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VLA Electronics Memorandum No. 193

T2 "IF COMBINER" TRANSMIT AND RECEIVE IF POWER MONITOR VOLTAGES

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Data checker diagnoses of proper T2 operation should be based on worst case threshold voltages. This paper calculates these thresh-holds and also presents clarified IF transmission level diagrams for both 4 IF and 2 IF systems.

To minimize confusion on IF transmission level settings the IF transmission level chart originally given in VLA Technical Reports 27 and 28, but since revised many times, is redrawn in Figure 1A for the 4 IF system and in Figure 1B for the 2 IF system. Much of the recent confusion over IF transmission levels resulted from misinterpretation of the IF signal level from the A Rack. In the new diagrams this level is defined as the sum total IF power, and not always the level for 2 IF's total (currently in use), nor the level for each individual IF signal. The original -25 dBm level given in VLA Technical Reports 27 and 28 referred to the sum total of all 4 IFs present in a 4 IF

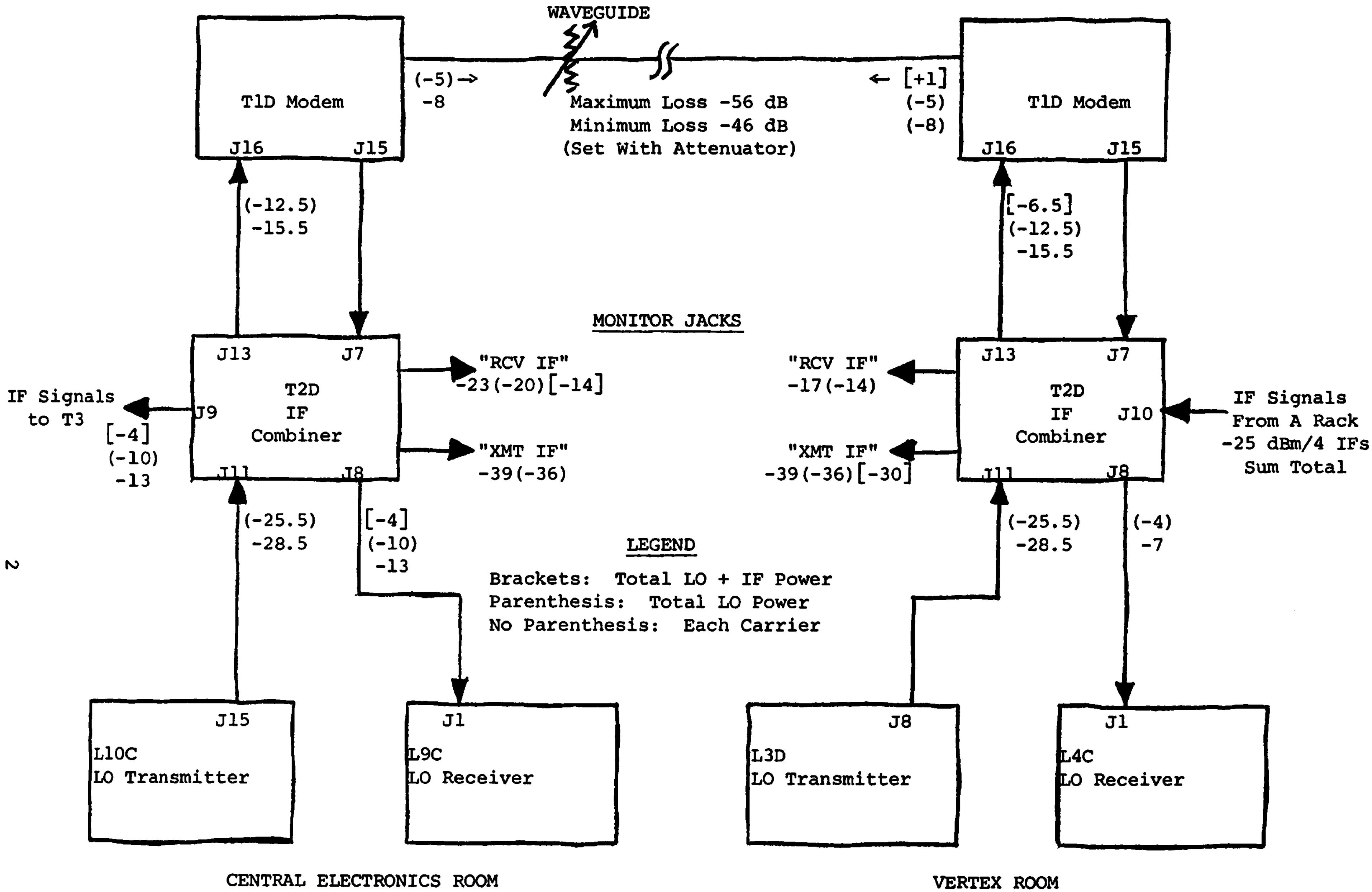


Figure 1A

IF Transmission Levels for 4 IF System - WED 7/16/80

All power levels are given in dBm and are typical levels to nearest 0.5 dB.
All signal levels are defined when the signal is on; they are not average levels.
Total LO + IF powers are defined with all 4 IF signals present.
(Based on DSB 770609)

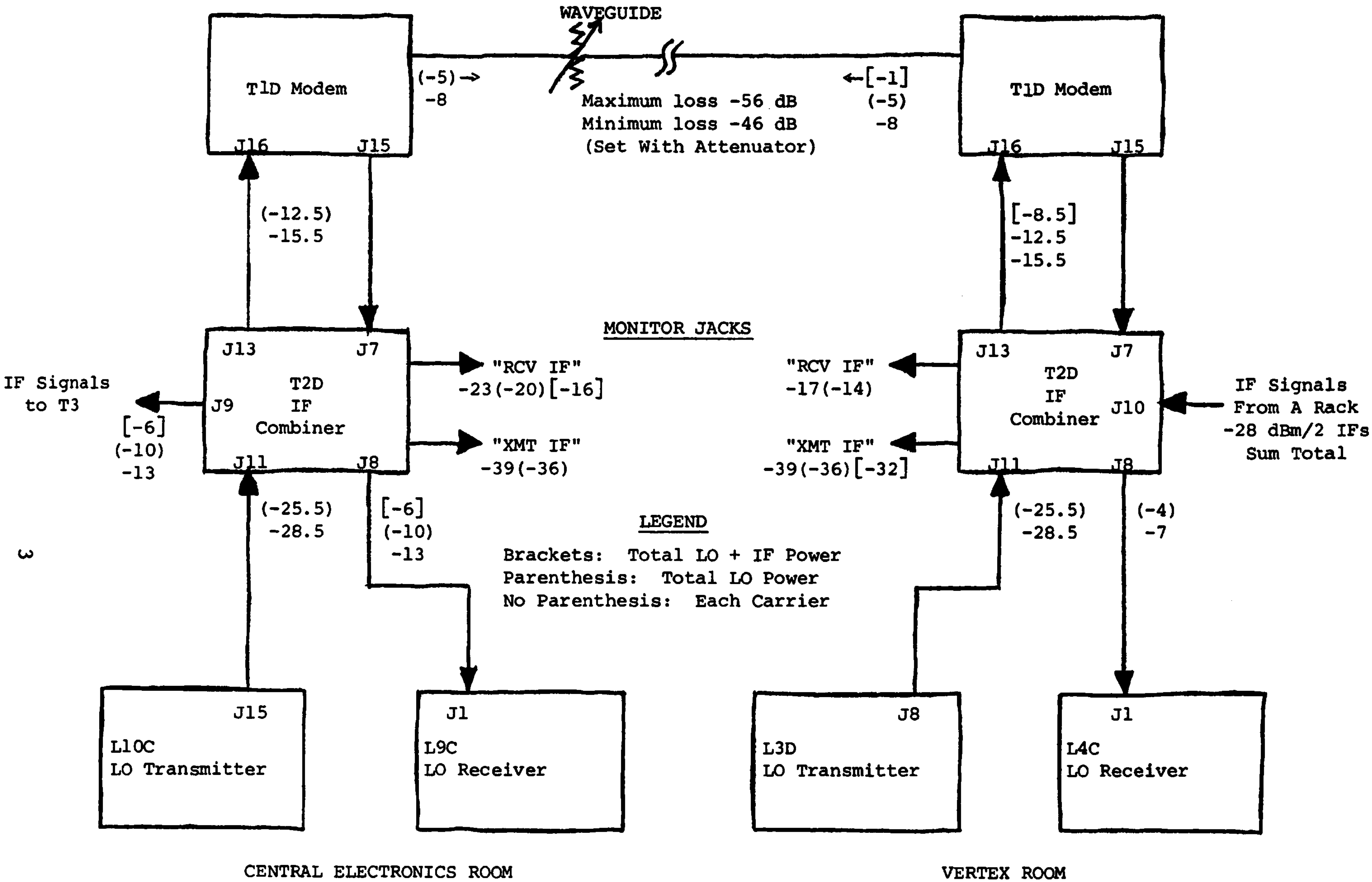


Figure 1B

IF Transmission Levels for 2 IF System - WED 7/16/80

All power levels are given in dBm and are typical levels to nearest 0.5 dB.
All signal levels are defined when the signal is on; they are not average levels.
Total LO + IF powers are defined with only 2 IF signals present.
(Based on DSB 770609)

system. This has been reaffirmed in A. R. Thompson's memo of May 30, 1980 concerning the IF input levels to the T2.

RMS variations in signal and detector levels were calculated for use as minimum and maximum detector voltages for the data checker since:

1. Worst case tolerances are based on a large number of individual components. Calculated cumulative worst case tolerances were found to be too large to be of any practical use in the data checker system.
2. Total rms tolerance values for a large number of individual components is a valid method for 95% of the cases, although they cannot be guaranteed.
3. A survey of T2 detector voltages for 23 antennas produced minimum and maximum voltages close to those predicted by the rms variations. See Figure 6.

The method of calculation of rms decibel tolerances is given below:

1. First the worst case cumulative tolerance in decibels was calculated as the sum of individual worst case errors.
2. The worst case peak to peak power variation was calculated from the resultant decibel tolerance.
3. The root mean square (σ) was assumed to be less than 1/5 of the worst case peak to peak variation. Since σ is an arithmetic variation from unity, and since logarithms give geometric variations, the total decibel variation had to be calculated based on the rms value (σ) divided by the arithmetic mean (μ) of the worst case peak to peak values.

FORMULAS

Total worst case variation in decibels, D;

$$+D_{total} = \Sigma_1^n + D_n$$

$$-D_{total} = \Sigma_1^n - D_n$$

Total worst case variation in power, P:

$$P_{min} = LOG_{10}^{-1} \left(\frac{-D_{total}}{10}\right)$$

$$P_{max} = LOG_{10}^{-1} \left(\frac{+D_{total}}{10}\right)$$

Root mean square deviation, σ:

$$\sigma < \frac{P_{max} \quad -P_{min}}{5} \quad \text{For 95\% probability.}$$

Mean, μ:

$$\mu = \frac{P_{max} \quad +P_{min}}{2}$$

Total root mean square variation in decibels, D:

$$+D_{rms} < 10 \text{ dB } LOG_{10} \left(1 + \frac{\sigma}{\mu}\right)$$

$$-D_{rms} > 10 \text{ dB } LOG_{10} \left(1 - \frac{\sigma}{\mu}\right)$$

Total root mean square variation in detector voltage, V, (assumes detector is square law):

$$V_{max\ rms} < \left(1 + \frac{\sigma}{\mu}\right) V_{nominal}$$

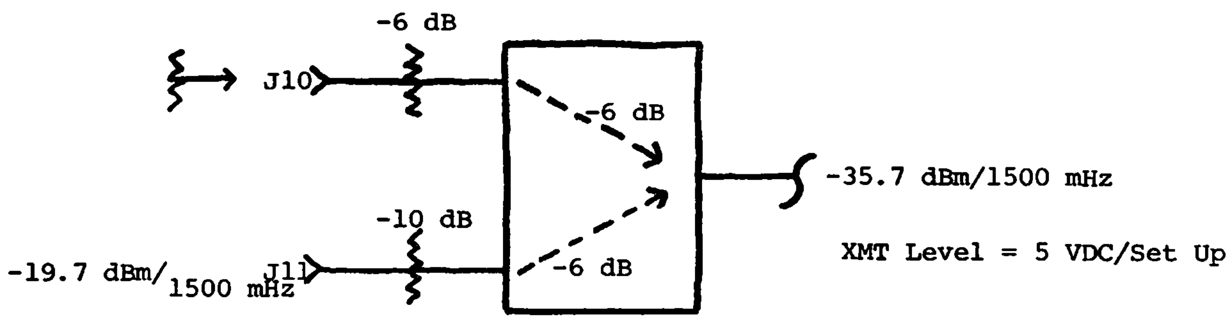
$$V_{min\ rms} > \left(1 - \frac{\sigma}{\mu}\right) V_{nominal}.$$

Nominal T2D "XMT LEVEL" detector output voltages to the DCS system are given in Figure 2. Since the dectector measures the sum of the IF and LO power levels the corresponding nominal power levels are shown at the output of the power combiner. RF and detector components after this point are ignored for simplicity of calculations since XMT levels can be calculated relative to the set up power level at this point. The "XMT LEVEL" detector is operated in the square law region so that its output voltage is proportional to input IF power.

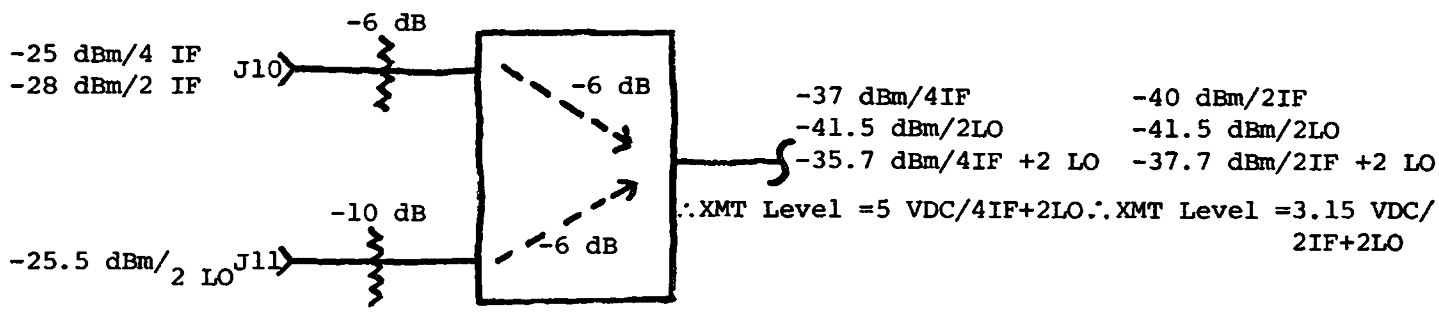
Minimum and maximum vertex room T2D XMT level voltages are dependent on L10C, L3D, and F4 output power tolerances (recently revised), A to B rack cable loss, relative power combining levels and tolerances, T2 IF passband variations, and T2 IF XMT level detector variations with frequency.

Note that total XMT level detector voltage tolerances are not just the linear sum of individual tolerances in the case of the vertex room because of the summing of different power levels and tolerances at the T2 power combiner. These calculations are not presented for simplicity. Data and results of these calculations are given in Figure 3.

T2 XMT SET UP



T2 XMT VERTEX ROOM



T2 XMT CENTRAL ELECTRONICS ROOM

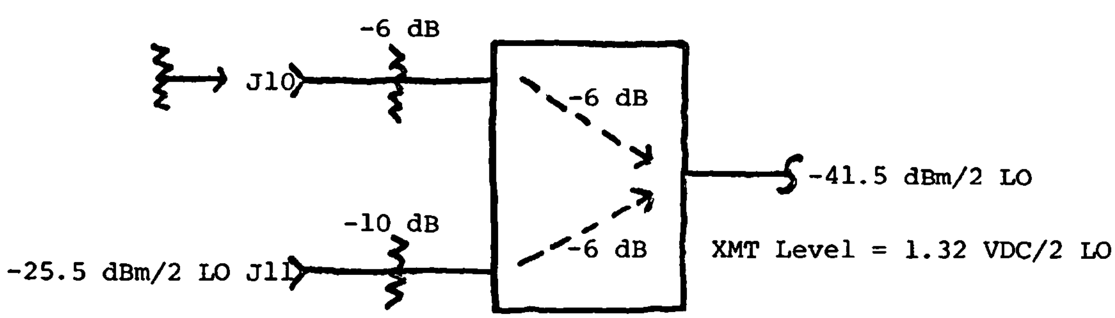


Figure 2

NOMINAL T2D XMT LEVEL VOLTAGE CALCULATIONS

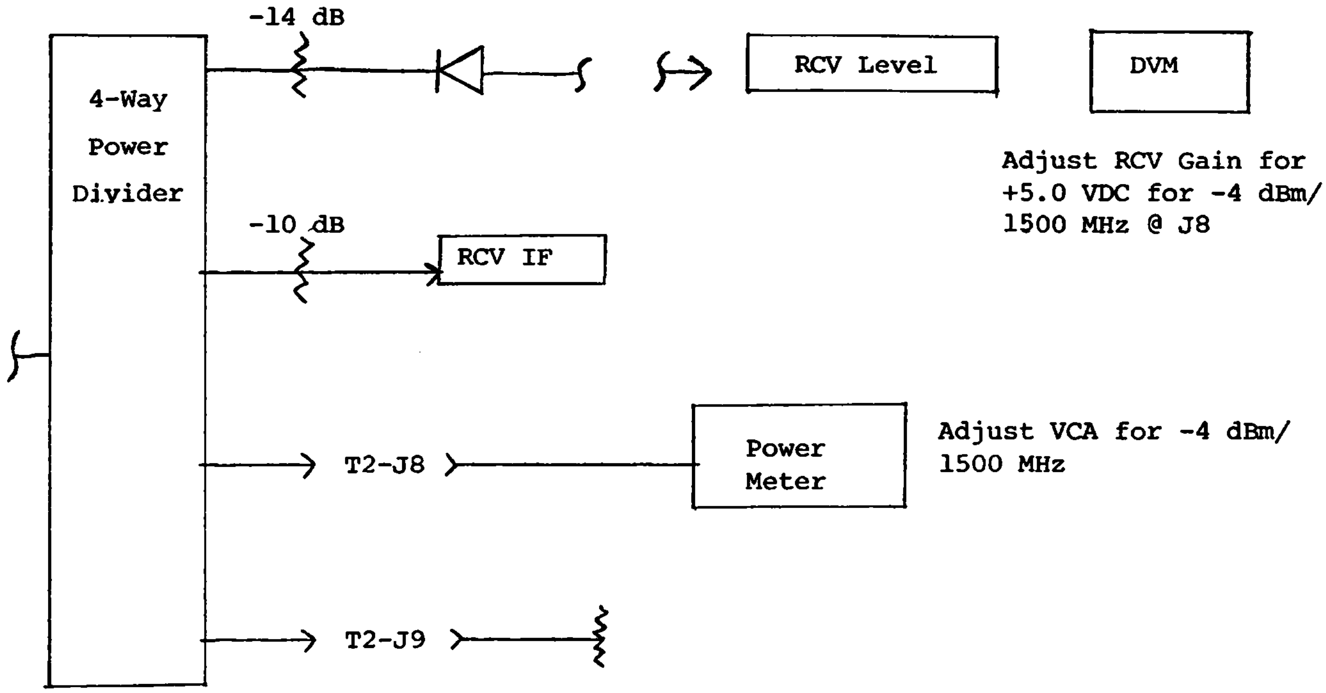
T2 XMT LEVEL TOLERANCES

Vertex Room	Tolerance
L3D output power @ T2-J11	±0.5 dB
Combined F4 output power	±1.3 dB
A to B rack cable loss	+0 dB -0.5 dB
T2 XMT IF passband variation	±2.7 dB
T2 XMT detector passband variation	±0.2 dB
Resultant Worst Case T2 XMT Level	(+1.9 to 12.6 VDC)
variation for 4 IF system	+4.0 dB -4.3 dB
Resultant Worst Case T2 XMT Level	(+1.2 to 7.7 VDC)
variation for 2 IF system	+3.9 dB -4.1 dB
RMS T2 XMT Level variation for	(+3.5 to +6.5 VDC)
4 IF system	+1.1 dB -1.5 dB
RMS T2 XMT Level variation for	(+2.2 to +4.1 VDC)
2 IF system	+1.1 dB -1.5 dB

Central Electronics Room	Tolerance
L10C output power @ T2-J11	±1.5 dB
T2 XMT IF passband variation	±2.7 dB
T2 XMT detector passband variation	±0.2 dB
Resultant Worst Case T2 XMT Level	(+0.5 to +3.6 VDC)
variation	±4.4 dB
RMS T2 XMT level variation	+1.2 to -1.6 dB
	(+0.9 to +1.7 VDC)

Figure 3

T2 RCV LEVEL SET UP



T2 RCV VERTEX ROOM

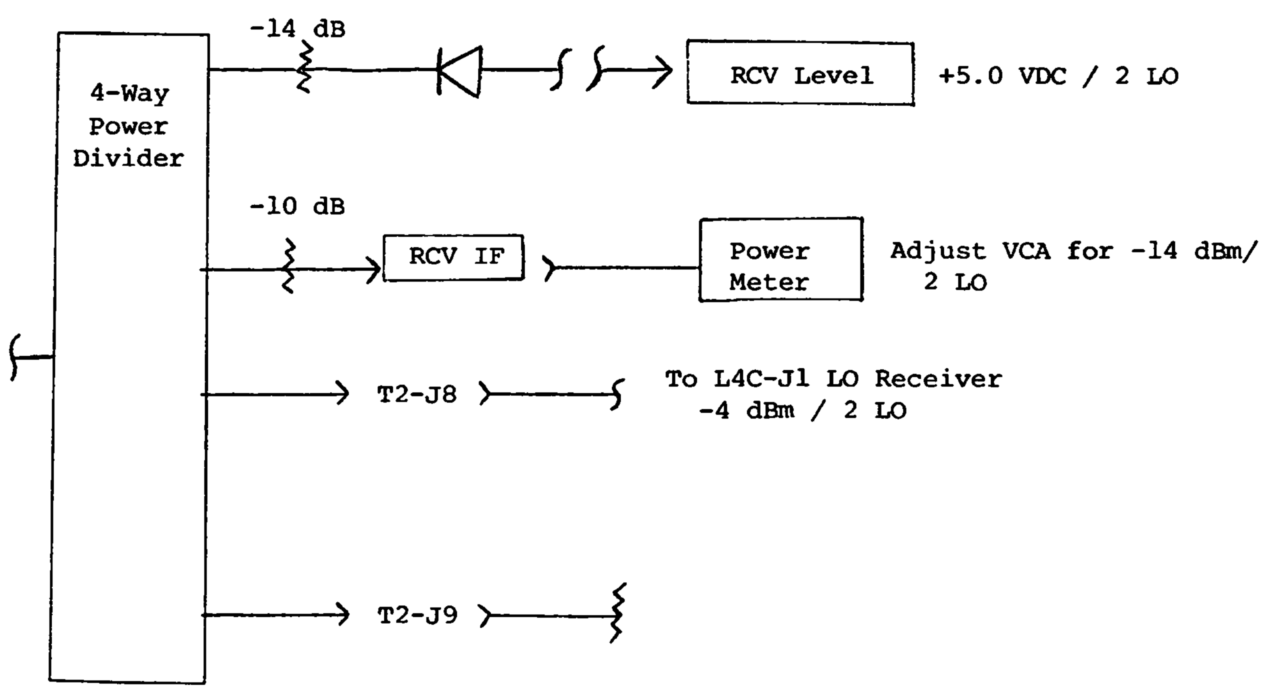


Figure 4

T2 RCV CENTRAL ELECTRONICS ROOM

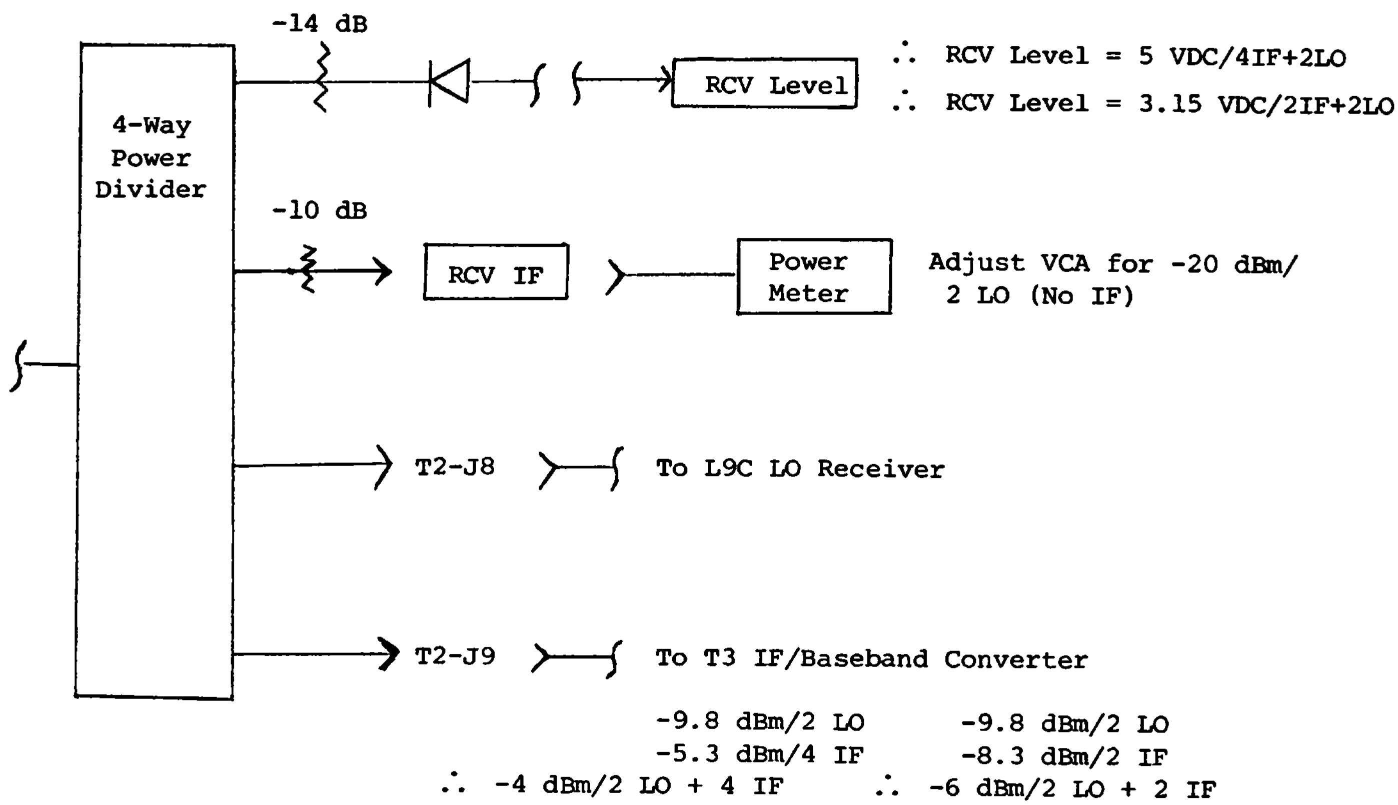


Figure 4 (cont.)

T2 RCV LEVEL TOLERANCES

Vertex Room	Tolerance
L10C Output Power @ T2-J11	±1.5 dB
T2 XMT IF Passband variation	±2.7 dB
T1 XMT IF Passband variation	±2.3 dB
Waveguide Passband variation	(Not Specified/ GHz/Channel)
T1 RCV IF Passband variation	±1.7 dB
T2 RCV IF Passband variation	±2.95 dB
T2 RCV IF 4-way Power Divider Balance	±0.2 dB
T2 RCV IF -14 dB Attenuator (NARDA)	±0.3 dB
T2 RCV IF -10 dB Attenuator (MECA)	±0.6 dB
T2 RCV Detector Passband variation	±0.2 dB
Resultant Worse Case T2 RCV Level variation	±12.45 dB (+0.3 v to +87.9 v)
RMS T2 RCV Level variation	+1.5 dB - 2.20 dB (+3.0 v to +7.0 v)

Figure 5

Central Electronics Room		Tolerance
L3D Output Power @ T2-J11		±0.5 dB/2 LO
Combined F4 Output Power	±1.3 dB/2 IF	±1.3 dB/4 IF
A to B Rack Cable Loss	+0 dB - 0.5 dB/2 IF	+0 dB - 0.5 dB/4 IF
	Sub Total/4 IF +2 LO =	+1.1 -1.4 dB
	Sub Total/2 IF +2 LO =	+1.0 -1.2 dB

T2 XMT IF Passband Response	±2.7 dB
T1 XMT IF Passband Response	±2.3 dB
Waveguide Passband Response	(Not Specified/GHz/Channel)
T1 RCV IF Passband Response	±1.7 dB
T2 RCV IF Passband Response	±2.95 dB
T2 RCV IF 4-way Power Divider Balance	±0.2 dB
T2 RCV IF -14 dB Attenuator (NARDA)	±0.3 dB
T2 RCV IF -10 dB Attenuator (MECA)	±0.6 dB
T2 RCV Detector Passband Variation	±0.2 dB

Resultant Worst Case T2 RCV Level Variation (+0.3 v to +80.2 v)

for 4 IF System +12.05 db -12.35 dB

Resultant Worst Case T2 RCV Level Variation (+0.2 v to +49.4 v)

for 2 IF System +11.95 dB -12.15 dB

RMS T2 RCV Level Variation (+3.0 v to +7.0 v)

for 4 IF System +1.5 dB -2.2 dB

RMS T2 RCV Level Variation (+1.9 v to +4.4 v)

for 2 IF System +1.5 dB -2.2 dB

Figure 5 (cont.)

A T2 XMT and RCV level survey versus antenna was conducted on 7/22/80. Only 2 IF signals (A and C) were present at this time. No checks were made on input levels, proper Front End operation, or the spectrum of the composite passband responses, although these antennas were considered to be operational at the time. It can be assumed that some units could have been defective or misadjusted.

Predicted RMS minimum and maximum values were based on a 95% probability of being correct for a Gaussian distribution. The survey chart bears this out, with the exception of Vertex Room T2 XMT level and Central Electronics Room T2 RCV level. However, the Front End IF power is 3 dB lower than specification for most antennas which would account for the Vertex Room T2 XMT level being lower than predicted for a large number of antennas. Since the Central Electronics Room T2 RCV level is set on LO power only, low IF power would similarly affect this reading.

A table of suggested data checker voltage limits for T2 RCV and XMT levels is presented in Figure 7, for both 4 IF and the 2 IF system in use today.

ANTENNA			VERTEX ROOM (2 IF)		CENTRAL ELECTRONICS ROOM (2 IF)	
ADR	ID	OPL	T2XMTLEVEL	T2RCVLEVEL	T2XMTLEVEL	T2RCVLEVEL
'33	1					
'21	2					
'32	3	√	1.020	5.135	1.040	2.585
'5	4	√	3.545	5.430	0.900	3.160
'14	5	√	1.910	5.200	1.120	2.400
'10	6					
'12	7	√	1.350	4.940	1.020	2.300
'6	8	√	2.085	5.135	0.945	1.685
'4	9	√	1.790	5.290	0.885	1.960
'13	10	√	2.815	4.735	1.020	1.700
'15	11	√	1.775	5.265	1.275	2.480
'20	12	√	2.140	5.900	1.115	2.375
'17	13	√	1.940	5.320	1.030	2.930
'3	14	√	3.375	5.465	1.160	2.975
'7	15	√	1.625	6.050	1.425	1.415
'22	16	√	1.580	5.525	1.305	2.070
'1	17	√	1.540	5.040	0.845	2.110
'16	18	√	1.055	4.975	0.950	2.200
'25	19	√	2.400	5.340	0.945	2.590
'26	20	√	3.420	5.375	1.305	4.220
'23	21	√	3.345	5.525	0.930	2.600
'11	22	√	2.985	4.645	0.800	3.445
'30	23	√	2.370	7.380	1.215	3.075
'24	24	√	3.845	4.965	0.915	3.755
'31	25	√	1.890	5.375	1.510	2.065
'27	26	√	1.690	6.355	0.770	1.395
'2	27					
	28					
Measured Max.			3.845	7.380	1.425	4.220
Predicted Max.			<4.1 RMS	<7.0 RMS	<1.7 RMS	<4.4 RMS
Measured Min.			1.020*	4.645	0.770	1.395*
Predicted Min.			>2.2 RMS	>3.0 RMS	>0.9 RMS	>1.9 RMS

*Note. F4 levels are -3 dB from specification for most antennas.

Therefore these voltages will be lower than predicted.

T2 XMT and RCV Level Survey Versus Antenna 7/22/80

Figure 6

4 IF SYSTEM DATA CHECKER VOLTAGE LIMITS

Vertex Room / Data Set 2

Adr.	Module	Description	Nominal	Range
'45	T2	Transmit IF Power	5	+3.5/+6.5
'46	T2	Receive IF Power	5	+3.0/+7.0

Central Electronics Room / Data Set 5

'45	T2	Transmit IF Power	1.32	+0.9/+1.7
'46	T2	Receive IF Power	5	+3.0/+7.0

2 IF SYSTEM DATA CHECKER VOLTAGE LIMITS

Vertex Room / Data Set 2

'45	T2	Transmit IF Power	3.15	+2.2/+4.1
'46	T2	Receive IF Power	5	+3.0/+7.0

Central Electronics Room / Data Set 5

'45	T2	Transmit IF Power	1.32	+0.9/+1.7
'46	T2	Receive IF Power	3.15	+1.9/+4.4

Data Checker Voltage Limits

Based on RMS Error Calculations

Figure 7

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8/15/80