FCC TYPE ACCEPTANCE REPORT

FOR THE

SB020D-1, 20 WATT TELEVISION TRANSMITTER

COMWAVE
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1.0 INTRODUCTION

This report contains all the required data for type acceptance of the Comwave model SB020D-1 television transmitter. The data presented was taken from tests performed on a production transmitter tuned to operate on ITFS channel H-1 (2650 – 2656 MHz). 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 SB020D-1 instruction manual. The transmitter 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

3.0 TEST EQUIPMENT

FCC Paragraph 2.947 (d)

The following is a list of major test equipment, which was used in testing the SB020D-1 transmitter for this report:

1)	Spectrum Analyzer	HP Model 8564E
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	2000 – 2700 MHz
3)	Operating Range	1-20 watts peak visual 0.032 – 0.63 watts average aural
4)	Power Rating	20 watts peak visual 0.68 watts average aural
5)	E & I on Final	Drain voltage 10 V Drain current 2.2 A each

6) Function of Active Devices

The following is a list of active devices in the RF and LO chains of the transmitter. The relative position of each device may be found by referring to the transmitter block diagram in the technical manual.

Microwave Upconverter/Amplifier

Microwave Synthesizer **Board 35-063-02**

U1	Dual Modulus Prescaler
U2	Synthesizer
U3	Comparator
U4	Regulator
U5, U7	Dividers
U6	Operational Amplifier

Voltage Controlled Oscillator **Board 33-291-01**

U1	Voltage Controlled Oscillator
U2	RF Amplifier
U3	Operational Amplifier
U4	Microwave Prescaler
U6	5 V Voltage Regulator
U7	Shunt Regulator

Distribution Amplifier **Board 40-207-01**

U1	RF Amplifier
U2	RF Amplifier
U8	5 V Regulator

IF Processor **Board 33-315-01**

D1, D2, D3, D4, D11, D12	Attenuator Diodes
D5, D6, D7, D8	Linearity Correctors
U1, U2, U4	IF Amplifier
D9	Protection Diode
U3	Voltage Regulator

U6	Operational Amplifiers
Q2	Transistor Switch
D10	IF Attenuator

Driver Module 04-056-01

Visual Mixer	**Board 40-060-04**
D1, D2	Visual IF to RF Mixer
Q1	RF Amplifier
Amplifier #1	**Board 40-102-04**
Q2	RF Amplifier
Q3	RF Amplifier
Amplifier #2	**Board 40-103-04**
Q4	RF Amplifier
Q5	RF Amplifier
Prefinal Amplifier	**Board 04-250-01**
Q1	RF Amplifier
Final Amplifier	**Board 04-254-01**
Q1	RF Amplifier
Q2	RF Amplifier
Q3	RF Amplifier
Q4	RF Amplifier
Q5	RF Amplifier
Q6	RF Amplifier
Q7	RF Amplifier
Q8	RF Amplifier

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

8.0 OVERALL ATTENUATION CHARACTERISTICS

FCC Paragraph 2.987/2.989/73.687

Visual Output Power	20 watts peak sync
% Video Modulation	87.5%
Type Video Modulation	Per FCC 73.687 (a) (4)
Aural Output Power	0 watts
Method of Measurement	Per FCC 73.687 (a) (2) & (4)

Overall Modulation:

Modulation Frequency (MHz)	Detected Output (dB)
0.2 (reference)	0.0
0.5	0.0
0.75	0.0
1.25	-6.05
2.1	-6.10
3.0	-5.95
3.58	-6.0
4.18	-6.1

9.0 FREQUENCY RESPONSE

FCC Paragraph 2.987/2.989/73.687 (a) (2)
November 1, 1991, ITFS/MMDS Ruling

Visual Output Power	20 watts peak sync
% Video Modulation	87.5%
Type Video Modulation	Per FCC 73.687 (a) (4)
Aural Output Power	0 watts
Method of Measurement	Per FCC 73.687 (a) (2) & (4)

Frequency Response:

Output Frequency (MHz)	Sidebands (MHz)	Relative to +200 KHz (dB)	Relative to Visual Carrier (dBc)
2646.50	-4.75	-52.50	-68.10
2647.07	-4.18	-52.60	-68.20
2647.67	-3.58	-49.84	-65.44
2648.25	-3.00	-46.35	-61.95
2649.00	-2.25	-45.76	-61.36
2650.00	-1.25	-22.80	-38.40
2650.50	-0.75	-0.78	-16.38
2650.75	-0.50	-0.49	-16.09
2651.25	Visual Carrier	----------	Reference
2651.75	+0.50	0.00	-15.6
2652.50	+1.25	+0.15	-15.45
2653.25	+2.00	+0.20	-15.40
2654.25	+3.00	+0.17	-15.43
2654.83	+3.58	+0.33	-15.27
2655.43	+4.18	-0.17	-15.77
2656.00	+4.75	-46.20	-61.80
2656.50	+5.25	-47.55	-63.15
2657.25	+6.00	-50.20	-65.80
2658.00	+6.75	-48.33	-63.93

Spectrum Analyzer Settings:

Center Frequency	2653 MHz
Span	13.00 MHz
Log/Div	10 dB
Resolution BW	30 KHz
VBW	3 MHz
Sweep	43.3 msec

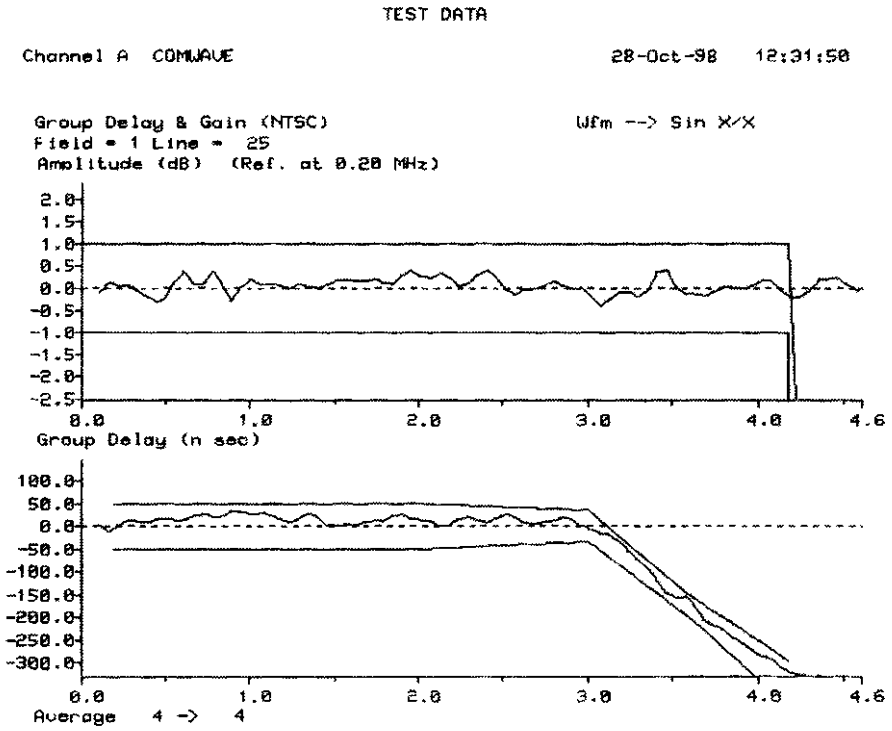
10.0 ENVELOPE DELAY

FCC Paragraph 73.687 (a) (3)

Visual Output Power	20 watts peak sync
% Visual Modulation	87.5%
Type Video Modulation	Per FCC 73.687 (a) (4)
Aural Output Power	0 watts
Method of Measurement	Per EIA RS-240, Section B (12c)

Delay vs. Frequency

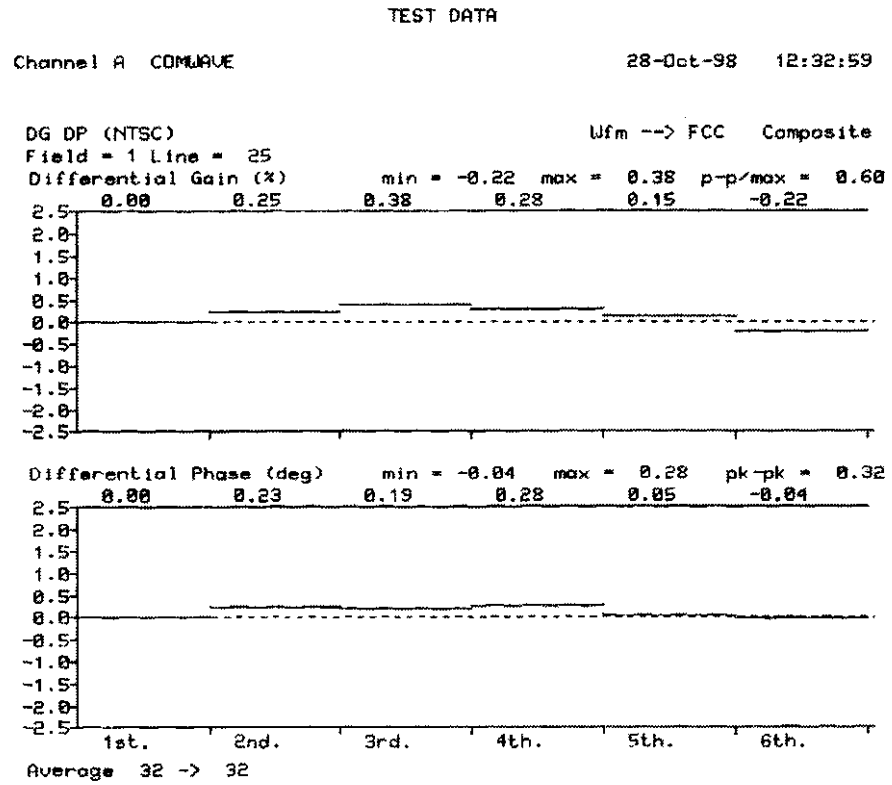
Frequency (MHz)	Delay (ns)
0.2 (reference)	0
0.5	+20.0
1.0	+30.0
1.5	0
2.1	+10.0
2.5	+40.0
3.0	-10.0
3.2	-15
3.4	-95.0
3.58	-130
4.0	>-150
4.18	>-150



11.0 DIFFERENTIAL PHASE AND GAIN

FCC Paragraph 73.687 (a) (9)/73.682 (a) (20) (vii)

Visual Output Power	20 watts peak sync
% Video Modulation	87.5%
Type Video Modulation	Per EIA RS-240, Section B (10c) & (11c)
Aural Output Power	.63 watts average
Method of Measurement	Per EIA RS-240, Section B (10c) & (11c)
Differential Phase	0.32 °
Differential Gain	0.60 %



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12.0 AURAL OCCUPIED BANDWIDTH

FCC Paragraph 2.202 (e) (5)

Visual Output Power	20 watts peak sync
% Video Modulation	87.5%
Type Video Modulation	Standard 10 riser stairstep
Aural Output Power	.63 watts average
% Aural Modulation	85% (21.25 KHz)
Aural Modulation Signal	15 KHz
Method of Measurement (Bn = 2M + 2DK):	Bandwidth was read at 0.5% (-23 dB) of mean power on a spectrum analyzer
Aural Occupied Bandwidth	80 KHz

13.0 AURAL FREQUENCY RESPONSE

FCC Paragraph 73.687 (b) (10)

Visual Output Power	20 watts peak sync
% Video Modulation	87.5%
Type Video Modulation	Standard 10 riser stairstep
Aural Output Power	.63 watts average
% Aural Modulation	100%, 50% and 25%
Aural Modulation Signal	50 Hz to 15 KHz

Aural Frequency Response

Frequency (Hz)	Output Relative to 1 KHz (dB) 100% Mod
50	-0.53
100	-0.53
400	-0.44
1000	0.0
3000	+4.08
5000	+7.60
7000	+9.54
12000	+13.62
15000	+16.12

14.0 SPURIOUS EMISSIONS AT ANTENNA TERMINALS

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

Visual Output Power	20 watts peak sync
% Video Modulation	87.5%
Type Video Modulation	Per EIA RS-240, Section A (6c)
Aural Output Power	.63 watts average
% Aural Modulation	0%

Spectrum Analyzer Setting — The 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 for 10 MHz to 10 GHz
Resolution Bandwidth	100 KHz
Video Filter	Out
Input Attenuator Setting	Input level was set for a full-scale calibration of the visual carrier 2651.25 MHz. All other frequencies were referenced to this point.

Spurious Emissions

Frequency (MHz)	Amplitude (dBc)		Relative to Peak Visual (MHz)	
2651.25	0	Visual Carrier	(reference)	
2642.25	-62	Visual Carrier	-9	
2646.75	-63	Visual Carrier	-4.5	
2647.67	-62	Visual Carrier	-3.58	
2658.41	-66	Visual Carrier	7.16	
2655.75	-65	Aural Carrier	+4.50	
2697.00	-69	Local Oscillator	+45.75	
5302.50	-69	Harmonic	x	2
7953.75	-62	Harmonic	x	3
10605.00	>-70	Harmonic	x	4
13256.25	>-70	Harmonic	x	5
15907.50	>-70	Harmonic	x	6
18558.75	>-70	Harmonic	x	7
21210.00	>-70	Harmonic	x	8
23861.25	>-70	Harmonic	x	9
26512.50	>-70	Harmonic	x	10

15.0 FIELD STRENGTH OF SPURIOUS RADIATION

FCC Paragraph 2.993, 2.997

Visual Output Power	20 watts peak sync
% Video Modulation	87.5%
Type Video Modulation	Standard 10 riser stairstep
Aural Output Power	0.63 watts average
% Aural Modulation	0%
Spectrum Analyzer Setting	The Spectrum Analyzer setting used to measure the spurious emissions at 10 meters from the transmitter was set as follows

Frequency Span	1 MHz per Division
Center Frequency	Adjusted continuously from 10 MHz to 10 GHz
Resolution Bandwidth	10 KHz
Video Bandwidth	10 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 (2591.25/1000)(GHz) + 92.4 dB

= 20 log (.010 Km) + 20 log (2.653) +92.4 dB

=

EIRP (dBmW) = 43 dBm (tx output) + 2.15dB (transmit dipole gain)
= 45.15 dBm

Received Level = **EIRP** dBm - **Path Loss** dB + 2.15 dB
= -13.57 dBm

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

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

$$= \text{Antilog}\left[\frac{-11.42\ \text{dBm} - 20\log[0.11308\ \text{m}] + 6.75}{20}\right]$$

$$= \text{Antilog}\ 0.4979$$

$$\mathbf{E} = 3.147\ \text{v/m}$$

Spurious Radiation:

The following measurements of radiation were taken and are given in terms of absolute and relative to the visual carrier

MHz	Absolute Received (dBm)	Absolute Field Intensity (v/m)	Relative to Level visual, dBc
2651.25	*Below analyzer threshold	N/A	<-89
2697.00	*Below analyzer threshold	N/A	<-89
45.75	*Below analyzer threshold	N/A	<-89
41.25	*Below analyzer threshold	N/A	<-89
Harmonics	*Below analyzer threshold	N/A	<-89

* Analyzer threshold = -89 dBm
The range of examination in these tests was from 10 MHz to 27 GHz.

16.0 FREQUENCY STABILITY

FCC Paragraph 2.995 (a) (3)/ 74.950 (a)/ 21.908, 21.101 (a)

Method of Measurement: The modulator and upconverter were Channel tested individually per FCC 21.995.

Microwave L.O. (Synthesized)	2697.00 MHz
IF Frequency (Modulator)	- 45.75 MHz
On Channel Frequency	2651.25 MHz

Frequency Stability over Temperature: **Modulator**

Temp. (C)	Visual (MHz)	Aural (MHz)	4.5 MHz Error (Hz)	Visual Carrier Error (Hz)
50	45.749987	41.249979	8.00	13.00
40	45.750024	41.250036	-12.00	-24.00
30	45.750116	41.250107	9.00	-116.00
20	45.750158	41.250137	21.00	-158.00
10	45.750227	41.250211	16.00	-227.00
0	45.750288	41.250271	17.00	-288.00
-10	45.750257	41.250238	19.00	-257.00
-20	45.750178	41.250157	21.00	-178.00
-30	45.749887	41.249896	-9.00	113.00

Frequency Stability over AC Input Voltage: **Modulator**

AC Line (V)	Visual (MHz)	Aural (MHz)	4.5 MHz Error (Hz)	Visual Carrier Error (Hz)
85	45.749987	41.249974	-13.00	13.00
90	45.749998	41.249997	-1.00	2.00
95	45.750002	41.250002	0.00	-2.00
100	45.750003	41.250002	-1.00	-3.00
110	45.750005	41.250000	-5.00	-5.00
115	45.750004	41.250003	-1.00	-4.00
120	45.750003	41.250002	-1.00	-3.00
130	45.750002	41.250002	0.00	-2.00
135	45.750003	41.250001	-2.00	-3.00

Frequency Stability over Temperature: **Microwave Upconverter PLL Local Oscillator**

Temp. (C)	Oscillator (MHz)	Error (Hz)
50	2697.000073	-73.00
40	2697.000045	-45.00
30	2697.000032	-32.00
20	2697.000015	-15.00
10	2697.000007	-7.00
0	2697.000002	-2.00
-10	2696.999982	18.00
-20	2696.999918	82.00
-30	2696.999978	22.00

Combining the worst case of modulator and oscillator frequency shift results in a 290.00 Hz channel error. This represents accuracy, which is well within the required channel ± 1,000 Hz tolerance requirement set on November 1, 1991, for ITFS/MMDS transmitters. The aural carrier also remained within the required 4.5 MHz ± 1,000 Hz tolerance.

Frequency Stability over AC Input Voltage:
Microwave Upconverter PLL Local Oscillator

AC Line (V)	Local Oscillator Frequency (MHz)	Error (Hz)
95	2696.999987	13.00
100	2697.000009	-9.00
110	2697.000009	-9.00
115	2697.000007	-7.00
120	2697.000008	-8.00
125	2697.000007	-7.00
130	2697.000009	-9.00
135	2697.000008	-8.00

NOTE:
Frequency stability of the microwave synthesizer was totally dependent on the accuracy and stability of the 10 MHz reference oscillator. This is a purchased item with 1 x 10^{-7} minimum stability specification.

17.0 SUMMARY

This report demonstrates that the SB020D-1 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. Frequency stability tests of the modulator and the voltage controlled crystal oscillator/multiplier over variations in temperature or input AC line voltage showed a maximum worst case frequency shift of 290.00 Hz.