TYPE ACCEPTANCE APPLICATION

for

AIRSYS ATM INC.
23501 West 84th Street
Shawnee, KS 66227
Phone: (913) 422-2600

Steve Sedlock,
Systems Engineer

MODEL: MK20AGS
GLIDE SLOPE GROUND STATION TRANSMITTER

FREQUENCY: 329.3-335.00 MHz

FCC ID: BOJ MK20AGS

Test Date: June 12, 1998

Certifying Engineer: Scot D Rogers

Scot D. Rogers
ROGERS CONSULTING LABS, INC.
11701 Craig
Overland Park, Kansas 66210
Phone: (913)339-6072
FAX: (913)339-6072

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FORWARD:

In accordance with the Federal Communications Code of Federal Regulations, dated October 1, 1997, Part 2 Subpart J, Paragraphs 2.905, 2.911, 2.913, 2.925, 2.926, 2.981 through 2.999, and Part 87 Subpart D, Paragraphs 87.131 through 87.147; the following is submitted:

List of Test Equipment

A Hewlett Packard 8591EM and or 8562A Spectrum Analyzer was used as the measuring device for the emissions testing. The analyzer settings used are described in the following table. Refer to Appendix for a complete list of Test Equipment.

HP SPECTRUM ANALYZER SETTINGS		
CONDUCTED EMISSIONS:		
RBW	AVG. BW	DETECTOR FUNCTION
9 kHz	30 kHz	Peak/Quasi Peak
RADIATED EMISSIONS (30 - 1000 MHz):		
RBW	AVG. BW	DETECTOR FUNCTION
120 kHz	300 kHz	Peak/Quasi Peak
RADIATED EMISSIONS (1 - 40 GHz):		
RBW	AVG. BW	DETECTOR FUNCTION
1 MHz	1 MHz	Peak/Average
ANTENNA CONDUCTED EMISSIONS:		
RBW	AVG. BW	DETECTOR FUNCTION
100 kHz	300 kHz	Peak

2.983 Application for Type Acceptance

a. Manufacturer: AIRSYS ATM INC.
23501 West 84th Street
Shawnee, KS 66227

b. Identification: Model: MK20AGS
FCC I.D.: BOJ MK20AGS

c. Plan to produce quantity production.

d. (1) Emission Type:

9K00A3N

(2) Frequency Range: Operates across the band of 329.3 to 335.0 MHz in 0.15 MHz increments.

(3) Operating Power Level:

Carrier :14 W nominal, software adjustable from 0 to 15.0 Watts.
Sibeband :3 W nominal, software adjustable from 0 to 4.0 Watts.

(4) Max P_o:

15 Watts.

(5) DC Voltages and Currents of PA Final:

The final amplifier runs at 3.2A @ 24V, 79 Watts.

(6) Function of Each Semiconductor Device in Transmitter:

Refer to attached circuit diagram and reference material.

(7) Circuit Diagrams:

Refer to attached circuit diagram and reference material.

(8) Instruction Book:

Refer to attached instruction manual attached.

(9) Tune Up Procedure for Output Power:

Refer to attached circuit diagram and reference material.

(10) Frequency Plan:

Refer to attached circuit diagram and reference material.

(11) Spurious and Limiting Circuits:

Refer to attached circuit diagram and reference material.

(12) Digital Modulation:

2.985 RF Power Output

Measurements Required:

Measurements shall be made to establish the radio frequency power delivered by the transmitter into the standard output termination. The power output shall be monitored and recorded and no adjustment shall be made to the transmitter after the test has begun, except as noted below:

If the power output is adjustable, measurements shall be made for the highest and lowest power levels.

Test Arrangement:

The r.f. power output was measured at the antenna terminals by connecting a directional coupler to the antenna port and measuring the output power with a spectrum analyzer. The directional coupler had an impedance of 50Ω to match the impedance of the standard antenna and had a 50Ω load for termination. An HP 8562A Spectrum Analyzer was used to measure the r.f. power at the antenna port. The data was taken in dBm and converted to watts as shown in the following Table.

P_{dBm} = power in dB above 1 milliwatt.
Milliwatts = $10^{(PdBm/10)}$
Watts = (Milliwatts)(0.001)(W/mW)

Results:

LOC CHANNEL	FREQUENCY	P_{dBm}	P_{mw}	P_w
110.70	330.20	41.75	14,962	15
110.10	334.40	41.73	14,894	15

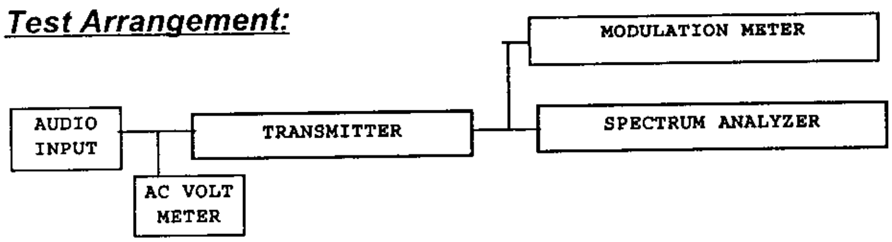
The specifications of Paragraph 2.985(a) and applicable Parts of 87 are met. There are no deviations to the specifications.

2.987 Modulation Characteristics

Measurements Required:

A curve or equivalent data which shows that the equipment will meet the modulation requirements of the rules under which the equipment is to be licensed shall be submitted.

Test Arrangement:



The r.f. output was coupled to a HP Spectrum Analyzer and a modulation meter. The spectrum analyzer was used to observe the r.f. spectrum with the transmitter operating in its various modes.

Results:

The glide slope transmitter incorporates a unique 90 and 150 Hz modulation scheme solely for use in the aviation services. Therefore, no modulation characteristics were measured. The specifications of 2.987 and applicable paragraphs of Part 87 are met. There are no deviations to the specifications

2.989 Occupied Bandwidth

Measurements Required:

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

Test Arrangement:

Results:

SIGNAL	F_c	O.B. kHz
CRS	330.1	1.0
CLR	330.2	1.0
COMBINED	330.2	9.0
CRS	334.4	1.0
CLR	334.4	1.0
COMBINED	334.4	9.0

Refer to figures 1 through 6 showing plots of the 99.5% output power of the transmitter. Data was taken for the different signal paths.

Requirements of 2.989 and applicable parts of Paragraph 87 are met . There are no deviations to the specifications.

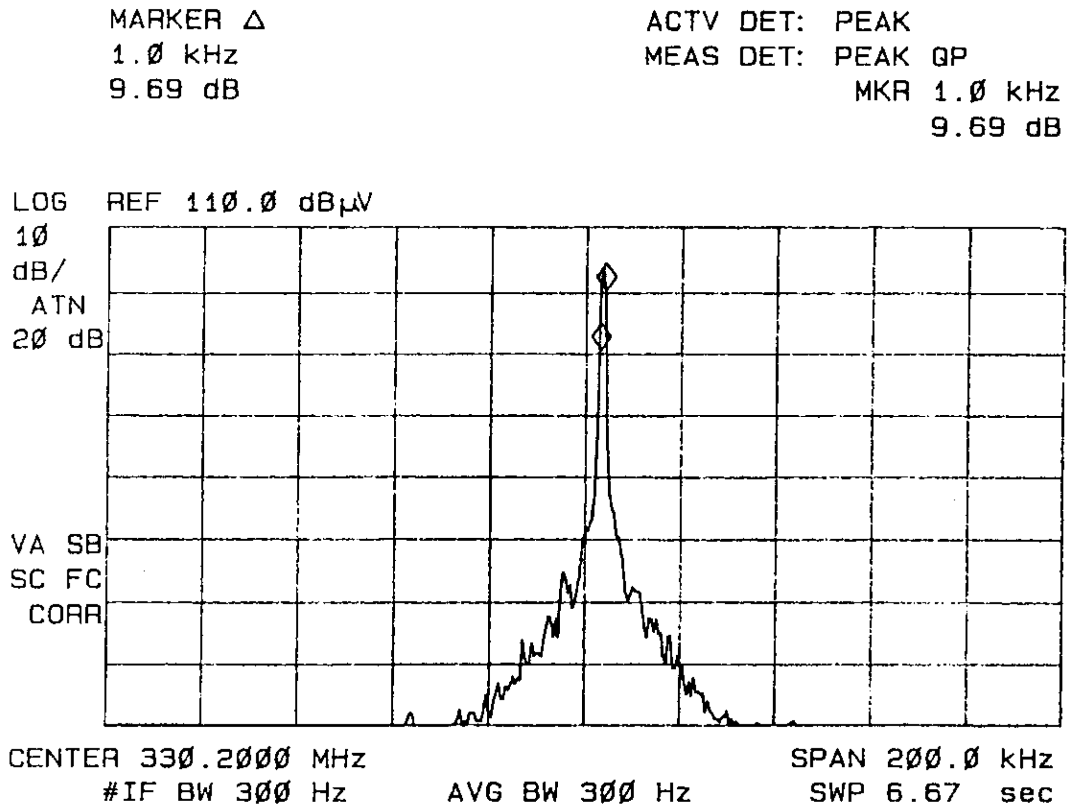


Figure 1: Occupied Band Width CRS.

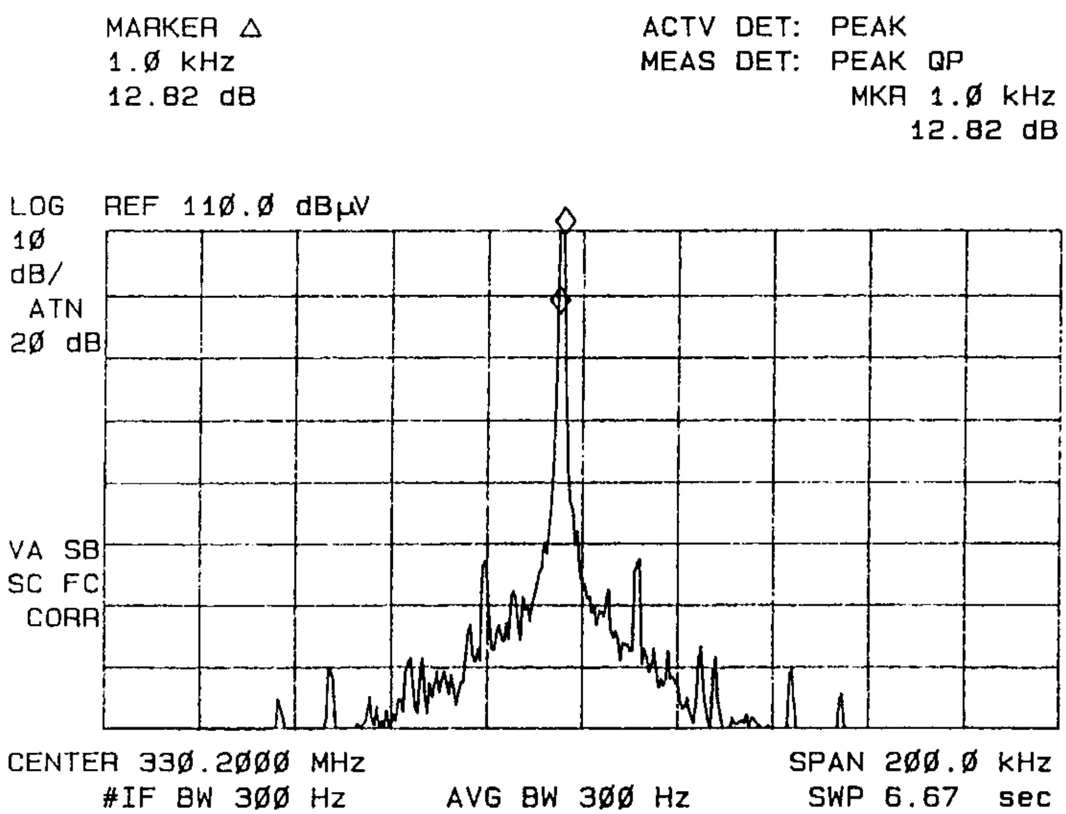


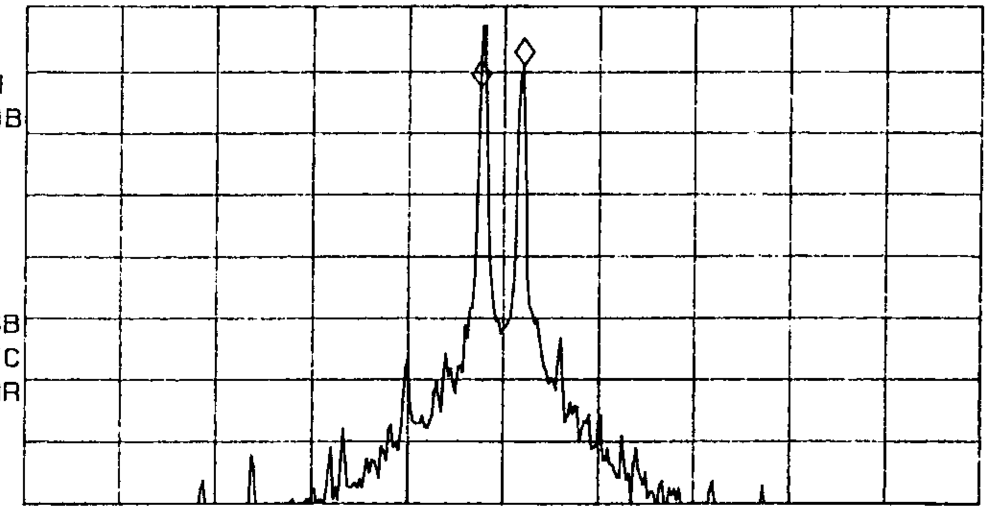
Figure 2: Occupied Band Width CLR.

MARKER Δ
9.0 kHz
3.55 dB

ACTV DET: PEAK
MEAS DET: PEAK QP
MKR 9.0 kHz
3.55 dB

LOG REF 110.0 dBμV
10
dB/
ATN
20 dB

VA SB
SC FC
CORR



CENTER 330.2000 MHz SPAN 200.0 kHz
#IF BW 300 Hz AVG BW 300 Hz SWP 6.67 sec

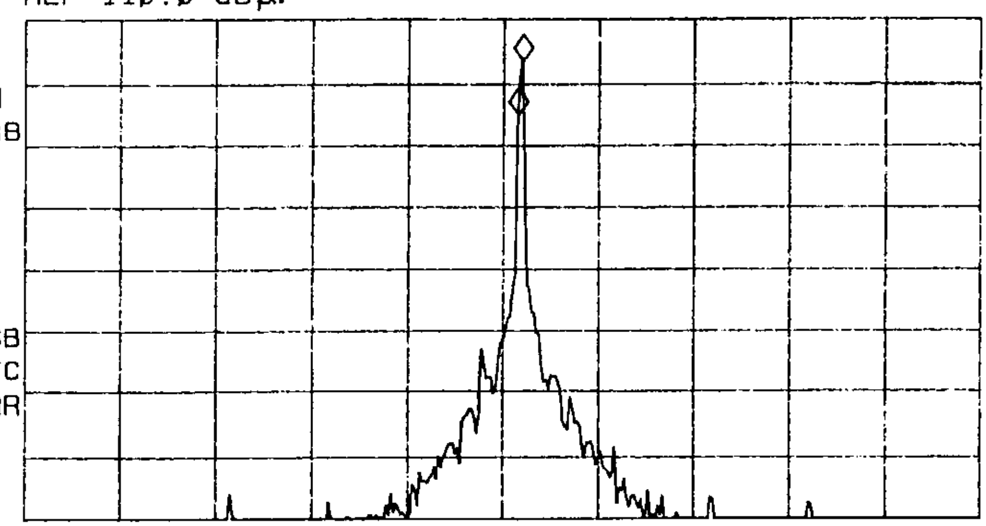
Figure 3: Occupied Band Width Combined.

MARKER Δ
1.0 kHz
8.64 dB

ACTV DET: PEAK
MEAS DET: PEAK QP
MKR 1.0 kHz
8.64 dB

LOG REF 110.0 dBμV
10
dB/
ATN
20 dB

VA SB
SC FC
CORR



CENTER 334.4000 MHz SPAN 200.0 kHz
#IF BW 300 Hz AVG BW 300 Hz SWP 6.67 sec

Figure 4: Occupied Bandwidth CRS.

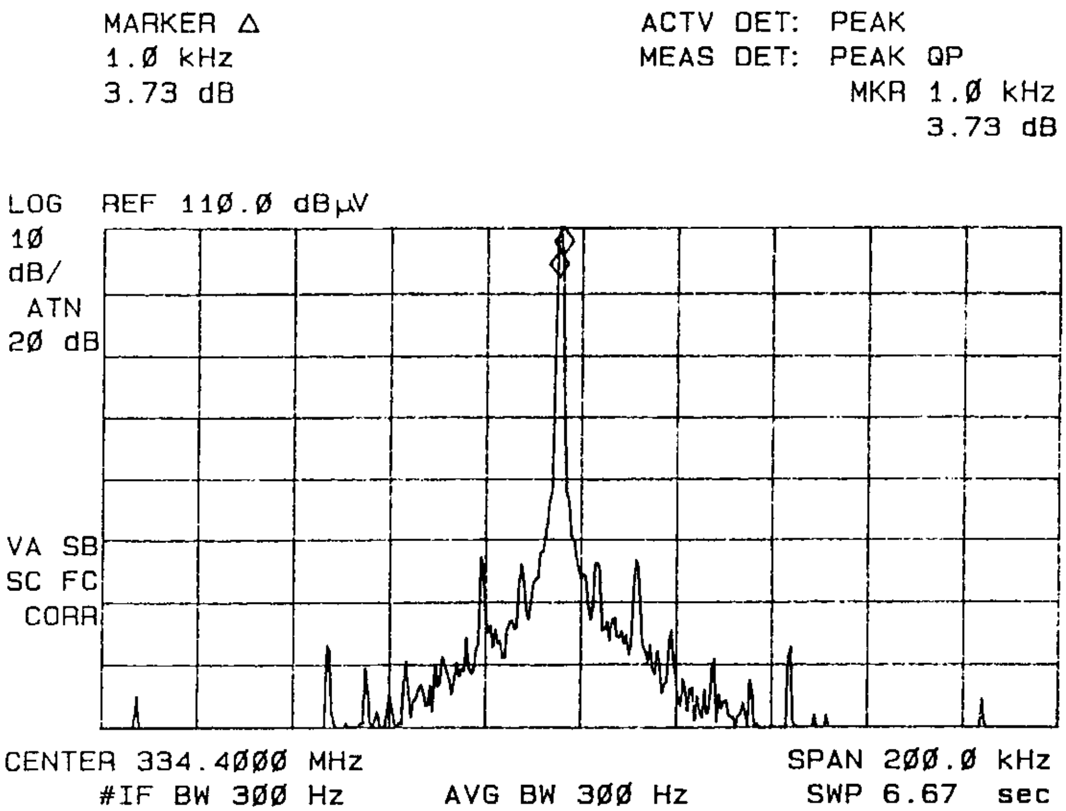


Figure 5: Occupied Band Width CLR.

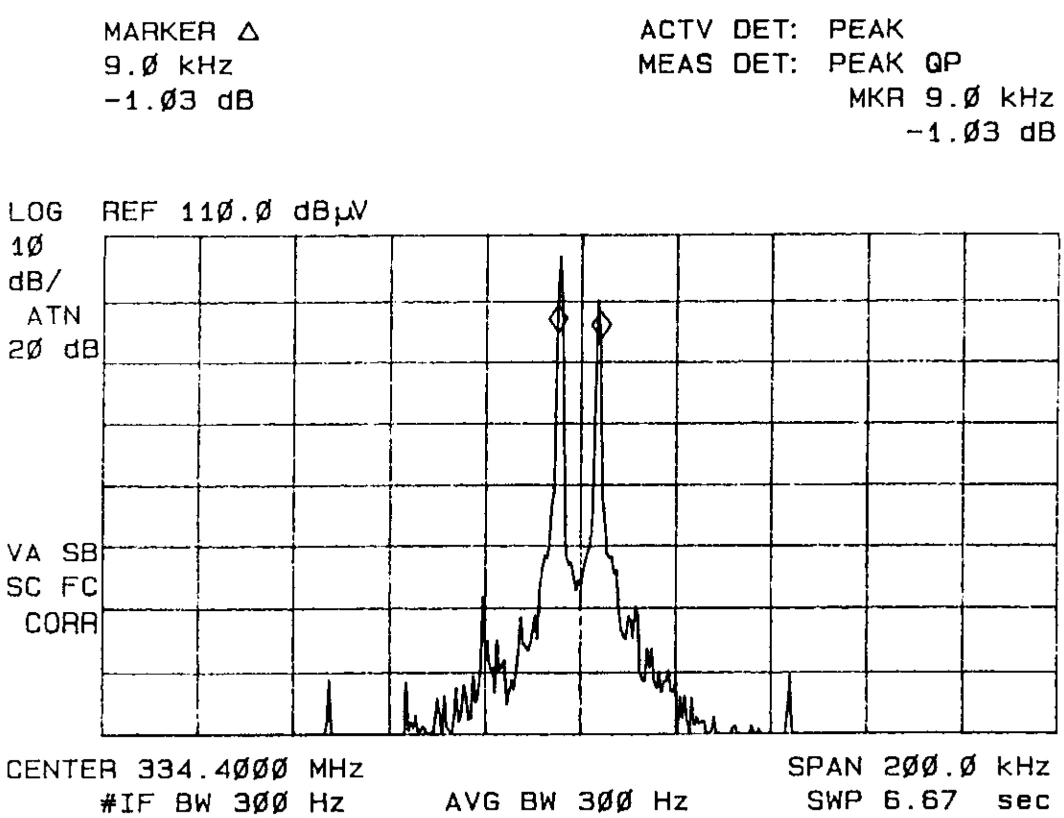


Figure 6: Occupied Band Width Combined.

2.991 Spurious Emissions at Antenna Terminals

Measurements Required:

The radio frequency voltage or power generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna.

Test Arrangement:

The r.f. output was coupled to an HP 8562A Spectrum Analyzer. The spectrum analyzer was used to observe the r.f. spectrum with the transmitter operated in all of the available modes. The frequency spectrum from 0 to 5 GHz was observed and plots produced of the frequency spectrum. Figures 7 and 8 represent data for the MK20AGS. Data taken per 2.991 and applicable parts of Part 87.

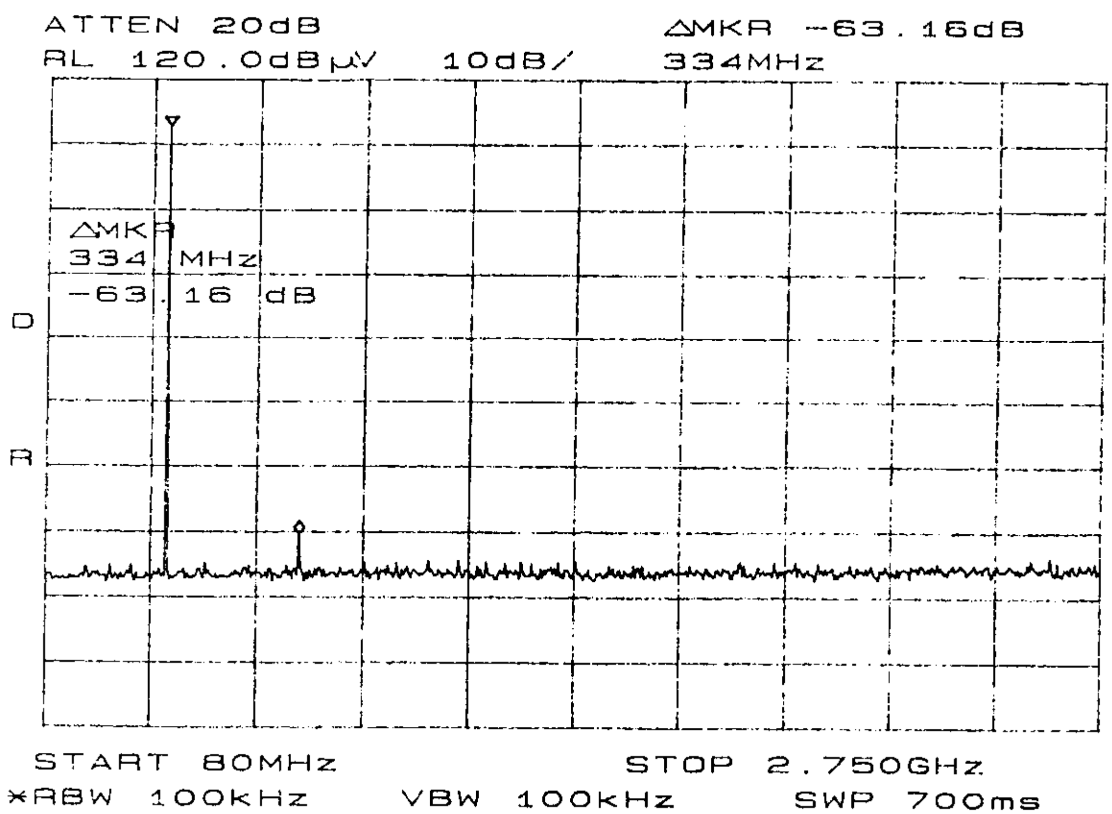


Figure 7: Emissions at Antenna Terminal.

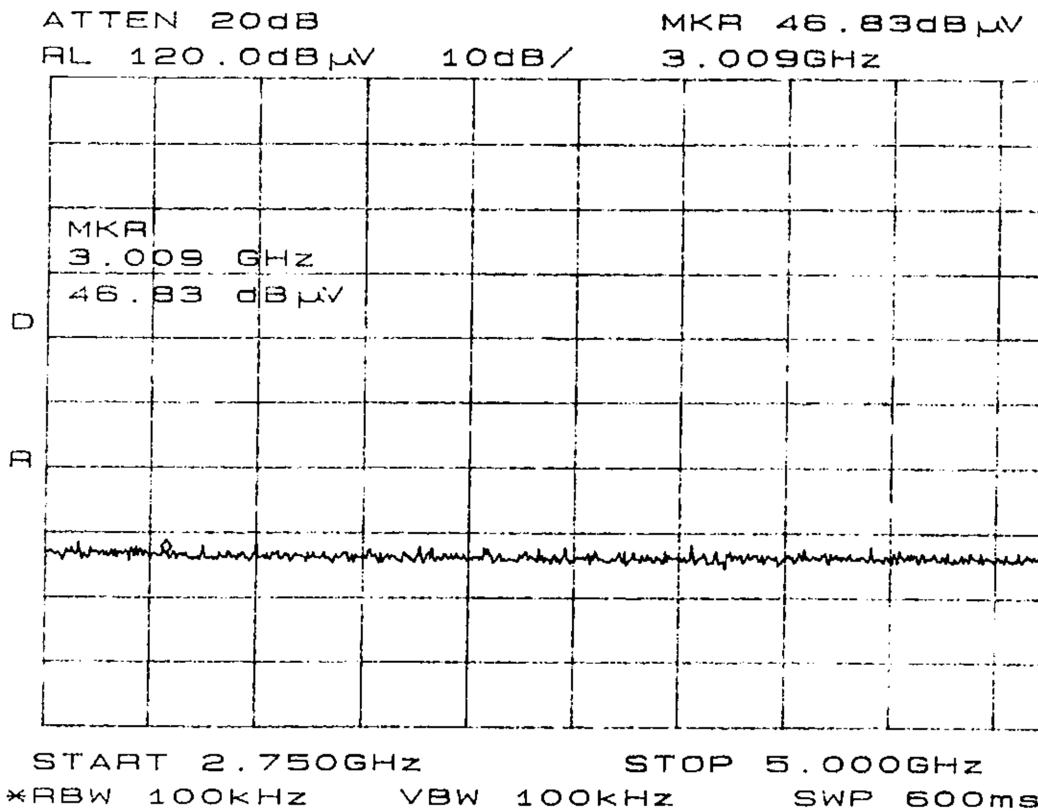


Figure 8: Emissions at Antenna Terminal.

Results:

Data taken per 2.991 and applicable parts of Part 87.135. Specifications of Paragraphs 2.991 and 2.997 are met. There are no deviations to the specifications.

FREQUENCY MHz	SPURIOUS FREQ. (MHz)	LEVEL BELOW CARRIER (dB)
334.4	668.8	63.1
	1003.2	67.1
	1337.6	67.5
	1672.0	69.1
	2006.4	69.0
	2340.8	68.2
	2675.2	68.3
	3009.6	66.0
	3344.0	65.8

2.993 Field Strength of Spurious Radiation

Measurements Required:.

Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation.

Test Arrangement:

The transmitter was placed on a wooden turntable 0.1 meters above the ground plane and at a distance of 3 meters from the FSM antenna. The transmitter was activated and the frequency spectrum of the fundamental was observed. The turntable was rotated though 360 degrees to locate the position registering the highest amplitude emission. The amplitude of the fundamental frequency was measured and recorded. The frequency spectrum was then searched for spurious emissions generated from the transmitter. The amplitude of each spurious emission was maximized by raising and lowering the FSM antenna and rotating the turntable before data was recorded. A log periodic antenna was used for frequencies of 200 MHz to 5 GHz and pyramidal horn antennas were used for frequencies of 5 GHz to 40 GHz. Emission levels were measured and recorded from the spectrum analyzer in dBμV. This level was then added to the antenna factor less the amplifier gain to calculate the field strength at 3 meters. Data was taken at the ROGERS CONSULTING LABS, INC. 3 meters open area test site (OATS) located in Paola, KS. A description of the test facility is on file with the FCC, Reference: 31040/SIT, 1300F2, dated October 15, 1996. The testing procedures used conforms to the procedures stated in the ANSI 63.4-1992 document.

Calculations made are as follows:

CFS = Calculated Field Strength
FSM = Field Strength Measurement
CFS = FSM + Antenna Factor - Amplifier Gain
CFS = 32.0 + 19.5 - 25
CFS = 26.5

The limit for emissions are defined by the following equations:

Limit = Amplitude of spurious emission must be attenuated by this amount below the level of the fundamental.

Calculating the field strength at 3 meters for the 15 watt transmitter was done as follows:

$$E = \frac{5.5\sqrt{PG}}{d}$$ where E is V/m, P is Watts, G = 1.64 and d is meters.

$$E = \frac{5.5\sqrt{15(1.64)}}{3} = 9.09 \text{ V/m} = 9.09E6\mu\text{V/m at 3 meters.}$$

This was converted to dBµV/m using (20*log µV/m) for convenience.

20*Log(9.09E6) = 139.2 dBµV/m @ 3 meters

$$\begin{aligned} \text{Attenuation} &= 43 + 10\ \text{Log}_{10}(P_w) \\ &= 43 + 10\ \text{Log}_{10}(15) \\ &= 54.8\ \text{dB} \\ \text{Limit} &= 139.2 - 54.8 \\ &= 84.4 \end{aligned}$$

Results:

Frequency (MHz)	FSM Horz. (dBµV)	FSM Vert. (dBµV)	Ant. Factor (dB)	Amp. Gain (dB)	CFS Horz.@ 3m (dBµV/m)	CFS Vert. @ 3m (dBµV/m)	Limit
668.8	32.0	30.6	19.5	25	26.5	25.1	84.4
1003.2	33.0	35.5	22.9	25	30.9	33.4	84.4
1337.6	32.5	32.6	24.8	25	32.3	32.4	84.4
1672.0	32.3	32.0	27.7	25	35.0	34.7	84.4
2006.4	32.5	31.5	30.0	25	37.5	36.5	84.4
2340.8	32.3	32.8	32.0	25	39.3	39.8	84.4
2675.2	32.0	33.8	34.0	25	41.0	42.8	84.4
3009.6	34.3	34.3	35.4	25	44.7	44.7	84.4
3344.0	33.6	33.3	36.0	25	44.6	44.3	84.4

Specifications of Paragraph 2.993, 2.997 and 87.139 are met. There are no deviations to the specifications.

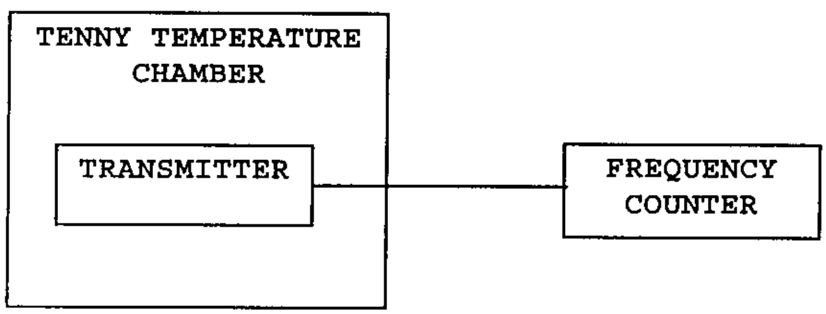
2.995 Frequency Stability

Measurements Required:

The frequency stability shall be measured with variations of ambient temperature from -30° to +50° centigrade. Measurements shall be made at the extremes of the temperature range and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. In addition to temperature stability the frequency stability shall be measured with variation of primary supply voltage as follows:

(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.
(2) For hand carried, batteries powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.
(3) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided.

Test Arrangement:



The measurement procedure outlined below shall be followed:

Step 1: The transmitter synthesizer shall be installed in an environmental test chamber whose temperature is controllable. Provision shall be made to measure the frequency of the unit.
Step 2: With the transmitter inoperative (power switched "OFF"), the temperature of the test chamber

shall be adjusted to +25°C. After a temperature stabilization period of one hour at +25°C, the transmitter shall be switched "ON" with standard test voltage applied.
<u>Step 3:</u> The carrier shall be keyed "ON", and the transmitter shall be operated unmodulated at full r.f. power output at the duty cycle for which it is rated, for a duration of at least 5 minutes. The r.f. carrier frequency shall be monitored and measurements shall be recorded.
<u>Step 4:</u> The test procedures outlined in Steps 2 and 3, shall be repeated after stabilizing the transmitter at the environmental temperatures specified, -30°C to 50°C in 10 degree increments.

The frequency stability was measured with variations in the power supply voltage from 85 to 115 percent of the nominal value and at the battery end point. An Elgar 1751 AC Power Supply was used to vary the ac voltage for the power input from 102 Vac to 138 Vac. The frequency was measured and the variation in parts per million was calculated. Data was taken per Paragraphs 2.995 and 87.133.

Results:

FREQ. (MHz)	FREQUENCY STABILITY VS TEMPERATURE IN PARTS PER MILLION (PPM)								
	Temperature in °C								
	-30	-20	-10	0	+10	+20	+30	+40	+50
332.00	3.8	-1.5	-3.2	-3.2	-1.9	0	-1.8	3.1	3.4

FREQUENCY IN MHz	STABILITY VS VOLTAGE VARIATION (±15%) IN PPM INPUT VOLTAGE		
	102 V_{ac}	120 Va_c	138 V_{ac}
334.4	0	0	0

The limit of 20 parts per million was specified in paragraph 87.133 for radionavigation equipment. Specifications of Paragraphs 2.995 and Paragraph 87.133 are met. There are no deviations to the specifications.

APPENDIX

Model: MK20AGS

1. Photos of Radiated Emissions Test Set Up.
2. Photos Case Front and Door Open.
3. Photos Synthesizer PCB.
4. Photo RF Board with Amplifiers.
5. Photo FCC ID Label.
6. Test Equipment List.
7. Rogers Qualifications.
8. FCC Site Approval Letter.

TEST EQUIPMENT LIST FOR ROGERS CONSULTING LABS, INC.

The equipment is used daily and kept in good calibration and operating condition. Calibration of critical items are checked for accuracy each time used.

List of Test Equipment:	Calibration Date:
Scope: Tektronix 2230	2/98
Wattmeter: Bird 43 with Load Bird 8085	2/98
Power Supplies: Sorensen SRL 20-25, DCR 150, DCR 140	2/98
H/V Power Supply: Fluke Model: 408B (SN:573)	2/98
R.F. Generator: Boonton 102F	2/98
R.F. Generator: HP 606A	2/98
R.F. Generator: HP 8614A	2/98
R.F. Generator: HP 8640B	2/98
Spectrum Analyzer: HP 8562A, Mixers: 11517A, 11980A & 11980K HP Adapters: 11518, 11519, 11520	2/98
Spectrum Analyzer: HP 8591 EM	6/97
Frequency Counter: Weston 1255	2/98
Frequency Counter: Leader LDC 825	2/98
Antenna: EMCO Log Periodic	9/97
Antenna: BCD 235/BNC Antenna Research	9/97
Antenna: EMCO Dipole Set 3121C	2/98
Antenna: C.D. B-100	2/98
Antenna: Solar 9229-1 & 9230-1	2/98
Antenna: EMCO 6509	2/98
Microline Freq. Meter: Model 27B	2/98
Dana Modulation Meter: Model 9008	2/98
Audio Oscillator: H.P. 200CD	2/98
R.F. Power Amp 65W Model: 470-A-1000	9/97
R.F. Power Amp 50W M185- 10-500	9/97
R.F. PreAmp CPPA-102	9/97
Shielded Room 5 M x 3 M x 2.5 M (100 dB Integrity)	
LISN 50 μHy/50 ohm/0.1 μf	9/97
LISN Compliance Eng. 240/20	2/98
SCS Power Amp Model: 2350A	2/98
Power Amp A.R. Model: 10W 1000M7	2/98
Linear Amp Mini Circuits: ZHL-1A (2 Units)	2/98
Combiner Unit Mini Circuits: ZSC-2-1 (2 Units)	2/98
ELGAR Model: 1751	2/98
ELGAR Model: TG 704A-3D	2/98
ELGAR Model: 400SD (PB)	2/98
ESD Test Set 2000i	10/95
Fast Transient Burst Generator Model: EFT/B-100	10/95
Current Probe: Singer CP-105	8/97
Current Probe: Solar 9108-1N	8/97
Field Intensity Meter: EFM-018	10/95

02/01/98

QUALIFICATIONS

of

SCOT D. ROGERS, ENGINEER

ROGERS CONSULTING LABS, INC.

Mr. Rogers has approximately 10 years experience in the field of electronics. Six years working in the automated controls industry and 4 years working with the design and development of radio communications equipment.

POSITIONS HELD:

Systems Engineer:	A/C Controls Mfg. Co., Inc. 6 Years
Electrical Engineer:	Rogers Consulting Labs, Inc. 4 Years

EDUCATIONAL BACKGROUND:

1) Bachelor of Science Degree in Electrical Engineering from Kansas State University.

2) Bachelor of Science Degree in Business Administration Kansas State University.

3) Several Specialized Training courses and seminars pertaining to Microprocessors and Software programming.

Scot D Rogers
Scot D. Rogers

6/18/98
Date

7/1/98

FEDERAL COMMUNICATIONS COMMISSION

7435 Oakland Mills Road
Columbia, MD 21046
Telephone: 301-725-1585 (ext-218)
Facsimile: 301-344-2050

October 15, 1996

IN REPLY REFER TO
31040/SIT
1300F2

Rogers Consulting Labs, Inc.
11701 Craig
Overland Park, KS 66210

Attention: Scot D. Rogers

Re: Measurement facility located at Paola
(3 meter site)

Gentlemen:

Your submission of the description of the subject measurement facility has been reviewed and found to be in compliance with the requirements of Section 2.948 of the FCC Rules. The description has, therefore, been placed on file and the name of your organization added to the Commission's list of facilities whose measurement data will be accepted in conjunction with applications for certification or notification under Parts 15 or 18 of the Commission's Rules. Our list will also indicate that the facility complies with the radiated and AC line conducted test site criteria in ANSI C63.4-1992. Please note that this filing must be updated for any changes made to the facility, and at least every three years the data on file must be certified as current.

Per your request; the above mentioned facility has been also added to our list of those who perform these measurement services for the public on a fee basis. This list is published periodically and is also available on the Laboratory's Public Access Link as described in the enclosed Public Notice.

Sincerely,

Thomas W. Phillips
Electronics Engineer
Customer Service Branch

Enclosure:
PAL PN

APPLICATION			REVISIONS			
DASH NO.	NEXT ASSY	USED ON	REV	DESCRIPTION	DATE	APPROVED
0001	120504-0001	MK20A				

REVISION	A				
SHEET NO.	1-50				
CONT. NO.		AIRSYS ATM	AIRSYS ATM, INC. SHAWNEE, KANSAS		
DRAWING/CHECKED BY		TEST PROCEDURE: Glideslope ~~LOCALIZER~~, MOD/PA			
E.E. APPROVAL					
M.E. APPROVAL					
C.E. APPROVAL					
Q.A. APPROVAL		SIZE A	FSCM NO. 65597	DWG NO. TP 120504	REV A
CONF. MGMT.					
COMP. LOG		SCALE NONE	FSC	SHEET 1 OF	

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1. SCOPE

This test procedure performs required tuning adjustments and verifies the performance requirements for the Glideslope Modulator / PA Circuit Card Assembly, 120504-0001. The tests are divided into Preliminary and Final categories. The separate data sheets for each category name test numbers which refer back to the same text.

The following two test procedures describe how to test the CCA using either the 129000-0776 test fixture or the 1291-60045-1 Interface Test Adapter (ITA) with HP VEE test software. The first procedure should be used for all preliminary adjustments ant tests and when using the test fixture for final tests. The second procedure should be used when using the ITA and HP VEE software for final tests.

NOTE: Using the semi-automated test with the ITA and HP VEE software is preferred for final test. See section 6.0.

NOTE: Any changes in this procedure should maintain consistency between the manual and semi-automatic implementation of tests.

2. NOTES

!!!!!! CAUTION !!!!!!

The UUT and its components are ESD sensitive. ESD precautions should be taken when handling the UUT and its components.

3. APPLICABLE DOCUMENTS

Document No.	Title	Size
120504	Assembly Drawing - MK20 Modulator / Power Amplifier	D
EL120504	Schematic - MK20 Modulator / Power Amplifier	C
PL120504	Parts List - MK20 Modulator / Power Amplifier	A
1291-60079 -1	HP VEE Object Files for 1291-60045 ITA testing 120504-0001	A
PL 1291-60045-1	Parts List - Interface Test Adapter	A
EL1291-60045-1	Schematic - Interface Test Adapter	C

4. REQUIRED EQUIPMENT

4.1 NON-AUTOMATED TESTING

Not all items are needed for each setup. Figure 2 describes the lowest cost setup for preliminary testing. Figure 1 describes a complete setup for both preliminary and final testing. Most preliminary setups will be something between the two extremes of Figures 1 and 2 if better equipment like digital power meters is available.

Qty	Fig. 1 & 2 ref.	Description
1	3.17	Test Fixture, Wilcox P/N 129000-0776
2	3.6	RF Power Meter HP437B or HP436A
2	3.6	RF Power Sensor HP8482A
1	3.5	Spectrum Analyzer HP8563E, or HP8568A
1	3.18	Multimeter, HP34401A or Fluke 8050A
1	3.2	Audio Analyzer, HP8903A or B
1	3.3	Modulation Analyzer HP8901A
1	3.1	Network Analyzer HP8753B or C, or HP8505A
1	3.12	Oscilloscope, general purpose
1	3.13	Tektronix PS280 Dual Power Supply or equivalent
1	3.14	Power Supply 0-30VDC, 5A, HP6291A
1	3.20	Power Supply 0-30VDC, HP721A or equal
1	3.16	RF Cable Set for W1-12
2	3.7	Directional Coupler, Narda 3020A
1	3.8	Coaxial Attenuator, Bird 500 W, 30dB
3	3.9, 3.10	Coaxial Attenuator, Narda 766-30
1	3.15a	Amplifier, Loc.GS w/ >+17dBm out & sample out
1	3.15b	Combiner, Loc/GS w/ <12dB loss & >20dB isolation
3	3.11, 3,19, 3.28	RF Load, 50 Ohm, 5 Watt
1	3.21	Special Adapter cable for filter tuning
1	3.22	Special Adapter cable for U1 & U13 sockets
1		Set, Special Modified UUT Covers
2	3.11, 3.19	RF adapter: N-type tee; female, male, female
1	3.23	Attenuator, TNC, 10dB
2	3.24	Attenuator, N, 10dB
1	3.25	Signal Generator, Boonton 102 etc.
1	3.26	Vector Voltmeter, HP8405A w/ 2 Tees & 2 loads
2	3.27	Termaline Wattmeter, Bird 612
1	3.29	Audio Oscillator, HP 200 or HP209

Verify that calibration dates for the test equipment have not expired.

4.2 SEMI-AUTOMATED TESTING

Qty	Description
1	Interface Test Adapter, Wilcox P/N 1291-60045-1
1	1291-60027-1 HPVEE Software Platform
1	1291-60078-1 HPVEE Object Files
2	RF Power Meter HP437B(GPIB Address 713, 723)
2	RF Power Sensor HP8482A
1	Spectrum Analyzer HP8563E(GPIB Address 716)
1	HP34401A Multimeter (GPIB Address 722)
1	HP8903B Audio Analyzer (GPIB Address 728)
1	Modulation Analyzer HP8901A (GPIB Address 714)
1	Network Analyzer HP8753B(GPIB Address 716)
1	Oscilloscope, general purpose
1	Power supply, 0-40 VDC., 6A., HP6291A
1	Power Supply, dual, for +/- 15 VDC, Tek PS280 or equivalent
7	GPIB Cable
1	Set, Special Modified UUT Covers
1	RF Cable Set for W1-12
1	Custom Cable Assembly, Wilcox P/N
1	Test lead, Pin plug to spring hook, Pomona 3785-24
1	Oscilloscope Probe, 50 Ohm out, Tek P6156
1	Amplifier, Loc.GS w/ >+17dBm out & sample out
1	Combiner, Loc/GS w/ <12dB loss & >20dB isolation
2	RF adapter: N-type tee; female, male, female
2	Directional Coupler, Narda
5	RF Load, 50 Ohm, 10Watt
1	Coaxial Attenuator, Bird 500 W, 30dB
3	Coaxial Attenuator, Narda 766-30

Verify that calibration dates for the test equipment have not expired.

5. NON-AUTOMATED TEST PROCEDURE

5.1 TEST FIXTURE VERIFICATION

Refer to section 6 for test fixture verification procedures. See Appendix A. in Paragraph 5.4. for calibration of power meters within the test setup.

5.2 TEST PROCEDURES

General: The data sheet is written such that after one has done a couple of assemblies it will prompt one enough so that it will seldom be necessary to refer to this text. The first digits 5.2 are omitted from the data sheet to save space but the test numbers do reference back to the text section. Conduct tests in the order given.

Although some of the test equipment used may be part of an ATE station, the testing is strictly manual. All patching is done by hand & the instruments are set up with the front panel controls. If an instrument appears to be locked up by the bus control mode switch it over to manual or cycle the power off & back on to revert to the manual mode.

The tests are divided into Preliminary and Final categories in order to reduce time required on busy ATE stations and better divide the work load between 2 or more persons. The preliminary tests are where the assembly gets debugged, tuned, & preliminary adjusted. Tests that require expensive test equipment such as spectrum or network analyzers are omitted. There are separate data sheets for Preliminary and Final with test numbers referencing back to the same text. Documenting that way makes it easy to change a test from one category to the other.

5.2.1 Presetting

A) Patch together the setup shown in figure 1 (Preliminary/Final set up) or figure 2 (Prelim. bench set up) but do not plug into J1 or J4 of UUT or apply audio to the fixture until told to.

B) Set up the two small supplies for +/- 15.0 +/- 0.1 VDC.

C) Set the large supply for 22 V DC.

D) Check DC resistances to ground of the three PS buses on the UUT. L22, L23, & R36 are probably the most convenient points. If they are not shorted and within limits check off data sheet.

E) Set current limit on all 3 supplies per data sheet. This is to prevent PWB damage in the event of a short to ground. The RFI gasket sometimes spreads too far & shorts a run.

F) Switch all three supplies off.

G) Remove covers of the UUT.

H) Place UUT on fixture and connect J2, J3 & J4.

I) Preset UUT pots & Var. Cap. per instructions on data sheet.

J) Preset all coils listed on data sheet to look like the last assembly after it passed all tests. Adjust L27 & L34 to look like each other.

K) Preset all four fixture controls fully CCW.

L) Set MK10 / MK20 switch for MK20.

M) Set MAIN / CAPTURE switch to MAIN.

5.2.2 PS Currents:

A) Turn on the +/- 15 Volt supplies (+&- 15 must be brought up together). If currents do not appear to be abnormally high proceed to turn on the +22 Volt supply.

B) Plug in digital multimeter set for 200 Mv scale to the appropriate jacks on test fixture and record the power supply currents. Scale factors are marked on the fixture.

C) If 22 Volt buss current was OK raise current limit to 4.0 Amps.

5.2.3 Detector Offsets:

Use the digital multimeter set on the 200 mv scale to measure the fixture test points listed on the data sheet.

Note: There is nothing to adjust to bring a high offset reading down. A high reading probably means an assembly error or a bad diode and this should be corrected before proceeding past test 7.

5.2.4 CSB Filter Tuning:

A) Switch off the 22 Volt Supply.

B) Remove jumpers at J5 and connect a special coax adapting cable to filter input J5-2 & J5-4.

C) Set the network analyzer up as a signal source as follows:
1. Set OUTPUT LEVEL controls for -13 dBm.
2. Set for CW mode.
3. Set FREQUENCY controls for 332.00 MHz.

D) Patch analyzer/generator output via the Wilcox Amplifier and a 10 dB pad (item 3.23) into J5-2 & 4. Don't omit the pad. It's purpose is to make the generator a 50 ohm source so that when the filter is tuned for maximum out it will have a 50 ohm input impedance. If you feel you need more signal into the Wattmeter, you may temporarily turn up the generator 10 dB. Don't go higher as you are apt to generate too many harmonics.

Note: Before beginning a new session of testing make sure that drive level is +13.0 +/- 0.5 dBm. Adjust network analyzer/generator level as necessary.

E) Monitor CSB output on DWM or VVM. Tune L8, L9, L11, & L6, in that order, for maximum output. If using DWM DO NOT REMOVE THE 30 dB DWM PAD! Power will be higher in later steps and you are likely to blow the expensive DWM head.

Note: Use ferrite and brass tuning slugs to test whether coils need more or less inductance. If ferrite slug causes output to increase, squeeze turns together. If brass slug causes an increase, stretch the coil. Proper tuning is when use of either slug causes a decrease in output.

Avoid drastic altering to the shape of the coils. Don't try to squeeze out the last .1dB of insertion loss because in doing so you are moving the design cut off frequency. Absolute insertion loss & phase measurements will be made in steps G through J.

F) Repeat step 5.2.4.E as necessary.

Note: A good alternative method of filter tuning is to tune for lowest VSWR, but that requires more equipment and patching.

G) Take the two coaxes designed to connect to the filter & hold them together using the shortest possible leads.

Establish phase and amplitude references. With a VVM the 180 Deg. scale should be accurate enough. Use the switch & knob to get your phase zero then don't touch these controls until finished with data in test 5.2.5.

Note: If you use some kind of special adapter estimate its phase drop and take it into account. The specs herein were established by holding the two ends together.

H) Separate the coaxes and connect them to filter input & output.

I) Read filter phase drop. Adjust only L8 & L9 for filter phase drop closest to spec on data sheet.

J) Read Insertion loss. If it is within specifications proceed, if not you may need to compromise some on insertion phase.

5.2.5 SBO Filter tuning:

A) Transfer the padded source from J5 to J7-2 & 4.

B) If using VVM per Figure 2 cross the CSB & SBO coaxes to J2 & J3 so channel A is used & VVM will lock. If using Figure 1 set up use the SBO DWM with it's 30 dB pad.

C) Tune L47, L48, L39, & L50 for maximum power in the same manner as the CSB.

D) Read filter phase drop. Note that the drop is specified as being an amount more than the CSB. Adjust only L47 & L48 for best phase reading. You may go back & compromise the CSB somewhat as long as when you are done all readings in 5.2.4 & 5.2.5 are within specifications.

E) Uncross the coaxes on J2 & J3.

5.2.6 Jumpers:

A) Remove special cable and 10 dB pad.

B) Install jumpers on J5 and J7 per data sheet.

5.2.7 Bias Currents:

Connect the multimeter set for 200 Mv scale across the referenced resistors. Use some kind of latch hook leads and be careful to avoid a short to ground which could burn open a series choke or board run. Turn on 28 V supply & adjust bias pots per data sheet limits. These bias adjustments are intended to be set cold. If one rechecks the readings after warm-up they can be expected to read considerably higher. Do not reset.

> Note: The pots used in this assembly have a symmetrical foot print. Be certain that they are all installed so power or voltage increases with CW rotation. You may do this visually at the start or wait until the pot is set.

5.2.8 CSB Reverse directivity:

A) Connect RF drive to J1 (+15 dBm).
B) Adjust CSB PWR control for 3 +/- .3 Watt out.

C) Connect DVM to TP6 on fixture.

D) Adjust L11 and L6 for minimum detected voltage at TP6.

Repeat 5.2.8.D. (A final touch up tuning along with specifications will come in Para 5.2.22.)

E) Turn CSB PWR control fully CCW.

5.2.9 SBO Reverse directivity:

A) Adjust SBO PWR control for 1 +/- .1 watts out.

B) Connect DVM to TP4 on fixture.

C) Adjust L39 and L50 for minimum detected voltage at TP4.

Repeat tuning of L39 & L50 until there is no significant improvement.

5.2.10 Not used

5.2.11 Not used

5.2.12 Not Used:

5.2.13 CSB Preliminary Tuning:

A) Check to be sure RF to UUT is back to +15 +/- .5 dBm.

B) Turn on 28 Volt supply and reset it for 22 volts.

C) Rotate the CSB PWR control on the test fixture fully CW and note the reading on the power meter connected to the CSB output. CW rotation of the CSB PWR control should produce a smooth increase in power output to over 5 Watts, even before tuning is attempted. If not there are problems to deal with.

> Note: When properly calibrated the digital wattmeters will read 1 mW = 1 Watt & 1 uW = 1 mW. Disregard calibration for the moment until you have a working PA. For preliminary testing the Bird Wattmeter is accurate enough.

D) Place your finger on U1, Q1, & Q2 cases to be sure they are properly heat sinked. If heat sinking & operation are normal the cases should be barely warm to the touch. Watch especially for loose mounting screws after the assembly has been reworked. Proper rework procedures make it necessary to remove the board from the heat sink to gain access to soldered pads under the board.

E) Set the toggle switch for CSB OPEN LOOP. Use a tuning tool (Ferrite slug one end, brass the other) to test each coil listed on the data sheet to see which way it needs to go, then squeeze or stretch it as necessary. Anticipate the installation of covers and avoid pushing the coils toward the cover edge. When finished return the OPEN LOOP switch to normal and turn CSB PWR control fully CCW.

5.2.14 SBO Preliminary Tuning:

Turn the SBO control fully clockwise and note the reading on the power meter connected to the SBO output. Clockwise rotation of the SBO PWR control should produce a smooth increase in power output to over 1 Watt, even before tuning is attempted. If not there are problems to deal with. Proceed as directed by data sheet in similar manner to the CSB tuning using the SBO OPEN LOOP switch position.

5.2.15 Phase Loop Centering:

The reader may note the order here is different than the localizer. The former can be tuned in a logical order & the early tests assure good results in later tests. Tuning of the Glideslope requires more art & repeating of tests. The tests in 5.2.15 - 5.2.18 have to be considered as an interacting group. If a later test required a readjustment, then it is necessary to go back and recheck at least some of the others in the group.

Test 16 is an optional test that can be used for trouble shooting purposes. It should be performed in its entirety if something suspicious shows up in the other tests. If things seem normal, but the TP1 measurement results show less than 5 degrees spare phase on either end, then one should do a check of the range of the Loop Phaser. It is not necessary to pull the hybrid or use the special cable.

The objective of the tests in this paragraph is to center the loop controlled phaser so that phase lock will hold over the entire range of the SBO phaser for the worst case conditions of frequency, bus voltage, and environment. If this is a PRELIMINARY test do all below, if it is a FINAL test simply take the data per data sheet.

A) Turn off power supplies & install test cover on CSB side only. This will more accurately represent that side for the phase adjustments to come. Turn power back on and set the supply for 28 Volts.

B) Check J6 to see that there are jumpers on 1 to 2 and 5 to 6. This is the only permissible way to jumper!

C) Take TP1 readings per data sheet to find the highest and lowest readings. Enter in light pencil. Generally the 336 MHz reading with TP9 = 0 V produces the highest TP1 voltage & 328 MHz with TP9 = 10 V produces the lowest.

D) Adjust L27 and L34 as necessary to center the TP1 readings so there is about the same amount of spare PHASE (not voltage) leftover at each extreme. Use table below. If more adjustment is needed one can also use L41, L45, & L46. These also affect SBO power out, but there is usually plenty of spare. Beyond that there is L28 & L31 (PMDT phaser), but these also have a big affect on tests 17 & 18.

   Here are some typical sets of limits on UUT TP1 required to achieve various amounts of reserve phase range:

+9.0V & -12.2V yield -3 Degrees
+7.0V & -12.0V yield 0 Degrees
+4.5V & -11.7V yield 5 Degrees
+2.6V & -11.5V yield 10 Degrees
+1.0V & -11.25V yield 15 Degrees
-0.3V & -11.0V yield 20 Degrees
-1.4V & -10.8V yield 25 Degrees
-2.4V & -10.6V yield 30 Degrees

Notes:

1. You can easily take your own data similar to the above by connecting test power supply to R107 & plotting output phase Vs PS voltage. Convert to TP1 equivalents by subtracting 15 volts.

2. The +7.0 & -12.0 limits on TP1 require some explanation: The battery low point of 22 volts limits upper limit of C94 voltage to 22 volts and TP1 to 22 - 15 (Zener CR17) = 7 volts. Maximum guaranteed swing out of Amp U7D is +/- 12 V. When U7D is -12 V, TP1 will also be -12 V, but C94 will be 15 volts higher at +3 V DC. It is very unlikely that a normal operating PA will ever approach the +7.0 & -12 limits which we are calling 0 reserve.

2. The L27 & L34 inductors together with C84 and C85 form a separate phaser to allow centering the loop controlled phaser. When adjusting keep both coils looking alike & leave the coils set for more inductance than ideal to allow for the cover.

3. If TP1 voltage is unaffected by L27 and L34 you have a problem in the loop and need to trouble shoot the circuits on sheet 5 associated with HY4, U3, U7A & U7D.

E) If all the above steps seemed to produce near normal results turn off the three supplies & install the SBO test cover. The test cover should have windows for touch up tuning of the coils. It is sufficient to use only a few screws.

F) Make the TP1 measurements per data sheet, then compare to the range specified for TP1. If necessary, make minor adjustments to better center the loop by further adjusting of L27 and L34.

5.2.16 SBO Loop Phaser:

A) Connect positive lead of a test supply (item 3.20 in test equipment list) to C94. The end of R107 that is nearest L40 provides a convenient place to clip on. Connect negative to chassis. This supply will over ride the control signal from the phase lock loop. Some supplies will not sink power & you may have difficulty reaching the lower voltage limit. If such is the case add a 470 ohm 2 watt pull down resistor across the supply.

B) Remove amplifier U13 and connect a special adapter between U13 socket pins 1 & 2 and the A input of Network Analyzer. Use a 30 dB pad at the analyzer input. With a VVM Prelim. setup patch the adapter to the input of the SBO coupler.

Note: Removing the U13 amplifier disables the amplitude loop, but with the SBO power control wide open the diodes in HY6 act like a limiter and level the output.

C) Patch CSB coupler output to R input of Network Analyzer.

D) Use a 30 dB pad at the analyzer input. With VVM keep channel A tee connected to CSB coupler/atten per Figure 2.

Set up Network Analyzer as follows:

Channel 1:	Channel 2:
Input: A/R	Input: A
Mode: Phase	Mode: Mag

E) Turn on supplies and reset for 28 V DC.
Check & set frequency for 332 MHz.
Set CSB for 3 W. (SBO is disabled)

Note: You should now be reading phase of your A input relative to CSB.
Add 30 dB to the Analyzer channel 2 reading and you will have amplitude in absolute dBm.

Phase readings are displayed digitally to three significant digits. Once a 0 reference is set the readings will go as far as +/- 180 Degrees. If one goes beyond 180 Degrees the readings will change sign and begin to drop. It is best to avoid this kind of confusion by setting the 0 reference at a point where the change from reference point is < 180 Degrees.

With VVM the amplitude reading must be increased by the coupler & atten losses. For this test phase can be read on the +/- 180 Deg. range. accurately enough. Adjust Meter Offset to either 0 or 180 Deg. so that needle is to the left of zero with test supply (item 3.20) set to 3 Volts.

Proceed to tune L40 & L42 as needed for the best combination of range, power, & power variation.

Note: If the power limit can't be reached, it may be necessary to adjust L27 & L34 (Adjust both alike). Check loss across C85. It should be no more than 3 dB.

This phaser is not linear. Typically a change from 3 to 4 volts at C94 will cause a change of nearly 20 deg. It takes a drop from 22 down to 14 to get a 20 deg change. Center of the 3-22 Volt range should occur about 9 V.

F) Remove the special cable and reinstall U13. Remove the power supply from C94 (R107). If VVM set up patch the SBO coupler back to J3 SBO output.

5.2.17 SBO Phaser Operation:

A) Leave Analyzer R input or VVM A input as in test 16.

B) If Analyzer patch A input via 30 dB pad to SBO coupler. If VVM use standard set up of figure 2.

C) Set for 0.2 W. SBO. You can read this and other low levels with the VVM. .2 W less 30 dB of attenuation is -7 dBm. Set CSB to 3 Watts & large supply to 28 Volts.

D) Adjust Phase control on fixture for 0 Volt at TP9.

E) Read reference phase. Set analyzer or VVM for Zero. The 180 degree scale on the VVM should be accurate enough unless one is very marginal. In that case use degree scale & index knob.

F) Increase Phase control Voltage to 10 Volts & take another phase reading.

G) Compute range. If the range is not acceptable adjust L28 and L31 and try again. More phase range is desirable at sub-system test level, but every bit added makes it harder to stay within the range of the loop over frequency & service conditions. Loop tests are in Para. 5.2.15.F

Note: This phaser is also non-linear. A change from 1 to 2 volts at TP9 will typically change phase 12 degrees while it takes a drop from 9 to 5.5 to get a 12 degree shift.

Phaser Amplitude Variations:

H) Recheck to be sure the SBO power is still approximately 0.2 Watts.

I) Set the SBO Wattmeter for indications in dBm. If prelim. set up, watch VVM Ch. B.

J) Adjust the fixture PHASE control throughout its range while observing changes in SBO power. Make a mental note of the highest and lowest readings, then subtract the two extremes and record the difference.

K) Put the Wattmeter back to reading in watts to avoid later confusion.

5.2.18 Absolute Output Phase:

A) Switch power supplies off and install both test covers.

B) Turn on power supplies and set for standard conditions:
332 MHz, 3 W. CSB, 0.2 W. SBO, 28 V DC. Retain supply at 28 volts until test 32.

C) Set Phase Control on fixture for 4 V DC at fixture TP9.

D) Patch A VVM tee to the -20dB sample port of the amplifier driving the Mod/PA.

E) Patch B VVM tee to the CSB forward coupler output.

F) Establish a zero phase reference on the CSB signal. Use the 180 degree scale of the VVM.

G) Interchange the two coaxes to CSB and SBO output of the Mod/PA. Reset VSWR alarm.

H) Read and record the SBO phase reading.

Note: If this reading is not within specification the most likely cause is abnormal phase drop in PMDT phaser. The tests in 17 only look at delta. You may retune L40 & L42 some here but you then have to redo both 15 & 17.

Besides the above the only other parts of the Mod/PA not within the loop are the directional couplers and the following two filter section. They were tested for phasedrop in Para 5.2.4 & 5.2.5. If you need more SBO lag here then go for more when you do 5.2.5. If you redo filter tuning you need to repeat 15.

5.2.19 CSB Open Loop Power:

Before one can take final data from this point on the wattmeters must be calibrated per the procedure in Appendix A. at Paragraph 5.4.

A) Turn the supplies on and reset the high power supply for 22 volts. 22 volts represents the lowest useful output from a normal lead acid battery bank. Recheck and set the RF drive to +17 dBm at 332.0 MHz if that wasn't done in test 4.

B) Set the fixture switch to CSB OPEN LOOP position and observe the CSB power meter reading. Return OPEN LOOP switch to normal position. Record on data sheet.

C) Change RF drive to 328 MHz and repeat step 5.2.19.B.

D) Change RF drive to 336 MHz and repeat step 5.2.19.B.

E) Study the results. If all the readings are in specification no further tuning is required. If the results show power dropping out on one end or the other than retune slightly to favor that frequency.

Note: Before changing any devices attempt to determine which stage has low gain by comparing measurements on the suspect assembly to a good one. Valuable measurements include drain currents which are easily measured by metering drop across the .1 & .01 ohm series resistors. If the hybrid amplifiers are suspect they are easily changed without soldering.

One can measure RF voltages at base and collector of each stage with the spectrum analyzer. To do this find a coax cable that will connect to the analyzer and is open on the far end. Solder a 510 ohm 1/4 watt carbon resistor in series with the center conductor at the open end. Prepare the shield so that it is less than a half inch long and can be held against the ground plane. The analyzer has a built in coupling capacitor to isolate the dc level, so don't use any pads (which may add a dc path) other than the 510 ohm resistor. The resistor will attenuate the signal voltage 20dB and the analyzer will not be damaged. This method of probing has the advantage that any abnormal frequencies created by parasitic oscillations will be spotted.

The VVM with Tee can also be used in a similar manner. The VVM can take up to +/- 50 VDC, but the 50 ohm load in the Tee will cause excess dissipation in a 510 ohm resistor. Use a 2700 ohm resistor for 34.8 dB of attenuation or use a .33 Pf capacitor for 29.6 dB of attenuation.

5.2.20 SBO Open Loop Power:

A) Set the fixture switch to SBO OPEN LOOP position and observe the SBO power meter readings for all three frequencies. Return OPEN LOOP switch to normal position. Record on data sheet. For best use of your time do both CSB and SBO tests at a given frequency before changing to the next frequency.

B) The hints provided in the note above apply here as well.

5.2.21 Signal Leakage for Zero Control Voltages:

A) Return the frequency to 332 MHz & turn both CSB PWR & SBO PWR pots fully CCW. Increase power supply voltage from 22 to 28 Volts.

B) Disconnect the drive from J1 and rezero the DWMs. Reconnect drive then read and record residual power levels. For VVM add the coupler & pad attenuation to the reading in dBm & use the dBm blanks on the data sheet.

Note: If VVM doesn't lock on CSB reading, temporarily cross coaxes to UUT J2 & J3 so channel A is to the SBO. Turn up SBO power to lock on channel A & read CSB with channel B. For SBO reading uncross coaxes & turn up CSB power until you get a lock on A, then read SBO on B.

5.2.22 Main Carrier Power Vs Control Voltage:
(Large Power Supply at 28 Volts)

A) Connect the multimeter to TP12 on the side of the test fixture.

B) Adjust CSB PWR control for 4.33 +/- .02 Volts.

C) Adjust R35 for 3.0 mW indicated (3 W output) on the CSB meter.

D) Adjust R82 for 0.2 mW indicated (0.2 W output) on the SBO meter.

Note: If any of the above pots run out of range, check for an abnormally high detector output or abnormal gain setting resistors. The readings taken at TP7 in test 5.2.27 & at TP2 in test 5.2.29 are valuable clues to what constitutes normal detector operation.

5.2.23 Directivity of Reverse Detectors:

A) CSB & SBO power levels were set correctly in previous test. Measure TP6 (CSB) and TP4 (SBO) with multimeter.

B) Switch off +28 Volts supply and connect good 50 ohm loads (Return loss > 36 dB) directly to the CSB and SBO outputs of the UUT. If you can confirm that the normal fixture loads have >36 dB return loss you do not need to use special loads.

C) Check for optimum tuning of L11 & L6 (CSB) and L39 & L50 (SBO) with ferrite/brass tuning tool and adjust accordingly for minimum detected voltage at TP6 and TP4. It is normal that these readings are sensitive to changes in frequency. Follow the data sheet specifications and compromise the tuning for best results over the band. If the reading at TP6 is too high after adjusting for a dip try another value for R13. If the reading at TP4 is too high try another value for R108. The allowable alternatives are noted in the schematic and listed in the PL.

Note: In doing this you are making a fine adjustment of load impedance presented to the reverse directional coupler thereby setting its directivity. Watch power output as well as voltage at TP6. You don't want to dip TP6 by causing power to drop drastically. The desired dip is quite sharp.

D) Turn off the power supplies and install the final covers in place of the test ones.

5.2.24 Phase Change with RF Power:

Retain the Analyzer setup of Section 5.2.16. (CSB to R, SBO to A)

A) Set CSB PWR for 4 W & check to see that the power supply voltage is 28 Volts. Set phaser control for 3 V at TP9.

B) Set Analyzer to establish a 0 Deg. phase reference.

C) Adjust CSB PWR slowly down to .3 W while watching the phase reading. Record the maximum positive and maximum negative deviations from zero. One reading may be zero if all the change is all in one direction. The usual maximum is at .3 W. Calculate the total deviation range and record the result. Return CSB PWR to 3W.

D) Turn phase control fully CCW.

E) Adjust SBO PWR for 0.3 W CW.

F) Rezero the analyzer.

G) Adjust SBO PWR slowly down to ..03 W while watching the phase reading. Record the maximum positive and maximum negative deviations from zero. One reading may be zero if all the change is all in one direction. Calculate the total deviation range and record the result. Return the SBO PWR to 0.2 W.

5.2.25 Phase Change with DC Supply:

A) Set CSB for 3 Watts, SBO for 0.2 Watts

B) Set DC supply for 28 Volts.

C) Set Analyzer to establish a 0 Deg. phase reference.

D) Turn DC supply down to 22 volts slowly while observing phase reading. Record the worst case reading.

5.2.26 Not Used

5.2.27 Power Detector Calibration CSB Forward:

A) Turn supplies back on and set CSB power to 3.0 Watts with fixture CSB PWR control.

B) Adjust R38 per data sheet.

C) Measure voltage at TP7 and record on data sheet.

5.2.28 Power Detector Calibration CSB Reverse:

A) Switch off the large power supply.

B) Remove CSB cable from J2 output & install the 25 ohm test load (item 3.11). This results in the desired 2:1 VSWR.

C) Switch the large supply back on.

D) Adjust R34 per data sheet & check it off. Note that there is no fixed signal on TP5, like the MK10 had, because the line is used for VSWR alarm reset.

E) Switch off the large power supply and restore normal 50 ohm load to J2.

5.2.29 Power Detector Calibration SBO Forward:

A) Switch the large power supply back on.

B) Set SBO PWR to 0.2 Watts.

C) Adjust R75 per data sheet & check it off.

D) Measure voltage at TP2 and record on data sheet.

5.2.30 Power Detector Calibration SBO Reverse:

A) Switch off the large power supply.

B) In manner similar to step 5.2.28.B above connect 25 ohm load to SBO output J3.

C) Switch large supply back on.

D) Adjust R96 per data sheet & check it off.

E) Measure voltage at TP4 and record on data sheet.

F) Switch off the large supply and restore normal fixture load.

5.2.31 VSWR Shutdown:

A) Press fixture VSWR RESET switch & note that Alarm LED on fixture lights.

B) Set CSB per data sheet then switch off large supply.

C) Remove CSB fixture load and substitute a 3:1 load. This load is easily made by adding a tee connector and third load to the 2:1 load used in prior tests.

D) Switch on large supply and note that there is near normal RF power indicated by about 5.2 volts on TP8. Also the VSWR Alarm LED on fixture should not be lit.

E) Switch off large supply & reconnect normal fixture load.

F) Switch on large supply & set power for 4 watts.

G) Remove the 3:1 load while Mod/PA is operating. VSWR ALARM LED should light and power drop drastically. Monitor power by reading voltage at TP8 & record.

H) Restore fixture load. The power may come back at this point or it may remain latched to a low state, either way is acceptable. Record yes or no on data sheet.

Note: A low frequency oscillation may be seen at the anode of SCRs that do not latch. This is an acceptable mode of operation. The intent of all this circuitry is to comply with FAA Spec 2100 Para. 3.3.2.2 that opening or shorting the output not cause damage.

I) Depress VSWR RESET switch, if necessary, and note that power comes back to normal and LED goes out.

J) Use data sheet as a guide and repeat the above process for the SBO channel.

5.2.32 Dynamic Checks SBO:

Up to this point all tests should have been without modulation of any kind and if the specifications have been met the assembly will probably work fine with modulation. Rather than simulate a complex signal of 90, 150, voice, & identification we will use a single 150Hz tone at high modulation percentages.

A) Locate the Audio Analyzer controls for frequency and level and key in 150.00 Hz at an output level of 2.75 V RMS but do not yet connect to fixture input jack.

B) Set SBO PWR control for Approx. 0.25 Watts CW output.

C) Connect an oscilloscope to TP13 on the test fixture to display the controlling SBO signal. Use DC coupling. Now connect the 150 Hz drive to the fixture and observe the modulation. Make slight changes in level out of the generator until downward modulation just reaches the 0 Volts base line indicating 100% modulation. Once set it should not be necessary to reset this level unless something changes in the setup.

D) Set SBO PWR control for 0.2 watt reading.

E) Now observe the detected SBO output waveform at TP2. It should be clean and not clipped on top or bottom, if so check off the data sheet. If you are in doubt as to what is or is not acceptable let the tests of Para. 5.2.35 & 5.2.37 be the determining factors as they have definite limits.

F) Decrease the large supply voltage from 28 to 22 Volts and repeat the above test.

> Note: The 436A Wattmeter reads true average power. When single tone 100% undistorted modulation is applied the indicated reading should be approximately 1.23 times what it was for CW. All power levels for tests 5.2.1 - 5.2.31 are in CW. For tests 5.2.32 & following the SBO power level is to be 0.3 watts when read with modulation present. For this waveform the peak power is twice the RMS power indicated by the DWM.

5.2.33 Dynamic Checks CSB:

If this is a Preliminary test skip the 1st two steps.

A) Patch the CSB & SBO sample signals from J2 and J6 on the ATE patch panel to the Wilcox combiner per Figure 1.

B) Patch the output of this combiner to the Modulation Analyzer via J32 on the patch panel.

C) Adjust SBO PWR control fully CCW & leave it there until it is again specifically mentioned.

D) Adjust CSB PWR control for 3 W CW.

E) Adjust CSB MOD% control on the fixture for 80% downward (-) AM modulation indicated on the Modulation Analyzer. Upward (+) modulation should read within 5% of the same reading. If Prelim test use O'scope connected to fixture TP7 to set for 80%.

F) Connect oscilloscope to TP7 on the fixture and observe the waveform. If OK check off data sheet.

G) Raise the power supply to 28 Volts and repeat the waveform check.

H) Lower the power supply back to 22 Volts.

5.2.34 CSB Distortion:

A) Patch the DETECTED OUTPUT of the Modulation Analyzer to the INPUT of the Audio Analyzer.

B) Read the total distortion indicated on the Audio Analyzer and record in the 332 MHz blank on the data sheet.

C) Reset the RF drive for 328 MHz and repeat the above.

D) Reset the RF drive for 336 MHz and repeat the above.

5.2.35 SBO Distortion:

Since this signal is double sideband suppressed carrier it cannot be detected with a simple diode detector. The practical way to deal with it is to combine it with unmodulated CSB of the correct phase and then measure it the same as the CSB signal.

A) Set SBO for 0.2 W at 332 MHz.

B) Turn CSB Mod % control on fixture fully CCW. Set CSB for approximately 0.5 watts.

C) Watch the Modulation Analyzer and adjust the PHASE control on the fixture for maximum modulation. Since range of the MK20 is much less than the MK10 it may be necessary to add line sections in one of the combiner inputs. Be sure that maximum observed is not at the end of the phaser range.

D) Adjust CSB power up or down as necessary to make the maximum observed modulation be 60 +/- 10%.

E) Readjust PHASE control for maximum modulation.

F) Patch the output of the Modulation Analyzer into the Audio Analyzer. Read and record the distortion. If it is a little high try more carefully readjusting PHASE.

G) Repeat for RF drive at 328 MHz and 336 MHz. At each frequency carefully readjust the phase for maximum Mod %.

5.2.36 CSB Spectrum:

A) Patch CSB signal sample from J2 on ATE panel to the RF Spectrum Analyzer (J34).

B) Follow the setup guidelines on the data sheet. Read and record the worst case readings you observe. Do not simply check off the data sheet.

5.2.37 SBO Spectrum:

Take these readings along with the CSB readings by simply retaining the correct setup and moving the patch cable from ATE panel Jack J2 to J6. Note that all SBO readings are referenced to the CSB carrier.

5.3 POST TEST PROCEDURES

A) Disconnect the cables from the unit under test.

B) Remove the unit under test from the test fixture.

C) Carefully place the UUT in a ESD resistant bag.

5.4 APPENDIX A: Calibration Procedure for Digital Wattmeters

Objective: To get the wattmeters to read directly & accurately in watts so one does not have to apply correction factors. When this procedure is accomplished the meter will read 1 watt as 1 milliwatt. 1 milliwatt will be read as 1 microwatt. Although the procedure here is written around the HP436A Power Meter, the HP437 may be used in the same manner by entering offset and cal factors to get readings in Watts.

Adjustability of the HP 436A Wattmeter: The calibration screw (CAL ADJ) has a wide range of adjustment; typically one can set for as little as 0.600 mW or as much as 1.75 MW when reading the internal 1 MW standard. That means that the required 30dB of attenuation to transform Watts to milliwatts can be in error by as much as +/- 2.2 dB and the meter will take up the slack.

Traceability: The accuracy of this final calibration depends mostly on the ability of the Calibration lab to provide accurate attenuation data on a 30 dB, 20 Watt pad, Narda 766-30. Past experience has shown this to be very accurate data.

Procedure:

1. Connect the head of the HP436A Wattmeter that is to be used for CSB measurements to it's internal calibrator.

2. Press ZERO button. When ZERO light goes out press 1 MW internal standard.
3.
4. Read the actual calibrated attenuation of a nominal 30 dB, 20 Watt Attenuator. Subtract this from 30.00 dB but be careful to use the correct sign. For example, a 29.5 dB pad will yield a signal that is 0.5 dB too strong so we need to set the meter to read -.5 dBm instead of 0 dBm = 1 MW.

5. Set HP 436A to read in dBm.

6. Adjust CALIBRATION adjustment so that meter reads the correction factor calculated in step 3 above. When finished switch MODE back to WATT.

7. Connect Wattmeter with the above pad directly to the CSB output of a known good PA.

8. Set the PA until the Wattmeter reads exactly 3.0 MW =Watts.

9. Turn the PA off by disconnecting the drive. Do not turn off the high voltage supplies as that will result in more drift.

10. Connect the Wattmeter the way it normally will be per Figure 1.

11. Turn the PA back on by reconnecting drive.

12. Adjust the meter calibration screw until the Wattmeter again reads exactly 3.0.

13. Transfer the Wattmeter head to it's internal calibrator and turn it on.

14. Read and record the number in terms of dBm or MW. That number will be what you use the next time you calibrate the Wattmeter. It is not necessary to repeat this procedure again until you replace a cable, attenuator, Wattmeter, or something else in the attenuation path.

15. Calibrating the SBO is much simpler. Remove drive & temporarily swap the SBO and CSB coaxes on J2 and J3.

16. Reapply drive & adjust SBO meter calibration screw for mW = 3.0 Watts.

17. Repeat steps 12 & 13 above for the SBO Wattmeter.

18. Switch off the 28 Volt supply and put everything back to normal.

5.5 Appendix B.: Theory of Operation

The Mark 20 Glideslope PA incorporates into one assembly the following functions:

a. CSB PA, 3 W nominal output
b. SBO PA, 0.2 W nominal output
c. Low pass filters for CSB & SBO
d. Calibrated detectors, forward & reverse, for CSB & SBO
e. Sideband phaser
f. Phase loop to lock SBO to CSB
g. Modulation circuitry with inverse feedback
h. VSWR detection & latched shutdown

The PA requires +/- 15 Volt DC power for the low level control circuitry and + 28 V for the rf power amplifiers.

Besides power the following drive signals are required for normal operation:
a. Unmodulated rf: 328-336 Mhz @ 50 Mw (+17 dbm)nominal
b. 0-10 V DC control voltage for SBO phaser
c. 0-5 V DC control voltage for CSB modulated with sum of 90 & 150 Hz
d. 0-5 V DC control voltage for SBO modulated with rectified 90-150 Hz
e. An SBO zero cross signal at TTL level

For test purposes, only the 150 Hz tone is used to simplify distortion measurements & test setup. When the PA is part of a system, parameters such as power, modulation, mod. bal., course width, & phase are all under keyboard and software control.

Here are some more key features of this assembly & ways in which it differs from MK1F & other previous equipment:
a. Modulation is done at low levels in a diode bridge mixer assembly.

b. The high level RF amplifiers are MOSFETs operated as linear amplifiers with adjustable bias. These devices have the advantages of high gain, low noise, relative immunity from thermal runaway, and ability to withstand severely mismatched loads without damage.
c. Hybrid amplifier modules are used for low level linear amplification.
d. SBO phase is controlled inside the power control loop so that amplitude and VSWR variations become insignificant.

MK20 hardware and test methods compared to the Mark 10:

VSWR Detection and Shutdown:

1. In the MK10 detected reverse power feeds back & gradually reduces forward power when it is above a fixed threshold. In the MK20 there is no linear control of forward power, instead high VSWR trips a latch that shuts off bias to the power MOSFETs. There are separate circuits for both CSB and SBO channels. The latch thresholds are fixed to hold on at a VSWR of 3:1 and trip off somewhere between that and an open.

2. A VSWR status signal on J4-8 goes high when either CSB or SBO VSWR detection circuits have latched on. On Mark 10 this pin was used for Capture Effect power control, a feature that has never been used.

3. A ground on J4-20 will reset both CSB and SBO latches. On MK10 this pin carried the fixed level CSB Reverse power signal.

General:

4. There is only one power control pot on Mark 20. Main CSB control is on pin 11 for both MK10 & MK20.

5. Bias levels on the power MOSFETs are considerably higher. The CSB final stage uses a .01 ohm shunt instead of .1 ohm.

6. There are two Pi low pass filter sections after the directional couplers instead of one. Having 2 coils to adjust instead of one should allow one to adjust for better directivity of the reverse power coupler.

7. The low pass filters are tuned for 50 ohms and other adjustments are used for tuning the last amplifier stage. The Minijumps that were seldom used on the MK10 must be used on all MK20 Assys.

8. The RF input and modulation/power control circuitry is a lot more complex. The goal of these changes was to get more attenuation range and thus cleaner SBO waveforms down in the V notch.

a. The MK20 has 2 added PIN diodes and a low pass filter ahead of CSB and SBO diode modulators.

b. The MK20 has a low loss isolating splitter to separate the RF input into CSB and SBO channels. MK10 uses Pi attenuators made from discreet resistors.
c. Input level on the MK10 was somewhat critical, not so the MK20.

Phase Loop:

9. There is a feedback control loop to maintain phase of SBO constant to the CSB reference. This is a slow acting loop intended to remove the phase variations caused by power changes, bus supply, temperature, etc. The loop includes everything but the directional couplers and final two sections of the low pass filters.

10. The PMDT controlled phaser in the MK20 (CR26, CR27, etc) has a range of about 65 degrees. The MK10 typically had a 100 Degree range. The MK20 has an added SBO polarity reversing header J6 shown on the schematic, but that is always supposed to be connected 1 to 2 and 5 to 6.

11. In addition to the phaser described above there is the loop controlled phaser (CR30, CR34, etc.)The loop phaser has a range of about 150 Degrees that must be centered under normal conditions.

12. Phase Loop Voltage is available at TP1 on the board and also via a 10K limiting resistor on J4 pin 9.

Circuit Theory:

The Schematic is 5 sheets broken down as follows:
Labeling the sheets per the list should save time.

Sheet 1 = Notes and Revisions
Sheet 2 = CSB
Sheet 3 = Audio/Control
Sheet 4 = SBO
Sheet 5 = Metering/VSWR Monitor/Phase Loop

Most of the circuitry can be deduced from reading the schematic, but the following discussion on the CSB circuitry may be helpful. Refer to sheet 3. A CSB control signal from the fixture (a mixture of DC and audio) is set at the correct level by pot R35. Amplifier U4 has a fixed gain of -1. U5 follows & in turn drives the diode modulator HY3 and PIN diodes CR2 & CR1 shown on sheet 2. Gain of U5 (sheet 3) is controlled by a signal fed back from the detected output. Refer to sheet 2 and note that CR5 detects a sample of the forward CSB output. Follow the detector output (Node N86) to sheet 5 where it goes through unity gain buffer amplifier U6. Follow U6 output through R48 and then back to U5 on sheet 3 completing the loop. U5 is a summing amplifier with inputs coming through R48 and R29.

U7c on sheet 5 buffers the CSB reverse detector (CR4 on sheet 2) and drives a VSWR level detector. The later is made up of Zener CR21 and associated resistors R51, R78, & R79. When the drive to SCR Q6 exceeds about 1 volt the SCR latches on lowering Nodes N204 & N85 from a normal level of about +6 volts to about -14 volts. N85 connects to bias setting pots R7 and R10 on sheet 2. Under normal conditions RF FETS Q1 & Q2 are biased with about 4 volts and a VSWR alarm drops that to about -9 Volts. That will turn off any FET unless the rf signal drive is extremely high. When the SCR is on it also pulls down the signal at CR6 anode (sheet 5). That in turn turns on Q4 and lights an LED indicator in the fixture. The SCR can be reset by clearing the VSWR condition and shorting J4-20 to ground. Doing that will turn on Q3 which turns on Q7 which shunts the current around SCR Q6. Once current in an SCR is reduced below the holding value it turns off.

The SBO channel is nearly identical to the CSB described above. The main difference is the addition of a SPDT analog switch (U11 on sheet 3).With a 0 on control pin 6, S1 input is on and S2 is off. With a TTL high on pin 6, S1 is off and S2 is on. Note that S1 is driven by a positive signal out of U10B while S2 is driven by the same but inverted signal from U10A. Half the time the positive signal is active and the other half the negative signal is active serving to balance out the carrier and generate the required DSB suppressed carrier signal. The zero crossing signal can be supplied so that it swings in the same direction as the analog signal or the opposite. The only purpose of this is to effect a 180 phase change for increasing range of the SBO phaser control.

5.7 DATA SHEETS

PRELIMINARY
DATA SHEET
for
Mark 20A GlideSlope PA Assy
WPN 120504-0001

S/N:______ Date:______ Tested By:___________________

(covers removed) All tests @ 332 MHz unless noted otherwise.
Tests 1-31 are without modulation.

1. Preset pots R7, R10, R109 full CCW & R35, R82, R34 CW.	____Ck
Preset Var. Cap C112 CCW so screw is flush with rim	____Ck
Preset coils L8, L9, L11, L6(CSB LPF)	____Ck
Preset coils L47, L48, L39, L50(SBO LPF)	____Ck
Preset coils L7, L1(CSB Amps)	____Ck
Preset coils L41, L45, L46 (SBO Amps)	____Ck
Preset coils L40, L42, L27, L34 (Loop phaser)	____Ck
L27 & L34 to look alike	
Preset coils L28, L31 (SBO phaser)	____Ck

Resistances to chassis:	-15 bus @ L22 > 1k ohms	_______Ck
	+15 bus @ L23 > 500 ohms	_______Ck
	+28 bus @ R36 > 1k ohms	_______Ck

2. PS currents:		UUT	UUT Spec	PS I Limit
	- 15 V	_______Ma.	(30-75 Ma)	0.2A
	+ 15 V	_______Ma.	(150-250 Ma).	4A
	+ 22 V	_______Ma.	(< 700 Ma)	1.0A

3. Detector offsets with no RF:

CSB FWD @	TP7 (<10mv)	________Ck
CSB REV @	TP6 (<50mv)	________Ck
SBO FWD @	TP2 (<6mv)	________Ck
SBO REV @	TP4 (<50mv)	________Ck

4. CSB Filter tuning at 332 MHz:
   Gen. with 10 dB pad into J5-2, Padded DWM/VVM to J2.
   Adjust L8, L9, L11, L6 for maximum output. ____Ck

   Adjust L8, L9 for best phase reading w/o exceeding Ins loss.
   Read phase drop ______ Deg. (60-105 Deg.0
   Read Insertion loss ______ dB (< 1.6 dB)

5. SBO Filter tuning at 332 MHz:
   Gen. with 10 dB pad into J7-2, Padded DWM/VVM to J3.
   Adjust L47, L48, L39, L50 for maximum output. ____Ck

Adjust L47, L48 for best phase reading w/o exceeding Ins loss.
Read Phase drop _____ Deg. (CSB drop + 50 to + 70 Deg.)
Read Insertion loss ______ dB (< 2.0 dB)

6. Place jumpers on J5-1 to J5-2 & J7-1 to J7-2. ____Ck

7. Set bias with supply at 28 Volts:
   Q1 bias @ R16, adj R7 for 25 +/- 3 Mv. ____Ck
   Q2 bias @ R36, adj R10 for 5 +/- 0.5 Mv. ____Ck
   Q9 bias @ R105, adj R109 for 25 +/- 3 Mv. ____Ck

8., 9., 10., 11., 12.: Not used

13. CSB tune @ 22 V, 332 MHz, L7, L4, L5, L1, C112 for max ___Ck
    U1, Q1, Q2 heat transfer OK ___Ck

14. SBO tune @ 22 volts, 332 MHz, L41, L45, L46 for max ___Ck
    U13, Q9 heat transfer OK ___Ck

(Install CSB test cover)

Conditions for steps 15 - 18: CSB = 3 W., SBO = 0.2 W.,
Freq. = 332 MHz, PS = 28 V

15. Phase Loop Centering: (Install SBO test cover before final data)

	328 MHz	336 MHz
TP9 = 0 V., TP1 =		_____ V. (*)
TP9 = 10 V., TP1 =	_____ V. (*)	

* All readings shall be between -12.2 and +9 Volts DC.
Readjust L27, L34 (keep them alike), L40, L42 as necessary to meet above limits. Also try to get about the same amount of spare phase range on either end. Use table in text to convert voltage to phase. If you have less than 5 degrees spare on either end perform the next step or at least make a range measurement.

16. SBO loop phaser: Connect DC PS to C94. (This section optional)
    Tune L40 & L42 as needed:
    Phase reading with PS at 3 V ______Deg.
    Phase reading with PS at 22V ______Deg.
    Total range ______Deg.(130 to 170 Deg.)
    Min. Power at U13-1 ______dBm (>+7.8 dBm)
    Power Variation _____dB (< 3 dB)

17. SBO Phaser operation: (Ref to CSB)

Phase reading for 0 V DC control at TP9 ______ Ref A

Phase reading for 10V DC control at TP9 ______ Ref B

Useable range (Ref B - Ref A) ______(63-75 Deg.)

Max Amplitude change for 0 to 10 V DC <.1 dB. ____Ck

Adjust L27 & L34 as necessary but keep them looking alike.

18. Absolute Phase of SBO compared to CSB (PS @ 28 V):

At 3.0 W CSB, 0.2 W SBO, Phase set for 4 V DC @ TP9:

With CSB referenced to Drive Sample 0Deg

With SBO referenced to Drive Sample ______ Deg

Spec: SBO to lag CSB by 120 to 160 Degrees

19. CSB open loop @ 22 volts, 328 MHz > 14 W. ____Ck

CSB open loop @ 22 volts, 332 MHz > 14 W. ____Ck

CSB open loop @ 22 volts, 336 MHz > 14 W. ____Ck

20. SBO open loop @ 22 volts, 328 MHz > 2.0 W. ____Ck

SBO open loop @ 22 volts, 332 MHz > 2.0 W. ____Ck

SBO open loop @ 22 volts, 336 MHz > 2.0 W. ____Ck

21. Signal leakage for zero control voltages (@ 28 V.):

332 MHz CSB out _____mW (<20 mW), SBO out_____mW (<1mW)

_____dBm (<+13 dBm) _____dBm (<0 dBm)

(Use mW or dBm what ever is most convenient.)

22. Power Out Vs control Voltage (@ 28 V):

adj. R35 for 3.0 +/- .020 W CSB with 4.33 V @ TP12 ____Ck

adj. R82 for 0.2 +/- .005 W SBO with 2.55 V @ TP13 ____Ck

23. Directivity of Reverse Detectors (@ 28 V):

		328 MHz	332 MHz	336 MHz
CSB @ 3W	TP6	_____V (<1.0V)	_____V (<.87V)	_____V (<1.0V)
SBO @ .2W	TP4	_____V (<.24V)	_____V (<.20V)	_____V (<.24V)

24. Phase change with power: (Ref to CSB) (PS @ 28 V)

(Phaser set for 3 V. @ TP9)

CSB at 4 Watts CW = 0 Deg. (Ref)

Max. shift 4W to 0.3W = _____ Deg.(+/- 12 Deg.)

25 P/O Final Data Sheet only

26 Not Used

(Final Covers Installed)

Power Detector calibr with CW @ 332 MHz, PS @ 28V (steps 27-30):

27. At 3 W CSB adj. R38 for 4.00 +/-0.05V @ TP8 _____Ck
    Same Conditions as above @ TP7 _____V (>1.1V)

28. At 3 W CSB & 2:1 VSWR adj. R34 for 2.50 +/-0.05V @ TP6 ___Ck

29. At 0.2 W SBO adjust R75 for 1.9 +/-0.03V @ TP1 _____Ck
    Same Conditions as above @ TP2 _____V (>.95V)

30. At 0.2 W SBO & 2:1 VSWR Adj. R96 for .64 +/-0.05V @ TP3 ___Ck
    Same Conditions as above @ TP4 _____V (>.65V)

31. VSWR shutdown (PS @ 28 V):
    Fixture VSWR Reset lights the Alarm LED ____Ck

    CSB with 3:1 load @ 5 W. (5.6V @ TP12) stays on ____Ck
    With 50 ohm load set power to 4 Watts (5.0V @ TP12)
    Open load on CSB & read fixture TP8 ____V (< 5.0V)
    Fixture VSWR Alarm LED lights ____Ck
    CSB normal power returns with 50 ohm load ____Ck
    Was a Fixture VSWR Reset required? ____(Y or N)

    SBO with 3:1 load @ 0.5 W (4.0V @ TP13) stays on ____Ck
    With 50 ohm load set power to 1.25 Watts.
    Open load on SBO & read fixture TP1 ____V (< 5V)
    Fixture VSWR Alarm LED lights ____Ck
    SBO normal power returns with 50 ohm load ____Ck
    Was a Fixture VSWR Reset required? ____(Y or N)

Dynamic Checks:

32. SBO @ 0.2 W with 150 Hz Mod, Waveform at TP2:
    clean and not clipped* with 22 V supply _____Ck
    clean and not clipped* with 28 V supply _____Ck

* V notch on bottom of waveform may be clipped off as much as 10 % of the total p-p voltage.

33. CSB @ 3.0 W, 80% Mod. 150 Hz, Waveform at TP7:
    clean and not clipped with 22 V supply _____Ck
    clean and not clipped with 28 V supply _____Ck

FINAL
DATA SHEET
for
Mark 20A GlideSlope PA Assy
WPN 120504-0001

S/N:______ Date:______ Tested By:____________________

(Final Covers On)All tests @ 332 MHz unless noted otherwise.
Tests 1-31 are without modulation.

Conditions for steps 16 & 17: CSB = 3 W, SBO = 0.2 W, Freq = 332 MHz, PS = 28 V

15. Phase Loop Centering:

	328 MHz	336 MHz
TP9 = 0 V., TP1 =		_____ V. (*)
TP9 = 10 V., TP1 =	_____ V. (*)	

* All readings shall be between -12.2 & +9 Volts DC.

16. P/O Preliminary Data Sheet only

17. SBO Phaser operation: (Ref to CSB)
Phase reading for 0 V DC control at TP9 ______ Ref A
Phase reading for 10V DC control at TP9 ______ Ref B
Useable range (Ref B - Ref A) ______(63-75 Deg.)

18. P/O Preliminary Data Sheet only

19. CSB open loop @ 22 volts, 328 MHz______ (> 14 W.)
CSB open loop @ 22 volts, 332 MHz______ (> 14 W.)
CSB open loop @ 22 volts, 336 MHz______ (> 14 W.)

20. SBO open loop @ 22 volts, 328 MHz______ (> 2.0 W.)
SBO open loop @ 22 volts, 332 MHz______ (> 2.0 W.)
SBO open loop @ 22 volts, 336 MHz______ (> 2.0 W.)

21. P/O Preliminary Data Sheet only

22. Power Out Vs control Voltage:
adj. R35 for 3.0 +/- .020 W CSB with 4.33 V @ TP12 ____Ck
adj. R82 for 0.2 +/- .005 W SBO with 2.55 V @ TP13 ____Ck

23. P/O Preliminary Data Sheet only

24. Phase change with power: (Ref to CSB) (PS @ 28 V)
(Phaser set for 3 V. @ TP9)

CSB at 4 Watts CW =	0 Deg. (Ref)
Max. shift 4W to 0.3W =	_____ Deg.(+/- 12 Deg.)
SBO at 0.3 Watts CW =	0 Deg. (Ref)
Max. shift .3W to .03W =	_____ Deg.(+/- 10 Deg.)

25. Phase change with PS voltage: (Ref to CSB)
CSB at 3 Watts CW, SBO = 0.2W, 28 V DC 0 Deg. (Ref)
Max. shift 28 to 22 V DC _____ Deg. (+/- 2 Deg.)

26. Not Used

Power Detector calibr with CW @ 332 MHz, PS @ 28 V (steps 27-30):

27. At 3 W CSB adj. R38 for 4.00 +/-0.05V @ TP8 _____Ck
Same Conditions as above @ TP7 _____V (>1.1V)

28. At 3 W CSB & 2:1 VSWR adj. R34 for 2.50 +/-0.05V @ TP6 ___Ck

29. At 0.2 W SBO adjust R75 for 1.9 +/-0.03V @ TP1 _____Ck
Same Conditions as above @ TP2 _____V (>.95V)

30. At 0.2 W SBO & 2:1 VSWR Adj. R96 for .64 +/-0.05V @ TP3 ___Ck
Same Conditions as above @ TP4 _____V (>.65V)

31. Prelim. Data Sheet Only

Dynamic Checks:

32. SBO @ 0.2 W with 150 Hz Mod, Waveform at TP2:
    clean and not clipped* with 22 V supply _____Ck
    clean and not clipped* with 28 V supply _____Ck

* V notch on bottom of waveform may be clipped off as much as 10 % of the total p-p voltage.

33. CSB @ 3.0 W, 80% Mod. 150 Hz, Waveform at TP7:
    clean and not clipped with 22 V supply _____Ck
    clean and not clipped with 28 V supply _____Ck

34. CSB @ 3.0 W, 80% Mod. 150 Hz, 22 V. supply:
    @ 328 MHz Dist _____% (<2%)
    @ 332 MHz Dist _____% (<2%)
    @ 336 MHz Dist _____% (<2%)

35. SBO @ 0.2 W recombined with CSB carrier & phased for max. amplitude, PS @ 22 Volts:
    @ 328 MHz Dist _____% (<2%)
    @ 332 MHz Dist _____% (<2%)
    @ 336 MHz Dist _____% (<2%)

36. CSB Spectrum @ 332 MHz (referenced to unmodulated carrier):
3 Watts with 80% Mod, PS @ 22 V:
* 332 +/- 50 MHz spurious sidebands _____(<-60dB)
** 332 +/- 1 MHz spurious sidebands _____(<-60dB)

37. SBO Spectrum @ 332 MHz (referenced to unmodulated carrier of CSB), 0.2 Watts 150 Hz Mod, PS @ 22 V:

* 332 +/- 50 MHz spurious sidebands _____(<-60dB)
** 332 +/- 1 MHz spurious sidebands _____(<-60dB)

*Reference unmodulated carrier at top of screen.
RBW = 300 kHz, VBW = 100 kHz, Shift G for averaging.
** Use auto BWs (RBW = 10 kHz, VBW = 10 kHz) & shift G for averaging.

Turn off averaging with Shift H.

6. SEMI-AUTOMATED TEST PROCEDURE

6.1 INTERFACE TEST ADAPTER VERIFICATION PROCEDURE

Following instructions in the test procedure for the HP VEE test platform, select **1291-60045-1 Modulator /PA ITA** to test the ITA. All necessary instructions, including setup diagrams, will be shown on screen.

If a failure is encountered in go-path testing, simply follow the instructions on screen.

6.2 TEST PROCEDURE

6.2.1 Test Procedures

Following instructions in the test procedure for the HP VEE test platform, select **Glideslope MOD/PA (120504-0001)** to test the UUT. All necessary instructions, including setup diagrams, will be shown on screen.

If a failure is encountered in go-path testing, the TPS software will automatically begin execution of a fault isolation tree which will narrow the cause of the failure down to the most likely test group. Simply follow the instructions on screen to perform fault isolation. The GPIB instruments may be used in local mode during troubleshooting.

6.3 POST TEST PROCEDURES

Turn off the UUT power and disconnect the cables and test points to the UUT. Carefully remove the UUT from the fixture and place it in an ESD resistant bag.

To shut down the computer, select FILE and EXIT from the HP VEE menu. Select NO when asked to save file. Exit windows and then turn off the computer.

6.4 TEST GROUPS

This section contains the UUT Test Group Schematic. This schematic, in conjunction with the Voltage Charts in the previous section, can be used as an aid in troubleshooting failures within the test groups. This schematic is the UUT schematic modified to show individual test groups.

6.5 TEST DESCRIPTIONS

This section contains brief descriptions of each of the tests that is run on the UUT during semi-automatic testing.

6.5.1 test1: SBO Phase Loop Operation at 328 MHz and Phase Voltage at 0VDC Test

A drive signal at 332 MHz from the Network Analyzer is applied to the ITA RF amplifier to produce +17dBm at J1 of the UUT. The CSB output of the UUT is connected through the CSB directional coupler and a 30dB 500W attenuator to the CSB Power meter. The SBO output of the UUT is connected through the SBO directional coupler and a 30dB 20W attenuator to the SBO Power meter. The **CSB Power** control on the ITA is set for 3W and the ITA **SBO Power** control is set for 0.2W. The drive frequency is changed to 328 MHz. The ITA **PHASE** control is set fully CCW. The DMM is used to measure UUT phase loop error voltage at UUT TP1& J4-9.

6.5.2 test2: Phaser Operation at 332 MHz and Phase Voltage at 0VDC Test

Conditions for test1 are maintained except that the Network Analyzer output is at 332 MHz. The DMM is used to measure UUT phase loop error voltage at UUT TP1& J4-9.

6.5.3 test3: SBO Phase Loop Operation at 336 MHz and Phase Voltage at 0VDC Test

Conditions for test1 are maintained except that the Network Analyzer output is at 336 MHz. The DMM is used to measure UUT phase loop error voltage at UUT TP1& J4-9.

6.5.4 test4: SBO Phase Loop Operation at 328 MHz and Phase Voltage at 10VDC Test

Conditions for test1 are maintained except that the Network Analyzer output is at 328 MHz. The DMM is connected to UUT J4-4 and **Phase** control is set for 10VDC. The DMM is used to measure UUT phase loop error voltage at UUT TP1& J4-9.

6.5.5 test5: Phaser Operation at 332 MHz and Phase Voltage at 10VDC Test

Conditions for test4 are maintained except that the Network Analyzer output is at 332 MHz. The DMM is used to measure UUT phase loop error voltage at UUT TP1& J4-9.

6.5.6 test6: SBO Phase Loop Operation at 336 MHz and Phase Voltage at 10VDC Test

Conditions for test4 are maintained except that the Network Analyzer output is at 336 MHz. The DMM is then used to measure UUT phase loop error voltage at UUT TP1 & J4-9.

6.5.7 test7: Phaser Range Test

Conditions for test4 are maintained except that the Network Analyzer output is at 332 MHz and ITA PHASE control is set for 0 VDC. A connection is made from the coupled output of the SBO directional coupler to the B input of the Network Analyzer through a 30dB attenuator. A phase reference measurement is first made by the Network Analyzer. The DMM is connected to UUT J4-4 and **Phase** control is set for 10VDC. A second phase measurement is taken by the Network Analyzer and the phase difference calculated.

6.5.8 test8: CSB Open Loop Power at 332 MHz

A drive signal at 332 MHz from the Network Analyzer is applied to the ITA RF amplifier to produce +17dBm at J1 of the UUT. The CSB output of the UUT is connected through a 30dB 500W attenuator to the CSB Power meter. The SBO output of the UUT is connected through a 30dB 20W attenuator to the SBO Power Meter. The ITA **Open Loop** switch defeats the UUT power control to produce maximum CSB output power.

6.5.9 test9: CSB Open Loop Power at 328 MHz

The conditions of test8 are repeated with a 328 MHz signal from the Network Analyzer.

6.5.10 test10: CSB Open Loop Power at 336 MHz

The conditions of test8 are repeated with a 336 MHz signal from the Network Analyzer.

6.5.11 test11: SBO Open Loop Power at 332 MHz

The conditions of test8 are repeated with a 332 MHz signal from the Network Analyzer.
The ITA **Open Loop** switch defeats the UUT power control to produce maximum SBO output power.

6.5.12 test12: SBO Open Loop Power at 328 MHz

The conditions of test11 are repeated with a 328 MHz signal from the Network Analyzer.

6.5.13 test13: SBO Open Loop Power at 336 MHz

The conditions of test11 are repeated with a 336 MHz signal from the Network Analyzer.

6.5.14 test14: CSB Power Output Vs Control Voltage Test

A drive signal at 332 MHz from the Network Analyzer is applied to the ITA RF amplifier to produce +17dBm at J1 of the UUT. The CSB output of the UUT is connected through a 30dB 500W attenuator to the CSB Power meter. The SBO output of the UUT is connected through a 30dB 20W attenuator to the SBO Power meter. The **CSB Power** control on the ITA is set for 4.33V at UUT J4-11 and R35 on UUT is used to set CSB power for 3W.

6.5.15 test15: SBO Power Output Vs Control Voltage Test

The connections are the same as test 14. The **SBO Power** control on the ITA is set for 2.55V at UUT J4-5 and R82 on UUT is used to set SBO power for 0.2W.

6.5.16 test16: CSB Phase Change with Power Output Test

A drive signal at 332 MHz from the Network Analyzer is applied to the ITA RF amplifier to produce +17dBm at J1 of the UUT. The CSB output of the UUT is connected through the CSB directional coupler and through a 30dB 500W attenuator to the CSB Power meter. The SBO output of the UUT is connected through the SBO directional coupler and through a 30dB 20W attenuator to the SBO Power meter. The coupled port of the CSB directional coupler is connected through a 30 dB attenuator to the A port of the Network Analyzer. The coupled port of the SBO directional coupler is connected through a 30 dB attenuator to the B port of the Network Analyzer. Phase is measured between the A and B ports. Power output is varied from 4 to 0.3W with the **CSB Power** control and measured on the CSB Power Meter. The maximum difference in phase is recorded.

6.5.17 test17: SBO Phase Change with Power Output Test

The connections are the same as test 16. Phase is measured between the A and B ports. Power output is varied from 0.3 to 0.03W with the **SBO Power** control and measured on the SBO Power Meter. The maximum difference in phase is recorded.

6.5.18 test18: Phase Change with Power Supply Voltage Change Test

The conditions of test17 are maintained and the phase measured as the 24 VDC supply voltage is stepped from 28 to 22 volts in one volt increments. The maximum difference in phase is recorded.

6.5.19 test19: SBO to CSB Absolute Phase Test (optional, operates singly)

The connections are the same as test 16. The R port of the Network Analyzer is connected to the sample port of the ITA RF amplifier. Phase is measured between the CSB directional coupler coupled port and the sample port of the ITA RF amplifier. The cables to the CSB and SBO outputs are reversed and a second phase reading is taken. The difference in phase is calculated.

6.5.20 test20: CSB Forward Power Detector Calibration Adjustment Test

The connections are the same as test 16. CSB power is set for 3W with ITA **CSB Power** control. CSB forward power detector output at J4-24 is read on the DMM and UUT R38 is adjusted for 4.00VDC.

6.5.21 test21: CSB Forward Power Detector Test Point Output Test

Conditions for test20 are maintained except the DMM is used to read output at J4-23.

6.5.22 test22: CSB Reverse Power Detector Calibration Adjustment Test

The connections are the same as test 16. CSB reverse power detector output at J4-22 is read on the DMM and UUT R34 is adjusted for 2.5VDC.

6.5.23 test23: CSB Reverse Power Detector Directivity Test

Conditions for test22 are maintained except the 2:1 VSWR load is replaced with a 10Watt 50 Ohm load with >36 dB return loss. The detector output at J4-22 is read on the DMM.

6.5.24 test24: SBO Forward Power Detector Calibration Adjustment Test

The connections are the same as test 16. SBO forward power detector output at J4-15 is read on the DMM and UUT R75 is adjusted for 1.9VDC.

6.5.25 test25: SBO Forward Power Detector Test Point Output Test

Conditions for test24 are maintained except the DMM is used to read output at J4-23.

6.5.26 test26: SBO Reverse Power Detector Calibration Adjustment Test

Conditions for test24 are maintained except that the SBO output of the UUT is connected to a 2:1 VSWR load. SBO reverse power detector output at J4-17 is read on the DMM and UUT R96 is adjusted for 0.64VDC.

6.5.27 test27: SBO Reverse Power Detector Test Point Output Test

Conditions for test26 are maintained except the DMM is used to read output at J4-19.

6.5.28 test28: SBO Reverse Power Detector Directivity Test

Conditions for test27 are maintained except the 2:1 VSWR load is replaced with a 50 Ohm 10 W. load with >36 dB return loss. The detector output at J4-19 is read on the DMM.

6.5.29 test29: SBO Modulation Waveform at 28VDC Test

A drive signal at 332 MHz from the Network Analyzer is applied to the ITA RF amplifier to produce +17 dBm at J1 of the UUT. The CSB output of the UUT is connected through the CSB directional coupler and through a 30dB 500W attenuator to the CSB Power meter. The SBO output of the UUT is connected through the SBO directional coupler and through a 30dB 20W attenuator to the SBO Power meter. A 150 Hz sine wave signal from the Audio Analyzer is applied to the audio input of the ITA. The ITA modulates the control lines to the UUT with the audio signal. The 24V power supply is adjusted to 28VDC and the ITA SBO power control is set for 3W. The detected waveform at UUT J1-16 is observed for clipping, distortion or spurious signals on the oscilloscope.

6.5.30 test30: SBO Modulation Waveform at 22VDC Test

The conditions of test29 are repeated with the ITA power supply adjusted to 22VDC.

6.5.31 test31: CSB Modulation Waveform at 22VDC Test

A drive signal at 332 MHz from the Network Analyzer is applied to the ITA RF amplifier to produce +17 dBm at J1 of the UUT. The CSB output of the UUT is connected through the CSB directional coupler and through a 30dB 500W attenuator to the CSB Power meter. The SBO output of the UUT is connected through the SBO directional coupler and through a 30dB 20W attenuator to the SBO Power meter. A 150 Hz sine wave signal from the Audio Analyzer is applied to the audio input of the ITA. The ITA modulates the control lines to the UUT with the audio signal. The 24V power supply is adjusted to 22VDC. Modulation percentage is measured on the Modulation Analyzer and the ITA CSB MOD % control is adjusted for 80%. The detected waveform at UUT J4-23 is observed for clipping, distortion, or spurious signals on the oscilloscope.

6.5.32 test32: CSB Modulation Waveform at 28VDC Test

The conditions of test31 are repeated with the 24V power supply adjusted to 28VDC.

6.5.33 test33: CSB Distortion Test at 332 MHz

Connections are like those in test31. Modulation percentage is measured on the Modulation Analyzer and ITA **CSB Mod%** control is set for 80%. The audio output of the Modulation analyzer is connected to the Audio analyzer input. Distortion is read on the Audio Analyzer.

6.5.34 test34: CSB Distortion Test at 328 MHz

Repeat of test 33.

6.5.35 test35: CSB Distortion Test at 336 MHz

Repeat of test 33.

6.5.36 test36: SBO Distortion Test at 332 MHz

Connections are like those in test33. The coupled ports of the directional couplers are connected to the ITA power combiner. The power combiner output is connected to the Modulation analyzer RF input. A 150 Hz sine wave signal from the Audio Analyzer is applied to the audio input of the ITA. The ITA modulates the SBO control line to the UUT with the audio signal. The ITA CSB Mod% control is set for 0. The 24V power supply is adjusted to 22VDC. The Modulation Analyzer detects the combined signal from the power combiner. The audio output of the Modulation analyzer is connected to the Audio analyzer input. The ITA **Phase** control is set for maximum modulation on the Modulation Analyzer and the ITA **CSB Power** control is set for about 60% modulation. Distortion is read on the Audio Analyzer.

6.5.37 test37: SBO Distortion Test at 328 MHz

Repeat of test 36.

6.5.38 test38: SBO Distortion Test at 336 MHz

Repeat of test 36.

6.5.39 test39: CSB Spectrum Test

Connections are like those in test33. The CSB Power is set for 3W with 80% modulation. The Spectrum Analyzer is connected to the coupled port of the CSB directional coupler. CSB spectrum is examined for spurious signals less than 60 dB below carrier using two different spans. The spans are 332 MHz +/- 1MHz & 332 MHz +/- 50MHz.

6.5.40 test40: SBO Spectrum Test

Connections are like those in test33 except that the coupled port of the SBO directional coupler is connected to the Spectrum Analyzer RF input. SBO output is set to 0.2 W and SBO spectrum is examined for spurious signals less than 60 dB below unmodulated CSB on the Spectrum Analyzer with the same spans as in test35.

6.6 TEST OPTION DESCRIPTIONS

This section contains brief descriptions of each of the tests that is available from the single test select menu but not performed in normal UUT semi-automatic testing.

6.6.1 xtest4: Current on UUT -15 Volt Line Test

The voltage drop across a 0.1 ohm resistor in series with the -15 V line is measured by the DMM and is converted into Amps.

6.6.2 xtest5: Current on UUT +15 Volt Line Test

The voltage drop across a 0.1 ohm resistor in series with the +15 V line is measured by the DMM and is converted into Amps.

6.6.3 xtest6: Current on UUT +24 Volt Line Test (+15 V off)

The voltage drop across a 0.01 ohm resistor in series with +24 V line is measured by the DMM and is converted into Amps.

6.6.4 xtest7: Current on UUT +24 Volt Line Test With Transistor Bias (+15 V on)

The voltage drop across a 0.01 ohm resistor in series with +24V line is measured by the DMM and is converted into Amps.

6.6.5 xtest36: CSB VSWR Alarm Not Active at 3:1 VSWR Test

A drive signal at 332 MHz from the Network Analyzer is applied to the ITA RF amplifier to produce +17 dBm at J1 of the UUT. The CSB output of the UUT is connected to a 3:1 VSWR load. The SBO output of the UUT is connected to a 30dB 20W attenuator. The **CSB Power** control on the ITA is set to command 5W by setting 5.6VDC at J4-11. Alarm status is observed on VSWR Alarm indicator of ITA. The LED should not be lit.

6.6.6 xtest37: CSB VSWR Alarm Active at High VSWR Test

Conditions of xtest 36 are maintained except the CSB Power control on the ITA is set to command 4W by setting 5.0 VDC at J4-11. The CSB output of the UUT is momentarily left open. The Alarm status is observed on VSWR Alarm indicator of ITA. The LED should be lit but may not be to full brilliance. Also forward power detector at J4-24 should read less than 5.0VDC.

6.6.7 xtest38: CSB Power Output Reduction By VSWR Alarm Test

This test is omitted for the Glide Slope because it doesn't always latch off.

6.6.8 xtest39: CSB Power Output After Reset of VSWR Alarm Test

Conditions of test 37 are maintained. The **Reset VSWR Alarm** switch is used to reset UUT. Power measured with Power Meter should be back to normal 4W. The UUT may or may not need a reset to get back to normal power.

6.6.9 xtest40: SBO VSWR Alarm Not Active at 3:1 VSWR Test

A drive signal at 332 MHz from the Network Analyzer is applied to the ITA RF amplifier to produce +17 dBm at J1 of the UUT. The SBO output of the UUT is connected to a 3:1 VSWR load. The CSB output of the UUT is connected to a 30dB 500W attenuator. The **SBO Power** control on the ITA is set to command 0.5W by setting 4.0VDC at J4-5. Alarm status is observed on VSWR Alarm indicator of ITA. The LED should not be lit.

Reset **SBO Power** control to command 1.25 Watts by setting 6.3VDC at J4-5.

6.6.10 xtest41: SBO VSWR Alarm Active at High VSWR Test

Conditions of xtest 40 are maintained except the SBO output of the UUT is momentarily left open. The Alarm status is observed on VSWR Alarm indicator of ITA. The LED should be lit.

6.6.11 xtest42: SBO Power Output Reduction By VSWR Alarm Test

This test is omitted for the Glide Slope because it doesn't always latch off.

6.6.12 xtest43: SBO Power Output After Reset of VSWR Alarm Test

Conditions of xtest 41 are maintained. The **Reset VSWR Alarm** switch resets UUT. Power measured with Power Meter should be back to normal 1.25W. (The UUT may or may not need a reset to get back to normal power.