FCC TYPE ACCEPTANCE REPORT

FOR THE

HPB250-A, 250 WATT ANALOG BOOSTER SYSTEM

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TABLE OF CONTENTS

1.0 INTRODUCTION

This report contains all the required data for type acceptance of the Communication Microwave Corp model HPB250-A analog booster system. The data presented was taken from tests performed on a production booster system designed to receive and amplify up to 31 ITFS/MMDS television channels, in the MDS and ITFS bands, for retransmission into shadowed service areas. Other information required for type acceptance, such as circuit diagrams and descriptions, photographs, and tune-up and maintenance procedures may be found in the Comwave HPB250-A instruction manual. The booster system design and resultant test data reflect the revised MMDS/ITFS requirements imposed November 1, 1991.

2.0 CERTIFICATION OF DATA

FCC Paragraph 2.909 (d)

Having personally conducted the tests contained in this report, I certify that the statements and data submitted are true and correct to the best of my knowledge.

Paulo Correa
Director of Engineering
Communication Microwave Corp

3.0 TEST EQUIPMENT

FCC Paragraph 2.947 (d)

The following is a list of major test equipment, which was used in testing the HPB250-A transmitter for this report:

1)	Spectrum Analyzer	HP Model 8593E
2)	Power Meter	HP Model 436A
3)	Frequency Counter	HP Model 5350B
4)	Digital Multimeter	Fluke Model 87
5)	TV Demodulator	TEK Model 1450-1
6)	Audio Analyzer	TEK Model VM700
7)	NTSC Test Set	TEK Model VM700
8)	NTSC Video Generator	TEK Model 1910
9)	Oscilloscope	TEK Model 2215
10)	Test Oscillator	HP 651B

4.0 DESCRIPTION OF EQUIPMENT

FCC Paragraph 2.983

1)	Type of Emission:	Visual - 5M75C3F Aural - 250KF3E
2)	Frequency Range:	2500-2700 MHz
3)	Operating Range:	+28.5 to +45dBm
4)	Power Rating:	1-2 Channels @ 45.0 dBm 3-4 Channels @ 40.0 dBm 5-8 Channels @ 36.5 dBm 9-16 Channels @ 32.0 dBm 17-31 Channels @ 28.5 dBm
5)	E & I on Final:	Drain voltage 10V Drain current 7A each

6) Function of Active Devices:

The following is a list of active devices in the RF chains of the HPB250-A transmitter. The relative position of each device may be found by referring to the block diagrams (refer to instruction manual Figure HG2-01008.

MDS DRIVER:

Final Amplifier	***Module 04-254-02***
Q1-Q7	RF Amplifiers
Power Amplifier #1	***Module 04-306-02***
Q1-Q5	RF Amplifiers
Power Amplifier #2	***Module 04-306-02***
Q1-Q5	RF Amplifiers
Power Amplifier #3	***Module 04-306-02***
Q1-Q5	RF Amplifiers

RF Precorrector		***Module 04-299-02***
	<u>Board 40-299-02</u>	
U1-U3		RF Amplifiers
D1, D2		Diodes
	<u>Board 40-227-02</u>	
U1, U2		RF Amplifiers
U3		Regulator
U4		OP Amplifier
Q1-Q4		Transistor
D1-D8		Diodes
RF Attenuator		***Module 13-102-02***
D1-D4		Pin Diodes
Q1		Transistor
D5-D8		Diodes
RF Attenuator		***Module 13-102-02***
D1-D4		Pin Diodes
Q1		Transistor
D5-D8		Diodes
Microwave Sensing Module		***Module 13-103-02***
D1-D6		Pin Diodes
Q1, Q2		Transistors
U2		Quad. Amplifier
U1		RF Amplifier
D11		Schottky Diodes
D7-D10		Diodes

MMDS DRIVER:

Final Amplifier		***Module 04-308-02***
U1, U2		RF Amplifiers
Power Amplifier #1		***Module 04-306-02***
Q1-Q5		RF Amplifiers
Power Amplifier #2		***Module 04-306-02***
Q1-Q5		RF Amplifiers
Power Amplifier #3		***Module 04-307-02***
U2-U5		RF Amplifiers
RF Precorrector		***Module 04-299-02***
	Board 40-226-02	
U1-U3		RF Amplifiers
D1, D2		Diodes
	Board 40-227-02	
U1, U2		RF Amplifiers
U3		Regulator
U4		OP Amplifiers
Q1-Q4		Transistors
D1-D8		Diodes
RF Attenuator		***Module 13-102-02***
D1-D4		Pin Diodes
Q1		Transistor
D5-D8		Diodes
RF Attenuator		***Module 13-102-02***
D1-D4		Pin Diodes
Q1		Transistor
D5-D8		Diodes

Microwave Sensing Module	*Module 13-103-02*
D1-D6	Pin Diodes
Q1, Q2	Transistors
U2	Quad. Amplifier
U1	RF Amplifier
D11	Schottky Diodes
D7-D10	Diodes

POWER AMPLIFIER SEGMENTS:

Module 04-294-02

IC1	SPDT Switch
D1	Diode Common Cathode
D2	Diode Dual Cathode
Q1-Q5	GaAs FET

POWER SUPPLY:

OEM

7)	Circuit Diagrams:	See Technical Manual.
8)	Instruction Books:	See Technical Manual.
9)	Tune Up Procedures:	See Technical Manual.
10)	Description of Oscillator Circuit and Frequency Stability Devices:	See Technical Manual.
11)	Describe Limiters:	Not used.
	Describe Spurious Suppression Circuits:	Not used.
12)	Describe Modulation Circuits:	See Technical Manual.

5.0 IDENTIFICATION LABEL

FCC Paragraph 2.983 (f), 2.1003 (a), 2.925, 2.926

FCC ID: CHP8BUHPB250-A
MODEL HPB250-A SIGNAL BOOSTER

WARNING: ***Do Not Exceed Per Channel Output Power Rating***

1-2 Channels	**45.0 dBm/ch**	**(31.6 W)/ch**
3-4 Channels	**40.0 dBm/ch**	**(10.0 W)/ch**
5-8 Channels	**36.5 dBm/ch**	**(4.5 W)/ch**
9-16 Channels	**32.0 dBm/ch**	**(1.6 W)/ch**
17-31 Channels	**28.5 dBm/ch**	**(0.7 W)/ch**

6.0 PHOTOGRAPHS

FCC Paragraph 2.983 (g) Included.

7.0 RF POWER OUTPUT MEASUREMENTS

FCC Paragraph 2.985

Visual Ouput Power:	45dBm peak sync
% Video Modulation:	87.5%
Type Video Modulation:	Per FCC 73.663 (b) (1)
Aural Power	30dBm average
Method of Measurement:	Per FCC 73.663 (b)

The booster was operated into a dummy load of substantially zero reactance with a resistance equal to the transmission line characteristic impedance. The booster's peak output power was determined with one channel using the factor 1.68 times the average output. The power meter was then substituted with a spectrum analyzer calibrated to full scale reading. Additional composite channels were added and levels adjusted by the following values:

1-2 Channels	**45.0 dBm/ch**	**(31.6 W)/ch**
3-4 Channels	**40.0 dBm/ch**	**(10.0 W)/ch**
5-8 Channels	**36.5 dBm/ch**	**(4.5 W)/ch**
9-16 Channels	**32.0 dBm/ch**	**(1.6 W)/ch**
17-31 Channels	**28.5 dBm/ch**	**(0.7 W)/ch**

The booster's % power meter was found to be within 2% of the indications provided by the external average power meter with output variations of 80% to 110% of the booster's rated output.

8.0 INPUT LEVEL VERSUS OUTPUT (A.G.C.)

FCC Paragraph 74.950 (f) (4)

Visual Output Power: **2 Channel @ 45.0 dBm**
8 Channels @ 36.5 dBm
31 Channels @ 28.5 dBm

Modulation: Composite Television Signals

Method of Measurement:

Thirty one leveled television channels were combined to the common input to the booster via a calibrated variable attenuator. The output level of +28.5dBm was set as outlined in the previous R.F. power output measurement. The attenuator was varied up and down to determine the low and high end.

AGC Range: > 34 dB

2 Channel Test (45 dBm/channel output):

Measured Input Level (dBm)	Measured Output Level (dBm)
-55	44.8
-50	44.8
-45	45.0
-40	45.2
-35	45.2
-25	45.0

8 Channel Test (36.5 dBm/channel output)

Measured Input Level (dBm)	Measured Output Level (dBm)
-55	36.3
-50	36.5
-45	36.5
-40	36.7
-35	36.7
-25	36.5

31 Channel Test (28.5 dBm/channel output)

Measured Input Level (dBm)	Measured Output Level (dBm)
-55	28.3
-50	28.5
-45	28.5
-40	28.7
-35	28.7
-25	28.5

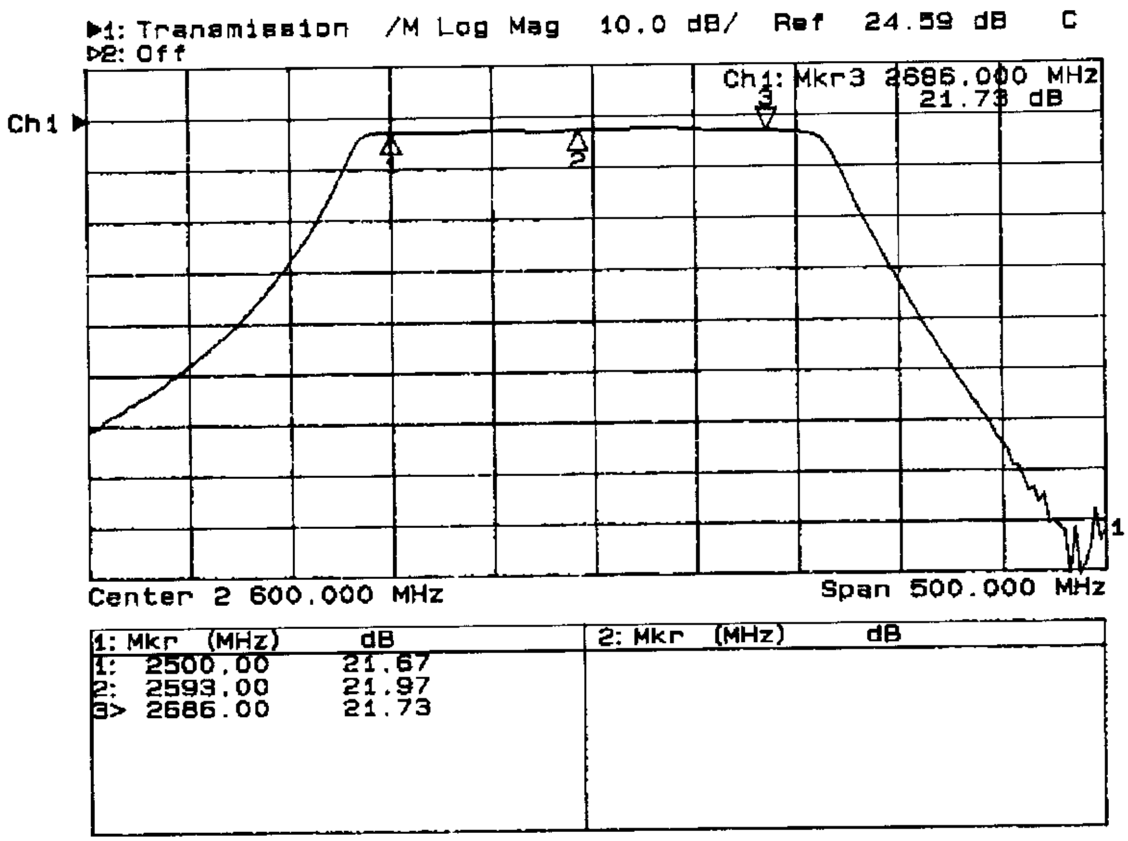
9.0 OVERALL ATTENUATION CHARACTERISTICS and OCCUPIED BANDWIDTH

FCC Paragraph 74.950(f) and 2.989 (h)

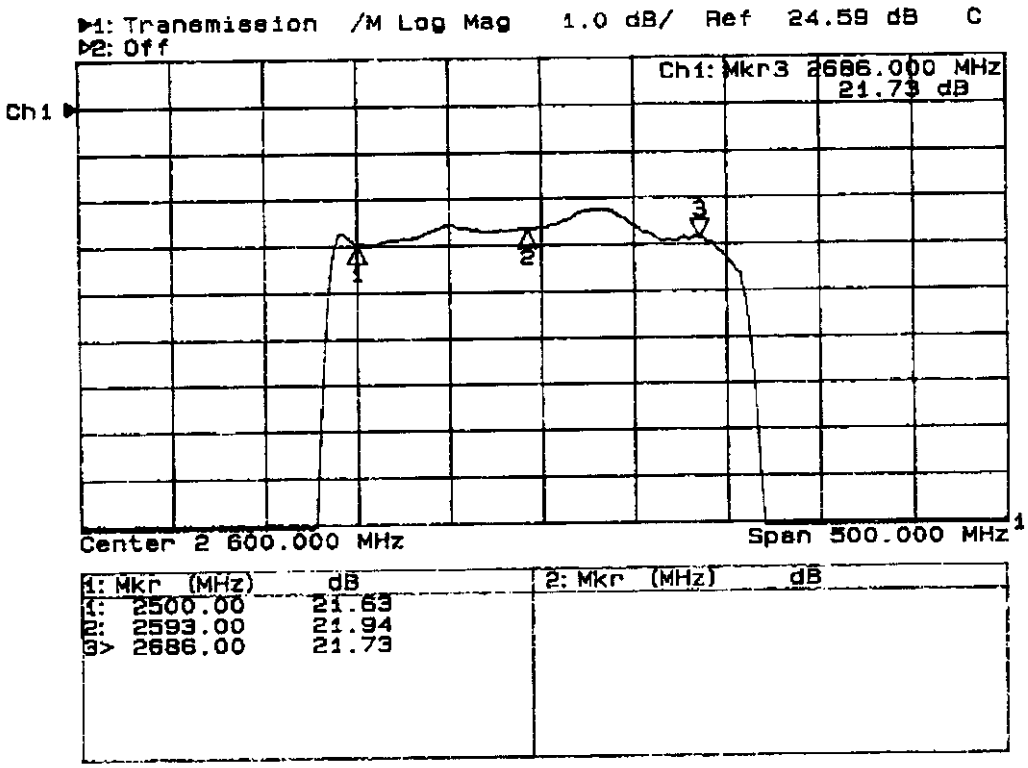
The HPB250-A is designed for retransmission of up to 31 analog modulated carriers with little or no distortion. The booster system does not include frequency-translating subsystems so the only distortion arises from the frequency response and linearity characteristics of the system.

FREQUENCY RESPONSE

Linear distortion arises primarily from the frequency response of the booster system. The frequency response of the HPB250-A is very flat and provides near perfect retransmission of carriers without linear distortion. The frequency response was measured by injecting a CW signal into the booster front end at a nominal input level of –30 dBm. The signal was swept from 2450 MHz to 2750 MHz and the output captured on an HP8593 spectrum analyzer. See plots 1 and 2 below:



Plot 1: Frequency Response of HPB250-A on 10 dB/div Scale



Plot 2: Frequency Response of HPB250-A on 1 dB/div Scale

10.0 SPURIOUS EMISSIONS AT ANTENNA TERMINALS

FCC Paragraph 2.991, 2.997, 21.908 (b)
November 1, 1991, ITFS/MMDS Ruling

Visual Output Power:	**1-2 Channels 45.0 dBm/ch (31.6 W)/ch** **3-4 Channels 40.0 dBm/ch (10.0 W)/ch** **5-8 Channels 36.5 dBm/ch (4.5 W)/ch** **9-16 Channels 32.0 dBm/ch (1.6 W)/ch** **17-31 Channels 28.5 dBm/ch (0.7 W)/ch**
Spectrum Analyzer Setting:	A spectrum analyzer setting used in conducting the spurious emissions test at the equipment output terminals was as follows:
Frequency Span:	2 MHz per Division
Center Frequency:	Adjusted continuously from 10 MHz to 27 GHz
Resolution Bandwidth:	100 KHz
Video Filter:	Out
Input Attenuator Setting:	Input level was set for a full scale calibration of the visual carrier. All other frequencies were referenced to this point.
Results:	Since there are no internal frequency sources, the only outputs were the MMDS signals and there resultant carrier to third order intermodulation products.
Spurious Emissions:	> -60dBc
Harmonic:	>-70dBc

SPECTRAL OCCUPANCY

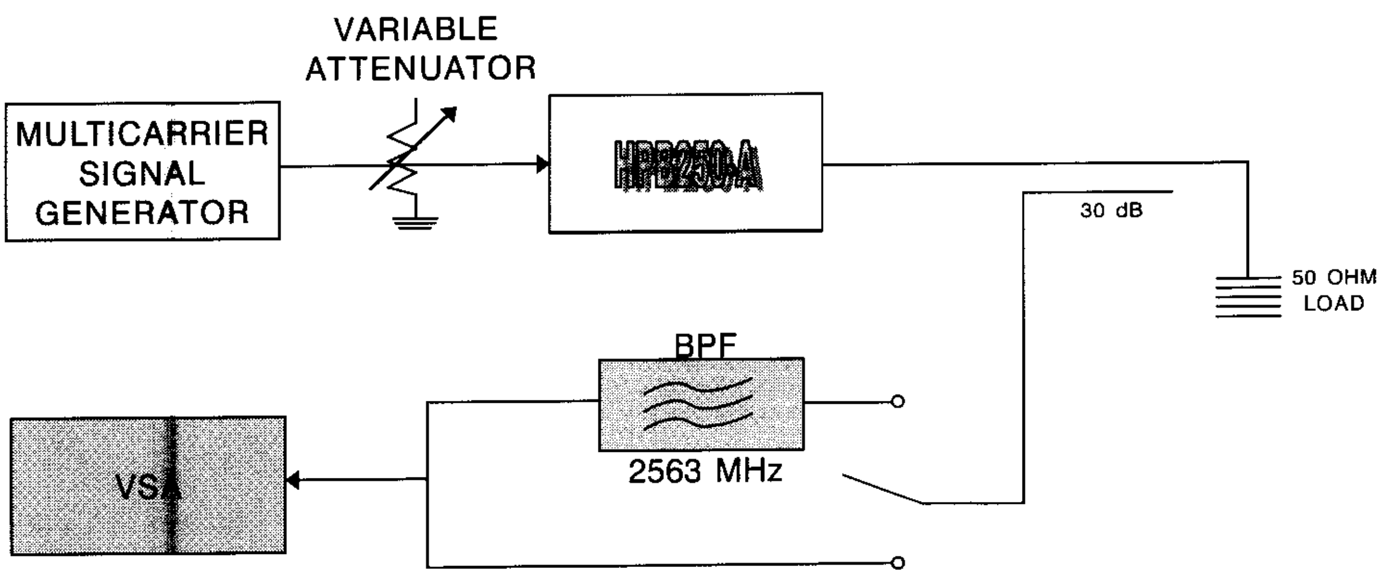
The following plots demonstrate the occupied bandwidth of the composite signal(s) at the output of the booster system power amplifier at the maximum rated peak power. The occupied bandwidth complies with the out of band emissions for analog systems. The signal(s) meets the requirements of out of band emissions less than -38 dB at the channel edge decreasing to less than -60 dB at ≤1 MHz and ≥ .5MHz from the channel edge relative to the peak of sync of the analog channel.

Due to the multi-carrier nature of the input/output signal(s), some additional measurements are necessary to accurately represent the spectral occupancy. This is due to the dynamic range of in-band signal power versus out-of-band power. In addition, we are concerned not only with the intermodulation products of a single carrier, but also those intercarrier products (sometimes referred to as CTB in the cable industry) that may appear out-of-band. For that reason, some explanation of the measurement technique is in order.

MEASUREMENT TECHNIQUE

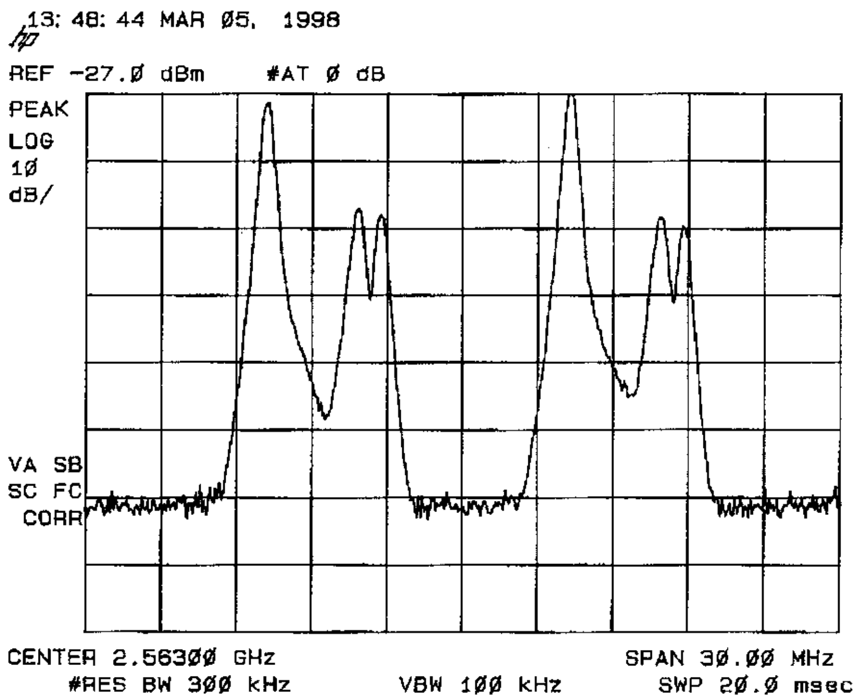
Accurately measuring out-of-band power requires sufficient dynamic range to measure both signal power and intermodulation products without undue influence from the instrumentation noise floor. Since the ultimate requirement for out-of-band signal power is –60 dB relative to in-band peak of sync power, we require at least 70 dB dynamic range to prevent noise floor interference from corrupting the measurement. To accomplish this, we have measured out-of-band power after filtering out the majority of in-band signal power since this allows us to reduce the noise floor of the spectrum analyzer. A block diagram of the test set-up is shown below:

BLOCK DIAGRAM TEST SET-UP



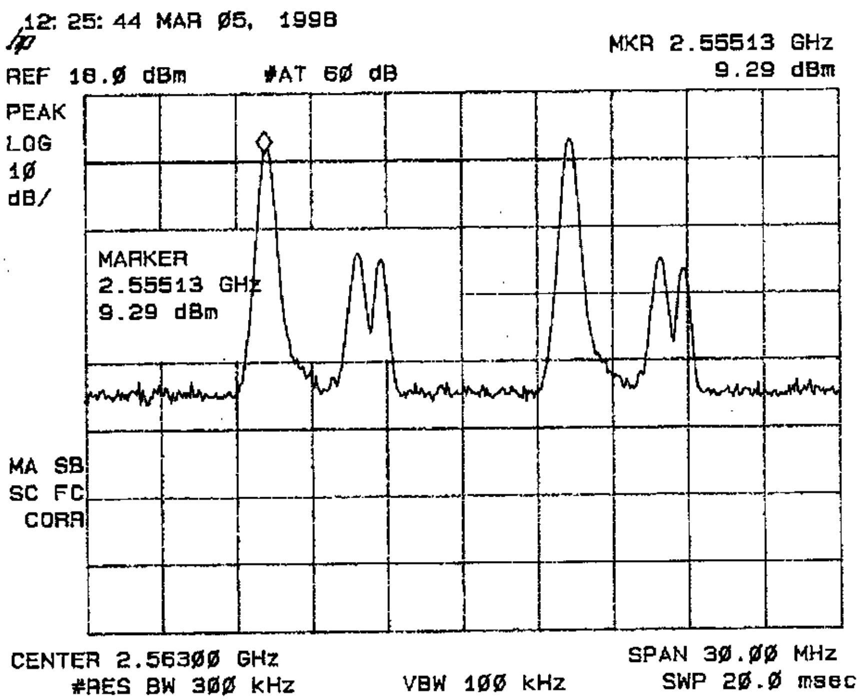
NARRATIVE DESCRIPTION OF OCCUPIED BANDWIDTH PLOTS

Plot 3 shows the booster-input signal for two carriers. Each carrier is modulated with 75% color bars. All plots were taken with a resolution bandwidth of 300 kHz for peak measurement and 30KHz resolution bandwidth for intermodulation measurement.

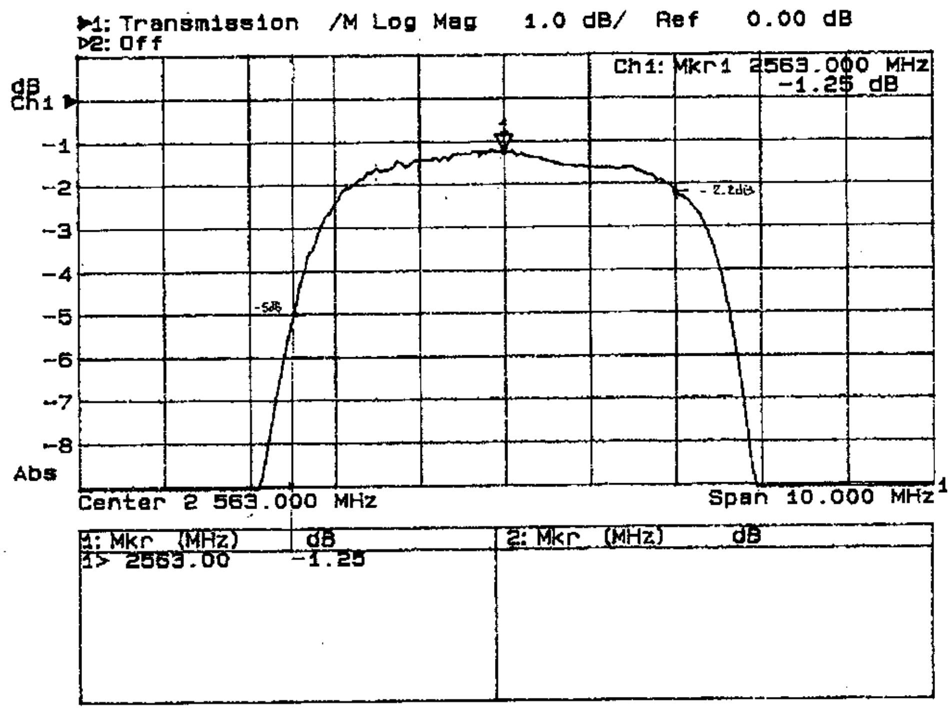


Plot 3: Two Carrier Composite Booster System Input Signal

Plot 4 shows the booster system output signal for two composite carriers with 75% color bars modulation at an SCL of 41 dBm as measured by an average power meter which corresponds to 45dBm peak of sync. The Spectrum Analyzer is set to display the in-band signal power (after 31.7-dB attenuation) of approximately 9.29 dBm. From these plots we can see that the out-of-band requirement to be better than –38 dB relative to peak of sync is met.



The Bandpass Filter is used to eliminate signal energy and allow us to reduce the Spectrum Analyzer input attenuator, thus lowering the noise floor to a level where we can accurately measure the out-of-band power. The Bandpass Filter has the following passband characteristics:

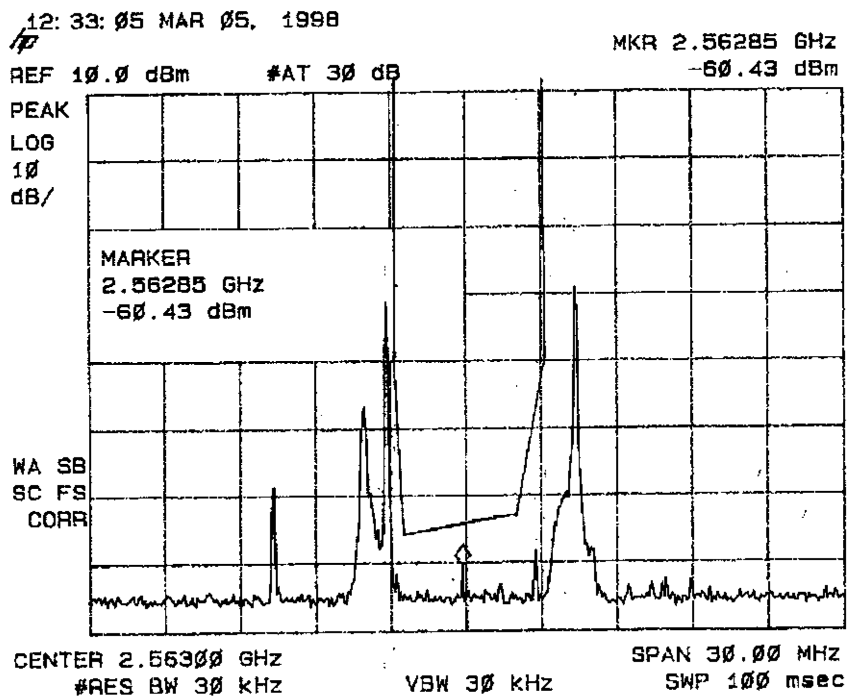


The mark with –5dB indicates attenuation of the filter at a frequency .5 MHz higher than the band edge of the lower adjacent channel. The mark with –2.2 dB, otherwise, indicates a frequency 1 MHz lower than the edge of the higher adjacent channel. The mark of –2 dB corresponds to the visual carrier.

In plot 5, the measured out-of-band power within the limits of the unoccupied channel is 60.43 dBm. Accounting for the filter insertion loss and two adjacent channels, we conclude that a single-carrier has relative out-of-band signal power given by:

$$-60.43 + 2.2 - 9.29 = 67.52 \text{ dB between } +.5 \text{ MHz and } -1 \text{ MHz of the band edges}$$

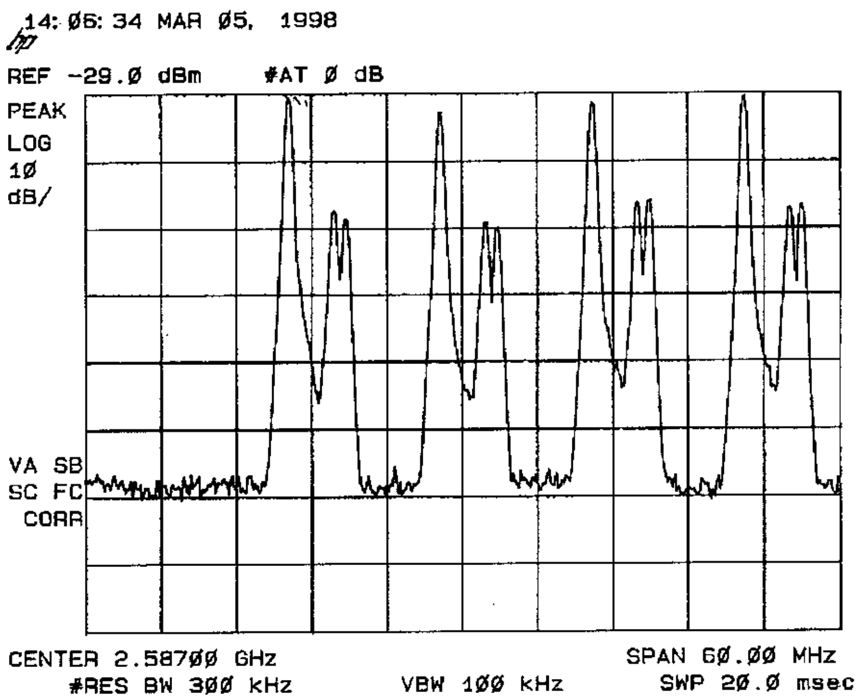
Moreover, the total measured power in the adjacent channel is more than 60 dB below the total in-band power. This shows that the system complies with the spectral occupancy mask established in FCC 74.936.



Plot 5

MULTI_CARRIER INTERMODULATION PRODUCTS

Since the HPB250-A is a multi-carrier booster system, we must also be concerned with intercarrier intermodulation products. These are the third order intermodulation products that occur at $2F_1$-F_2 and $2F_2$-F_1. In plot 6, the analog carriers are positioned so that the $2F_1$-F_2 product falls into the passband of the Bandpass Filter.



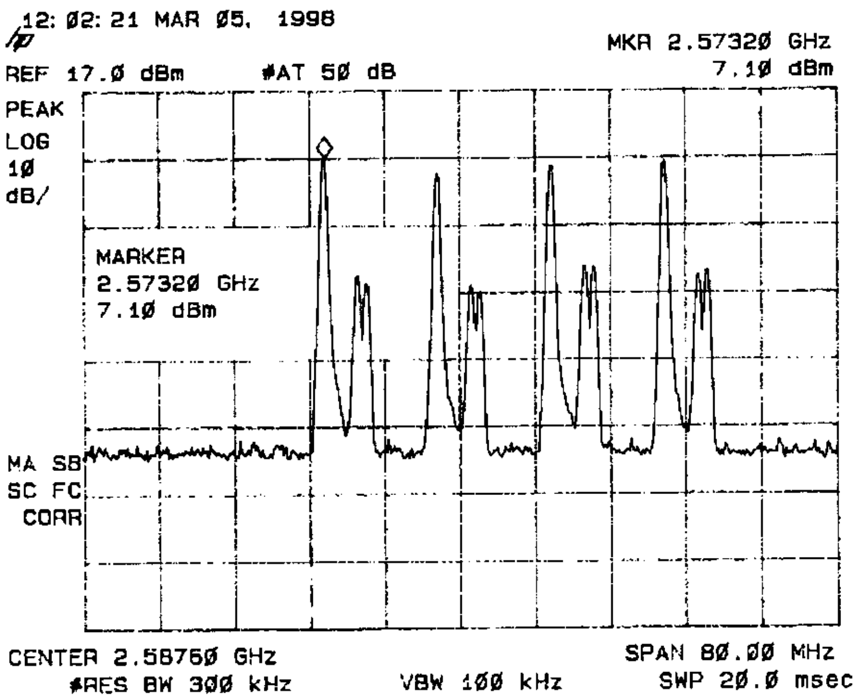
Plot 6

FOUR CARRIER MEASUREMENTS:

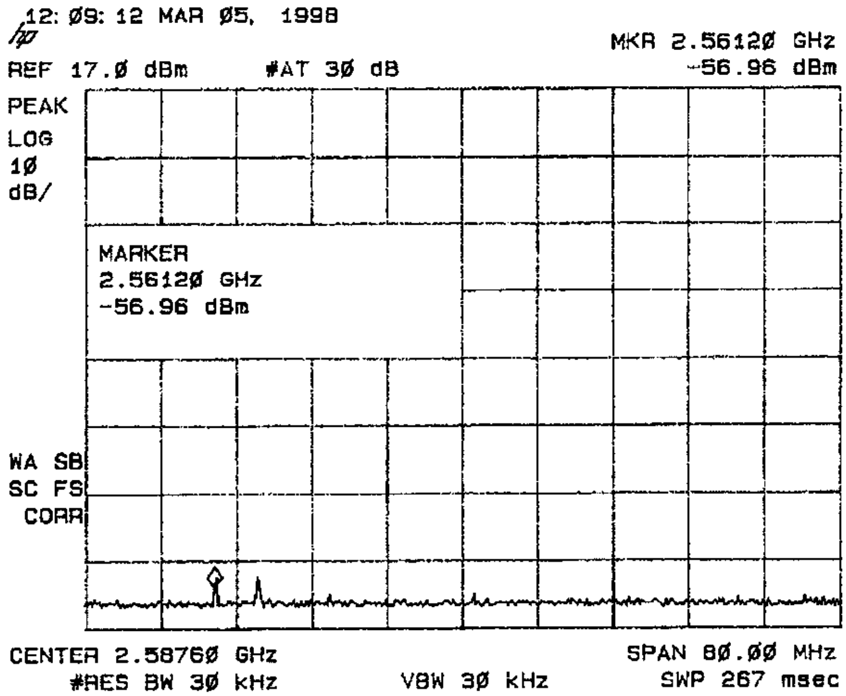
Plot 7 shows the output of the HPB250-A with four analog carriers. The reference is moved to –7.1 dBm since the power per carrier is 3 dB lower and the attenuator was set to 28.7 dB attenuation. Plot 8 shows the IM3 measurement with four carriers. In this case, an additional 2 dB back-off in output power was required to maintain the same level of out-of-band power as shown in plot 8.

The additional back-off shown in plot 8 follows the well known requirement for multi-carrier systems. Specifically, Leffel [1] cites results showing the back-off requirement for constant IM product power as being asymptotic to 4 dB as the number of carriers approach infinity. Our laboratory test results reflect the back-off requirement predicted by Leffel. That requirement is incorporated in the rated output power per carrier as the number of carriers is increased.

[1] Leffel, Michael, "Intermodulation Distortion in a Multi-Signal Environment", RF Design, June 1995.



Plot 7



Plot 8

$$IM_3 = -(7.1\ \text{dBm} - 2\ \text{dB}_{\text{filter loss}} - (-56.96\ \text{dBm})) = -62\ \text{dBc}$$

11.0 FIELD STRENGTH OF SPURIOUS RADIATION

FCC Paragraph 2.993, 2.997

Visual Output Power:	**1 Channel @ 45.0 dBm** **8 Channels @ 36.5 dBm** **31 Channels @ 28.5 dBm**
Modulation:	Composite Television Signals
Spectrum Analyzer Settings:	A spectrum analyzer used to measure the spurious emissions at a distance of 10 meters from the television transmitter was set as follows:
Frequency Span:	1 MHz per division
Center Frequency:	Adjusted continuously from 10 MHz to 27 GHz
Resolution Bandwidth:	100 KHz
Video Bandwidth:	100 KHz
Analyzer Noise Threshold:	<-89 dBm

Method of Measurement:

Absolute power of the spurious radiation was measured on a spectrum analyzer at a distance of 10 meters from the transmitter. The radiation was received with a half-wave dipole antenna (gain = 2.15 dB) and measured as an absolute power level; therefore, all measurements include the dipole gain. The relative levels of the received spurious signals were calculated with respect to the absolute power level of the transmitter's visual output received with a dipole at 10 meters. The visual received power level was calculated using:

Received Level @ 10 meters (dBm) = EIRP (dBm) - Path Loss (dB) + 2.15 dB

Path Loss (dB) = 20 log distance(Km) + 20 log frequency(GHz) + 92.4 dB
= 20 log (.010 Km) + 20 log (2.557 GHz) + 92.4 dB
= 60.55 dB

EIRP (dBmW) = 40.00 dBm (tx output) + 2.15dB (transmit dipole gain)
= 42.15 dBm

Received Level = 42.15 dBm – 60.55 dB + 2.15 dB
= -16.25 dBm

The Electric Field Intensity E(v/m) incident on a receive dipole antenna was found using:

$$\mathbf{E}\,(v/m) = \text{Antilog}\left[\frac{(\text{Received Level} - 2.15\text{ dB}) - 20\log \text{wavelength(m)} + 6.75}{20}\right]$$

$$= \text{Antilog}\left[\frac{-16.25\text{ dBm} - 20\log[.1173\text{ m}] + 6.75}{20}\right]$$

$$= \text{Antilog}\ ..4557$$

$$\mathbf{E} = 2.855\text{ V/m}$$

Spurious Radiation:

Due to the total shielded component design needed for the high system gain enclosure, no radiated signals were detected to the threshold of the analyzer.

* Analyzer threshold = -89 dBm

12.0 FREQUENCY STABILITY

FCC Paragraph 2.995 (a-3), (d-1), 74.950 (a), 21.908, 21.101 (a)

Frequency Stability does not apply; there is no Frequency Translation.

13.0 SUMMARY

This report demonstrates that the HPB250-A television transmitter meets or exceeds the FCC type acceptance criteria. Peak output power was verified with direct measurement of power at microwave. Measurement of spurious emissions at the RF output revealed no emissions above -60 dBc. Field strength measurements of spurious emissions revealed no detectable emissions down to the analyzer noise threshold of < - 89 dBm.