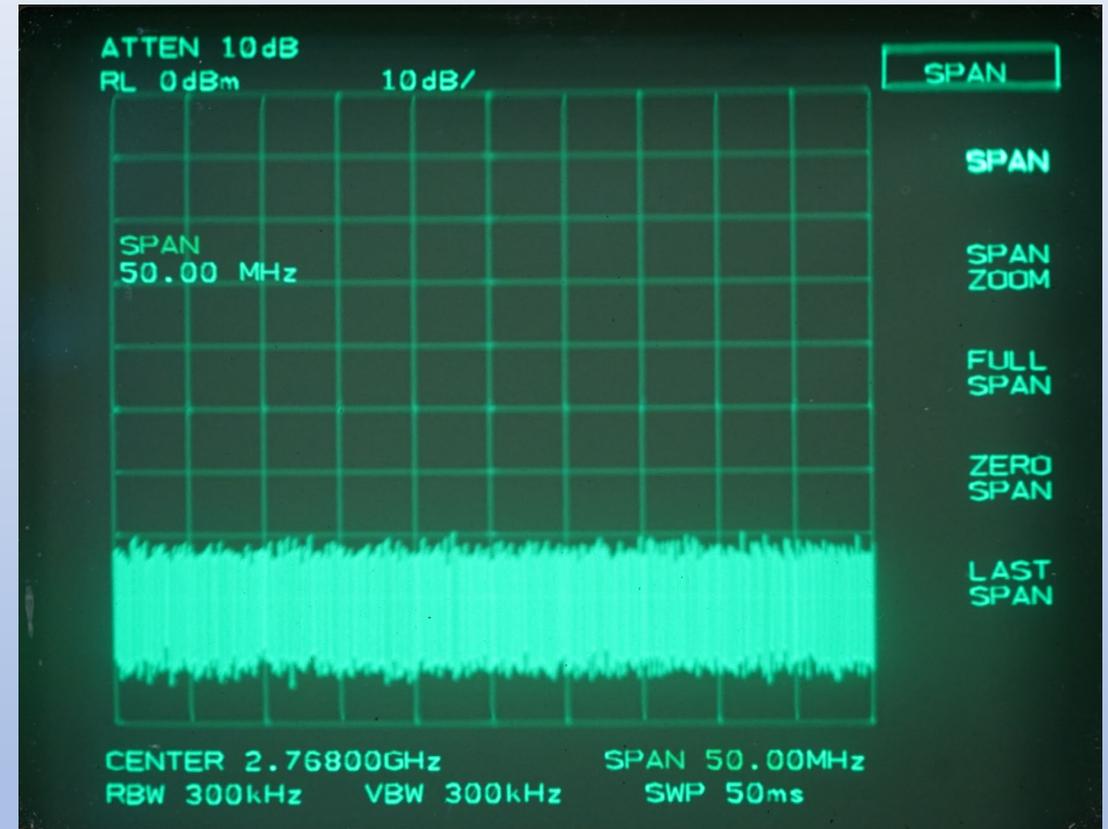
5.5.11.5 Internal Attenuation and Reference Level Selection.

1. Press **AMPLITUDE** pushbutton switch.

2. Press **REFERENCE LEVEL** pushbutton switch.

3. Using spectrum analyzer data entry keyboard, enter **Ø** and end selection by pressing **dB** pushbutton switch. Selected reference level is displayed on CRT screen.
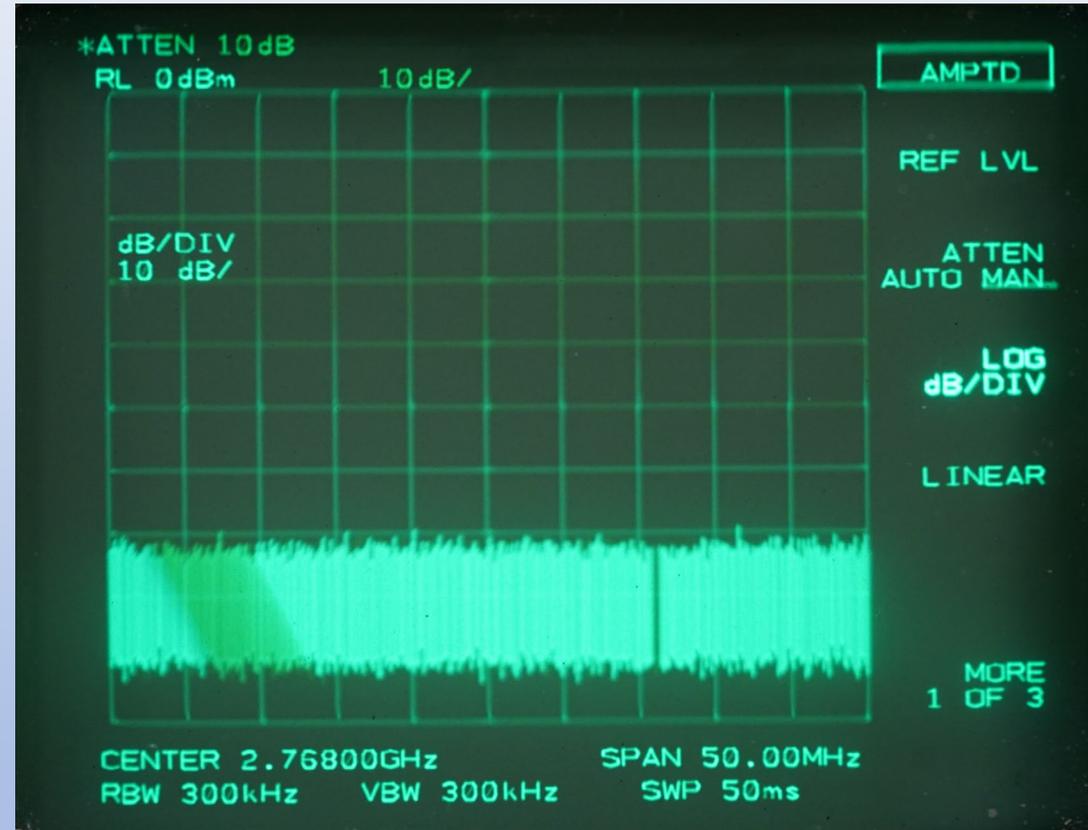
4. Press **ATTENUATION AUTO/MANUAL** pushbutton switch. `ATTENUATION AUTO/MANUAL` label on CRT intensifies.

5. Press **ATTENUATION AUTO/MANUAL** pushbutton switch again to move underline symbol to `MANUAL`.

6. Using spectrum analyzer data entry keyboard, enter **1Ø** and end selection by pressing **dB** pushbutton switch. Selected attenuation is displayed on CRT screen.
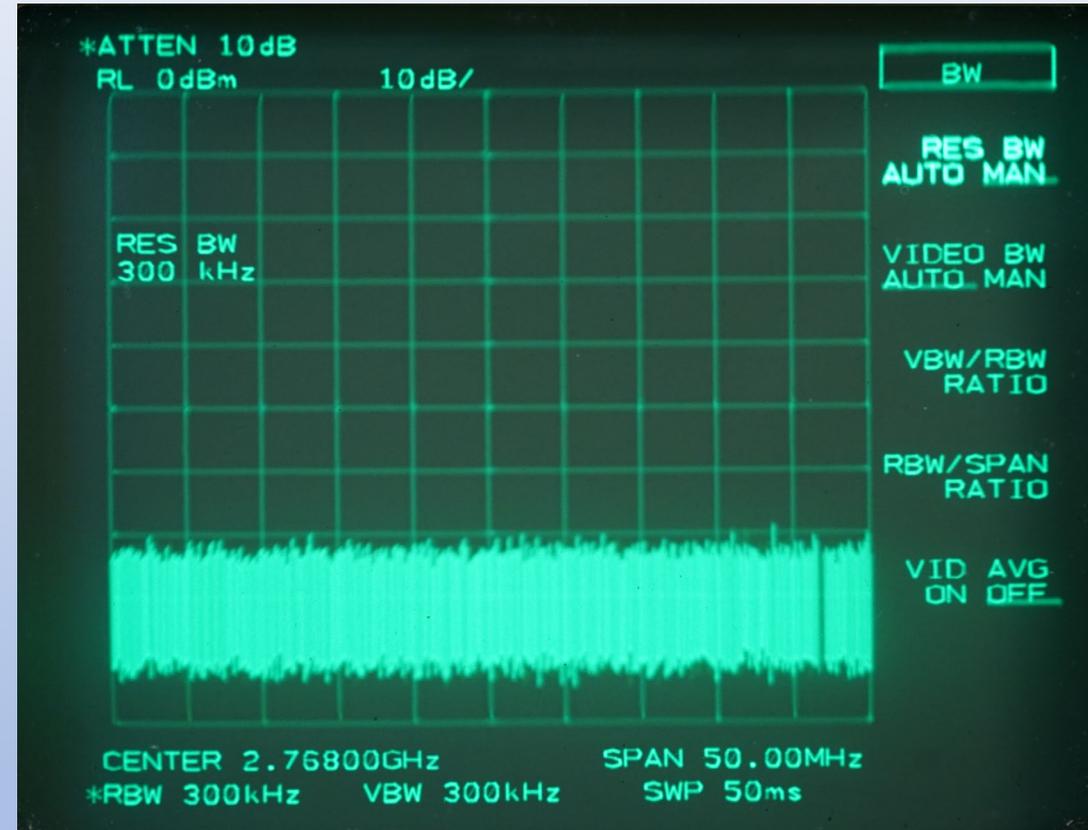
7. Press **LOG/dB/DIV** pushbutton switch. `LOG/DB/DIV`
label on CRT intensifies.

8. Using spectrum analyzer data entry keyboard, enter **1Ø** and
end selection by pressing **dB** pushbutton switch. Selected
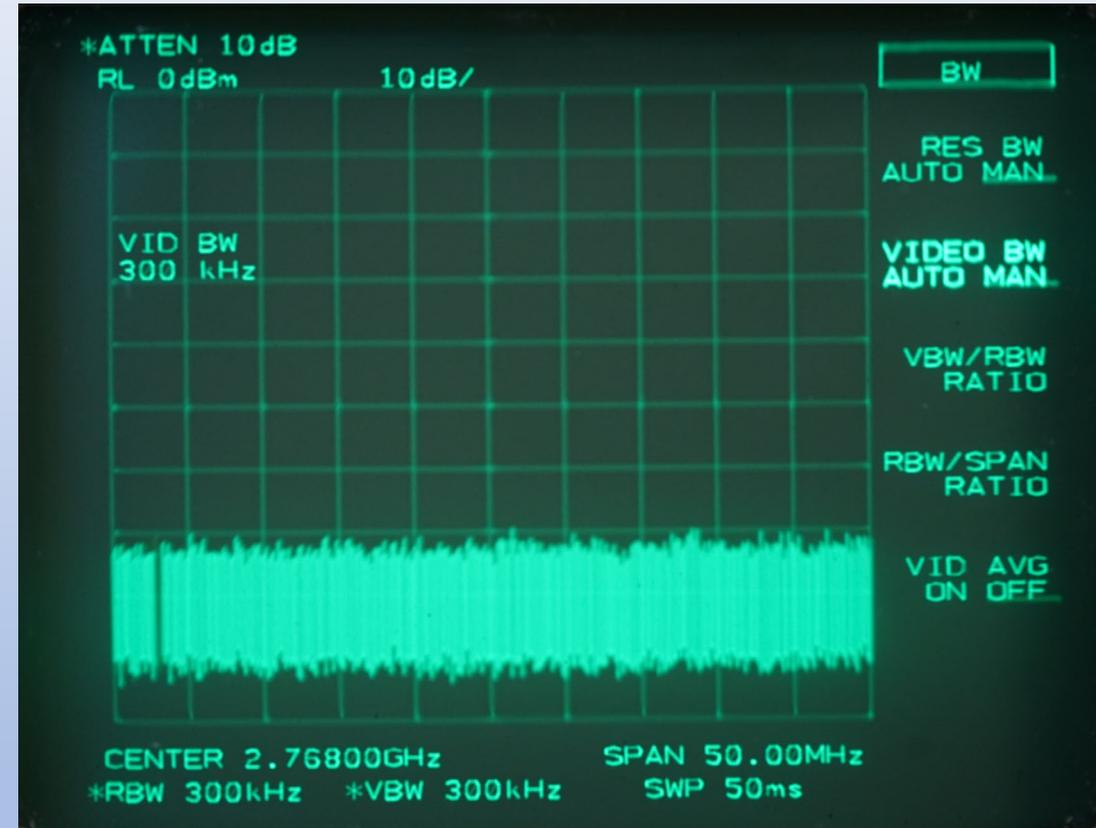`dB/DIV` is displayed on CRT screen.

5.5.11.6 Bandwidth Selection.

1. Press **BW** (bandwidth) pushbutton switch. `BW` selection screen is displayed on CRT screen.

2. Press **RES BW AUTO/MANUAL** pushbutton switch. `RES BW AUTO/MANUAL` label on CRT intensifies.

3. Press **RES BW AUTO/MANUAL** pushbutton switch again to move underline symbol to `MANUAL` (if not already there).

4. Using spectrum analyzer data entry keyboard, enter **3ØØ** and end selection by pressing **KHz** pushbutton switch. Selected `RES BW` is displayed on CRT screen.
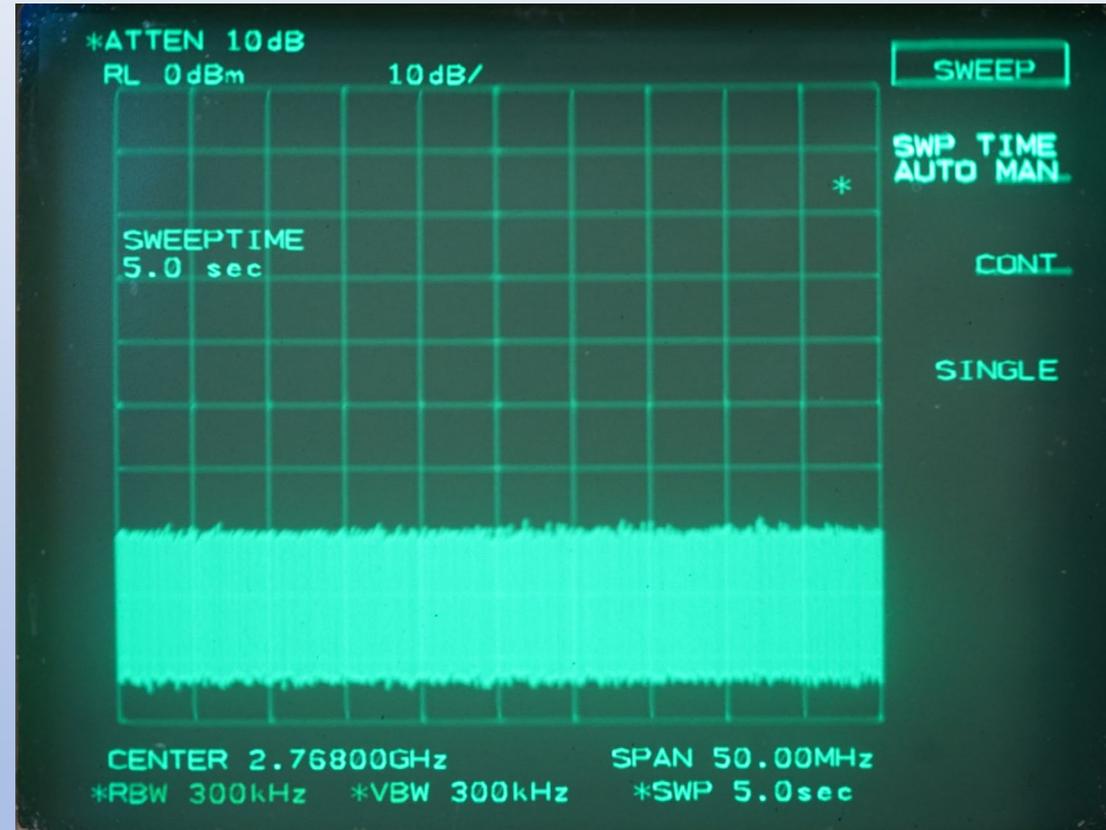
5. Press **VIDEO BW AUTO/MANUAL** pushbutton switch.
`VIDEO BW AUTO/MANUAL`
label on CRT intensifies.

6. Press **VIDEO BW AUTO/MANUAL** pushbutton switch
again to move underline symbol
to `MANUAL`.

7. Using spectrum analyzer data entry keyboard, enter **3ØØ** and
end selection by pressing
**KHz** pushbutton switch. Selected VID BW is displayed on CRT
screen (300 KHz).

5.5.11.7 Spectrum Triggering and Sweep Time Selection.

1. Press **TRIG** (trigger) pushbutton switch. `TRIGGERING` selection screen is displayed on CRT screen.

2. Press **FREE RUN** pushbutton switch. `FREE RUN` label on CRT intensifies.

3. Press **SWEEP** pushbutton switch. `SWEEP` selection screen is displayed on CRT screen.

4. Using spectrum analyzer data entry keyboard, enter **5** and end selection by pressing **SECOND** pushbutton switch. Selected sweep time is displayed on CRT screen.

5. Press **TRACE**, select **MORE** (at bottom of selection screen), select **DETECTOR MODES**, select **DETECTOR POS PEAK**.
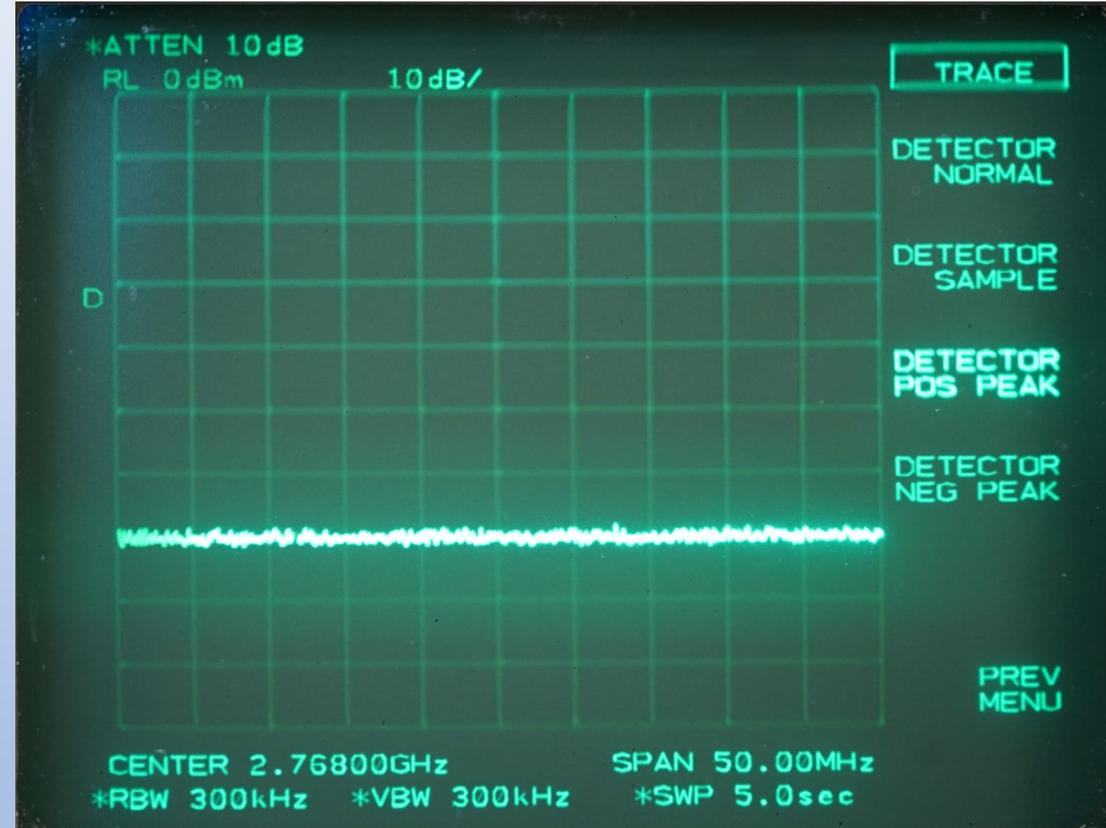
5.5.11.8 Bandwidth Measurements.

NOTE

The total attenuation between the klystron and the spectrum analyzer should
be approximately 81 dB. This ensures the peak power into the spectrum analyzer
is approximately 7.5 dBm.

1. Adjust the variable attenuator combination (0 to 11 dB and 0 to 110 dB) to insert 28 dB of additional attenuation. This attenuation value will be fine-tuned in step 3.

2. On the Main RDA HCI, click on **System Test Software** and **Yes** to confirm. Click **Control ►AME/Receiver Control**; and select the following:

Test Source: **KLYSTRON OUTPUT**

Pulse Width: **Short Pulse**

PRF: **D5**

Click: **Inject Signal**

3. Observe klystron spectral display on the spectrum analyzer and compare to the example of typical spectrum envelope shown in Figure 5-16. Insert or remove attenuation in 1 dB steps on the variable attenuators until the pulse peak is at the top graticule and/or the dynamic range is maximized. (See following NOTE.)

NOTE

The best dynamic range (pulse peak above noise floor) on the HP8563A
Spectrum Analyzer is normally achieved when the peak of the pulse is at the
top graticule line. The better the dynamic range, the easier it will be to make
the 80 dB down spectral measurement (especially for non-spectrum filter systems).
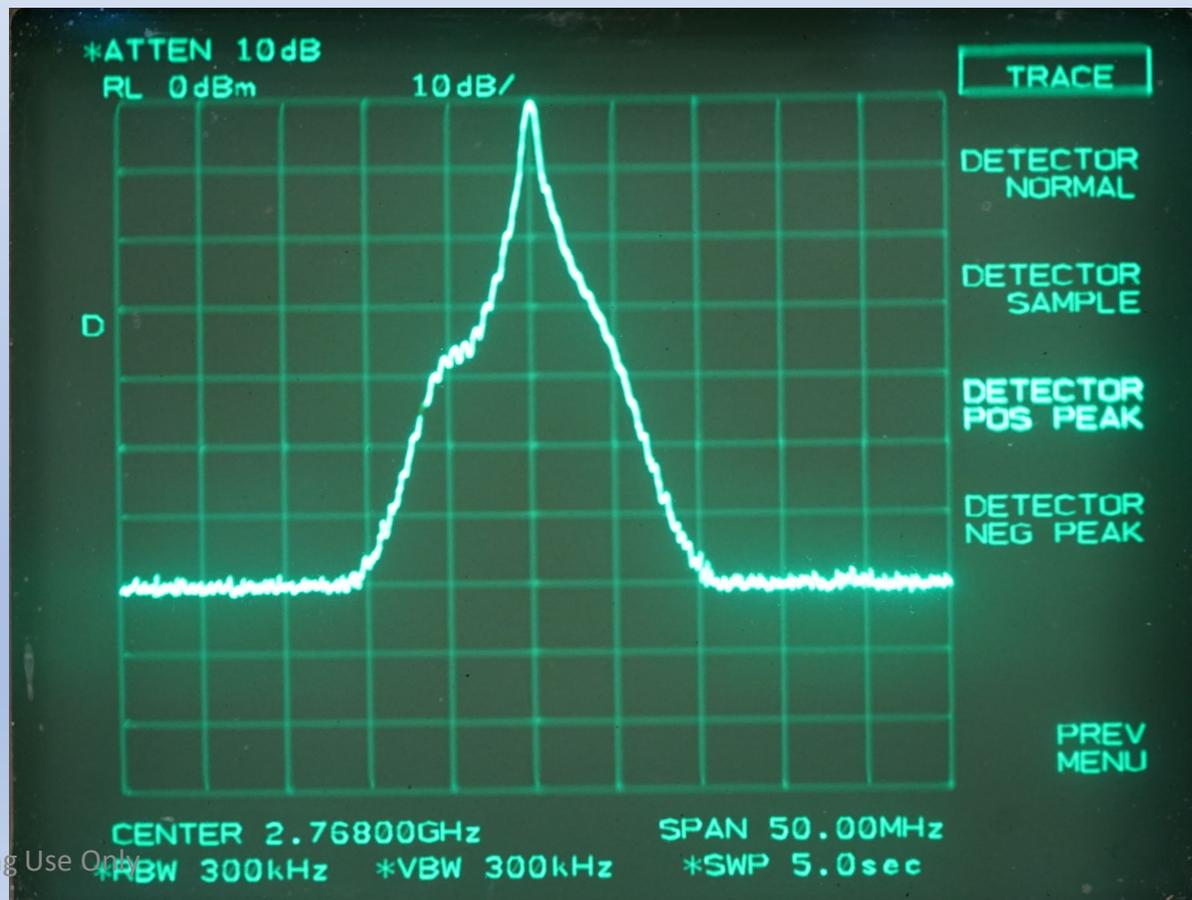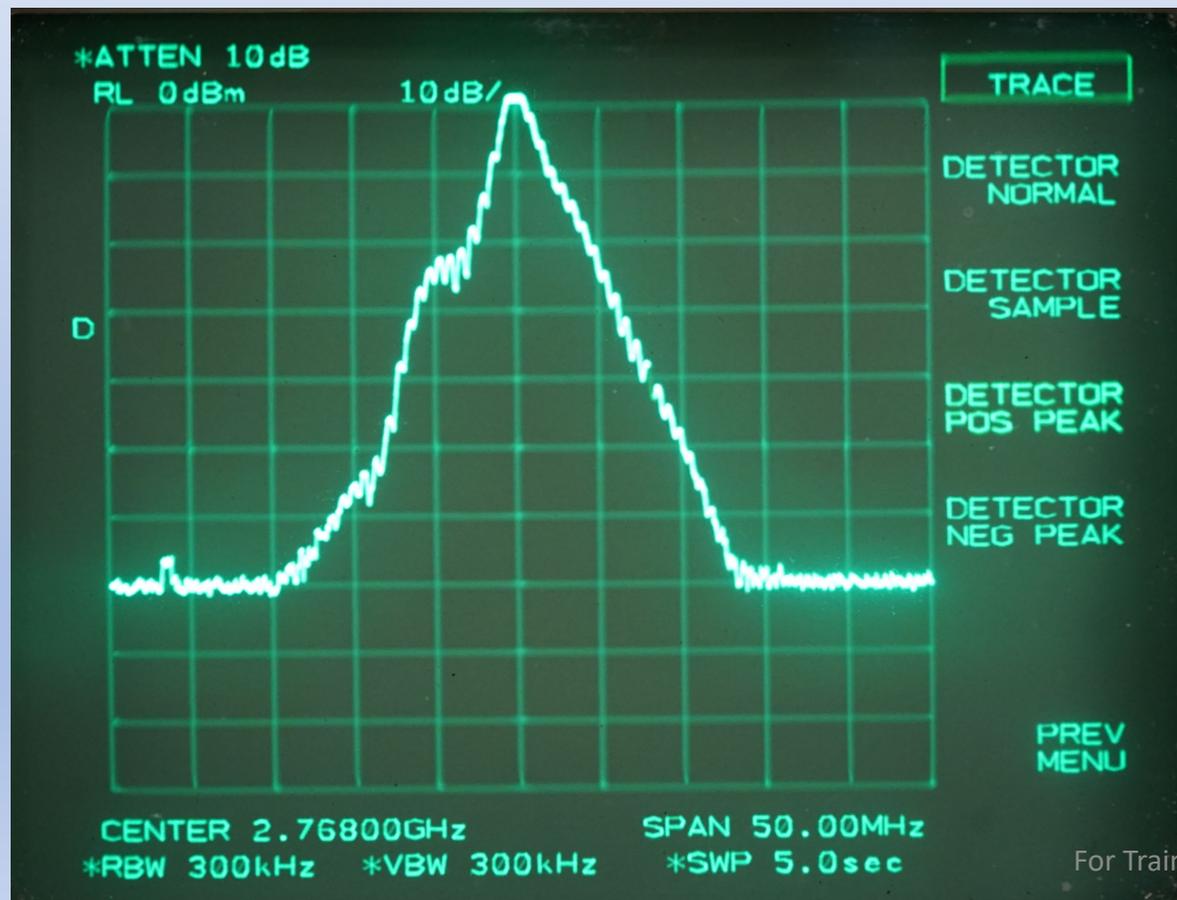
4. Press **TRACE** pushbutton switch. Spectrum analyzer CRT will display trace control screen

5. Press **MAX HOLD A** parameter pushbutton switch.

NOTE

For the close-in frequency response, klystron cavity turning is most effective.
Klystron tuning has little effect on spurious narrow responses greater
than the -80 dB down level. These are usually due to defects in the RF Generator
4/104A1 or the Pulse Shaper 3A5 (see paragraph 5.5.11.8, steps 19 through 34).
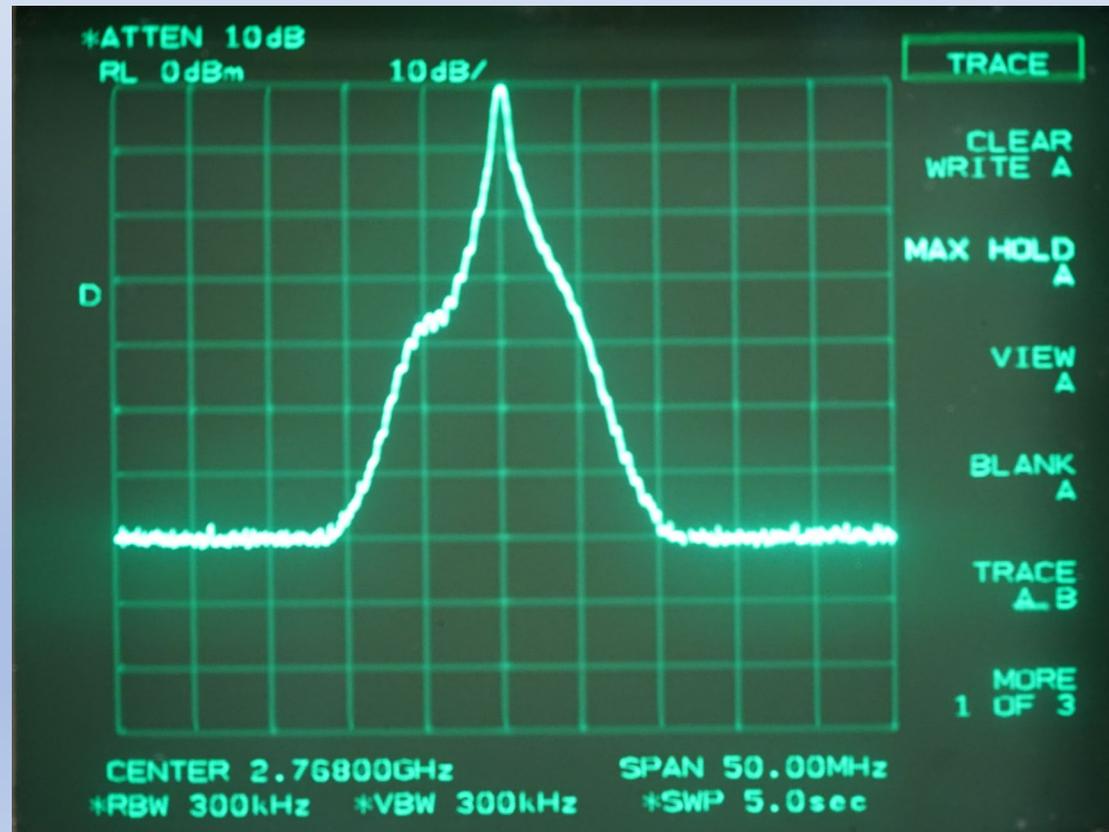
6. Press **PEAK SEARCH** pushbutton switch (located in marker section). A marker will appear at the top of pulse. Press **MKR** and select **MARKER DELTA**; and rotate knob to place marker at -40 dB point on the leadi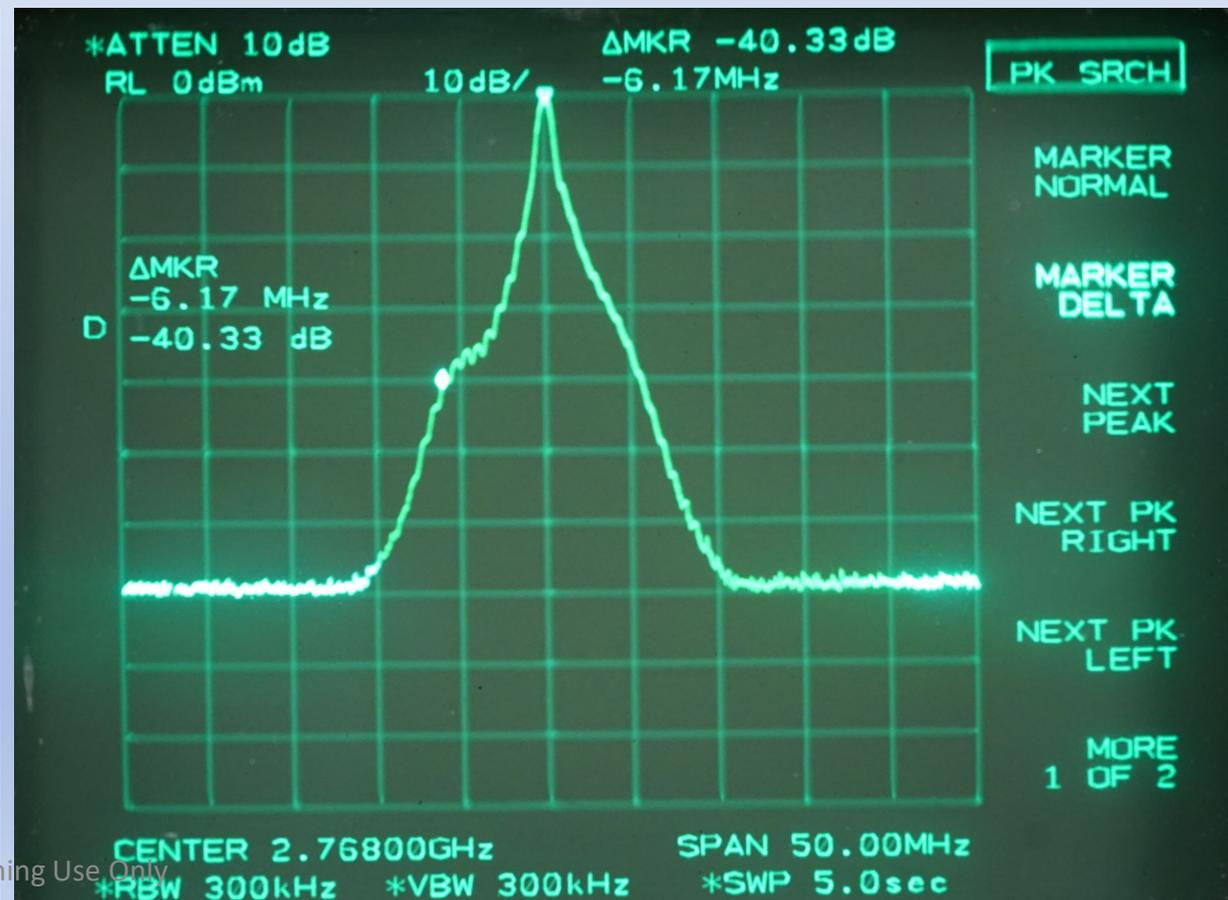ng edge of the pulse (marker at or slightly below -40 dB). Make note of the Delta MKR frequency displayed in the upper left quadrant or top right of the display; this is the lower half bandwidth at the -40 dB down point. The -40 dB half bandwidth (relative value) shall be less than or equal to 7.26 MHz.

A link to the -40dB half bandwidth measurement can be found here:
https://training.weather.gov/nwstc/NEXRAD/transmitter/index.html
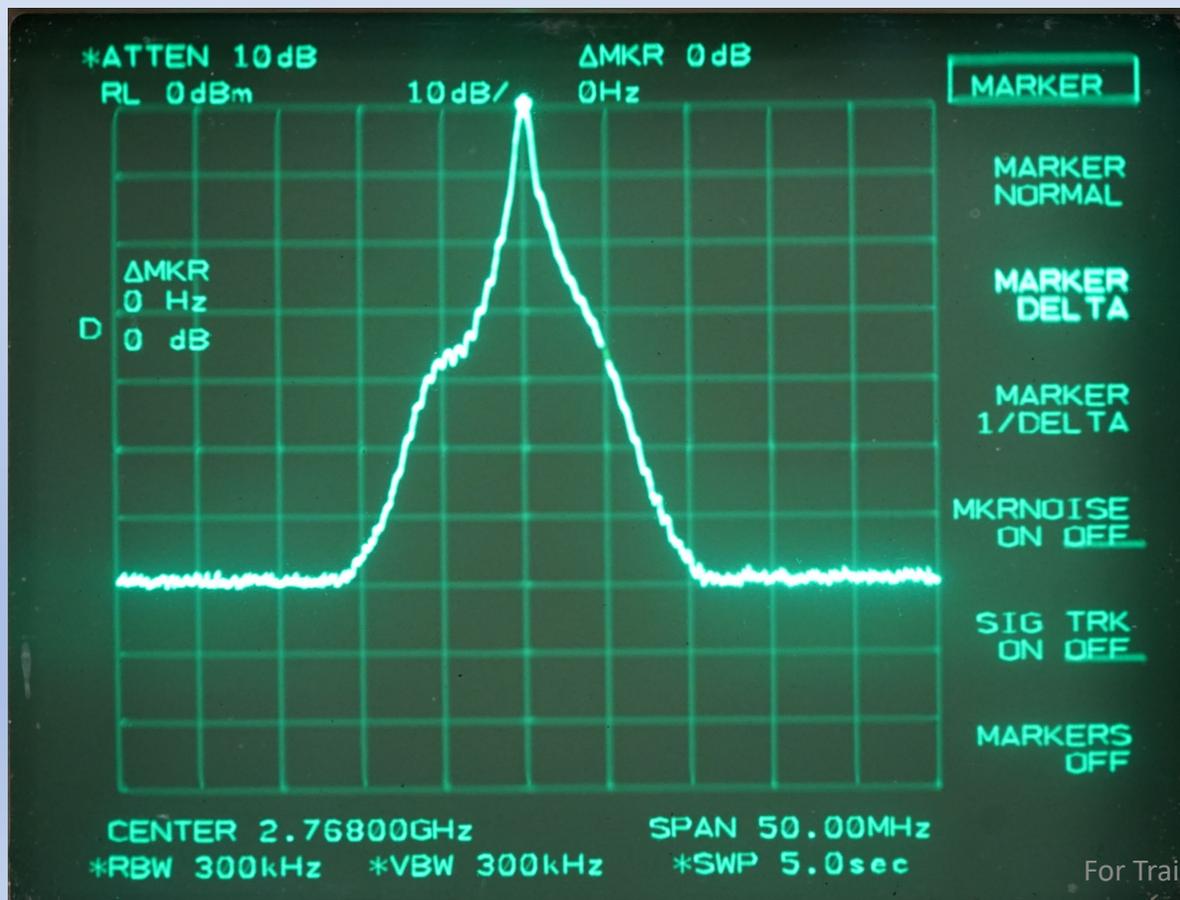
7. Rotate knob to place marker at -40 dB point on the trailing edge of the pulse (marker at or slightly below -40 dB). Make note of Delta MKR frequency displayed in the upper left quadrant or top right of the display; this is the upper half-bandwidth at the -40 dB down point. The -40 dB half bandwidth shall be less than or equal to 7.26 MHz. **If both of the -40 dB half bandwidth requirements are met, proceed to step 9.**

A link to the -40dB half bandwidth measurement can be found here:
https://training.weather.gov/nwstc/NEXRAD/transmitter/index.html
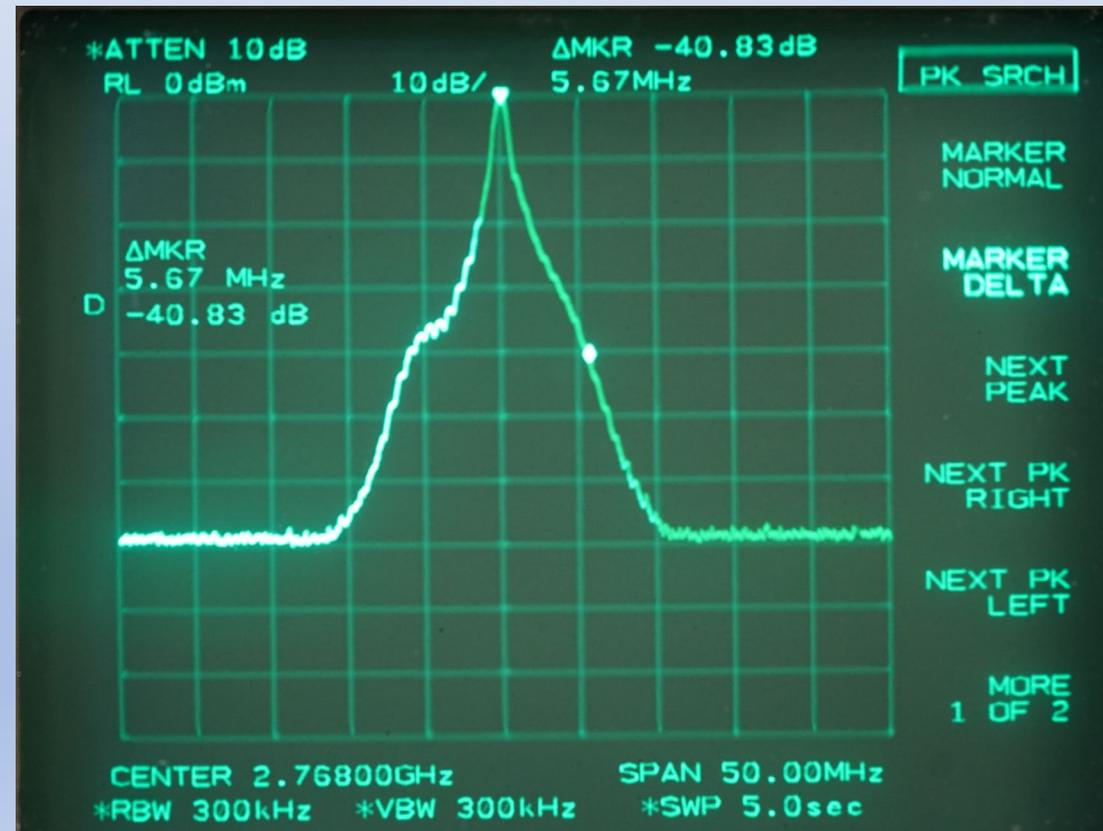
For Training Use Only

8. It is very rare a spectrum would not meet -40 dB half-bandwidth requirements. If the -40 dB half-bandwidth is greater than 7.26 MHz, re-tune cavities 4 and 5 slightly to slow up the rise/fall time of the detected output pulse and re-check the -40 dB half-bandwidth. If the spectrum still does not meet the requirements on the high frequency side (upper -40 dB halfbandwidth) slightly tune cavity #3 (less than three counts on the dial) to slow up the rise and fall times and achieve spectrum requirements. If adjustments are necessary, press **TRACE** and **CLEAR WRITE A** on the spectrum analyzer so the display is no longer at MAX HOLD. Spectrum problems can be caused by poor spectral purity in the Pulse Shaper A5 and/or RF Generator 4A1. If spectrum requirements cannot be met by cavity tuning, proceed to step 23.

9. Press **SPAN**. Enter **2ØØ MHz** with data entry keyboard. If necessary, reset Video Bandwidth (VBW) and Resolution Bandwidth (RBW) back to 300 KHz.

10. Press **TRACE** and **CLEAR WRITE A**.

11. Press **MKR** and select **NORMAL MARKER**. Press **PEAK SEARCH**, and select **MARKER DELTA**.
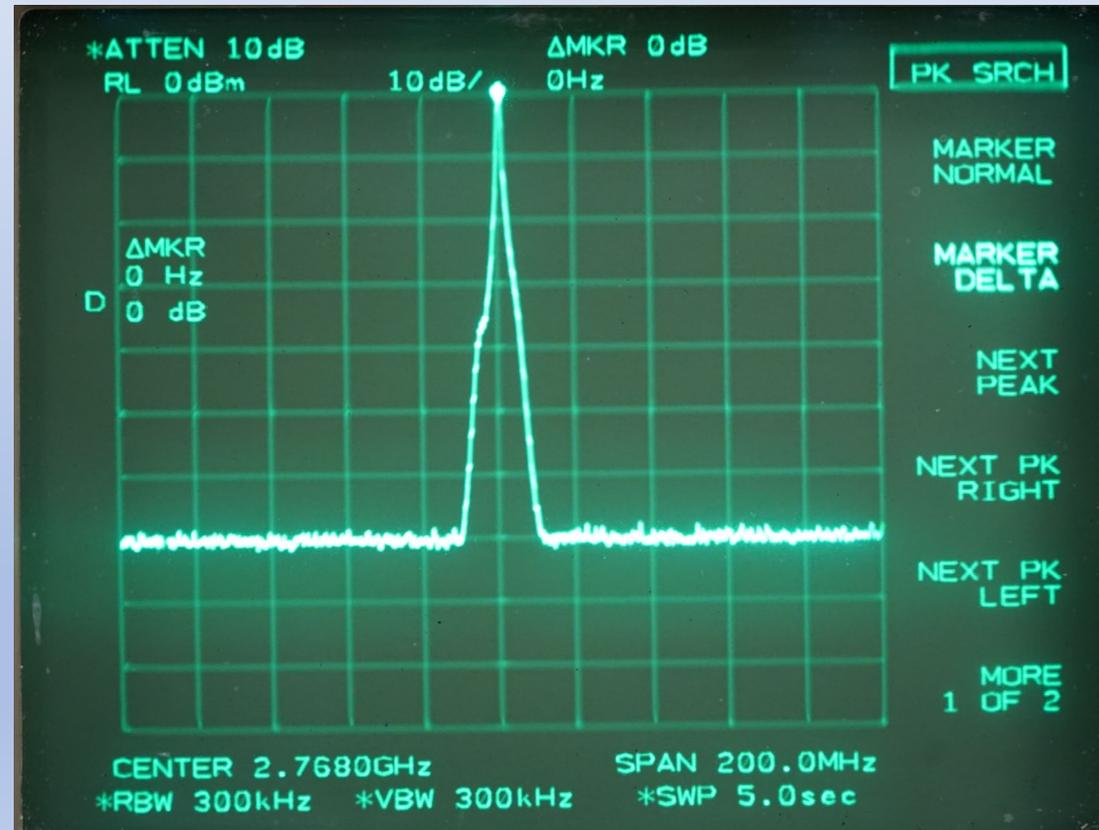
12. Remove 16 dB from the variable attenuator combination. This saturates the pulse 16 dB above the top graticule (0 dBm) but the marker delta is still referenced to the original peak of the pulse as if it was still at the top of the graticule (see Figure 5-17).

NOTE

The sharp 'spurs' shown in Figure 5-17 are not real spectrum-related anomalies (in this example). They are a by-product of over driving the spectrum analyzer's internal mixer. As the external attenuation is decreased by 1 dB intervals, these anomalous spurs caused by over driving the mixer will popup with levels near 5 to 15 dB above the analyzer's noise floor. Real spurs that could be actual spectral issues would increase above the noise floor in a linear manner by 1 dB every time 1 dB is removed from the external attenuators. If they appear real, check the spectral purity of Pulse Shaper 3A5 and Frequency Generator 4A1 beginning at step 19 (after measuring the -80 dB down bandwidths in steps 10 through 18).

**Figure 5-17. Typical Spectrum Envelope
(-80 dB Measurement)**
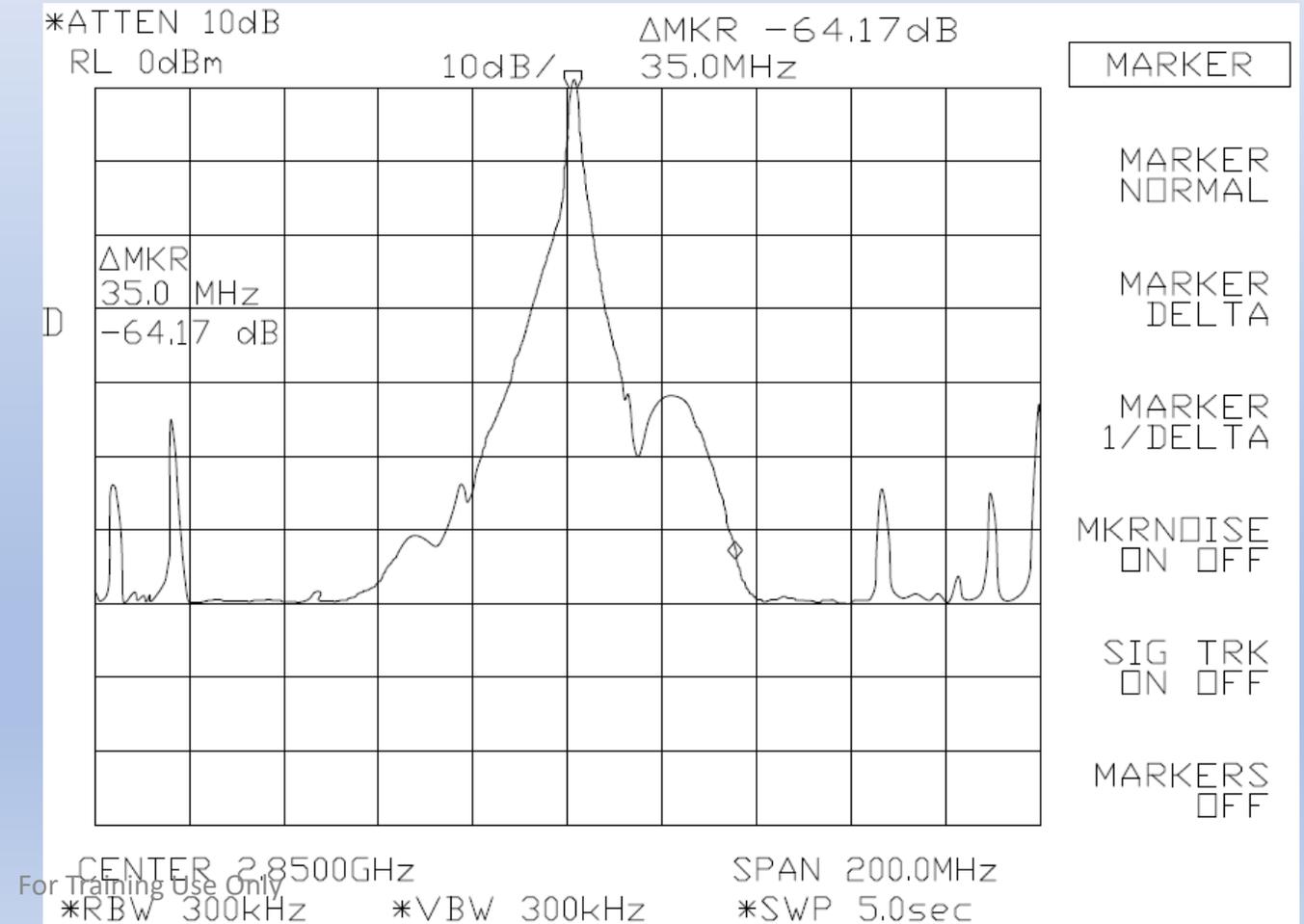
"As the external attenuation is decreased by 1 dB intervals, these anomalous spurs caused by over driving the mixer will popup with levels near 5 to 15 dB above the analyzer's noise floor."

In this example, one dB has been removed and the spur increases more than one dB.

ΔMKR
−43.7 MHz
−67.17 dB

ΔMKR
−44.3 MHz
−58.00 dB
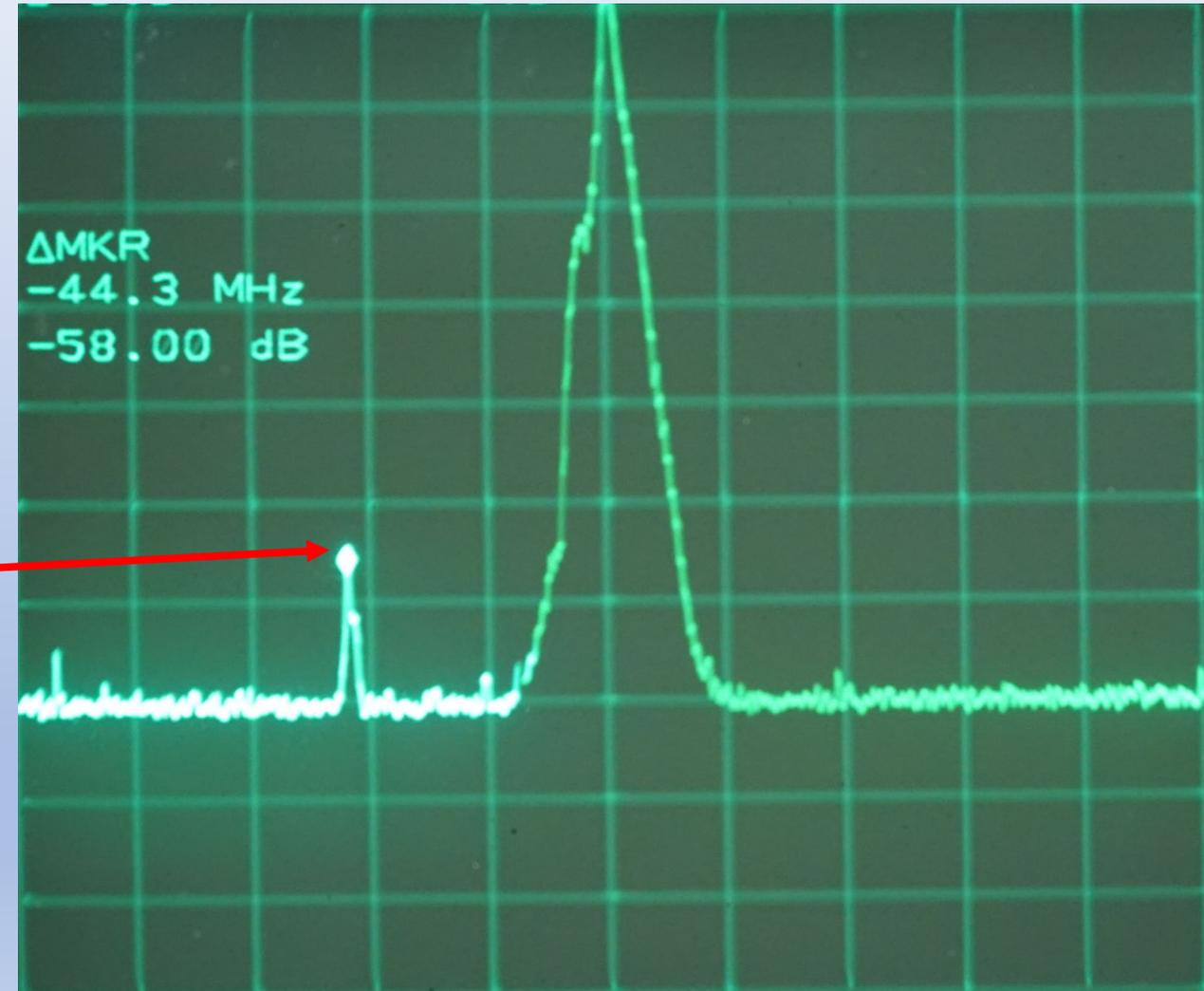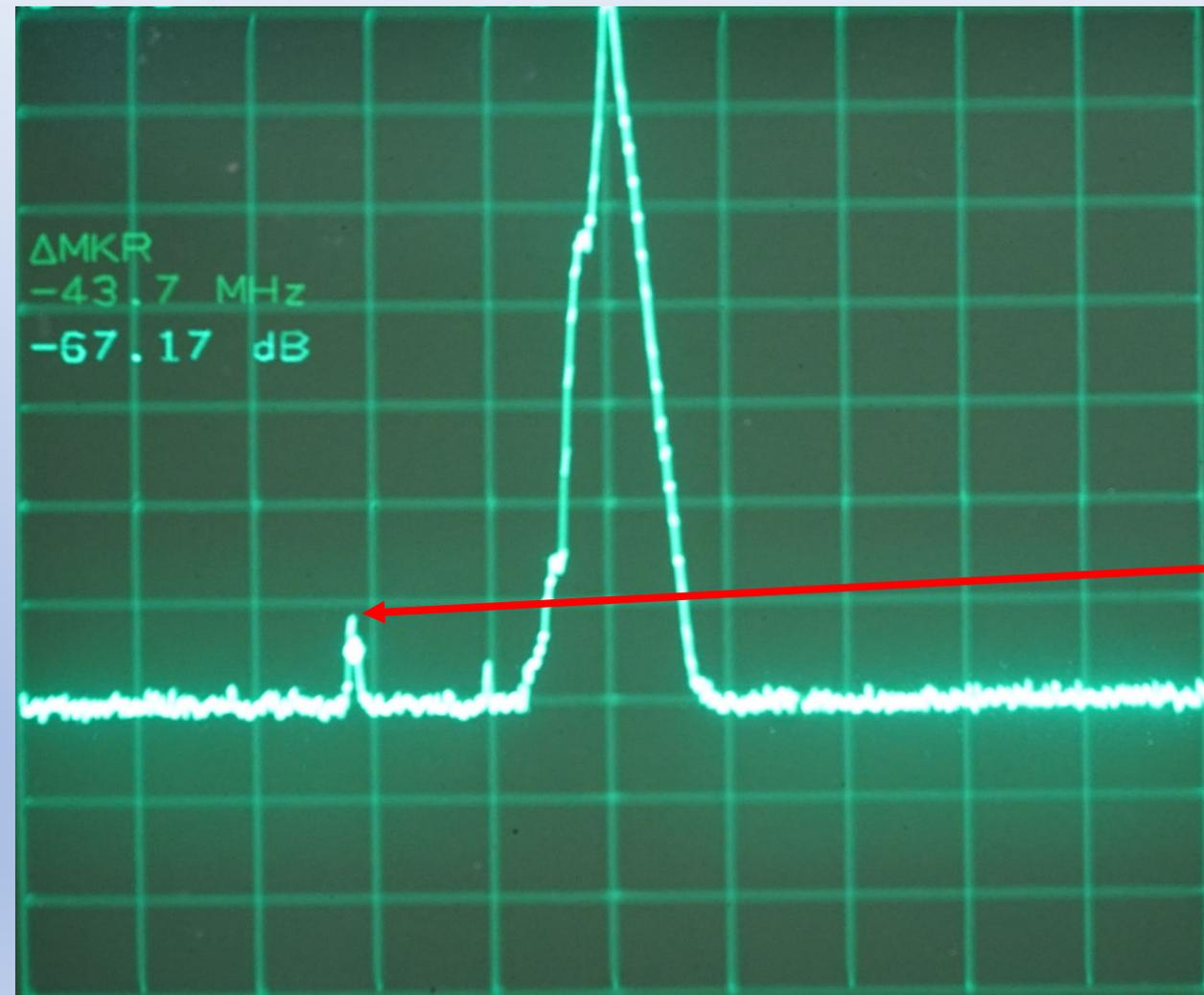
13. Rotate knob to place marker at the -64 dB point (marker at or slightly below -64 dB) on the leading edge of the pulse. **(The -80 dB down points will indicate -64 dB as 16 dB was removed from attenuation combination.)**. Make note of the Delta MKR frequency displayed in the upper left quadrant or top right of the display; this is the lower half bandwidth of the -80 dB down half bandwidth point. The -80 dB half bandwidth (relative value) shall be less than or equal to 72.6 MHz. **(22.94 MHz if spectrum filter is installed in system)**.

A link to the -80dB half bandwidth measurement can be found here:
https://training.weather.gov/nwstc/NEXRAD/transmitter/index.html
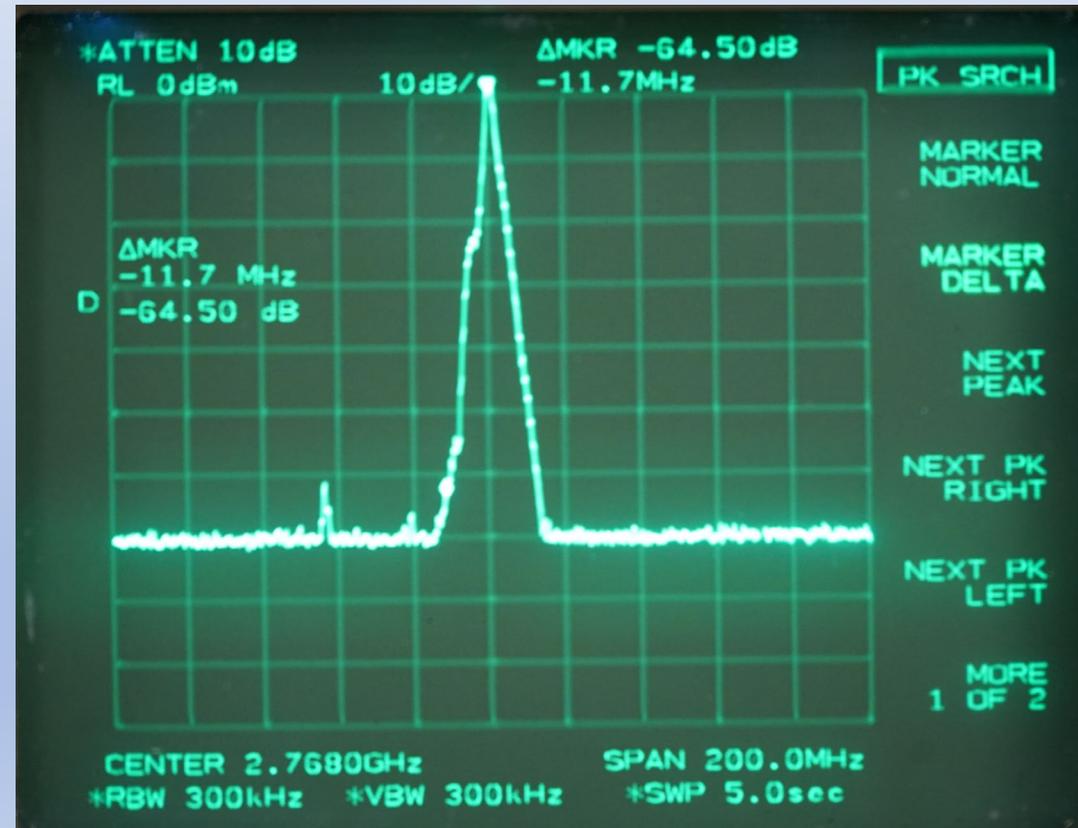
14. Rotate knob to place marker at -64 dB point (marker at or slightly below -64 dB) on the trailing edge of the pulse. Make note of Delta MKR frequency displayed in the upper left quadrant or top right of the display; this is the upper half bandwidth at the -80 dB down point. The -80 dB half bandwidth shall be less than or equal to 72.6 MHz **(22.94 MHz if spectrum filter is installed in the system)**. If these values are met and no real anomalous spurs exist (see step 13 NOTE), this procedure is complete. If real anomalous spurs exist, proceed to step 19.

A link to the -80dB half bandwidth measurement can be found here:
https://training.weather.gov/nwstc/NEXRAD/transmitter/index.html

For Training Use Only
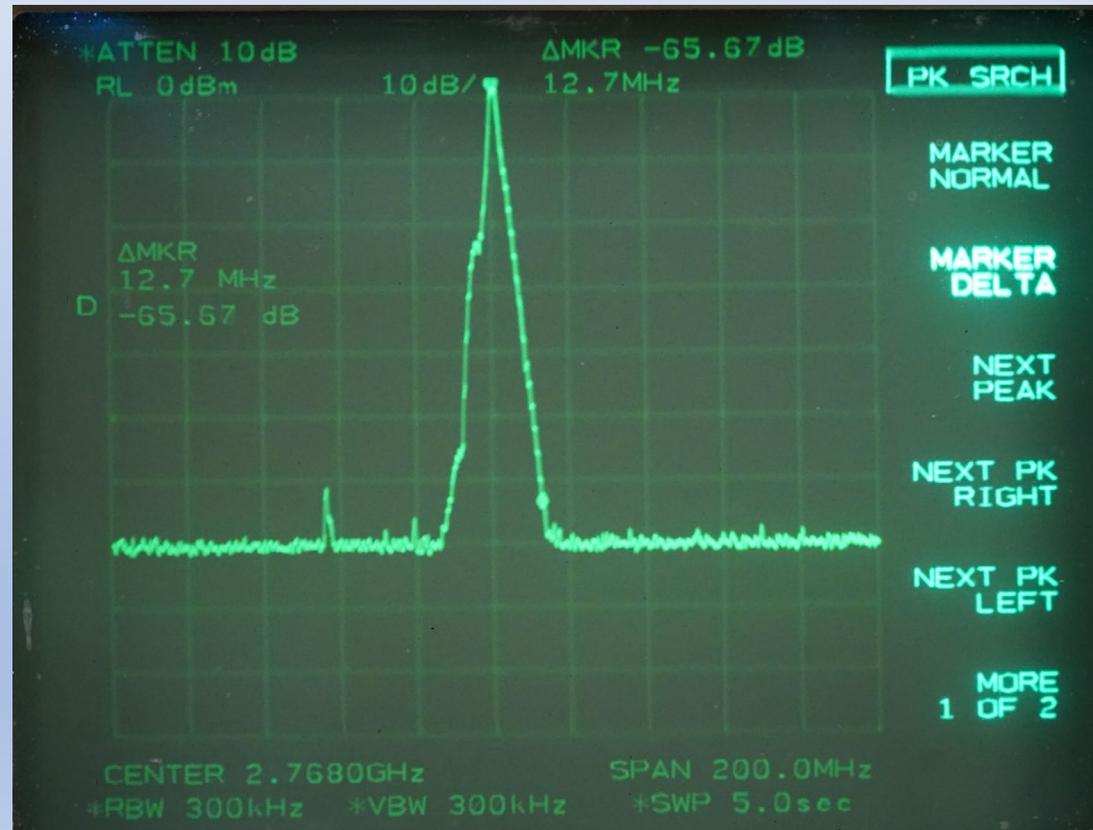
15. **If the -80 dB requirements are not met, and the system is not equipped with a spectrum filter, perform steps 16, 17, and 18 which follow.** If the system is equipped with a spectrum filter and the -80 dB requirements are not met, the spectrum filter is probably defective and should be replaced.

16. If the -80 dB requirement is not met on the low frequency side, lower cavity #2 by one count. Readjust cavity 4 (and 5 if necessary) to achieve proper rise time (150 ± 25 nsec) and pulse shape. Re-evaluate the bandwidth on the low frequency side. Also, in some cases, it may be necessary to readjust the PFN voltage to improve low frequency bandwidth and meet pulse shape and power requirements.

17. If the -80 dB requirement is not met on the high frequency side and the -40 dB requirement is met, lower cavity #3 by 3 counts. Readjust cavity 4 (and 5 if necessary) to achieve proper rise time (150 ± 25 nsec) and pulse shape. Re-evaluate the bandwidth on the high frequency side.

NOTE
When viewing affects of cavity tuning it is best to set the scan rate to 1 second on the spectrum analyzer. Also, the spectrum analyzer must be set in a mode that allows the trace to refresh as adjustments are made (i.e., not MAX HOLD A).

18. If the -80 dB requirement is still not met on the high frequency side, repeat step 17 as necessary, but only lowering cavity #3 one additional count at a time. This can be repeated as many as three times (cavity #3 as much as 6 counts below its initial setting).

19. Perform the following steps to check the spectral purity of the Pulse Shaper A5 output at \3A5J4. **Steps 19 through 31 are only required if the spectrum requirements cannot be met by cavity tuning or if real anomalous spurs exist** (see NOTE before step 13).

20. In `AME/Receiver Control` window, select the following:

Test Source: **NONE**
Click: **Inject Signal**

21. Install an SMA (M)-to-Type-N (F) adapter on A5J4.

22. Disconnect the two variable attenuators and spectrum analyzer from the 4 way splitter shown in Figure 5-15 and connect them to A5J4 using a Type-N test cable.

23. Close the `AME/Receiver Control` window and in the STS menu select **Control ► Transmitter Control** and select the following:

RF Drive/Triggers: **On**

24. Measure the -40 dB and -80 dB half bandwidths as described in steps 4 through 14 above. The same half band width requirements must be met (i.e., -40 dB less than 7.26 MHz and -80 dB less than 72.6 MHz). It may be necessary to adjust the spectrum analyzer's settings or the attenuator settings to optimize the spectrum analyzer's dynamic range (see step 4). If troubleshooting, for anomalous spurs, verify they do not exist out of the pulse shaper.

25. If the spectrum requirements are met at 3A5J4, both RF Generator 4A1 and Pulse Shaper A5 are operating correctly because they are in series. Disconnect all test equipment, reconnect all disconnected cables. Remove and replace the klystron per paragraph 5.3.25 (see NOTE).

NOTE

Before replacing the klystron tube, ensure all previous steps and procedures
have been properly performed. Contact the WSR-88D Hotline, 1-800-643-
3363, for further guidance.

26. If the spectrum requirements are not met at 3A5J4, turn sources off.

27. Remove cable 4/104W129 from the RF Generator 4A1 at 4A1J1.

28. Disconnect the SMA (M)-to-Type-N (F) adapter from A5J4.

29. Connect the adapter to RF Generator 4A1J1.

30. Connect a Type-N cable from the adapter to the attenuator - spectrum analyzer combination.

31. Measure the -40 dB half bandwidth, as described in steps 4 through 8. There is not enough peak power at this point to perform the -80 dB half-bandwidth measurement. If the halfbandwidth requirements cannot be met or if real anomalous spurs exist (see NOTE before step 13), the RF generator is defective and must be replaced. If the RF generator is good, but the output at A5J4 is bad, the Pulse Shaper A5 requires replacement. Replace the defective component and/or components and perform the Transmitter Pulse Width Adjustment TR5 and TR6 procedure, beginning at paragraph 5.5.12.

32. Remove adapter and Type-N cable and reconnect cable 4/104W129 to RF Generator 4A1J1.

33. Close all `System Test Software` windows by clicking **Close**, **File**, and **Exit**. Click **Yes** and **OK** at pop-up windows.

34. Return the system to remote operation by performing the procedures in paragraph 3.4.1.5, steps 3 and 4.