

EXHIBIT 14 CFR 47, Part 2.1033, c(14)

TEST DATA

The test data required by FCC CFR 47, Part 2, Clause 2.1046 through Clause 2.1057, inclusive, measured in accordance with the procedures set out in Clause 2.1041 are shown as in the attached **Test Report**.

Department of Compliance Approval

**Title: Test of Spectrum II Microwave Radio System (28GHz)
to FCC CFR 47, Part 2 & Part 101**

Customer: Digital Microwave Corporation

1. SUMMARY

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**Title: Test of Spectrum II Microwave Radio System (28GHz)
to FCC CFR 47, Part 2 & Part 101**

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1. SUMMARY

The product **SPECTRUM II Microwave Radio System (28GHz)** was tested in accordance with the following standard(s).

CFR 47 - Part 2 and Part 101.

The Equipment Under Test (EUT) passed all required tests.

This report shows all data required by FCC CFR 47, Part 2.1046 through 2.1057.

1.1 BRIEF DESCRIPTION OF THE EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) is the Spectrum II Microwave Radio System operated at 28GHz. The EUT was manufactured by Digital Microwave Corporation.

The Spectrum II is a platform of digital microwave radios. It features a modular design made up of three major components, the Indoor Unit (IDU), the Outdoor Unit (ODU) and the antenna. The IDU is typically mounted outdoors on a tower or building. A single coaxial cable connects the IDU to the ODU. This coaxial cable carries DC power, transmit/receive data, and ODU-to-IDU telemetry. The antenna is typically connected to the ODU.

The IDU contains the multiplexing, demultiplexing, demodulating, control and diagnostic circuits and is typically mounted in a standard EIA equipment rack. The ODU contains the radio frequency (RF) circuits.

An additional unit, the Local Maintenance Terminal (LMT), provides facilities for configuring and monitoring the radio. It consists of a customer-supplied personal computer, software and a cable connected to the IDU.

Spectrum II utilizes four-level frequency shift keying (4 FSK) modulation.

1.2 TESTS REQUIRED

As required by the FCC regulations, the following measurements are done accordingly.

1.2.1 RF power output (§2.1046 and §101.113)

1.2.2 Modulation characteristics (§2.1047 and §101.141)

1.2.3 Occupied bandwidth (§2.1049 and §101.109)

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- 1.2.4 Spurious emissions at antenna terminals (§2.1051 and §101.111)
- 1.2.5 Field strength of spurious radiation (§2.1053, §2.1057, and §101.111)
- 1.2.6 Frequency stability (§2.1055 and §101.107)

1.3 SUMMARY OF TEST RESULTS

The test results are summarized as below.

Test No.	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6
Result	P	P	P	P	P	P

Note:

- P - Compliance with the requirements of the specification for this test.
 - U - The results were within the measurement uncertainties hence any decision regarding compliance will be made by the enforcing agency.
 - F - Did not compliance with the requirements of the specification for this test.
 - N/A - Not applicable.
-

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2. MEASUREMENTS AND DERIVED RESULTS

This part contains the brief description of the used test method(s) and derived test results. Details of the test method(s) used have been recorded and are kept on file by the laboratory. Wherever possible, the test method(s) described in specific standard(s) have been used.

The measurements described in this report were performed at the premise of Digital Microwave Corporation, 170 Rose Orchard Way, San Jose, California 95134, and Digital Microwave Corporation, 3325 South 116th Street, Seattle, Washington 98168 (for spurious radiations test only).

2.1 RF POWER OUTPUT

This test is to measure the power level (amplitude) of the signal being transmitted by the EUT. This is simply done by measuring the power out of the unit with a power meter.

The calculation and method used to determine the carrier power on the basis of measured power in the frequency load attached to the transmitter output terminals is shown as below.

RF Power Output = Power Meter's Reading + Path Loss

The Path Loss is the attenuation along the path of the coupling and interconnections. The procedure to make Path Loss measurement is shown as in Work Instructions - RCAS-WI-001.

The power output was measured at the RF output terminals when the transmitter was adjusted in accordance with the tune-up procedure to give the values of the dc voltages applied to and the dc currents into the several elements of the final radio frequency amplifying device for normal operation over the power range.

Ambient temperature:	22 °C
Relative humidity:	41 %
Rated output power:	16 - 24 dBm
Limits set as per CFR47, §101.113:	55dBW / 85 dBm

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Measurement and derived results

CHANNELS	RF POWER OUTPUT
Ch.21 (27,705 MHz)	22.85 dBm
Ch.22 (27,715 MHz)	22.90 dBm
Ch.23 (27,725 MHz)	23.15 dBm
Ch.24 (27,735 MHz)	22.58 dBm
Ch.25 (27,745 MHz)	23.13 dBm
Ch.26 (27,755 MHz)	23.18 dBm
Ch.27 (27,765 MHz)	23.27 dBm
Ch.28 (27,775 MHz)	23.27 dBm
Ch.29 (27,785 MHz)	22.89 dBm
Ch.30 (27,795 MHz)	22.95 dBm

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2.2 MODULATION CHARACTERISTICS

This part is to give a detailed description of the modulation system to be used in the EUT. It includes the response characteristics (frequency, phase and amplitude) of filters used.

Refer to EXHIBIT 13.

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2.3 OCCUPIED BANDWIDTH

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5% of the total mean power radiated by a given emission.

The occupied bandwidth was measured using the integrated function (OCCUPIED POWER BW) as in the spectrum analyser that was used for testing. This function integrates the power displayed and places the delta markers at the points containing 99% of the power. The power bandwidth routine first computes the combined power of all signal responses contained in the trace. It then computes the bandwidth equal to the percentage of the total power and displays this value on-screen.

The maximum authorized bandwidth is 850MHz for frequency band from 27.5GHz to 28.35GHz as specified as per §101.109.

Ambient temperature: 22.5°c
Relative humidity: 44 %
Limits set as per CFR47, §101.109: 850MHz

Measurement and derived results

CHANNELS	OCCUPIED BW
Ch.21 (27,705 MHz)	11.83 MHz
Ch.22 (27,715 MHz)	12.08 MHz
Ch.23 (27,725 MHz)	11.92 MHz
Ch.24 (27,735 MHz)	11.83 MHz
Ch.25 (27,745 MHz)	12.00 MHz
Ch.26 (27,755 MHz)	11.75 MHz
Ch.27 (27,765 MHz)	12.25 MHz
Ch.28 (27,775 MHz)	11.67 MHz
Ch.29 (27,785 MHz)	12.00 MHz
Ch.30 (27,795 MHz)	12.00 MHz

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2.4 SPURIOUS EMISSIONS AT ANTENNA TERMINALS

The spurious frequency was checked at the equipment output terminal. The terminal was loaded with an artificial antenna. The magnitude of each harmonic and other spurious emission was detected when the equipment was operated under the same conditions as that for occupied bandwidth measurement.

The magnitude of spurious emissions that are attenuated more than 20dB below the permissive value is not reported here.

Ambient temperature: 22°c
Relative humidity: 42 %
Limits set as per CFR47, §101.111: As Eq.1 & Eq.2 shown as below

As required as per §101.111, (a), (2), (ii), in any 1MHz band, the center frequency of which is removed from the assigned frequency by more than 50% up to and including 250% of the authorized bandwidth: As specified by the following equation but in no event less than 11dB:

$$A=11+0.4(P-50)+10\text{Log}_{10}B \tag{Eq.1}$$

A: Attenuation (dB) below the mean output power level.
P: Percent removed from the carrier frequency.
B: Authorized bandwidth in MHz.

RBW and VBW of spectrum analyser were set as 1 MHz and 10 kHz respectively.

All channels (from Ch.21 to Ch.30) were examined against this specification. The bandwidth of the EUT is 10MHz. Thus, for each channel, the frequency ranges investigated were from (f_c + 5) MHz to (f_c + 25) MHz and from (f_c - 25) MHz to (f_c - 5) MHz.

The worst case results are shown as below.

Frequency Removed (MHz)	Attenuation below carrier (dB)
-25	-57
-10	-52
-5	-25
0	0
5	-23
10	-50
25	-56

Also, as required as per §101.111, (a), (2), (iii), in any 4kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth, at least 43 + 10 log(mean output power in watts) dB, or 80dB, (Eq.2)

whichever is the lesser attenuation.

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In this case, the attenuation is required to be no less than $43+10\text{Log}(\text{Mean Output Power}) = 29\text{dB}$.

All channels (from Ch.21 to Ch.30) were examined against this specification. The bandwidth of the EUT is 10MHz. Thus, for each channel, the frequency ranges investigated were from 9kHz ($f_c - 25$) MHz and from ($f_c + 25$) MHz to 110 GHz.

The RBW of the spectrum analyser was set as below instead of specified 4kHz.

3 kHz (limited by the spectrum analyser) – from 10kHz to 30MHz

30 kHz – from 26.5 to 75 GHz

300 kHz – from 75 GHz to 110 GHz

1 MHz – from 30 MHz to 26.5 GHz

The method is to scan the required frequency ranges. If there is any potential interference observed (peak is less than 10 dB closer to the limit), the frequency span would be reduced to focus on that spot frequency and employ 4kHz RBW for further investigation.

There is no potential interference emissions observed during the whole frequency range sweeping. All emissions are attenuated more than 40dB.

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2.5 FIELD STRENGTH OF SPURIOUS RADIATION - RADIATED EMISSIONS

Measurement was made to detect spurious emissions that may be caused directly from the power leads under normal conditions of installation and operation. The magnitude of each harmonic and other spurious emission is supplied in this report.

The test was done in a shielded room (7m*4m*4m). The EUT was put on a turn-table raised up 1.5m above ground floor. The antenna was set 3m away from the EUT and 1.5m above the ground floor.

Ambient temperature: 21°c
Relative humidity: 48%
Limits set as per CFR47, §101.111: As Eq.1 & Eq.2 shown as above:

The relative radiated powers of spurious emissions with the reference to the rated power output of the transmitter are listed below.

Freq. (MHz)	Polarization	Level (dBm)	Limit (dBm)	Margin (dB)	Pass/Fail
154.5	Vertical	-44.5	-29.0	15.5	Pass
280.0	Vertical	-47.0	-29.0	18.0	Pass
256.5	Horizontal	-47.8	-29.0	18.8	Pass
167.0	Vertical	-51.5	-29.0	22.5	Pass
301.5	Vertical	-51.8	-29.0	22.8	Pass
297.0	Horizontal	-52.5	-29.0	23.5	Pass

There is no spurious within 20dB of the limit for other frequencies.

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2.6 FREQUENCY STABILITY

The frequency stability was measured with variation of ambient temperature as follows:

-30° C, -20° C, -10° C, 0° C, +10° C, +20° C, +30° C, +40° C, and +50° C

Prior to frequency measurement, a period of time sufficient to stabilize all of the components of the oscillator circuit at each level was allowed.

The variation of primary supply voltage from 85% (20.40VDC) to 115% (27.60VDC) of the nominal value (24VDC) was implemented to measure the frequency stability.

The frequency tolerance is 0.001% for all fixed and base stations with the frequency band from 27.5GHz to 28.35GHz as per §101.107.

The test results are shown as following tables.

Temp	VDC	Ch.21	Ch.22	Ch.23	Ch.24	Ch.25
-30°C	20.40	0.0000731%	0.0000707%	0.0000690%	0.0000679%	0.0000674%
	24.00	0.0000317%	0.0000313%	0.0000304%	0.0000301%	0.0000291%
	27.60	0.0000598%	0.0000590%	0.0000587%	0.0000585%	0.0000581%
-20°C	20.40	0.0000685%	0.0000683%	0.0000683%	0.0000678%	0.0000677%
	24.00	0.0000632%	0.0000634%	0.0000638%	0.0000642%	0.0000643%
	27.60	0.0000545%	0.0000513%	0.0000555%	0.0000566%	0.0000570%
-10°C	20.40	0.0001303%	0.0001304%	0.0001304%	0.0001304%	0.0001303%
	24.00	0.0001302%	0.0001301%	0.0001301%	0.0001302%	0.0001300%
	27.60	0.0001301%	0.0001301%	0.0001301%	0.0001299%	0.0001299%
0°C	20.40	0.0001097%	0.0001095%	0.0001095%	0.0001094%	0.0001093%
	24.00	0.0001097%	0.0001099%	0.0001100%	0.0001102%	0.0001103%
	27.60	0.0001124%	0.0001122%	0.0001121%	0.0001118%	0.0001118%
10°C	20.40	0.0001076%	0.0001076%	0.0001073%	0.0001074%	0.0001076%
	24.00	0.0001067%	0.0001066%	0.0001063%	0.0001063%	0.0001062%

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	27.60	0.0001007%	0.0001017%	0.0001018%	0.0001024%	0.0000999%
20°C	20.40	0.0000283%	0.0000284%	0.0000289%	0.0000296%	0.0000304%
	24.00	0.0000426%	0.0000401%	0.0000393%	0.0000384%	0.0000380%
	27.60	0.0000433%	0.0000443%	0.0000449%	0.0000458%	0.0000590%
30°C	20.40	0.0000109%	0.0000103%	0.0000098%	0.0000091%	0.0000085%
	24.00	-0.0000028%	-0.0000025%	-0.0000004%	-0.0000004%	0.0000012%
	27.60	-0.0000004%	-0.0000005%	-0.0000006%	-0.0000006%	0.0000007%
40°C	20.40	-0.0000378%	-0.0000377%	-0.0000383%	-0.0000384%	-0.0000386%
	24.00	-0.0000413%	-0.0000410%	-0.0000411%	-0.0000408%	-0.0000406%
	27.60	-0.0000415%	-0.0000416%	-0.0000417%	-0.0000417%	-0.0000418%
50°C	20.40	0.0000195%	0.0000203%	0.0000208%	0.0000214%	0.0000221%
	24.00	0.0000335%	0.0000333%	0.0000330%	0.0000329%	0.0000308%
	27.60	0.0000341%	0.0000345%	0.0000347%	0.0000349%	0.0000351%

Temp	VDC	Ch.26	Ch.27	Ch.28	Ch.29	Ch.30
-30°C	20.40	0.0000659%	0.0000649%	0.0000641%	0.0000635%	0.0000633%
	24.00	0.0000324%	0.0000324%	0.0000286%	0.0000287%	0.0000285%
	27.60	0.0000581%	0.0000577%	0.0000572%	0.0000571%	0.0000566%
-20°C	20.40	0.0000675%	0.0000673%	0.0000664%	0.0000660%	0.0000660%
	24.00	0.0000645%	0.0000622%	0.0000646%	0.0000649%	0.0000656%
	27.60	0.0000578%	0.0000582%	0.0000585%	0.0000589%	0.0000592%
-10°C	20.40	0.0001303%	0.0001303%	0.0001304%	0.0001306%	0.0001307%
	24.00	0.0001299%	0.0001299%	0.0001300%	0.0001300%	0.0001301%

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	27.60	0.0001300%	0.0001302%	0.0001301%	0.0001309%	0.0001299%
0°C	20.40	0.0001083%	0.0001091%	0.0001091%	0.0001088%	0.0001090%
	24.00	0.0001103%	0.0001103%	0.0001105%	0.0001108%	0.0001108%
	27.60	0.0001117%	0.0001113%	0.0001113%	0.0001111%	0.0001109%
10°C	20.40	0.0001076%	0.0001077%	0.0001075%	0.0001076%	0.0001078%
	24.00	0.0001061%	0.0001059%	0.0001054%	0.0001032%	0.0001021%
	27.60	0.0001009%	0.0001014%	0.0001005%	0.0001004%	0.0001014%
20°C	20.40	0.0000306%	0.0000309%	0.0000313%	0.0000319%	0.0000324%
	24.00	0.0000371%	0.0000366%	0.0000346%	0.0000333%	0.0000329%
	27.60	0.0000597%	0.0000608%	0.0000745%	0.0000754%	0.0000763%
30°C	20.40	0.0000081%	0.0000074%	0.0000068%	0.0000063%	0.0000058%
	24.00	0.0000021%	0.0000028%	0.0000035%	0.0000042%	0.0000046%
	27.60	-0.0000074%	-0.0000079%	-0.0000085%	-0.0000100%	-0.0000011%
40°C	20.40	-0.0000378%	-0.0000379%	-0.0000383%	-0.0000384%	-0.0000386%
	24.00	-0.0000405%	-0.0000403%	-0.0000403%	-0.0000402%	-0.0000399%
	27.60	-0.0000418%	-0.0000417%	-0.0000416%	-0.0000415%	-0.0000414%
50°C	20.40	0.0000233%	0.0000244%	0.0000245%	0.0000247%	0.0000249%
	24.00	0.0000305%	0.0000286%	0.0000283%	0.0000280%	0.0000274%
	27.60	0.0000353%	0.0000361%	0.0000362%	0.0000367%	0.0000367%

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3. LIST OF TEST EQUIPMENT USED

Spectrum Analyzer: HP8565E & HP8563E

Preselector & mixer: HP 11974A (26.5GHz- 40GHz)
HP 11974U (40GHZ-60GHZ)
HP 11974V (50GHZ-75GHZ)
HP 11970W (75GHZ-110GHZ)
MILLITECH 9259 (110GHZ-170GHZ)

Signal Generator: HP83640A

Power Meter: HP437B

Power sensor: HP 8481H (10MHz-18GHz)
HP 8485A (50MHz- 26.5GHz)
HP 8486A (26.5GHz- 40GHz)
HP 8487D (50MHz- 50GHz)

Frequency counter: HP 5352B

Antenna: EMCO 3141 (30MHz-2GHz)
EMCO 3115 (1GHz-18GHz)
SYSTRON DONNER DBFA-520-15 (18GHz-26.5GHz)
WAVELINE 1099 (26.5GHz-40GHz)
MILLITECH SGH-19-RP000 (40GHz-60GHz)
MILLITECH SGH-15-RP000 (50GHz-75GHz)
ALPHA INDUSTRIES 861W/387 (75GHz-110GHz)
AEROWAVE 06-7025 (110GHz-170GHz)

Amplifier: HP 8447F

EXHIBIT 15 CFR 47, Part 2.1033, c(15, 16, 17)

Not Applicable.

EXHIBIT 13 CFR 47, Part 2.1033, c(13)

MODULATION CHARACTERISTICS

The SPECTRUM II radio is employed to process digital information of various types. Voice, data, video, and many other information types can be encoded and transmitted across this radio system.

The necessary bandwidth is 10.0MHz.

The modulation of the radio is 4FSK and the nature of the modulation signal is "two or more channels containing quantized or digital information".

Thus, the emission designator can be stated as 10M0F7W

The 10M0 portion of the designator is derived as follows

10M0 = 10.0MHz necessary bandwidth [CFR47 Part 202(a)]

The F7W portion of the designator is derived as follows

F = Frequency Modulation [CFR47 Part 2.201(c)]

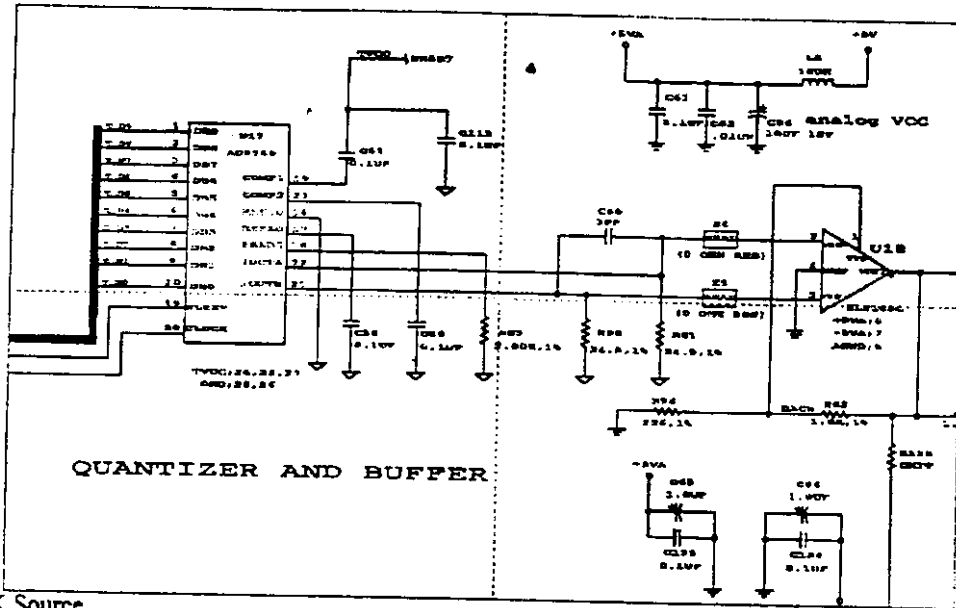
7 = the nature of the modulation [CFR47 Part 2.201(d)]

W = the type of information transmitted [CFR47 Part 2.201(e)]

Transmitter Spurious and Modulation Control

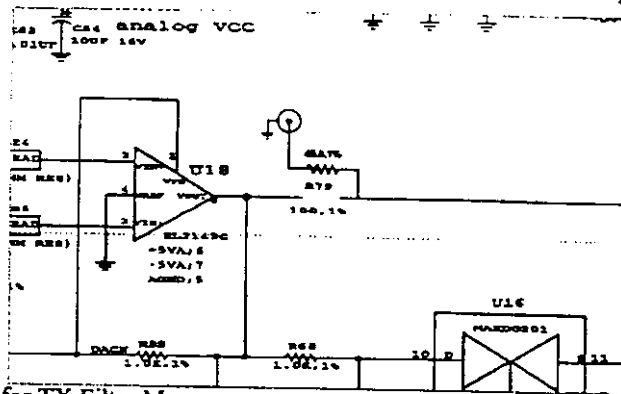
1. Introduction

1.1. This document describes expected and measured transmit filter on DS-3 4FSK Signal Processor Printed Circuit Assembly (SigProc).

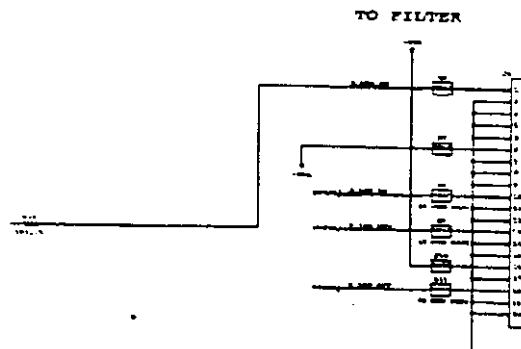


1.2. Fig. 1 4FSK Source

- 1.2.1. The 4FSK waveform is sourced by a 10-Bit Video DAC AD9760-50. At present the DAC only outputs one of four levels, and all filtering is performed by the analog transmit filters.
- 1.2.2. The differential output of the DAC is amplified by an analog differential amplifier EL2142C; this has the effect of carrying a terminated differential signal across a noisy digital groundplane to become a single-sided waveform on a quiet groundplane.
- 1.2.3. The output of this amplifier is designed to not limit for the maximum DAC output excursion

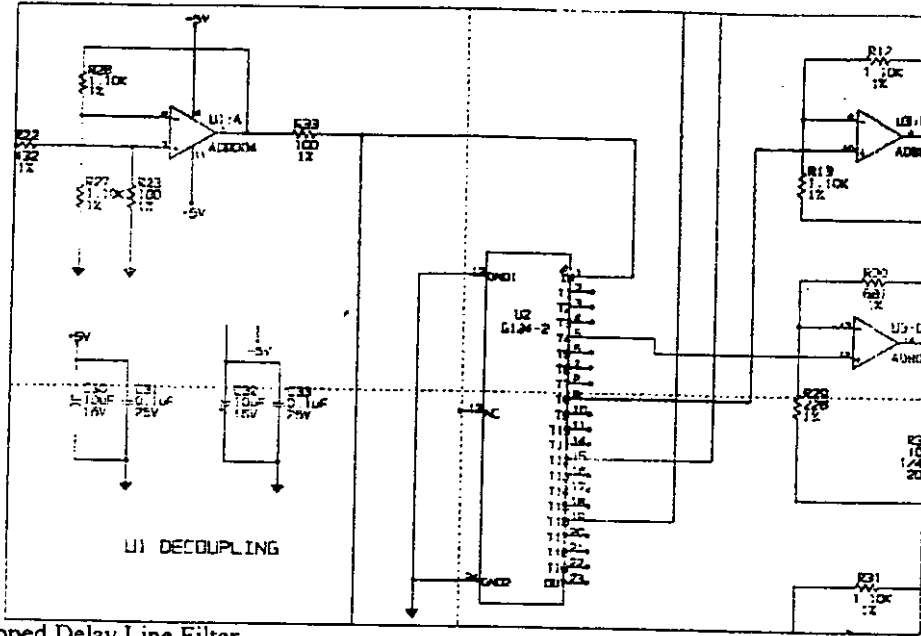


1.3. Fig. 2 Test Connection for TX Filter Measurement.

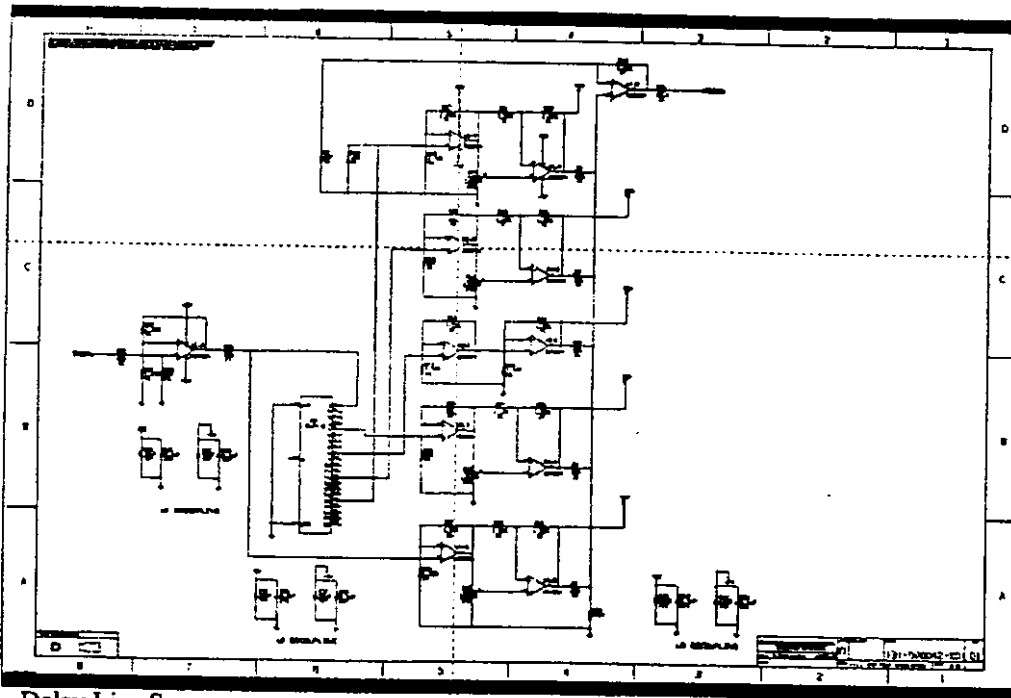


1.4. Fig. 3 SigProc Filter Daughter Card Interface

adjustable within a specified range using a potentiometer. Taps are spaced at intervals of about one symbol time (40.6ns).

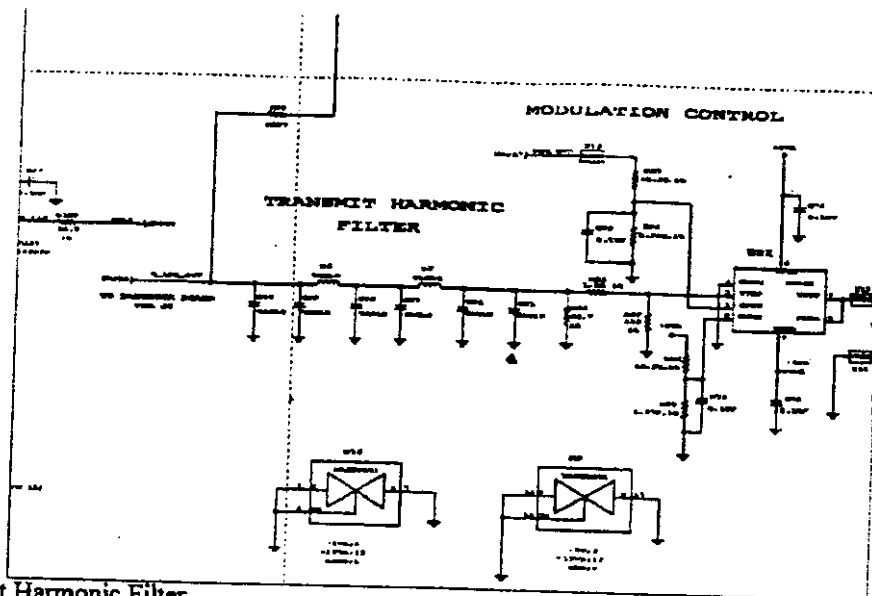


1.5. Fig. 4 Tapped Delay Line Filter



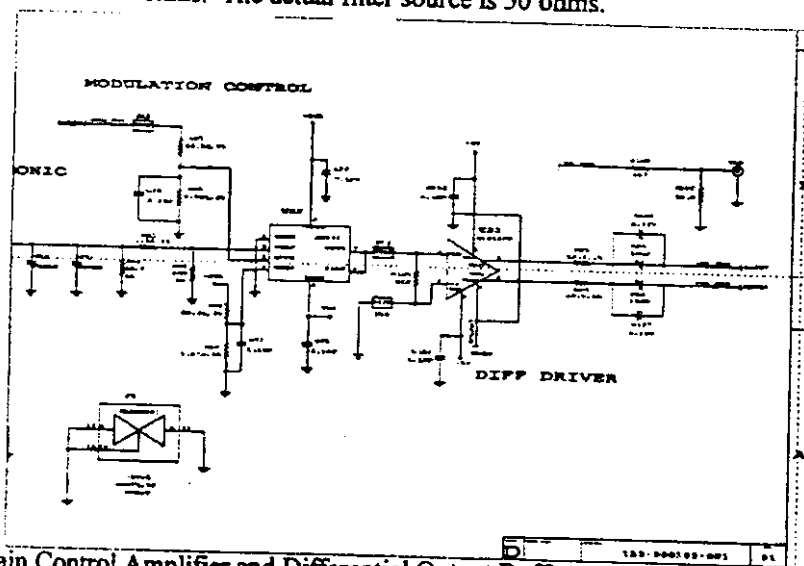
1.6. Fig. 5 Delay Line Summer

- 1.6.1. Unfiltered four-level waveforms spaced at about 1 symbol interval are scaled, possibly inverted and added in the tapped delay line filter
- 1.6.2. The center tap is fixed: all other taps are adjustable
- 1.6.3. The center tap has a fixed gain of 1
- 1.6.4. The two taps immediately adjacent to the center tap have a maximum gain of $\pm .4129$
- 1.6.5. The two end taps have a maximum gain of $\pm .1000$
- 1.6.6. This equalizer is used to cancel a major part of the linear part of the intersymbol interference that the subsequent radio creates.



1.7. Fig. 6 Transmit Harmonic Filter

- 1.7.1. The equalized output is filtered using a Chebyshev 5th-order filter with 66 ohm source and load impedance. The filter output is matched using a pi-pad into the 100-ohm input impedance of the voltage-controlled amplifier.
- 1.7.2. The filter ratio of C_{IN} to C₁ is 127/220 or .5772 (.1dB ripple Chebyshev filter is .5807 ratio)
- 1.7.3. Inductors are wound toroids (9 turns of 30AWG enameled wire wound in a single layer on MICROMETALS T25-2 ferrite core, .446uH 5% adjusted and set by manufacturer using Q-Dope adhesive, marked with yellow dot on red wire) with design Q exceeding 140 for frequencies between 4.0MHz and 15 MHz.
- 1.7.4. The prototype filter inductance is .28665 uH
- 1.7.5. The prototype filter capacitance is 98.1661pF
- 1.7.6. The prototype filter resistance is 54 ohms
- 1.7.7. The prototype filter frequency is 30MHz
- 1.7.8. The actual filter load is 47 ohms. The actual filter source is 50 ohms.



1.8. Fig. 7 Transmit Gain Control Amplifier and Differential Output Buffer

- 1.8.1. The filter output is into an adjustable-gain amplifier with 100 ohms input impedance through a matching pad. This amplifier is used during system adjustment test to set the FM modulation index. The adjustment range is ± 6 dB adjustable in .05dB increments.
- 1.8.2. The eye waveform is examined at TP2 during module test to verify the eye pattern closely matches a pictured eye pattern in terms of eye shape and closure and amplitude. The transmit RF spectrum is verified against a mask during Factory Acceptance Testing, as is the system BER performance versus RF level over temperature.
- 1.8.3. The Gain Control Amplifier output drives a differential amplifier (which bridges from the relatively-quiet PCA to the noisy backplane/receiver).

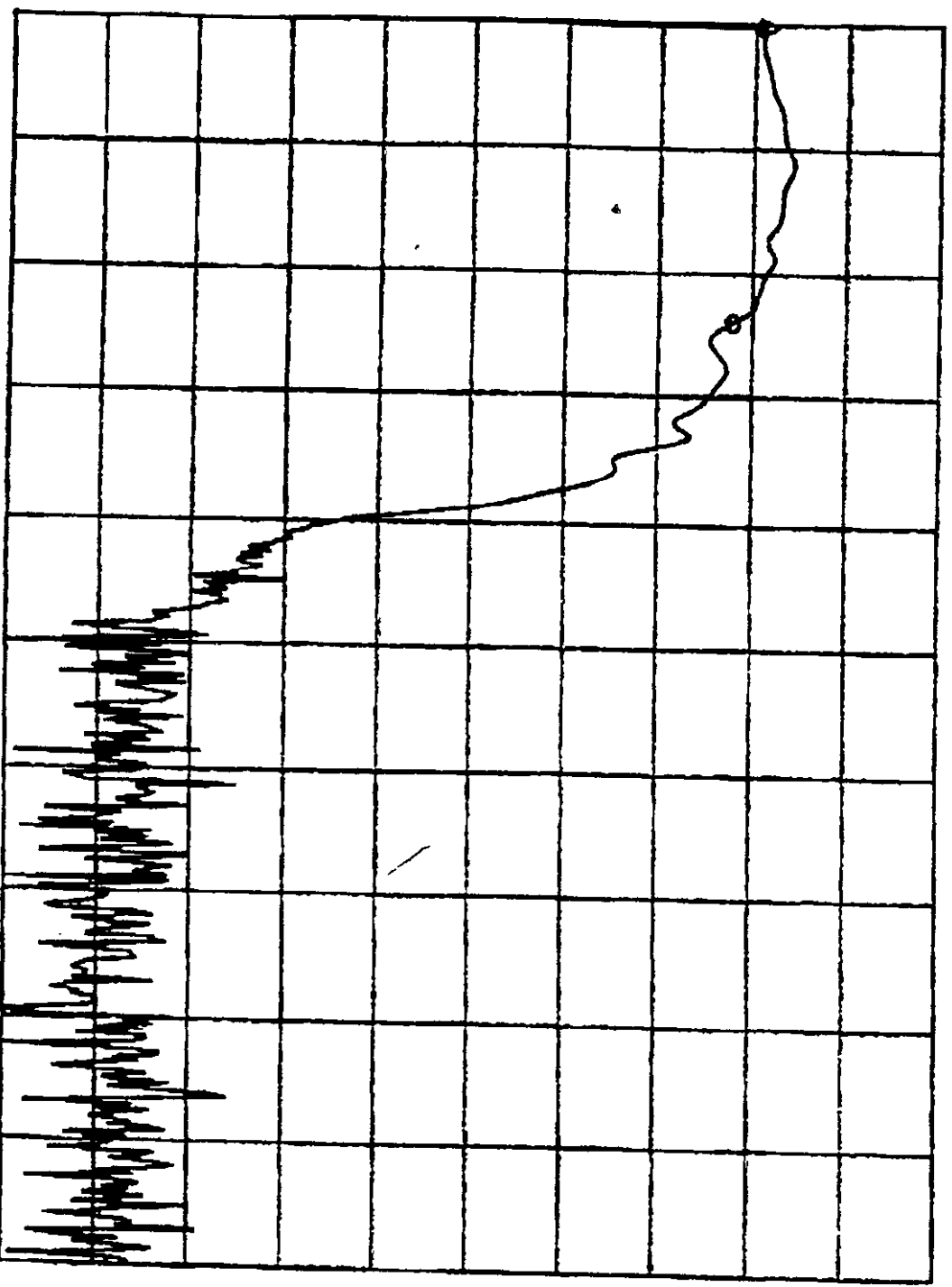
Measured Transmitter Filter

- 2.1. An HP3577B Network Analyzer (5Hz - 200MHz) is connected to the UUT, which has been mounted in a standard DMC Link Simulator Test Fixture.
- 2.2. R79 100 1% is removed. The resistor is replaced by the B (output) port of the Network Analyzer and a 50 ohm 1% resistor (return loss is not measured).
- 2.3. The PWB TX-EYE output is measured at the Link Simulator TX EYE output, which is connected directly to the A (input) Port of the Network Analyzer. This output is one-half of the normal differential SigProc output
- 2.4. The gain and group delay of the connection

REF LEVEL /DIV OFFSET 23 750 000.000HZ
-10.000DBm 10.000DB MAG (A) -3.158DB

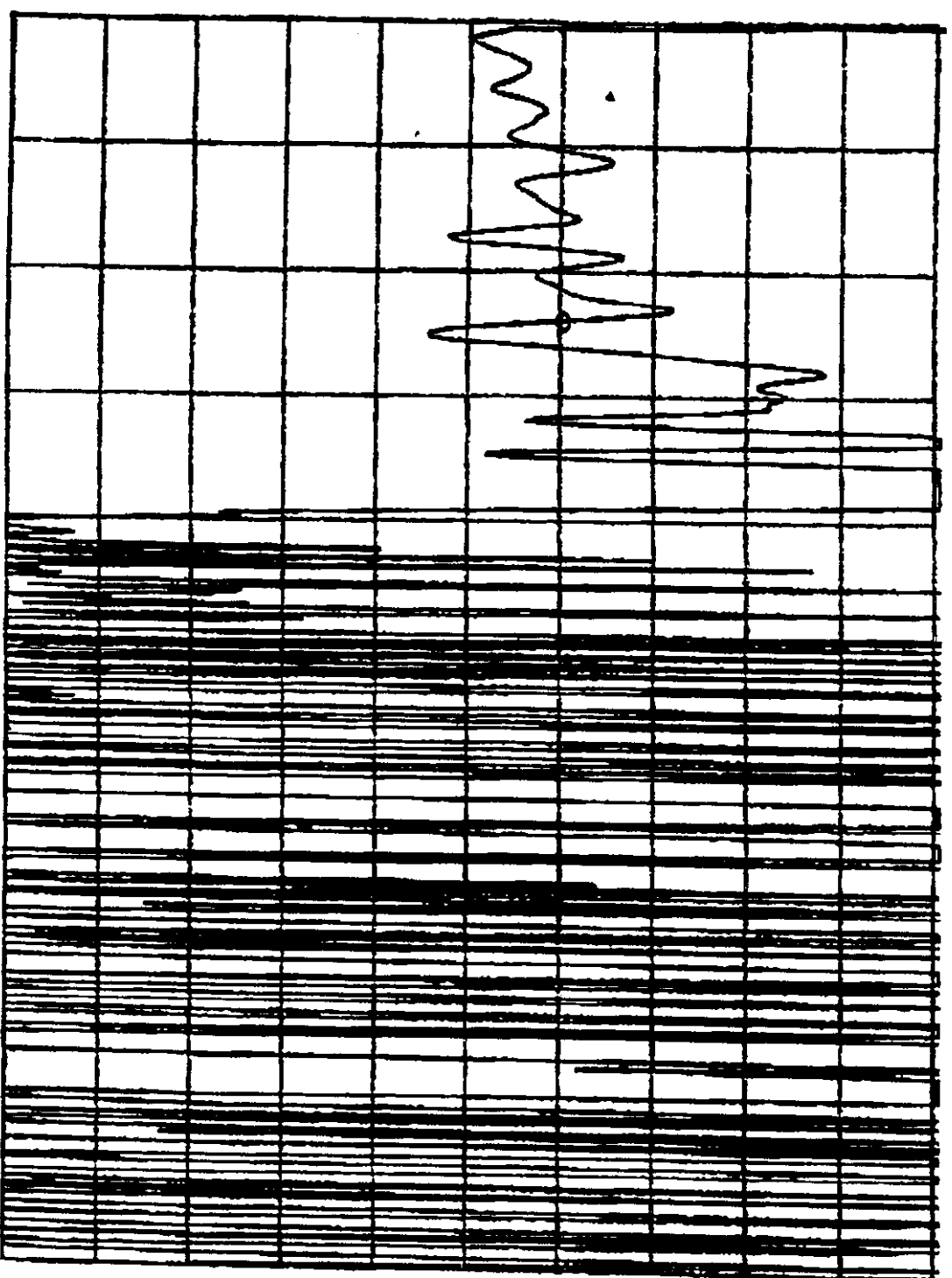
START 0.000HZ
AMPTD -10.0DBm

STOP 100 000 000.000HZ



MAY 26, 1999
PETER J CASTROVIN
PROB: R Banning
Single-Sided DS-SS
Tensun's Filter
and Equalizer
Amplitude versus Freq.

REF LEVEL /DIV OFFSET 23 750 000.000HZ
120.00NSEC 20.000NSEC DELAY (A) 140.98NSEC



START 0.000HZ
AMP TD -10.0dBm

STOP 100 000 000.000HZ
DELAY APER 500.0KHZ

MAY 26, 1989
PETER J. CASI
PLAT: R BIANCHI
Single - Sided
Transmit F, W
Equalizer
Graw Delay
FAVORABLE