APPLICATION		
DASH NO.	NEXT ASSY	USED ON
-001		940-0300
-001		940-0330
-001		940-0400

TITLE SHEET

INDEX

Typed signatures constitute approval. Actual signatures on file at Honeywell in Redmond WA.

CONTRACT NO.		PRECIOUS METAL INDICATOR CODE:	Honeywell International Inc. Redmond, Washington 98073-9701			Honeywell
------------------		NA				
DRAWN	J. Jones	1/26/04	**SPEC, FCC ACCEPTANCE REPORT FOR TPA-100A**			
CHECK	J. Spence	1/26/04				
ENGR	L. King	1/26/04				
MFG	.	.				
QA	.	.	SIZE	CAGE CODE	DWG NO.	REV.
APVD	.	.	A	97896	070-4700-001	B
APVD	.	.	SCALE: NONE		SHEET 1 OF 35	

REVISION STATUS OF SHEETS INDEX													
		ADDED SHEETS						ADDED SHEETS					
SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR	SHEET NUMBER	REV LTR		
1 - 28	-												
ALL	A												
ALL	B												

REVISIONS				
SH	REV	DESCRIPTION	DATE	APPROVED
1-29	-	Initial release per ER:735211 Reason:05 , Severity:10	01/27/04	
ALL	A	Direct update per ER 738347 Reason: 05, Severity: 10 Sheet 6, Corrected Emissions Designator from 40M0 V1D to 10M0 V1D Sheet 19, Added 4 and 6 MCU Images. Sheet 25, Corrected Occupied Bandwidth from < 40 MHz to < 20 MHz. Sheet 26, Corrected Requested Bandwidth from 40MHz to 20 MHz Also added text.	03/17/04	J. Spence M. Cooley L. King G. Childs D. Chace
ALL	B	Direct update per ER 738431 Reason: 05, Severity: 10 Sheet 26, Corrected frequency range from 6 GHz to 12 GHz also Added text : “An additional test was performed from 1 to 12 GHz narrow band only.” Sheet 26, Added 1 – 12 GHz narrowband settings. Sheet 27, Added “Radiated NarrowBand Vertical & Horizontal 1 – 12 GHz Sheet 32, Added IMAGE (Radiated NarrowBand Vertical 1 – 12 GHz) Sheet 33, Added IMAGE (Radiated NarrowBand Horizontal 1 – 12 GHz) Sheet 35, Added H.P Spectrum Analyzer to the equipment list.	03/19/04	J. Spence J. Jones L. King G. Childs D. Chace

Table of Contents

Product Description

The TPA-100 series is the latest addition to Honeywell's Traffic Alert and Collision Avoidance (TCAS) product line. The unit is designed to meet the RTCA DO-185A TCAS II requirements and the RTCA DO-160D environmental/EMI/HIRF requirements. Each unit described below will be certified to Technical Standard Order (TSO), C119b.

This TCAS product line includes both commercial and military 6MCU and 4MCU ARINC 600 processors. The commercial 6MCU unit, p/n 940-0300-001, is designed for installation on air transport category aircraft. The ARINC 600 6MCU size designation indicates the unit is approximately 6-7 inches wide, while a 4MCU unit is approximately 4-5 inches wide. The commercial 4MCU unit, p/n 940-0400-001, is intended to be installed on business and regional aircraft. The military version, p/n 940-0330-001, is designed for use on airlift/ tanker aircraft, commonly known as MILACAS-XR. Each part number described above is based on the same hardware design and platform. There is no difference in hardware configuration between these units. The difference between the 4 and 6MCU is simply external case packaging. The military unit uses the identical hardware as the commercial unit, the only difference is software functionality.

The mechanical design of the TPA-100A is based on revolutionary, yet fundamental concepts, which take advantage of today's technology. A Liquid Crystal Display (LCD) is located on the front cover of the processor. The LCD can display configuration, system and LRU health status and report fault isolation data. A PCMCIA card slot is also located on the front cover, which will enable software loading and recording of flight information. The TPA-100A can record up to 60 Traffic Alert (TAs) and 10 Resolution Advisories (RAs). The unit will operate on either 115 VAC or 28 VDC power and does not require external cooling.

Unit Under Test (UUT) Description

Unit Part Number	940-0300-001
Serial Numbers	00159, 00161 and 00162
Mod Status	1 through 6
Flight Software Load	65
ATP Software Load	18

Emission Designator

10M0V1D (Mixed PAM and DPSK from Mode S Transponder)
10M0K1D (Mode C Transponders)

Frequency Range

Transmitter:	1030 ± 0.01 Mhz
Receiver:	1090 ± 3.0 Mhz

Range of Operating Power

Each of 4 ports:	46.5 ± 2.0 dBm
	28.2 to 70.8 W
Total Power:	52.5 ± 2.0 dBm
	178 to 282 W

Maximum Power Rating

Total:	+54.5 dBm
Per Port:	+48.5 dBm

The maximum output power required is that specified for satisfactory operation by the FAA per DO-185A.

Maximum RF Output Power: 400 W

Transmitter DC Voltages and Currents

The following voltages and currents exist on the TCAS Transmitter Module:

Applicable Stage	Supply Voltage	Supply Current
Output Stage	+32VDC	15.0A
Driver Stage #2	+26VDC	0.400A
Driver Stage #1	+5V Pulse	0.030A

Please refer to the description of the TCAS Transmitter Modules and related circuits in TPA100A Theory of Operation section of this report.

Function of Active Devices

The following devices are used in the TPA-100A Transmitter:

Ref Symbol	Function	MFG P/N	Honeywell P/N
U5,U9,U11,U15	Amplifier	MSA-2643	322-1380-001
U253-256	Pre-driver	MHVIC910HR2	322-1373-001
Q3,Q4,Q9,Q10	Final Amp	BLA1011-200	341-0984-001

Circuit Diagrams

See Attachment 1.

Instruction Books

See Attachment 2.

Transmitter Alignment Procedure

There is no alignment procedure for the TPA-100A transmitter. Shown below is the test procedure.

TPA-100A Transmitter Test

1. Introduction
2. Test Panel Setup
2.1 Start panel
2.2 Select board number, or type in TX BOARD window.
2.3 Left mouse click in BITE TX3 window, select Current Monitor.
2.4 Drop down menu in DMM SELECT, select 36V supply.
2.5 Enable "TRIGGER", "TX_MOD", "TX_MD2", "TX_ON" signals by selecting buttons to left of each.
3. Continuity Test
Connect transmitter module 722-4432-002 to test fixture and attach all power and RF connections. (Refer to diagram in appendix for proper connections.)
3.1 Turn on +7V supply only.
3.2 Check the +7V supply for current limiting.
3.3 Check the Digital Attenuator bits for shorts:
Set attenuators for all channels to maximum atten using the "gang" setting, -31dB.
3.3.1 Load PLD
3.3.2 Monitor +7V supply for current limiting
3.4 Check the IQ DAQ bits for shorts:
3.4.1 Set all bits to DAQs by loading "128" in the the I and Q fields and "gang" all DAQs.
3.4.2 Load PLD
3.4.3 Monitor +7V supply for current limiting
4. Set Timing, Set Driver and Ouput Bias Levels:
4.1 Enable "TRIGGER", "TX_MOD", "TX_MD2", "TX_ON" signals by selecting buttons to left of each.
4.2 Go to OPERATE drop down menu, select SETUP, disable remaining two columns, go back to OPERATE.
4.3 Set timing column1 to 2US, column2 to 500NS, column3 to 800NS, column4 to 750NS, column5 to 2US
4.4 Adjust bias control for each driver and output stage, using slider or rocker switch to set proper bias.
4.5 Record bias current and bit setting for driver and output of each channel
Bias Control Procedure
1. Turn on external +7V and +36V power supplies
2. Enable TX_ON and TX_MOD by selecting buttons to left of each.
3. Disable all timing columns except column 6 (AM mod). Go to OPERATE drop down menu, select SETUP, disable remaining two columns, go back to OPERATE.
4. Set column 6 timing to 4 uS
5. OFF uS window: set period off time to 320 us
6. N FILTER window: reset filters to 4 samples.
7. Zero and null pulses: select RESET, NULL & SET DELTAS filters buttons.
8. In BIAS CONTROL REGISTER: Set each driver (DRVR) and each output (OUTP) stage one at a time.
9. Enable AUTO located in BIAS CONFG area.
10. Select LOAD FIFO then CONFIG/START
5. Timing Requirements
Use Crystal Detector with 20dB pad,
O'Scope settings: BW @ 20 Mhz, 500nS/ Div, 200mV/Div, Avg @ 16 samples
Measurement of risetime, falltime and pulse width:
Rise and fall time measured between 1dB and 20dB below peak power level.
Pulse width measured at 6dB below peak power level.
Spec: Risetime 50 – 100nsec, Fall time, 50 – 200nsec, Pulse Width, 750 – 850nsec
5.1 Set AGC-3dB, W/S att. -6dB Ch.1,3 &4
5.2 Set W/S -9dB Ch.2
5.3 Set pulse width to 800nS (“TX_MD2”)
5.4 Check rise, fall and pulse width
5.5 Set AGC-3dB, W/S att. -26dB Ch.1,3 &4
5.6 Set W/S -29dB Ch.2.
5.7 Set pulse width to 800nS.
5.8 Check rise, fall and pulse width
6. Power Out:

Spectrum analyzer settings: Freq. 1030 Mhz, Span 200 Mhz, Res. BW 3 Mhz, Swp 3.5s, + offset. Use spectrum analyzer to measure 2^{nd} harmonic.
Assure input to PPM/spectrum analyzer is padded, protected from high power. Use PPM to measure power out and Cal port power.
Cal Port measurements: From CAL CHANNEL window select CHANNEL (1,2,3 or 4) FORWARD

6.1 Set timing 6mS rep, 1uS width
6.2 Set phase to 0
6.3 Set AGC to 6dB Ch. 1,3 & 4
6.4 Set W/S attenuator to 0
6.5 Record data

TX Cal Reverse Path

Make sure RF is off and that all stages of the amplifer are biased off.
Test can be done using either a signal generator and spectrum analyzer or a VNA.

6.7 Using external generator, inject 0dBm CW power into the output of each channel and measure the output power at the TX_CAL output connector, J6. Use the tx control software to set the output to each channel return path.

Pulse Droop

Spec: -.5dB max

6.8 Set pulse width to 30uS.
6.9 Set AGC-3dB, W/S att. -6dB Ch.1,3 &4
6.10Set W/S -9dB Ch.2
6.11Check pulse droop, in dB, between 1uS and 29uS for each channel

7. Spectrum (ATCRBS)

Measure each channel alone, with all other channels off.

7.1 Set AGC to 3 dB channels 1,3 &4.
7.2 W/S att. to 3 dB channels 1,3 &4.
7.3 W/S att. to 3 dB channel 2.
7.4 Set up spectrum analyzer as follows: Freq: 1030 Mhz, Span 200 Mhz, Res BW 3 Mhz
7.5 Take peak marker reading, set delta marker.
7.6 Set spectrum analyzer lower freq to 970 Mhz, upper freq to 990 Mhz and Res BW to 100 Khz.
7.7 Take reading at 970 Mhz delta marker and 990 Mhz delta marker.
7.8 Set spectrum analyzer lower freq to 1070 Mhz, upper freq to 1090 Mhz and Res BW to 100 Khz.
7.9 Take reading at 1070 Mhz delta marker and 1090 delta marker.

8. Relative Phase, Each Ch

Each channel measured alone.
Use AD 8302 phase detector.

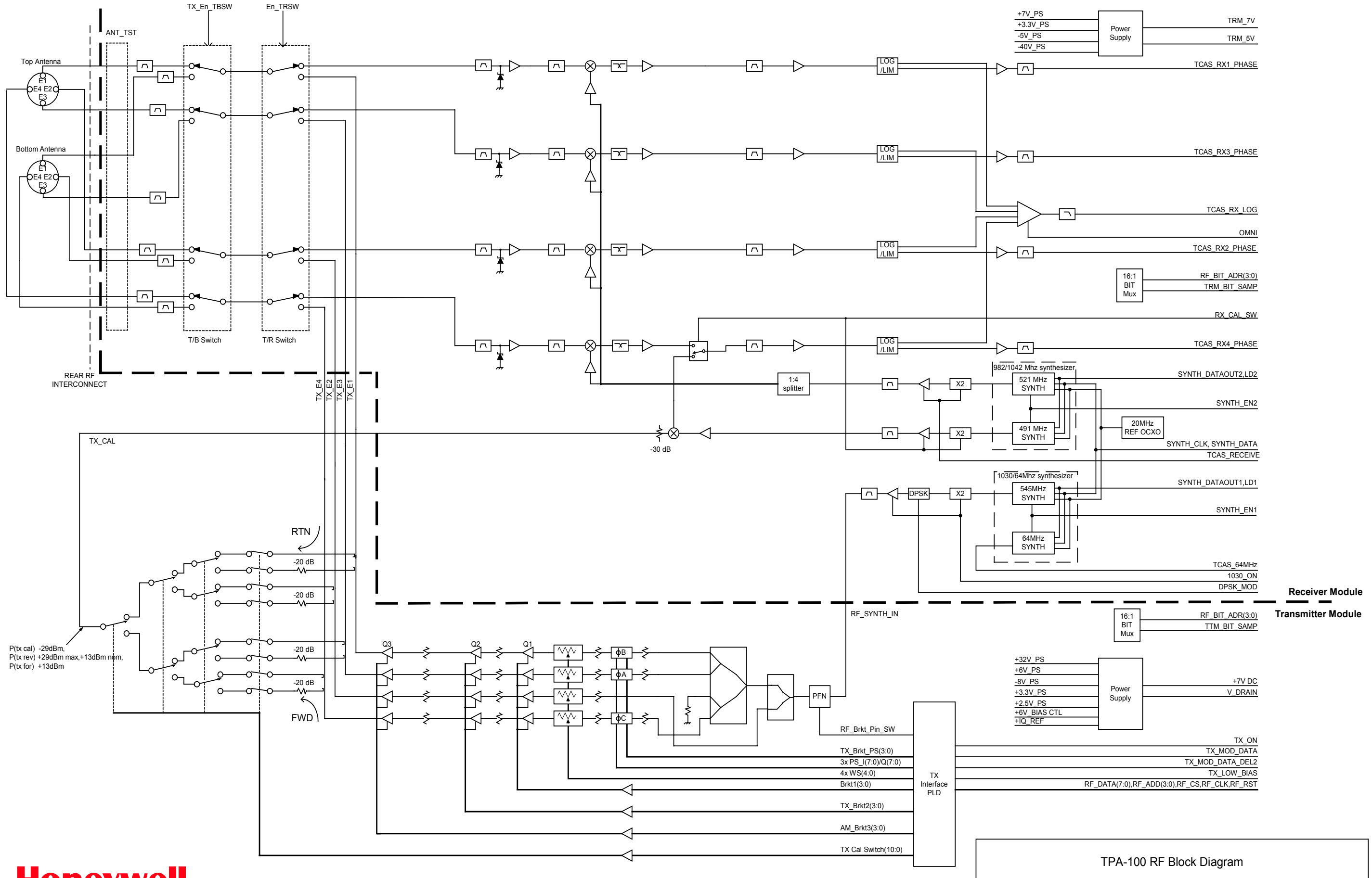
8.1 Set AGC to -3dB Ch. 1, 3 & 4
8.2 Set W/S att. to -6 Ch. 1,3 & 4 .
8.3 Ch.2 set to -9dB
8.4 Record voltage setting of phase detector output from scope.

9. Relative Phase, All Chs Coupling to Ch 2

Gang IQ so channels 1,3 &4 change together.

9.1 Set AGC to -3dB Ch. 1, 3 & 4
9.2 Set W/S att. to -6 Ch. 1,3 & 4
9.3 Ch.2 set to -9dB.
9.4 Measure Pout for Ch.2 for phase shift of Ch. 1,3 & 4

TPA-100A RF Theory of Operation



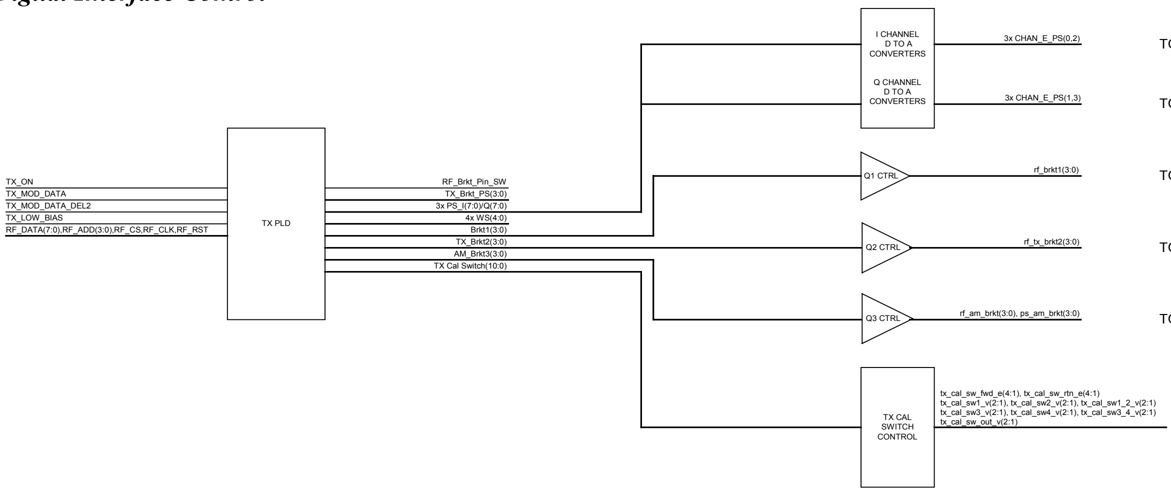
TPA-100 RF Block Diagram

Transmitter Assembly

The transmitter consists of the following primary sub circuits:

- Digital interface control
- RF modulator / pulse forming network
- Four power amplifier channels
- RF amplifier bias control
- Integrated phase shifters
- Integrated Whisper/Shout attenuators
- Transmitter calibration

Digital Interface Control



The digital interface control consists of a programmable logic device (PLD), three sets of 8-bit digital to analog converters (DACs), three sets of bias drivers and four quad analog switches.

The PLD contains one-time programmable logic gates configured to drive the phase shifters, digital attenuators, RF power amplifier gates, RF modulation signals and transmitter calibration switches. The PLD inputs are the timing brackets which drive the RF power amplifier gates, 4 address lines, 8 data lines and chip select, clock and reset lines. The output levels of the PLD are 3.3V TTL.

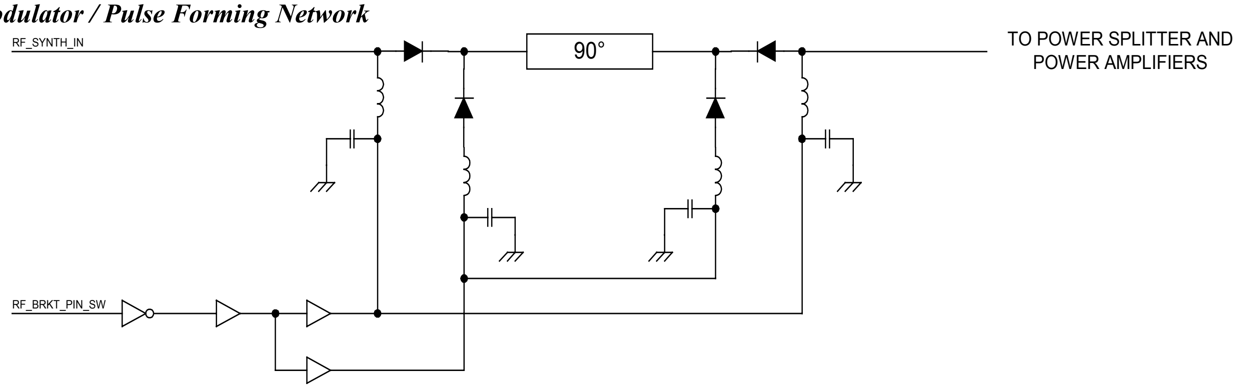
RF channels 1, 3 and 4 contain phase shifters. Channel 2 is the reference channel and does not use a phase shifter. Three pairs of 8-bit DACs control the three RF phase shifters. Each 8-bit DAC controls an I channel or a Q channel of the associated phase shifter.

Each DAC takes a TTL input from the PLD and outputs an analog level to the associated phase shifter in the RF channel.

Bias drivers which take TTL signals from the PLD control the timing of each of the three stages of the power amplifier channels. A current source controls stage 1. A bias control circuit controls the voltage levels at the gates of stages 2 and 3.

The transmitter calibration circuit consists of a network of Monolithic Microwave Integrated Circuit (MMIC) switches controlled using four quad analog switches. The PLD controls the analog switches using a logic map to switch the selected RF path to the calibration output connector.

RF Modulator / Pulse Forming Network

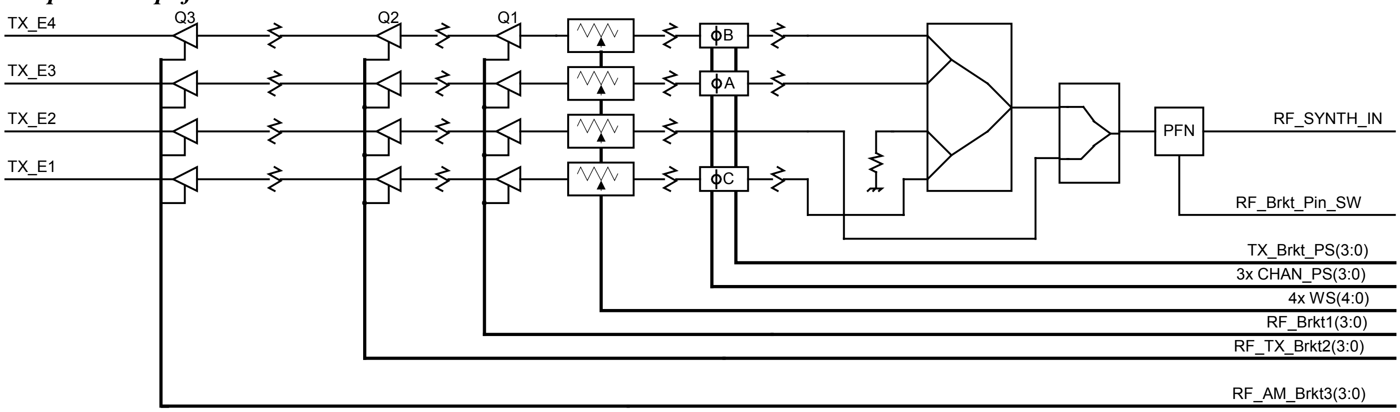


The pulse forming network (PFN) directly modulates the RF signal generated from the receiver assembly.

The PLD drives a TTL signal to an inverter gate at RF_BRKT_PIN_SW. The inverter gate shifts the voltage level into the PFN and drives the control amplifiers. The control amplifiers drive the PIN diodes of the RF circuit and modulate the RF signal received at RF_SYNTH_IN. The PIN diodes in the RF circuit attenuate or pass the RF signal as they are activated by the control amplifiers.

The 90 degree phase shift, comprised of lumped components, increases the attenuating capability of the RF circuit.

Four power amplifier channels



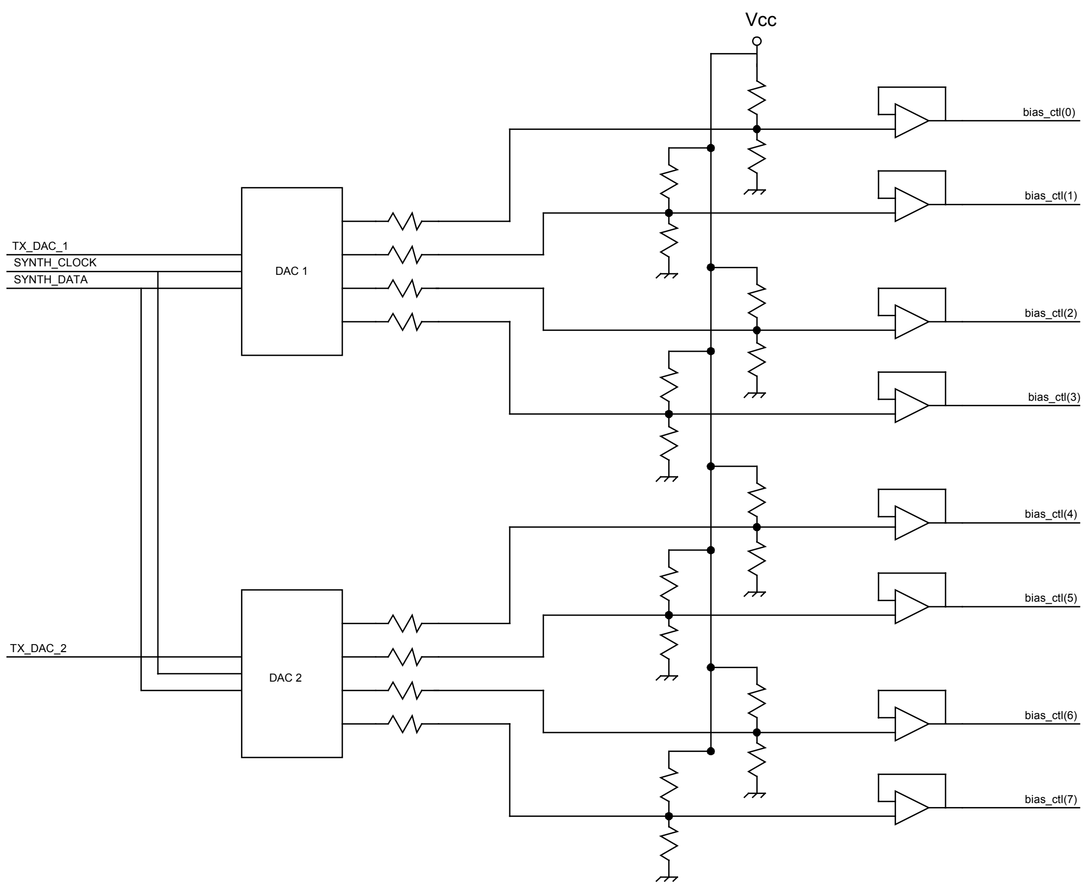
The four power amplifiers comprise 3 stages. Each stage is gated on during the transmit cycle.

The first stage uses a MMIC gain block capable of delivering +9 dbm.

The second stage is a commercial IC which is made up of 3 stages. It is capable of delivering 10 watts of power. The gain is controlled by adjusting the level of each gate voltage driven separately by rf_tx_brkt2(0), rf_tx_brkt2(1), rf_tx_brkt2(2), and rf_tx_brkt2(3) . The gain is adjusted to compensate for temperature variation of the chain. The drain voltage is set to 26 volts.

The output stage is an LDMOS device capable of delivering 200 watts. The gate voltage is adjusted for a drain current of 1.8 amp when no rf signal is present. The gate voltages are independently controlled with rf_am_brkt3(0), rf_am_brkt3(1) , rf_am_brkt3(2), and rf_am_brkt3(3). The drain voltage is set to 32 volts using 4 linear voltage regulators

RF amplifier bias control



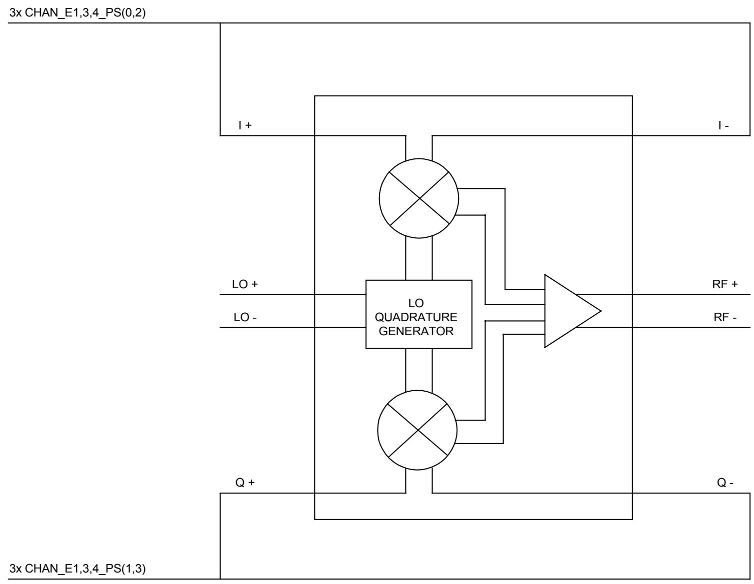
The peak current of the stage 1 IC is set to 27ma using feedback amplifiers Q13, Q14, Q15, and Q16.

The gate signal timing pulses tx_brkt2(0), tx_brkt2(1), tx_brkt2(2), tx_brkt2(3) going to the 2nd stage amplifier MHVIC910HR2 are ac coupled to prevent excessive duration of the transmitted pulse. The level of each gate signal bias_ctl(0), bias_ctl(2), bias_ctl(4), bias_ctl(6) is adjusted by measuring the drain current in each IC. The current is measured by measuring the voltage across R468 (1 ohm). This voltage is proportional to the 26 volt power supply going to the power amplifier.

The gate bias to the output stage is adjusted to control the drain current. The power supply voltage to the MOSFET driver is adjusted to control the 4 gate bias lines (bias_ctl(1), bias_ctl(3), bias_ctl(5), bias_ctl(7)) . The gate bias is ac coupled to prevent CW transmission in the case of a digital fault. The drain current is measured by measuring the voltage across 1 ohm resistor, R468.

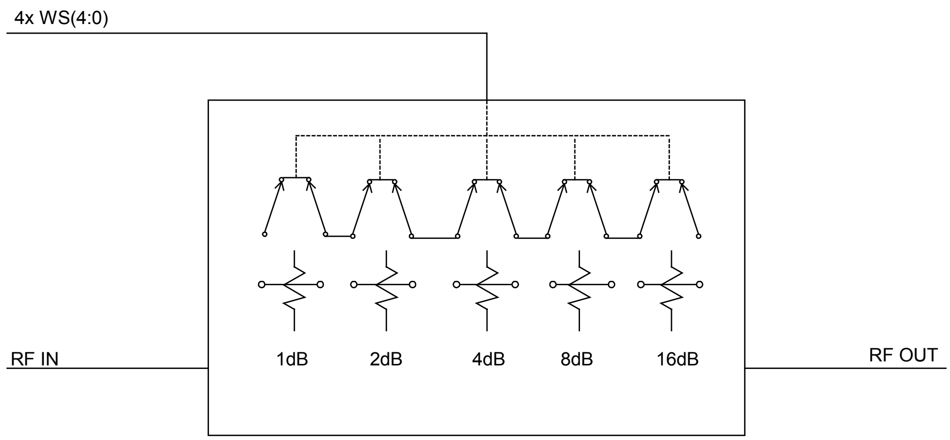
Software turns on each stage individually to make current measurements.

Integrated phase shifters



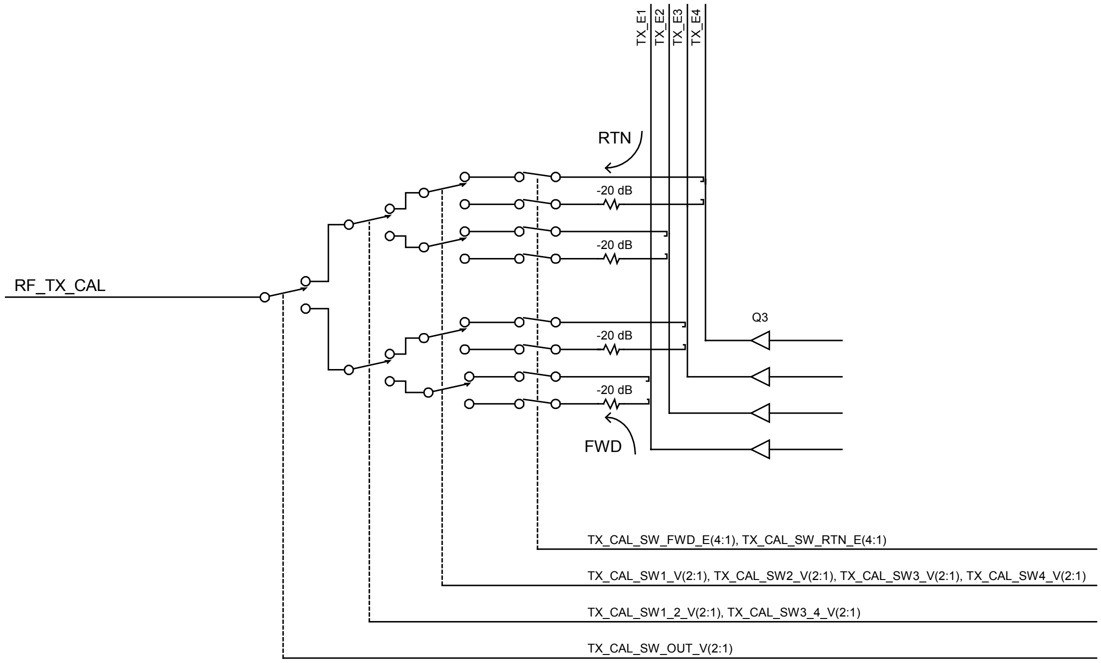
The 3 phase shifters use I/Q modulators to adjust the phase. The Q and I input level are differential signalscoming from 8 bit DACs. The I and Q input signals also adjust the gain by up to 6 db. They are labeled chan_e1_ps(3:0) ,chan_e3_ps(3:0), chan_e4_ps(3:0). The phase shifters are turned on only during the transmit cycle by TTL signals rf_tx_brkt_ps(0), rf_tx_brkt_ps(2), and rf_tx_brkt_ps(3).

Integrated Whisper/Shout attenuators



Each of the four power amplifier channels uses a whisper/shout attenuator. The whisper/shout attenuators use a commercial MMIC which is a 5-bit digital attenuator with integral TTL driver. The PLD directly controls the whisper/shout attenuator for each channel independently through signals WS_E1(4:0), WS_E2(4:0), WS_E3(4:0) and WS_E4(4:0). The attenuation step size is 1dB and provides 31dB of total attenuation range.

Transmitter calibration



The transmitter calibration network consists of four printed couplers and three sets of MMIC switches.

At the output of each of the four power amplifier channels there is a printed coupler used to sample the RF power level at the output of the transmitter. The forward arm of each coupler contains a 20dB attenuator to protect the MMIC switches in the calibration network.

The first set of MMIC switches are single pole – single throw and switch either the forward or return arm of the printed coupler into the calibration network. These are controlled using the TX_CAL_SW_FWD_E(4:1) and TX_CAL_SW_RTN_E(4:1) signals.

The second set of MMIC switches selects the channel which is to be calibrated. These are controlled using the TX_CAL_SW1_V(2:1), TX_CAL_SW2_V(2:1), TX_CAL_SW3_V(2:1) and TX_CAL_SW4_V(2:1) signals.

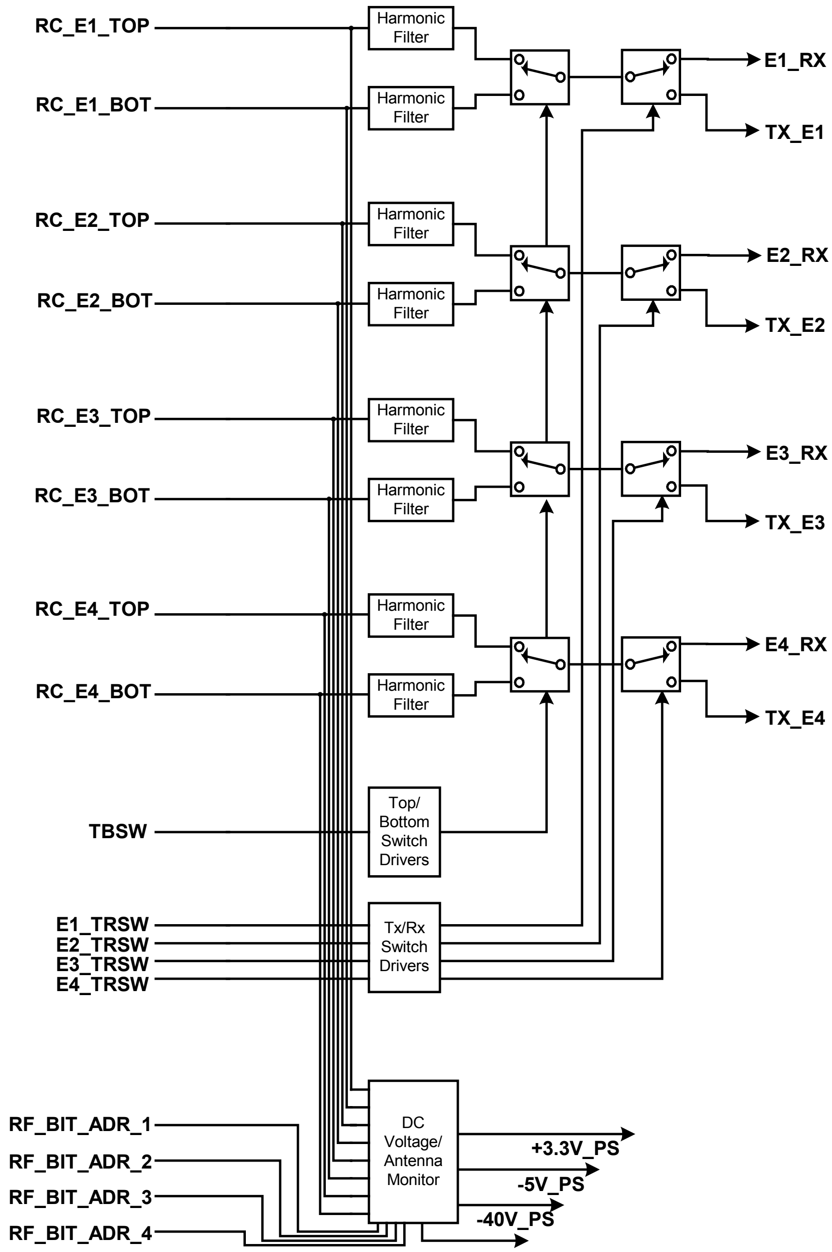
The third set of MMIC switches connects the selected channel to the output connector. These are controlled using the TX_CAL_SW1_2_V(2:1) and TX_CAL_SW3_4_V(2:1) and TX_CAL_SW_OUT_V(2:1) signals.

Receiver Assembly

The receiver consists of the following primary sub circuits.

- RF Switch
- Low Noise Amplifiers (LNA)
- Intermediate Frequency (I-F)
- Synthesizer

RF Switch



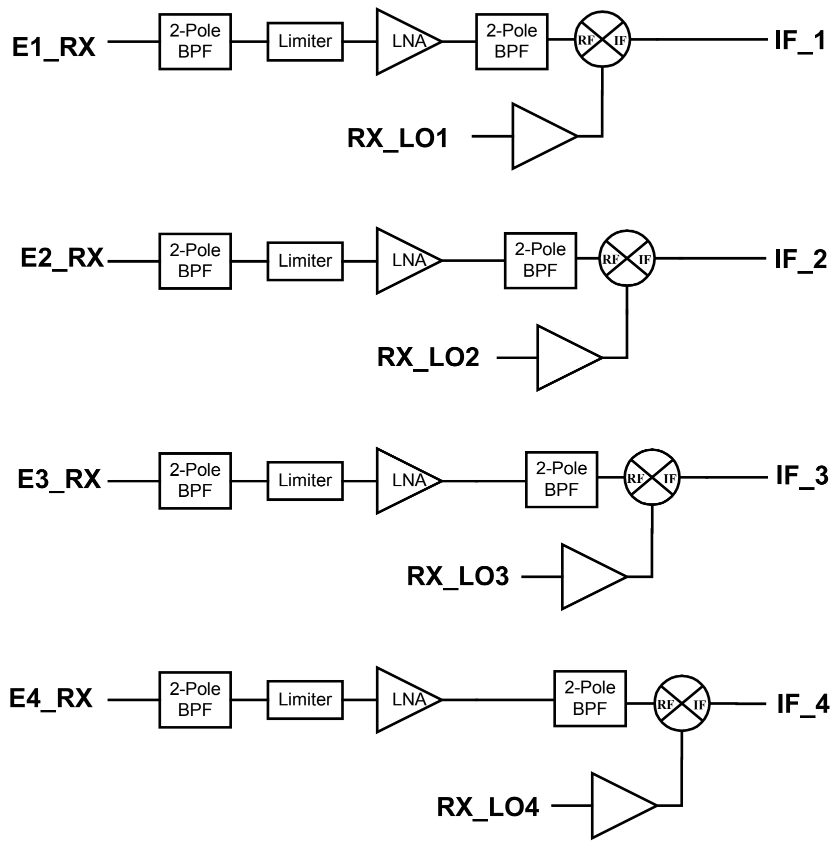
The rf switch section contains the top/bottom antenna switch, transmit/receive switch, top/bottom switch drivers, and transmit/receive switch drivers. The block diagram for this section is presented in Figure 1. The rf switch's consists of an arrangement of one-quarter wavelength microstrips with pin diodes that provide multiple rf pathways. The top/bottom switch has common control for the four channels and the transmit/receive switch has individual control for each channel. Each of the eight inputs has a harmonic filter before the rf switches.

The rf switching elements are controlled individually by four power MOSFET drivers and are controlled by the logic signals TBSW, E1_TRSW, E2_TRSW, E3_TRSW, and E4_TRSW. Switching time is 400 nano seconds, or less.

The top/bottom switch provides 20 dB minimum isolation between elements. The transmit/receive switch provides 20 dB minimum isolation between paths.

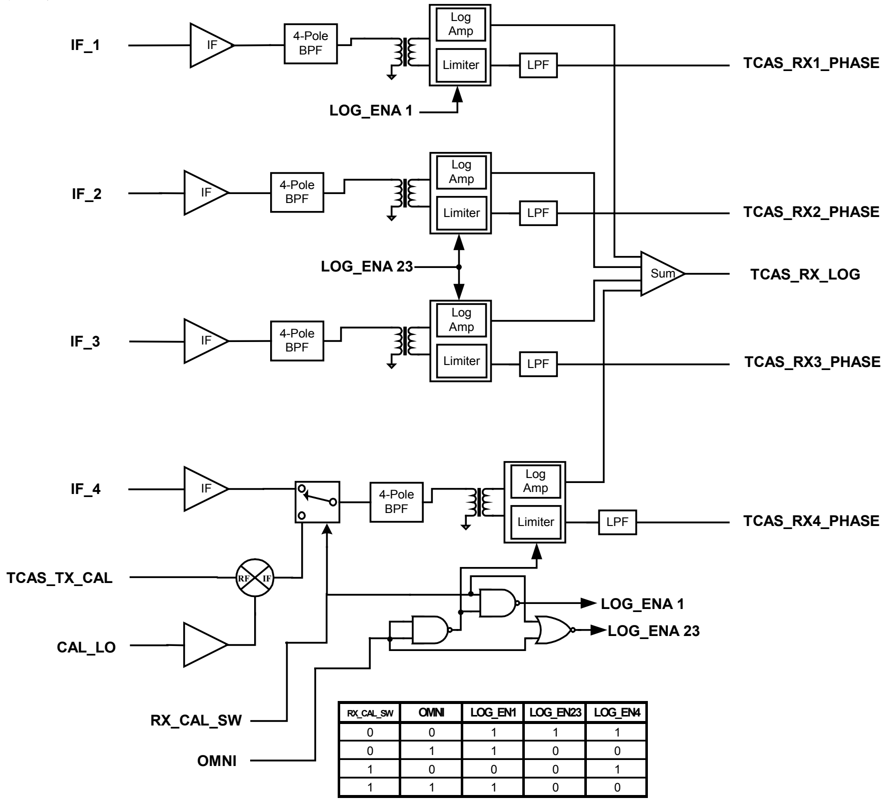
E1_RX through E4_RX are then routed to the LNA section of the receiver board. TX_E1 through TX_E4 are each routed to a connector that sends the signal directly to the transmitter module.

Low Noise Amplifier (LNA)



The low noise amplifier section is shown in Figure 2. This section includes low noise amplifier and 1090 MHz bandpass filtering for the input rf signals for the four receiver channels. This section rejects image frequencies and any other noise outside the selected band. The low-leveled received signals in each receiver channel are filtered, high-Q ceramic 2-pole BPF, boosted to a higher level by the LNA, and further filtered by another identical ceramic filter. A diode limiter circuit is used after the first ceramic filter for protection from high input power. The 1090 MHz received signal is mixed with the 1042 MHz RX_LO (1-4) to produce the 48 MHz intermediate frequency (i-f) output for each channel that is sent to the i-f section. Each 1042 MHz RX_LO signal is applied to a rf gain block amplifier to apply proper signal strength for the mixers.

Intermediate Frequency (I-F)

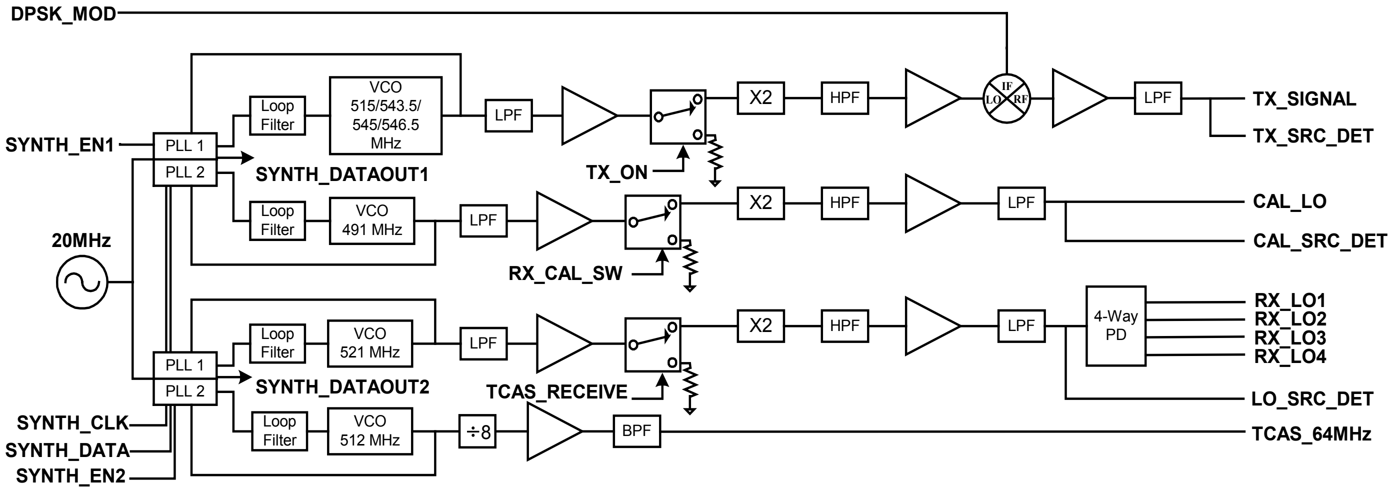


RX_CAL_SW	OMNI	LOG_EN1	LOG_EN23	LOG_EN4
0	0	1	1	1
0	1	1	0	0
1	0	0	0	1
1	1	1	0	0

The intermediate frequency (i-f) section, shown in block diagram form in Figure 3, provides addition stage of amplification for each of the four receiver channels, provides additional filtering for the 48MHz i-f signals, and divides each channel into limited video to the digital module, and a summed log signal to the digital module.

The i-f inputs from the LNA section (IF_1, IF_2, IF_3, and IF_4), that are received replies from the antenna are each amplified and filtered through a 4-pole band pass filter (BPF). The IF_4 signal differs from the other channels in there is a single pole double throw (SPDT) which can route in the TCAS_TX_CAL signal for transmitter calibration. These signals are then applied to a limiting-logarithmic amplifier. A lumped element low pass filter further filters the limiting signal. Each log amplifier produces an output that is a logarithmic function of its input. The outputs from the four log amplifiers are applied to a log summer and buffer circuit, which produces a negative pulse output scaled to 20 millivolts per dB. The TCAS_RX_LOG output is routed to the digital module where it is decoded to determine range and altitude.

Synthesizer



The synthesizer, shown in block diagram form in Figure 4, produces the TX_SIGNAL, CAL_LO, RX_LO (1-4), and TCAS_64MHz. The TX_SIGNAL generates the following frequencies, 1030MHz, 1087MHz, 1090MHz, and 1093MHz. The calibration LO (CAL_LO) frequency is 982 MHz. The receiver LO (RX_LO) frequency is 1042MHz. The TCAS_64MHz frequency is 64MHz.

Each signal is generated from a single 20 MHz crystal oscillator, which is installed in an oven for precise performance over a wide range of operation temperatures. The 20 MHz signal is applied to two separate dual Phase Lock Loop (PLL) IC. Each PLL circuit operates a voltage controlled oscillator with a loop filter to generate the synthesized frequency. The synthesized frequencies are 521MHz for the RX_LO, 512 MHz for the TCAS _64 MHz, and 491 MHz for the CAL_LO. The TX_SIGNAL can generate four different synthesized frequencies, 515, 543.5, 545, and 546.5 MHz, depending on transmitter operation.

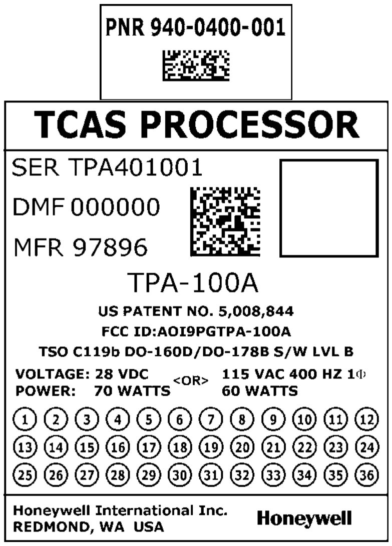
The following synthesized signals TX_SIGNAL, CAL_LO, and RX_LO are applied to hybrid low pass filter (LPF) and RF gain block. A single pole double throw (SPDT) RF switch is used as an on-off switch. The switch's second output is a RF termination. This is controlled by a TTL signal for each synthesized frequency. The synthesized frequency is then doubled to obtain the output frequency. It is filtered with a hybrid band pass filter (HPF) and isolated with RF gain block.

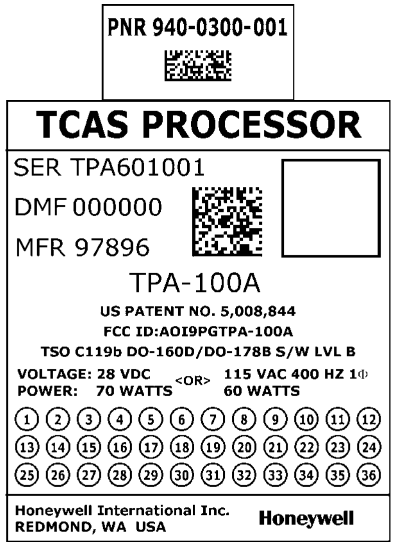
The TX_SIGNAL is routed to the DPSK mixer, where it can be mixed with a modulated DPSK signal that is generated by 250ns pulse square wave with a 50% duty cycle from the digital module. An additional RF gain stage is used for isolation and then the signal is further filtered by hybrid LPF and then sent directly to the transmitter module.

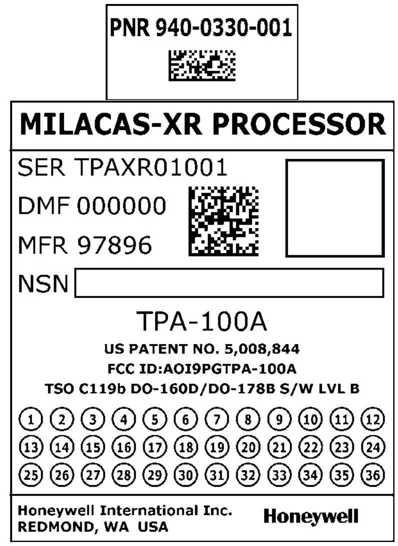
The CAL_LO and RX_LO frequencies are filtered by a hybrid LPF. The CAL_LO is routed to the calibration mixer and the RX_LO is split into four signals by a hybrid Wilkinson power divider and routed to the each channel's mixer in the LNA section.

The TCAS_64MHz signal differs from the other signals in the synthesized frequency (512 MHz) is applied to a divide by 8 circuit to obtain the final frequency of 64 MHz. This signal is applied to a RF gain block and then a lumped element band pass filter (BPF). The signal is then routed through the JAE connector to the digital module. This signal is always on when the PLL chip has been programmed.

Identification Plate







LRU Photographs

6 MCU

4 MCU

Test Procedures and Data

Interrogation Test Modes

The TPA100A uses the following test modes for making transmitter measurements.

1. Mode S Test Mode 1 - A Mode S interrogation format with a short P6 pulse, but containing a data block whose bit values are all ONE. The interrogation rate is 50 per second, nominal.
2. Mode S Test Mode 2 - A Mode S interrogation format with a long P6 pulse, but containing a data block whose bit values are all ONE. The interrogation rate is 50 per second, nominal.
3. Mode S Test Mode 3 - A Mode S interrogation format with a long P6 pulse containing no internal modulation (i.e., no sync or data phase reversals). The interrogation rate is 50 per second, nominal.
4. Mode C Test Mode 1 - A standard Mode C only all-call interrogation at a rate of 50 per second, nominal.
5. Whisper-Shout Test Mode 2 - A standard high resolution whisper-shout sequence for the minimum TCAS as defined in DO-185A subparagraph 2.2.4.5.4.1.2 at 10 per second, nominal.
6. No-Interrogation Test Mode - A mode in which the TCAS transmitter is programmed to transmit no interrogations but otherwise is active.

RF Power Output

Test Procedure:
The TPA-100A peak pulse power was measured at each of the four antenna ports while in interrogation test mode 2. The data is shown below.

Test Limits:

Each of four ports:	+46.0dBm ± 2.0dB
Total power output:	+52.0dBm ± 2.0dB

Test Results:

Antenna Port E1:	47.9 dBm	61.7 watts
Antenna Port E2:	46.7 dBm	46.8 watts
Antenna Port E3:	47.5 dBm	56.2 watts
Antenna Port E4:	46.0 dBm	39.8 watts
Total Power output:	53.1 dBm	204.5 watts

Pulse Characteristics

Test Procedure:
The TPA100A pulse characteristics were measured while operating in interrogation test modes 1, 2, and 4. The data is shown below.

Test Limits:

Mode C Only "All-Call" (P1, P2, P3, P4)

Pulse Duration:		0.800 ± 0.050 uSec
Rise Time:		0.050 to 0.100 uSec
Decay Time:		0.050 to 0.200 uSec
Pulse Spacing:	P1 to P2	2.000 ± 0.100 uSec
	P1 to P3	21.000 ± 0.100 uSec
	P3 to P4	2.000 ± 0.040 uSec

Mode S

Pulse Duration:	P1, P2	0.800 ± 0.050 uSec
	P6 (short)	16.250 ± 0.050 uSec
	P6 (long)	30.250 ±0.125 uSec
Rise Time:		0.050 to 0.100 uSec
Decay Time:		0.050 to 0.200 uSec
Pulse Spacing:	P1 to P2	2.000 ± 0.040 uSec
	P2 to Sync Phase Reversal	2.750 ± 0.040 uSec
	P6 Leading Edge to Sync Phase Reversal	1.250 ± 0.040 uSec

Test Results:

Mode C Only "All-Call" (P1, P2, P3, P4)

		P1	P2	P3	P4	
Pulse Duration:		0.818	0.811	0.815	0.820	uSec
Rise Time:		0.088	0.090	0.093	0.085	uSec
Decay Time:		0.101	0.079	0.102	0.103	uSec
Pulse Spacing:	P1 to P2	2.01 uSec				
	P1 to P3	21.0 uSec				
	P3 to P4	1.98 uSec				

Mode S

		P1	P2	P6	
Pulse Duration:	P1, P2	0.794	0.800		uSec
	P6 (short)			16.30	uSec
	P6 (long)			30.30	uSec
Rise Time:		0.097	0.090	0.090	uSec
Decay Time:		0.105	0.102	0.104	uSec
Pulse Spacing:	P1 to P2	1.99 uSec			
	P2 to Sync Phase Reversal	2.73 uSec			
	P6 Leading Edge to Sync Phase Reversal	1.24 uSec			

Occupied Bandwidth

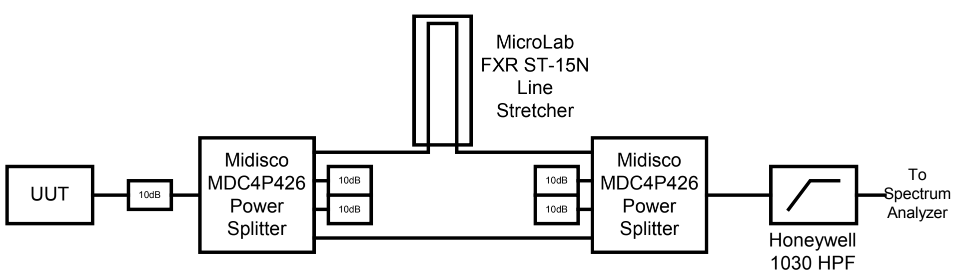
Test Procedure:

Connect each antenna port to a spectrum analyzer through a 60 dB attenuator. Set the spectrum analyzer as follows:

Scan Width : 20 MHz/div
Resolution Bandwidth : 100 KHz for spectrum, 3 MHz for occupied BW
Center Frequency : 1030 MHz
Reference Level : +50 dBm

Program TCAS for Mode S test mode 3 and top antenna. Measure peak power at 1030 Mhz. Program TCAS for Mode S test mode 2 and verify proper signal spectrum bounds.

A notch filter was used to prevent the power at 1030 MHz from causing spurious responses in the spectrum analyzer when measuring the 2nd and 3rd harmonics. The filter is shown below as well as its response.



Notch Filter Response	1030 MHz	2060MHz	3090MHz
	-51 dB	-28 dB	-25 dB

Test Limits:

Occupied Bandwidth: < 20 Mhz for 99% of transmitted power.

In addition to the FCC requirement of Occupied Bandwidth, the FAA limits the output spectrum per DO-185A, Paragraph 2.2.3.3 as shown below:

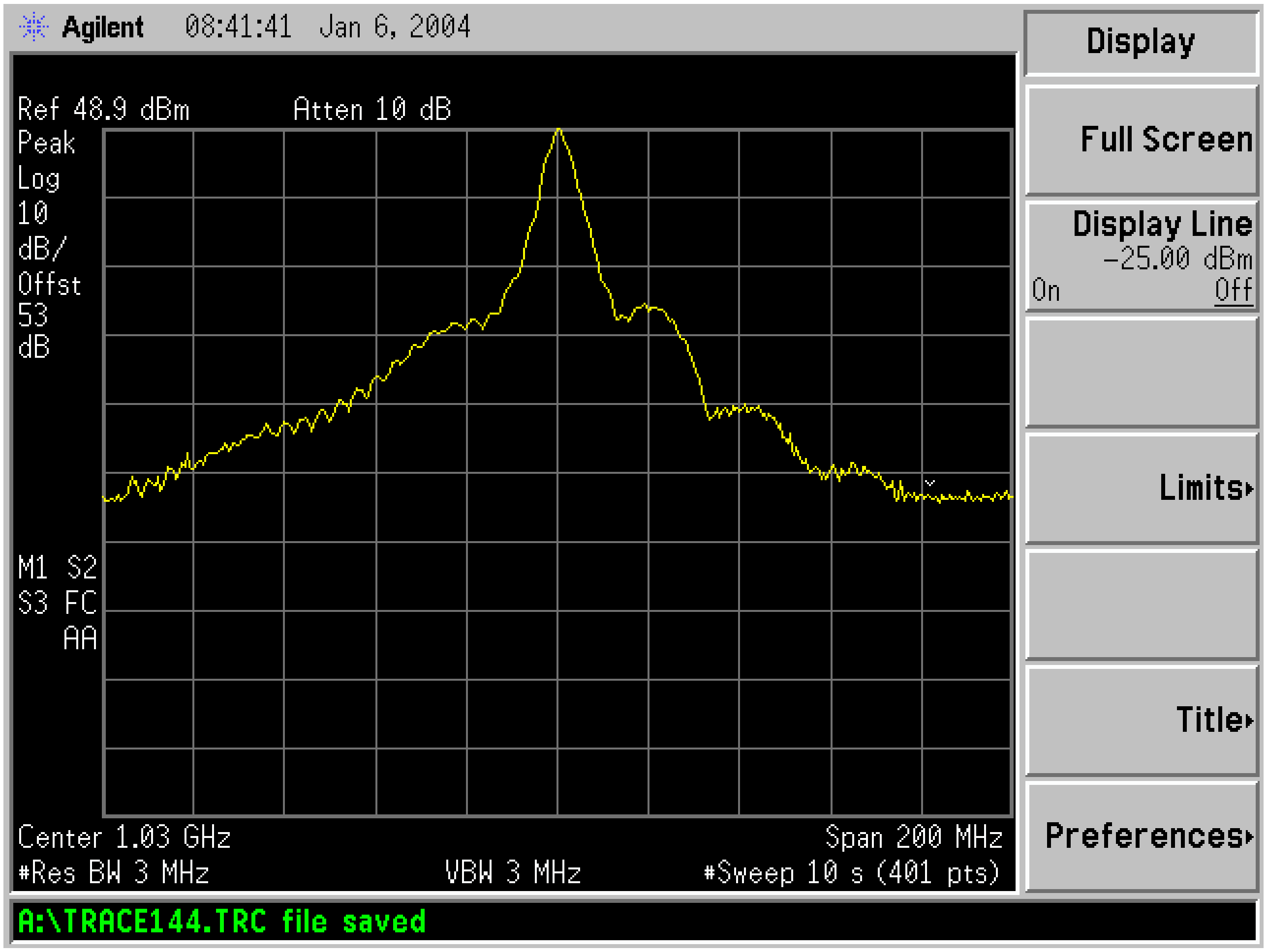
Frequency Difference (MHz From Carrier)	Maximum Relative Power (dB Down From Peak)
.GE. 4 and .LT. 6	6
.GE. 6 and .LT. 8	11
.GE. 8 and .LT. 10	15
.GE.10 and .LT. 20	19
.GE.20 and .LT. 30	31
.GE.30 and .LT. 40	38
.GE.40 and .LT. 50	43
.GE.50 and .LT. 60	47
.GE.60 and .LT. 90	50
.GE.90	60

Test Results:

The output spectrums were recorded for each antenna port and analyzed for conformance with the above definition of occupied bandwidth. It was established that 99% of the total transmitted power was contained in a 23.8 Mhz bandwidth and that the remaining energy was equally distributed on both sides of the occupied band, centered on the assigned frequency.

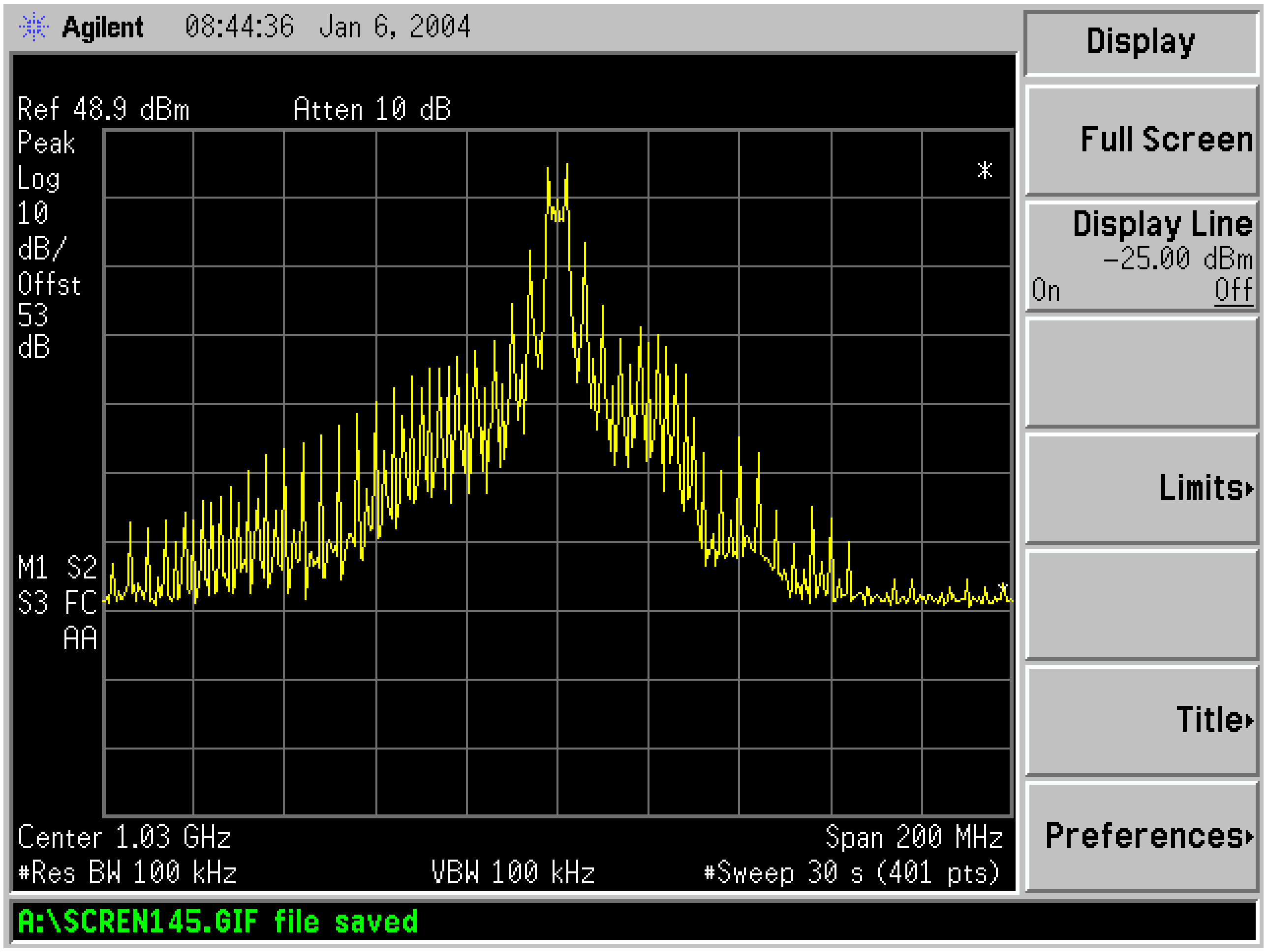
Requested Bandwidth: 20 Mhz
Measured Occupied Bandwidth: 23.8 Mhz

The requested BW is based on unmodulated pulse. However, the mode S pulse has 4 MHz DPSK data embedded in it causing spectral spreading. The requirements of RTCA DO-185A allows for 40 MHz occupied BW.



It was further shown that the transmitted energy was in conformance with the above referenced FAA requirements as shown by the data and figure below.

Mode S Test Mode 3 Ref Amplitude @ 1030Mhz			47.9dBm	46.7dBm	47.5dBm	46.0dBm
Mode S Test Mode 2 Amplitude @ 1030Mhz						
Frequency offset from 1030Mhz	Start – Stop Frequency	Limit (-dB)	E1 Data (dB)	E2 Data (dB)	E3 Data (dB)	E4 Data (dB)
GE 4 and LT 6						
	1024.1-1026	6	25.7	26.2	24.1	25.4
	1034-1035.9	6	24.3	27	17.4	24.5
GE 6 and LT 8						
	1022.1-1024	11	17.8	18.9	16.5	18.2
	1036-1037.9	11	17.1	20.0	17.4	17.1
GE 8 and LT 10						
	1020.1-1022	15	34.5	35.6	32.6	35.2
	1038-1039.9	15	34.7	38.4	35.2	34.2
GE 10 and LT 20						
	1010.1-1020	19	27.5	29.5	25.6	29.1
	1040-1049.9	19	29.2	33.0	29.5	27.8
GE 20 and LT 30						
	1000.1-1010	31	36.4	42.1	35.0	39.2
	1050-1059.9	31	34.0	41.3	33.8	36.4
GE 30 and LT 40						
	990.1-1000	38	46.4	53.0	46.2	50.6
	1060-1069.9	38	50.9	50.3	46.0	53.7
GE 40 and LT 50						
	980.1-990	43	51.2	62.0	52.0	57.3
	1070-1079.9	43	55.5	57.7	50.0	56.2
GE 50 and LT 60						
	970.1-980	47	54.1	63.2	53.1	60.1
	1080-1089.9	47	59.7	68.4	56.2	66.1
GE 60 and LT 90						
	940.1-970	50	58.2	66.8	57.2	63.8
	1090-1119.9	50	65.8	69.6	67.7	68.3


Agilent 08:44:36 Jan 6, 2004
Ref 48.9 dBm Atten 10 dB
Peak
Log
10
dB/
Offst
53
dB
M1 S2
S3 FC
AA
Center 1.03 GHz
Span 200 MHz
#Res BW 100 kHz
VBW 100 kHz
#Sweep 30 s (401 pts)
Display
Full Screen
Display Line
-25.00 dBm
On Off
Limits
Title
Preferences
A:\SCREN145.GIF file saved

Spurious Emissions at Antenna Terminals

Test Procedure:

The TPA-100A spurious emissions at each of the four antenna ports were investigated from 150 KHz to 12 GHz, with specific measurements at local oscillator and transmitter harmonic frequencies. Set the spectrum analyzer to 100 KHz resolution BW.

The results and worst case spurious outputs are recorded below.

Test Limits:

Frequency Difference (MHz From Carrier)	Maximum Emission Level (dB Below Peak Power)
.GE. 20 and .LT. 40	25
.GE. 40 and .LT. 100	35
.GT. 100	60

Test Results:

Frequency Difference	Maximum Emission Level (dBc)			
(MHz From Carrier)	E1	E2	E3	E4
1030 Mhz (carrier)	0 (+47.9dBm)	0 (+46.7dBm)	0 (+47.5dBm)	0 (+46.0dBm)
1090 Mhz (LO)	65.8 (-17.9 dBm)	68.4 (-21.7 dBm)	67.7 (-20.2 dBm)	68.3 (-22.3dBm)
2060 Mhz (2^{nd} harm.)	87.1 (-39.2 dBm)	84.6 (-37.9 dBm)	86.2 (-38.7 dBm)	85.3 (-39.3 dBm)
3090 Mhz (3^{rd} harm.)	88.2 (-40.3 dBm)	80.0 (-33.3 dBm)	83.7 (-36.2 dBm)	88.0 (-42.0 dBm)

These emissions were all greater than 18.8 dB below the limits per FCC Rules and Regulations Part 87.139. All other emissions were greater than 19.8 dB below the FCC limits.

Field Strength of Spurious Radiation

Test Procedure:

Spurious radiation from the case and cables of the TPA-100A was measured in accordance with DO-160D, and with respect to FCC requirements, from 150 KHz to 6 GHz for both narrow and broad band energy. An additional test was performed from 1 to 12 GHz narrow band only. The test was conducted using a test site meeting the requirements of both the FCC and FAA as specified in DO-160D. To ensure maximum emissions measurements, the antennas were oriented both vertically and horizontally.

The EMI receiver broadband settings were as follows:

Start Frequency	Stop Frequency	Step Width	Detector	Meas. Time	IF BW
25.0 MHz	30.0 MHz	5.0 kHz	MaxPeak	20.0 ms	10 kHz
30.0 MHz	200.0 MHz	50.0 kHz	MaxPeak	20.0 ms	100 kHz
200.0 MHz	400.0 MHz	50.0 kHz	MaxPeak	20.0 ms	100 kHz
400.0 MHz	1.0 GHz	500.0 kHz	MaxPeak	20.0 ms	1 MHz
1.0 GHz	1.2 GHz	500.0 kHz	MaxPeak	20.0 ms	1 MHz

The EMI receiver narrowband settings were as follows:

Start Frequency	Stop Frequency	Step Width	Detector	Meas. Time	IF BW
25.0 MHz	30.0 MHz	500.0 Hz	MaxPeak	20.0 ms	1 kHz
30.0 MHz	200.0 MHz	5.0 kHz	MaxPeak	20.0 ms	10 kHz
200.0 MHz	400.0 MHz	5.0 kHz	MaxPeak	20.0 ms	10 kHz
400.0 MHz	1.0 GHz	50.0 kHz	MaxPeak	20.0 ms	100 kHz
1.0 GHz	6.0 GHz	50.0 kHz	MaxPeak	20.0 ms	100 kHz
1.0 GHz	12.0 GHz	50.0 KHz	MaxPeak	20.0 ms	100 kHz

Test Limits:

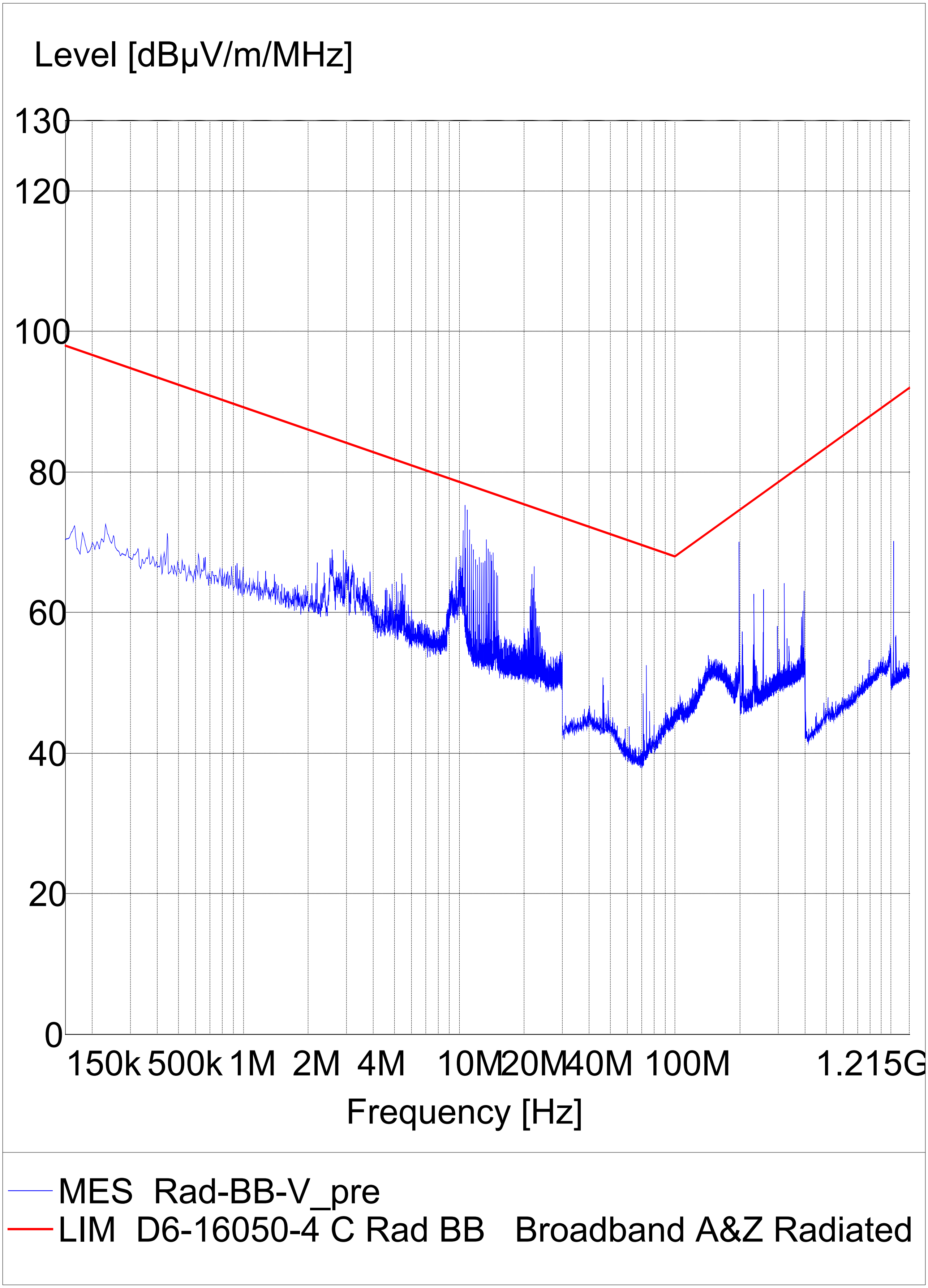
Frequency Difference (MHz From Carrier)	Maximum Emission Level (dB Below Peak Power)
.GE. 20 and .LT. 40	25
.GE. 40 and .LT. 100	35
.GT. 100	60

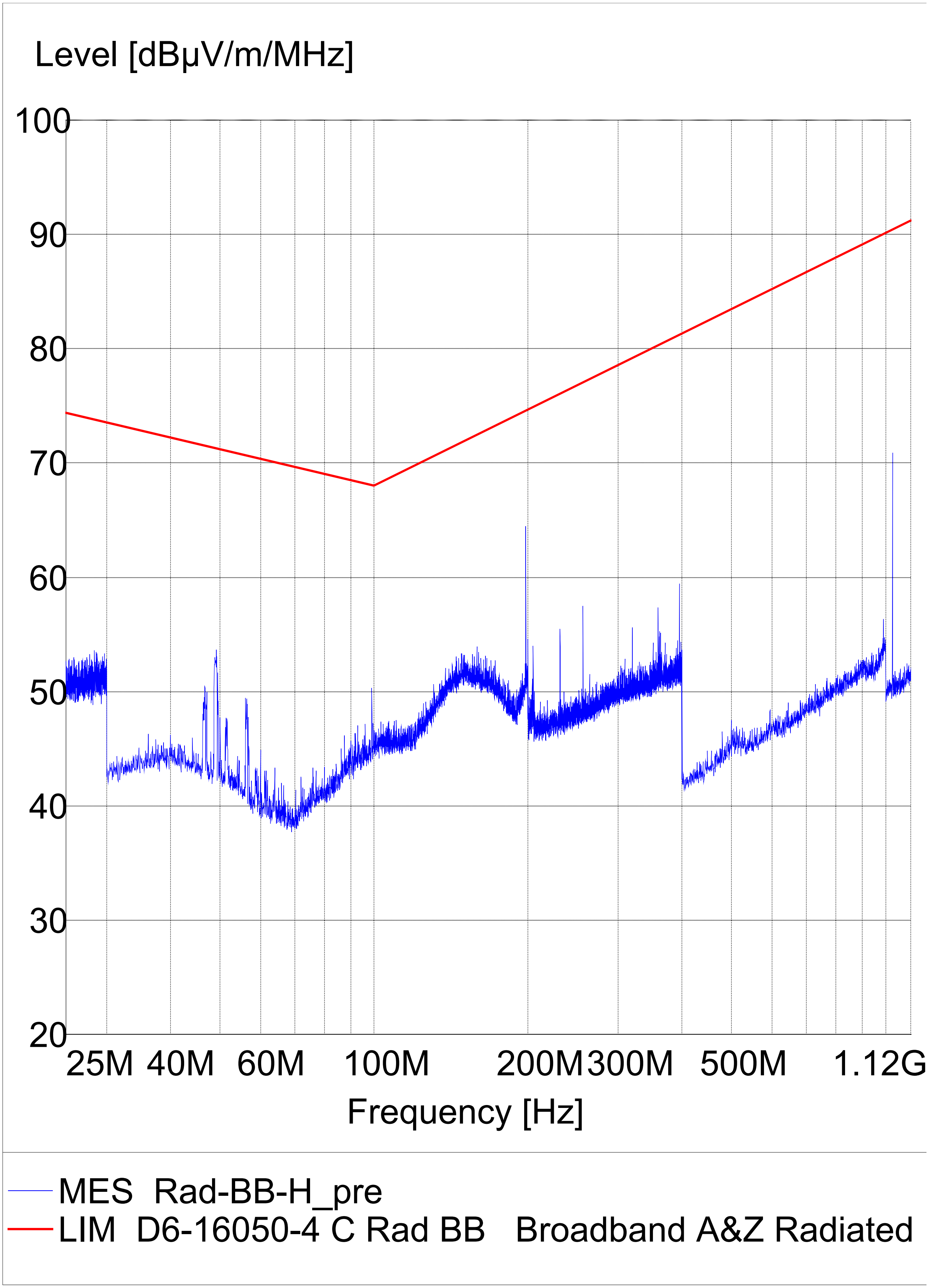
Test Results:

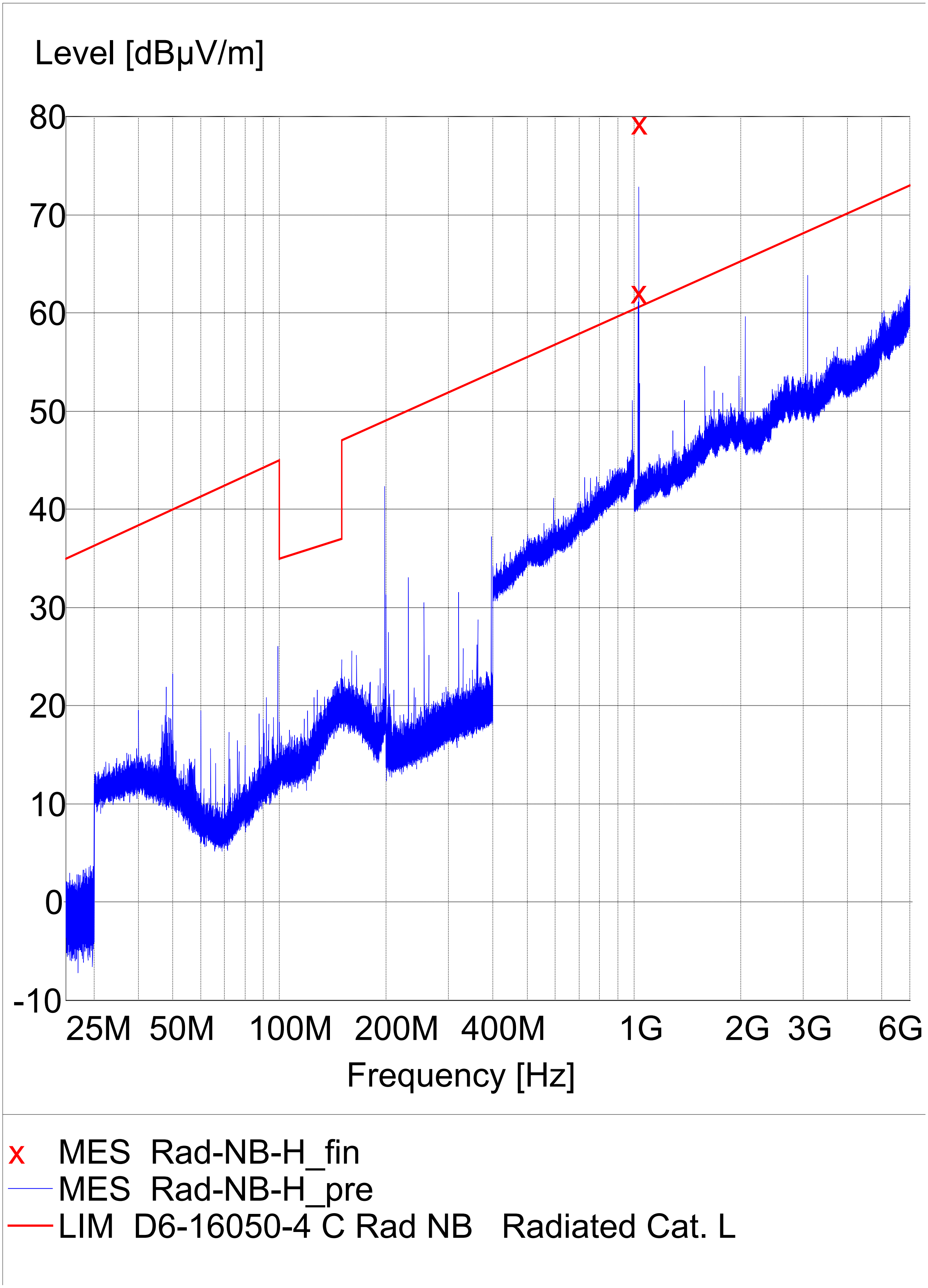
In all cases the spurious levels outside of exclusion zones were within limits. Exclusion zones include transmitter frequency and harmonics.

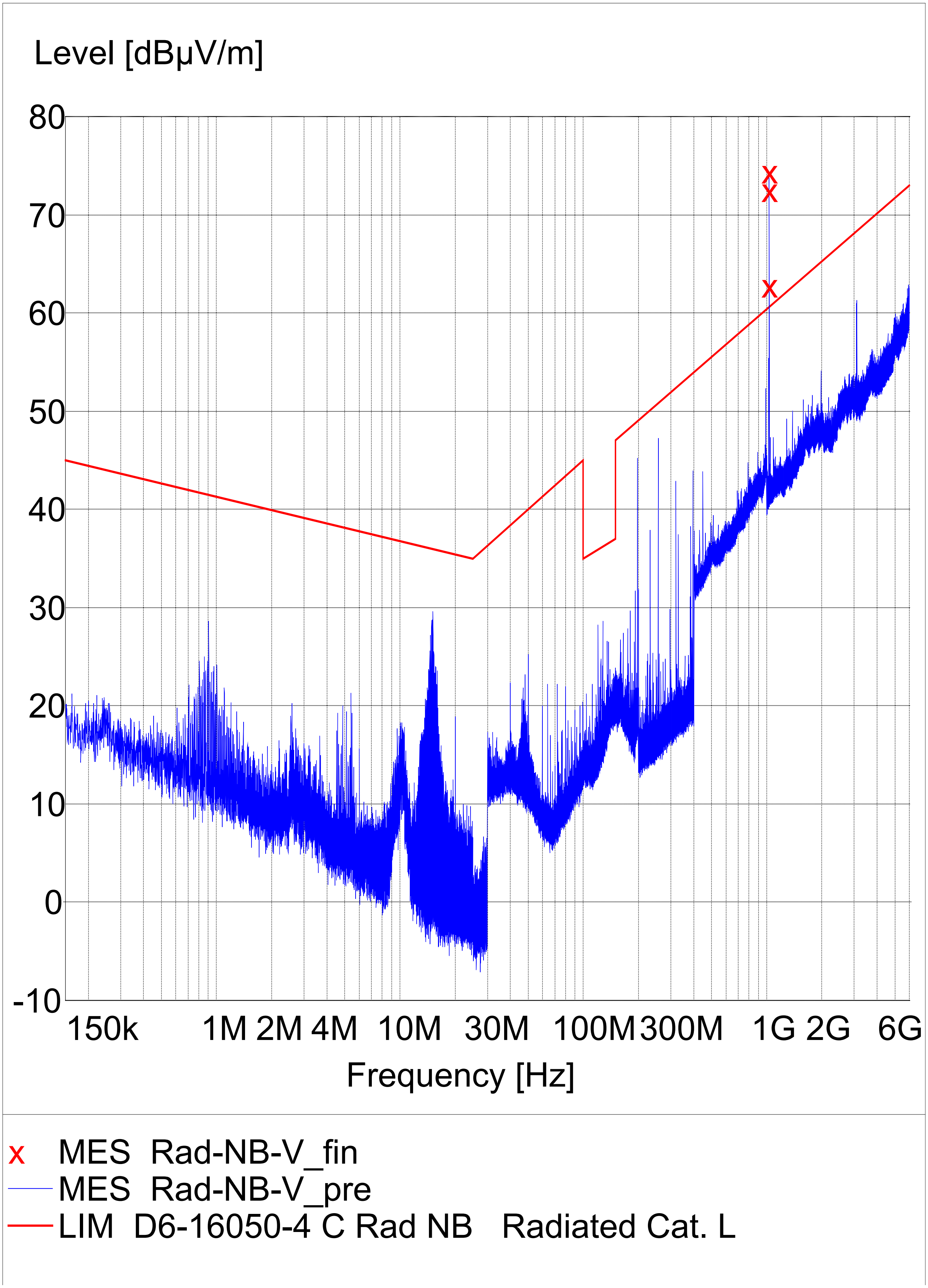
Charts below are:

Radiated BroadBand Vertical	150 KHz – 1.215 GHz
Radiated BroadBand Horizontal	25 MHz – 1.12 GHz
Radiated NarrowBand Horizontal	25 MHz – 6 GHz
Radiated NarrowBand Vertical	150 KHz – 6 GHz
Radiated NarrowBand Vertical	1 GHz – 12 GHz
Radiated NarrowBand Horizontal	1 GHz – 12 GHz


Level [dBµV/m/MHz]
130
120
100
80
60
40
20
0
150k 500k 1M 2M 4M 10M 20M 40M 100M 1.215G
Frequency [Hz]
MES Rad-BB-V_pre
LIM D6-16050-4 C Rad BB Broadband A&Z Radiated


Level [dBµV/m/MHz]
100
90
80
70
60
50
40
30
20
25M 40M 60M 100M 200M 300M 500M 1.12G
Frequency [Hz]
MES Rad-BB-H_pre
LIM D6-16050-4 C Rad BB Broadband A&Z Radiated


Level [dBµV/m]
80
70
60
50
40
30
20
10
0
-10
25M 50M 100M 200M 400M 1G 2G 3G 6G
Frequency [Hz]
x MES Rad-NB-H_fin
MES Rad-NB-H_pre
LIM D6-16050-4 C Rad NB Radiated Cat. L



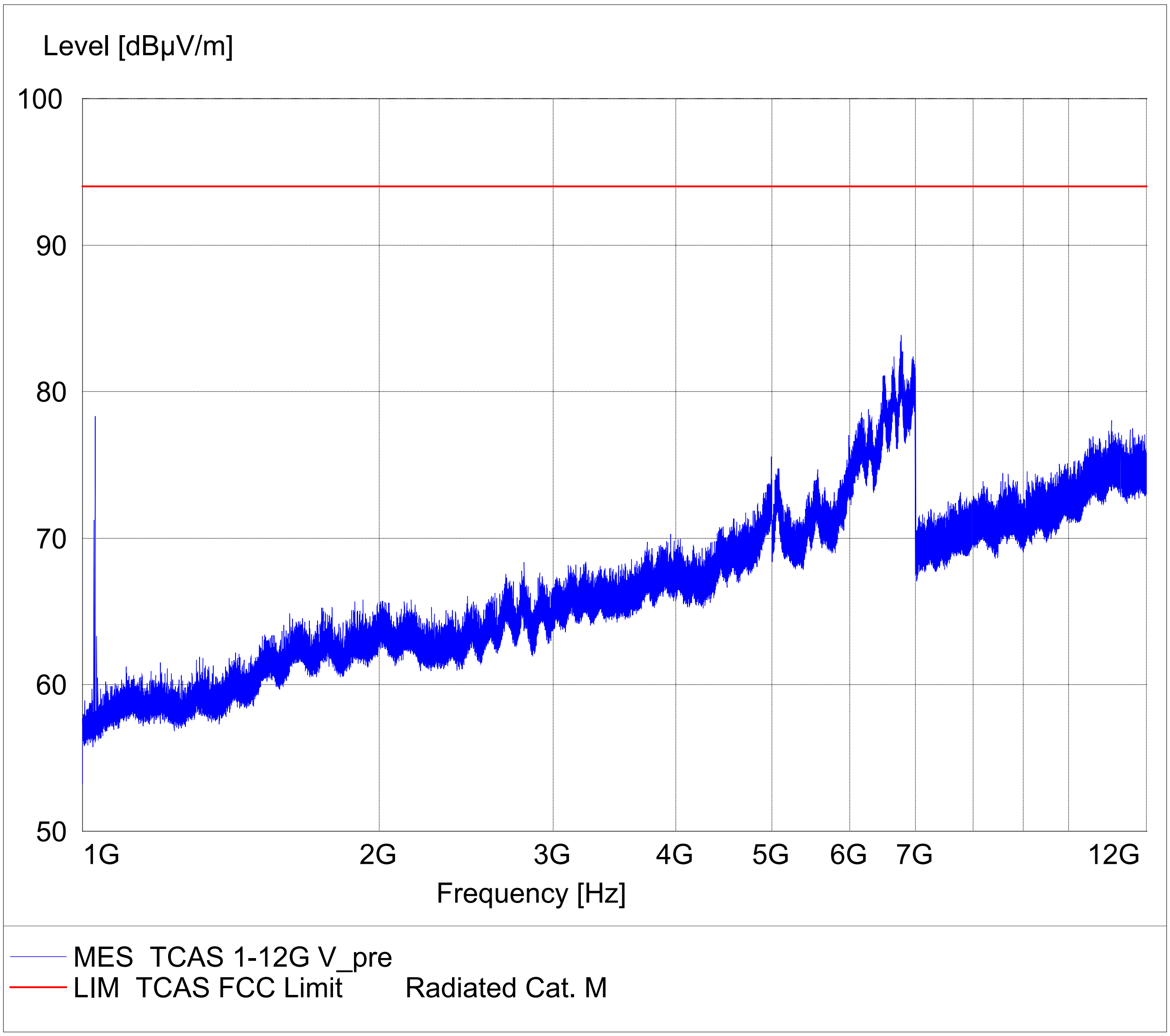
Level [dBµV/m]
80
70
60
50
40
30
20
10
0
-10
150k
1M 2M 4M
10M
30M
100M 300M
1G 2G
6G
Frequency [Hz]
x MES Rad-NB-V_fin
MES Rad-NB-V_pre
LIM D6-16050-4 C Rad NB Radiated Cat. L

Unit Under Test: TCAS TPA-100A
Part Number: 940-0300-001
Serial Number: 00161
Procedure Number: 070-4700-001
Operator: Paul Hoyt
Test Details: NB Radiated Emissions, Vertical Antenna, AC PWR
Comment: 1 GHz to 12 GHz
Start of Test: 19 MAR 04

SCAN TABLE: "TCAS Rad NB 1-12GHz"

Short Description: DO160B/C Radiated Emissions

Start Frequency	Stop Frequency	Step Width	Detector	Meas. Time	IF Bandw.	Transducer
1.0 GHz	12.0 GHz	50.0 kHz	MaxPeak	20.0 ms	100 kHz	96001 s/n 2041



Honeywell International Inc.

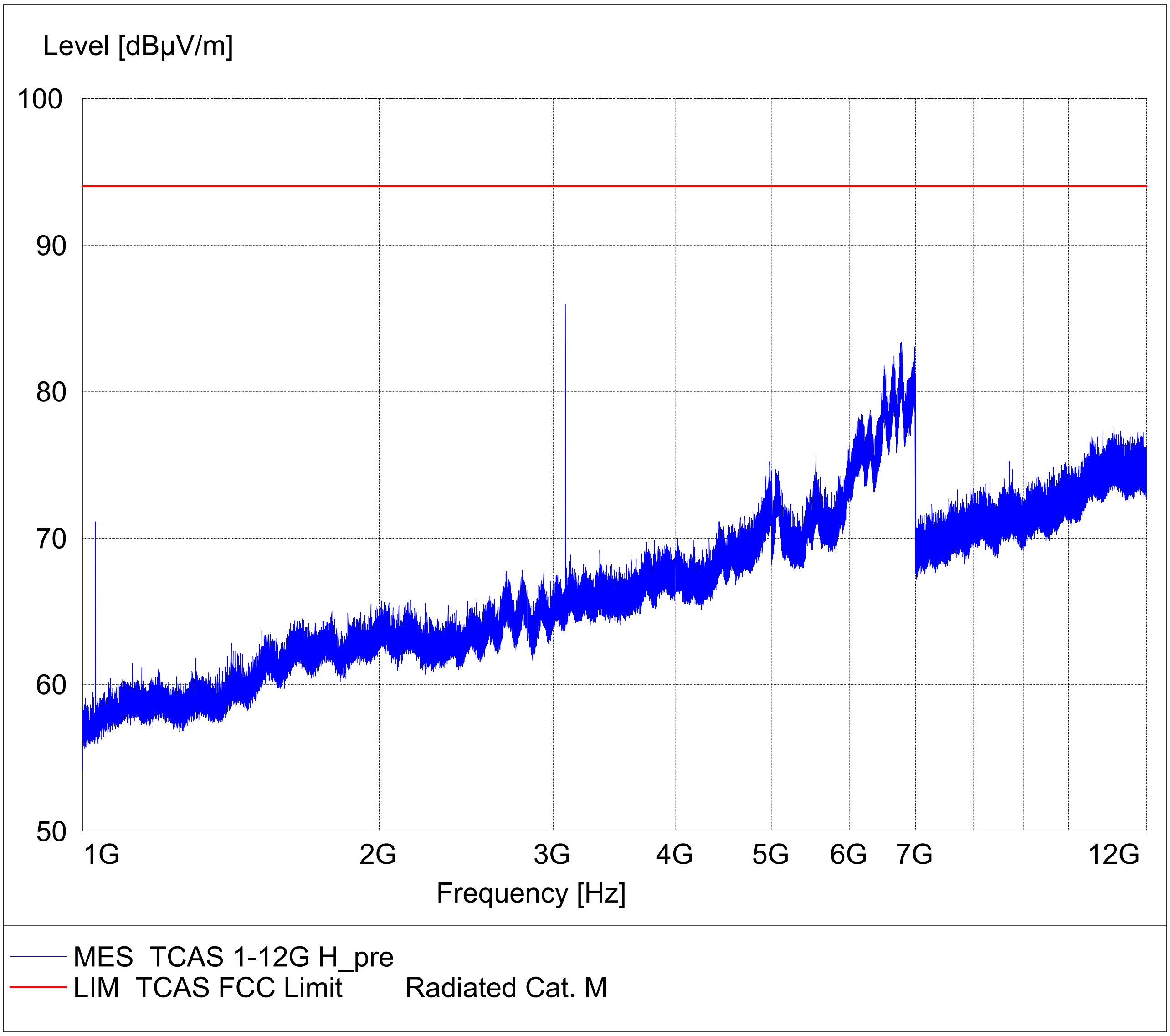
Redmond, Washington 98073

Unit Under Test: TCAS TPA-100A
Part Number: 940-0300-001
Serial Number: 00161
Procedure Number: 070-4700-001
Operator: Paul Hoyt
Test Details: NB Radiated Emissions, Horizontal Antenna, AC PWR
Comment: 1 GHz to 12 GHz
Start of Test: 19 MAR 04

SCAN TABLE: "TCAS Rad NB 1-12GHz"

Short Description: DO160B/C Radiated Emissions

Start Frequency	Stop Frequency	Step Width	Detector	Meas. Time	IF Bandw.	Transducer
1.0 GHz	12.0 GHz	50.0 kHz	MaxPeak	20.0 ms	100 kHz	96001 s/n 2041



Frequency Stability

Transmitter Frequency Stability

Test Procedure:

The TPA-100A was placed into a controlled temperature chamber and stabilized at the temperature indicated. The UUT was then operated for fifteen minutes after which time the transmitter frequency was measured.

Test Limits:

± 20 PPM or ± 20.6 Khz from the +25°C frequency over a temperature range from –55°C to +70°C.

Test Results:

Temperature (°C)	Frequency (Mhz)	Deviation from +25°C (Khz)
-55	1029.998	-1.0
-40	1029.998	-1.0
-20	1029.998	-1.0
0	1029.998	-1.0
+25	1029.999	0.0
+30	1029.999	0.0
+50	1030.000	+1.0
+70	1029.999	0.0

Crystal Oven Thermal Time Constant

Test Procedure:

The response of the oven-stabilized oscillator was measured. The UUT was stabilized at the test temperature with power off. Immediately after the UUT was turned on, and each successive minute thereafter, the frequency was measured until no further change was recorded.

Test Limits:

Per DO-160D and DO-185A: Less than 30 minutes.

Test Results:

	Frequency (Mhz)		
Elapsed time (min)	-55°C	25°C	+70°C
0	1029.998	1029.999	1029.999
1	1029.998	1029.999	1029.999
2	1029.998	1029.999	1029.999
3	1029.997	1029.999	1029.999
4	1029.998	1029.999	1029.999
5	1029.998	1029.999	1029.999

Frequency Stability with Supply Voltage Variations

Test Procedure:

The transmitter frequency variation due to a ± 15% primary power variation was measured at +25°C.

Test Limits:

± 20 PPM or ± 20.6 Khz from nominal primary input power for a ± 15% variation of primary input power.

Test Results:

Input Voltage (Vrms)	Frequency (Mhz)	Deviation (Khz)
115% 132 Vrms	1029.999	1.0
100% 115 Vrms	1029.999	1.0
85% 97 Vrms	1029.999	1.0

Equipment List

1. TPT-81A TCAS Interface Test Panel
2. 400 Hz Power Supply, Elgar 1001SL with 400SP plug in
3. Tektronix TDS 640A Digital Oscilloscope
4. RGS 2000 TCAS Reply Generator
5. Miscellaneous Power Attenuators
6. Agilent E4404B Spectrum Analyzer
7. QualMark Model OVS-2.5 HALT/HASS System
8. Hewlett Packard, Model 8596E, Spectrum Analyzer

Note: All test equipment was in calibration.