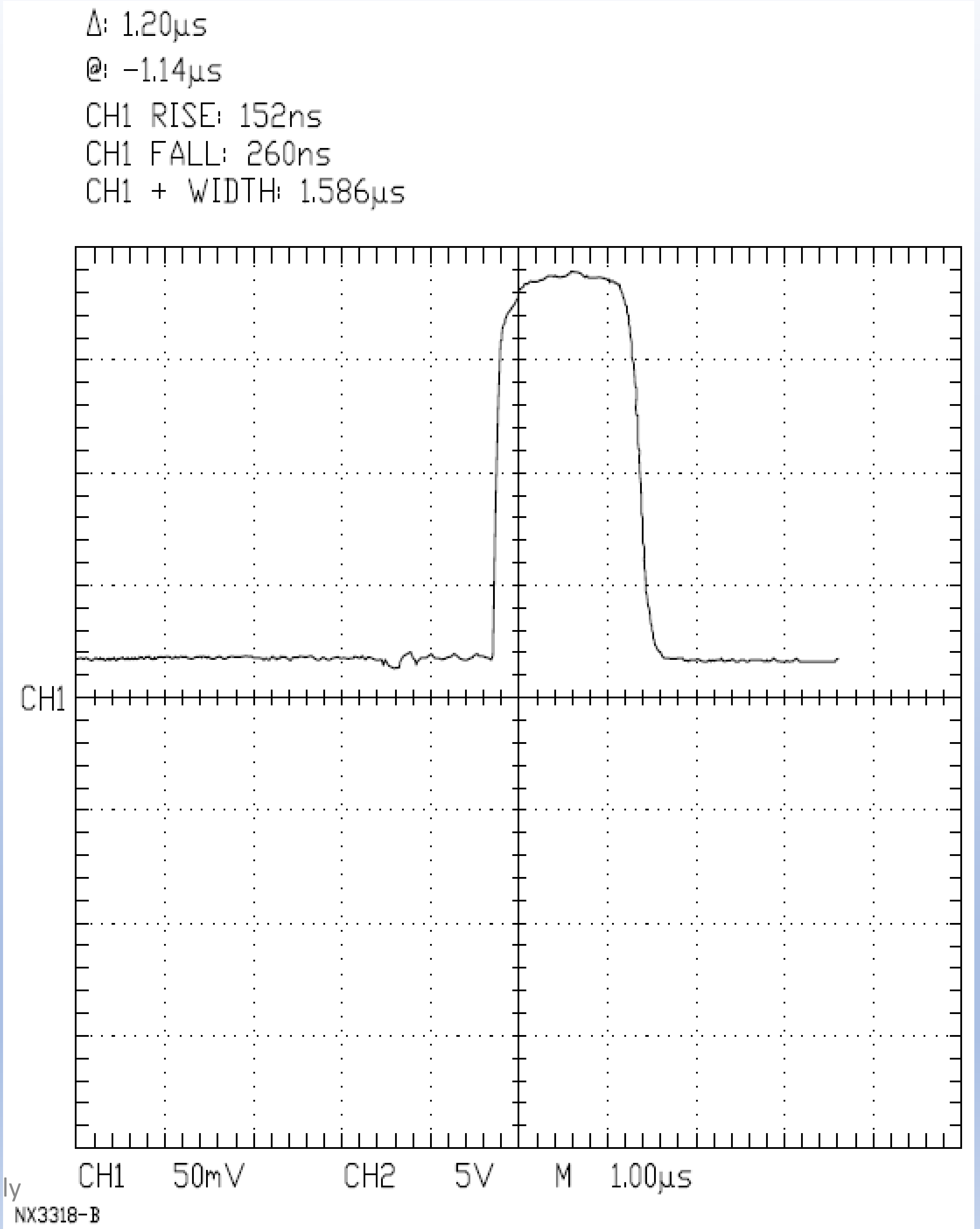
KLYSTRON TRANSMITTER TUNING.

5.5.10 KLYSTRON TRANSMITTER TUNING.

It’s all about the output

This procedure sets the output of the transmitter



The Goal

700 kW ± 50 kW or 88.45 dB ± .30 dB

- Short Pulse
  - Rise time is 150 ± 25 nsec
  - -6dB (50%) pulse width of 1.57 ± .05 µsec
- Long Pulse
  - -6dB (50%) pulse width of 4.71 ± .1 µsec

(We set the pulse width at the -6dB point and then report the -3dB point to the software)

Variable that we will control to get the output pulse to specifications

Pulse Width

PFN Voltage (driving power for tube)

Tube Cavity Tuning

Considerations

- The first place we can measure the tube output is 1AT4, several components downstream of the tube.
- In tuning the tube, we will connect more test equipment than is normally in the system, this increases the variable to the measurement.
- The stronger we turn on the tube (PFN voltage), the sharper the rise time.
- The more we tune the cavities for more power the sharper the rise time.
- Turning the tube on more or more productive cavity tunning reduces the pulse width.
- We must balance the above-mentioned variables to produce the correct output.

5.5.10.2 Initial Conditions/Preliminary Setup.

The following alignments are prerequisites for klystron tuning, ensure they have been performed before proceeding:

- Low Voltage Power Supply Alignment - paragraph 5.5.2
- Filament Current Adjustment - paragraph 5.5.3
- Focus Coil Current Adjustment - paragraph 5.5.4
- RF Drive Adjustment - paragraph 5.5.8
- RF Bracketing Adjustment - paragraph 5.5.9
- PFN Voltage Calibration - paragraph 4.5.5.5

NOTE

If the Klystron was replaced, skip step 1 because the system is already in local control and the transmitter is powered down.

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

2. Calibrate power meter and Power Sensor HP8481H per paragraph 3.4.4.

3. Remove the center bay transmitter cabinet door.

We should already be here

4. Record the following information from the klystron nameplate located on the klystron tube.

Tube Manufacturer___________________________

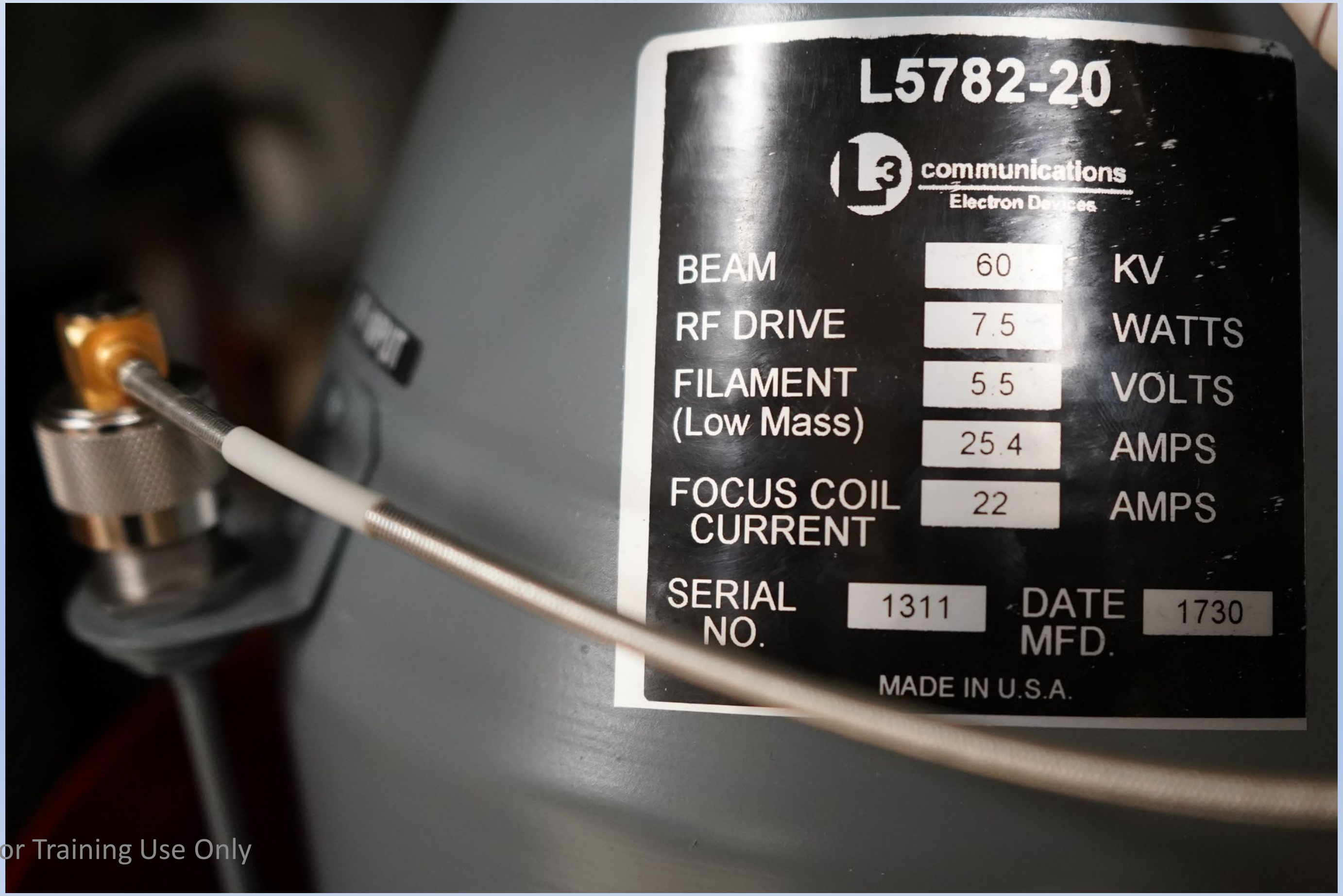
RF DRIVE_____________________________Watts

FILAMENT____________________________Amps

FOCUS COIL CURRENT________________Amps

Serial Number_________________________________

Litton is now L3



5. Locate the klystron data sheet. If the data sheet is missing, or the serial number does not match, contact the WSR-88D Hotline, 1-800-643-3363, for help in obtaining a valid data sheet.

L3 Electron Devices

TEST	SYMBOL	RESULTS	MIN	MAX	UNITS
HOLDING PERIOD	t	4 Days	48	–	hours
VACUUM after holding period		0	–	1.0	μA
AIR FLOW	Q	189	160	–	cfm
SOLENOID CURRENT	Isol	21.0	–	25	Adc
SOLENOID VOLTAGE	Esol	55.7	–	100	Vdc
HEATER VOLTAGE *	Ef	5.5	5.0	7.0	Vac
HEATER CURRENT *	If	25.3	20	32	Aac
CATHODE CURRENT @ epy = 60 kV	ik	30.4	26.4	31.5	A
EMISSION @ Ef = NPV - 0.5V	ΔIk	1.3	–	2	A
OPERATING CONDITIONS					
BEAM VOLTAGE NOTE 3	epy	60	–	62	kV
CATHODE CURRENT NOTE 3	ik	30.4	–	–	A
PULSE REPETITION FREQ. NOTE 4	PRF	478			
PULSE WIDTH (epy) NOTE 4	tp(epy)	6.9	–	–	μs
PULSE WIDTH (rf)	tp(rf)	4.18	–	–	μs
DRIVE POWER	pd	OPERATE at 7.5	–	7.5	W
X-RADIATION @ 0 rf drive	XR	.01	–	2.0	mR/h

POWER MEASUREMENTS & TUNER CHARACTERISTICS

FREQ. MHz	TUNER SETTINGS (NOTE 1, 2) 1	2	3	4	5	6	OUTPUT POWER .75 MW (min)	EFFICIENCY 43% (min)	X-RAY 2mR/h (max)
2700	30	25	30	22	19	31	.82	45.0	.10
2720	32	27	32	25	21	32	.82	45.0	.04
2740	34	30	34	29	24	34	.79	43.3	.04
2760	38	33	37	32	26	35	.82	45.0	.04
2780	41	35	40	34	29	39	.82	45.0	.09
2800	44	38	44	37	33	42	.81	44.4	.05
2820	48	41	48	39	36	43	.79	43.3	.03
2840	51	45	52	42	39	46	.83	45.5	.13
2860	54	48	56	46	43	51	.82	45.0	.09
2880	58	52	60	50	47	56	.83	45.5	.10
2900	63	55	65	54	50	60	.81	44.4	.08
2920	68	60	70	58	56	67	.82	45.0	.06
2940	73	64	74	63	60	72	.81	44.4	.09
2960	79	68	79	68	66	78	.81	44.4	.07
2980	83	73	86	71	71	85	.81	44.4	.07
3000	90	79	95	76	78	94	.79	43.3	.07

PHASE SENSITIVITY (Measured at f_0=2900 MHz) N/A °/kV

NOTES:
1. "O" reference on tuners is counter-clockwise rotation stop
2. Cavity tuning indicator #1 is the lowest indicator (@ cathode end)
3. Measured at pulse flat top
4. PRF and pulse width adjusted to give a video duty = .0033, pulse width at 70% amplitude

* Roll-off data attached ☐

TESTED BY: JM DATE: 7/18/14
MECH. CHECK BY: DATE: 7/21/14
TEST SUPERVISOR: DATE: 7/23/14
L-3 Q.A.: DATE: JUL 25 2014

TEST DATA SHEET
L5782-20 Klystron
SER NO: 936

AUG 2014 ACCEPTED K. McCurry NWS/NRC

FORM: 0486377 REV: A ECO 75848 APPROVAL DATE: 11-15-2013 PAGES 1 OF 1

L-3 COMMUNICATIONS PROPRIETARY

CPI Communications & Power Industries microwave power products division

TEST PERFORMANCE SHEET
PULSED KLYSTRON AMPLIFIER
VKS-8287/VKS-8287A
SERIAL NO. 1189

Test Procedure: 5.484
ECO: KG611391
Date: August 19, 2013
Rev. F
Page 11 of 12

Sheet 1 of 2

	Ef Vac	epy kV	pd W (Max)	Frequency MHz (Min)	Frequency MHz (Max)	tp (epy)* μsec	tp (rf)* μsec	tk min (Min)	Air Flow cfm	Isol Adc (Max)
TEST CONDITION 1:	NPV	NPV	9	2700	3000	3.25	2.75	12	160	25

Test Proc. No.	Test	Symbol	Limits Min	Max.	Results	Units
6.1	**Hold Period:** No Voltages	t	48	- - -	96	hours
	Vacuum Test: No operating voltages	P	- - -	10–7	1.0x10-9	torr
6.2	**Heater Voltage:** TC1	Ef	5.0	7.0	5.5	Vac
	Heater Current @ Ef = NPV	If	20	32	26.6	Aac
6.3	**Solenoid Current**	Isol	- - -	25	21.0	Adc
6.4	**Cathode Current:** TC1	ik	26.4	31.5	30.8	a
	except epy = 60 kV					a
6.5	**Emission:** TC1, except epy = 60 kV					
	Ef = NPV –0.5 V	Δik	- - -	2.0	0.4	a
6.6	**Power Output:** TC1	po	0.75	- - -	See Table	Mw
	Beam Voltage	epy	- - -	65	60	kV
	Cathode Current	ik	- - -	- - -	30.8	a
	Bandwidth @ –0.5 dB	BW	15	- - -	See Table	MHz
	Inverse Beam Voltage	epx	- - -	- - -	18.6	kV
	Drive Power	pd	- - -	9	See Table	W
	Efficiency	Eff	43	- - -	See Table	%
6.7	**X-radiation,** Probe Distance = 12"	XR	- - -	2	See Table	mR/hr
	X-radiation @ pd = 0, Probe Distance = 12"	XR	- - -	2	0.1	mR/hr

CAUTION:
(1) All voltages are with respect to cathode. For safety, external package must be grounded.
(2) If dc heater voltage is used on this device, the heater must be negative with respect to the heater-cathode.

PRODUCT TYPE	OUTLINE DRAWING NO.	PRODUCT SAFETY REVIEW
VKS-8287	093411	026369
VKS-8287A	099812	026369

Visual and Mechanical Product Examination: *Inspected By* CPI-MPP QA68 Date AUG 19 2014

Tested By: Larry Huff L.L. Date: 08-14-14 CPI QA: AUG 19 2014 CPI MPP QA1

Communications & Power Industries LLC • Microwave Power Products Division • P.O. Box 50750 • Palo Alto • California • 94303-0750

For Training Use Only

CPI Communications & Power Industries microwave power products division

TEST PERFORMANCE SHEET
PULSED KLYSTRON AMPLIFIER
VKS-8287/VKS-8287A
SERIAL NO. 1189

Test Procedure: 5.484
ECO: KG611391
Date: August 19, 2013
Rev. F
Page 12 of 12

Sheet 2 of 2

Test Condition 1: Same as TPS 1

Freq. (MHz)	Digital Cavity Tuning Indicator 1	2	3	4	5	6	po ≥0.75 Mw	Eff ≥43	BW ≥15 MHz	X-ray ≤2 mR	pd ≤9 W
2700	33	33	40	30	30	31	0.99	53.5	28	0.1	2.0
2720	35	35	43	32	32	33	0.99	53.5	28	---	2.0
2740	38	38	45	34	34	36	0.99	53.5	27	---	2.0
2760	41	41	49	37	36	39	0.99	53.5	28	---	2.0
2780	44	44	52	40	38	42	0.99	53.5	27	---	2.0
2800	47	46	55	42	41	44	0.99	53.5	26	0.1	2.0
2820	51	50	59	45	43	47	0.99	53.5	26	---	2.0
2840	55	54	63	50	45	50	0.99	53.5	27	---	2.0
2860	59	58	67	54	47	54	0.98	53.0	29	---	2.0
2880	63	61	72	56	51	58	0.98	53.0	27	---	2.0
2900	68	66	77	60	54	65	0.98	53.0	26	0.1	2.0
2920	73	71	83	65	57	68	0.98	53.0	29	---	2.0
2940	78	75	88	69	61	72	0.98	53.0	27	---	2.0
2960	84	81	95	73	65	78	0.98	53.0	28	---	2.0
2980	91	88	103	79	70	83	0.96	51.9	30	---	2.0
3000	99	94	110	85	74	89	0.96	51.9	30	0.1	2.0

NOTE: "O" reference on tuners is counterclockwise rotation stop.
Digital cavity tuning indicator number 1 is the lowest indicator (near the cathode end of the klystron).

Tested By: Larry Huff L.L. Date: 08-14-14 CPI QA: AUG 19 2014 CPI MPP QA1

Communications & Power Industries LLC • Microwave Power Products Division • P.O. Box 50750 • Palo Alto • California • 94303-0750

Voltages and Currents of the tubes are listed

L3 Electron Devices

TEST	SYMBOL	RESULTS	MIN	MAX	UNITS
HOLDING PERIOD	t	4 Days	48	–	hours
VACUUM after holding period		0	–	1.0	µA
AIR FLOW	Q	189	160	–	cfm
SOLENOID CURRENT	Isol	21.0	–	25	Adc
SOLENOID VOLTAGE	Esol	55.7	–	100	Vdc
HEATER VOLTAGE *	Ef	5.5	5.0	7.0	Vac
HEATER CURRENT *	If	25.3	20	32	Aac
CATHODE CURRENT @ epy = 60 kV	ik	30.4	26.4	31.5	A
EMISSION @ Ef = NPV - 0.5V	ΔIk	1.3	–	2	A
OPERATING CONDITIONS					
BEAM VOLTAGE NOTE 3	epy	60	–	62	kV
CATHODE CURRENT NOTE 3	ik	30.4	–	–	A
PULSE REPETITION FREQ. NOTE 4	PRF	478			
PULSE WIDTH (epy) NOTE 4	tp(epy)	6.9	–	–	µs
PULSE WIDTH (rf)	tp(rf)	4.18	–	–	µs
DRIVE POWER	pd	OPERATE at 7.5	–	7.5	W
X-RADIATION @ 0 rf drive	XR	.01	–	2.0	mR/h

	Ef Vac	epy kV	pd W (Max)	Frequency MHz (Min)	Frequency MHz (Max)	tp (epy)* µsec	tp (rf)* µsec	tk min (Min)	Air Flow cfm	Isol Adc (Max)
TEST CONDITION 1:	NPV	NPV	9	2700	3000	3.25	2.75	12	160	25

Test Proc. No.	Test	Symbol	Limits Min	Limits Max.	Results	Units
6.1	**Hold Period:** No Voltages	t	48	- - -	96	hours
	Vacuum Test: No operating voltages	P	- - -	10^{-7}	1.0x10-9	torr
6.2	**Heater Voltage:** TC1	Ef	5.0	7.0	5.5	Vac
	Heater Current @ Ef = NPV	If	20	32	26.6	Aac
6.3	**Solenoid Current**	Isol	- - -	25	21.0	Adc
6.4	**Cathode Current:** TC1	ik	26.4	31.5	30.8	a
	except epy = 60 kV					a
6.5	**Emission:** TC1, except epy = 60 kV Ef = NPV –0.5 V	Δik	- - -	2.0	0.4	a
6.6	**Power Output:** TC1	po	0.75	- - -	See Table	Mw
	Beam Voltage	epy	- - -	65	60	kV
	Cathode Current	ik	- - -	- - -	30.8	a
	Bandwidth @ –0.5 dB	BW	15	- - -	See Table	MHz
	Inverse Beam Voltage	epx	- - -	- - -	18.6	kV
	Drive Power	pd	- - -	9	See Table	W
	Efficiency	Eff	43	- - -	See Table	%
6.7	**X-radiation,** Probe Distance = 12"	XR	- - -	2	See Table	mR/hr
	X-radiation @ pd = 0, Probe Distance = 12"	XR	- - -	2	0.1	mR/hr

CAUTION:
(1) All voltages are with respect to cathode. For safety, external package must be grounded.
(2) If dc heater voltage is used on this device, the heater must be negative with respect to the heater-cathode.

6. From the klystron data sheet, determine the manufacturers setting from the site frequency. It may be necessary to interpolate values if the site frequency is not listed. Make a list of settings.

POWER MEASUREMENTS & TUNER CHARACTERISTICS

FREQ. MHz	TUNER SETTINGS (NOTE 1, 2)						OUTPUT POWER	EFFICIENCY	X-RAY
	1	2	3	4	5	6	.75 MW (min)	43% (min)	2mR/h (max)
2700	30	25	30	22	19	31	.82	45.0	.10
2720	32	27	32	25	21	32	.82	45.0	.04
2740	34	30	34	29	24	34	.79	43.3	.04
2760	38	33	37	32	26	35	.82	45.0	.04
2780	41	35	40	34	29	39	.82	45.0	.09
2800	44	38	44	37	33	42	.81	44.4	.05
2820	48	41	48	39	36	43	.79	43.3	.03
2840	51	45	52	42	39	46	.83	45.5	.13
2860	54	48	56	46	43	51	.82	45.0	.09
2880	58	52	60	50	47	56	.83	45.5	.10
2900	63	55	65	54	50	60	.81	44.4	.08
2920	68	60	70	58	56	67	.82	45.0	.06
2940	73	64	74	63	60	72	.81	44.4	.09
2960	79	68	79	68	66	78	.81	44.4	.07
2980	83	73	86	71	71	85	.81	44.4	.07
3000	90	79	95	76	78	94	.79	43.3	.07

PHASE SENSITIVITY (Measured at f_0=2900 MHz) N/A °/ kV

Freq. (MHz)	Digital Cavity Tuning Indicator						po	Eff	BW	X-ray	pd
	1	2	3	4	5	6	≥0.75 Mw	≥43	≥15 MHz	≤2 mR	≤9 W
2700	33	33	40	30	30	31	0.99	53.5	28	0.1	2.0
2720	35	35	43	32	32	33	0.99	53.5	28	---	2.0
2740	38	38	45	34	34	36	0.99	53.5	27	---	2.0
2760	41	41	49	37	36	39	0.99	53.5	28	---	2.0
2780	44	44	52	40	38	42	0.99	53.5	27	---	2.0
2800	47	46	55	42	41	44	0.99	53.5	26	0.1	2.0
2820	51	50	59	45	43	47	0.99	53.5	26	---	2.0
2840	55	54	63	50	45	50	0.99	53.5	27	---	2.0
2860	59	58	67	54	47	54	0.98	53.0	29	---	2.0
2880	63	61	72	56	51	58	0.98	53.0	27	---	2.0
2900	68	66	77	60	54	65	0.98	53.0	26	0.1	2.0
2920	73	71	83	65	57	68	0.98	53.0	29	---	2.0
2940	78	75	88	69	61	72	0.98	53.0	27	---	2.0
2960	84	81	95	73	65	78	0.98	53.0	28	---	2.0
2980	91	88	103	79	70	83	0.96	51.9	30	---	2.0
3000	99	94	110	85	74	89	0.96	51.9	30	0.1	2.0

NOTE: "O" reference on tuners is counterclockwise rotation stop.
Digital cavity tuning indicator number 1 is the lowest indicator (near the cathode end of the klystron).

6. From the klystron data sheet, determine the manufacturers setting from the site frequency. It may be necessary to interpolate values if the site frequency is not listed. Make a list of settings.

Site Frequency	Cavity Number	Dial Setting
______________	6 (top)	___________
	5	___________
	4	___________
	3	___________
	2	___________
	1 (bottom)	___________

Site Frequency	Cavity Number	Dial Setting
__2800________	6 (top)	___44_____
	5	___41_____
	4	___42_____
	3	___55_____
	2	___46_____
	1 (bottom)	___47_____

Freq. (MHz)	Digital Cavity Tuning Indicator					
	1	2	3	4	5	6
2700	33	33	40	30	30	31
2720	35	35	43	32	32	33
2740	38	38	45	34	34	36
2760	41	41	49	37	36	39
2780	44	44	52	40	38	42
2800	47	46	55	42	41	44
2820	51	50	59	45	43	47
2840	55	54	63	50	45	50
2860	59	58	67	54	47	54
2880	63	61	72	56	51	58
2900	68	66	77	60	54	65
2920	73	71	83	65	57	68
2940	78	75	88	69	61	72
2960	84	81	95	73	65	78
2980	91	88	103	79	70	83
3000	99	94	110	85	74	89

6. From the klystron data sheet, determine the manufacturers setting from the site frequency. It may be necessary to interpolate values if the site frequency is not listed. Make a list of settings.

Frequency In MHz	1 Bottom	2	3	4	5	6 Top	
2760	41	41	49	37	36	39	Data sheet values for 2760
2780	44	44	52	40	38	42	Data sheet values for 2780
Dial Diff	3	3	3	3	2	3	2780 value – 2760 value =
Diff / 20Mhz	.15	.15	.15	.15	.10	.15	Dial diff / difference in frequency (20MHz)
Offset	1.2	1.2	1.2	1.2	0.8	1.2	Dial diff * offset in MHz (2768-2760=8)
Final value	42.2	42.2	50.2	38.2	36.8	40.2	2760 value + Dial diff =

Freq. (MHz)	Digital Cavity Tuning Indicator					
	1	2	3	4	5	6
2700	33	33	40	30	30	31
2720	35	35	43	32	32	33
2740	38	38	45	34	34	36
2760	41	41	49	37	36	39
2780	44	44	52	40	38	42
2800	47	46	55	42	41	44

Site Frequency	Cavity Number	Dial Setting
___2768________	6 (top)	___42.2___
	5	___42.2___
	4	___50.2___
	3	___38.2___
	2	___36.8___
	1 (bottom)	___40.2___

7. At the klystron, zero the cavities by performing the following:

a. Insert tuning wand into cavity 1 and rotate CCW until tuning stop is reached. Do not force the adjustments beyond the stop.

b. Set counter to read 00000.

c. Repeat steps a and b for cavities 2 through 6.

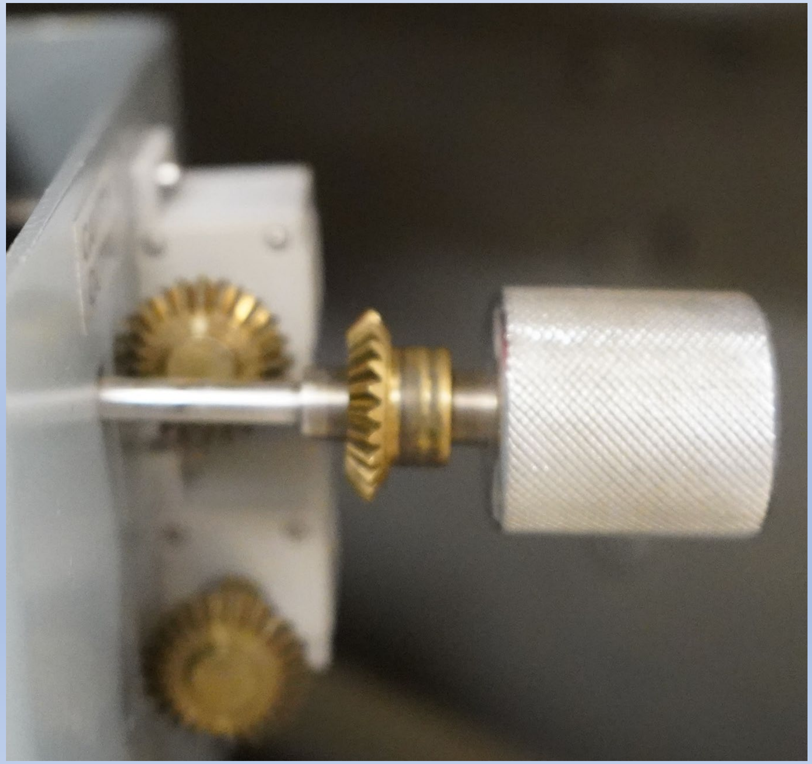
NOTE

Cavity counters may have as much as one full number movement before cavity is engaged. To compensate for this play, begin turning tuning wand CW until resistance is felt. Once resistance is felt, pull tuning wand out slightly and set cavity counter to 0000. Engage tuning wand and continue with cavity tuning. Any offset from perfect zero will need to be accounted for when setting the cavity.

Please read the "Note". It does a good job of explaining what you want to do.

You want to be consistent here:

Use the same amount of resistance to call zero.



8. Set the klystron cavities to the data sheet values interpolated for your site frequency from step 6.

Site Frequency	Cavity Number	Dial Setting
____________	6 (top)	__________
	5	__________
	4	__________
	3	__________
	2	__________
	1 (bottom)	__________

9. Perform paragraph 5.5.10.2.1 only if the klystron tube has been replaced. If only tuning the transmitter, proceed to paragraph 5.5.10.3.

5.5.10.2.1 Break-In Procedure for New Klystron Tube.

This is only needed if you are installing a new tube. You're warming it up slowly and drawing down the vacuum (as seen on the vacuum current meter) in the tube.

1. After klystron installation is complete, set AUXILIARY POWER CB2 to **ON**. This begins the filament preheat period.

2. Set HIGH VOLTAGE POWER CB1 to **ON**.

NOTE

The transmitter can fault out regularly during the break-in process with modulator or klystron current and voltage type faults. Clear the faults and try several times to get the transmitter to stay up. This usually only take a few times for the transmitter to stay up.

3. Check the initial value of the vacuum pump current. Record vacuum pump current.
Initial Vacuum Pump Current ______________µamp

4. After preheat is complete and AVAILABLE lamp is illuminated, check the vacuum pump current is less than 10 µAmps. If not, continue the warm-up period until the vacuum pump current is less than 10 µAmps.

5. Record Variable RF Drive Attenuator AT1 dial setting.
AT1 Dial Setting ____________________

6. Rotate AT1 fully CCW.

7. At Transmitter Control Panel A1, rotate the PFN Voltage Control Potentiometer A1R3 CCW three full turns.

8. 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: **S1**
Click: **Inject Signal**

9. After 20 minutes, rotate the PFN potentiometer A1R3 one full turn CW.

10. Wait an additional 20 minutes, rotate the PFN potentiometer A1R3 one full turn CW.

11. After an additional 20 minutes, adjust A1R3 to set PFN voltage to 4.6, which corresponds to a PFN voltage of 4600V on the PFN Voltage Meter A1M5.

12. Rotate AT1 to the setting noted in step 5.

13. Allow the klystron to burn in for an additional 20 minutes.

14. Note the focus coil current. It shall be equal to data sheet value ± .5A.

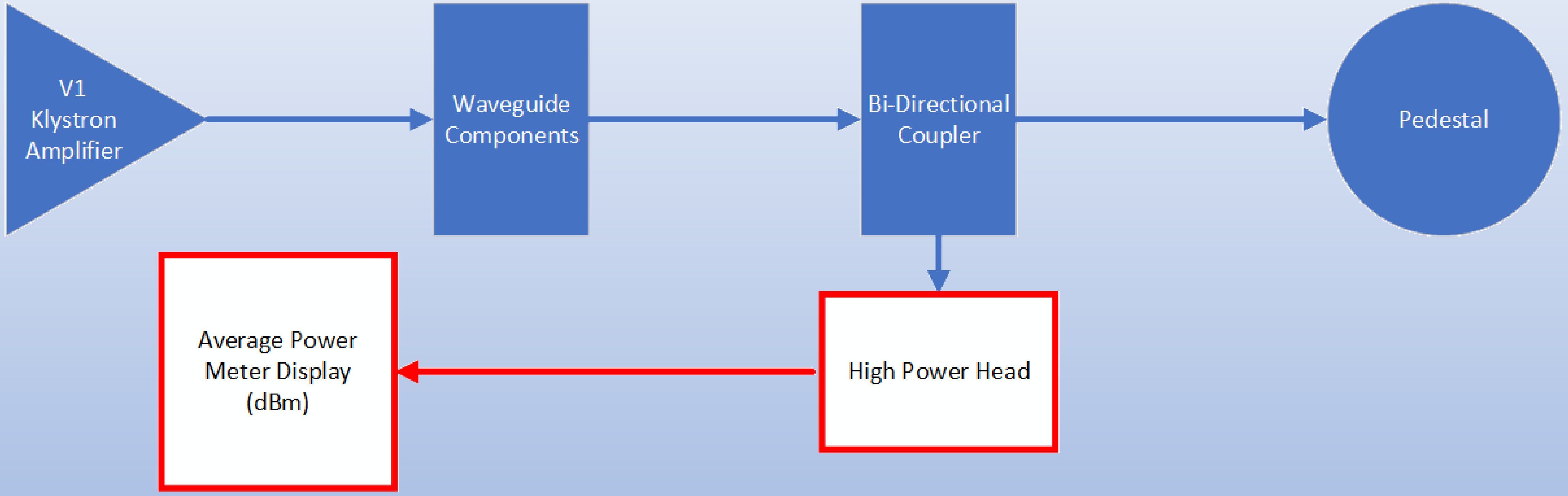
15. In the `AME/Receiver Control` window, select the following:

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

16. Proceed to paragraph 5.5.10.3.

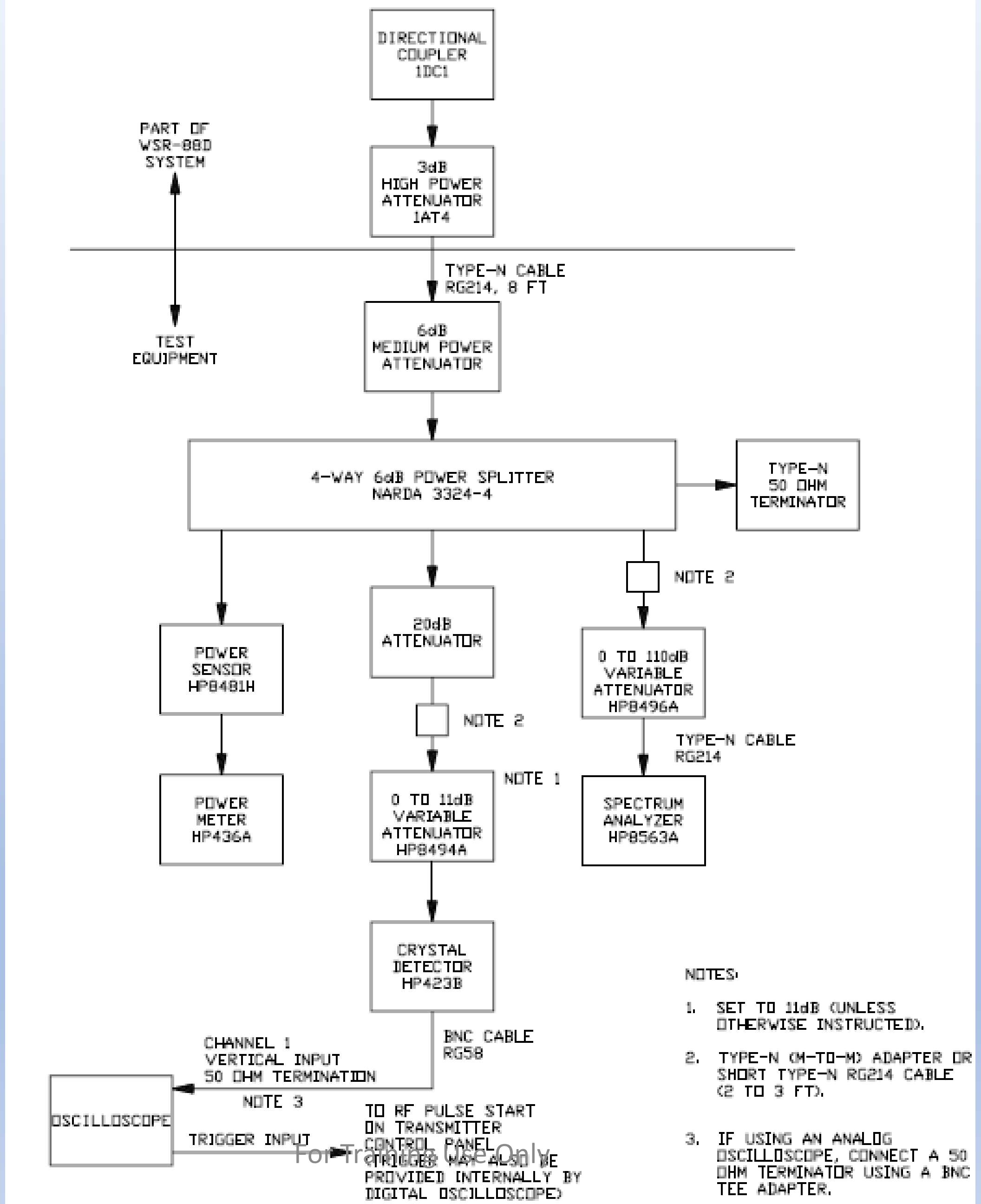
5.5.10.3 Procedure. Steps 1 – 10 measure the equipment test path.

Steps 1-4 measure the power at 1AT4

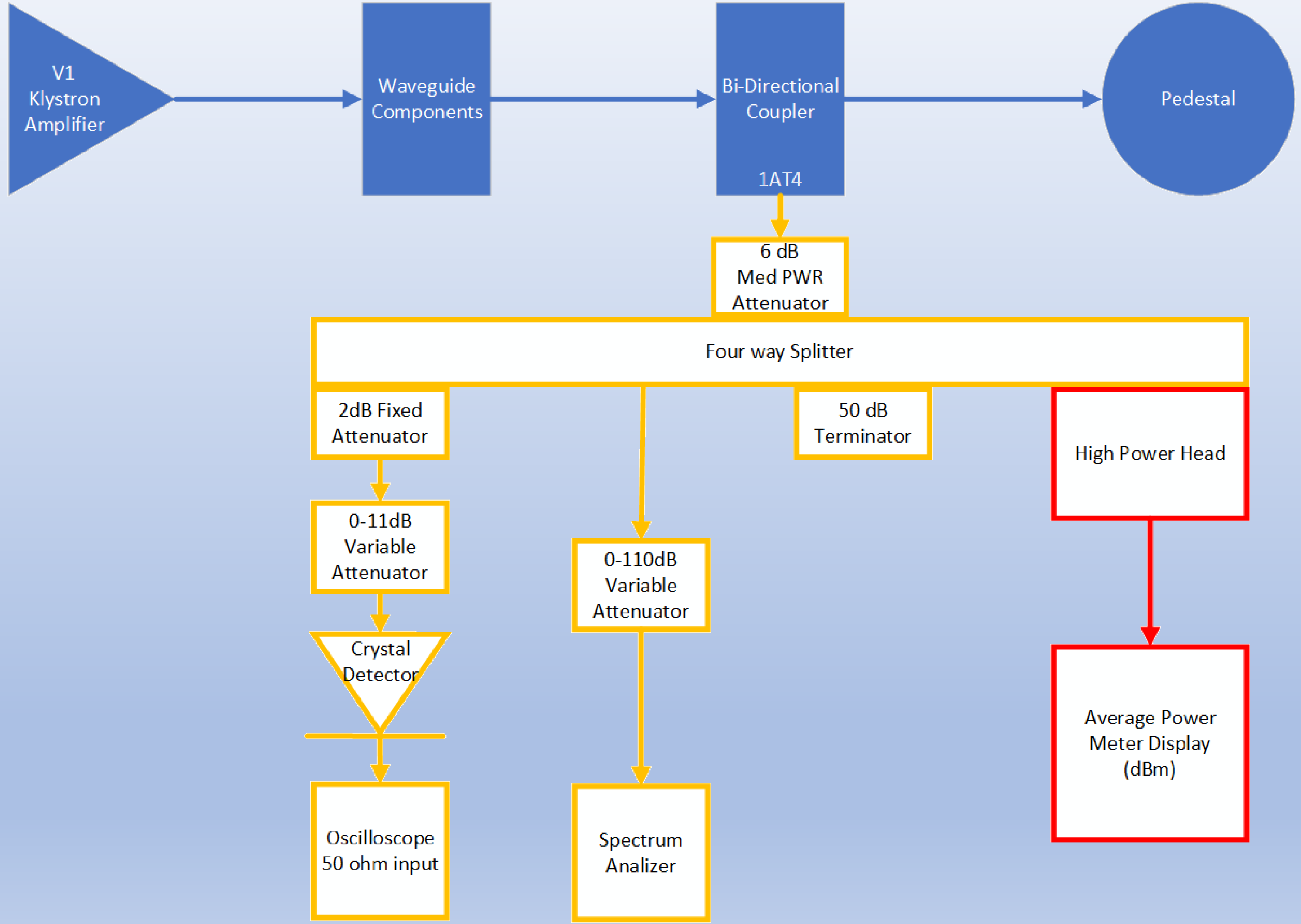


This is the closest to the klystron place that we can make a forward power measurement

Steps 5-9 configure up some test equipment to make measurements associated with the klystron tune.

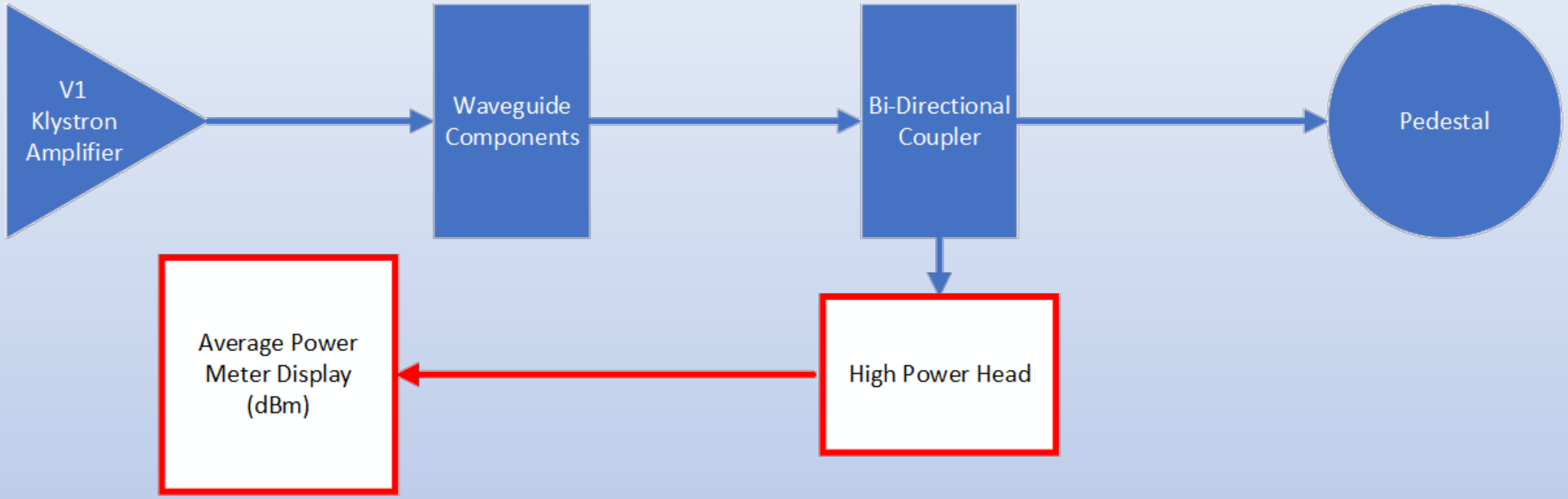


Step 10 measures the power at the 4-way splitter in the test equipment. This measures the loss shown in gold



5.5.10.3 Procedure.

1. Connect Power Sensor HP8481H to Attenuator 1AT4.



2. If not already accomplished, on the Main RDA HCI, click on **System Test Software** and **Yes** to confirm. Click **Control ► AME/Receiver Control**.

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

Test Source: **KLYSTRON OUTPUT**
Pulse Width: **Short Pulse**
PRF: **S1**
Click: **Inject Signal**

4. At Transmitter Control Panel A1, adjust A1R3 until the PFN VOLTAGE Meter A1M5 reads 4.6 which corresponds to a PFN voltage of 4600V.

NWSTC Note: Make sure you set the 4600V ***BEFORE*** *you make the measurement below.*

Allow power meter to stabilize, and record power meter reading:
Power @1AT4________________________dBm

NWSTC Note:
This is part of the math in step 20.

This measurement is compared to the measurement in step 10 to measure the test equipment loss. This power is assumed to not change until after step 10. If this power changes before step 10 is made, then the math in step 20 is off by that amount.

5. In the `AME/Receiver Control` window, select the following:
Test Source: **NONE**
Click: **Inject Signal**

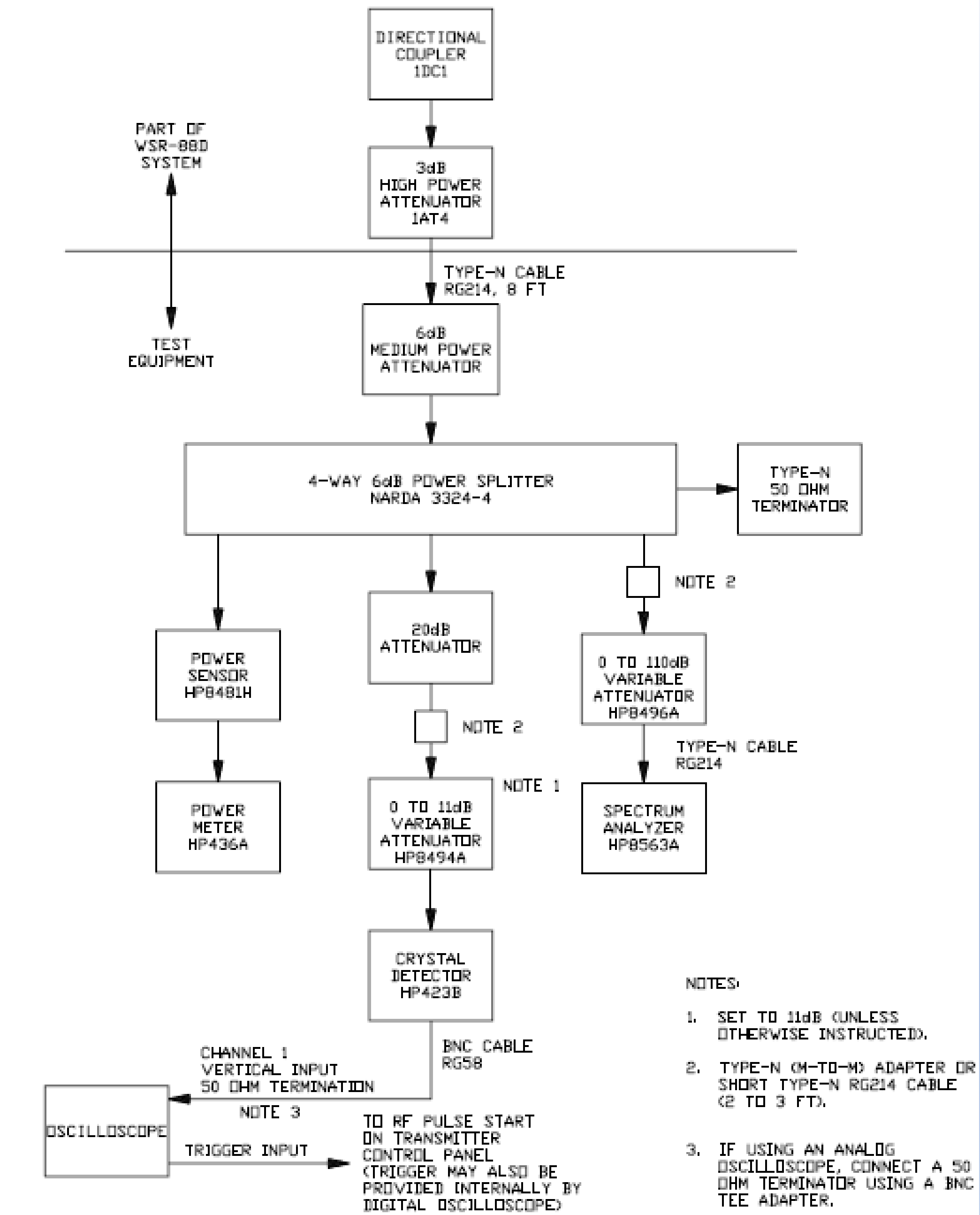
6. Disconnect power meter and sensor from Attenuator 1AT4.

7. Connect test equipment per Figure 5-6.

NWSTC Note:
Build this like figure 5-6, not the simplified NWSTC drawing

8. Set the 0 to 11 dB variable attenuator to 6 dB.

9. In the `AME/Receiver Control` window, select the following:
Test Source: **KLYSTRON OUTPUT**
Pulse Width: **Short Pulse**
PRF: **S1**
Click: **Inject Signal**



10. Allow power meter to stabilize, and record reading.

Power @ 4-way splitter ______________dBm.

NWSTC Note:

If the power meter shows no power or under the lower limit, check the cavity pre-tune and make sure you don't have the top and bottom turned around.

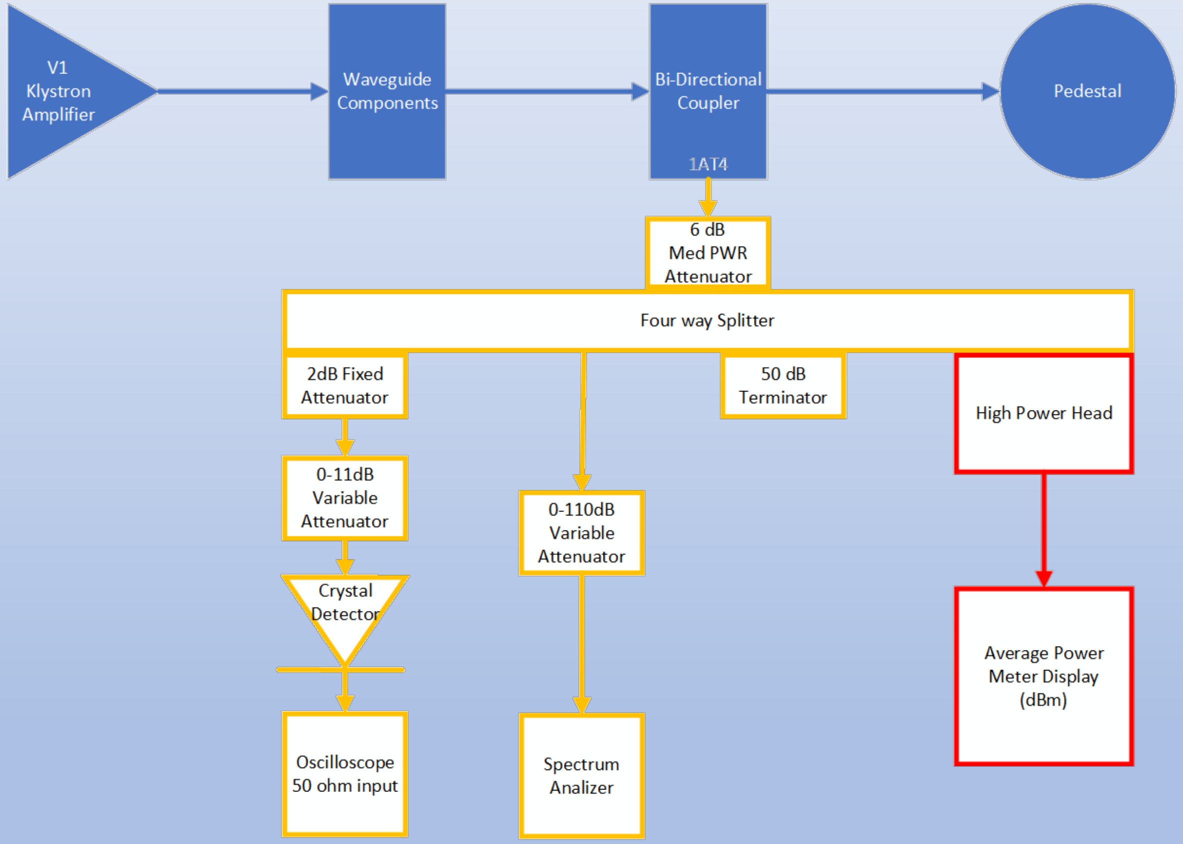
This will give us the loss of the test equipment.

If you are concerned that the klystron power has changed due to cooling while figure 5-6 was built, you can do the following:

Measure the power at the 4 way splitter until you have a stable measurement:

Then quickly turn high voltage off and move the power meter to 1AT4, turn high voltage back on and measure per step 4 and update the measurement.

The important thing is that nothing (tune, pfn voltage or pulse width) has changed between step 4 and step 10.



11. Using the klystron tuning tool, adjust klystron cavities 1 and 6 for peak power reading as observed on the power meter.
12. Set up the oscilloscope to measure the output detected pulse by performing the following:

NOTE

Oscilloscope procedures may vary according to model being used.

a. Trigger the oscilloscope by performing the following. Ensure the oscilloscope is terminated at 50 Ω (internally or externally).

For digital oscilloscopes: Trigger to channel 1, positive slope.

For analog oscilloscopes: Trigger to RF Pulse Start on the Transmitter Control Panel A1.

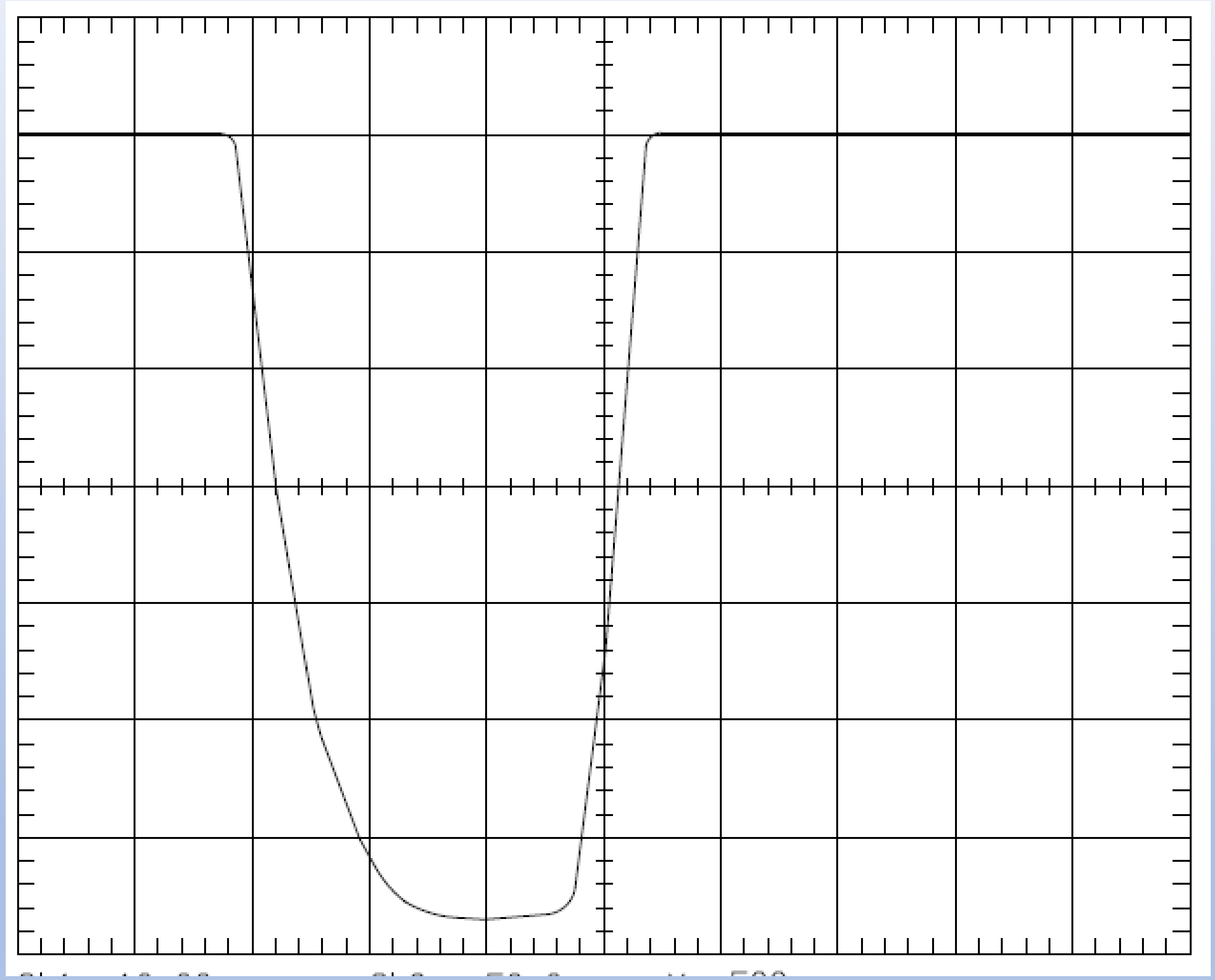
b. Adjust V/division for best displayed pulse. This setting is usually between 10 and 50 mV/cm.

c. Set the time/division to 0.5 µsec/div (500 nsec).

NOTE

If the displayed pulse is a negative going pulse, measure fall time instead of rise time.

13. Observe the waveform is similar to Figure 5-8.



14. Measure the rise time by performing the following:

NOTE
Rise time is measured on the leading edge of the detected pulse between 10% and 90% vertical graticules of the pulse amplitude.

For analog oscilloscope:

a. Use V/div variable knob to set the pulse baseline to 0% and the peak at 100%. When adjusting cavity #4, this knob may need to be adjusted to maintain to 0-100% amplitude.

b. Use cursors to measure rise time between the 10% and 90% marks.

Rise Time ________________nsec

For digital oscilloscope:
c. Press the **MEASUREMENT** button to display the measurement window.

d. Select measurement for channel 1.

e. Select rise time.

f. Set reference levels to 90% for high and 10% for low.

Rise Time ________________nsec

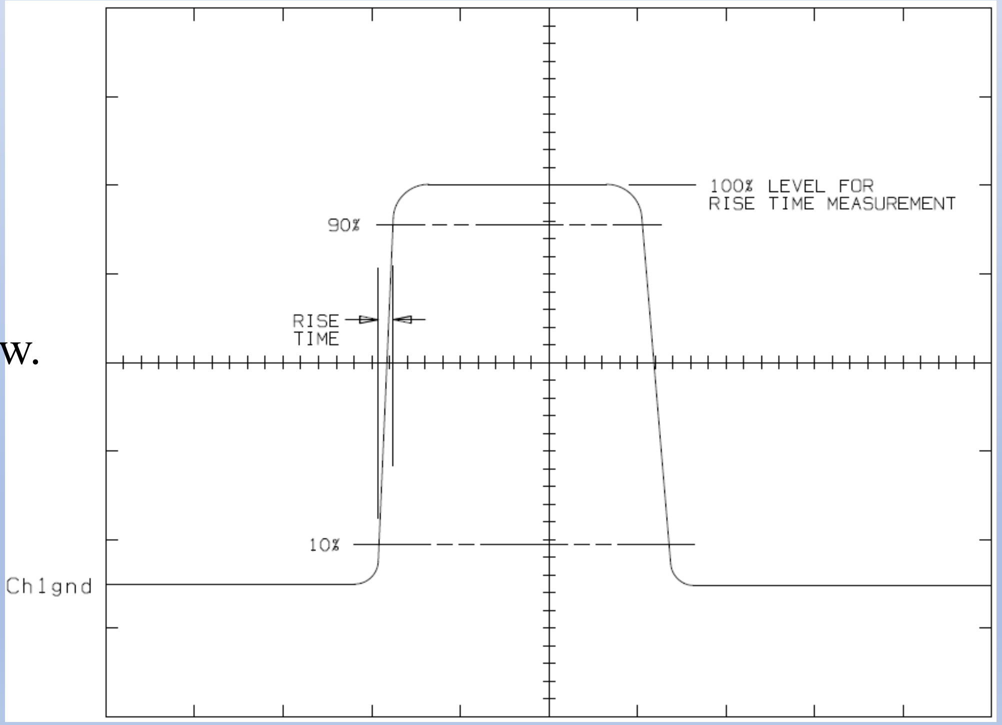
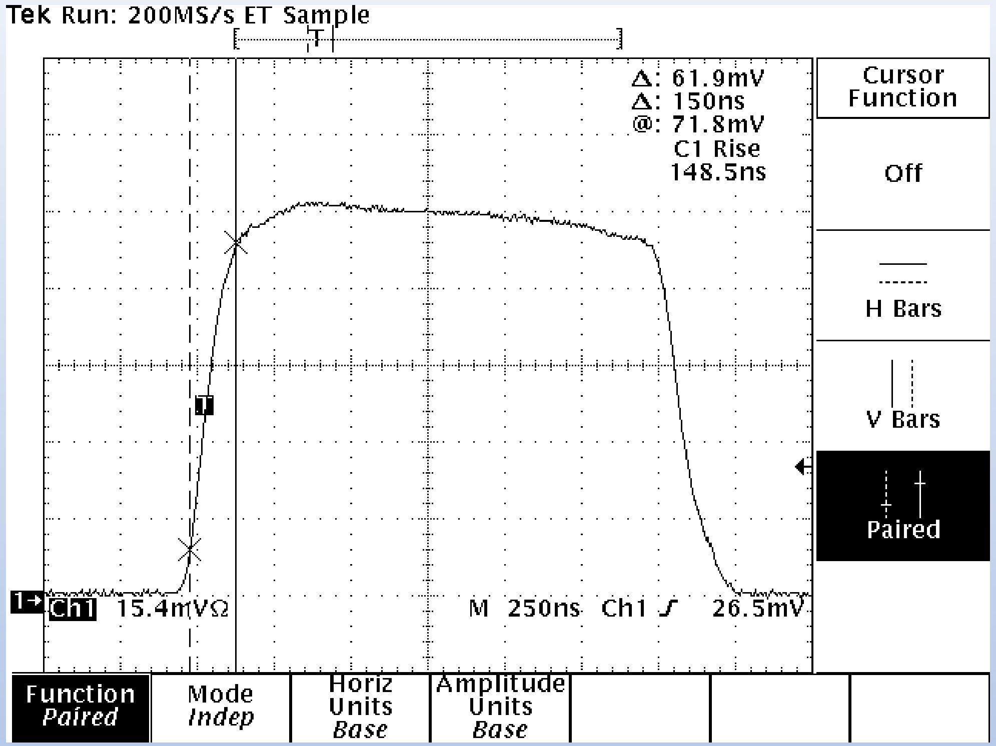


Figure 5-8. Detected Output Pulse

NWSTC Job Aid: Rise time Measurements



Setting an oscilloscope to display is included in the video at the following link
https://www.youtube.com/watch?v=ayl1onqprd4&list=PLYsC5TDceC_YX2TqR3sLmPVebLj_VipU1
TDS420 automatic setup from 0:00-0:35 and 1:00-1:15. Manual setup is shown from 1:15-2:50

15. Tune cavity #4 ONLY to produce a waveform similar to Figure 5-12 which is considerably flatter on the top and has a Rise Time of 150 ± 25 nsec. There is a "sweet spot" in the tuning of cavity #4 just before the waveform starts to deteriorate as shown if Figure 5-13. If the rise time has become too steep, back off the tuning of cavity #4 to obtain a Rise Time of 150 ± 25 nsec.

This has been determined to be the best compromise of a flat top while meeting the radiated spectrum requirements. The ideal waveform is shown in Figure 5-11

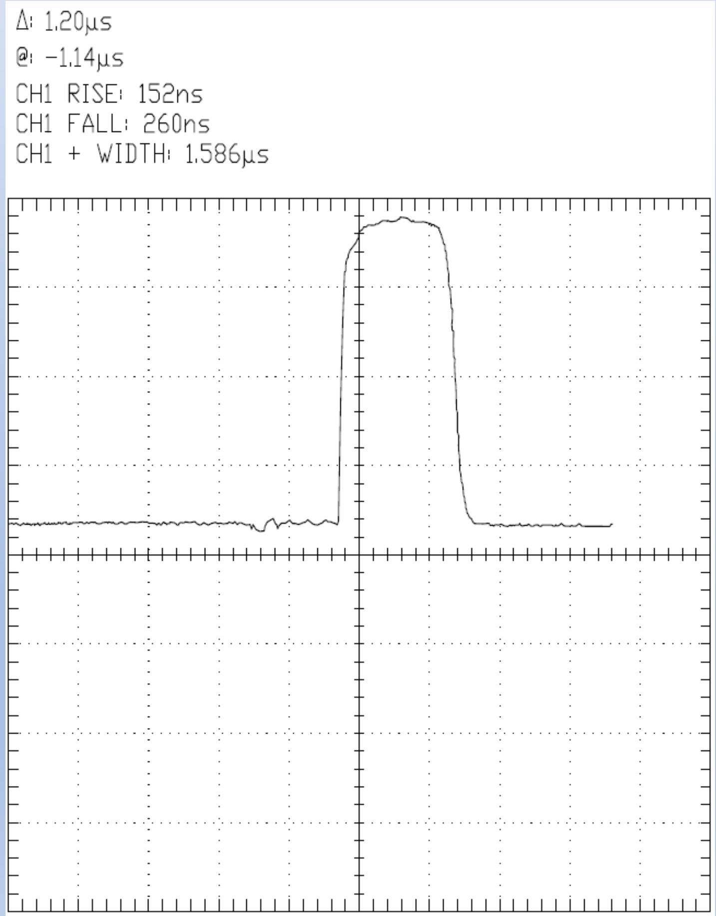


Figure 5-11

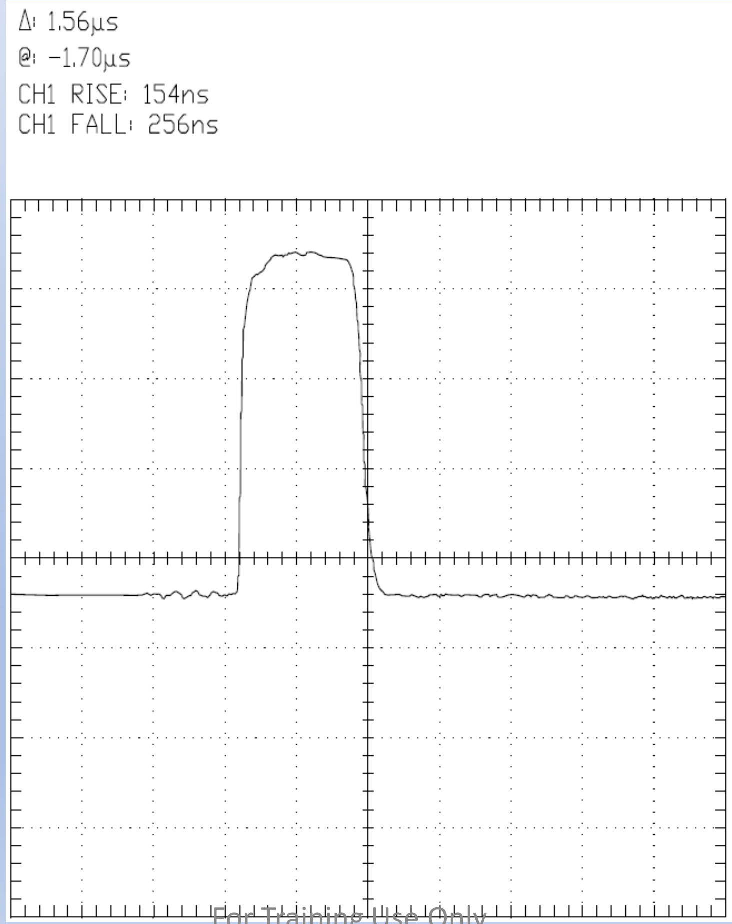


Figure 5-12

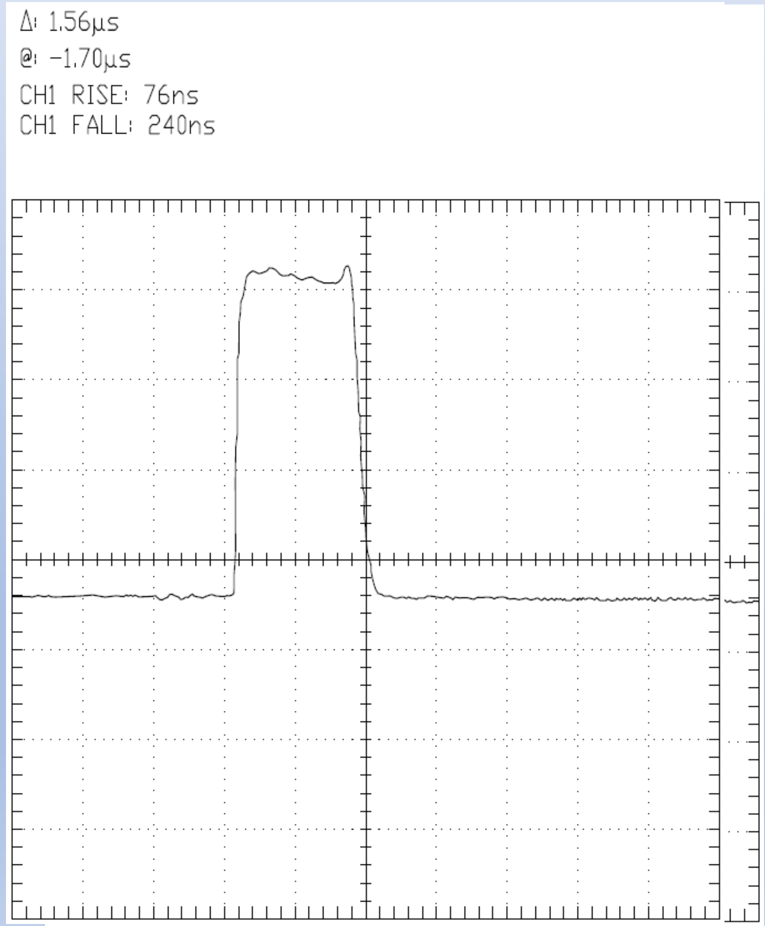
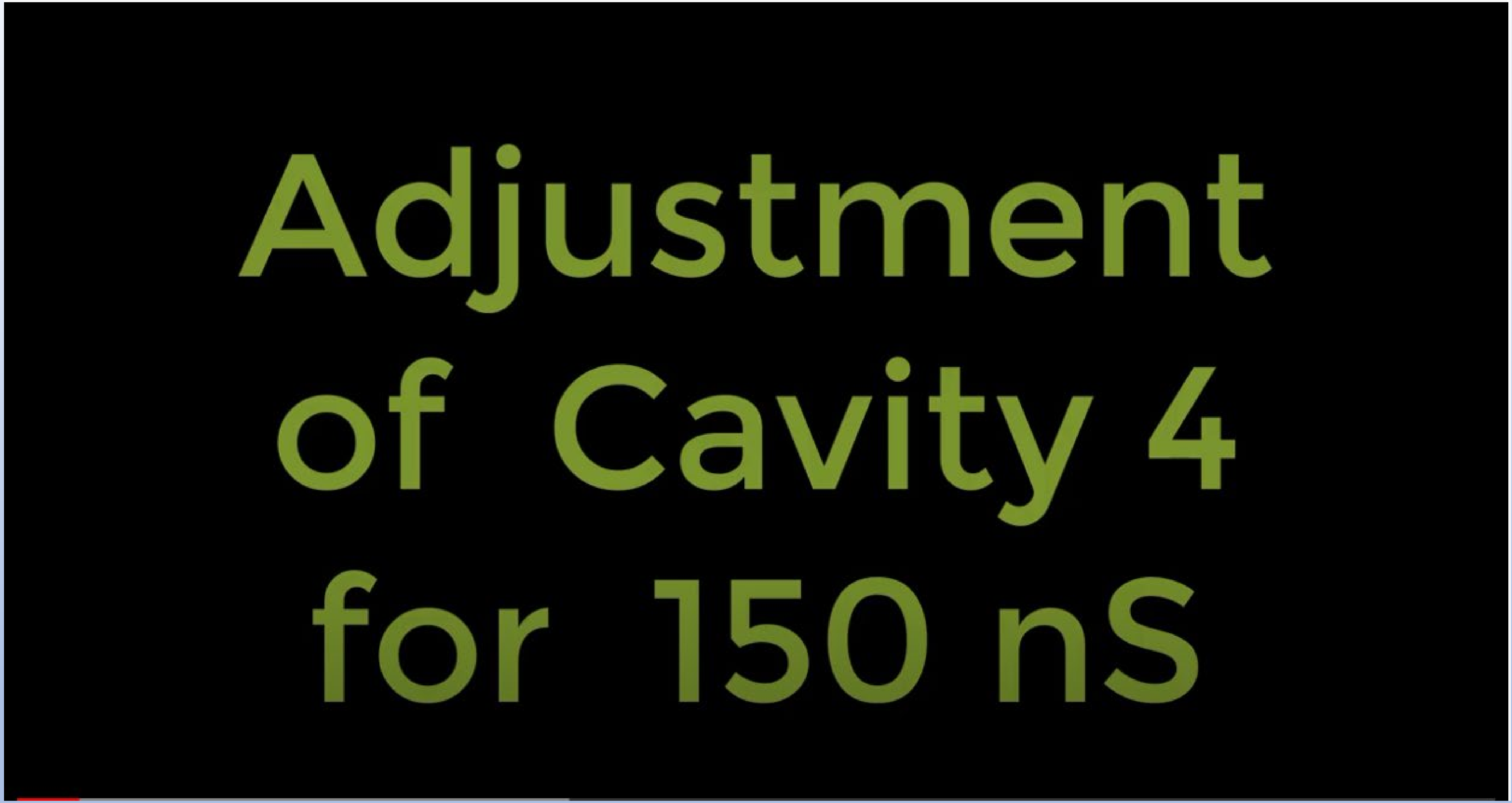


Figure 5-13

NWSTC Job Aid: Cavity 4 adjustment



Adjustment of cavity 4 is included in the video at the following link between 0:35 and 1:00
https://www.youtube.com/watch?v=ayl1onqprd4&list=PLYsC5TDceC_YX2TqR3sLmPVebLj_VipU1

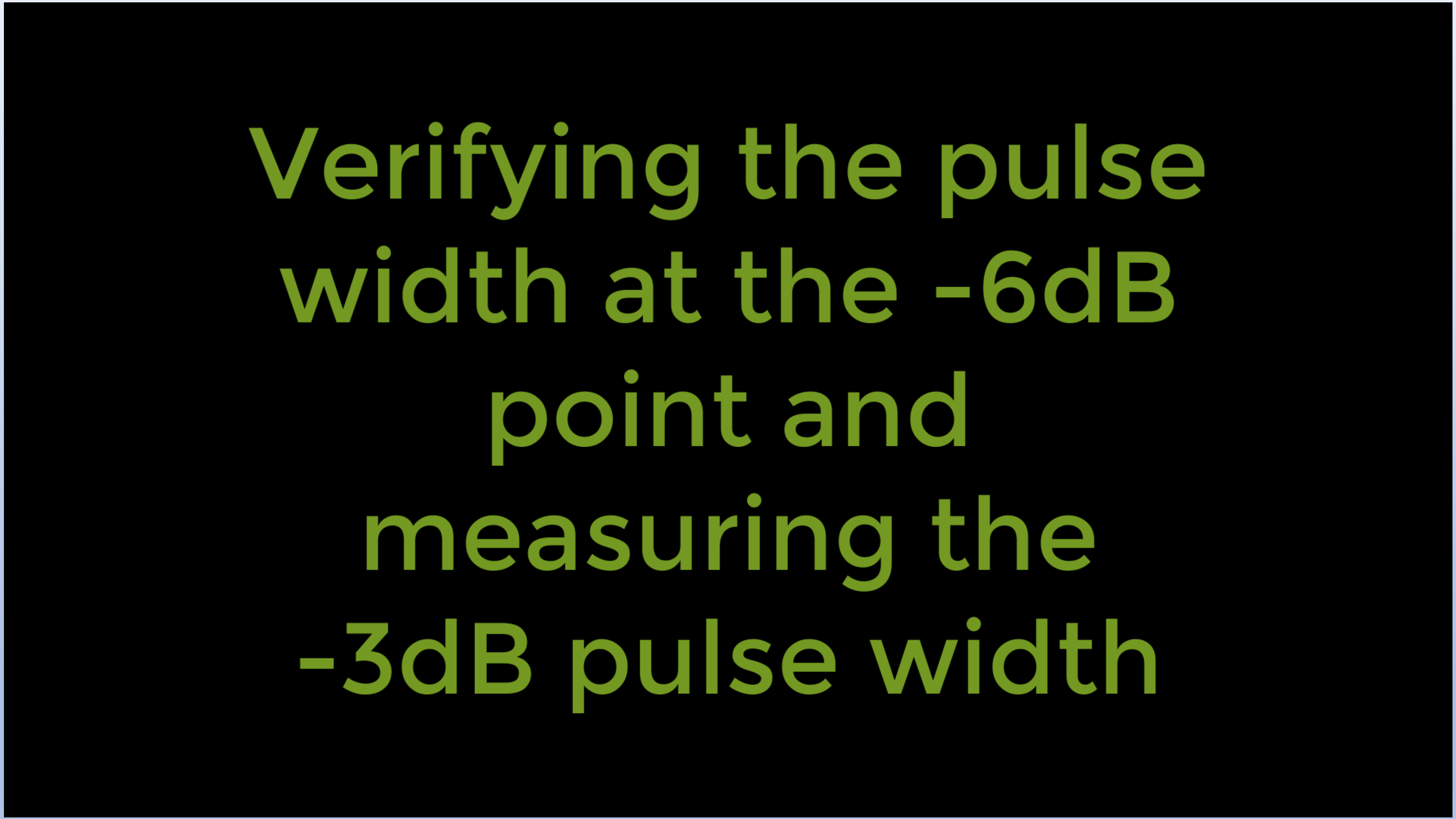
A link will also be found at: https://training.weather.gov/nwstc/NEXRAD/transmitter/index.html

-6dB pulse width measurement and adjustment

-3dB pulse width measurement

- The idea is to put your pulse on the screen with the top of the pulse on the center graticule.
- Remove 6dB from the circuit.
- The points where the pulse crosses the center graticule is the pulse width for -6dB.
- You can use the vertical cursors to measure the point that it crosses the center graticule.
- If the pulse width needs adjusting, you adjust and measure again if needed.
- By adding back 3dB, the pulse will cross the center graticule at the -3dB point.
- We measure this for power calculations (average to peak measurements)

-6dB pulse width measurement and adjustment and -3dB pulse width measurement Continued



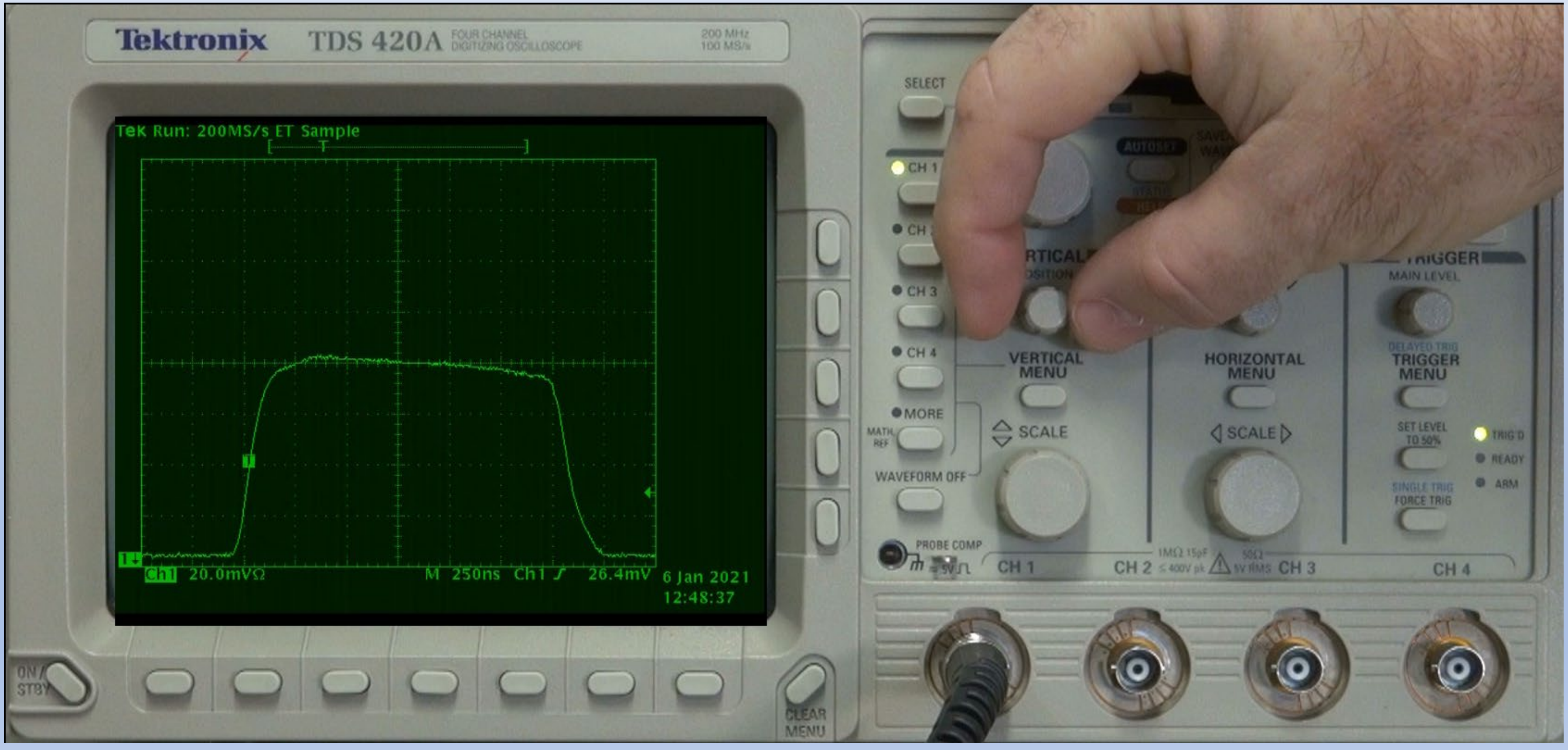
See video link at https://training.weather.gov/nwstc/NEXRAD/transmitter/index.html

NOTE

When the attenuation is removed in the next step, the pulse will increase in amplitude and will not be fully displayed on the oscilloscope. Do not adjust vertical position until after pulse width measurements are made.

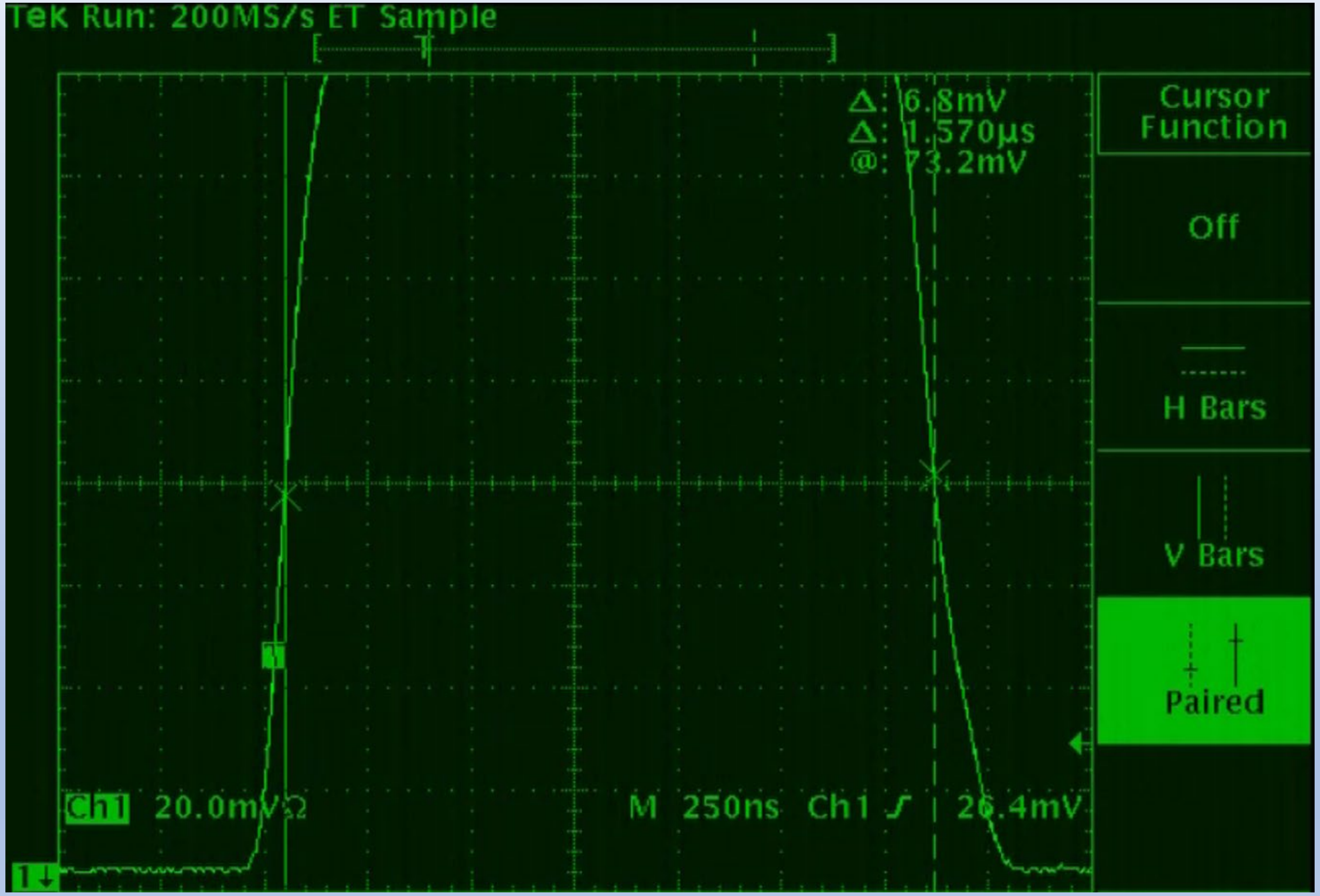
16. Measure positive pulse width by performing the following:

a. Adjust the oscilloscope vertical position controls to display the peak of the pulse at the center graticule line.



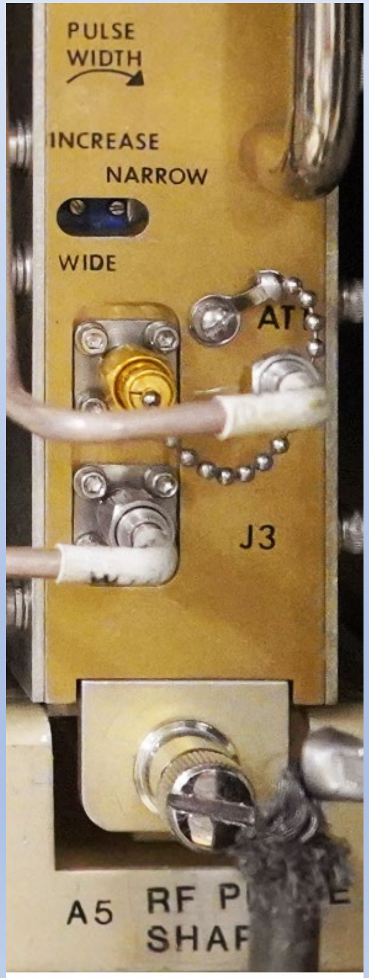
b. Remove 6 dB from the 0 to 11 dB variable attenuator.

c. Adjust the vertical time cursors, so they are on the leading edge and trailing edge of the pulse at the center graticule line (previous 100% level).



-6dB pulse width measurement and adjustment

d. The Channel 1 Positive Pulse Width should measure 1.57 ± .05 μsec. If not, adjust Pulse Shaper A5 NARROW adjustment.

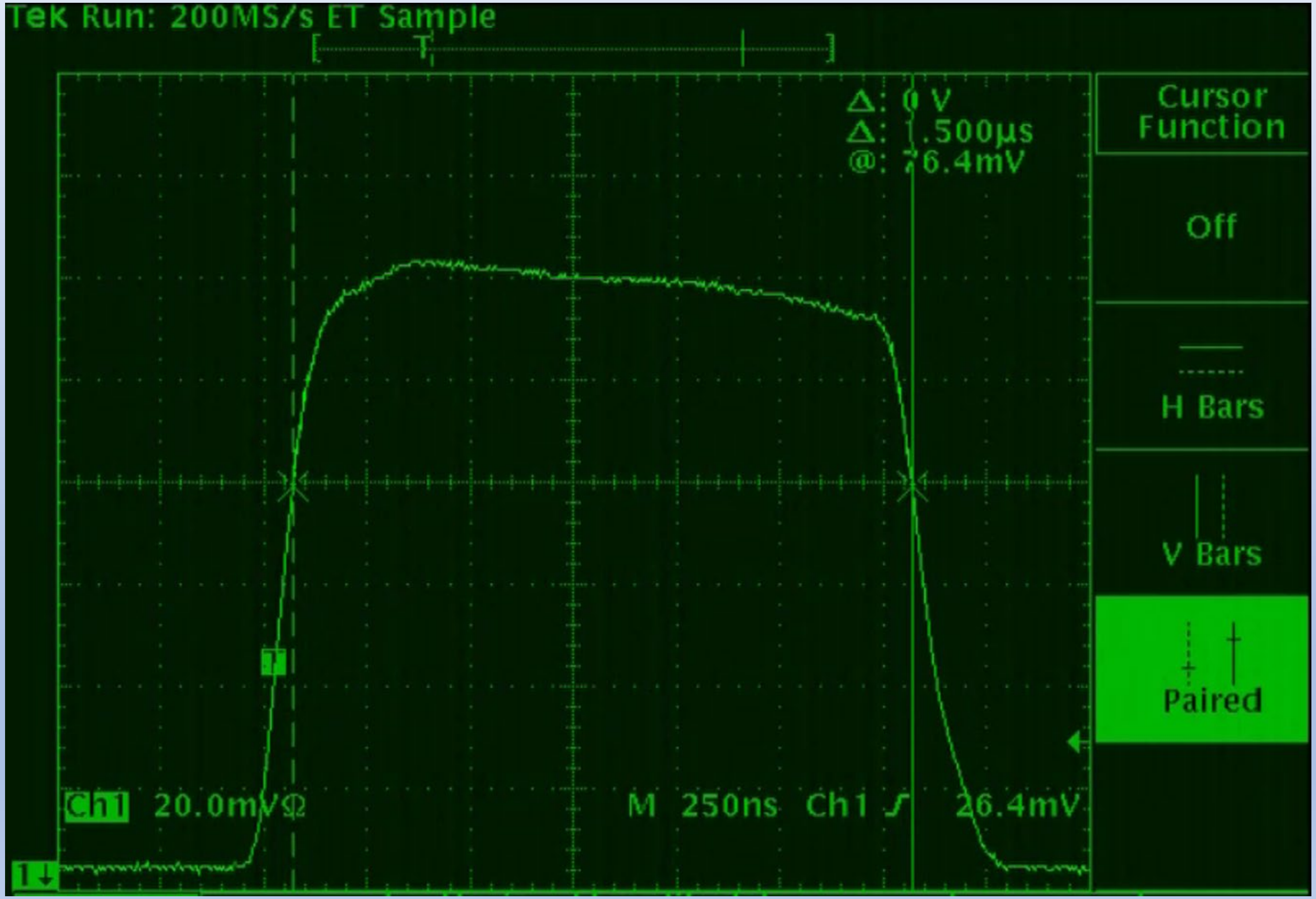


See Video link at
https://training.weather.gov/nwstc/NEXRAD/transmitter/index.html

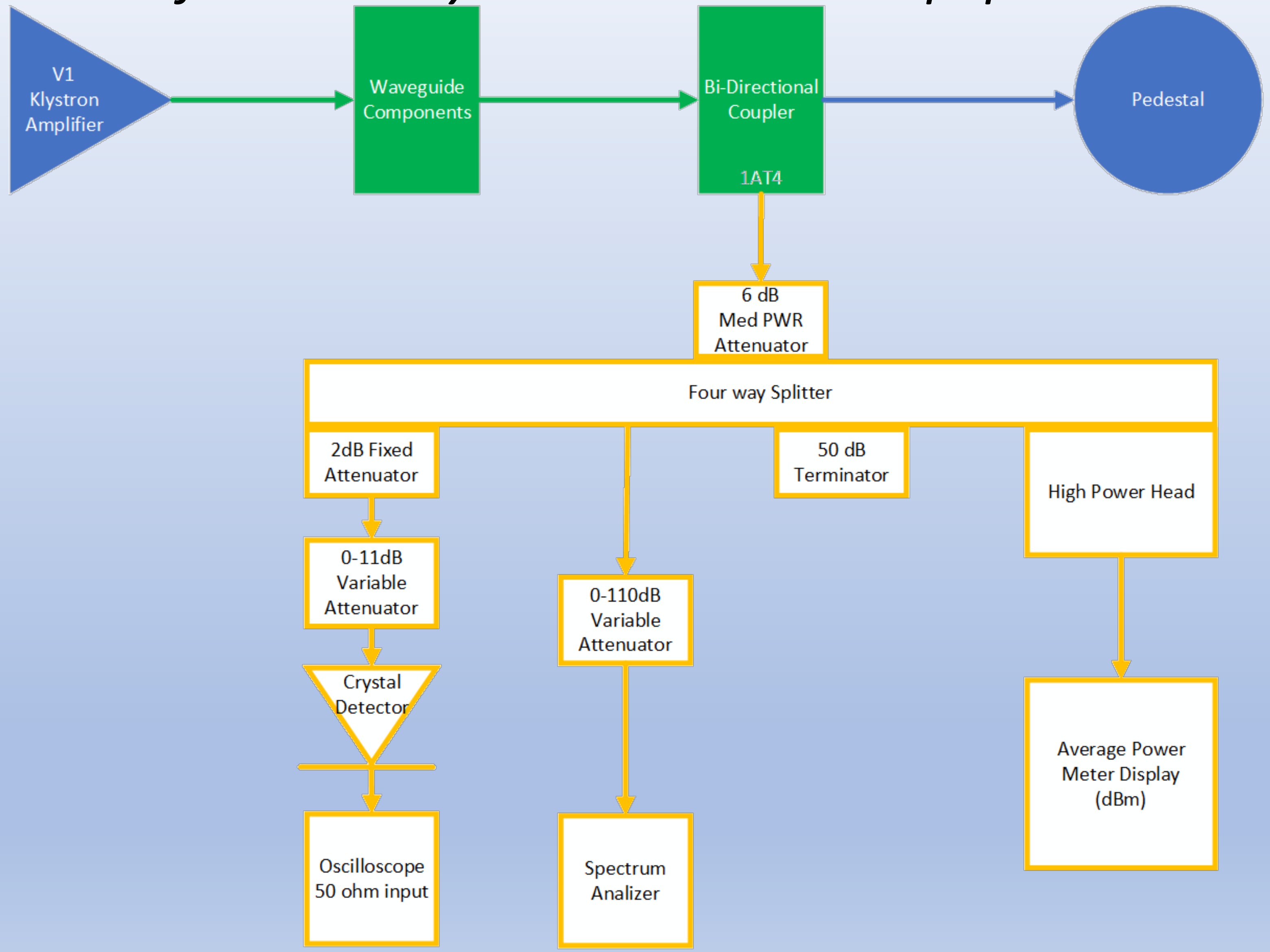
-3dB pulse width measurement

e. Add 3 dB to the variable attenuator, readjust cursor to center graticule, and record pulse width.

3 dB Pulse Width ________________µsec



Now we need to find the path loss from the klystron to the test equipment.



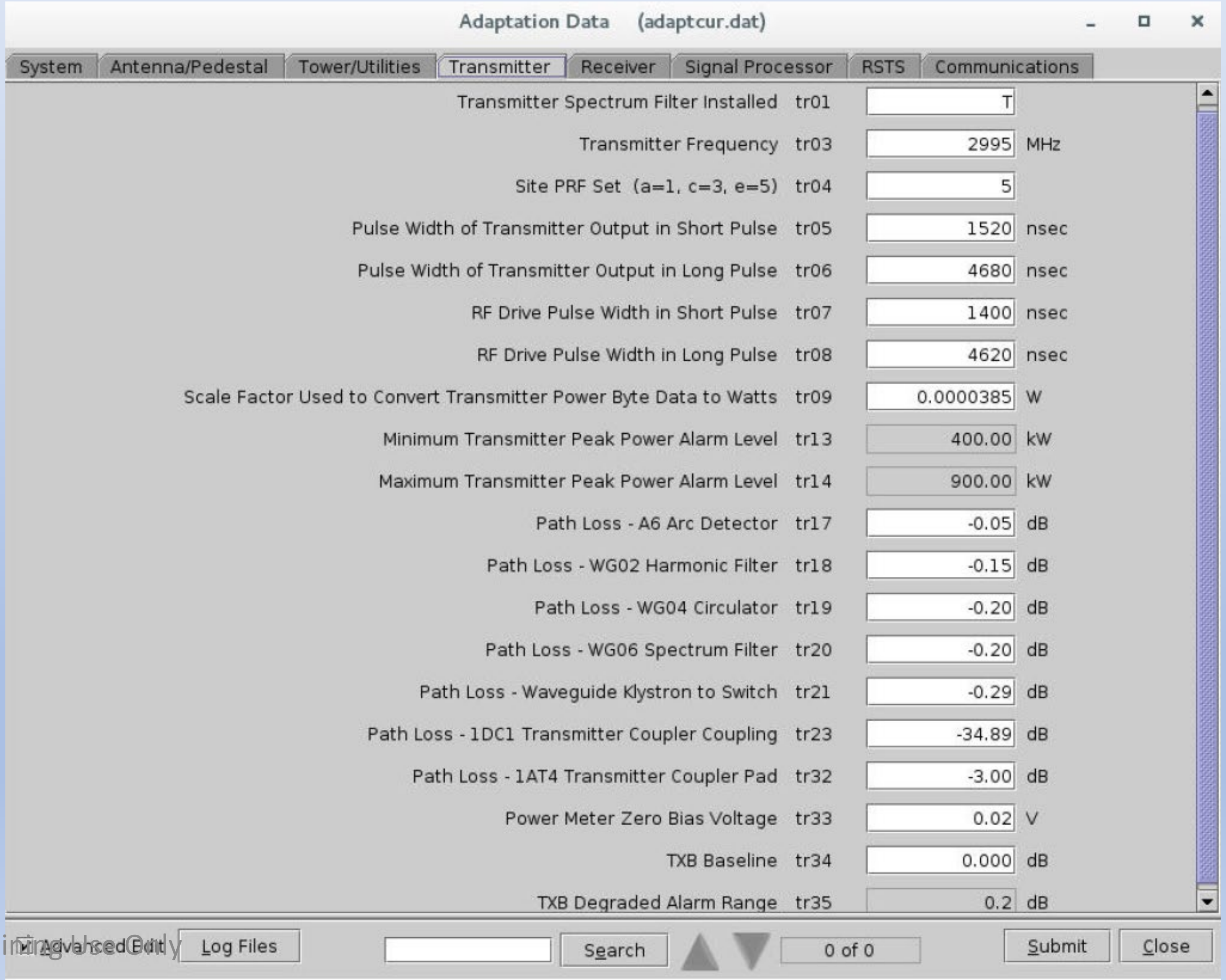
This is shown in the simplified drawing in green.

The losses will be taken from the adaptable parameters in the RADAR software.

17. Obtain Transmitter Adaptation Data by performing the following steps:
At the `System Test Software` window:

a. Select **View**, **Adaptation Data**, and **adatpcur.dat.**

b. At the `Adaptation Data` menu, click the **Transmitter** tab.



c. Record the TR values 17 through 21, 23, and 32.

TR17________ TR18________
TR19________ TR20________
TR21________

TR23________

TR32________

d. At the `Adaptation Data` menu, click **Close**.

18. Calculate the path loss from the klystron to the power sensor as follows:
PL_KLY_1AT4 = TR17 + TR18 + TR19 + TR20 + TR21 + TR23 + TR32

=______ + ______ + ______ + ______ + ______ + ______ + ______

=______dB

NOTE

Value should be a negative number. A typical value is -38.30 dB.

TR17 = Path Loss - A6 Arc Detector

TR18 = Path Loss - WG02 Harmonic Filter

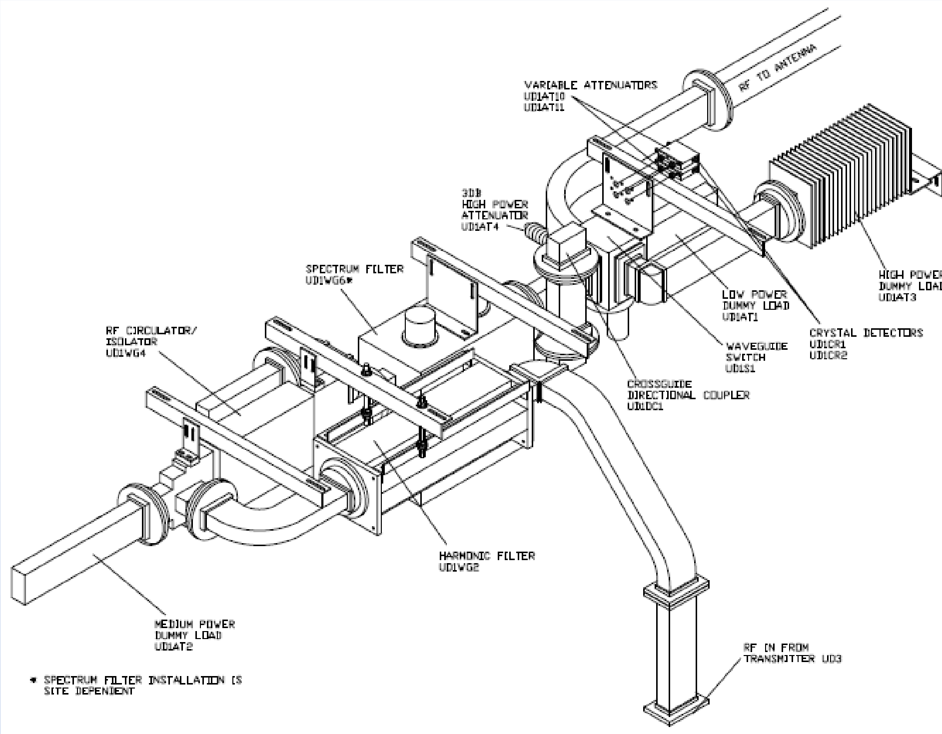
TR19 = Path Loss - WG04 Circulator

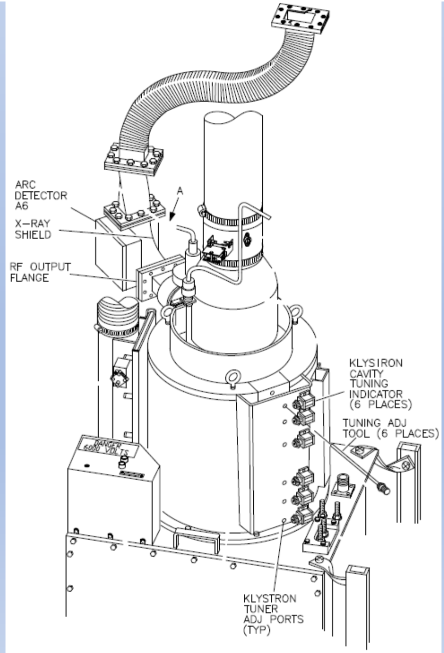
TR20 = Path Loss - WG06 Spectrum Filter (*does not exist in all systems*)

TR21 = Path Loss – Waveguide Klystron to Switch

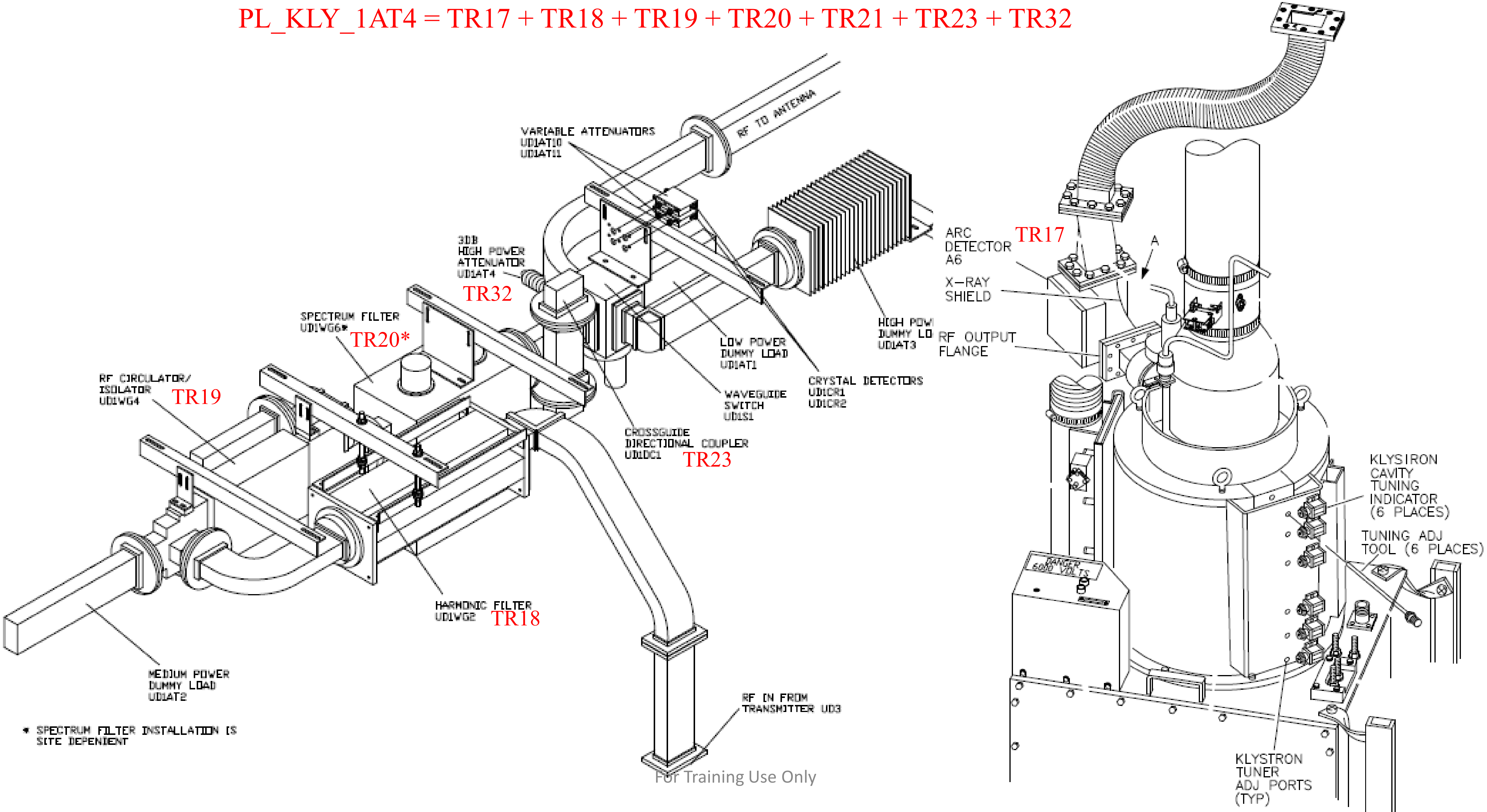
TR23 = Path Loss - 1DC1 Transmitter Coupler Coupling

TR32 = Path Loss - 1AT4 Transmitter Coupler Pad





PL_KLY_1AT4 = TR17 + TR18 + TR19 + TR20 + TR21 + TR23 + TR32



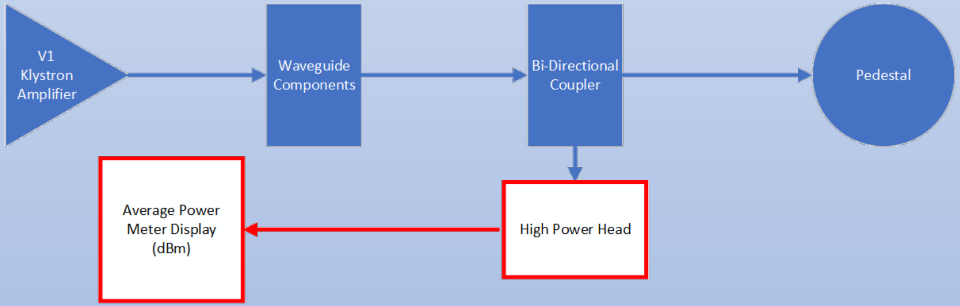
19. Record power meter reading.

Power Reading through test set ______________________dB

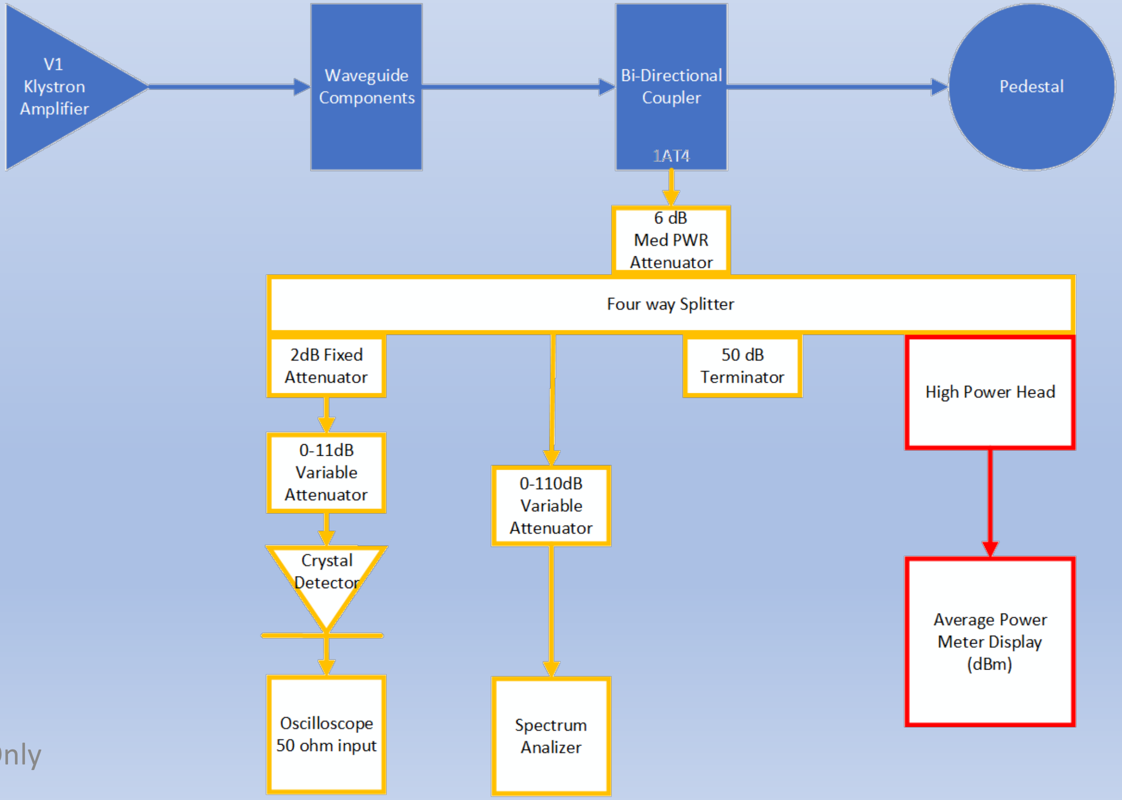
NWSTC note: Here is the math for the test setup that we took measurements for in earlier steps

20. Calculate the path loss for test setup by performing the following:

PL_Test Setup = Power @1AT4 (Step 4) - Power through 4 Way Splitter (Step 10) = __________dB



—



21. Use Table 5-4 to determine duty cycle for the PRF set and pulse width from step 16.

Duty Cycle dB = ____________dB

Table 5-4. Duty Cycle Conversion (Narrow Pulse)

Duty Cycle (DCdB) for Associated -3dB Pulse Widths using PRF S1 NARROW PULSE													
PW (3 dB µsec) →		1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.56	1.57	1.58	1.59
Xtal set	PRF(Hz)												
A	326	-33.17	-33.14	.33.11	-33.08	-33.05	-33.02	-32.99	-32.96	-32.94	-32.91	-32.88	-32.85
C	322	-33.22	-33.19	-33.16	-33.13	-33.10	-33.07	-33.05	-33.02	-32.99	-32.96	-32.93	-32.91
E	318	-33.27	-33.24	-33.21	-33.19	-33.16	-33.13	-33.10	-33.07	-33.04	-33.02	-32.99	-32.96

PRF crystal (xtal set) determined by adaptable parameter TR04 setting (1=A, 3=C, 5=E). See Table 5-6 through Table 5-8.
The PRF set currently being used is also listed in the STS `AME/Receiver Control` window.

Now we need to figure out what an average power meter connected to the "test setup" will read when we have 700,000 Watts Peak out of the klystron.

22. Determine target power meter reading by performing the following:

Klystron Peak Power @ 700 kW = 88.45
Duty Cycle dB (step 21) = ________dB (this will be a negative number)
PL_KLY_1AT4 (step 18) = _________dB (this value will be a negative number)
PL_Test Setup = (step 20) = _________dB (this value will be a negative number)

Klystron Peak Power (88.45) + Duty Cycle dB + PL_KLY_1AT4 + PL_Test Setup = ___dB

NOTE

88.45 dB is equivalent to 700 kW of power. Transmitter power must be adjusted to 700 kW ± 50 kW or 88.45 dB ± .30 dB.

For example: 88.45 + (-33.19) + (-38.31) + (-14.22) = 2.73

23. At Transmitter Control Panel A1, refine the power meter measurement by adjusting the PFN voltage potentiometer A1R3. Increase or decrease PFN to reach the targeted value from step 22. Do not exceed 5200V. Nominal PFN Meter reading is 4800V.

NWSTC note: Changing the PFN voltage normally changes the rise time of the pulse

24. Verify pulse rise time is 150 ± 25 nsec. If outside specification, adjust cavity #4 until rise time meets spec.

NWSTC note: Changing the PFN voltage will change the amplitude and may change the width of the pulse. Ensure that the pulse peak is at the center graticule before you remove the 6dB

25. Recheck the pulse width still matches pulse width measured in step 16. If pulse width has changed, repeat steps 21 through 23 with new pulse width.

Remember to add the 3db back in to measure the -3dB pulse width.

26. Measure 3 dB pulse width (as in step 16). Record this value in nsec. This measurement will become adaptable parameter TR5.

Example: 3 dB Pulse Width = 1.52 µS (tr05 = 1520 nsec)
3 dB Pulse Width = ________nsec

NWSTC note: TR5 is the adaptation data value that the computer uses for power calculations in short pulse

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

Pulse Width: **Long Pulse**
PRF: **S1**
Click: **Inject Signal**

28. Check a waveform similar to Figure 5-14 is obtained for long pulse.

NWSTC note:
You will need to change your horizontal time base on the oscilloscope

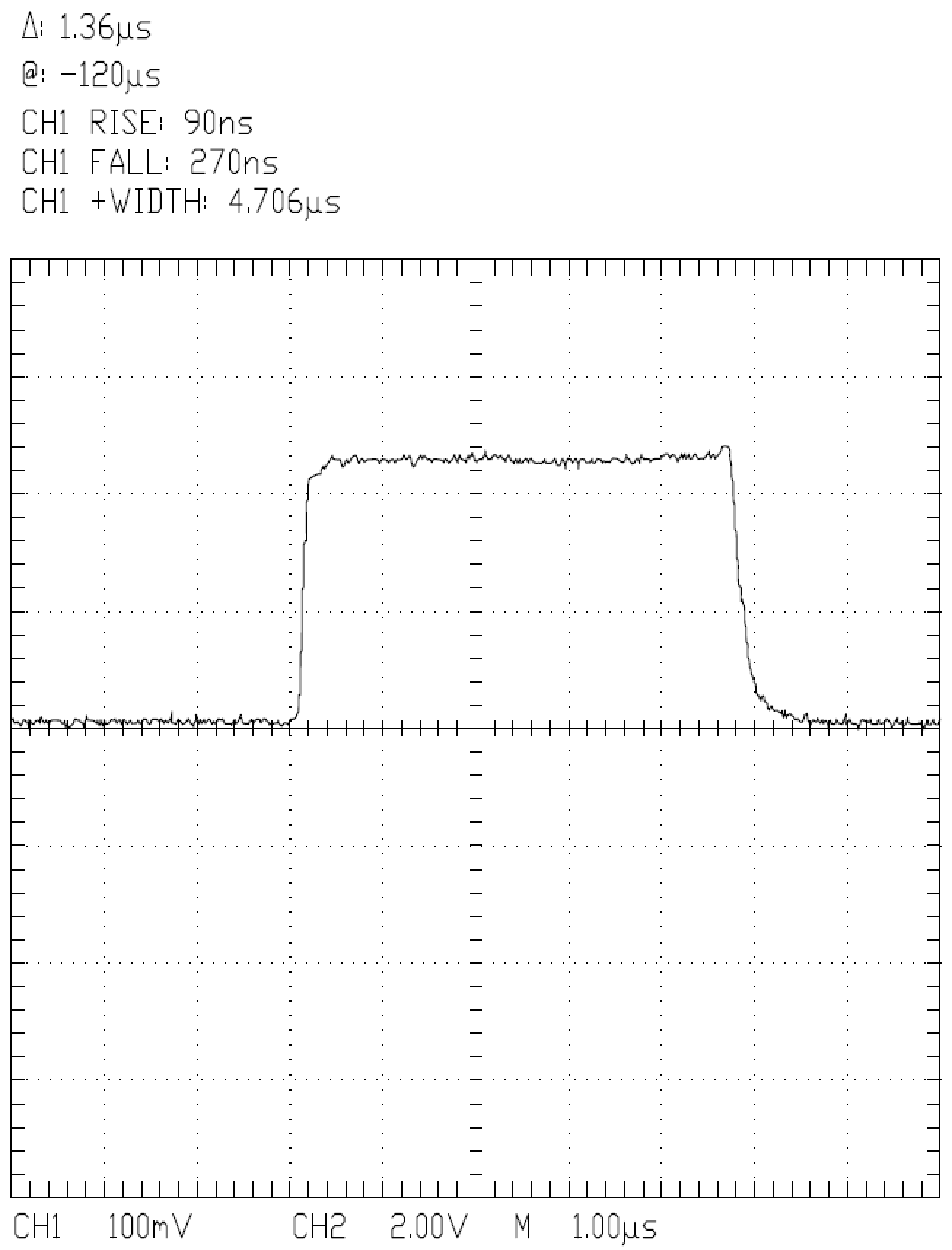


Figure 5-14

Now we will adjust the -6dB pulse width for **4.71 ± .1 µsec and measure the -3dB pulse width**

29. Measure positive pulse width by performing the following:

a. Adjust the oscilloscope vertical position controls to display the peak of the pulse at the center graticule line.

b. Remove 6 dB from the variable attenuator.

c. Adjust the vertical time cursors so they are on the leading edge and trailing edge of the pulse at the center graticule line (previous 100% level).

d. The Channel 1 Positive Pulse Width should measure 4.71 ± .1 µsec. If not, adjust Pulse Shaper 3A5 WIDE adjustment.

e. Add 3 dB to the variable attenuator, readjust cursor to center graticule, and record pulse width.

3 dB Pulse Width _________________µsec

NOTE

Once set, do not adjust vertical position until after measurements are made.

30. Use Table 5-5 to determine duty cycle for the PRF set and pulse width from step 29.

Duty Cycle dB = ____________________dB

Table 5-5. Duty Cycle Conversion (Wide Pulse)

Duty Cycle (DCdB) for Associated -3dB Pulse Widths using PRF S1

WIDE PULSE

PW (3 dB µsec) →		4.48	4.49	4.50	4.51	4.52	4.53	4.54	4.55	4.56	4.57	4.58	4.59	4.60	4.61
Xtal set	PRF(Hz)														
A	326	-28.36	-28.35	-28.34	-28.33	-28.32	-28.31	-28.30	-28.29	-28.28	-28.27	-28.26	-28.25	-28.24	-28.23
C	322	-28.41	-28.40	-28.39	-28.38	-28.37	-28.36	-28.35	-28.34	-28.33	-28.32	-28.31	-28.30	-28.29	-28.28
E	318	-28.46	-28.45	-28.44	-28.43	-28.42	-28.41	-28.41	-28.40	-28.39	-28.38	-28.37	-28.36	-28.35	-28.34

Duty Cycle (DCdB) for Associated -3dB Pulse Widths using PRF S1

WIDE PULSE

PW (3 dB µsec) →		4.62	4.63	4.64	4.65	4.66	4.67	4.68	4.69	4.70	4.71	4.72	4.73	4.74	4.75
Xtal set	PRF(Hz)														
A	326	-28.22	-28.21	-28.20	-28.19	-28.18	-28.17	-28.17	-28.16	-28.15	-28.14	-28.13	-28.12	-28.11	-28.10
C	322	-28.28	-28.27	-28.26	-28.25	-28.24	-28.23	-28.22	-28.21	-28.20	-28.19	-28.18	-28.17	-28.16	-28.15
E	318	-28.33	-28.32	-28.31	-28.30	-28.29	-28.28	-28.27	-28.26	-28.25	-28.25	-28.24	-28.23	-28.22	-28.21

PRF crystal (xtal set) determined by adaptable parameter TR04 setting (1=A, 3=C, 5=E). See Table 5-6 through Table 5-8.
The PRF set currently being used is also listed in the STS AME/Receiver Control window.

Now we figure out what an average power meter connected to the “test setup” will read when we have 700,000 Watts Peak out of the klystron in long pulse.

31. Determine target power meter reading by performing the following:

Klystron Peak Power @ 700 kW = 88.45

Duty Cycle dB (step 30) = ____________dB (this will be a negative number)

PL_KLY_1AT4 (step 18) = ____________dB (this value will be a negative number)

PL_Test Setup = (step 20) =____________dB (this value will be a negative number)

Klystron Peak Power + Duty Cycle dB + PL_KLY_1AT4 + PL_Test Setup = _______________dB

32. At Transmitter Control Panel A1, refine the power meter measurement by adjusting the PFN voltage potentiometer A1R3. Increase or decrease PFN to reach the targeted value from step

31. Do not exceed 5200V. Nominal PFN meter reading is 4800V.

33. Measure 3 dB pulse width. Record this value in nsec. This measurement will become adaptable parameter TR6.

Example: 3 dB Pulse Width = 4.71 µS (tr06 = 4710 nsec)

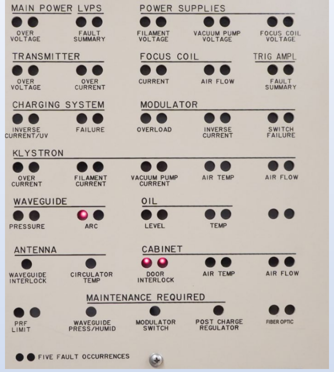
3 dB Pulse Width = ________________nsec

NWSTC note: TR6 is the adaptation data value that the computer uses for power calculations in long pulse

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

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

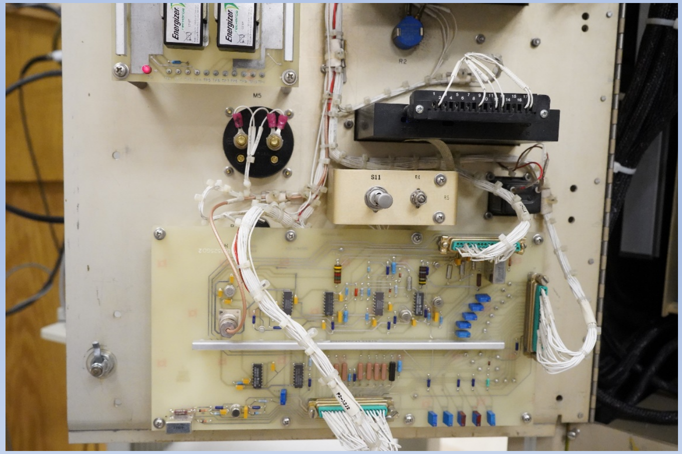
35. Open the Transmitter Control Panel A1 door; notice the cabinet door interlock fault will illuminate.

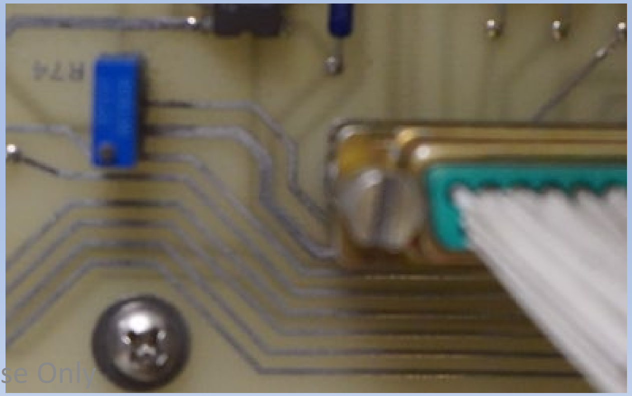


NWSTC note: One lamp is 1-4 occurrences; two lamps indicate the fault has happened 5 times

36. Insert the interlock bypass tool on cabinet door Interlock Switch S4 per paragraph 5.1.4.1 and press **Fault Display Reset** to clear fault monitor board.

37. Locate Narrow PFN Voltage Adjust A1A2R74 on the bottom backside of the panel door (small blue potentiometer).





We set the transmitter up for 700KW in short pulse.
We then set the power of the transmitter in long pulse by adjusting A1R3.

When we return to short pulse, the only thing that has been changed is the PFN voltage.
A1A2R74 is the offset for long and short PFN voltage. This adjustment allows us to stay closer to 700KW in both widths.

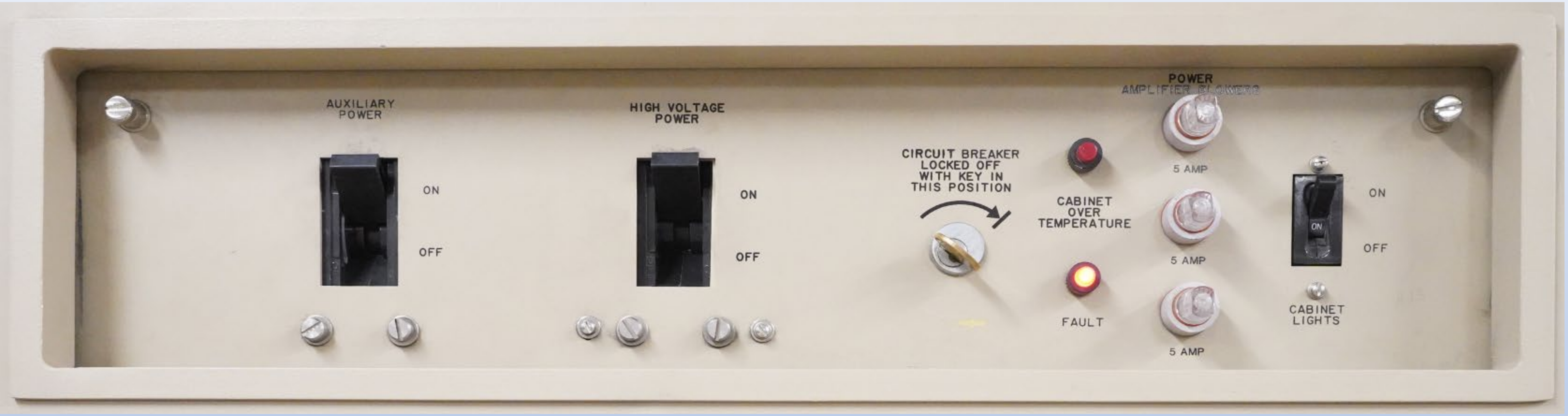
38. In the `AME/Receiver Control` window, select the following:

Test Source: **KLYSTRON OUTPUT**
Pulse Width: **Short Pulse**
PRF: **S1**
Click: **Inject Signal**

39. Tuning potentiometer A1A2R74 will increase or decrease peak power for short pulse approximately 40 kW. CW turns increase power and CCW turns decrease. Turn potentiometer A1A2R74 to increase or decrease according to the readings in step 22.

40. In the `AME/Receiver Control` window, select the following:
Test Source: **NONE**
Click: **Inject Signal**

41. Remove the interlock bypass tool from the door interlock, and close left panel door and ensure the fault indicator in the transmitter control panel goes out after approximately 5 seconds.



Press **Fault Display Reset** to clear fault monitor board.

42. Disconnect all test equipment.

NOTE

Anytime adjustments are made that affect the output pulse shape, the IFDR Alignment procedure should be performed and adaptation data items R40 and R41 should be updated per NWS EHB 6-513, paragraph 6.6.3.16.

43. Perform the IFDR Alignment Procedure per NWS EHB 6-513, SECTION 6.5.

NWSTC note: The "*IFDR Alignment Procedure*" will be covered in a separate module found at:
https://training.weather.gov/nwstc/NEXRAD/transmitter/index.html
Or
https://training.weather.gov/nwstc/NEXRAD/receiver/index.html

44. Update the TR5 and TR6 in adaptation data per NWS EHB 6-513, paragraph 6.6.3.16.

45. Click **RDA ► Restart RDASC**, and **Yes** at the `Confirm Restart RDASC` window.
Log back into the HCI once the restart is complete.

NWSTC note: Changes to adaptation data take effect after the application software is restarted. Step 45 does that.

NWSTC note:
Steps 46 - 52 match the displayed power measured by 4A26 and displayed by the computer to the power measured at 1AT4 (the location that the "test setup" was plugged into.

There is an analog to digital conversion, and this sets the scaling factor (TR9)

46. Connect Power Sensor HP8481H to Attenuator 1AT4.

47. On the Main RDA HCI, click on **System Test Software** and **Yes** to confirm. Click **Control ► AME/Receiver Control**.

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

Test Source: **KLYSTRON OUTPUT**
Pulse Width: **Short Pulse**
PRF: **S1**
Click: **Inject Signal**

49. Record the power level displayed on the power meter.

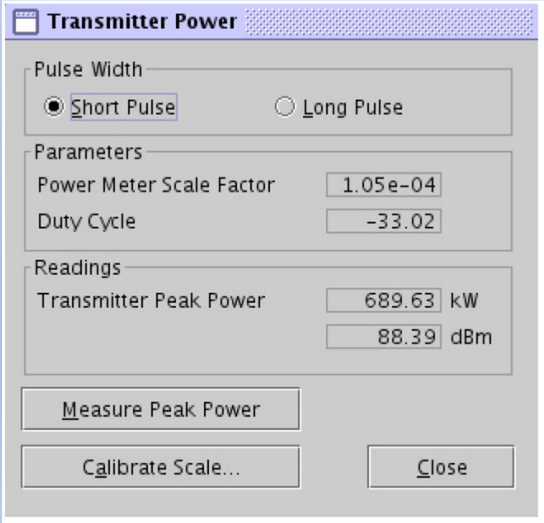
50. In the `AME/Receiver Control` window, select the following:

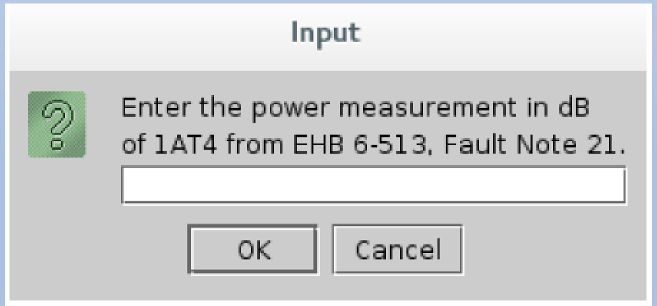
Test Source: **NONE**
Click: **Inject Signal**

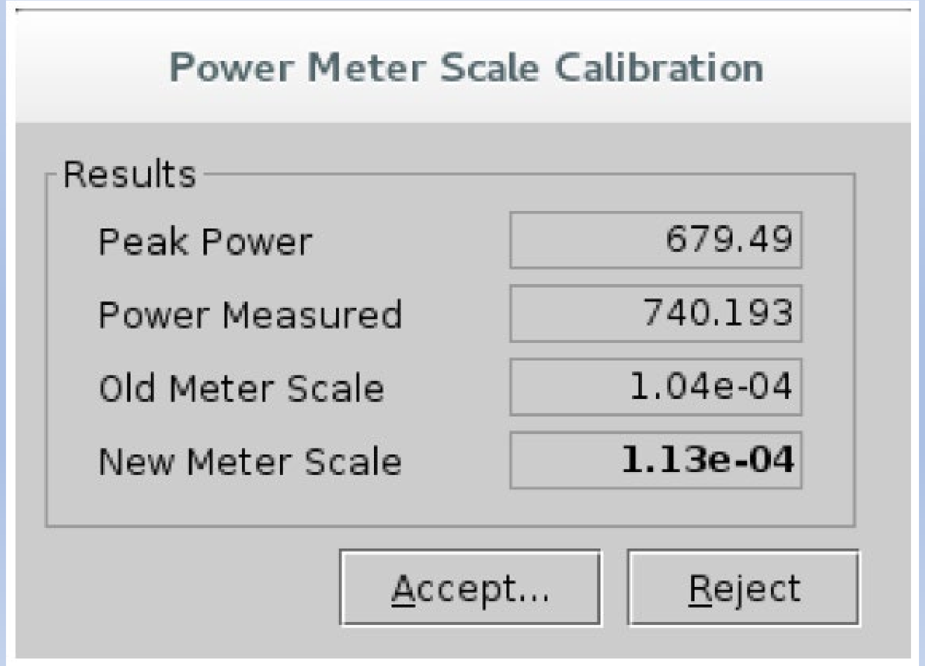
51. Disconnect the power sensor and reconnect cable W61/161 to Attenuator 1AT4.

52. In the `System Test Software` window, click **Calibration ►Transmitter Power**. Ensure the short pulse radio button is selected and click **Calibrate Scale**.

When prompted, enter the power level measured at 1AT4, in step 49.

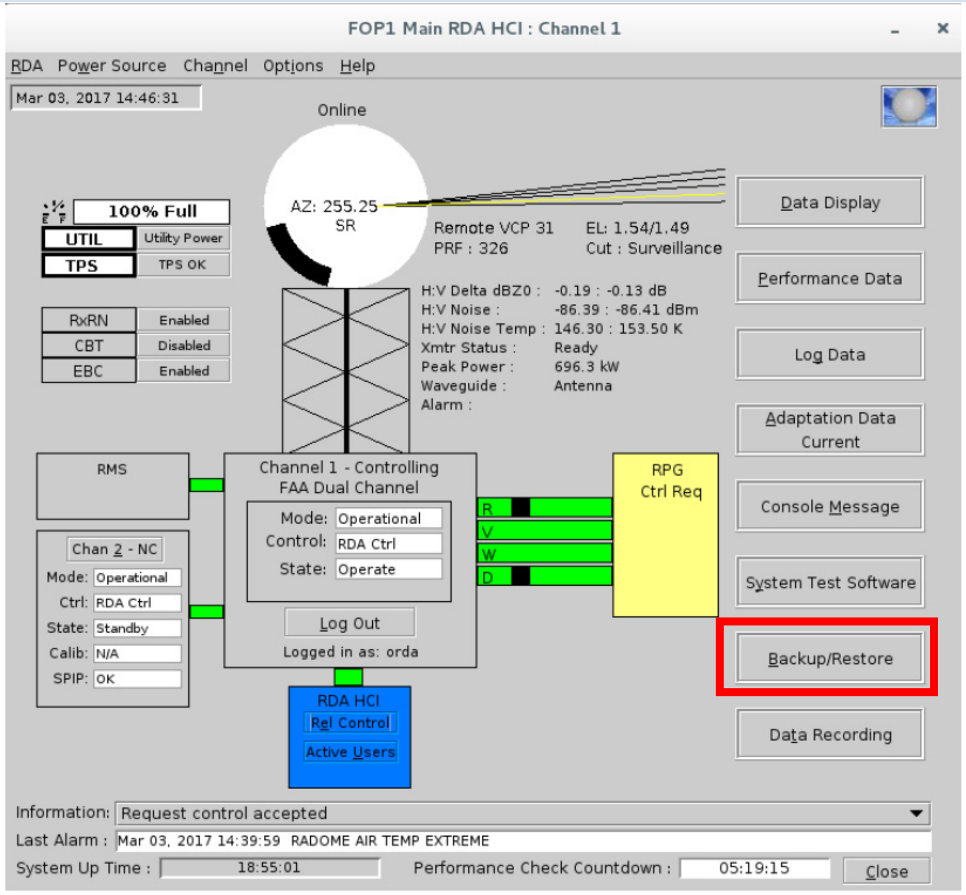




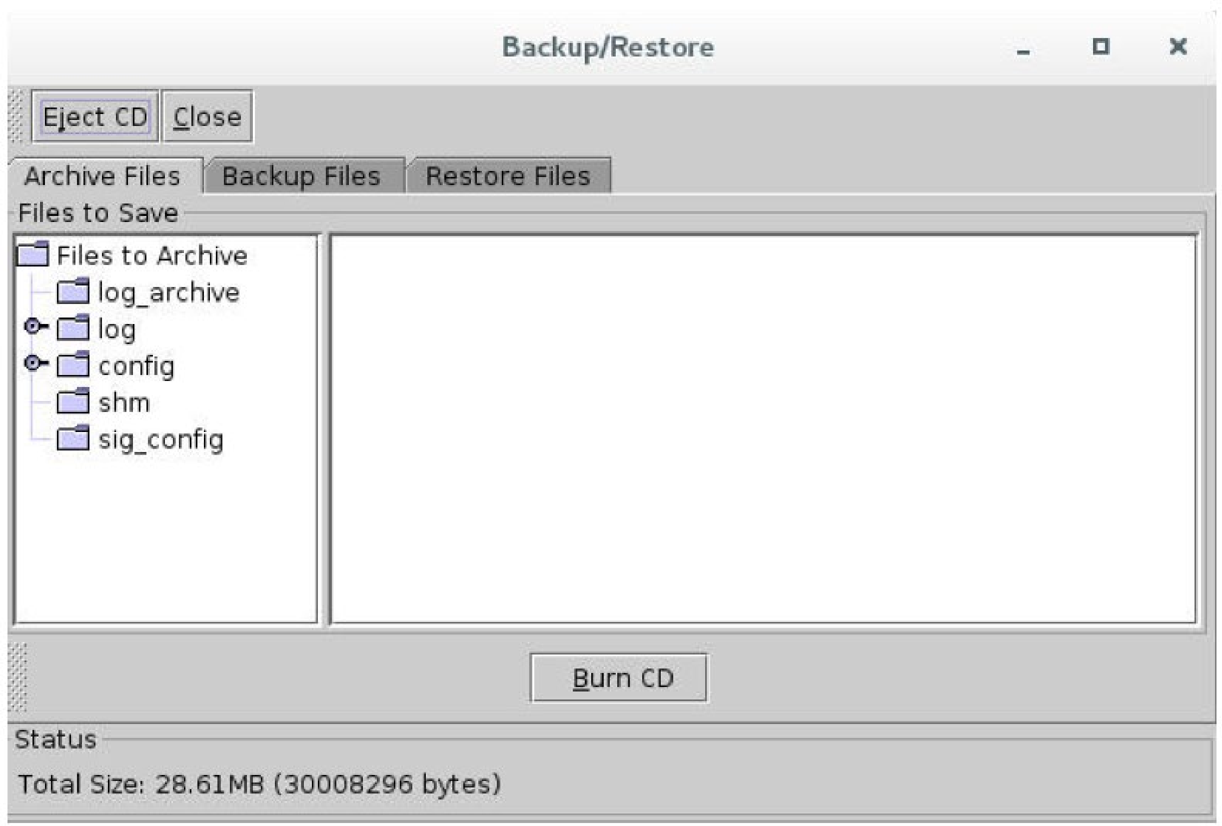


NWSTC note:
Step 53 creates a backup of the changes that have been made to the software configurations. USE a CD (DVDs fail currently 2020)

53. Create a backup by performing the Backup Files procedure in NWS EHB 6-513, Section 4.9.



NWSTC note:
An "Archive" saves log files, A "Backup" does not.



NWSTC note:
Step 54 records what the A1M4 meter reads when things are normal

54. Complete this procedure by updating the Transmitter Parameter and Adjustment Record Card with new values at all 15 positions by performing paragraph 5.5.17, steps 3 through 7.

3A1S9 POS	TRANSMITTER PARAMETER	M4 READING (SP/PRF D5)	HIGH VOLTAGE	OPERATIONAL LIMITS
1	+5 VDC PS		OFF/ON	5.0 +/- 0.5 V
2	+15 VDC PS		OFF/ON	15.0 +/- 0.5 V
3	-15 VDC PS		OFF/ON	-15.0 +/- 0.5 V
4	+28 VDC PS		OFF/ON	28.0 +/- 1.0 V
5	+45 VDC PS		OFF/ON	45.0 +/- 1.5 V
6	+280 VDC PS		OFF/ON	240 - 370 V
7	FPA FILAMENT PS		OFF/ON	40 - 70 V
8	FPA FILAMENT VOLTAGE		OFF/ON	NAMEPLATE +/- 2.0 V
9	FPA FOCUS COIL PS		ON	40 - 85 V
10	FPA VACUUM PUMP PS		OFF/ON	2.75 - 4.00 KV
11	FPA CATHODE CURRENT		ON	20 (PRF S1) - 95 mA (PRF D8)
12	FPA BEAM VOLTAGE		ON	20 (PRF S1) - 95 KV (PRF D8)
13	MOD INVERSE CURRENT		ON	2.0 (PRF S1) - 20 mA (PRF D8)
14	PFN CHARGE CURRENT		ON	0.5 (PRF S1) - 4.5 A (PRF D8)
15	REGULATOR CURRENT		ON	5.0 - 20.0 mA
16	OFF	DATE:	NAME:	