RM Italy HLA-305V HF Amplifier Test Report

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Figure 1: HLA-305V HF Amplifier, with cooling fans.

Introduction: This report describes a comprehensive test suite performed on an HLA-305V HF amplifier manufactured by RM Italy. Test descriptions and results obtained will be presented. The tests were conducted in my home RF lab, April 15 – 19, 2015.

A: Test Plan.

1. Swept small-signal gain, +10 dBm drive power, 2 - 30 MHz.

2. Swept input return loss, 50 ohms, 2 - 30 MHz.

3. Drive level, power gain and DC input current I_D on all HF amateur bands for rated 200W CW output and maximum CW output.

4. Noise floor & stability on all bands with input & output terminated in 50Ω (4a: Stability check with input & output unterminated).

5. 2-tone IMD 3^{rd} – 9^{th} order on 1.8, 3.6, 14.1 and 28.2 MHz at rated 200W PEP output.

6. Harmonic suppression to 8^{th} order on 3.6, 14, 21.2 and 28.2 MHz at maximum CW output.

7. Correct operation of protective circuits.

B: Test Equipment List.

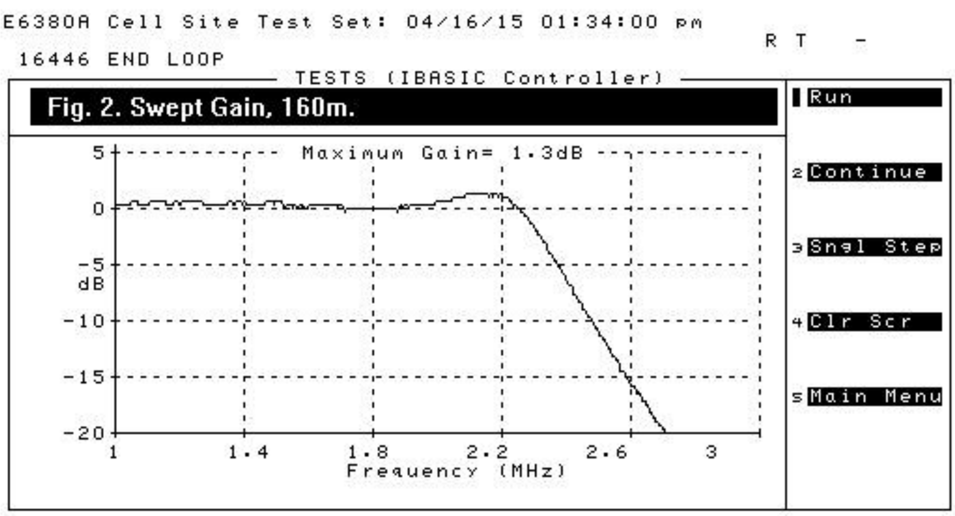
1. HP/Agilent 8935 Series E6380 Communications Test Set.
2. Amtronix SW2012N 0.5 – 1000 MHz Return Loss Bridge (RLB).
3. HP/Agilent 8563E Spectrum Analyzer.
4. HP/Agilent 437B Power Meter w/8481A Power Sensor.
5. Millivac MV-723B RF Millivoltmeter with probe.
6. Bird 43 RF Wattmeter w/25W HF element.
7. JFW 50FH-030-300 300W 30 dB Power Attenuator.
8. Weinschel 25W 20 dB Power Attenuator.
9. Other assorted fixed RF pads.
10. Icom IC-703+ HF/6m Transceiver (as exciter).
11. Fluke 365 AC/DC Clamp-on Meter.
12. Racal/Newmar 115-12-35CD 35A Power Supply.

C: Performance Tests on HLA-305V Amplifier, S/N 280714.

1. Swept small-signal gain, 0 or +10 dBm drive power, 2 - 30 MHz.

Test Procedure: On 8935, connect DUPLEX OUT via 6 dB pad to DUT TRX and DUT ANT via 6 + 15 dB pads to ANT IN. Run Swept Gain (in RFTOOLS menu) for the frequency ranges shown in Figures 2- 7, with +10 dBm output level and 5 dB max. gain. Set DUT bandswitch to each range in turn. -2 dBm on screen ≡ 15 dB gain. Key DUT (ground PTT line).

Test Results in Figures 2 – 7.



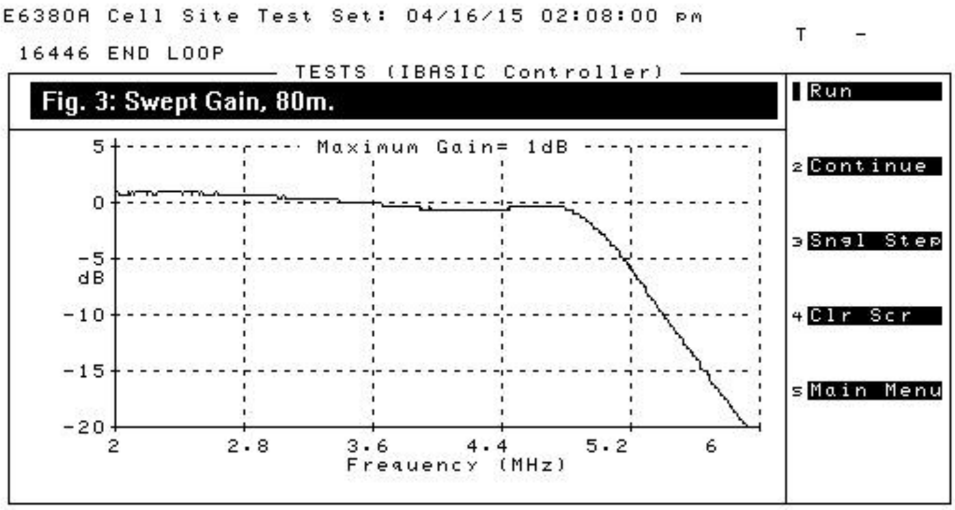


Fig. 3: Swept Gain, 80m.

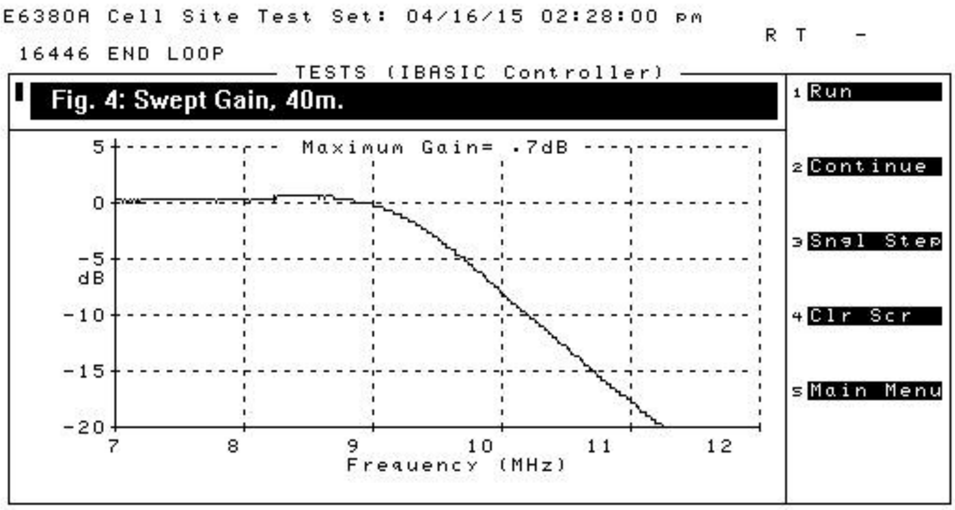


Fig. 4: Swept Gain, 40m.

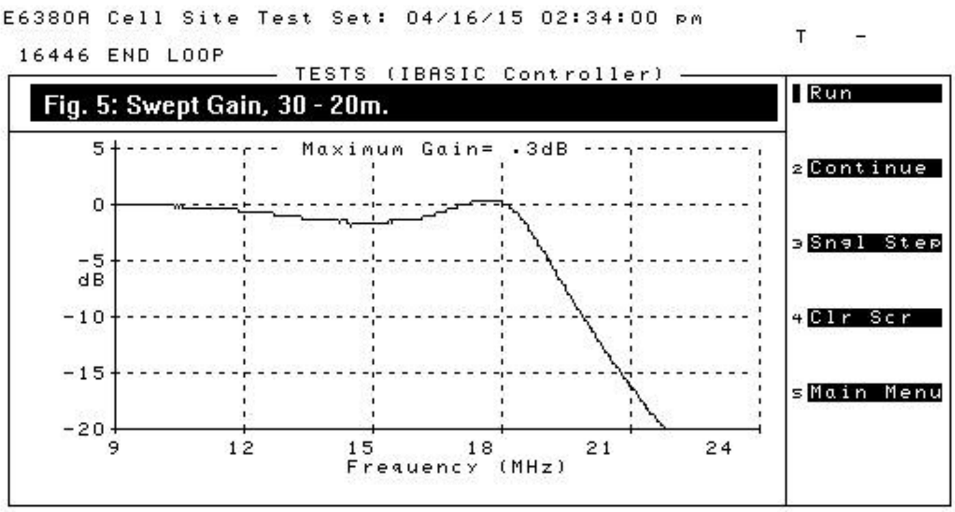


Fig. 5: Swept Gain, 30 - 20m.

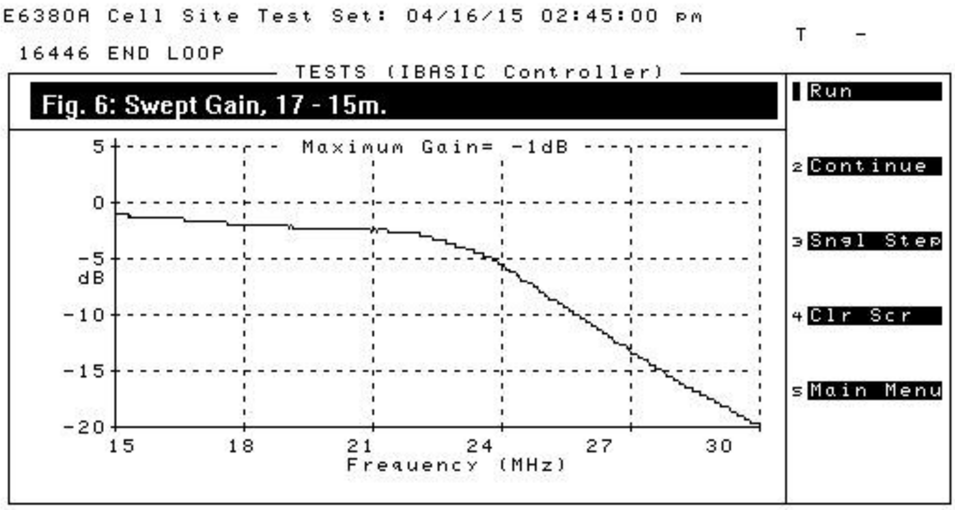


Fig. 6: Swept Gain, 17 - 15m.

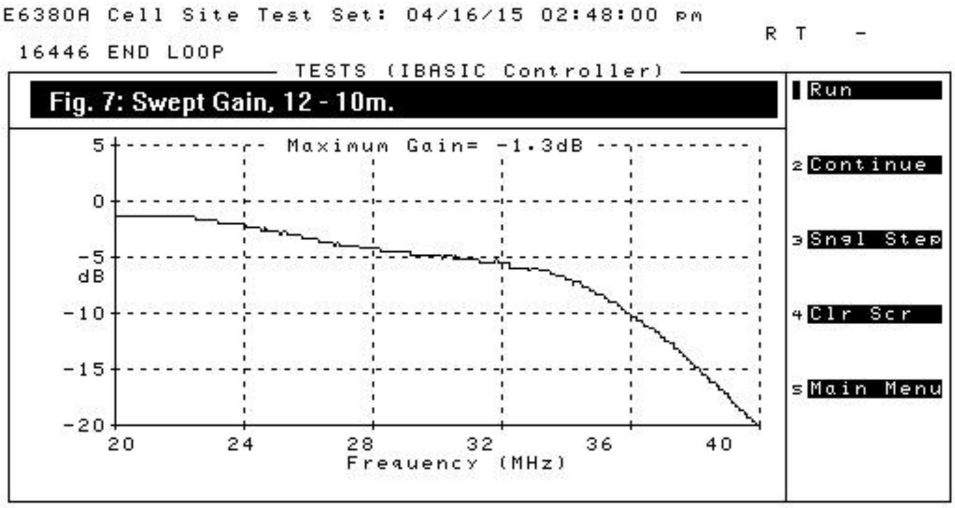


Fig. 7: Swept Gain, 12 - 10m.

2. Swept input return loss (RL), 2 - 30 MHz.
Test Procedure: On 8935, connect DUPLEX OUT via 6 dB pad to RLB IN and RLB OUT via 6 dB pad to ANT IN. Connect RLB DUT port to DUT TRX. Terminate DUT ANT in 50Ω. Run Swept Return Loss (in RFTOOLS menu) for 2 – 32 MHz range, with 0 dBm output level and 50 dB max. RL. Key DUT via PTT line. ***Test Results:*** Refer to Figure 8.

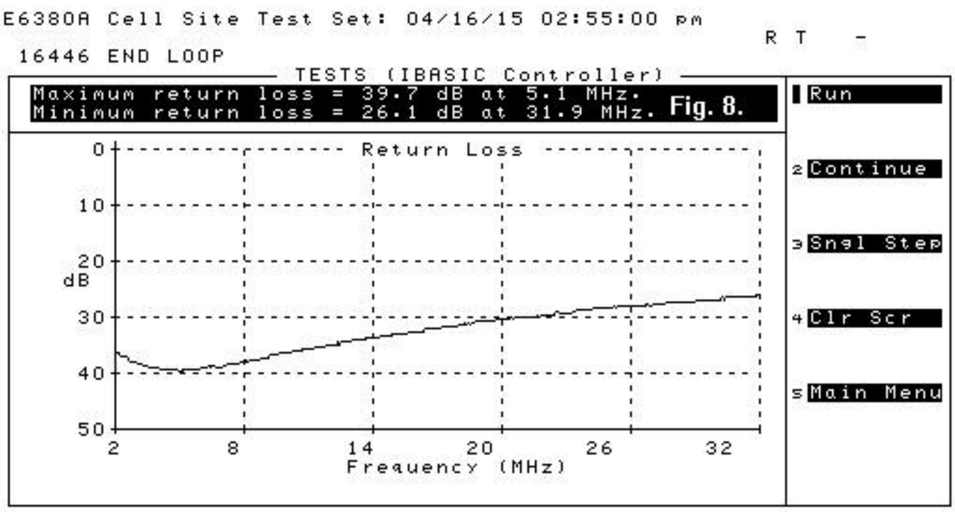


Fig. 8.

3. Drive level, power gain and ID on all HF amateur bands (200W & max. output)

Test Procedure: Connect IC-703+ (exciter) ANT socket via Bird 43 wattmeter to DUT TRX. Set IC-703 MODE to RTTY. Tune IC-703+ to each test frequency in turn. Using DUT SET button, enable VOX. Set DUT bandswitch to AUTO. Connect DUT ANT via 30 dB + 20 dB power attenuators + 10 dB pad to 8481A sensor of HP/Agilent 437B power meter. Configure 437B for +60 dB offset, "W" scale. Set DUT switches to SSB, HI, ON respectively. Key exciter in RTTY mode and adjust its output (drive level) for 200W output. At each test frequency, record DUT output on 437B, and DC input current I_D on Fluke 365 meter clamped around (+) power lead to DUT. Repeat test on all test frequencies with DUT centre switch set to LO. Repeat test with 10W drive, for maximum CW output.
Test Results: See Tables 1 and 2. Case temperature during test runs: 29 - 33°C.

Table 1: Drive, P_O, I_D and Power Gain for P_O = 200W CW

f MHz	Drive W	P_O W		I_D A		Efficiency %	
	for Po = 200W	HI	LO	HI	LO	HI	LO
1.9	2.2		125	29.1	19.1	51	48
3.6	2.5		116	26.4	18.7	56	46
7.1	2.8		110	22.9	17.7	66	46
10.1	3.0		115	21.9	16.7	68	51
14.1	4.5	200	125	28.4	21.7	52	43
18.1	4.5		118	25.0	19.3	59	45
21.2	5.0		122	25.4	19.5	58	46
24.9	5.0		123	25.9	19.7	57	46
28.2	7.5		130	33.2	25.9	45	37

Table 2: I_D, P_O and Power Gain for 10W Drive (Max. P_O)

f MHz	I_D A		P_O W		Pwr Gain dB	
	HI	LO	HI	LO	HI	LO
1.9	32.2	33.6	283	276	14.5	14.4
3.6	32.6	33.2	318	298	15	14.7
7.1	27.3	26.3	294	275	14.6	14.3
10.1	31.0	27.0	283	245	14.5	13.8
14.1	34.1	29.9	284	213	14.5	13.2
18.1	31.7	25.9	284	216	14.5	13.3
21.2	30.1	25.2	271	203	14.3	13.0
24.9	31.6	25.2	256	194	14.0	12.8
28.2	34.3	28.0	218	157	13.3	11.9

4. Noise floor & stability on all bands with input & output terminated in 50Ω.

Test Procedure: Terminate DUT RTX in 50Ω. Connect DUT ANT via 30 dB power attenuator to Millivac MV-723B probe. Carefully zero MV-723B. Set DUT bandswitch to each range in turn and key DUT via PTT line. MV-723B should not move off zero, even on lowest range (1 mV). Note I_{DQ} (standing current). Repeat test with DUT TRX unterminated.

Test Results: $I_{DQ} \approx 0.5$A. DUT is stable throughout test.

4a. Stability on all bands with input & output unterminated.

Test Procedure: Remove terminations from DUT TRX and ANT. Observe I_D on clamp-on meter. Key DUT via PTT line on each frequency range in turn. I_D should not increase above previously-measured I_{DQ} value.

Test Results: $I_{DQ} \approx 0.5$A. DUT is stable throughout test.

5. 2-tone IMD 3rd – 9th order on 1.8, 3.6, 14.1 and 28.2 MHz at rated PEP output.

Test Procedure: Connect IC-703+ (exciter) ANT socket via Bird 43 wattmeter to DUT TRX. Connect IC-703+ MOD IN (ACC Pin 11) to 8935 AUDIO OUT. Set 8935 AF GEN 1 to 700 Hz, AUDIO OUT, 50 mV. Set 8935 AF GEN 2 to 1.7 kHz, AUDIO OUT, 50 mV. Connect DUT ANT via attenuators to 8481D power sensor as per Test 3.

Tune IC-703+ to each test frequency in turn. Using DUT SET button, enable VOX. Set DUT bandswitch to AUTO. Set DUT switches to SSB, HI, ON respectively. Key exciter in RTTY mode and adjust its RF output (drive) for 200W CW output on each band in turn. Note vertical amplitude of CW output signal for each band.

Next, connect DUT ANT via 30 dB + 20 dB power attenuators + 10 dB pad to 8563E spectrum analyzer (FREQ = test frequency, SPAN 20 kHz, REF LVL -10 dB, RBW 100 Hz, VBW = 100 Hz.) Key exciter in USB (> 7 MHz) or LSB (< 7 MHz) mode, and adjust 8935AF GEN 1 & 2 levels for 2 equal tones 6 dB below CW level on each band in turn.

Test Results: See Figures 9 – 12 and Table 3.

Figure 9.

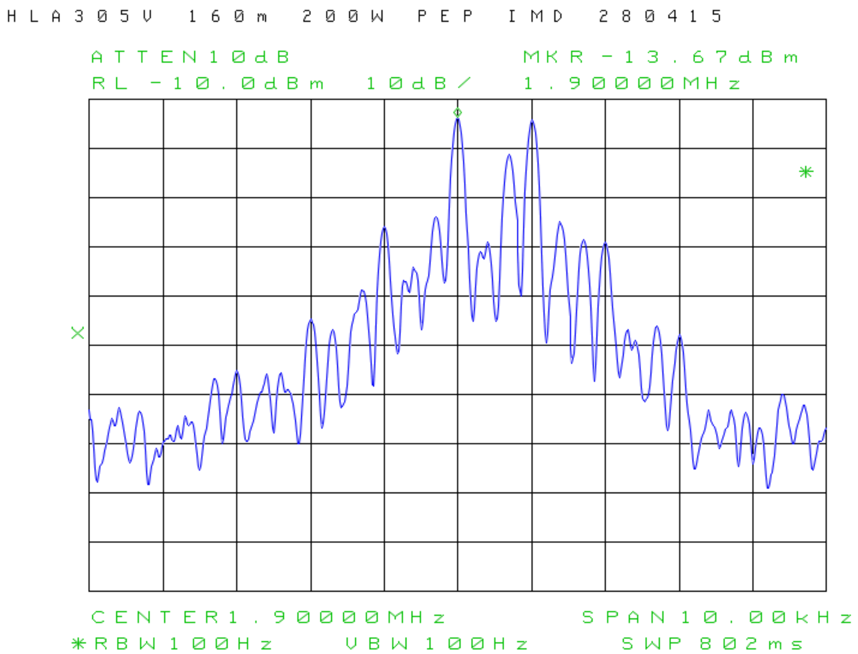


Figure 10.

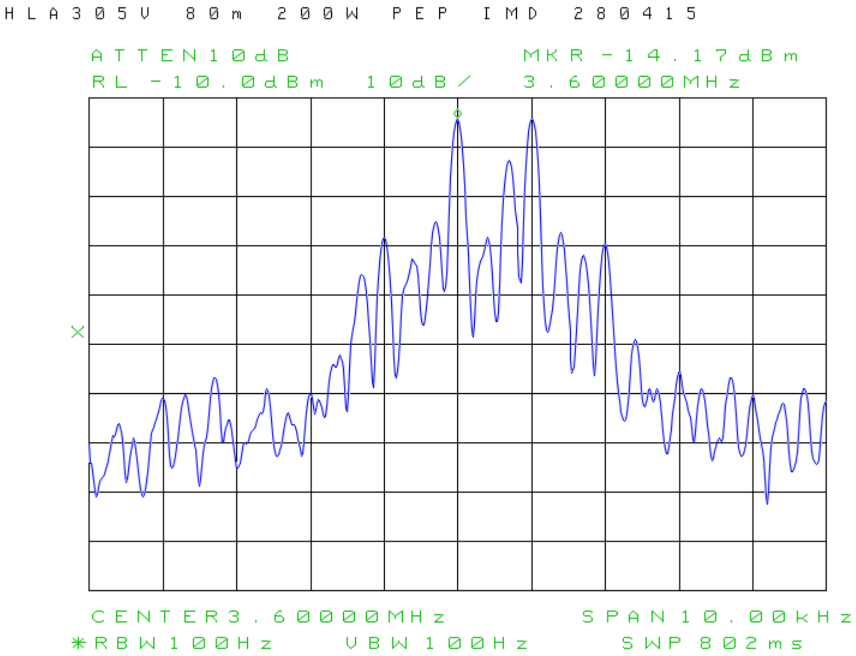


Figure 11.

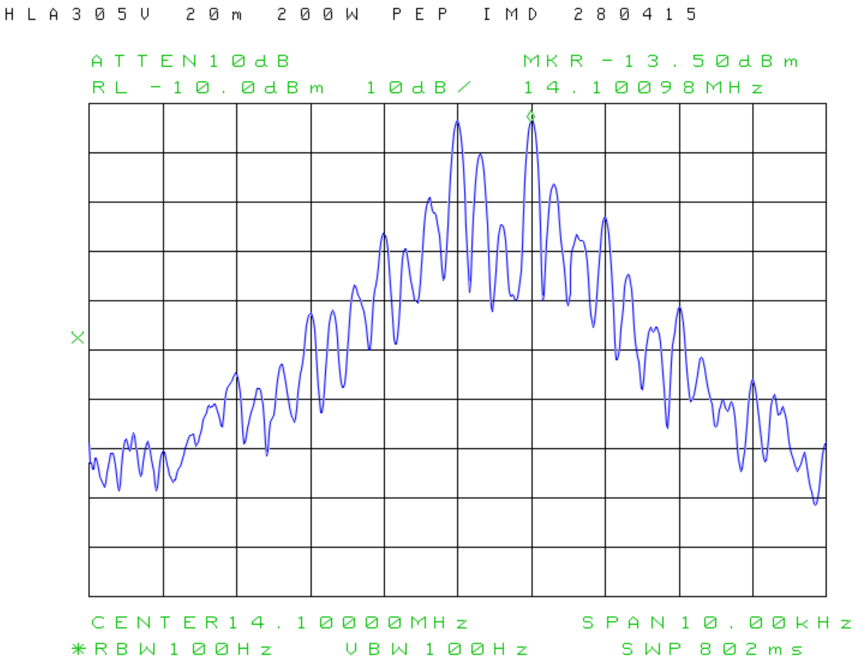


Figure 12.

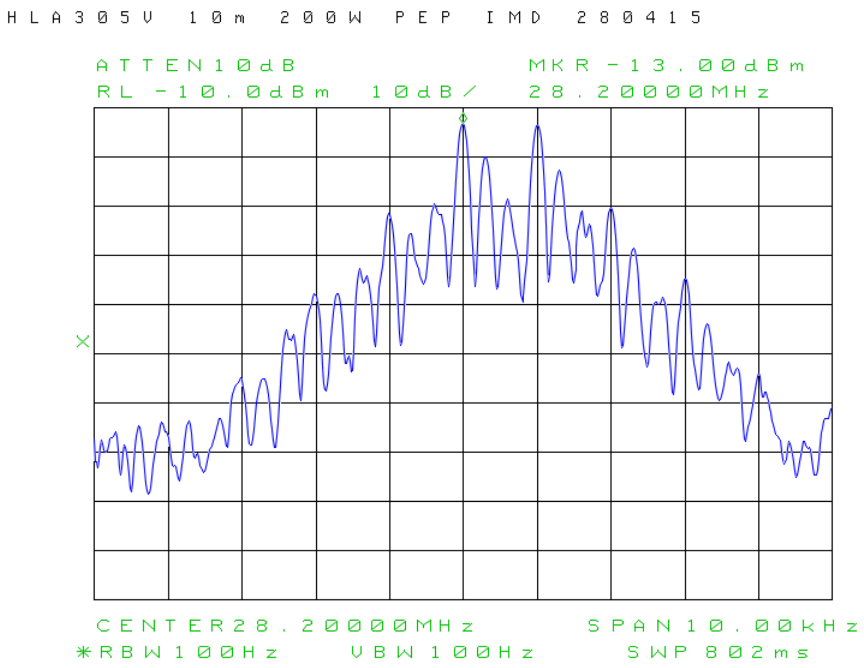
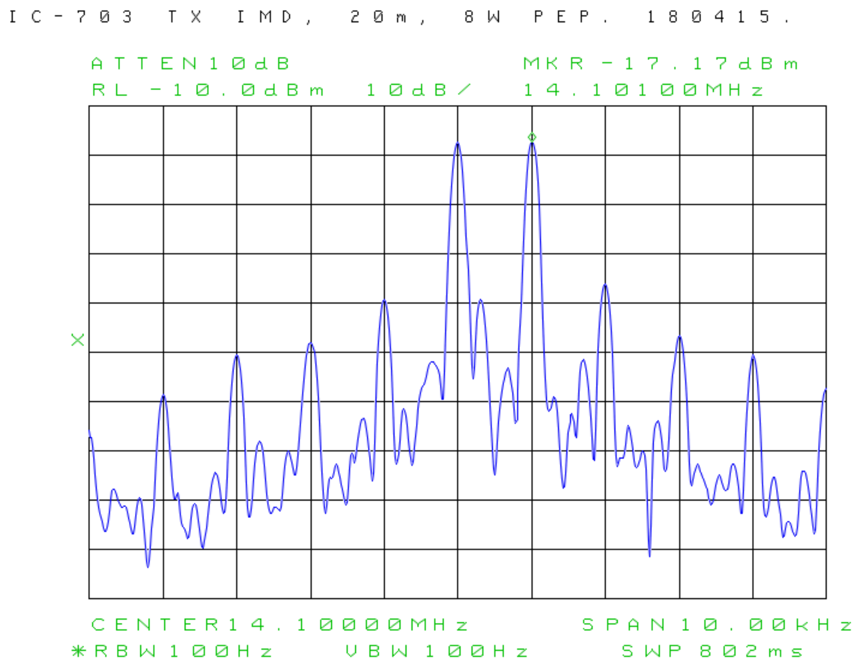


Table 3: IMD by band.

Band	IMD in dB relative to 2-tone PEP			
	IMD3	IMD5	IMD7	IMD9
160m	-31	-50	-67	-73
80m	-32	-60	-65	-63
20m	-29	-46	-59	-73
10m	-24	-40	-58	-67

Note: For reference purposes, the IC-703+ exciter's 2-tone IMD at 14.1 MHz was also measured. (See Figure 13.) Values obtained were: IMD3 = -38, IMD5 = -47, IMD7 = -49, IMD9 = -59 (dB relative to 2-tone PEP) at 8W output. At the drive levels required for 200W PEP output (except on 10m). it is felt that the IMD degradation due to the exciter should be negligible at a first approximation.

Figure 13.



6. Harmonic suppression to 8th order on 1.9, 3.6, 7.1, 14.1, 21.2 & 28.2 MHz at 250W CW output (200W on 10m).

Test Procedure: As per Test 7 above, except that exciter remains in RTTY mode and HP/Agilent 85672A spurious response utility is run on 8563 spectrum analyzer to measure harmonics on selected frequencies.
Test Results: Refer to Figures 14 – 19. Harmonic suppression is well within regulatory requirements.

Figure 14.

HLA305V Harmonics 160m 250W CW 170415

HARMONIC MEASUREMENT RESULTS

FUNDAMENTAL SIGNAL: 1.900 MHz
-16.7 dBm

HARMONIC	LEVEL dBc	FREQUENCY
2	-69.0	3.800 MHz
3	-69.8	5.700 MHz
4	-79.3 *	7.601 MHz
5	-72.7	9.501 MHz
6	-84.5	11.40 MHz
7	-74.0	13.30 MHz
8	-81.5	15.20 MHz

* MEASURED LEVEL MAY BE NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION= .1 %
(OF HARMONICS MEASURED)

Figure 15.

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HLA305V Harmonics 80m 250W CW 170415

HARMONIC MEASUREMENT RESULTS

FUNDAMENTAL SIGNAL: 3.600 MHz
                    -16.8 dBm

HARMONIC   LEVEL dBc   FREQUENCY
   2        -68.8       7.200 MHz
   3        -75.2      10.80 MHz
   4        -74.2      14.40 MHz
   5        -79.0*     18.00 MHz
   6        -98.8*     21.60 MHz
   7        -77.7      25.20 MHz
   8        -84.5      28.80 MHz

  *  MEASURED LEVEL MAY BE
     NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION=      0 %
 (OF HARMONICS MEASURED)
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Figure 16.

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HLA305V Harmonics 40m 250W CW 170415

HARMONIC MEASUREMENT RESULTS

FUNDAMENTAL SIGNAL: 7.100 MHz
                    -16.3 dBm

HARMONIC   LEVEL dBc   FREQUENCY
   2        -64.0      14.20 MHz
   3        -78.2      21.30 MHz
   4        -81.8      28.40 MHz
   5        -73.0      35.50 MHz
   6        -97.0*     42.60 MHz
   7        -77.7      49.70 MHz
   8        -97.0*     56.80 MHz

  *  MEASURED LEVEL MAY BE
     NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION=     .1 %
 (OF HARMONICS MEASURED)
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Figure 17.

HLA305V Harmonics 20m 250W CW 170415

HARMONIC MEASUREMENT RESULTS

FUNDAMENTAL SIGNAL: 14.10MHz
-16.0dBm

HARMONIC	LEVEL dBc	FREQUENCY
2	-71.5	28.20MHz
3	-78.8	42.30MHz
4	-82.8 *	56.40MHz
5	-89.3	70.50MHz
6	-95.5 *	84.60MHz
7	-90.2	98.70MHz
8	-96.5 *	112.8MHz

* MEASURED LEVEL MAY BE NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION= 0 %
(OF HARMONICS MEASURED)

Figure 18.

HLA305V Harmonics 15m 250W CW 170415

HARMONIC MEASUREMENT RESULTS

FUNDAMENTAL SIGNAL: 21.20MHz
-16.0dBm

HARMONIC	LEVEL dBc	FREQUENCY
2	-71.2 *	42.40MHz
3	-90.8 *	63.60MHz
4	-86.0	84.80MHz
5	-90.8	106.0MHz
6	-90.0	127.2MHz
7	-87.5	148.4MHz
8	-95.3 *	169.6MHz

* MEASURED LEVEL MAY BE NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION= 0 %
(OF HARMONICS MEASURED)

Figure 19.

HLA305V Harmonics 10m 200W CW 170415

HARMONIC MEASUREMENT RESULTS

FUNDAMENTAL SIGNAL: 28.20 MHz
-17.2 dBm

HARMONIC	LEVEL dBc	FREQUENCY
2	-74.5 *	56.40 MHz
3	-76.7	84.60 MHz
4	-88.8	112.8 MHz
5	-74.8	141.0 MHz
6	-85.2	169.2 MHz
7	-86.0	197.4 MHz
8	-92.3	225.6 MHz

* MEASURED LEVEL MAY BE NOISE OR LOST SIGNAL.

TOTAL HARMONIC DISTORTION = 0 %
(OF HARMONICS MEASURED)

7. Correct operation of protective circuits.

Test Procedure: The only protective feature tested here is the incorrect-band trip. Set the bandswitch manually to 30-20m, and then apply 8W drive on 3.6 MHz in RTTY mode. Observe that the DUT immediately goes into standby with 5 warning beeps, and that the red triangular ⚠ indicator lights steadily. Verify that cycling POWER switch off and on resets the trip.
Test Results: This feature operates correctly.

D: Comments.

1. The HLA-350V HF amplifier is easy to install and configure, and lends itself very well to mobile operation where it will typically be remote-mounted (e.g. in the trunk of a vehicle). The VOX mode is especially useful for remote operation.
2. The maximum power gain ≈ 14 dB falls within US FCC requirements, and allows use of a low-powered exciter. This is advantageous in installations where battery power is limited.
3. Although somewhat degraded on 10m, IMD performance is adequate for mobile and portable operation at 200W PEP output. The exciter's IMD products contribute in some measure to the overall system IMD, but one should note that in a "real-world" operating environment the amplifier will invariably be driven by a transceiver with IMD3 in the -35 dB range (relative to 2-tone PEP).
4. The HLA-350V's harmonic suppression is excellent.
5. Return loss ≥ 26 dB ensures that the amplifier will present a 1.1 or better VSWR to the exciter across the entire HF range. No tuner is required at the exciter output.
6. The HLA-350V appears to be unconditionally stable, and will not add noise to the transmitted signal.
7. The HLA-350V's generous heatsink cools the amplifier very well, even during key-down operation at full output when testing.
8. There is a boot-up delay of ≈ 4 sec. on power-up, with a beep at the end of the boot sequence indicating the ready state. This is normal.