Reference

Aurora™ 5800

5.8 GHz
Digital Radio

RMN-112862-E02

Issue 2, January 31, 2000

next level solutions

Caveat

Spread spectrum point-to-point radio relay links like Aurora's are allowed by various regulatory agencies to operate unlicensed on a "noninterference basis". Because of the unlicensed nature, the Aurora radios require neither frequency licensing nor prior coordination in most regions. Good engineering judgment needs to be exercised by the operator and professional installer to avoid selecting paths or locations near equipment or facilities that could generate interfering signals. Such equipment might include microwave ovens and other high-power ISM devices. Additionally, precaution should be taken when links are deployed in a region where a large number of other 5.8-GHz, point-to-point or point-to-multipoint links are installed.

The Aurora installation software with its adjustable power feature is for professional installer use *only*, as mandated by the Federal Communications Commission (FCC, Part 15) and the European Telecommunications Standard Institute (ETS 300-328). The customer version is provided with the adjustable power feature disengaged.

Harris Corporation does not assume any liability or damage arising out of the application or *mis*use of this Aurora radio product and its software.

Warranty

Any warranties or conditions made herein by Harris are exclusive, made in lieu of all other warranties or conditions, express or implied (except to title) including, but not limited to, any implied warranty or condition of merchantability, any implied warranty or condition of fitness for a particular purpose, or any warranty or condition arising out of performance or custom or usage of trade. Customer acknowledges any circumstances causing any such exclusive or limited remedy to fail of its essential purpose shall not affect any Harris warranty.

Aurora 5800 contains no user-serviceable or replaceable parts.

Limitation of Damages

Harris' total and maximum liability under this agreement, or in connection with the subject matter of this agreement, or any transaction related to this agreement, shall be limited to one-half (1/2) of the aggregate amount paid to Harris, regardless of the basis for such liability. The customer acknowledges and agrees that this section shall be enforceable in the event of any claim made in connection with this agreement, including, but not limited to, any claim for failure of delivery. In no event shall Harris be liable for any punitive, special, incidental, or consequential damages, including, but not limited to, lost profits, opportunities, or savings, or for any loss of use of, or loss of data or information of any kind, however caused, or for any full or partial loss of performance of any product, even if Harris has been advised of the possibility of such damages.

I.S./ISO 9001/EN 29001

We're ISO certified.

HARRIS CORPORATION
Microwave Communications Division
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Redwood Shores, CA 94065-1421

http://www.microwave.harris.com

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Customer Support

Refer to Chapter 9 for detailed information on Customer Support.

Caveat

Aurora 5800 contains no user-serviceable or replaceable parts. If the radio fails, return the entire unit to Harris.

Do not attempt to change switch settings reserved for factory use (as indicated in the manual), or repair or replace internal components. To do so will invalidate the warranty.

Repair and Return

If you require module repair service, call the Customer Service Center and first request a Return Material Authorization (RMA) number. This request ensures that the repair will be done in a timely manner and prevents any delays caused by incomplete or missing information.

Please provide the following information when you call (or fax):

- Your name, company, and telephone number (fax number)
- Part Number and Serial Number (see label on the back of the shelf)
- Purchase Order Number
- Billing and shipping addresses

- Any special return packing or shipping instructions
- Any special customs clearance information required

Service Center Locations

The Customer Service Center locations and telephone numbers:

U.S.A.

Harris Microwave Communications Division
Attn: Customer Service, RMA #_ _ _ _ _
5727 Farinon Drive
San Antonio, TX 78249

Canada

Harris Microwave Communications Division
Attn: Customer Service, RMA #_ _ _ _ _
3, Hotel de Ville
Dollard-des-Ormeaux, Quebec
CANADA H9B 3G4

Telephone and Fax Numbers

Tel: 1-800-227-8332 (U.S.A.)
1-800-465-4654 (Canada)
(+1) 514-421-8333
Fax: (+1) 514-421-3555

Technical Support

Customer Resource Center

If you are experiencing a traffic-affecting or traffic-threatening situation, technical assistance is available 24 hours a day, 7 days a week, including holidays. If you call the Customer Resource Center during nonbusiness hours, a Product Support Engineer will return your call within 30 minutes.

Please provide the following information when you call.

- Your name, company, and telephone number.
- Equipment type, part number, and serial number (see label on back of shelf).
- Detailed description of the problem.

Business Hours

Normal business hours for the Customer Resource Center:

6:30 A.M. to 5:00 P.M. (Pacific Time)
Monday through Friday

Telephone Numbers

Technical support telephone numbers:

U.S.A. only	1-800-227-8332 (+1) 650-594-3800
Canada	1-800-465-4654

Fax Number

Technical support fax number:

U.S.A.	(+1) 650-594-3621
Canada	(+1) 514-685-4580

Internet

E-mail: crcusa@harris.com
World Wide Web: http://www.microwave.harris.com/cservice

Customer Training

Telephone Number

1-800-227-8332 (U.S.A.)
1-800-465-4654 (Canada)

Training Centers

Canada

Harris Microwave Communications Division
3, Hotel de Ville
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U.S.A.

California

Harris Microwave Communications Division
330 Twin Dolphin Drive
Redwood Shores, CA 94065-1421

Texas

Harris Microwave Communications Division
5727 Farinon Drive
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Chapter 1 Introduction

Aurora 5800 Overview

The Aurora 5800 is a spread-spectrum, digital microwave radio that operates in the 5.725 to 5.85 GHz Industrial, Scientific, and Medical (ISM) frequency band. It provides wireless interconnection for private wireless access, Internet service access, LAN/WAN, cellular, and PCS/PCN systems.

The Aurora radio offers deployment of standard T1 (DSX-1) or E1 (CEPT-1) and 2×T1 or 2×E1 wireless service with a typical distance from 1 to over 24 km (15 miles) (with 28-dBi, flat-panel antenna). It provides reliable, full-duplex, digital communication between two sites with line-of-sight clearance.

This radio offers three frequency pairs at 1×E1 (2.048 Mbit/s) and 1×T1 (1.544 Mbit/s) or two frequency pairs at 2×E1/T1 in the 5.8 GHz band.

Additionally, the Aurora 5800 features a voice/data orderwire and a network management systems channel. The network management systems channel provides a SCAN channel to integrate into Harris’ FarScan element manager or an SNMP-based interface to integrate into an SNMP manager.

There is a built-in Craft Interface Tool (CIT) user interface for local and remote radio monitoring and control.

The Aurora uses Direct Sequence Spread Spectrum (DSSS) processing that reduces the transmitted power density and the potential for interference into neighboring communication systems.

The Aurora can be used in point-to-point and repeater configurations. In the repeater configuration, the radios serve as links between sites that are beyond each other's range or whose paths are obstructed.

This radio supports either indoor or outdoor environment. This is a compact lightweight radio that requires only one rack-mounting space for a rack or table-top placement in an indoor environment. This radio requires one open rack-mounting space (1 RMS) above and one below. For placement outdoors this radio can be installed in an outdoor cabinet.

Aurora 5800 links operate license-exempt on a "no-interference, nonprotection" basis in the U.S.A. and in many countries and regions worldwide. In Canada, however, Aurora 5800 links share the existing 5.725 to 5.85 GHz "Super 2" point-to-point band and therefore may be subject to interference coordination and Industry Canada licensing procedures.

Related Publications

FarScan for Windows Instruction Manual

Chapter 2
Product Description

Physical Description

Front View

Figure 2-1 Aurora 5800 front view

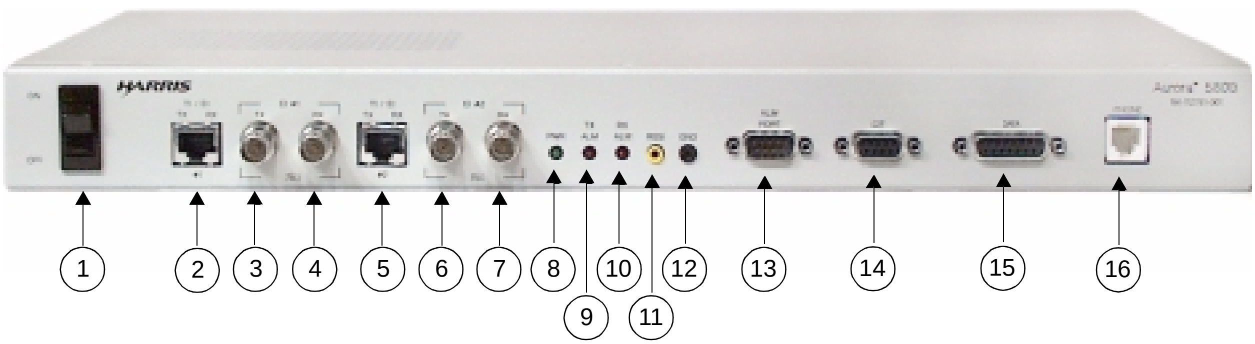


Table 2-1 Aurora 5800 front panel information

Call-out	Label	Description	Additional Information
1	ON/OFF	Power switch	
2	T1/E1, TX, RX, #1	UTP/RJ-48C, E1/T1 interface	Table 2-2
3	E1 #1 TX	Coax/BNC E1 interface	Use 75-ohm cables

Call-out	Label	Description	Additional Information
4	E1 #1 RX	Coax/BNC E1 interface	Use 75-ohm cables
5	T1/E1, TX, RX, #2	UTP/RJ-48C, E1/T1 interface	Table 2-2
6	E1 #2 TX	Coax/BNC E1 interface	Use 75-ohm cables
7	E1 #2 RX	Coax/BNC E1 interface	Use 75-ohm cables
8	PWR	Power indicator LED	
9	TX ALM	Transmitter power alarm, red LED, active high	
10	RX ALM	Receiver sync alarm, red LED, active high	
11	RSSI	Receiver Signal Strength Indicator: yellow, 0 to 4.8 volts, corresponding to approximately receiver input level of Σ–90 to –10 dBm	
12	GND	Ground test jack, black	
13	ALM PORT	RS-232, 9-pin, DE-9 male, TX and RX alarms by dry contact relays	Table 2-3
14	CIT	RS-232, 9-pin, DE-9, female, craft interface tool port	Table 2-4
15	DATA	DA-15, female, asynchronous data port	Table 2-5
16	PHONE	2-wire, RJ-11, voice orderwire port	Table 2-6

Back View

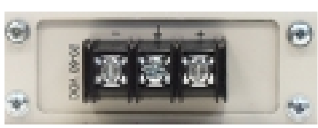
Figure 2-2 shows the Aurora radio's back panel with an N-type antenna connector. The standard input power connector is an AC connector as shown in Figure 2-2. Optionally, if DC power is required, an input battery power connector block (Figure 2-3) replaces the AC power connector.

Also, an example of a customer-service label is shown in Figure 2-2. This label contains information such as technical data and serial number.

Figure 2-2 Aurora 5800 back view

DC Connector

Figure 2-3 DC connector



T1/E1 Line Interface

T1/E1 Interface Connector

An RJ-45 connector is provided on the front panel of the radio for this line interface. The connection follows FCC Section 68.104(c) specified RJ-48C standard. The pinout specification is shown in Table 2-2.

Figure 2-4 RJ-48C

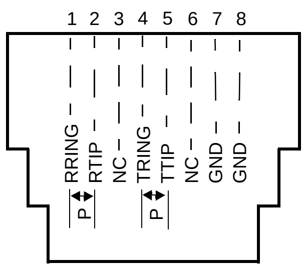


Table 2-2 RJ-48C pinout specification

Pin	Function
1	RRING, DS-1/E1 input to the Aurora
2	RTIP, DS-1/E1 input to the Aurora
3, 6	Not used
4	TRING, DS-1/E1 output from the Aurora
5	TTIP, DS-1/E1 output from the Aurora
7,8	GND

Unbalanced E1 Interface

A pair of BNC connectors are provided on the front panel of the radio for this line interface, one for transmit data and the other for receive data. Use 75-ohm coaxial cables for these connections.

Alarm Port

Dry relay contacts are provided for the TX power alarm and RX signal alarm. Interface to third-party element manager system is through these contacts. The specification for the relays are listed in Table 2-3.

Figure 2-5 Alarm port, RS-232, male

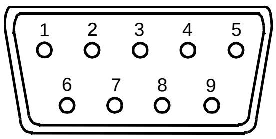


Table 2-3 Alarm port pinout specification

Pin	Signal	Function
1	K1_P	TX alarm relay COM
2	K1_NO	TX alarm relay NO (alarm close)
3		No connection
4	K2_P	RX alarm relay COM
5	K2_NO	RX alarm relay NO (alarm close)
6	K1_NC	TX alarm relay NC (alarm open)
7		No connection
8		No connection
9	K2_NC	RX alarm relay NC (alarm open)

CIT Port

Figure 2-6 CIT port, RS-232, female

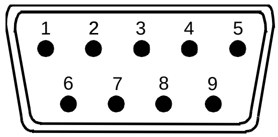


Table 2-4 CIT port pinout specification

Pin	Signal	Function
1		No connection
2	TXD	Transmit data, RS-232
3	RXD	Receive data, RS-232
4		No connection
5		GND
6 to 9		No connection

DATA Port

Figure 2-7 DA-15, female

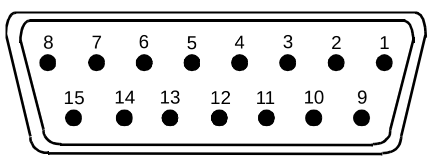


Table 2-5 *DA-15 pinout specification*

Pin	Signal	Function
1		No connection
2	RS232_TX	Transmit data
3	RS232_RX	Receive data
4 to 6		No connection
7		GND
8 to 15		No connection

PHONE

Figure 2-8 *RJ-11*

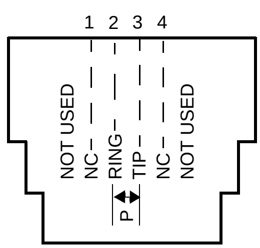


Table 2-6 *RJ-11 pinout specification*

Pin	Signal	Function
1		No connection
2	RING	Receive from handset
3	TIP	Transmit from handset
4		No connection

Harris recommends phones with electronic ringers.

Hardware Assemblies

The Aurora 5800 radio contains 7 hardware assemblies:

- Modem
- Upconverter
- TX Power Amplifier
- RX Low Noise Amplifier
- Down Converter
- Antenna Diplexer
- Power Supply

Customer-interface software is included for field-specific programming and diagnostics. This software utility is accessed through the CIT port.

Modem

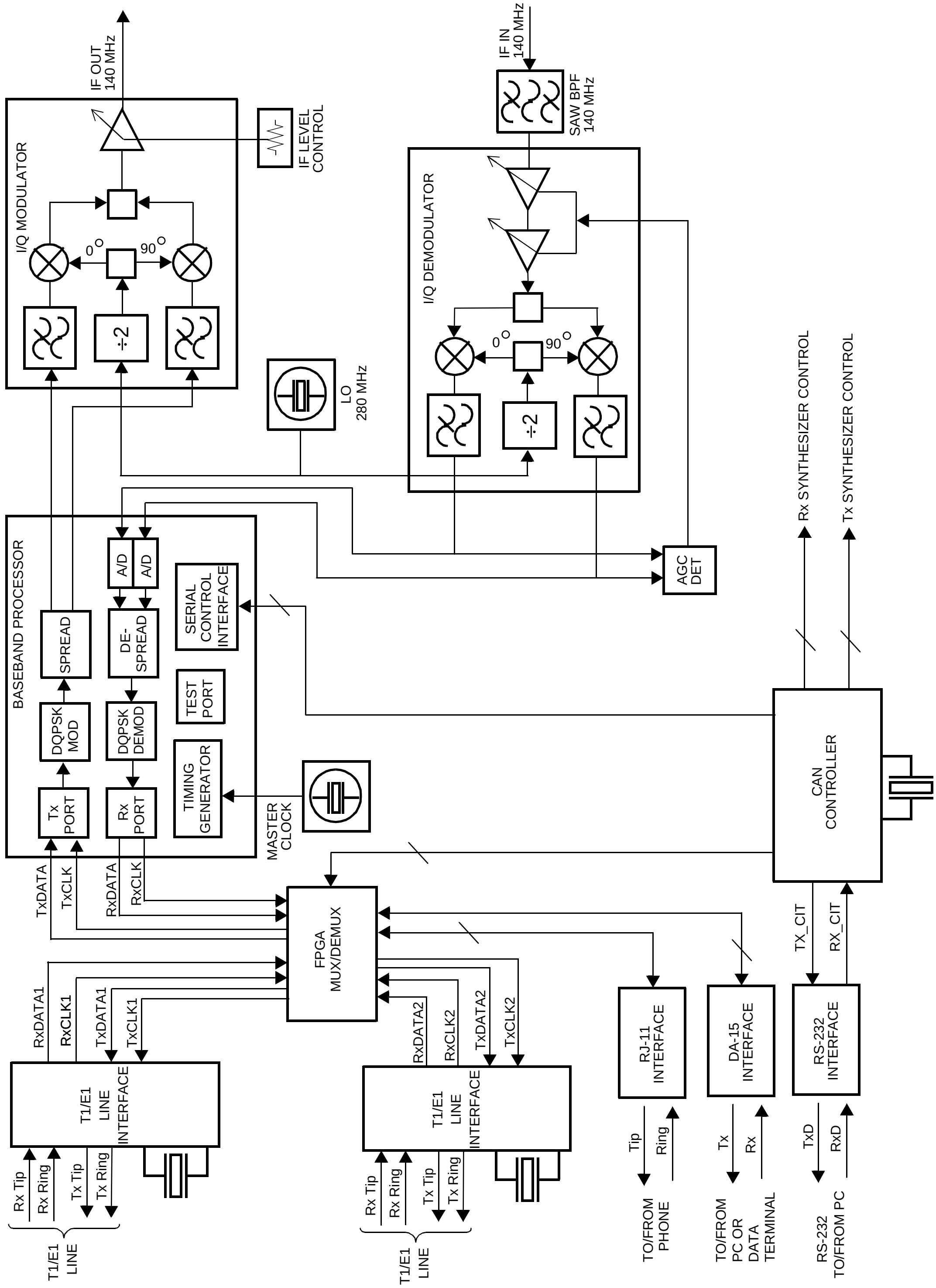
The Modem contains a Direct Sequence Spread Spectrum (DSSS) baseband processing section, an I and Q modulator, an IF AGC amplifier with an I/Q demodulator, and a microcontroller section. Figure 2-9 shows the Modem block diagram.

Transmit Direction

In the transmit direction, incoming one-channel or two-channel T1/E1 standard data is converted into NRZ data by the T1/E1 line interface circuit. The line interface circuit also recovers the bit rate clock (1.544 MHz or 2.048 MHz) from the input tributary and then multiplexes it with the Master Clock (MCLK) of the DSSS processor.

The voice orderwire samples the analog voice signal from the telephone handset and compresses it to 16 kb/s. It contains a RING generator that rings when the remote radio handset is OFFHOOK. When the handset is ONHOOK, the channel serves as a general-purpose, asynchronous, data-communications channel.

Figure 2-9 Modem block diagram



An asynchronous RS-232 (CIT) port provides a 19.2 kb/s communication link for local and remote radio configuration and monitoring.

The DATA port serves as an asynchronous data service channel that provides a 4800 kb/s communication link.

The T1/E1 tributary, the voice orderwire channel, and the RS-232 and the DA-15 data service channels are multiplexed to form an aggregate rate of 1.664 Mb/s, 2.176 Mb/s, 3.208
Mb/s, and 4.224 Mb/s for T1, E1, 2T1, and 2E1, respectively, which is then inputted into the baseband processor.

The baseband processor performs scrambling, differential encoding, I and Q symbol generation, and spreading. For DQPSK operation, the input data is demultiplexed to become I and Q output symbols, and spread by a PN code. The PN code is user-programmable: 15 chips for T1 rate data, and 11 chips for E1, 2T1, and 2E1 rate data. Hence, the chip rate (fchip) is 12.48 Mcps for T1 rate, 11.968 Mcps for E1 rate, 17.644 Mcps for 2T1 rate, and 23.232 Mcps for 2E1 rate.

The I and Q outputs from the baseband processor are input to the I/Q modulator. The I and Q signals then modulate an IF carrier signal to generate a 140-MHz IF DQPSK signal.

Receive Direction

The received 140-MHz IF signal is first passed through a SAW bandpass filter, then inputted to the I/Q demodulator. The IF signal is then demodulated into I and Q signals. The demodulator, together with a front-end AGC amplifier, provides a total of 70 dB of AGC. The demodulated I and Q baseband signals are then outputted to the baseband processor.

The baseband processor contains two 3-bit A/Ds, carrier and symbol synchronization and tracking, despreading, differential decoding, and descrambling. The quantized I and Q signals pass to a pair of 16-tap matched filters for calculating the signal correlation with the PN sequence. The output goes through a carrier phase rotation and acquisition process. The baseband processor also includes a frequency loop that tracks and removes the carrier frequency offset.

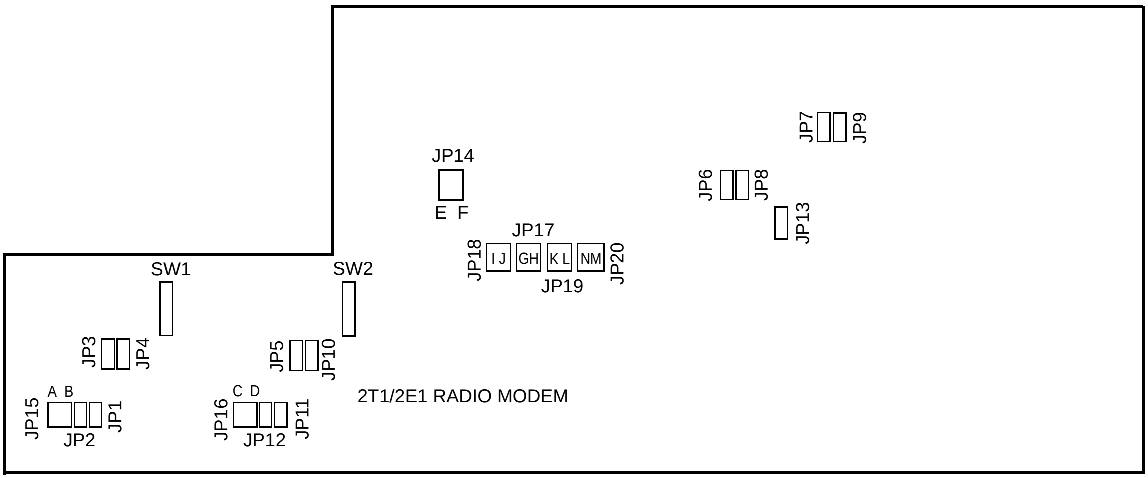
The PN correlator uses two samples per chip and despreads the chip rate back to the original data rate. This process provides 10.4 dB of processing gain for 11 chips per bit or 11.76 dB for 15 chips per bit. The correlator output pulse is further tracked by a symbol timing loop performing bit synchronization. The frequency and phase of the signal are corrected from an NCO that is driven by the phase-locked loop (PLL).

Demodulation of the signal in the early stages of acquisition is done by delay and subtraction of the phase samples. Once PLL tracking of the carrier is established, the PLL switches to a narrower loop, which achieves a better BER performance margin during the rest of demodulation. The demodulated signal is further differentially decoded and descrambled, then demultiplexed to recover the T1/E1, 2T1/2E1 tributary, the data service channel, and the voice orderwire.

The radio uses a CAN microcontroller to provide system configuration, including baseband processor, ADPCM codec, RF transmit and receive frequency synthesizer initialization, control, and monitoring. The system default configuration is initially built-in. The customer can use the Microsoft Windows-based Aurora 5800 software to reconfigure the baseband processor, and the transmit and receive synthesizers by using the radio's RS-232 interface. The new configuration can be downloaded into the radio and stored in the controller EEPROM.

Jumper Settings

Figure 2-10 Modem, component side



Do not change any of the settings marked “factory use only” in the following table. Doing so may invalidate the warranty.

Table 2-7 Jumper settings

Jumper	T1 Rate	E1 Rate 120 ohms	E1 Rate 75 ohms	2T1 Rate	2E1 Rate 120 ohms	2E1 Rate 75 ohms
JP1, JP2	OFF	OFF	ON	OFF	OFF	ON
JP3, JP4, JP5	OFF	OFF	ON	OFF	OFF	ON
JP6 to JP9	ON (normal operation); OFF (factory use only)					
JP10	OFF	OFF	ON	OFF	OFF	ON
JP11, JP12	OFF	OFF	ON	OFF	OFF	ON
JP13	ON (normal operation); OFF (factory use only)					
JP14	E (normal operation); F (CAN controller in-circuit programming)					
JP15	A	A	B	A	A	B
JP16	NA	NA	NA	C	C	D
JP17	G (normal operation); H (CAN controller in-circuit programming)					
JP18	I (normal operation); J (factory use only)					
JP19	K (normal operation); L (CAN controller in-circuit programming)					
JP20	M (normal operation); N (CAN controller in-circuit programming)					

NA = Not applicable.

DIP Switch Settings

Table 2-8 SW1 and SW2 positions

Position	AMI Encoder	B8ZS Encoder	HDB3 Encoder	Comment
1	OFF	ON	ON	
2	ON (default setting)			OFF (factory use only)
3	OFF	ON	ON	
4	ON (default setting)			OFF (factory use only)
5	ON (default setting)			OFF (factory use only)
6			ON	
7	See Table 2-9.		ON	
8			ON	

Close = ON; Open = OFF

Table 2-9 SW1 and SW2 positions, options

Position			Option Selected	Application
6	7	8		
ON	OFF	OFF	0 to 133 feet	T1
OFF	ON	ON	133 to 266 feet	
OFF	ON	OFF	266 to 399 feet	
OFF	OFF	ON	399 to 533 feet	
OFF	OFF	OFF	533 to 655 feet	
ON	ON	ON	75 ohm (with JP1 and JP2 OFF) 120 ohm	E1
ON	ON	OFF	AT&T CB113	Repeater
ON	OFF	ON	FCC Part 68, Option A	Network interface
ON	OFF	OFF		

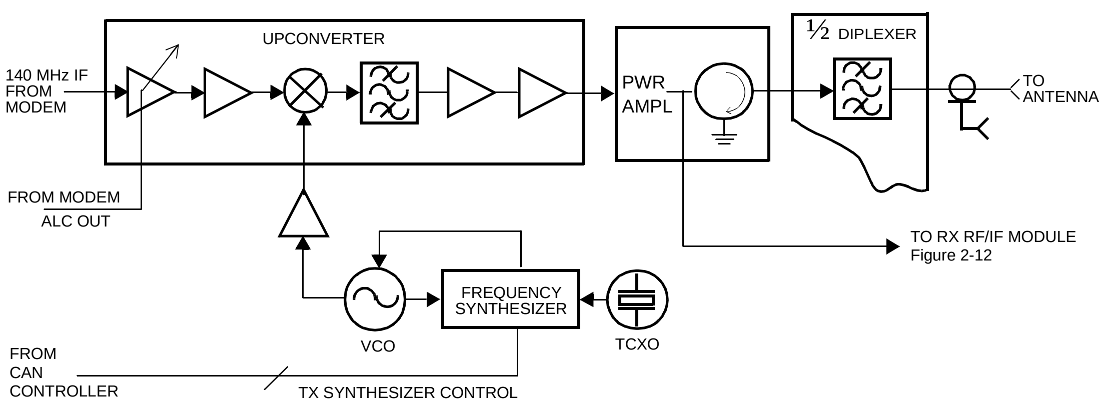
Close = ON; Open = OFF

Upconverter and Power Amplifier

The Upconverter receives the 140-MHz IF signal from the modem. The signal passes into the variable gain amplifier (VGA) section that provides about 10 dB AGC range. The IF signal is then mixed with the LO signal that is generated from the transmit synthesizer. The RF bandpass filter section at the output is centered at f0 5.7875 GHz with passband BW of 125-MHz and a minimum rejection ratio of 40 dBc at f0 + 232.5 MHz.

The filtered upper sideband RF signal then passes into the RF intermediate power amplifier (PA) to generate a linear power up to about 0 dBm level. The ALC function keeps the transmit PA at a constant output power level for all the operating temperature range. The PA provides about 23 dB gain and generates up to about +23 dBm maximum output level.

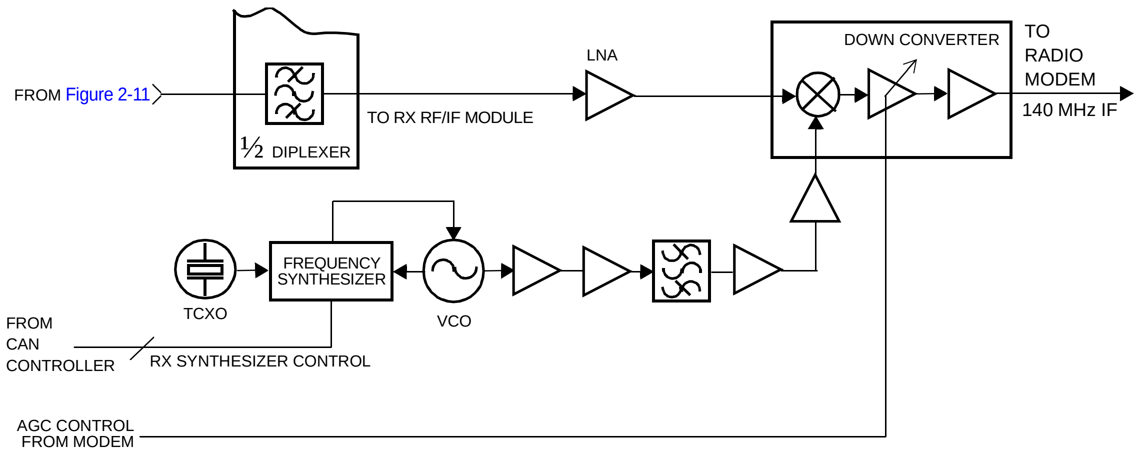
Figure 2-11 Upconverter and Power Amplifier block diagram



Down Converter and Low-Noise Amplifier

The incoming RF signal from the Antenna Coupling Unit (ACU) is amplified by a Low-Noise Amplifier (LNA) and then passes into the Down Converter (Figure 2-12). The signal is amplified and then mixed with the LO signal to down-convert it to a 140-MHz IF signal.

Figure 2-12   Down Converter block diagram



Nominal Frequencies

The nominal frequencies of the Upconverter and Down Converter LO synthesizers are initially set at the factory. The LO frequencies can be reprogrammed in the field by using the Aurora 5800 utility software.

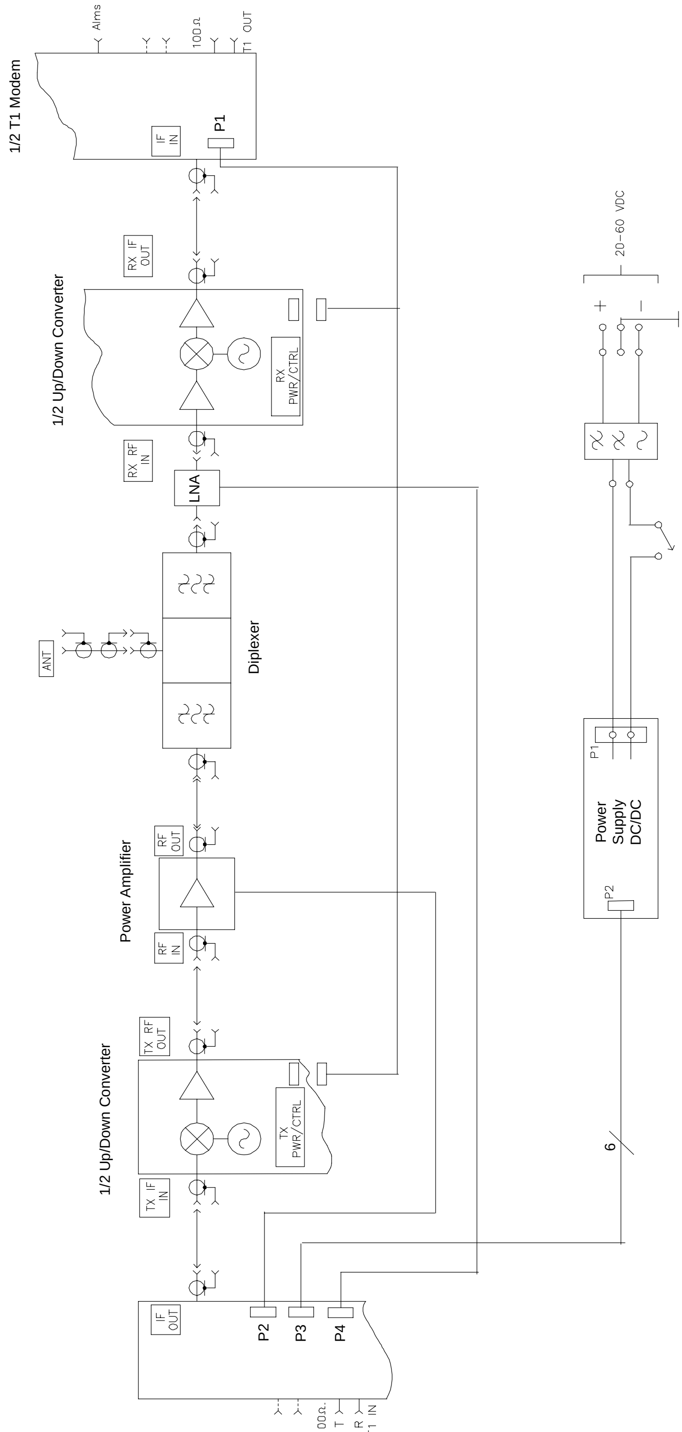
Antenna Diplexer

The antenna diplexer consists of two cavity-type filters. The transmit-section insertion loss and the receive-section insertion loss are both less than 3 dB. The return loss is typically better than 16 dB. The diplexer provides more than 80-dB isolation between the transmit and receive sections. This isolation prevents the receiver LNA from being overloaded by transmitter power leakage.

Aurora 5800 Block Diagram

Figure 2-13 is a block diagram of the Aurora 5800 radio.

Figure 2-13 Aurora 5800 block diagram (DC operation shown)



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Chapter 3
System Description

Frequency Plans

Coexistence with Other Radio Links

The Aurora can coexist with other similar radio links in the vicinity. Operation with other links can be achieved through the use of different spreading codes, frequencies, “building blockage”, and antenna pattern and polarization separation. In congested urban areas, Harris recommends the use of a larger, more directional antenna; the narrower beam width allows less interference into the receiving Aurora and lowers interference levels into other radios in the vicinity.

Aurora Frequency Plan

The Aurora has one standard frequency plan available. Figure 3-1 and Figure 3-2 illustrate this plan. The “A” frequency pair uses the first and third frequencies shown. One site transmits on A1 and receives on A2. The site at the opposite end of the link transmits on A2 and receives on A1. The “B” frequency pair uses the second and fourth frequencies shown in the illustration. One of the two pairs may work better than the other in a particular area based on the nature of the interference.

Figure 3-1 Aurora 5800 T1/E1 frequency plan

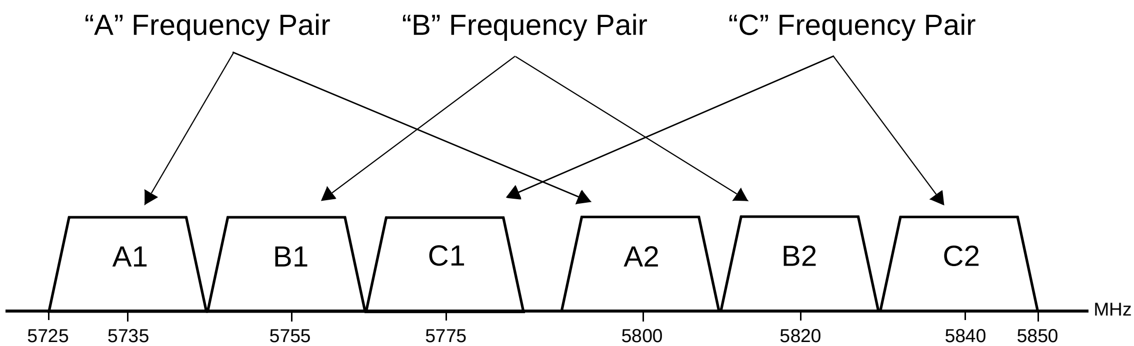
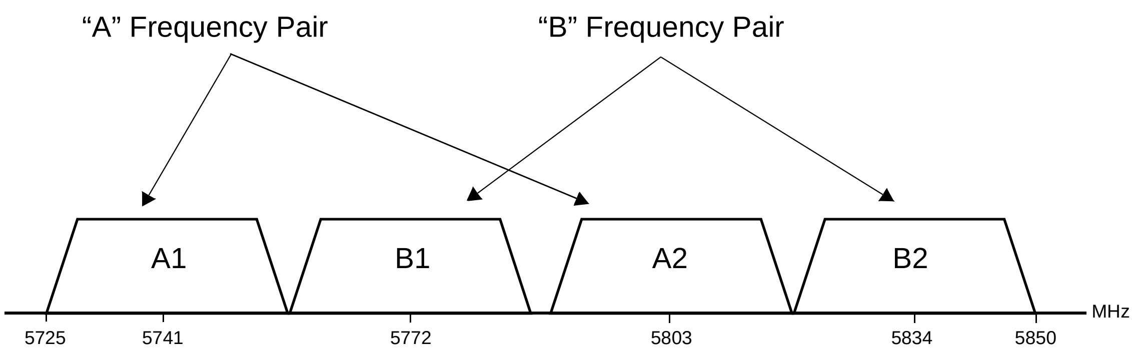


Figure 3-2 Aurora 5800 2T1/2E1 frequency plan



Spread Sequence Pseudo-random Number (PN) Selection

The Aurora radio can be configured with different spread sequence codes. The use of different codes on nearby Aurora 5800 co-channel links ensures interlink privacy. However, the assignment of different codes to adjacent or nearby links does not lower interference levels. Co-channel interference may degrade receiver thresholds and thus reducing fade margins, which increases multipath outages in Aurora links, but usually not beyond the link’s outage objective.

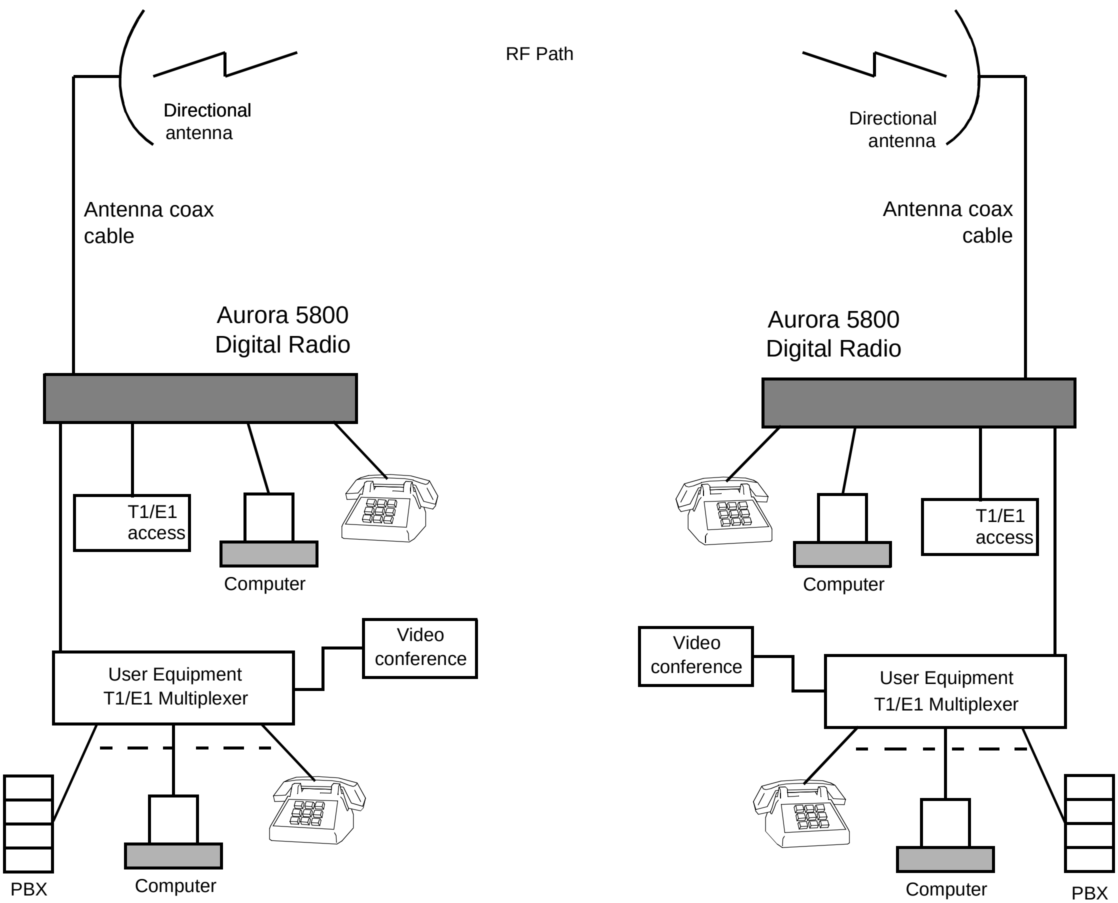
The Aurora 5800 has four preset PN spread sequence codes. Every unit shipped to a customer contains a default code.

Aurora 5800 Radio Configurations

Point-to-Point Configuration

In a point-to-point configuration, two radios communicate only with each other. Either or both of the radios may be mobile, as long as they remain within each other's range. Figure 3-3 shows a typical point-to-point radio setup.

Figure 3-3 Point-to-point configuration

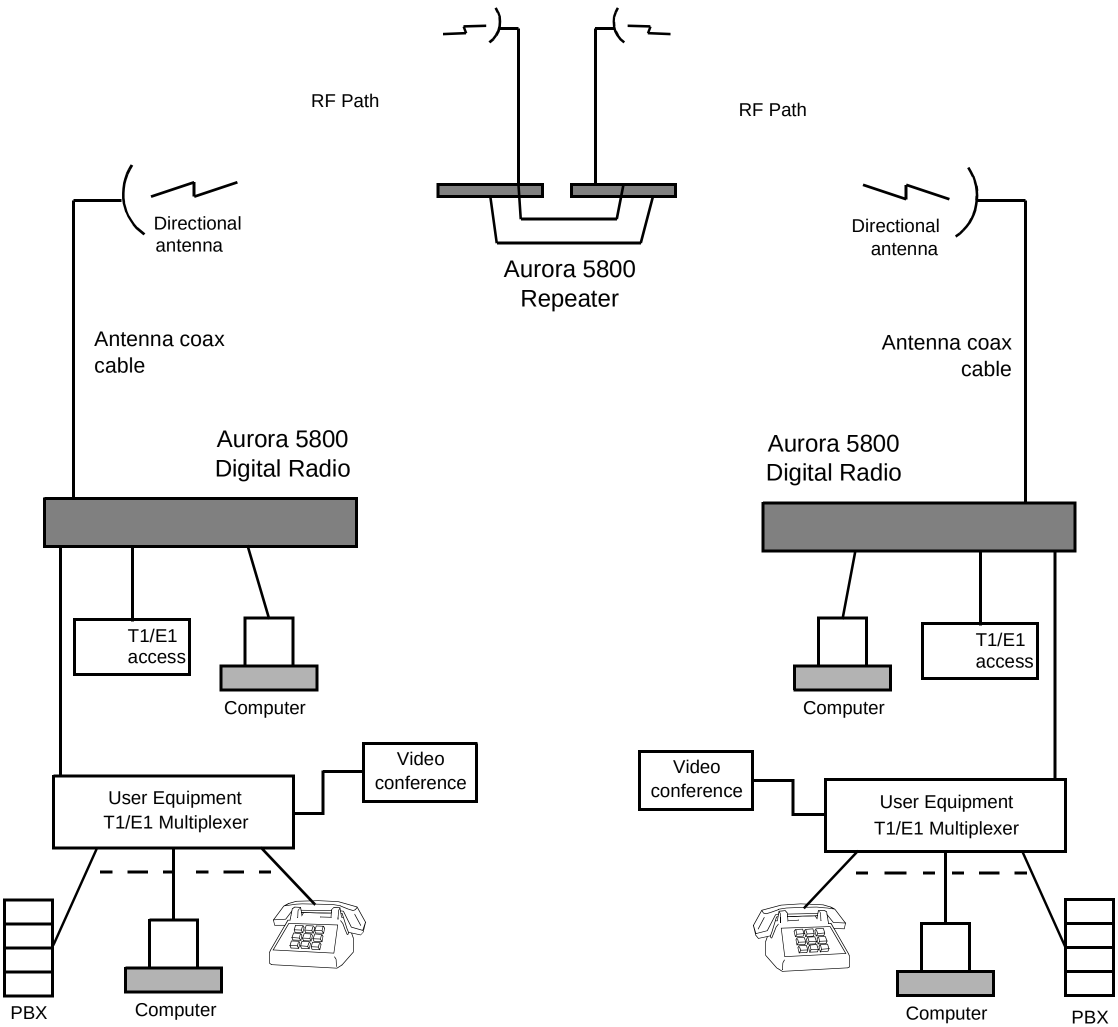


Repeater Configuration

A repeater extends the maximum communication range beyond that of a single hop. In this configuration, two additional radios are installed between the terminal radios in the hop. Each of these intermediate radios faces one of the terminal radios in the hop. A transmission from one end of the hop is received by the repeater radio facing it, is passed on to the other radio in the repeater, and then relayed to the far-end radio. Figure 3-4 illustrates this configuration.

Besides Aurora 5800 “active repeaters”, other 5.8 GHz repeater options are available, including “passive reflectors” and “beam benders” (back-to-back antennas) if one RF path is very short, and solar-powered “RF” repeaters.

Figure 3-4 Repeater configuration



For repeater configurations, make sure there is enough frequency separation on the two transmitting channels. Use different antenna directions, polarization, or channel frequencies to achieve this separation.

Multihop and Hubbing Arrangements

Network Planning

Three transmit/receive frequency pairs are available to single T1/E1 links, and two pairs are assigned to 2T1/2E2 links for hubbing and multihopping Aurora 5800 radio links in the 5735 to 5850 MHz ISM band (see Figure 3-1).

T1/E1, 20-MHz bandwidth, go/return RF channels:

- Pair A: 5735/5800 MHz
- Pair B: 5755/5820 MHz
- Pair C: 5775/5840 MHz

2T1/2E1, 31-MHz bandwidth, go/return RF channels:

- Pair A: 5741/5803 MHz
- Pair B: 5772/5834 MHz

Any of these duplex RF channels may be assigned a new Aurora 5800 link, taking into consideration possible interference to and from other links in the area that has been assigned the same channels.

Each spread-spectrum radio in the area has a discrete PN spread sequence code assigned by user selection, as explained on page 44. While the use of different PN codes does mitigate the effect of external interference on the victim radio's thresholds and fade margins by a minimal amount, perhaps by only a dB or two, it does ensure that only wanted data is demultiplexed on a link.

Interference into a digital receiver is acceptable as long as it does not degrade its threshold (fade margin) for increased outage or degraded errored-second performance beyond the user's performance objectives. Many shorter Aurora 5800 links may be so deployed with very low (< 20 dB) fade margins, permitting very high levels of co-channel interference that would otherwise be unacceptable on longer fading hops.

The planning of a complex network of Aurora 5800 links may include the following:

- The selection and placement of antennas on towers, rooftops, and building walls
- RF channel and polarization assignments
- Aurora 5800 power output adjustments and PN spread sequence code selections
- The calculation of acceptable levels of interference, accommodating the link's fade characteristics and performance objectives

With careful planning, even the most complex Aurora 5800 networks and systems may be commissioned in most areas.

Parallel-Path Arrangement for Higher Capacity or Protection

Two Aurora 5800 radios that are assigned the same frequency pair may be paralleled on a single path either with dual-polarized antennas or separate cross-polarized antennas positioned at similar heights. With these separate antennas at the same elevation, paralleled paths fade together, ensuring that the > 9 dB carrier-to-interference (C/I) ratio objective for error-free data transmission is maintained at all times.

A single-polarized antenna may also be assigned to provide either a protection channel (through a T1 switch) or to double the link capacity. The requirement is, however, that the radios be assigned different RF channel pairs and that 3-dB hybrid couplers combine these radios to a common antenna feed system. This additional 6-dB path loss is acceptable in meeting the user's performance objectives on most shorter paths.

Multihop Networking Arrangement through Repeaters

Longer Aurora 5800 paths of hops connected in tandem fade independently, that is, a victim path could fade to its threshold (outage) point while the co-channel interference from another path is high.

The two interference mechanisms are:

- Receive backside reception from and transmit backside radiation to an adjacent link
- Overshoot from a path two hops away

Backside interference is eliminated by the assignment of different RF channels on adjacent hops out of a repeater by a “four-frequency” plan (two duplex channels).

Interlink overshoot interference is mitigated by cross-polarizing every other hop, H-H-V-V-H and so forth, on tandem systems; and/or by ensuring that the links are not deployed in a straight line, that is, path azimuths are staggered by at least 3 to 5 degrees for adequate antenna discrimination to overshoot interference.

Hubbing (Star) Networking Arrangement Out of a Node

Aurora 5800 spur links out of a node or repeater site provide point-to-point T1/E1 connectivity to multiple sites in an area. With the limited number of two or three RF channel pairs available to a user, co-channel interference out of a nodal site must be taken into consideration so that link performance beyond the user’s objectives will not be degraded.

Interference into other links out of a hub site is mitigated by the following examples:

- Use of different RF duplex channels
- Cross-polarization between links
- (Usually larger or shrouded) antennas with higher discriminations
- Reduced power outputs on short paths
- Blockage with antennas positioned on the opposite sides of buildings or elevator penthouses
- PN code selection to prevent intelligible crosstalk
- Changing some links to Aurora 2400 (in the 2.4 GHz band)

Wanted and Unwanted Signal Path Antennas at a Hub Site

At the Same Elevation (correlated path fading)

With antennas assigned to the wanted and interfering (co-channel) interference paths at the same elevation, C and I tend to fade together. This tendency lowers the C/I objective to about 9 dB, similar to the parallel-path example on page 49. It is necessary only to cross-polarize the interference and wanted paths for > 20-dB isolation to meet this objective easily.

At Different Elevations (independent path fading)

At hub sites with independently fading wanted and interfering signals, C/I = the interfering transmission signal's antenna discrimination to the victim path's azimuth.

Interference does not affect the performance of an Aurora 5800 link if the following C/I ratio is not exceeded.

C/I = Fade Margin + T/I
= Required Tx Antenna Discrimination, dB

where

- Fade Margin is the victim radio link's fade margin necessary to meet its outage objectives, typically 15 to 35 dB.
- T/I is the victim receiver's threshold-to-interference ratio. For the Aurora 5800 (Figure E-10):

  15 dB, co-channel
  –15 dB, adjacent channel

Therefore, if a longer Aurora 5800 link is assigned antennas to provide a 35-dB fade margin (–55 dBm median RSL) to meet its outage objective (see Chapter 5), the C/I ratio at the victim receiver should not exceed about 35 + 15 = 50 dB (–105 dBm interference level).

In this case, a standard 4-foot parabolic antenna with > 100/135 degree discrimination angle for co- and cross-polarized paths respectively (or a 6-foot antenna with 30/90 degree discrimination angles) to the interfering radio at the hub site would be suitable.

If a shorter Aurora 5800 link's outage objective is met with only 20-dB fade margin, and the computed free-space RSL is the same (-55 dBm), a lower 20 + 15 = 35 dB C/I is acceptable (–75 dBm interference level). Then, Aurora 5800 radio's standard 2-foot square antenna, cross-polarized to the victim link, is suitable.

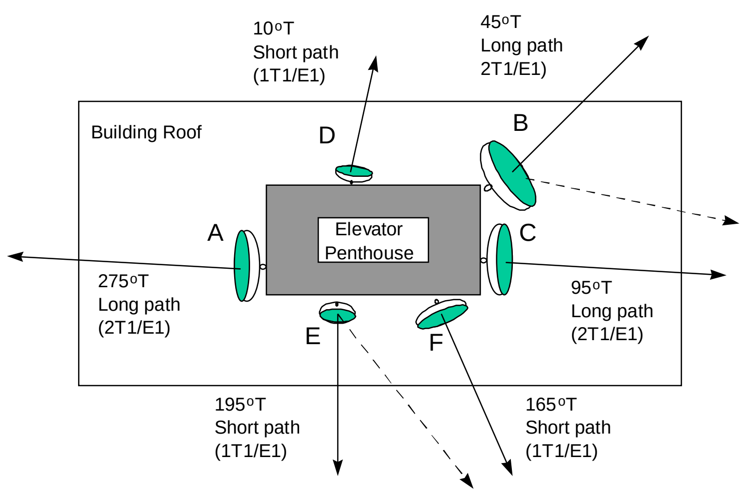
Hubbing Examples

Hubbing arrangements are categorized as blocking and nonblocking.

Blocking Arrangement

To introduce blockage, Aurora 5800 radio's antennas are positioned on the opposite sides of the building roofs, water tanks, microwave shelters, and so forth, thus greatly reducing interfering signal coupling between links. See Figure 3-5.

Figure 3-5 Roof mounting with building blockage



Channel Assignments for the Long 2T1/E1 Paths

Antenna A is placed on the opposite side of the elevator penthouse hut from antennas B and C on the building roof. The blockage provided by the hut reduces the interference level > 20 dB between path A to the west, and paths B and C to the east, permitting the co-channel assignment of A to B or C even on co-polarized paths with small antennas.

Exposed interference paths are shown–path B to/from path C, for example. With only a single antenna discrimination and no interference blockage, paths B and C are assigned adjacent channels with cross-polarization.

Paths E and F are short with low fade activity; so higher interference levels with smaller antennas are permitted.

As previously discussed, the required antenna discrimination is computed from

C/I = Required Fade Margin + T/I.

In the long A, B, and C paths, the required fade margin necessary to meet the performance objectives might be 35 dB. For a co-channel operation, the T/I is 15 dB, requiring 50 dB of antenna discrimination. 4 ft (1.2 m) antennas cross-polarized between paths B and C provide this necessary discrimination with a path azimuth differences > 20^{o}. All three paths are thus assigned the same RF channel with B cross-polarized to A and C.

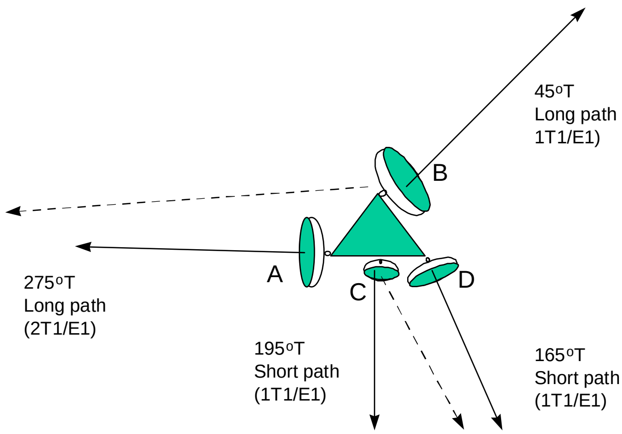
Channel Assignments for the Short 1T1/E1 Paths

Assignments to these shorter paths are to the channels adjacent to the long paths to reduce the interference level by > 30 dB. The short paths may be assigned 2 ft (0.6 m) dishes, with paths E and F cross-polarized. These smaller cross-polarized antennas provide about 43 dB discrimination between paths E and F, which meets the 25 + 15 = 40 dB C/I objective (25 dB required fade margin and 15 dB co-channel T/I).

The Aurora 5800 transmitter power outputs on the short paths E and F may be reduced to lower the interference levels. This process reduces fade margins while still meeting the performance objectives on these short paths.

Figure 3-6 shows a hubbing example at sites with no interlink blockage, as often occurs with tower-mounted antennas. In this arrangement, channel assignments made to a large number of links at a common hubbing site may take into account additional cases of acceptable levels of threshold (fade margin) degradation.

Figure 3-6 Tower mounting with no blockage



Channel assignments are first made to the longer, fading paths. With no blockage, larger antennas provide higher discriminations between the longer paths. A and D are co-channel cross-polarized; C and D are assigned an adjacent channel cross-polarized, with perhaps > 5 dB of allowable threshold degradation taken on these short nonfading hops.

Of course, in very difficult cases (many long fading hops out of a hubbing site, for example), HP antennas with shrouds providing > 20 dB additional discrimination may be assigned.

Conclusion

These hubbing examples are but a few of the many hubbing acceptable arrangements for Aurora 5800 links. Nearly any number of Aurora 5800 links can be hubbed at a single site, with RF channel assignments, path polarizations, antenna sizes and types, Aurora 5800 power output adjustments, acceptable fade margin degradation to short nonfading hops, and PN code selection all carefully considered to meet the network’s performance objectives.

Harris MCD Service

Harris Microwave Communications Division can provide rapid assistance in the optimum selection of antenna feed systems that meet regulatory and performance objectives for any specific Aurora 5800 single link, paralleled link, multihop, or hubbing application necessary to meet the user's networking arrangement and performance objectives.

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Chapter 4
Technical Specifications

Features

- 5.725 to 5.85 GHz ISM bands
- Point-to-point, line of sight up to 15 miles (24 km) (standard 28-dBi, flat-panel antenna)
- Full frequency duplex operation
- Standard T1 (DSX-1) or E1 (CEPT-1), and 2×T1 or 2×E1 interfaces
- Typical RF power, +19 dBm
- Direct sequence spread spectrum coding and DQPSK modulation
- –88 dBm (T1/E1) and –86 dBm (2×T1/2×E1) typical receiver threshold at BER = 10^{-6}
- Synthesized transmitter and receiver frequencies
- Three frequency-channel plans for T1/E1 and two frequency-channel plans for 2T1/2E1
- Digital voice orderwire and data wayside traffic
- Craft Interface Tool (CIT) interface for local and remote radio monitoring and control
- Supports repeater configuration
- SNMP network management with external proxy agent

Performance (One Hop)

System Gain (at BER=10^{-6})

Carrier Designator	Value
T1/E1	107 dB
2×T1/2×E1	105 dB, typical

Frequency Plan (Standard)

Carrier Designator	Frequency Pair	Band (GHz)	
T1/E1	A	5.735	5.800
	B	5.755	5.820
	C	5.775	5.840
2T1/2E1	A	5.741	5.803
	B	5.772	5.834

Acquisition Time

< 50 ms

Transmission Delay

Path	Time (µs, max.)
Radio only	50
10 mi/16 km	100
20 mi/32 km	150

Dispersive Fade Margin

Better than 60 dB at BER = 1×10^{-3}

MTBF

430,000 hours

Transmitter

Specifications

Characteristic	Value
Output power	+19 dBm, typical at antenna port (+10 dBm min.)
Power density	< +8 dBm/3 kHz
Spurious/Harmonics	< –60 dBc
Frequency range	5.725 to 5.85 GHz
Frequency stability	Within ±20 kHz
Frequency selection	Synthesizer default value stored in MCU, and software-selectable
Increments	500 kHz
IF frequency	140 MHz
Modulation	Direct Sequence Spread Spectrum, DQPSK

PN Code and Chip Rate

Barker or Modified Barker Codes:

Data Rate	Chip Rate
T1 (Aggr. 1.664 Mb/s)	15 chips/bit, 12.48 Mcp/s
E1 (Aggr. 2.176 Mb/s)	11 chips/bit, 11.968 Mcp/s
2T1 (Aggr. 3.208 Mb/s)	11 chips/bit, 17.644 Mcp/s

Receiver

Specifications

Characteristic	Value
Noise figure	8 dB max. at antenna port
Image rejection	80 dB minimum
AGC range	70 dB
Frequency selection	Synthesizer default value stored in MCU, and software-selectable
Increments	500 kHz
IF frequency	140 MHz
Processing gain	≥ 10 dB
Demodulation	Noncoherent (matched filtering correlation)
Carrier acquisition range	Better than ±100 kHz
Carrier tracking range	Better than ±150 kHz
Clock acquisition range	Better than ±100 PPM

Receiver Level

–40 dBm nominal

–20 dBm max., no performance degradation

–10 dBm max., no damage

Receiver Level at 10^{-6} BER

Threshold	T1/E1	2T1/2E1
Maximum	–89 dBm	–87 dBm
Typical	–90 dBm	–88 dBm

Antenna/Diplexer

Specifications

Characteristic	Value
Antenna (optional)	28-dBi gain, flat-panel antenna
Mechanics	External antenna, internal ACU
Antenna port	N-type female connector
Impedance	50 ohms
Return loss	≥ 18 dB
ACU RF filter type	Cavity diplexer with internal temperature compensation

Frequency Spacing

C-Band

Carrier Designator	Value
T1/E1	65 MHz T-R
2T1/2E1	62 MHz T-R

Digital Data Interface

Data Capacity

- 1×T1 or
- 1×E1 or
- 2×T1 or
- 2×E1

T1 Specifications

Characteristic	Specifications
Digital interface	DSX-1, meets ITU-T G.703, G.824, AT&T Pub 62411, Bellcore GR-499-CORE
Connector	RJ-48C, balanced, 100 ohms
Line code	B8ZS or AMI (DIP switch selectable)
Continuity	Input T1 signal, 1.544 Mb/s ± 130 PPM Pattern should be pseudorandom $\geq 2^{15} - 1$ Requirement: error-free performance
Minimum input level	−6 dB below nominal (0 dB = 2.4 Vp)

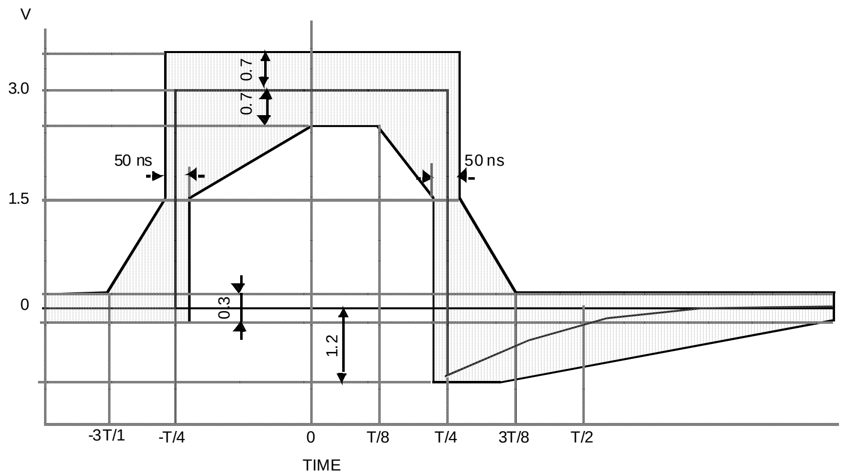
Pulse Shape

Meets ITU-T G.703 mask as shown in Figure 4-1.

Pattern should be pseudorandom $\geq 2^{15} - 1$

Requirement: error-free performance

Figure 4-1 Pulse mask for T1



Jitter

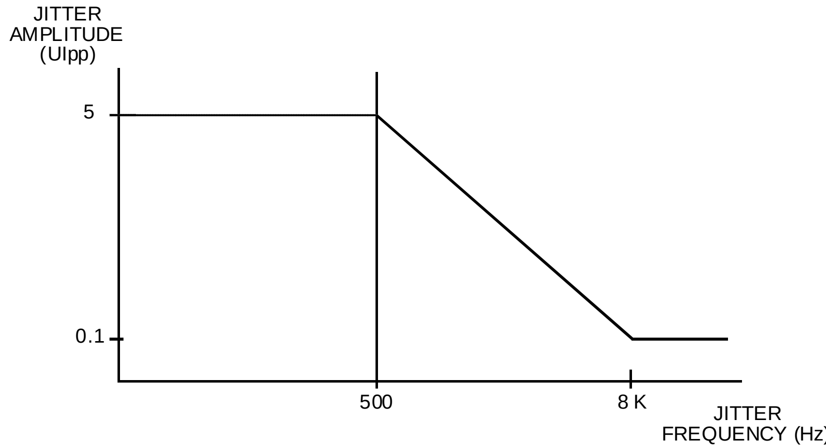
Output Jitter

According to ITU-T G.824, the peak-to-peak limit is as follows:

B1	5.0 UI	BPF cutoff: lower 10 Hz and high 40 kHz
B2	0.1 UI	BPF cutoff: lower 8 Hz and high 40 kHz

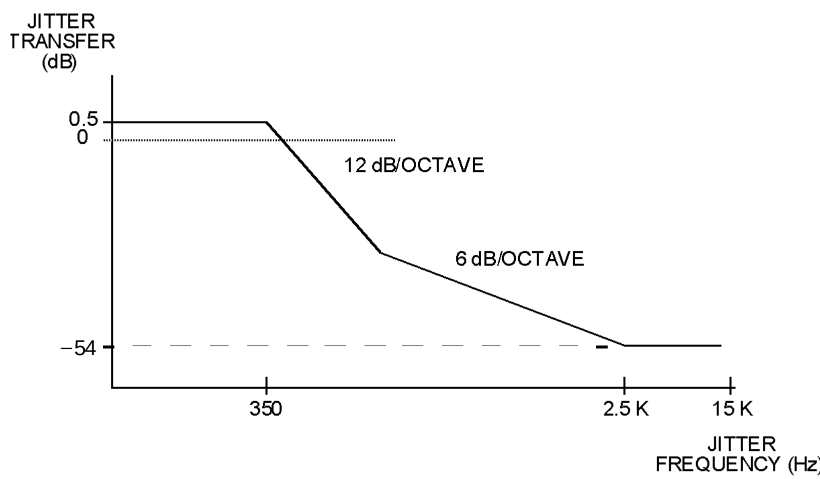
Input Jitter Tolerance

Figure 4-2 Input jitter tolerance



Jitter Transfer Function Tolerance

Figure 4-3 Jitter transfer function tolerance



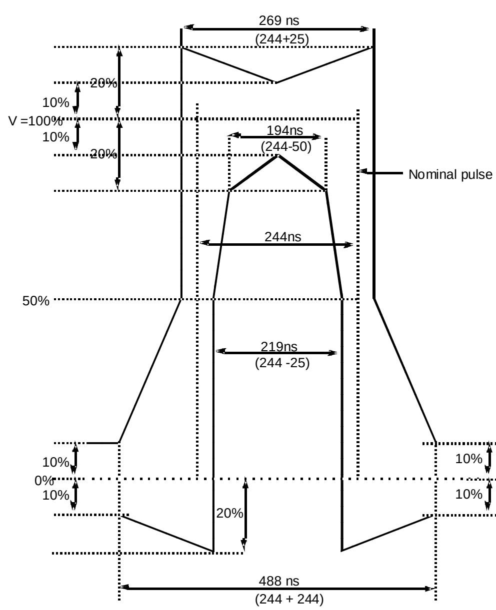
E1 Specifications

Characteristic	Specifications
Digital interface	CEPT-1, meets ITU-T G.703, G.823
Connector	BNC, unbalanced, 75 ohms, or RJ-48C, balanced, 120 ohms
Line code	HDB3 or AMI (DIP switch selectable)
Continuity	Input E1 signal 2.048 Mb/s ± 50 PPM Pattern should be pseudorandom > 2^{15}-1 Requirement: error-free performance
Minimum input level	–12 dB below nominal (0dB = 2.4 Vp)

Pulse Shape

Meets ITU-T G.703 mask as shown in Figure 4-4.

Figure 4-4 Pulse shape



Jitter

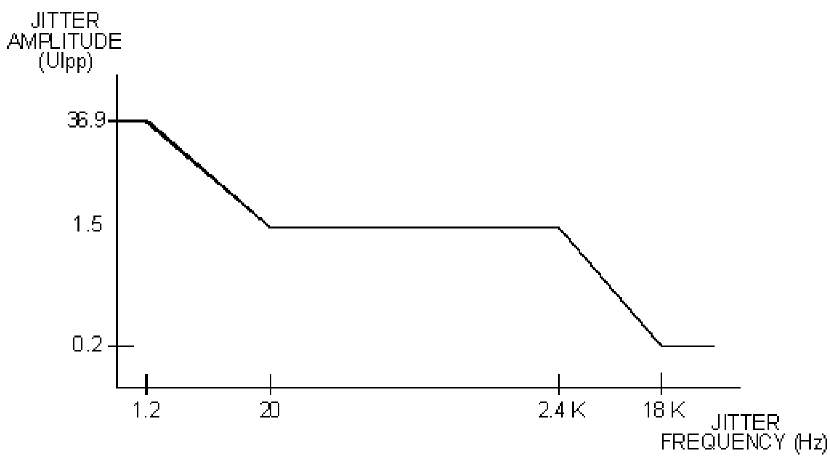
Output Jitter

According to ITU-T G.823, the peak-to-peak limit is as follows:

B1	1.5 UI	BPF cutoff: lower 20 Hz and high 20 kHz
B2	0.05 UI	BPF cutoff: lower 18 kHz and high 100 kHz

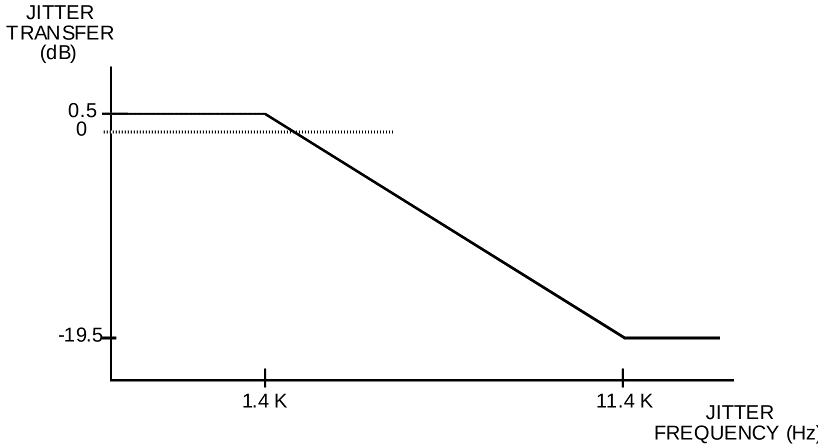
Input Jitter Tolerance

Figure 4-5 Input jitter tolerance



Jitter Transfer Function

Figure 4-6 Jitter transfer function



Ports, Indicators, Test Points, and Alarms

Ports

Port	Specifications
ALARM	TX and RX alarms by dry contact relays, DE-9, male
DATA	DA-15, asynchronous, female
PHONE	Voice orderwire, 2-wire, RJ-11
PHONE	Voice orderwire, 2-wire, RJ-11

Programmability

Default system factory-configured
Software-programmable with a PC through RS-232 CIT port

Front-Panel LED Indicators

Label	Color	Indication
PWR	Green	Power is on
TX ALM	Red, active high	Transmitter power alarm
RX ALM	Red, active high	Receiver sync alarm

Front-Panel Test Jacks

Label	Test
RSSI	Receiver Signal Strength Indicator: yellow, 0 to 4.8 volts, corresponding to approximately receive input level of –90 to –20 dBm
GND	Ground, black

Built-in Diagnostics (through RS-232)

- SIGNAL LOSS
- AIS
- RX synthesizer lock alarm
- TX synthesizer lock alarm

Power Specifications

Characteristic	Value
Input Voltage	AC supply: Universal AC 100 to 250 V DC supply: ± 21 to 60 V
Output Voltage	+5 V, 3 A, maximum +12 V, 2 A, maximum –5 V, 0.3 A, maximum
Power Consumption	30 watts, maximum
Fuse	Built in with the power supply

Environmental Specifications

Characteristic	Value	
Operational Temperature	0 to +50°C	32 to 122°F
Storage Temperature	–40 to +70°C	–40 to 158°F
Humidity	95% noncondensing	
Altitude (above sea level)	4,572 meters	15,000 feet

Mechanical Specifications

The Aurora 5800 radio requires one rack-mounting space (RMS) for a rack, plus one open RMS above and one open RMS below, or table-top placement in an indoor environment. For placement outdoors this radio can be installed in an outdoor cabinet.

Characteristic	Value	
Height	1.75 inches	45 mm
Width	17 inches	432 mm
Depth (including the connectors)	11.8 inches	300 mm
Weight	7.7 lb	3.5 kg

Chapter 5
Installation Planning

General

Spread-spectrum, point-to-point radio relay links like Aurora's are allowed by various regulatory agencies to operate unlicensed on a "no-interference, nonprotection basis". Because of the unlicensed nature, the Aurora radios require neither licensing nor prior frequency coordination in most regions, including the U.S.A.

Caveat

The Aurora installation software with its adjustable power feature is for professional installer use only, as mandated by the Federal Communications Commission (FCC, Part 15).

Harris Corporation does not assume any liability or damage arising out of the application or misuse of this Aurora radio product and its software.

Interference

While it is expected that many Aurora 5800 links will be deployed in urban areas that are (or will be) frequency-congested, the robust nature of the digital modulation and spread spectrum technology should mitigate any noticeable customer traffic degradation caused by interference.

However, good engineering judgment should be exercised by the operator and professional installer before selecting paths or locations near equipment or facilities that could generate interfering signals. Such equipment might include high-power ISM devices. Additionally, precaution should be taken when links are deployed in a region where a large number of other 5.8-GHz, point-to-point or point-to-multipoint links are installed.

In some interference cases, threshold degradation causing an increase in short-term multipath outage or a slightly degraded Residual Bit Error Ratio (RBER) may occur, either or both of which can probably be tolerated.

As a general rule, the deployment of a larger antenna with a smaller beam width and higher front-to-back ratio, an antenna relocation for better interference shielding, or a polarization change are often very effective in mitigating most interference cases. These subjects are discussed in a later section. Such field changes, to mitigate interference and to otherwise improve Aurora 5800 link performance, require no prior regulatory approval in unlicensed links.

Performance and Economic Considerations

Aurora 5800 microwave transport offers significant technical and economic advantages over conventional copper- or fiber-based leased or owned transport alternatives when availability, cost-effectiveness, implementation time, security, and difficult terrain or access are significant network design considerations.

Ref. [1] describes how the economic and technical challenges of creating a new telecommunications infrastructure are met more effectively with point-to-point radio links than with traditional wireline-based solutions.

When Aurora 5800 digital transport facilities are compared to conventional leased-line services, the following four factors are taken into consideration:

- Transmission quality and reliability
- Circuit availability
- Short-haul costs
- Construction time

The infrastructure of most telephone networks has inherent regulatory or technical characteristics that limit its ability to meet microwave's superior transmission quality, reliability, and other performance and availability characteristics.

It is not unusual for the telephone company's "local loop" subscriber facility to have an RBER of 100 times, or more, worse than microwave links along with a long-term outage (unavailability) measured in hours per year. Simple and highly reliable Aurora 5800 microwave links can provide customers with superior service.

Microwave's short-term reliability standards, in excess of 99.995% to 99.999% (a few minutes outage per year), are often significantly better than those associated with typical leased copper services.

Antenna Installation

Instructions for antenna installation usually are part of the antenna kit. Follow these instructions for good and effective antenna installation.

RF output power is set by Harris or authorized distributor. Do not change antennas, cable length, or type. To do so may violate regulatory rules.
If changes are necessary, contact Harris Customer Service or your authorized distributor.

Radio performance is affected by all aspects of antenna installation, including:

- Antenna type
- Line-of-sight path fade characteristics
- Antenna orientation
- Antenna placement
- Distance between antennas
- Distance between the radio and its antenna

To prevent equipment damage and shock hazard caused by lightning, antenna installation and the grounding system must comply with NEC or IEC standards, and local regulatory requirements.

Harris does not provide grounding kits.

Antenna Selection

Neither antenna power input nor EIRP constraints in North America (and most other regions that allocate this band for unlicensed point-to-point, radio-relay applications) limit the gain (size) of 5.8 GHz antennas.

Although the 28-dBi flat-panel antenna is standard with the Aurora 5800, any other antenna may be used. Most Aurora 5800 applications deploy nonpressurized antennas with N-type fittings for connection to foam coaxial feeders, however.

This device emits non-ionizing radiation. To meet RF safety requirements, steps must be taken to prevent all personnel from being closer than one (1) meter from the antenna main beam when the transmitter is operational.

Antenna Selection Criteria

All antenna designs address two concerns: *directivity* and *gain*. A third criterion in selecting an antenna is *polarization*.

Directivity

A highly focused directional antenna should be used for maximum sensitivity and power. This type of antenna also rejects signals not coming from the desired direction and provides a desirable increase in signal-to-noise performance.

Gain

Antenna performance is measured in “dBi” where “i” stands for “isotropic,” which describes the standard spherical radiation pattern. If the semiparabolic directional antenna has a gain of 24 dBi, it represents power and sensitivity levels that are over 200 times greater than those of a 0-dBi antenna. The FCC has a new rule on how much antenna gain affects the input power to the antenna and the output power of a radio operating in the 2400-MHz ISM band, but this rule does not apply to the 5.8-GHz links.

Polarization

All 5.8-GHz antennas offer a choice of linear polarization. Aurora 5800 radios usually operate with antennas that are polarized either vertically or horizontally, *as long as the polarization is the same at both ends of the path*. Cross-polarization greatly reduces signal strength.

Site Selection

Link Performance

Aurora 5800 radio's link performance can be characterized not unlike that of any conventional 6-GHz, point-to-point, nondiversity microwave link. Ref. [2] lists various availability and outage models and objectives from which to select.

While the "short-haul" objective (about 27 min/yr or 9 min/any month, end-to-end, one-way T1/E1 trunk outage) may be suitable for most applications, many Aurora 5800 radios are often used for temporary links or as an alternative to copper wire services. A higher outage objective may therefore be assigned to a DSSS link, resulting in significant savings in the cost of antennas and support structures.

Aurora 5800 radio's wide, robust transmitted spectra reduce the probability of multipath fade outage on these links. In sharp contrast to FM analog radio links where the RF carrier disappears, or a broadband Quadrature Phase-Shift Keying (QPSK) or other digital links where increased multipath outage occurs with signal distortion (dispersion), spread-spectrum signals are not nearly as affected by multipath notches.

Aurora 5800 radio's Dispersive Fade Margins (DFMs), the measure of its sensitivity to path-generated spectrum distortion, exceed 60 dB and are thus disregarded in performance calculations.

For this reason, the addition of diversity protection to lower multipath fade outage is rarely necessary to meet performance objectives. If equipment protection is needed, then dual Aurora 5800 radios on cross-polarized or separate antennas with T1 or E1 span line switches are suggested. Vertically separated antennas (paths) provide a reduction in multipath outage, although T1/E1 span line switching is not hitless.

Path Clearance and Reliability

As a general rule, spread-spectrum links can be assigned about the same 0.6 F_1 at $k = 1$[1] path clearance as standard (licensed point-to-point analog and digital radio-relay links) in the 6-GHz band.

Since many Aurora 5800 links are short and nondiversity, low clearance paths over reflective terrain (such as open fields or lakes) are usually more stable (fade-free) than those with excessive path clearance.

Tables of link reliability under different conditions of terrain, climate, antenna size, and path distance are available from Harris [Ref. 3]. The received signal level and path reliability (outage or SESR) results under a wide variation of link design conditions can be determined by using Harris MCD's *StarLink* shareware personal path engineering computer program, which is available at no cost. [Ref. 4]

Antenna Site Selection

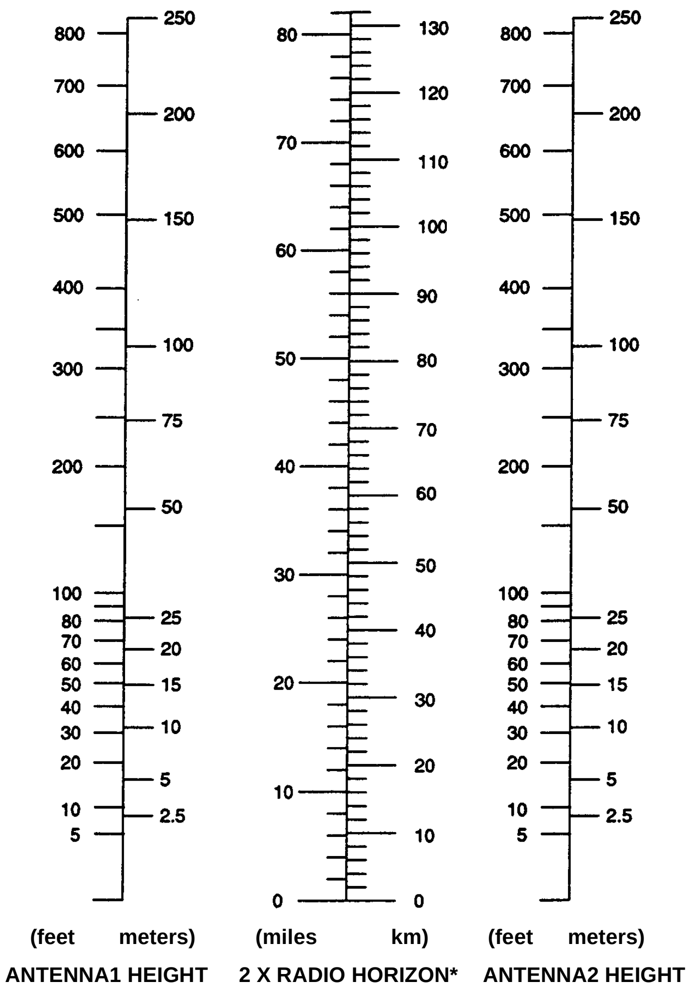
A good antenna site has the following qualifications:

- A clear line of sight for optimum power and maximum range
- Sufficient elevation for maximum line-of-sight range
- Correct orientation and correct directional aim at the target antenna
- Shortest possible distance between antenna and radio unit

1. "*k*" is the ratio of the radius of curvature (refractivity) of the radio path to that of the earth. A $k = 1$ (no refractive ray bending over a true earth) is commonly used for longer paths.

A reasonable approximation of the radio horizon (line-of-sight) based on antenna height is shown in Figure 5-1. On the chart, set a straight-edge so that it crosses the height of one antenna in the column on the left and the height of the other antenna in the column on the right; the radio horizon in miles or kilometers is shown where the straight-edge crosses the center column.

Figure 5-1 Antenna height chart



*Path length for grazing clearance over flat terrain without trees or other obstructions.

Antenna Cable Selection

Harris recommends low-loss and low-cost RF cables to connect the radio to the antenna. Andrew's LDF4-50A coaxial cable is standard with the Aurora 5800 radio. See Table 5-1 for cable characteristics.

Table 5-1 LDF4-50A cable parameters

Characteristic	Value
Cable Part Number	LDF4-50A
Nominal Size (in.)	1/2
Impedance (ohms)	50
Approx. Atten, at 5.8 GHz dB/100 ft (dB/100 m)	6.5 (21)
Weight, lb/ft (kg/m)	0.15 (0.22)
Diameter over Jacket, in. (mm)	0.63 (16)
Min. Bending Radius, in. (mm)	5 (125)

Antenna Alignment

The antenna can be aligned by monitoring the RSSI test jack. Use a digital multimeter to measure the RSSI voltage when adjusting the direction of the antenna. The RSSI level of 0 to 4.8 VDC corresponds to the receiver input level of approximately -90 to -20 dBm. See Table 5-2.

Typical RSSI Voltage versus Receiver Input Level

Table 5-2 Typical RSSI voltage versus receiver input level

RX Input Level (dBm)	RSSI Voltage (V)
–90	–0.05
–85	0.69
–80	1.34
–75	1.83
–70	2.30
–65	2.67
–60	3.01
–55	3.28
–50	3.54
–45	3.77
–40	4.00
–35	4.20
–30	4.39
–25	4.58
–20	4.75

Point-to-Point Path Analysis

Programs that allow you to perform path analysis are available from several vendors. In any case, the following steps should be followed.

1. Plot the location of each antenna on a topographical site map.
2. Draw lines showing the radio path between sites.
3. On a graph paper, plot the distance (horizontal axis, in miles or kilometers) versus the ground elevation (vertical axis, in feet or meters).
4. Identify all obstructions on the radio path line on the map, including hills, vegetation, and buildings or structures that will interfere with radio transmission.
5. Plot each obstruction on the graph by marking the elevation and distance from the sites.
6. For each obstruction, compute the increment to the height of each obstruction to allow for the earth's curvature.

$$h1 = \frac{d1 \times d2}{Ck}$$

where

$h1$ = additional height increment in feet or meters,

$d1$ = distance of obstruction from site in miles or kilometers,

$d2$ = distance of the obstruction from the second site in miles or kilometers,

C = 1.5 for English units or 12.75 for metric units, and

k = a refractive index of 1.33 for both English and metric units.

Add the additional height increment, *h1*, to the elevations plotted on your graph.

7. Compute another increment to the height of each obstruction for the Fresnel zone.

$$h2 = C\sqrt{\frac{d1 \times d2}{f \times D}}$$

where

h2	=	60% of the first Fresnel zone in feet or meter,
C	=	43.26 for English or 10.38 for metric units,
d1	=	the distance of the obstruction from the first site in miles or kilometers,
d2	=	the distance of the obstruction from the second site in miles or kilometers,
f	=	5.8 GHz in English or metric units, and
D	=	total path length (*d1* + *d2*) in miles or kilometers.

Add the *h2* increment to the elevations on the graph.

8. Determine the ideal antenna height by drawing a line on the graph between the sites and across the top of the obstruction heights. Note the elevation of each antenna site.

9. Use the following formula to determine the free-space path.

$$L = C + 20\log(D) + 20\log(f)$$

where

L	=	the path loss in dB,
C	=	96.6 for English units (distance in miles) and 92.4 for metric units (distance in kilometers),
D	=	distance in miles or kilometers, and
f	=	the signal frequency (5.8 GHz for both English and metric units for the Aurora radio).

For example, for a 15-mile path, path loss

= 96.6 + 20 log 15 + 20 log 5.8 GHz = 136 dB.

For a 15-km path, path loss

= 92.4 + 20 log 15 + 20 log 5.8 GHz = 131 dB.

10. Calculate the unfaded Received Signal Level (RSL).

RSL= TX Power + TX Antenna Gain – Coax Loss
– Free Space Loss + RX Antenna Gain
– Coax Loss

For example, if the TX Power is +19 dBm, the Coax Loss is 2 dB for the TX and 2 dB for the RX, the Antenna Gain is 28 dBi for the TX and 28 dBi for the RX, and the Path Loss is 136 dB, then

RSL= +19 dBm + 28 dBi – 2 dB – 136 dB + 28 dBi
– 2 dB

= – 65 dBm

11. Calculate the Fade Margin (FM)

FM = RSL – Receiver Sensitivity at 10^{-3} BER (outage)

FM = –65 – (–90) = 25 dB.

Examples of Transmission Distances

Table 5-3 lists some examples of the FCC-compliant Aurora 5800 possible transmission distances for different antennas and different transmit output powers.

Table 5-3 Examples of maximum free-space transmission distance

Assumption: 32.8 ft (10 m) LDF4-50A cable feed for both antennas and 25 dB fade margin for BER $10^{-6}/10^{-3}$

Antenna Gain (dBi)	Transmit Output Power (+19 dBm) EIRP (dBm)	Transmit Output Power (+19 dBm) Transmission Distance (miles/km) BER $10^{-6}/10^{-3}$
28	45	13/15
28.5	45.5	14/18
31.4	48.4	28/35
34.8	51.8	61/77

Notes:

1. 32.8 ft (10 m) LDF4-50A cable loss approximately 2 dB.
2. Typical T1/E1 Aurora receiver threshold, –88 dBm at BER 10^{-6} (static threshold) and –90 dBm at BER 10^{-3} (outage threshold).
3. Free-space, path-loss calculation:

   $L = C + 20 \log (D) + 20 \log (f)$.

   L = the path loss in dB.

   C = 96.6 for distance in miles and 92.4 for distance in kilometers.

   D = distance in miles or kilometers.

   f = the signal frequency in MHz.

   For example, for

   output power = 19 dBm,
   antenna gain = 28 dBi,
   TX antenna cable loss = 2 dB,

the TX EIRP = 19 + 28 – 2 = 45 dBm.

The receiver antenna net gain = 28 – 2 (cable loss) = 26 dB;

hence the total path loss with this radio system =
45 + 26 + 90 – 25 (required fade margin) = 136 dB,

that corresponds to a free-space distance of about 15 miles. With 23 dB (2 dB less) fade margin for a 10^{-6} BER static point, this distance reduces to 13 miles.

If the actual transmission distance is reduced to 10 miles, the path loss is about 132 dB; then the system has about 27-dB fade margin for BER 10^{-6} and 29-dB fade margin for BER 10^{-3}.

Spacing Requirement

If the Aurora radio is being installed in an equipment rack, leave one rack space above the radio and one rack space below the radio.

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Chapter 6
Software Utility Program

Aurora Software

The Aurora 5800 is shipped with a diskette containing a utility program, *AURORA5800*, that is used to configure the radio for proper operation. The utility can also be used to monitor the built-in alarms and status indicators.

Installing the Software

The *AURORA5800* utility program can be installed and executed on any PC running the Microsoft Windows 95, 98, or NT 4.0 operating system. To install the software, do the following:

1. Insert *AURORA5800* **Setup Disk 1** in the computer's disk drive (usually drive **A**:).

2. From the Windows or NT **Start** menu, select

   Settings
   Control Panel
   Add/Remove Programs.

   The setup program guides you through the install process, and you can select which directory you want the *AURORA5800* installed.

Running the Software

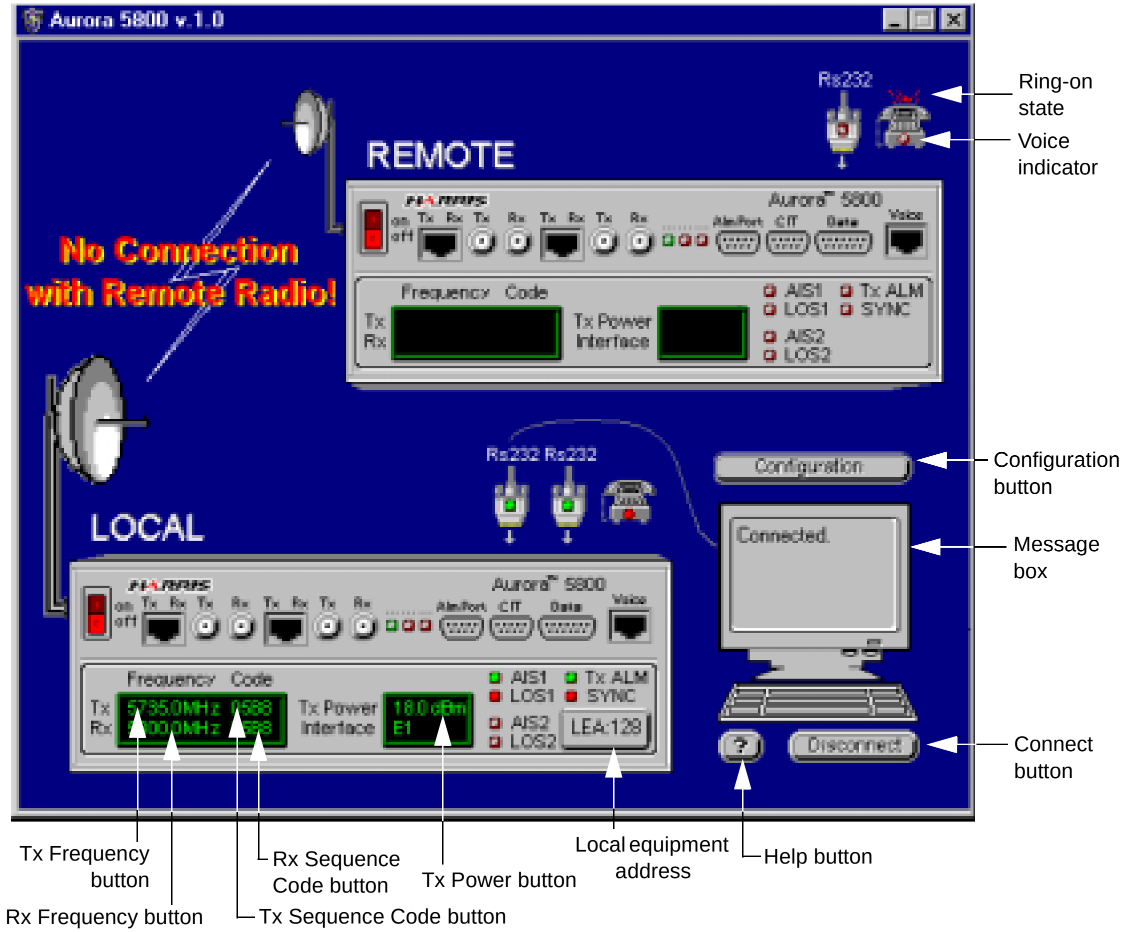
Once it is installed, you can run the *AURORA5800* program by

1. clicking on the **Start** button and
2. choosing **Programs** from the **Start** menu and then
3. choosing **AURORA5800** from the submenu.

AURORA5800 Main Window

A few moments after you start *AURORA5800*, the main window (Figure 6-1) appears.

Figure 6-1 AURORA5800 main window



Features

From the main window, you can

- Make selections to set the transmit and receive frequencies.
- Define the spread code.
- Adjust the Tx output power.
- Save connection configurations.
- Monitor the radio’s alarms/status levels.
- See the latest transmit/receive frequencies and PN spread codes.

Status/Alarms

Six status and alarm conditions are monitored and displayed on the *AURORA5800* main window.

Table 6-1 Alarms

Alarm Designation	Color	Status
LOS1 LOS2	Green	No loss of signal.
	Red	Receiver loss of signal when either receiving 175 consecutive zeros or received signal amplitude drops below 0.3 V peak threshold.
AIS1 AIS2	Green	Normal.
	Red	Unframed all one's is detected (criteria of less than three zeros out at 2048-bit period).
Tx ALM	Green	Transmit power is above threshold level (okay).
	Red	Transmit power has dropped below a preset threshold level.
SYNC	Green	Traffic is normal.
	Red	Synchronization alarm.

Green indicates that everything is running okay. Red indicates an alarm condition.

Phone

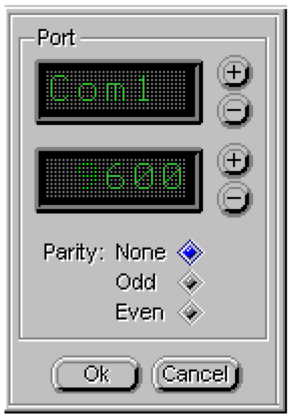
The green light on the phone icon indicates a voice connection. A red splash above the phone indicates a ring-on state.

Connection Configuration

If FarScan is locally connected to the Aurora 5800 radio's CIT port, then you must select 9600 b/s and no parity.

From the main window (Figure 6-1), click the **Configuration** button. The Connection Configuration dialog box appears.

Figure 6-2 Connection Configuration dialog box



1. To select the COM Port the Aurora 5800 radio is connected to, click the + or – button.
2. To select the bit rate for the selected COM Port, click the + or – button.
3. To change the parity, click the appropriate button.
4. Click the **Ok** button to save the changes in "aurora.cfg" file.

Connecting the COMM Port

The RS-232 user interface connector is on the front panel of the Aurora radio.

1. From the main window (Figure 6-1) double-click the

   Connect button at the lower right-hand side.

2. The *AURORA5800* searches the selected comm port that is connected to the radio. A message “connecting over COMx . . .” appears.

3. When the radio is detected at that Comm port, the word “Connected” appears in the message box.

4. The main window displays the radio default configuration parameters.

   T1/E1 interface
   Tx and Rx Spread Sequence
   Tx and Rx RF Frequency
   Tx Output Power level
   Alarms

   The **Connect** button changes to **Disconnect**.

Frequency

From the main window (Figure 6-1), click on the **Tx** or the **Rx Frequency** button. The Set Frequency dialog box appears. Figure 6-3 is an example of a **Set Rx Frequency** dialog box.

Figure 6-3 Set Rx Frequency dialog box

1. To change the frequency, click the + or – button.

2. When the desired frequency appears, click the **Ok** button.

Small adjustments are possible. Frequency can be adjusted up to 500 kHz away from the nominal channel plan.

If the frequency is changed, ensure that the corresponding frequency at the far end is changed also.

If the selected frequency is not the same as the frequency displayed on the label, the radio does not function correctly.

Spread Code

From the main window (Figure 6-1), click on the **Tx** or the **Rx Sequence** code button. The Set Sequence dialog box appears. Figure 6-4 is an example of the **Set Rx Sequence** dialog box.

Figure 6-4 Set Rx Sequence dialog box

There are 4 preset codes to choose from.

1. To change the code, click the ∧ or ∨ button.

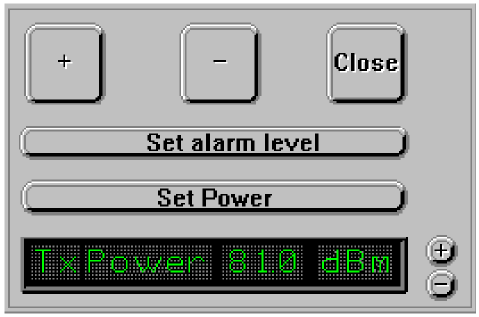
2. When the desired code appears, click the **Ok** button to download the new value.

Ensure that the Transmit Code *at the far end is the same as the* Receive Code *at the near end. Otherwise, the radio link does not operate properly.*

Tx Output Power

From the main window (Figure 6-1), click on the **Tx Power Interface** button. The **Tx Power Settings** dialog box (Figure 6-5) appears.

Figure 6-5 Tx Power Settings dialog box



Set Alarm Level

1. Use an RF Power Meter to monitor the actual power at the antenna port.

2. Click the big + and – buttons at the top of the dialog box to set the desired alarm power level.

   The alarm level may be 3 dB below the output level.

3. Click the **Set alarm level** button to save this setting.

Set Power

4. Click the big + and – buttons at the top of the dialog box to set the nominal power level.

Tx Power Display

5. Click the small + and – buttons at the bottom right-hand side of the dialog box to display the nominal power level.

6. Click the **Set Power** button to save this setting.

   This setting is displayed as a reminder only. This feature does not track the actual power level.

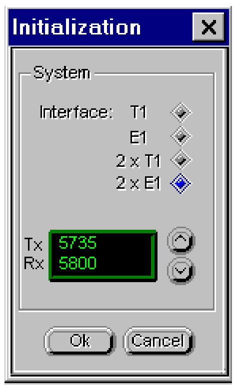
Init Hardware

This dialog box is available only to the professional installer.

1. Right-click the mouse.

2. Choose **Init**. The Initialization dialog box (Figure 6-6) appears.

Figure 6-6 Initialization dialog box



3. Select **Interface** type.

4. Click the up and down buttons to select the nominal radio frequency pairs.

   Refer to the frequencies shown on the back label.

5. Click the **Ok** button to set the new values and start the initialization procedure.

Quitting the *AURORA5800* Program

To quit the program, from the main window click the **X** in the upper right-hand corner.

Chapter 7
Troubleshooting Guideline

General

This guideline is offered in troubleshooting the Aurora radio in the unlikely event a trouble occurs. This guideline is intended for new installations only.

Always check the radio pairs on a bench before field installation. To perform the bench test, use:

- 0-dBi omni antennas
  or
- Cables with a coaxial 60-dB attenuator.

Once the radio is installed, normal operation is indicated by the following conditions:

- The green PWR LED is on.
- The red TX ALM and RX ALM LEDs are off.
- The RSSI level is between 0 and 4.8 VDC.

Call the Harris Customer Resource Center if the trouble is not resolved.

Power LED Off

If no communication link is achieved, and if the PWR LED (green) is off:

- Check the power switch on the left front panel of the radio.
- Check the connections to the power source.
- Check the power source itself for availability of power.

TX Power Alarm

If the TX ALM LED (red) is on:

- The transmit output power level may be too low (3 dB lower than nominal).

Use the *AURORA5800* software program to check the power level.

RX Data Alarm

If the RX ALM LED (red) is on:

- There may be a problem in the receive path resulting in a low received signal level, or
- The far-end transmitter output power is too low or off, or
- There may be a problem with the antenna connection or alignment.

Check the receiver's RSSI voltage level with a DMM.

- Level should be between 0 and 4.8 VDC.
- If the level is too low (closer to 0 VDC), the antenna may not be properly aligned. Adjust the antenna direction to increase RSSI reading. Check the coaxial cable connections.

If the RSSI level cannot be improved with antenna adjustment, the remote site transmitter may have a Tx Power alarm.

- Go to the remote site and check and correct the transmitter's output power level.

Software Diagnosis

If the LEDs and RSSI are normal but still no communication link can be established, use the Aurora 5800 utility software to troubleshoot the problem. The software's diagnostics provides additional information about the receive and transmit synthesizers, and the status of the LOS and AIS for the digital interface.

If the synthesizer has failed or if there is an LOS or AIS alarm, then the radio does not operate normally. In addition, ensure that the radio pairs are configured correctly by re-downloading the receive and transmit synthesizer frequencies and the spread sequence into the radio processor, and then reset the radio transmit power to nominal levels. See the back label for frequency-pair information.

LOS Alarm

Loss of Signal (LOS) means the DS-1/E1 signal is missing at the input of the modem board.

Interference Resolution

If, after the link is installed, too many path errors are indicated on the T1 or E1 test set, a potential interference problem may exist. Try the following corrective steps.

1. Rotate the antenna direction slightly, and see if there is an improvement in the BER.

2. If no improvement is achieved, rotate the polarization of the antenna at both ends of the link by 90^{o}.

3. If still no improvement is achieved after 2., use the *SSRadio* software utility program to change the Transmitter and Receiver Spread Sequence.

   The software provides four different PNs. Use a PN other than the currently installed one, and check for improvement. Make sure the Transmitter Spread Sequence at one end is the same as the Receiver Spread Sequence at the opposite end. Harris recommends that you use different transmit and receive codes within the same radio to minimize the transmit power leakage into the receiver.

4. If no obvious improvement is achieved from the preceding steps, use the *SSRadio* software and make a slight adjustment to either the transmit or receive synthesizer frequency, or both.
   - Do not make an adjustment of more than ±500 kHz from the nominal channel plan (to avoid operating outside of the diplexer filters' passband).
   - Ensure that the transmit frequency at one end matches the receive frequency at the opposite end.

Chapter 8
Connecting to FarScan

Introduction

FarScan is a computer-based network supervision system that runs in Microsoft Windows.

FarScan performs five primary functions:

- Manual command execution
- Polling (AutoPoll and SelectPoll)
- Equipment activity logging
- FarScan networking
- Paging

Hardware Interface

The FarScan computer can be connected to the Harris radio network locally, or remotely by using standard modems connected to a telephone line.

Hardwire Connection

Aurora 5800 radio can be connected to FarScan locally by using the FarScan interface cable.

The cable (Harris part number 087-108906-025) is connected to the CIT port on the Aurora 5800 radio. Refer to Chapter 2 for more information on the CIT port.

Modem Connection

A null modem cable is connected to the DATA port (15-pin) on the Aurora 5800 radio. Refer to Chapter 2 for more information on the DATA port.

Software Interface

Refer to Chapter 6 for instructions on how to connect the COMM port.

For More Information

Refer to the *FarScan for Windows Instruction Manual* for more information.

Chapter 9
Customer Service and Warranty Information

Warranty and Product Support

Warranty and product support information is provided at the time of purchase with the sales invoice and other sales documents. Read the warranty information on page 108 for the equipment or assembly before contacting the Microwave Communications Division (MCD) Customer Service.

Ordering Spares

Harris MCD Aurora 5800 is designed to be repaired at the shelf level. For this reason, parts lists are not furnished with an order, nor are they available.

All orders must be at the top radio shelf level for a complete unit. Make all inquiries for spare radios to the Spare Products Support Center at the following address.

Harris Microwave Communications Division
Spare Products Support Center
3, Hotel de Ville
Dollard-des-Ormeaux, Quebec
CANADA H9B 3G4

Tel: 1-800-227-8332 (U.S.A.)
1-800-465-4654 (Canada)
(+1) 514-421-8333
Fax: (+1) 514-421-3555

The Customer Resource Center is now available on the worldwide web at http://www.microwave.harris.com/cservice/.

Repair and Return

Harris MCD repairs all its manufactured products as well as coordinates repairs on vendor items that are part of its systems. The standard repair turnaround time for current models of some products is 5 working days upon receipt of the defective parts. Repair turnaround time for other products is 15 working days. Discontinued items repair turnaround is subject to the availability of spares.

Emergency repair is available with a 24-hour turnaround time for current production models of some products and 48 hours for other products. Turnaround time for Manufacturing Discontinued items is subject to the nature of the problems. Emergency repairs are billed at actual repair price (zero for warranty units) plus some surcharge per radio. Our normal shipping time is 4 P.M. (Central Time) unless special shipping instruction is requested.

Repair charges and turnaround time for OEM (vendor) items are set by Harris MCD suppliers. Our close working relationships with our suppliers assure us of the best repair prices and turnaround time. Repair charges are billed at supplier's cost plus the necessary handling fee.

Module Exchange

You may prefer to receive a replacement radio before you send your defective unit to us. Harris MCD maintains an inventory of many different configurations that can be shipped to you within 24 hours. Radios that require retuning or reconfiguring can be shipped within 48 hours.

All exchanged radios must be returned to us within 15 days to avoid getting invoiced for the difference between the exchange price and the list price.

Evaluation Fee

There is an evaluation charge per unit if no trouble is found and no repair is required.

Unrepairable Units

Equipment that has been damaged because of customer negligence or that has parts removed will be repaired at the prevailing flat repair fee, or on a time-and-material basis, whichever is higher and regardless of the warranty status. Any equipment that is determined to be unrepairable will be returned to the customer. An evaluation fee will be assessed. This fee will be refunded if the customer purchases a replacement radio within 30 days.

Return Freight

Harris MCD prepays standard return freight back to our customers on warranty repairs. Return freight back to customers on billable repairs is invoiced to the customers. The customer pays for shipping units to Harris MCD for both warranty and out-of-warranty repairs. Special shipping requests may be subject to additional charge.

All shipments outside the continental USA and Canada are subject to additional handling charge per shipment.

Please pack the unit carefully using static-free, sturdy packaging to prevent damage during transit.

Return Material Authorization

Before sending in your equipment for repair, first contact the Harris MCD and request a return material authorization (RMA) number. Obtaining an RMA number insures you that the repairs will be done in a timely manner and prevents any delays due to incomplete information.

Please provide the following information:

1. Your name, company, and telephone number.
2. Equipment type, part number, and sales order number (labeled on back of shelf).
3. Detailed description of the problem.
4. Purchase order number.
5. Billing and shipping addresses.
6. Any special return packing or shipping instructions.
7. If required, customs clearance information.

Repair Telephone and Fax Numbers

U.S.A. and Canada

Tel: 1-800-227-8332 (U.S.A. only)
1-800-465-4654 (Canada only)
(+1) 514-421-8333
Fax: (+1) 514-421-3555

Repair Service Locations

When you receive the RMA number, the Harris MCD customer service representative will instruct you to ship your defective unit(s) to one of the following addresses.

U.S.A.

Harris Microwave Communications Division
Attn: Customer Service, RMA #_ _ _ _ _
5727 Farinon Drive
San Antonio, TX 78249

Canada

Harris Microwave Communications Division
Attn: Customer Service, RMA #_ _ _ _ _
3, Hotel de Ville
Dollard-des-Ormeaux, Quebec
CANADA H9B 3G4

Customer Training

Harris MCD offers courses in microwave, lightwave, and multiplex system operation designed to maximize product performance and minimize maintenance costs. Regular classes are held in our Redwood Shores, California, and Montreal, Canada facilities. Special classes can be held at customer sites. Training is available for standard products. All other training requirements must be quoted by the Customer Training Department. For information call 1-800-227-8332 or 1-800-465-4654.

Standard Product Warranty Terms

Harris MCD warrants that each product of its own manufacture shall, at the time of delivery and for a period of 24 months thereafter, be free from defects in materials and workmanship. For such products that are installed by Harris MCD, this warranty shall extend for 18 months from date of installation, provided that the time from the date of delivery to the date of installation does not exceed 6 months. Such warranty shall not include any consumable components to which a specific manufacturer’s guarantee applies. If any Harris MCD product shall prove to be defective in materials or workmanship under normal intended usage, operation, and maintenance during the applicable warranty period as determined by Harris MCD after examination of the product claimed to be defective, then Harris MCD shall repair or replace, at Harris MCD’s sole option, such defective product, in accordance with procedures specified below, at its own expense, exclusive, however, of the cost of labor by the customer’s own employees, agents or contractors in identifying, removing or replacing the defective part(s) of the product.

In composite equipment assemblies and systems, which include equipment of such other than Harris MCD manufacture, Harris MCD’s responsibility under this warranty provision for the non-Harris MCD manufactured portion of the equipment shall be limited to the other equipment manufacturer’s standard warranty. Provided, however, that if the other manufacturer’s standard warranty period is of a shorter duration than the warranty period applicable to Harris MCD’s manufactured equipment, then Harris MCD shall extend additional coverage to such other equipment manufacturer's warranty equal to the differential in time between the expiration of the other manufacturer's warranty and the duration of Harris MCD's manufactured equipment warranty applicable to such order. Harris MCD shall repair or replace, at Harris MCD's sole option, such other manufacturer's defective part(s) within 60 days after receipt of such parts by Harris MCD in accordance with the below specified procedures, at Harris MCD's own expense, exclusive, however, of cost of labor by the customer's own employees, agents or contractors in identifying, removing or replacing the defective part(s) of the product.

An authorization to return products to Harris MCD under this warranty must be obtained from a Harris MCD representative prior to making shipment to Harris MCD's plant, and all returns shall be shipped freight prepaid. Collect shipments will not be accepted, but Harris MCD will prepay return freight charges on repaired and replaced products found to be actually defective.

Liability of Harris MCD for breach of any and all warranties hereunder is expressly limited to the repair or replacement of defective products as set forth in this section, and in no event shall Harris MCD be liable for special, incidental or consequential damages by reason of any breach of warranty or defect in materials or workmanship. Harris MCD shall not be responsible for repair or replacement of products that have been subjected to neglect, accident or improper use, or that have been altered by other than authorized Harris MCD personnel.

Any warranties or conditions made herein by Harris are exclusive, made in lieu of all other warranties or conditions, express or implied (except to title) including, but not limited to, any implied warranty or condition of merchantability, any implied warranty or condition of fitness for a particular purpose, or any warranty or condition arising out of performance or custom or usage of trade. Customer acknowledges any circumstances causing any such exclusive or limited remedy to fail of its essential purpose shall not affect any Harris warranty.

Limitation of Damages

Harris' total and maximum liability under this agreement or in connection with the subject matter of this agreement or any transaction related to this agreement, shall be limited to one-half (1/2) of the aggregate amount paid to Harris, regardless of the basis for such liability. Customer acknowledges and agrees this section shall be enforceable in the event of any claim made in connection with this agreement, including, but not limited to, any claim for failure of delivery. In no event shall Harris be liable for any punitive, special, incidental, or consequential damages, including, but not limited to lost profits, opportunities or savings or for any loss of use of, or loss of data or information of any kind, however caused or for any full or partial loss of performance of any product, even if Harris has been advised of the possibility of such damages.

Appendix A
Transmit or Receive RF Filter Responses

This appendix includes actual results from laboratory tests.

T1/E1 Diplexers

The RF filter response graphs are shown in Figure A-1 through Figure A-6.

Figure A-1 Filter with center frequency of 5.735 GHz

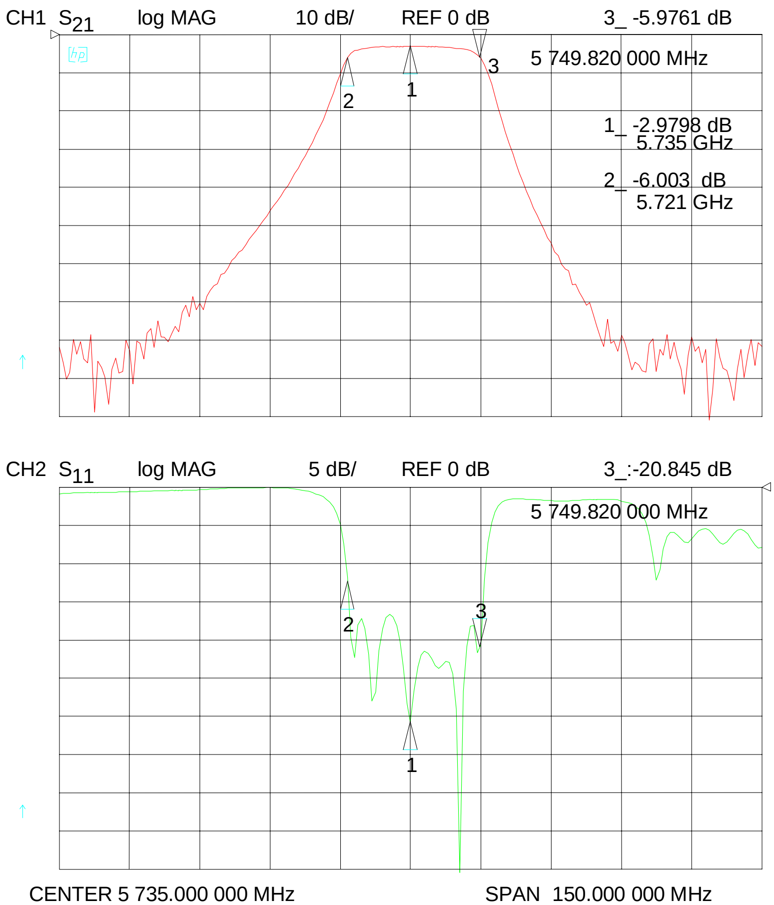


Figure A-2 Filter with center frequency of 5.755 GHz

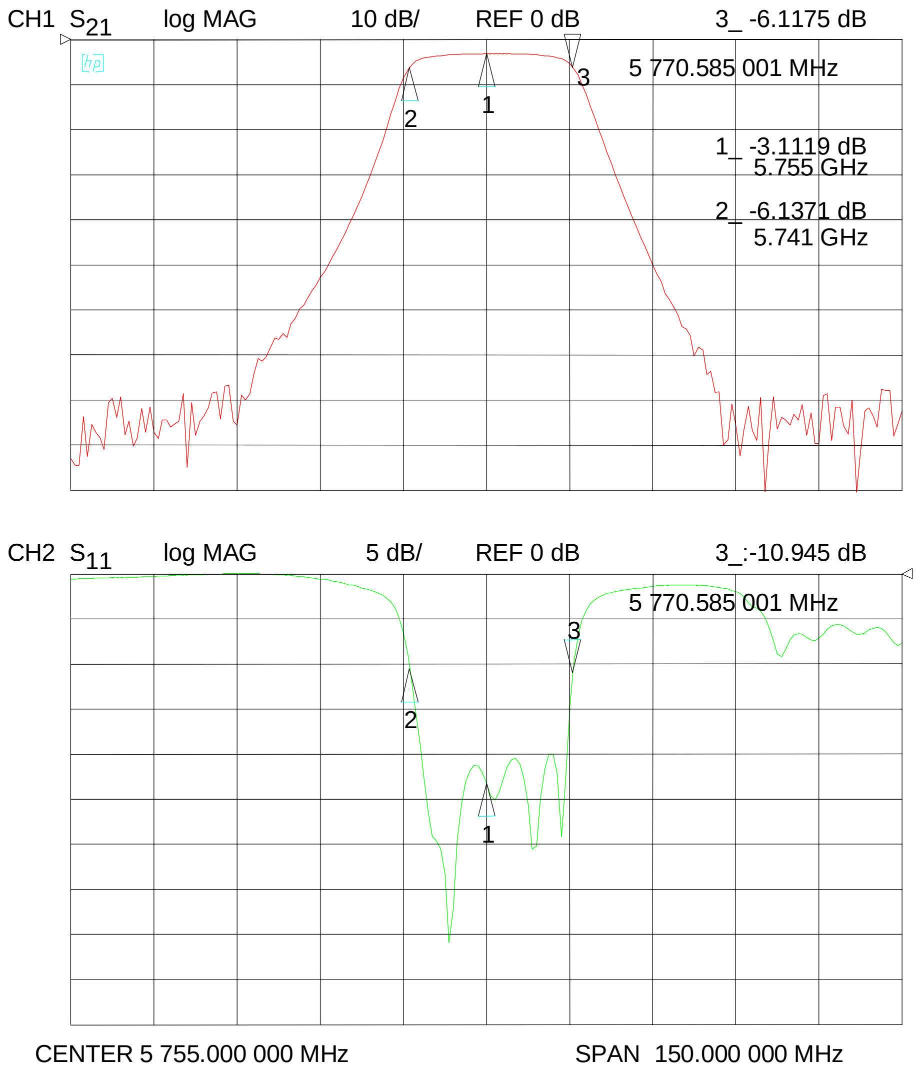


Figure A-3 Filter with center frequency of 5.775 GHz

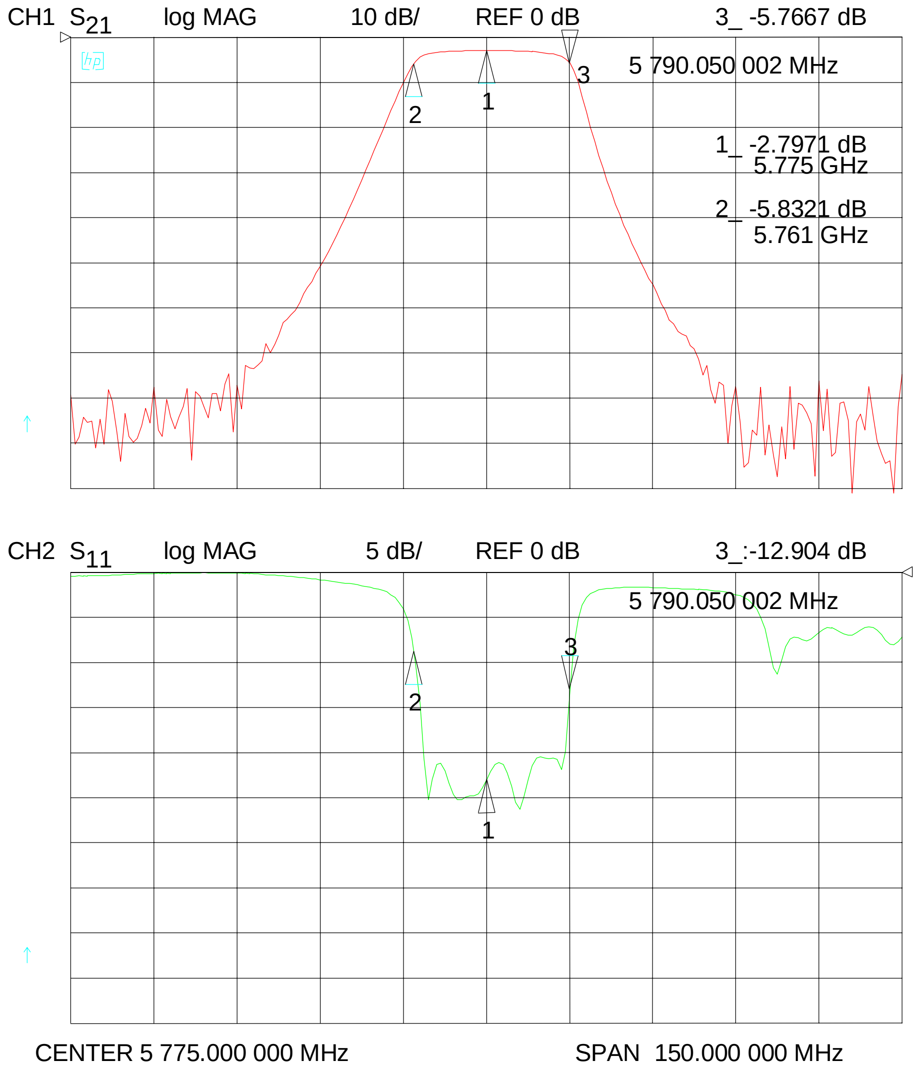


Figure A-4   Filter with center frequency of 5.8 GHz

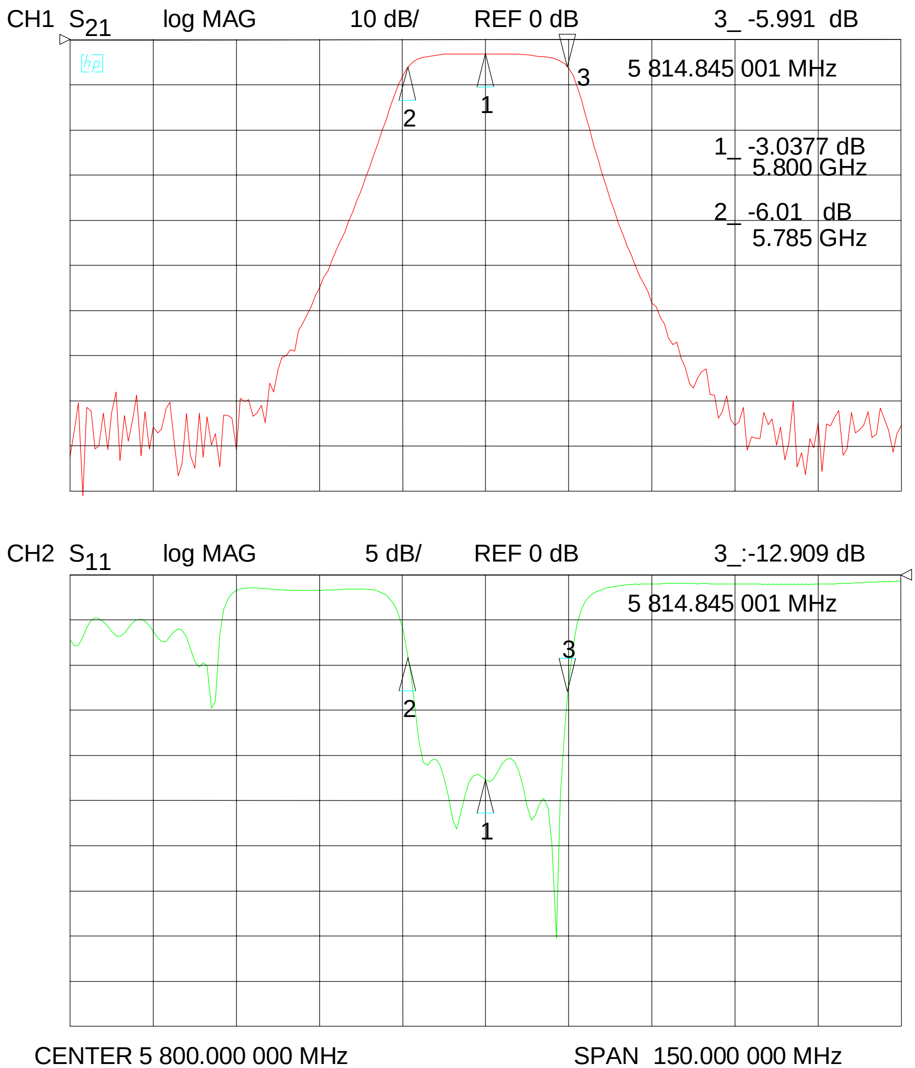


Figure A-5 Filter with center frequency of 5.82 GHz

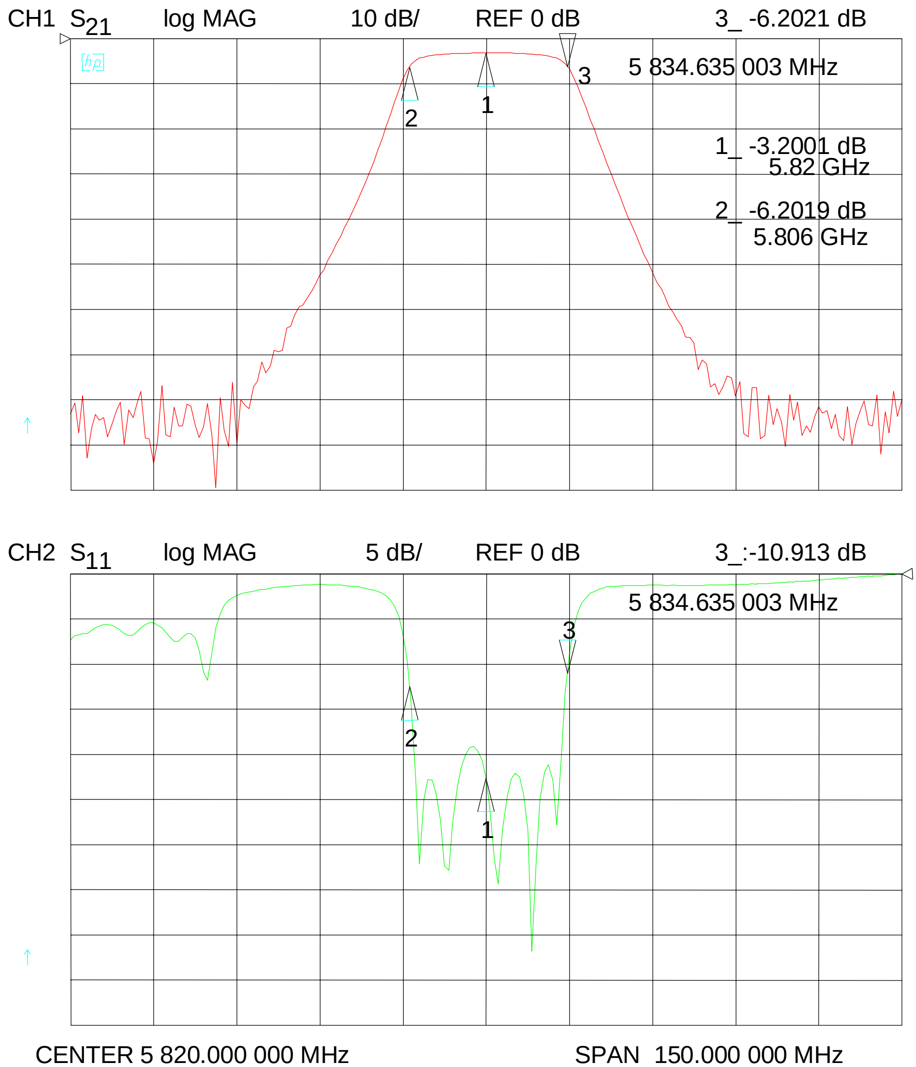
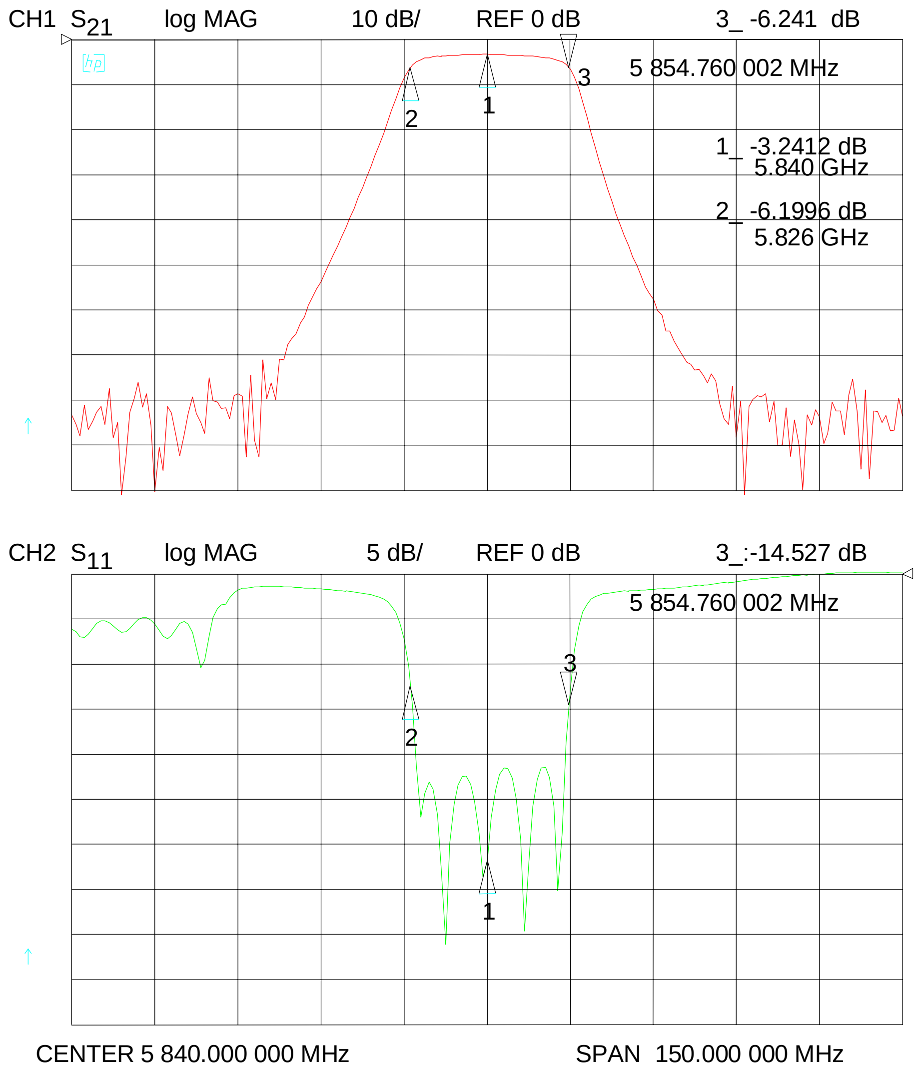


Figure A-6 Filter with center frequency of 5.84 GHz



2T1/2E1 Diplexers

Figure A-7   Filter with center frequency of 5.741 GHz

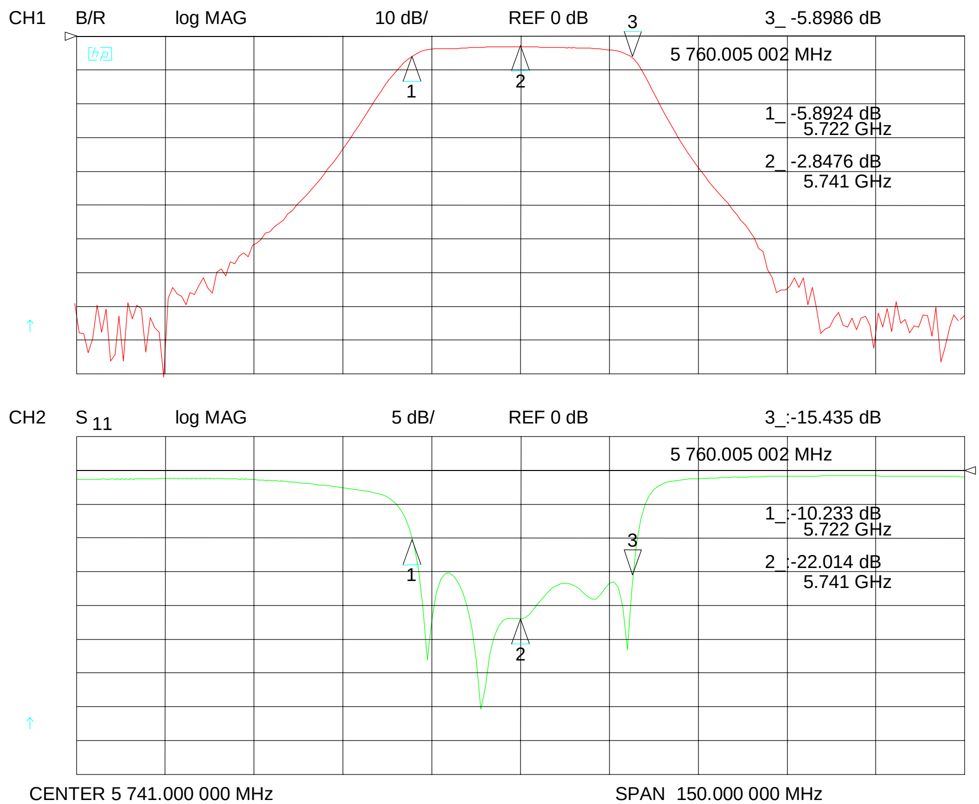


Figure A-8 Filter with center frequency of 5.772 GHz

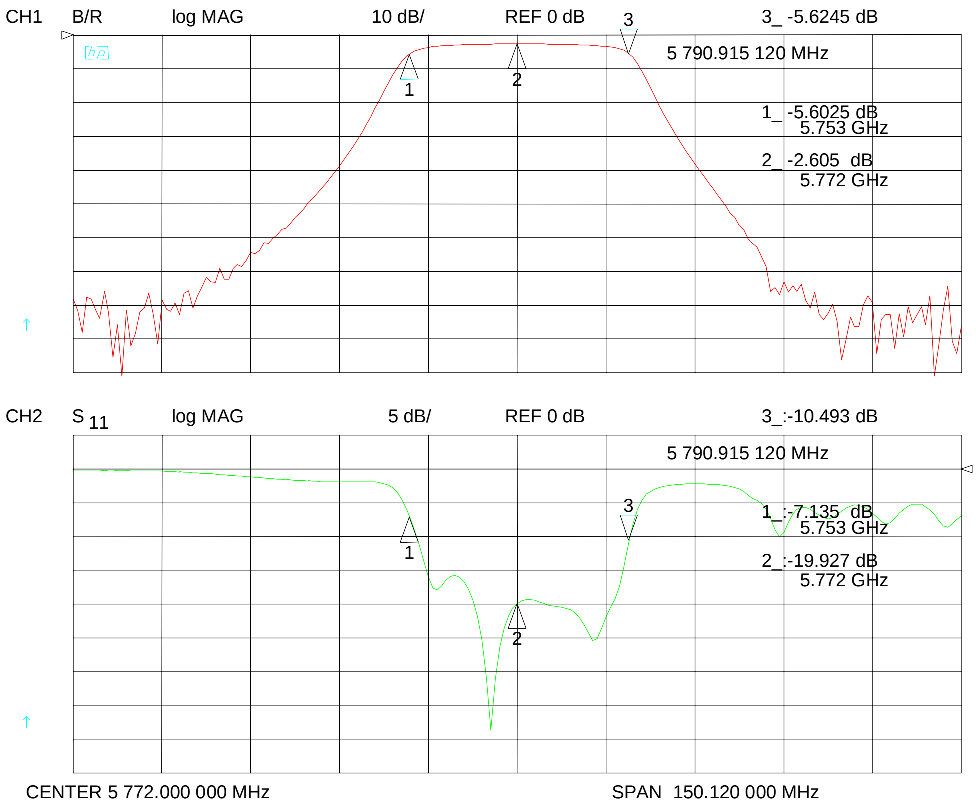


Figure A-9 Filter with center frequency of 5.803 GHz

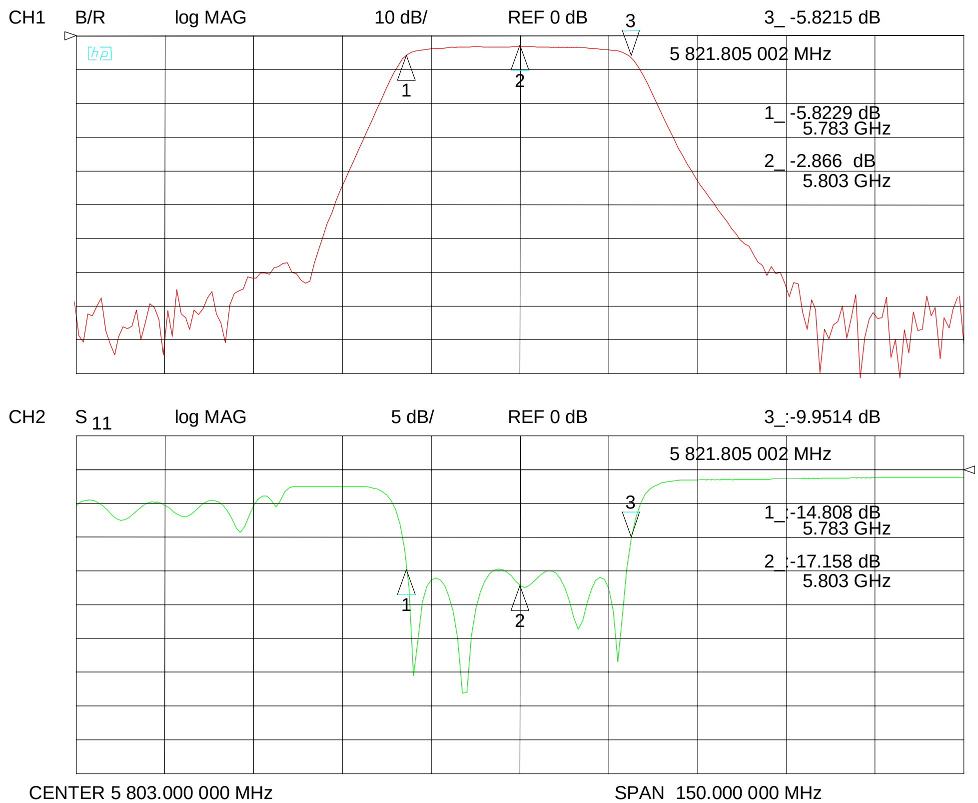
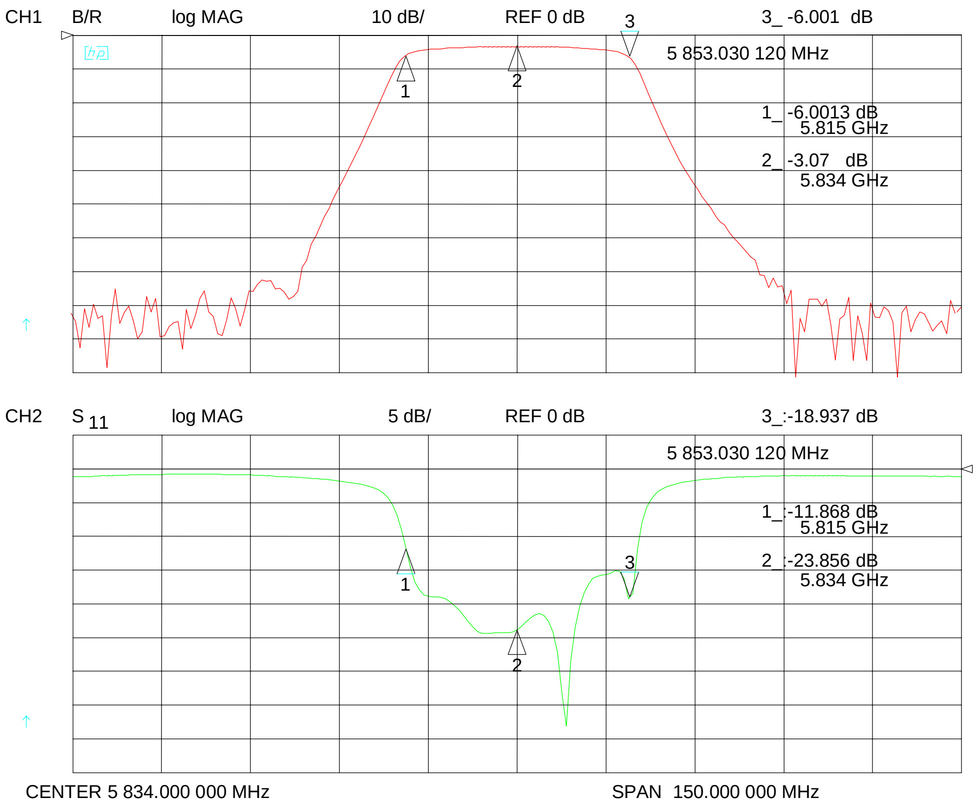


Figure A-10 Filter with center frequency of 5.834 GHz



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Appendix B
Typical Radio Performance Results for T1

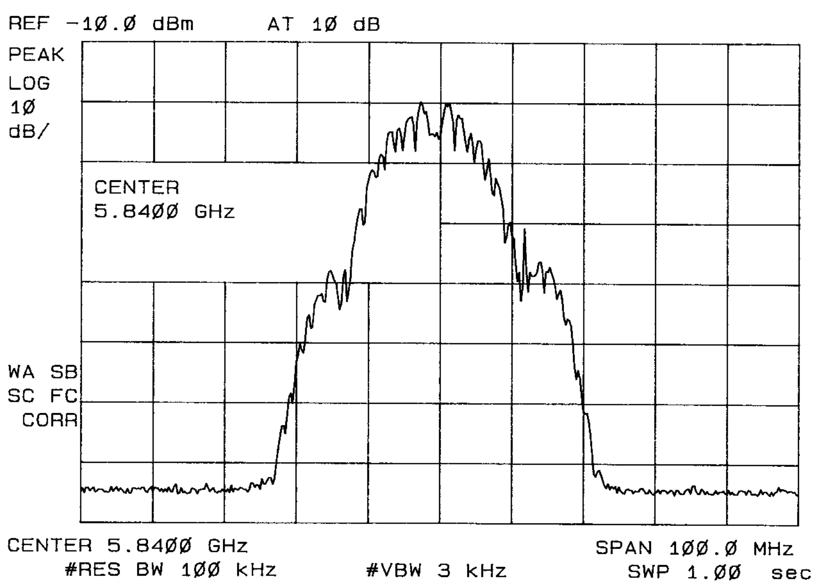
This appendix includes actual results from laboratory tests.

Refer to Appendix A for RF filter response graphs.

Transmitter RF Test

Transmit RF Spectrum (FCC Part 15.247)

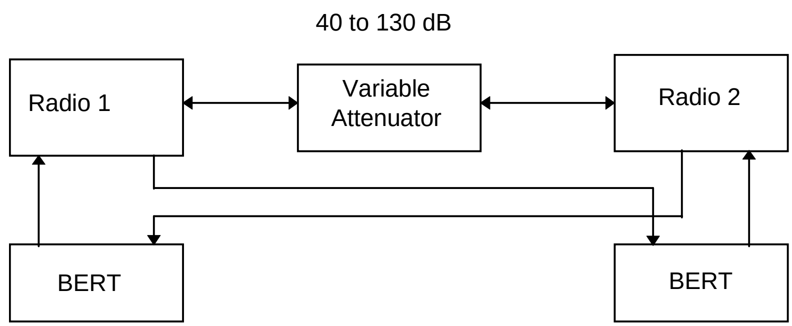
Figure B-1 Transmit RF spectrum



Receiver Tests

Test Setup

Figure B-2 ***Receiver test setup***



Direction	Transmit	Receive
A	Radio 1 at 5775 MHz	Radio 2 at 5775 MHz
B	Radio 2 at 5840 MHz	Radio 1 at 5840 MHz

Receiver Sensitivity

Code used: 2CF8

Requirement: Input threshold at BER $10^{-6} \leq -87$ dBm
Results: Both directions use same spread sequence.

Code	Direction	Input Threshold at BER 10^{-6} (dBm)
3F0C	A	–92
	B	–91
2CF8	A	–91
	B	–90
1F35	A	–90
	B	–89

Dispersive Fade Margin

Test Conditions

Direction A code: 1F35
Direction B code: 1F35

Fade simulator is inserted in the 140-MHz IF path.
RCV input level is at nominal - 40 dBm.

Direction A

See Table B-1 and Table B-2 for the results of this test for Direction A.

Table B-1 Direction A, minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
134	40 at 134.8 MHz	40 at 136.3 MHz		
136	19.0	24.5		
138	20.4	24.5	40 at 139.2 MHz	40
140	32.0	33.5	39.4	39.0
142	24.4	27.5	40 at 140.5 MHz	40
144	27.8	40 at 143.5 MHz		
145	40 at 144.4 MHz			

Table B-2 Direction A, non-minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
134	40 at 135.7 MHz			
136	39.5	> 40		
138	39.0	> 40	> 40.0	> 40.0
140	32.8	> 40	> 40.0	> 40.0
142	25.9	> 40	> 40.0	> 40.0
144	31.0	40 at 143.3 MHz		
146	40 at 144.4 MHz			

DFM = 56.17 dB for BER = 1E-6
DFM = 64.70 dB for BER = 1E-3

See Figure B-3 for the W curve at BER = 1E-6, and Figure B-4 for the W curve at BER = 1E-3.

Figure B-3 W Curve at BER=1E-6, Direction A

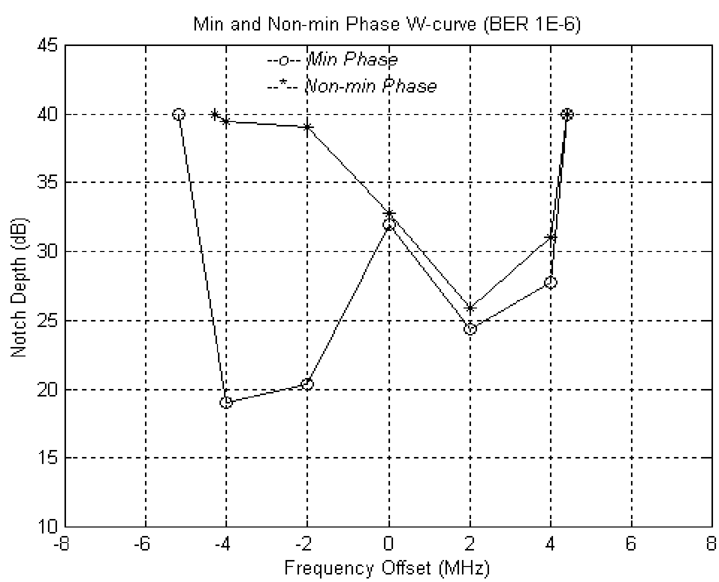
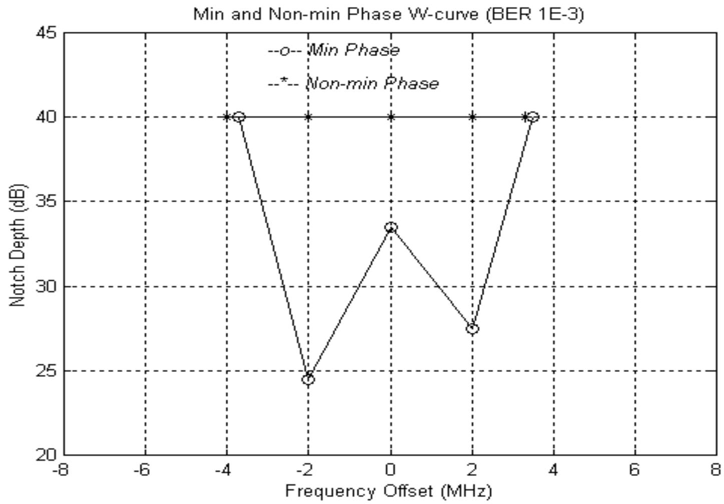


Figure B-4 W Curve at BER = 1E-3, Direction A



Direction B

See Table B-3 and Table B-4 for the results of this test for Direction B.

Table B-3 Direction B, minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
134	40 at 134.8 MHz	40 at 135.8 MHz		
136	21.0	28.0		
138	27.5	29.5	40 at 138.5 MHz	40.0
140	27.4	32.0	37.0	34.0
142	22.0	28.2	33.0	30.0
144	27.0	> 40	> 40	
144.3	40.0			

Table B-4 Direction B, non-minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
135.7	40.0			
136	39.5			
138	39.0	> 40.0	> 40.0	> 40.0
140	32.8	> 40.0	> 40.0	> 40.0
142	25.9	28.5	34.0	31.0
144	31.0	40 at 143.3 MHz	> 40	> 40
144.4	40.0			

DFM = 57.74 dB for BER = 1E-6
DFM = 68.86 dB for BER = 1E-3

See Figure B-5 for the W curve at BER = 1E-6 and Figure B-6 for the W curve at BER = 1E-3.

Figure B-5 W Curve at BER = 1E-6, Direction B

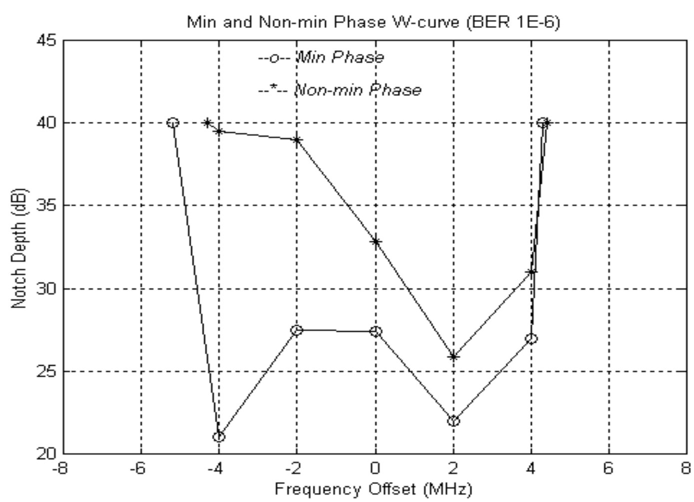
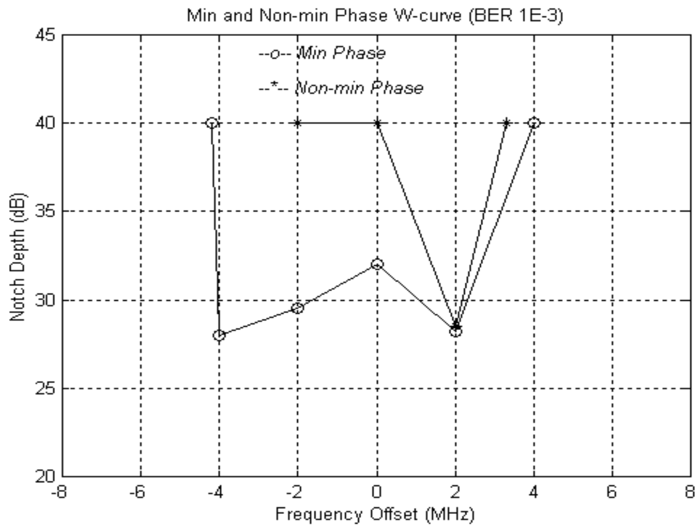


Figure B-6 W Curve at BER = 1E-3, Direction B



Dynamic Fading

Sweep Notch Depth Range

See Table B-5 for sweep notch depth range at certain notch frequencies for BER < 10^{-6} region; elapse time = 0.1 sec.

Table B-5 ***Sweep notch depth range***

Notch Frequency (MHz)	Direction A Notch Depth (dB)		Direction B Notch Depth (dB)	
	Minimal Phase	Non-minimal Phase	Minimal Phase	Non-minimal Phase
135.0	0 to 28	0 to 36	0 to 18	0 to 32
138.0	0 to 17	0 to 35	0 to 30	0 to 40
140.0	0 to 26	0 to 30	0 to 31	0 to 26
142.0	0 to 18	0 to 21	0 to 28	0 to 18
145.0	0 to 39	0 to 40	0 to 40	0 to 40

Sweep Notch Frequency

Table B-6 ***Checking for error notch depth region, elapse time: 0.1 sec (equivalent to sweep speed 600 MHz/sec)***

Notch Frequency (MHz)	Direction A Notch Depth (dB)		Direction B Notch Depth (dB)	
	Minimal Phase	Non-minimal Phase	Minimal Phase	Non-minimal Phase
115 to 165	17.5	21.0	19.0	22.0

Flat Fading

Sweep for ultimate error-free attenuation range (flat fading), elapse time: 0.1 sec.

Note: Attenuation is inserted in the IF path. RF AGC is disabled. Only the dynamic performance of the IF AGC is tested.

Direction A: 0 to 55 dB
Direction B: 0 to 55 dB

Interference Performance

The effect of an interfering signal into a digital radio receiver is characterized by a 1 dB degradation in the BER=1×10^{-6} (static) and 1×10^{-3} (outage) thresholds. The standard for this characteristic is the threshold-to-interference (T/I) ratio, as defined in EIA/TIA Document TSB-10-F. [Ref 5]

The test was performed for sinewave (narrowband) interference and for like signal (wideband) interference. The method used in this test follows the TIA Bulletin TSB-10-F Standard T/I measurement recommendation.

The C/I uses nominal receiver input level (–40 dBm), and then interference is injected to get a BER of 10^{-6}. C/I is the ratio of the signal to interference ratio at this point, measured in direction A only.

Narrowband Interference

Figure B-7 T/I versus narrowband interference frequency offset

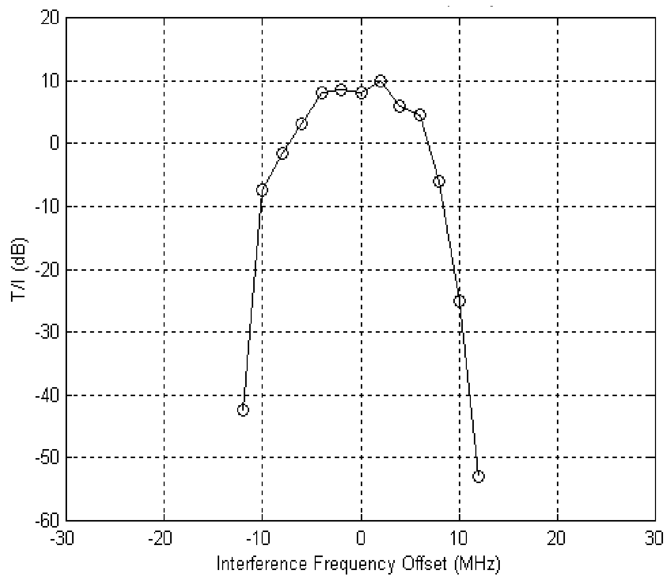
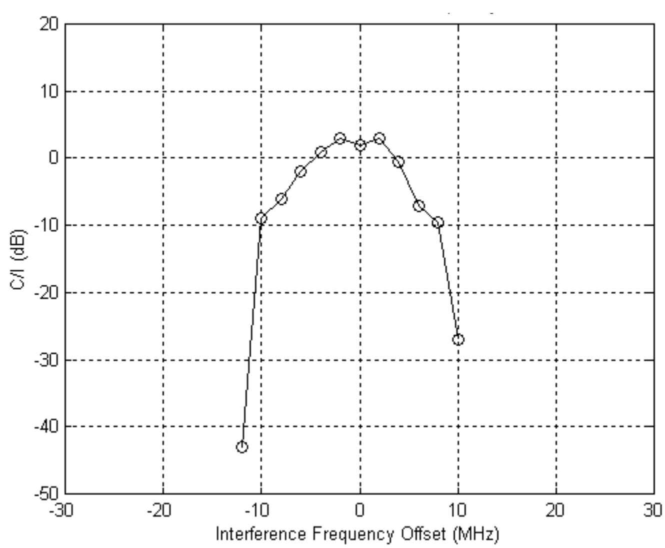


Figure B-8 C/I versus narrowband interference frequency offset



Wideband Interference

Figure B-9 T/I versus wideband interference frequency offset (Directions A and B, same code, 1F35)

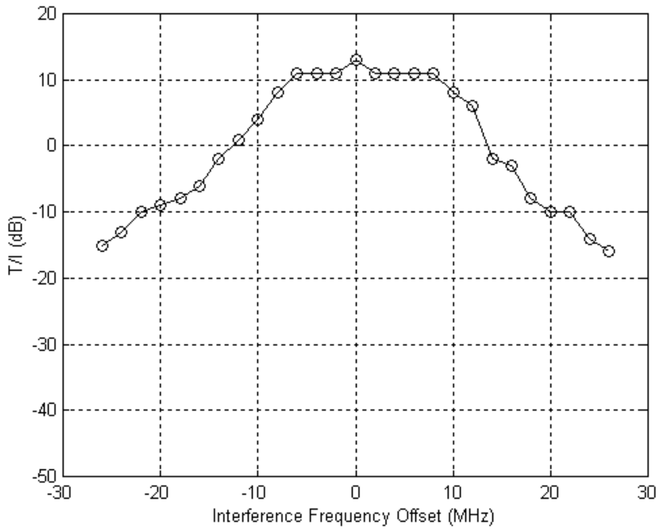


Figure B-10 T/I versus wideband interference frequency offset (Direction A: 1F35, Direction B: 3F0C)

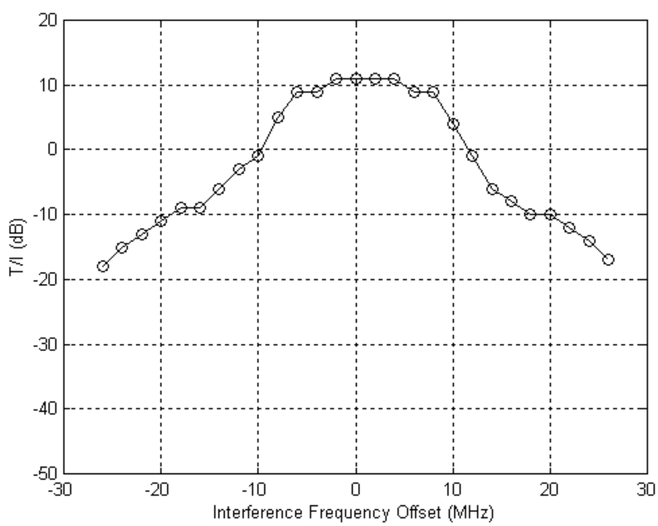
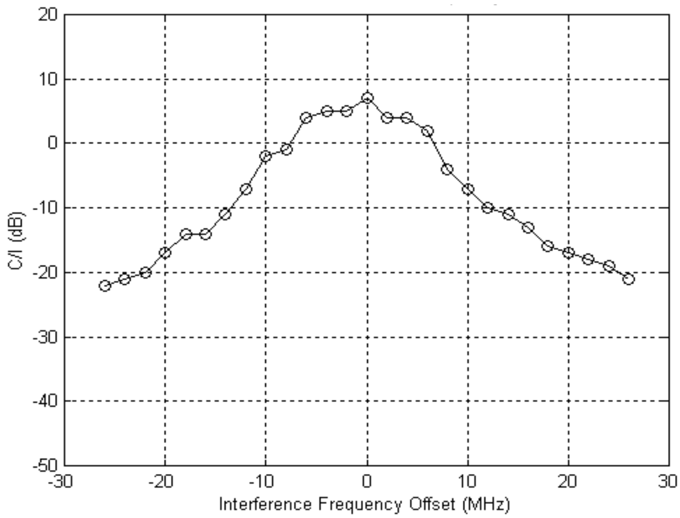


Figure B-11 C/I versus wideband interference frequency offset



FCC Part 15, Compliance Processing Gain Performance Test

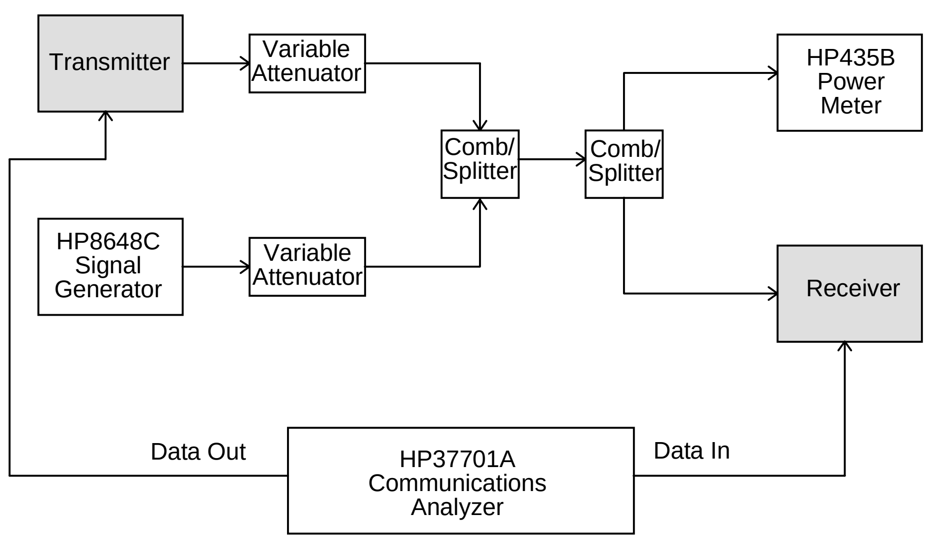
Test method recommended by FCC 97-114 is the CW Jamming Margin Method.

Characteristic	Value
Data rate	T1 (1.544 Mb/s)
Chip rate	11 chips/bit
Designed processing gain	10.4 dB

Test Setup

Test setup is shown in Figure B-12.

Figure B-12 Processing gain test setup



Jamming Margin (J/S Ratio) (for BER 10-5)

The test was performed in Direction B. 50 kHz increments were used in this test; the worst 20% were discarded. See Table B-7.

After the worst 20% (64 points marked with (x)) were discarded, the lowest J/S ratio was - 0.5 dB (marked with (**)).

Hence $M_j = -0.5$ dB.

The S/N ratio for ideal noncoherent receiver is calculated from

$Pe = ½\, e^{(-½\, (S/N)_o)}$,

where $Pe = 10^{-5}$.

Hence $(S/N)_o = 13.3$ dB.

The processing gain can be calculated as

$G_p = (S/N)_o + M_j + L_{sys}$

where L_{sys} = System Loss.

No more than 2 dB loss is allowed (we assumed 0 dB).

Hence $G_p = 13.3 - 0.5 + 0.0 = 12.8$ dB, better than the designed coding gain of 10.4 dB and better than the FCC's minimum requirement of 10 dB.

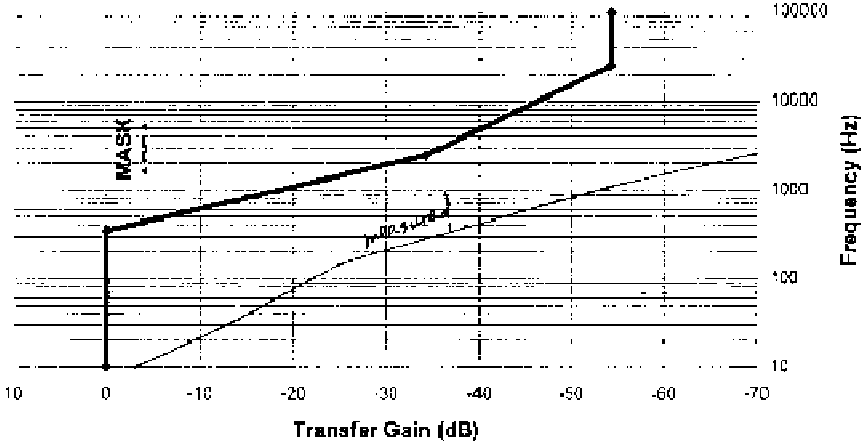
Table B-7 Jamming margin (J/S ratio) (for BER 10^{-5}) for T1

Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)
–8.00	5.2	–6.00	0.8	–4.00	2.5	–2.00	(x) –0.5
.05	5.3	.05	–0.1	.05	2.0	.05	(x) –0.8
.10	5.6	.10	(x) –1.0	.10	1.5	.10	(x) –1.1
.15	6.1	.15	(x) –1.7	.15	1.4	.15	(x) –1.3
.20	6.0	.20	(x) –1.8	.20	1.6	.20	(x) –1.4
.25	6.2	.25	(x) –2.0	.25	1.3	.25	(x) –1.5
.30	6.5	.30	(x) –2.0	.30	1.3	.30	(x) –1.9
.35	6.5	.35	(x) –1.7	.35	1.8	.35	(x) –1.3
.40	6.8	.40	(x) –0.8	.40	1.6	.40	(x) –1.3
.45	7.2	.45	–0.2	.45	1.2	.45	(x) –1.3
.50	7.2	.50	1.2	.50	0.8	.50	(x) –0.6
.55	6.7	.55	1.9	.55	0.3	.55	–0.3
.60	6.2	.60	2.8	.60	0.0	.60	0.1
.65	6.0	.65	3.3	.65	–0.4	.65	0.1
.70	5.4	.70	3.4	.70	–0.5	.70	–0.2
.75	5.4	.75	3.6	.75	(x) –0.8	.75	–0.1
.80	4.6	.80	3.9	.80	–0.2	.80	–0.3
.85	4.2	.85	3.8	.85	**(**) –0.5**	.85	–0.2
.90	3.8	.90	3.6	.90	–0.5	.90	0.1
.95	3.9	.95	2.9	.95	0.4	.95	0.0
–7.00	3.8	–5.00	2.3	–3.00	0.5	–1.00	0.6
.05	3.7	.05	1.9	.05	1.0	.05	0.9
.10	3.8	.10	1.2	.10	1.3	.10	1.8
.15	3.7	.15	1.0	.15	1.2	.15	2.1
.20	3.7	.20	0.5	.20	2.0	.20	2.1
.25	3.8	.25	0.8	.25	2.6	.25	2.1
.30	3.3	.30	0.8	.30	3.0	.30	2.4
.35	3.7	.35	0.8	.35	3.9	.35	2.5
.40	3.7	.40	1.5	.40	4.5	.40	2.3
.45	4.2	.45	1.5	.45	4.4	.45	2.2
.50	4.3	.50	1.6	.50	4.2	.50	1.5
.55	3.7	.55	2.1	.55	4.0	.55	1.0
.60	3.1	.60	2.1	.60	3.5	.60	–0.1
.65	3.0	.65	2.8	.65	3.2	.65	(x) –1.7
.70	2.9	.70	2.8	.70	2.9	.70	(x) –3.0
.75	2.8	.75	2.9	.75	2.1	.75	(x) –4.0
.80	3.1	.80	3.4	.80	1.9	.80	(x) –4.6
.85	3.5	.85	3.9	.85	0.8	.85	(x) –4.8
.90	3.0	.90	3.9	.90	0.8	.90	(x) –5.2
.95	3.4	.95	3.3	.95	0.3	.95	(x) –5.8

Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)
0.00	(x) –4.3	+2.00	(x) –2.1	+4.00	3.9	+6.00	–0.2
.05	(x) –4.3	.05	(x) –2.1	.05	4.4	.05	2.0
.10	(x) –4.9	.10	(x) –1.8	.10	4.1	.10	2.2
.15	(x) –4.7	.15	(x) –1.1	.15	4.0	.15	2.8
.20	(x) –3.8	.20	0.0	.20	3.5	.20	3.6
.25	(x) –3.5	.25	0.5	.25	3.5	.25	4.5
.30	(x) –2.2	.30	1.1	.30	2.8	.30	5.1
.35	(x) –1.4	.35	2.0	.35	2.3	.35	6.0
.40	(x) –0.5	.40	2.6	.40	1.7	.40	6.1
.45	0.1	.45	3.3	.45	1.2	.45	6.4
.50	0.3	.50	3.5	.50	1.0	.50	6.0
.55	0.3	.55	3.3	.55	0.7	.55	5.1
.60	0.7	.60	2.8	.60	0.7	.60	4.4
.65	0.8	.65	2.4	.65	1.1	.65	4.0
.70	0.8	.70	1.9	.70	1.1	.70	3.4
.75	0.8	.75	1.3	.75	1.6	.75	3.1
.80	1.2	.80	0.6	.80	1.6	.80	3.1
.85	1.2	.85	–0.3	.85	2.2	.85	3.4
.90	1.3	.90	(x) –0.8	.90	2.4	.90	3.4
.95	0.8	.95	(x) –1.1	.95	2.8	.95	4.0
+1.00	0.4	+3.00	(x) –1.4	+5.00	3.5	+7.00	4.1
.05	–0.2	.05	(x) –0.5	.05	3.4	.05	4.2
.10	(x) –0.5	.10	–0.1	.10	3.4	.10	5.2
.15	(x) –1.5	.15	–0.1	.15	2.9	.15	5.9
.20	(x) –1.7	.20	0.0	.20	2.3	.20	6.4
.25	(x) –1.8	.25	0.0	.25	1.9	.25	7.2
.30	(x) –2.6	.30	0.8	.30	2.2	.30	7.6
.35	(x) –2.2	.35	1.0	.35	2.2	.35	7.9
.40	(x) –2.5	.40	1.1	.40	2.1	.40	7.9
.45	(x) –2.1	.45	1.2	.45	2.3	.45	7.9
.50	(x) –2.4	.50	0.8	.50	1.7	.50	7.7
.55	(x) –2.3	.55	0.7	.55	1.3	.55	7.0
.60	(x) –2.4	.60	0.8	.60	0.8	.60	6.2
.65	(x) –3.0	.65	0.9	.65	0.8	.65	5.5
.70	(x) –2.5	.70	0.7	.70	–0.2	.70	5.4
.75	(x) –1.7	.75	1.4	.75	(x) –0.5	.75	5.7
.80	(x) –1.9	.80	1.2	.80	(x) –0.5	.80	5.9
.85	(x) –1.9	.85	1.3	.85	–0.3	.85	6.4
.90	(x) –1.8	.90	2.2	.90	–0.3	.90	6.3
.95	(x) –2.1	.95	2.8	.95	(x) –0.7	.95	6.5
						+8.00	6.7

Jitter Transfer Function

Figure 0-1 Jitter transfer (DS1)



Environmental Performance

Temperature Performance

Direction B, Code: 2CF8

Temperature (°C)	Tx Power (dBm)	Rx Threshold (dBm)
0	19.2	–91
25	19.0	–90
50	18.7	–88.5

Long-Term Error Performance

Receiver input level is set at the nominal –40 dBm at room temperature. Both transmitter and receiver achieved error-free performance over temperature cycling for 0°C to +50°C for continuous 8-hour testing.

Power Consumption Measurement

Input: 110 VAC
Power consumed: 21 watts

Appendix C
Typical Radio Performance Results for E1

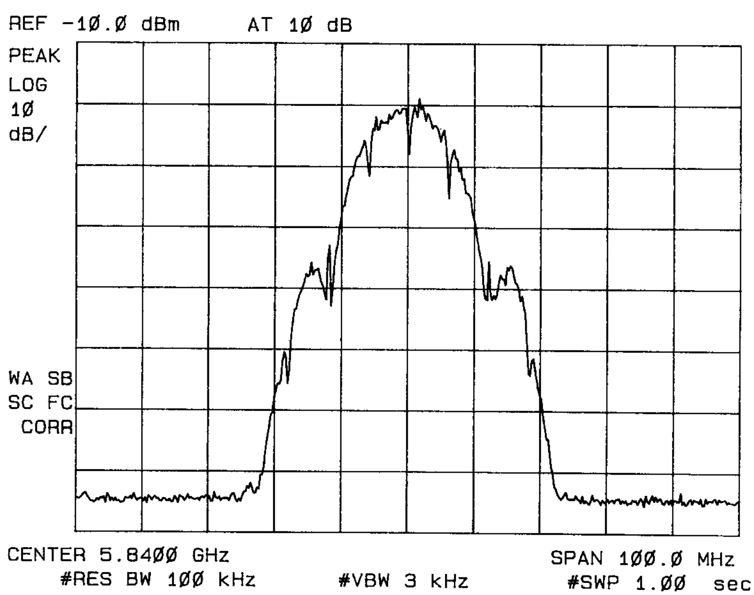
This appendix includes actual results from laboratory tests.

See Appendix A for RF filter response graphs.

Transmitter RF Test

Transmit RF Spectrum

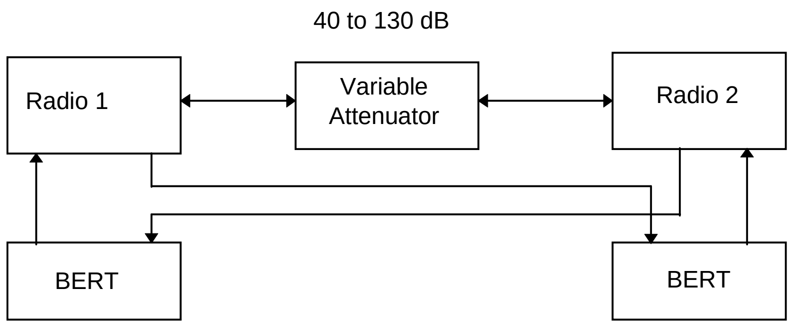
Figure C-1 Transmit RF spectrum



Receiver Tests

Test Setup

Figure C-2 ***Receiver test setup***



Direction	Transmit	Receive
A	Radio 1 at 5775 MHz	Radio 2 at 5775 MHz
B	Radio 2 at 5840 MHz	Radio 1 at 5840 MHz

Receiver Sensitivity

Code used: 05B8
Requirement: Input threshold at BER $10^{-6} \leq -87$ dBm
Results: Both directions use same spread sequence.

Table C-1 ***Receiver sensitivity***

Direction	Rx Input (dBm)	At
A	–90	BER = 1E-6
	–94	BER = 1E-3
	–96	Sync loss
	–95	Re-acquisition
B	–89	BER = 1E-6
	–93	BER = 1E-3
	–96	Sync loss
	–95	Re-acquisition

Dispersive Fade Margin

Test Conditions

Direction A code: 05B8
Direction B code: 05B8

Fade simulator is inserted in the 140-MHz IF path.
RCV input level is at nominal – 40 dBm.

Direction A

See Table C-2 and Table C-3 for the results of this test for Direction A.

Table C-2 ***Direction A, minimal phase***

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
	40 at 135.7 MHz			
136	24.0	40 at 135.1 MHz		
138	29.3	33.1	> 40	> 40
140	33.4	36.4	> 40	> 40
142	27.1	32.0	> 40	> 40
144	30.0	40 at 142.7 MHz		
	40 at 144.4 MHz			

Table C-3 **Direction A,** ***non-minimal phase***

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
	40 at 135.9 MHz			
136	39.0			
138	34.7	> 40	> 40.0	> 40.0
140	> 40	> 40	> 40.0	> 40.0
142	28.0	34	> 40.0	> 40.0
144	40	40 at 142.6 MHz		

DFM = 62.17 dB for BER = 1E-6
DFM = 70.26 dB for BER = 1E-3

See Figure C-3 for the W curve at BER = 1E-6, and Figure C-4 for the W curve at BER = 1E-3.

Figure C-3 W Curve at BER=1E-6, Direction A

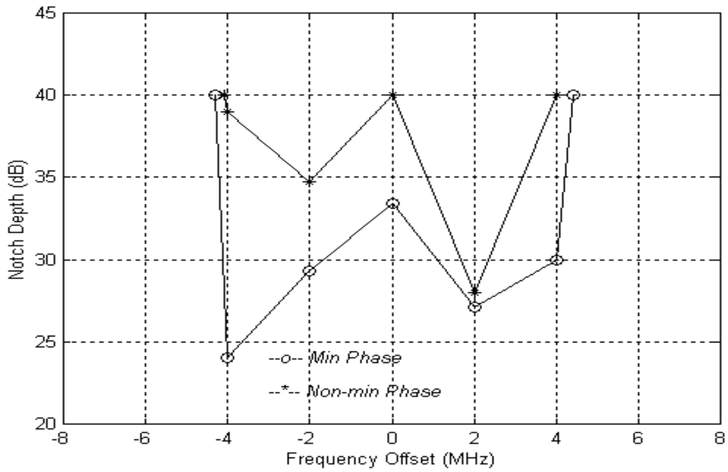
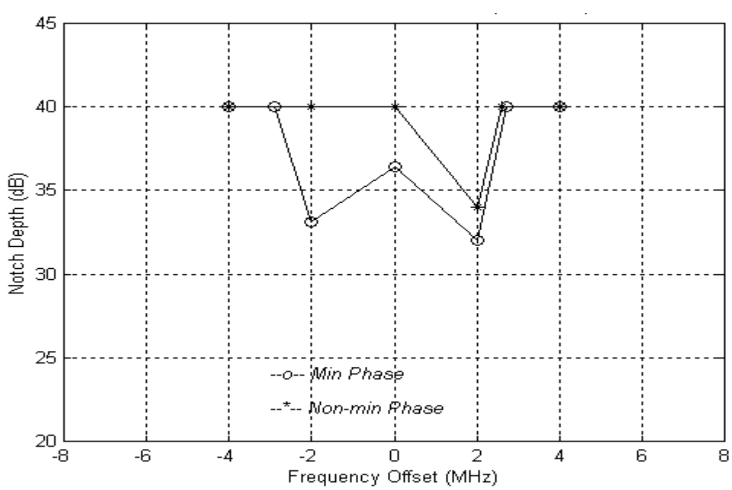


Figure C-4 W Curve at BER = 1E-3, Direction A



Direction B

See Table C-4 and Table C-5 for the results of this test for Direction B.

Table C-4 Direction B, minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
	40 at 135.9 MHz			
136	39.0			
138	34.7	> 40	> 40.0	> 40.0
140	> 40	> 40	> 40.0	> 40.0
142	28.0	34	> 40.0	> 40.0
144	40	40 at 142.6 MHz		

Table C-5 Direction B, non-minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
136	40 at 136.2 MHz			
138	39.1	> 40	> 40	> 40
140	> 40	> 40	> 40	> 40
142	33.3	> 40	> 40	> 40
144	40 at 143.6 MHz			

DFM = 66.91 dB for BER = 1E-6
DFM = 71.05 dB for BER = 1E-3

See Figure C-5 for the W curve at BER = 1E-6 and Figure C-6 for the W curve at BER = 1E-3.

Figure C-5 W Curve at BER = 1E-6, Direction B

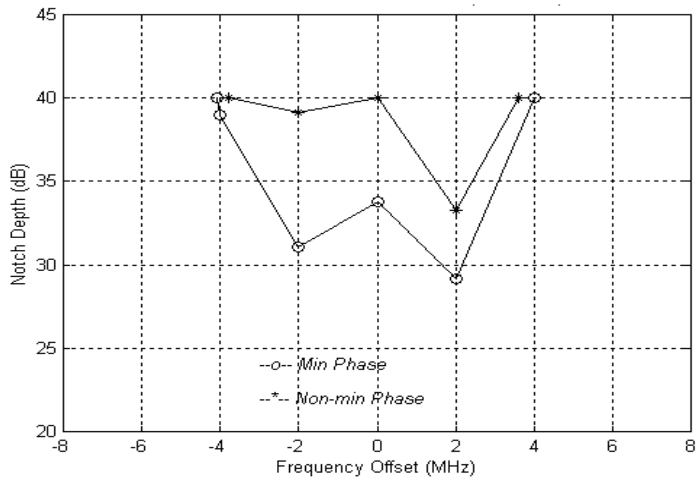
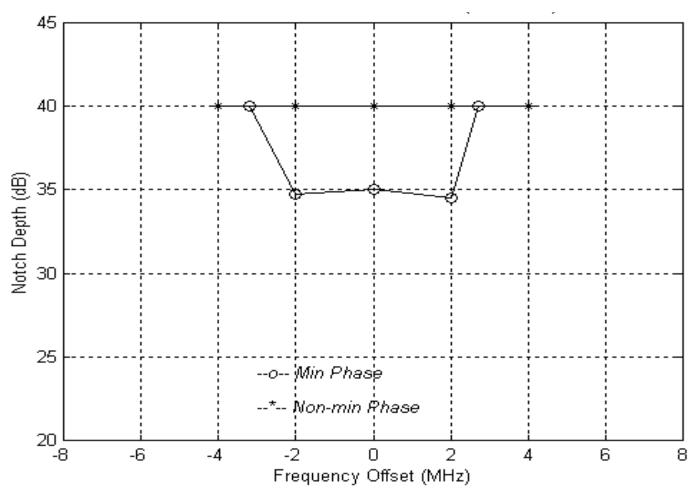


Figure C-6 W Curve at BER = 1E-3, Direction B



Dynamic Fading

Sweep Notch Depth Range

Table C-6 ***Sweep notch depth range for ultimate error-free region (elapse time: 0.1 sec)***

Notch Frequency (MHz)	Direction A Notch Depth (dB)		Direction B Notch Depth (dB)	
	Minimal Phase	Non-minimal Phase	Minimal Phase	Non-minimal Phase
135.0	0 to 40	0 to 40	0 to 40	0 to 40
140.0	0 to 33	0 to 40	0 to 32	0 to 40
145.0	0 to 40	0 to 40	0 to 40	0 to 40

Sweep Notch Frequency

Table C-7 ***Checking for error notch depth region, elapse time: 0.1 sec (equivalent to sweep speed 600 MHz/sec)***

Notch Frequency (MHz)	Direction A Notch Depth (dB)		Direction B Notch Depth (dB)	
	Minimal Phase	Non-minimal Phase	Minimal Phase	Non-minimal Phase
115 to 165	23.0	27.0	28.0	32.0

Flat Fading

Sweep for ultimate error-free attenuation range (flat fading), elapse time: 0.1 sec.

Note: Attenuation is inserted in the IF path. RF AGC is disabled. Only the dynamic performance of the IF AGC is tested.

Direction A: 0 to 65 dB
Direction B: 0 to 65 dB

Interference Performance

The effect of an interfering signal into a digital radio receiver is characterized by a 1 dB degradation in the BER=1×10^{-6} (static) and 1×10^{-3} (outage) thresholds. The standard for this characteristic is the threshold-to-interference (T/I) ratio, as defined in EIA/TIA Document TSB-10-F. [5]

The test was performed for sinewave (narrowband) interference and for like signal (wideband) interference. The method used in this test follows the TIA Bulletin TSB-10-F Standard T/I measurement recommendation.

The C/I uses nominal receiver input level (–40 dBm), and then interference is injected to get a BER of 10^{-6}. C/I is the ratio of the signal to interference ratio at this point, measured in direction A only.

Narrowband Interference

Figure C-7 T/I versus narrowband interference frequency offset

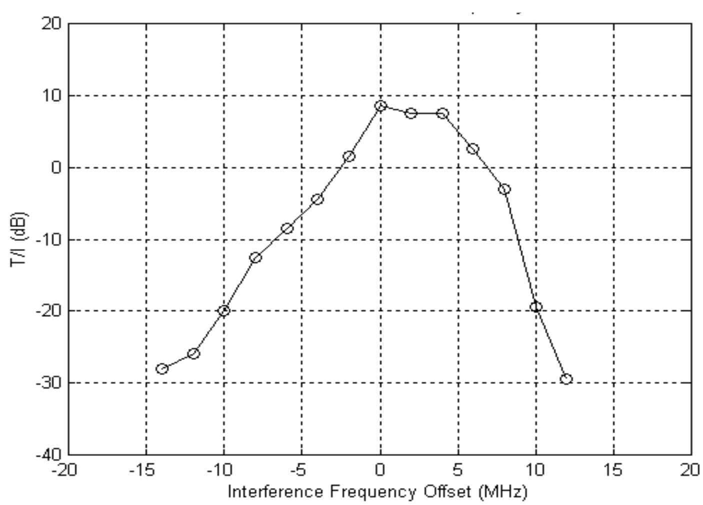
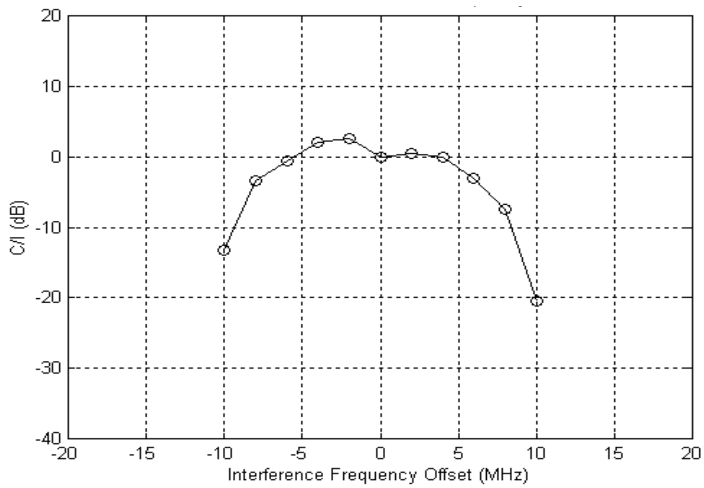


Figure C-8 C/I versus narrowband interference frequency offset



Wideband Interference

Figure C-9 T/I versus wideband interference frequency offset (Directions A and B, same code, 05B8)

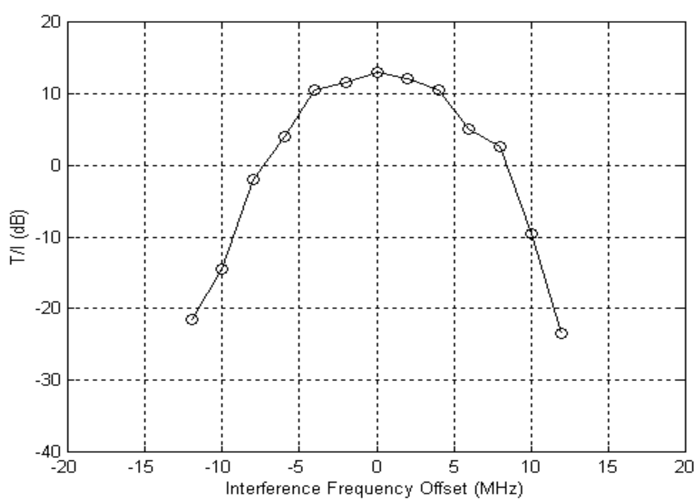


Figure C-10 T/I versus wideband interference frequency offset (Direction A: 05B8, Direction B: 0247)

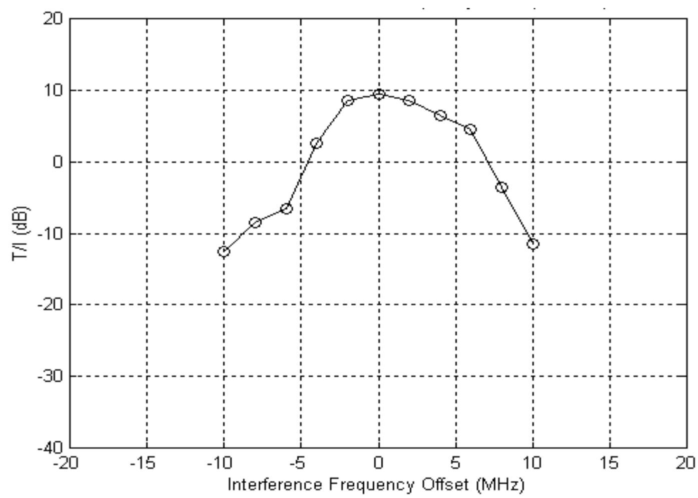
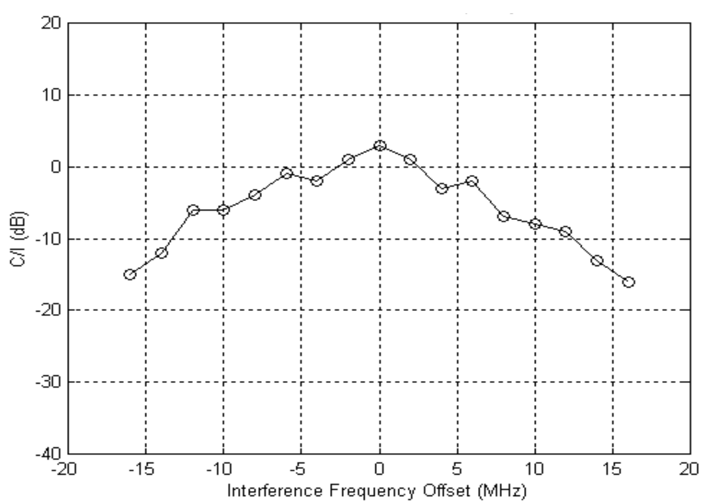


Figure C-11 C/I versus wideband interference frequency offset



Jitter Performance

Input Jitter Tolerance

HDB3 input ports were tested according to ITU-T Rec. G.823, Table 2 ($2^{15}-1$ pseudorandom test signal used).

Table C-8 Test results, input jitter tolerance

Test Frequency	Jitter Frequency (Hz)	Tolerable Input Jitter (UI_{p-p})	G.823 Lower Limit (UI_{p-p})
f_0	1.2×10^{-5}	> 40	36.9
f_1	20	10	1.5
f_2	2.4 k	10	1.5
f_3	18 k	3.6	0.2
f_4	100 k	0.7	0.2

The input jitter tolerance complies with Figure 3/G.823 and Table 2/G.823 requirements.

Output Jitter

The output jitter complies with Figure 4/G.823 and Table 3/G.921 (same pseudorandom test signal used as in preceding test). The output jitter in the absence of input jitter frequency in the range f_0 to f_4, is less than 0.1 UI_{p-p}; Table 3/G.921 allows for 0.2 UI_{p-p}.

Jitter Gain

The jitter gain in the frequency range, f_0 to f_4, is far below (worst case, –4 dB) the limit of 3 dB specified in Section 1.3.2.3/G.921.

Jitter Transfer Characteristic

Table C-9 shows that test results exceeded the standards of Figure 4/G.823 and AT&T 62411.

Table C-9 Test results, jitter transfer characteristic

Test Frequency	Jitter Frequency (Hz)	Jitter Attenuation (dB)	AT&T 62411 Upper Limit (dB)
f_0	1.2×10^{-5}	4.0	0
f_5	20	28.0	0
f_6	2 k	45.0	40
	> 2 k	> 45.0	40

Environmental Performance

Temperature Performance

Temperature (°C)	Tx Power (dBm)	Rx Threshold (dBm)
0	19.2	–91
25	19.0	–89
50	18.7	–88.5

Long-Term Error Performance

Receiver input level is set at the nominal –40 dBm at room temperature. Both transmitter and receiver achieved error-free performance over temperature cycling for 0°C to +50°C for continuous 8-hour testing.

Power Consumption Measurement

Input: 110 VAC
Power consumed: 21 watts

Appendix D
Typical Radio Performance Results for 2T1

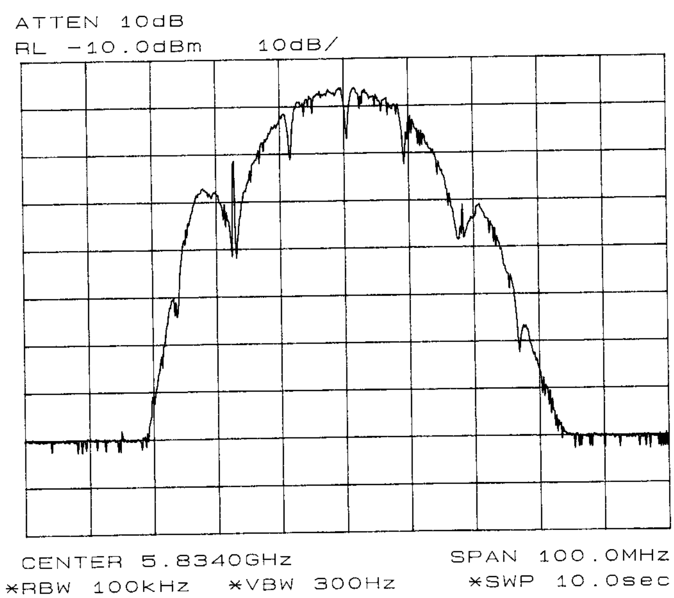
This appendix includes actual results from laboratory tests.

Refer to Appendix A for RF filter response graphs.

Transmitter RF Test

Transmit RF Spectrum (FCC Part 15.247)

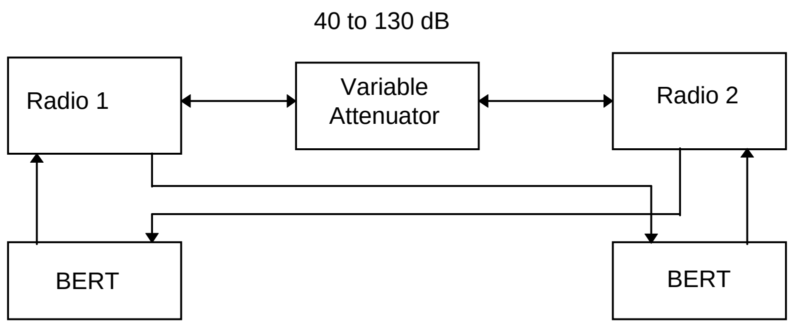
Figure D-1 Transmit RF spectrum



Receiver Tests

Test Setup

Figure D-2   Receiver test setup



Direction	Transmit	Receive
A	Radio 1 at 5741 MHz	Radio 2 at 5741 MHz
B	Radio 2 at 5803 MHz	Radio 1 at 5803 MHz

Receiver Sensitivity

Code used: 05B8
Requirement: Input threshold at BER $10^{-6} \leq -85$ dBm
Results: Both directions use same spread sequence.

Table D-1 Receiver sensitivity

Direction	Rx Input (dBm)	At
A	–90	BER = 1E-6
	–95	Sync loss
	–94	Re-acquisition
B	–89	BER = 1E-6
	–94	Sync loss
	–93	Re-acquisition

Dispersive Fade Margin

Test Conditions

Direction A code: 05B8
Direction B code: 05B8

Fade simulator is inserted in the 140-MHz IF path.
RCV input level is at nominal –40 dBm.

Direction A

See Table D-2 and Table D-3 for the results of this test for Direction A.

Table D-2 Direction A, minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
134	40.0			
136	28.0	> 40	> 40	> 40
138	25.5	> 40	> 40	> 40
140	29.5	> 40	> 40	> 40
142	29.5	> 40	> 40	> 40
144	31.5	> 40	> 40	> 40
146	40 at 144.5 MHz			

Table D-3 Direction A, non-minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
134	> 40			
136	> 40	> 40	> 40	> 40
138	> 40	> 40	> 40	> 40
140	> 40	> 40	> 40	> 40
142	34.0	> 40	> 40	> 40
144	30.0	> 40	> 40	> 40
146	40 at 144.8 MHz			

DFM = 61.68 dB for BER = 1E-6
DFM = 74.54 dB for BER = 1E-3

See Figure D-3 for the W curve at BER = 1E-6, and Figure D-4 for the W curve at BER = 1E-3.

Figure D-3 W Curve at BER=1E-6, Direction A

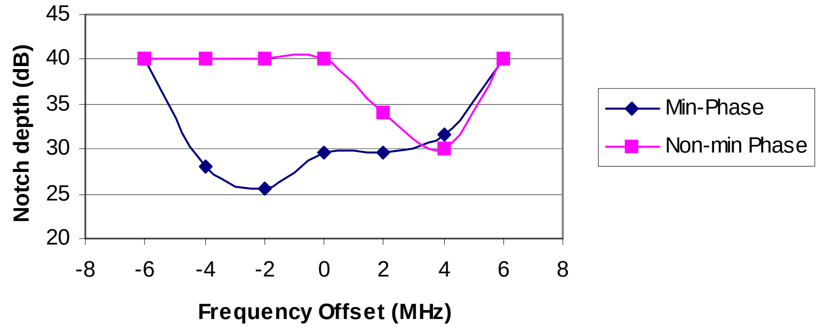
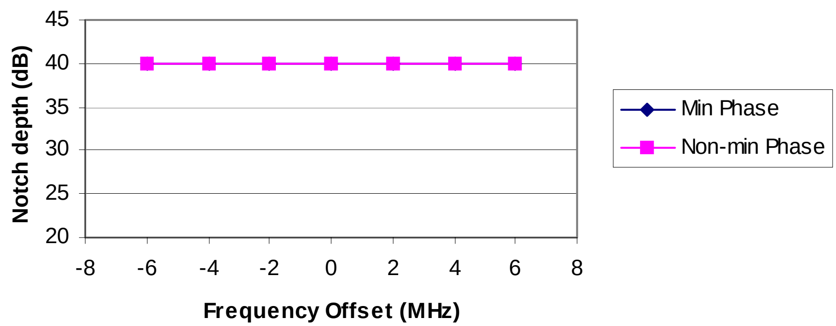


Figure D-4 W Curve at BER=1E-3, Direction A



Direction B

See Table D-4 and Table D-5 for the results of this test for Direction B.

Table D-4 Direction B, minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
134	40 at 134.5 MHz			
136	28.5	> 40	> 40	> 40
138	40.0	> 40	> 40	> 40
140	31.0	> 40	> 40	> 40
142	31.0	> 40	> 40	> 40
144	34.0	> 40	> 40	> 40
146	40 at 144.6 MHz			

Table D-5 Direction B, non-minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
134	> 40			
136	> 40	> 40	> 40	> 40
138	> 40	> 40	> 40	> 40
140	> 40	> 40	> 40	> 40
142	37.0	> 40	> 40	> 40
144	39.0	> 40	> 40	> 40
146	40 at 144.2 MHz			

DFM = 66.27 dB for BER = 1E-6
DFM = 74.54 dB for BER = 1E-3

See Figure D-5 for the W curve at BER = 1E-6 and Figure D-6 for the W curve at BER = 1E-3.

Figure D-5 W Curve at BER=1E-6, Direction B

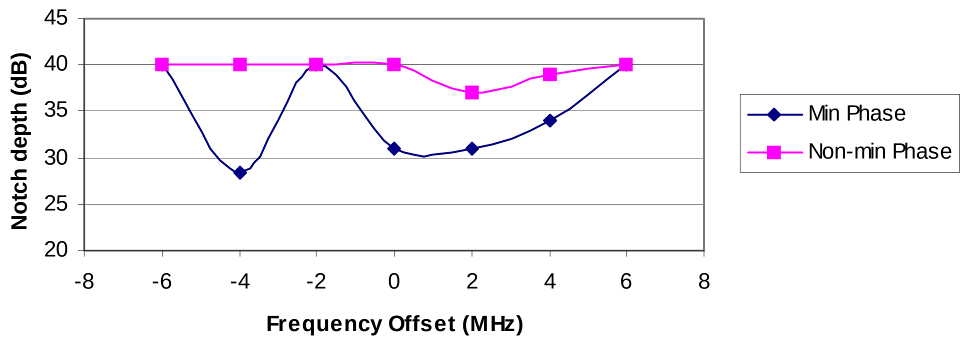
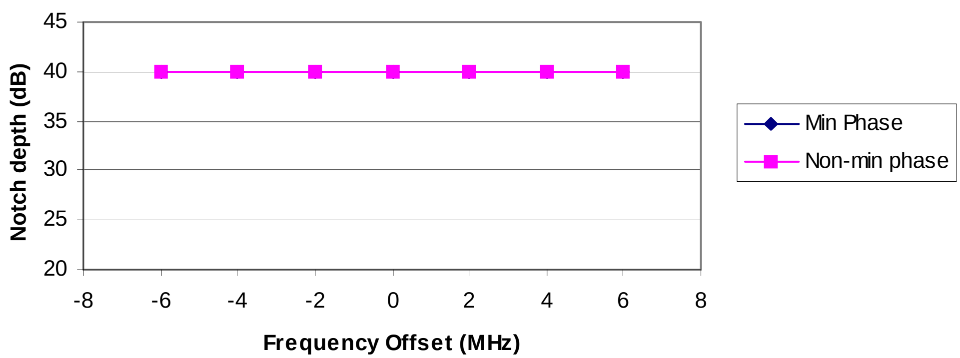


Figure D-6 W Curve at BER = 1E-3, Direction B



Dynamic Fading

Sweep Notch Depth Range

Table D-6 ***Sweep notch depth range for ultimate error-free region (elapse time: 0.1 sec)***

Notch Frequency (MHz)	Direction A Notch Depth (dB)		Direction B Notch Depth (dB)	
	Minimal Phase	Non-minimal Phase	Minimal Phase	Non-minimal Phase
135.0	28.0	> 40	26.0	> 40
140.0	30.0	> 40	31.0	> 40
145.0	30.0	> 40	> 40	> 40

Sweep Notch Frequency

Table D-7 ***Checking for error notch depth region, elapse time: 0.1 sec (equivalent to sweep speed 600 MHz/sec)***

Notch Frequency (MHz)	Direction A Notch Depth (dB)		Direction B Notch Depth (dB)	
	Minimal Phase	Non-minimal Phase	Minimal Phase	Non-minimal Phase
115 to 165	26.0	31.0	24.0	28.0

Flat Fading

Sweep for ultimate error-free attenuation range (flat fading), elapse time: 0.1 sec.

Note: Attenuation is inserted in the IF path. RF AGC is disabled. Only the dynamic performance of the IF AGC is tested.

Direction A: 0 to 62 dB
Direction B: 0 to 64 dB

Interference Performance

The effect of an interfering signal into a digital radio receiver is characterized by a 1-dB degradation in the BER=1×10^{-6} (static) and 1×10^{-3} (outage) thresholds. The standard for this characteristic is the threshold-to-interference (T/I) ratio, as defined in EIA/TIA Document TSB-10-F. [5]

The test was performed for sinewave (narrowband) interference and for like signal (wideband) interference. The method used in this test follows the TIA Bulletin TSB-10-F Standard T/I measurement recommendation.

The C/I uses nominal receiver input level (–40 dBm), and then interference is injected to get a BER of 10^{-6}. C/I is the ratio of the signal to interference ratio at this point, measured in direction A only.

Narrowband Interference

Figure D-7 T/I versus narrowband interference frequency offset

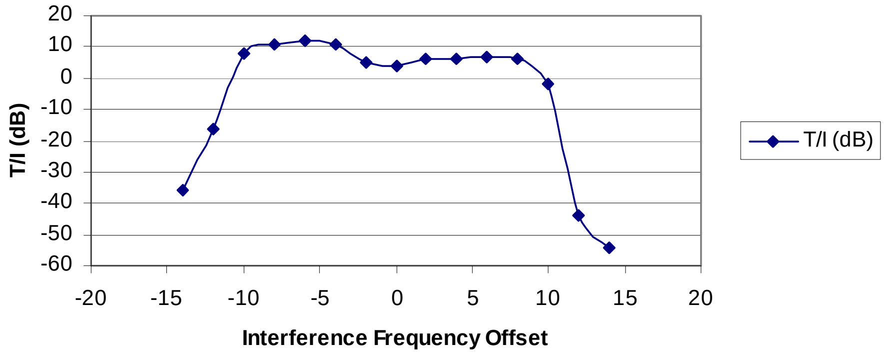
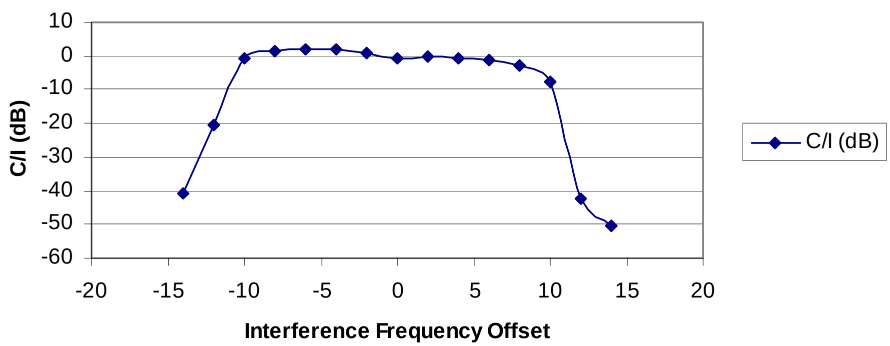


Figure D-8 C/I versus narrowband interference frequency offset



Wideband Interference

Figure D-9 T/I versus wideband interference frequency offset (Directions A and B, same code, 05B8)

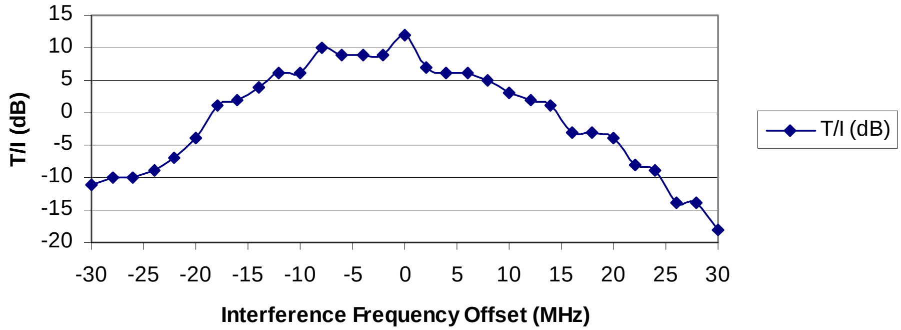


Figure D-10 T/I versus wideband interference frequency offset (Direction A: 05B8, Direction B: 3F0C)

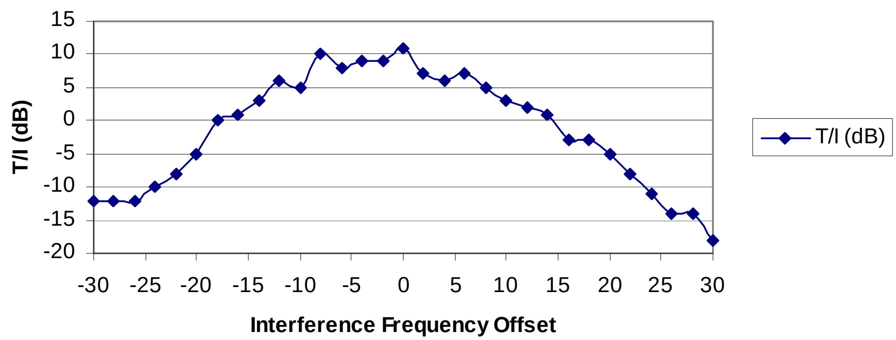
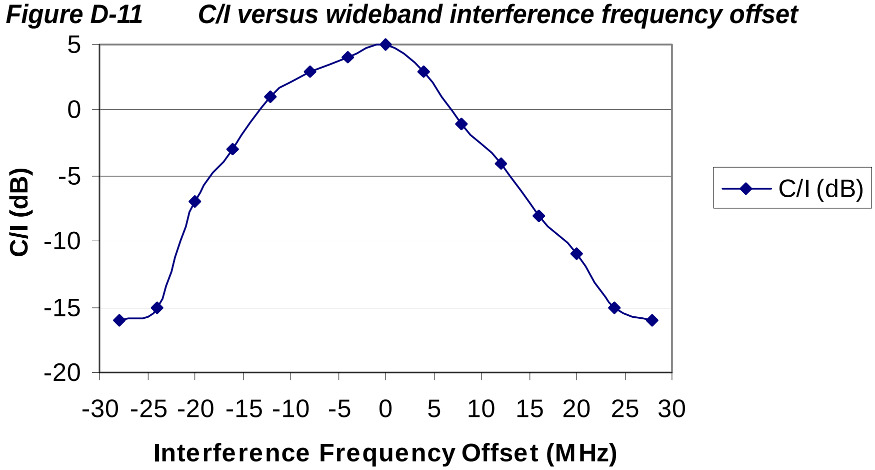


Figure D-11 C/I versus wideband interference frequency offset



FCC Part 15, Compliance Processing Gain Performance Test

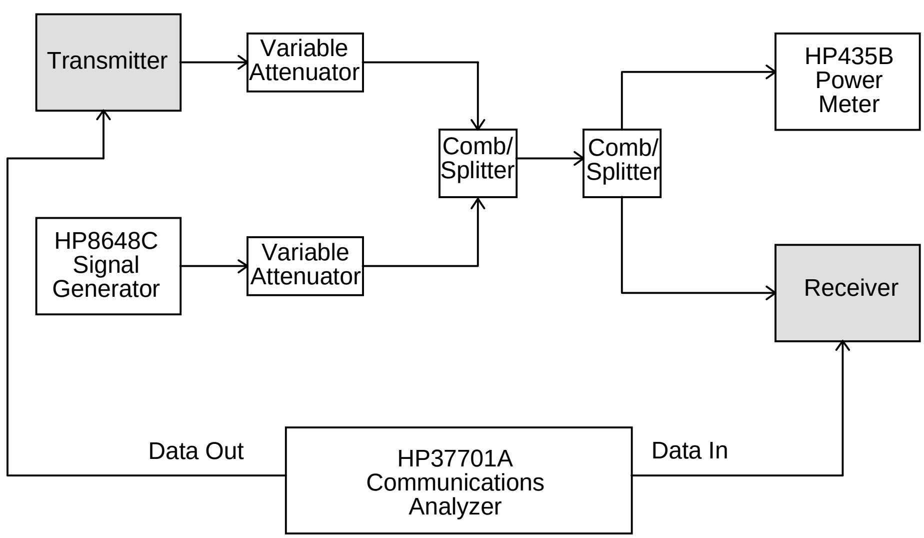
Test method recommended by FCC 97-114 is the CW Jamming Margin Method.

Characteristic	Value
Data rate	2T1 (3.208 Mb/s)
Chip rate	11 chips/bit
Designed processing gain	10.4 dB

Test Setup

Test setup is shown in Figure D-12.

Figure D-12 Processing gain test setup



Jamming Margin (J/S Ratio) (for BER 10^{-5})

The test was performed in Direction B. 50-kHz increments were used in this test; the worst 20% were discarded. See Table D-8.

After the worst 20% (64 points marked with (x)) were discarded, the lowest J/S ratio was –1.2 dB (marked with (**)).

Hence $M_j = -1.2$ dB.

The S/N ratio for ideal noncoherent receiver is calculated from

$Pe = ½\, e^{(-½\,(S/N)_o)}$,

where $Pe = 10^{-5}$.

Hence $(S/N)_o = 13.3$ dB.

The processing gain can be calculated as

$G_p = (S/N)_o + M_j + L_{sys}$

where L_{sys} = System Loss.

No more than 2-dB loss is allowed (we assumed 0 dB).

Hence $G_p = 13.3 - 1.2 + 0.0 = 12.1$ dB, better than the designed coding gain of 10.4 dB and better than the FCC's minimum requirement of 10 dB.

Table D-8 Jamming margin (J/S ratio) (for BER 10^{-5}) for 2T1

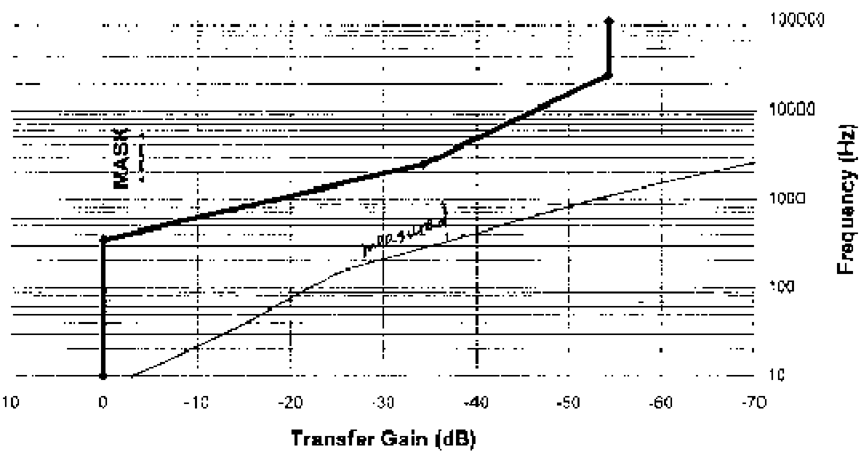
Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)
–10.00	0.4	–8.00	–1.2	–6.00	(x) –1.6	–4.00	(x) –1.5
.05	0.4	.05	–1.1	.05	(x) –1.6	.05	(x) –1.4
.10	0.4	.10	–1.2	.10	(x) –1.7	.10	(x) –1.3
.15	0.4	.15	(x) –1.3	.15	(x) –1.7	.15	(x) –1.3
.20	0.4	.20	(x) –1.7	.20	(x) –1.7	.20	(x) –1.3
.25	0.4	.25	(x) –1.5	.25	(x) –1.7	.25	(x) –1.3
.30	0.5	.30	(x) –1.6	.30	(x) –1.7	.30	(x) –1.3
.35	0.4	.35	(x) –1.7	.35	(x) –1.5	.35	(x) –1.3
.40	0.3	.40	(x) –1.8	.40	(x) –1.4	.40	(x) –1.3
.45	0.3	.45	(x) –1.7	.45	(x) –1.3	.45	(x) –1.4
.50	0.3	.50	(x) –1.7	.50	–1.2	.50	(x) –1.5
.55	0.3	.55	(x) –1.8	.55	–1.2	.55	(x) –1.2
.60	0.3	.60	(x) –1.8	.60	(x) –1.3	.60	–1.0
.65	0.3	.65	(x) –1.8	.65	(x) –1.3	.65	–1.0
.70	0.3	.70	(x) –1.8	.70	–1.2	.70	–0.9
.75	0.4	.75	(x) –1.6	.75	–1.2	.75	–0.8
.80	0.5	.80	(x) –1.5	.80	(x) –1.6	.80	–0.5
.85	0.4	.85	(x) –1.5	.85	(x) –1.5	.85	–0.6
.90	0.3	.90	(x) –1.4	.90	(x) –1.3	.90	–0.7
.95	0.2	.95	(x) –1.4	.95	(x) –1.5	.95	–0.8
–9.00	0.1	–7.00	(x) –1.3	–5.00	(x) –1.6	–3.00	–0.9
.05	–0.1	.05	(x) –1.3	.05	(x) –1.6	.05	–0.9
.10	–0.1	.10	–1.0	.10	(x) –1.6	.10	–0.9
.15	–0.2	.15	–1.1	.15	(x) –1.5	.15	–1.0
.20	–0.2	.20	–1.1	.20	(x) –1.6	.20	(x) –1.2
.25	–0.1	.25	–1.2	.25	(x) –1.7	.25	(x) –1.2
.30	–0.1	.30	**(**) –1.2**	.30	(x) –1.7	.30	(x) –1.2
.35	–0.1	.35	–1.1	.35	(x) –1.6	.35	–1.1
.40	0.0	.40	–1.1	.40	(x) –1.6	.40	–1.0
.45	–0.1	.45	(x) –1.3	.45	(x) –1.6	.45	–1.0
.50	–0.2	.50	(x) –1.4	.50	(x) –1.6	.50	–0.9
.55	–0.2	.55	(x) –1.3	.55	(x) –1.7	.55	–0.6
.60	–0.3	.60	(x) –1.4	.60	(x) –1.7	.60	–0.3
.65	–0.3	.65	(x) –1.6	.65	(x) –1.6	.65	–0.5
.70	–0.4	.70	(x) –1.7	.70	(x) –1.7	.70	–0.7
.75	–0.4	.75	(x) –1.7	.75	(x) –1.3	.75	–0.4
.80	–0.4	.80	(x) –1.7	.80	–0.7	.80	–0.3
.85	–0.4	.85	(x) –1.5	.85	(x) –1.6	.85	–0.2
.90	–0.6	.90	(x) –1.4	.90	(x) –1.9	.90	–0.1
.95	–0.6	.95	(x) –1.5	.95	(x) –1.7	.95	–0.1

Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)
–2.00	–0.1	0.00	1.0	+2.00	1.3	+4.00	1.5
.05	–0.2	.05	0.9	.05	1.3	.05	1.6
.10	–0.3	.10	0.9	.10	1.4	.10	1.5
.15	–0.2	.15	0.8	.15	1.3	.15	1.4
.20	–0.1	.20	0.7	.20	1.3	.20	1.5
.25	–0.1	.25	0.9	.25	1.3	.25	1.4
.30	–0.1	.30	1.1	.30	1.3	.30	1.3
.35	0.0	.35	0.9	.35	1.4	.35	1.3
.40	0.1	.40	0.8	.40	1.2	.40	1.2
.45	0.0	.45	1.0	.45	1.2	.45	1.2
.50	0.0	.50	1.2	.50	1.3	.50	1.1
.55	–0.2	.55	1.1	.55	1.1	.55	1.1
.60	–0.4	.60	1.0	.60	1.0	.60	1.2
.65	–0.4	.65	1.0	.65	1.1	.65	1.2
.70	–0.4	.70	1.0	.70	1.2	.70	1.2
.75	–0.5	.75	0.9	.75	1.3	.75	1.3
.80	–0.7	.80	0.8	.80	1.4	.80	1.4
.85	–0.7	.85	0.6	.85	1.2	.85	1.4
.90	–0.7	.90	0.4	.90	1.3	.90	1.5
.95	–0.4	.95	–0.1	.95	1.4	.95	1.4
–1.00	–0.2	+1.00	–0.2	+3.00	1.5	+5.00	1.3
.05	–0.2	.05	–0.1	.05	1.5	.05	1.7
.10	–0.1	.10	–0.6	.10	1.5	.10	1.8
.15	0.0	.15	0.1	.15	1.5	.15	1.7
.20	0.1	.20	0.2	.20	1.6	.20	1.7
.25	0.2	.25	0.3	.25	1.7	.25	1.7
.30	0.3	.30	0.4	.30	1.6	.30	1.6
.35	0.3	.35	0.5	.35	1.5	.35	1.8
.40	0.4	.40	0.7	.40	1.6	.40	2.0
.45	0.5	.45	0.8	.45	1.6	.45	1.7
.50	0.6	.50	1.0	.50	1.6	.50	1.6
.55	0.4	.55	1.0	.55	1.7	.55	1.7
.60	0.2	.60	1.1	.60	1.8	.60	1.6
.65	0.3	.65	0.6	.65	1.7	.65	1.6
.70	0.5	.70	0.3	.70	1.8	.70	1.7
.75	0.7	.75	0.5	.75	1.6	.75	1.8
.80	0.9	.80	1.1	.80	1.7	.80	1.8
.85	0.8	.85	1.1	.85	1.7	.85	1.7
.90	0.7	.90	1.1	.90	1.8	.90	1.8
.95	0.8	.95	1.2	.95	1.7	.95	1.8

Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)	Freq. Offset (MHz)	J/S (dB)
+6.00	1.8	+7.00	3.2	+8.00	3.8	+9.00	6.7
.05	1.8	.05	3.1	.05	4.1	.05	6.8
.10	1.8	.10	3.0	.10	4.6	.10	7.1
.15	2.0	.15	3.0	.15	5.2	.15	7.2
.20	2.1	.20	3.0	.20	6.0	.20	7.4
.25	2.0	.25	3.1	.25	6.0	.25	7.4
.30	1.9	.30	3.1	.30	5.2	.30	7.3
.35	1.9	.35	2.8	.35	5.3	.35	7.7
.40	1.9	.40	2.5	.40	5.5	.40	7.9
.45	2.2	.45	2.6	.45	5.6	.45	8.0
.50	2.6	.50	2.8	.50	5.7	.50	6.9
.55	2.5	.55	2.5	.55	5.7	.55	8.2
.60	2.5	.60	2.2	.60	5.8	.60	8.0
.65	2.7	.65	2.4	.65	5.8	.65	8.1
.70	3.0	.70	2.5	.70	5.9	.70	8.2
.75	2.9	.75	3.0	.75	6.0	.75	8.8
.80	2.7	.80	3.3	.80	6.2	.80	9.2
.85	2.7	.85	3.3	.85	6.4	.85	9.2
.90	2.8	.90	3.2	.90	6.6	.90	9.2
.95	2.9	.95	3.5	.95	6.6	.95	9.8
						+10.00	10.2

Jitter Transfer Function

Figure D-13 Jitter transfer (DS1)



Environmental Performance

Temperature Performance

Direction B, Code: 05B8

Temperature (°C)	Tx Power (dBm)	Rx Threshold (dBm)
0	19.2	–90
25	19.0	–89
50	18.7	–87.5

Long-Term Error Performance

Receiver input level is set at the nominal –40 dBm at room temperature. Both transmitter and receiver achieved error-free performance over temperature cycling for 0°C to +50°C for continuous 8-hour testing.

Power Consumption Measurement

Input: 110 VAC
Power consumed: 21 watts

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Appendix E
Typical Radio Performance Results for 2E1

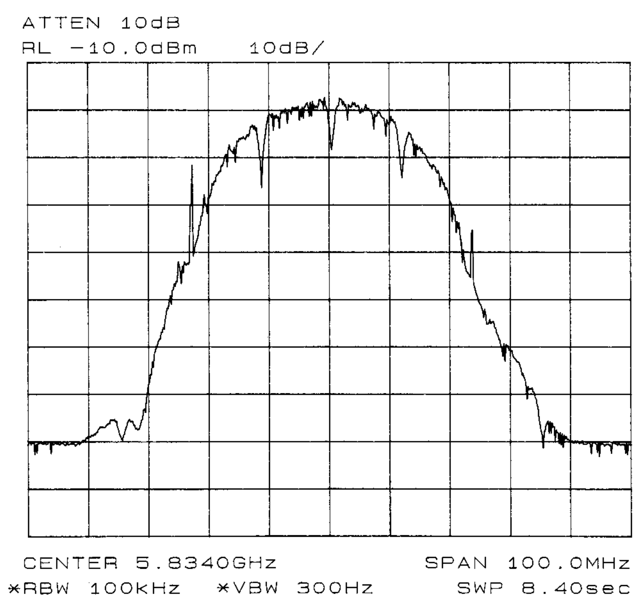
This appendix includes actual results from laboratory tests.

Refer to Appendix A for RF filter response graphs.

Transmitter RF Test

Transmit RF Spectrum

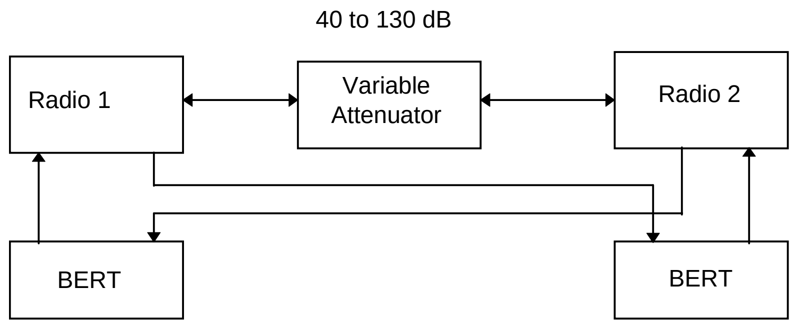
Figure E-1 Transmit RF spectrum



Receiver Tests

Test Setup

Figure E-2 Receiver test setup



Direction	Transmit	Receive
A	Radio 1 at 5772 MHz	Radio 2 at 5772 MHz
B	Radio 2 at 5834 MHz	Radio 1 at 5834 MHz

Receiver Sensitivity

Code used: 05B8
Requirement: Input threshold at BER $10^{-6} \leq -85$ dBm
Results: Both directions use same spread sequence.

Table E-1 Receiver sensitivity

Direction	Rx Input (dBm)	At
A	–88	BER = 1E-6
	–93	Sync loss
	–92	Re-acquisition
B	–87	BER = 1E-6
	–93	Sync loss
	–92	Re-acquisition

Dispersive Fade Margin

Test Conditions

Direction A code: 05B8
Direction B code: 05B8

Fade simulator is inserted in the 140-MHz IF path.
RCV input level is at nominal - 40 dBm.

Direction A

See Table E-2 and Table E-3 for the results of this test for Direction A.

Table E-2 *Direction A, minimal phase*

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
132	40 at 132.4 MHz			
134	32.8	> 40		
136	28.5	33.0	> 40	> 40
138	25.0	29.0	> 40	> 40
140	26.0	30.0	> 40	> 40
142	23.7	32.0	> 40	> 40
144	20.5	> 40	> 40	> 40
146	20.4			
148	30.0			
	40 at 149.5 MHz			

Table E-3 *Direction A, non-minimal phase*

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
132	> 40			
134	> 40			
136	> 40	> 40		
138	> 40	> 40		
140	> 40	> 40		
142	22.2	> 40		
144	19.4	> 40		
146	18.0			
148	22.0			
	40 at 149 MHz			

DFM = 51.6 dB for BER = 1E-6
DFM = 63.01 dB for BER = 1E-3

See Figure E-3 for the W curve at BER = 1E-6, and Figure E-4 for the W curve at BER = 1E-3.

Figure E-3 W Curve at BER=1E-6, Direction A

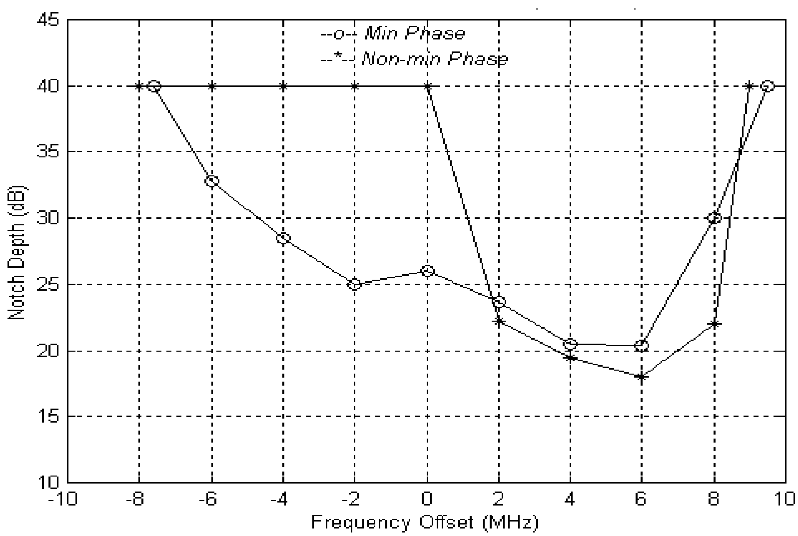
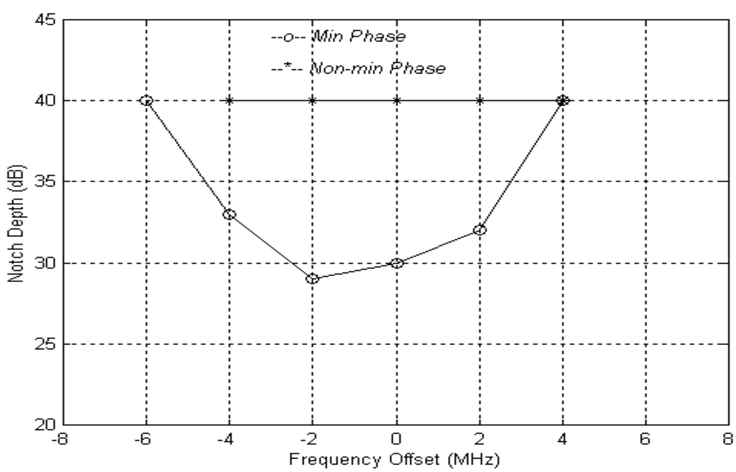


Figure E-4 W Curve at BER=1E-3, Direction A



Direction B

See Table E-4 and Table E-5 for the results of this test for Direction B.

Table E-4 Direction B, minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
136	> 40			
138	> 40	> 40		
140	> 40	> 40		
142	33	> 40		
144	36			
146	> 40			

Table E-5 Direction B, non-minimal phase

Notch Frequency (MHz)	Notch Depth (dB) at BER 1E-6	Notch Depth (dB) at BER 1E-3	Notch Depth (dB) at Sync Loss	Notch Depth (dB) at Re-acquisition
136	> 40			
138	> 40	> 40		
140	> 40	> 40		
142	39	> 40		
144	25			
146	> 40			

DFM = 67.34 dB for BER = 1E-6
DFM = 76.3 dB for BER = 1E-3

See Figure E-5 for the W curve at BER = 1E-6 and Figure E-6 for the W curve at BER = 1E-3.

Figure E-5 W Curve at BER = 1E-6, Direction B

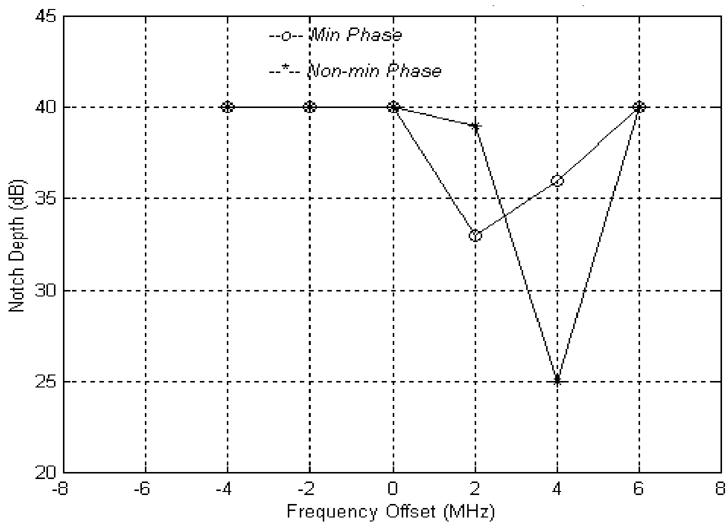
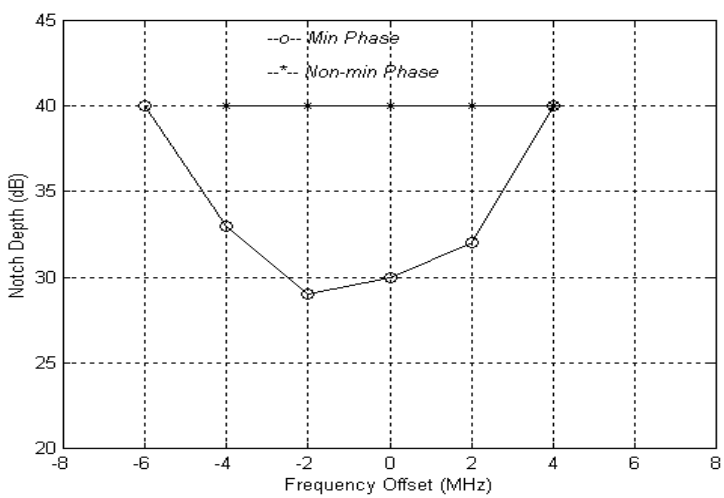


Figure E-6 W Curve at BER=1E-3, Direction B



Dynamic Fading

Sweep Notch Depth Range

Table E-6 ***Sweep notch depth range for ultimate error-free region (elapse time: 0.1 sec)***

Notch Frequency (MHz)	Direction A Notch Depth (dB)		Direction B Notch Depth (dB)	
	Minimal Phase	Non-minimal Phase	Minimal Phase	Non-minimal Phase
135.0	0 to 31	0 to > 40	0 to 24	0 to > 40
140.0	0 to 27	0 to > 40	0 to 29	0 to > 40
145.0	0 to 18	0 to 18	0 to 31	0 to 25

Sweep Notch Frequency

Table E-7 ***Checking for error notch depth region, elapse time: 0.1 sec (equivalent to sweep speed 600 MHz/sec)***

Notch Frequency (MHz)	Direction A Notch Depth (dB)		Direction B Notch Depth (dB)	
	Minimal Phase	Non-minimal Phase	Minimal Phase	Non-minimal Phase
115 to 165	19.0	19.0	22.0	24.0

Flat Fading

Sweep for ultimate error-free attenuation range (flat fading), elapse time: 0.1 sec.

Note: Attenuation is inserted in the IF path. RF AGC is disabled. Only the dynamic performance of the IF AGC is tested.

Direction A: 0 to 61 dB
Direction B: 0 to 62 dB

Interference Performance

The effect of an interfering signal into a digital radio receiver is characterized by a 1-dB degradation in the BER=1×10^{-6} (static) and 1×10^{-3} (outage) thresholds. The standard for this characteristic is the threshold-to-interference (T/I) ratio, as defined in EIA/TIA Document TSB-10-F. [Ref 5]

The test was performed for sinewave (narrowband) interference and for like signal (wideband) interference. The method used in this test follows the TIA Bulletin TSB-10-F Standard T/I measurement recommendation.

The C/I uses nominal receiver input level (–40 dBm), and then interference is injected to get a BER of 10^{-6}. C/I is the ratio of the signal to interference ratio at this point, measured in direction A only.

See Figure E-7 to Figure E-11.

Narrowband Interference

Figure E-7 T/I versus narrowband interference frequency offset

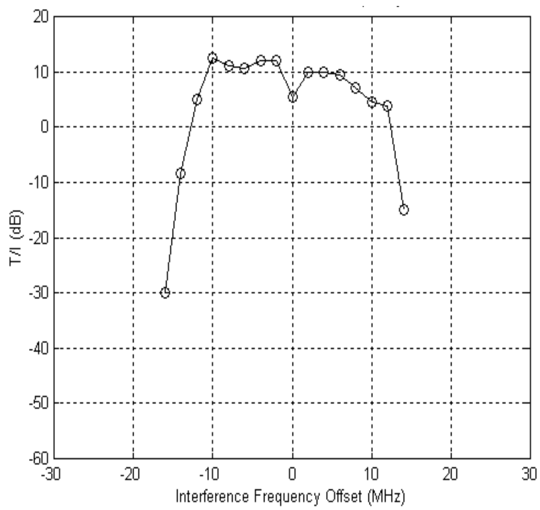
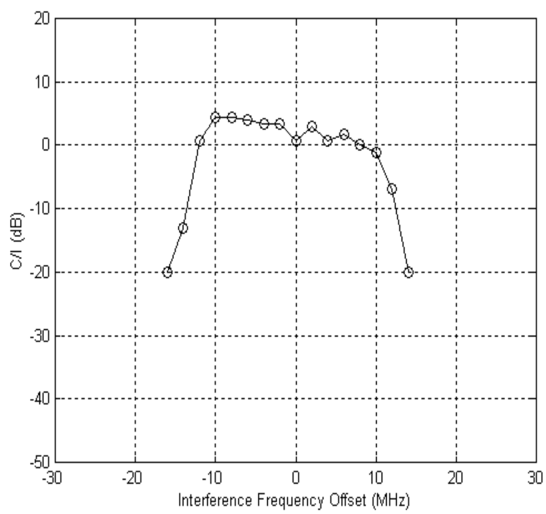


Figure E-8 C/I versus narrowband interference frequency offset



Wideband Interference

Figure E-9 T/I versus wideband interference frequency offset (Directions A and B, same code, 05B8)

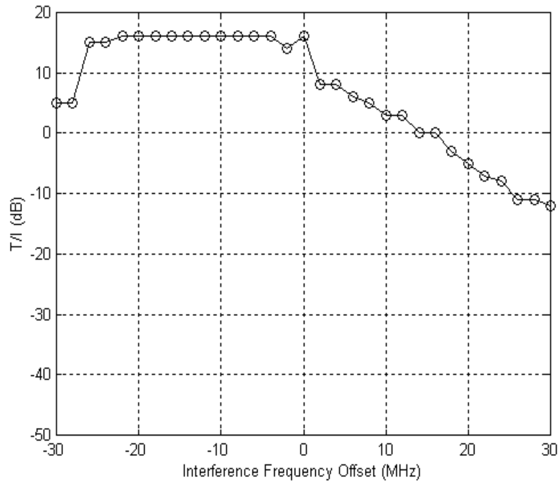


Figure E-10 T/I versus wideband interference frequency offset (Direction A: 05B8, Direction B: 0247)

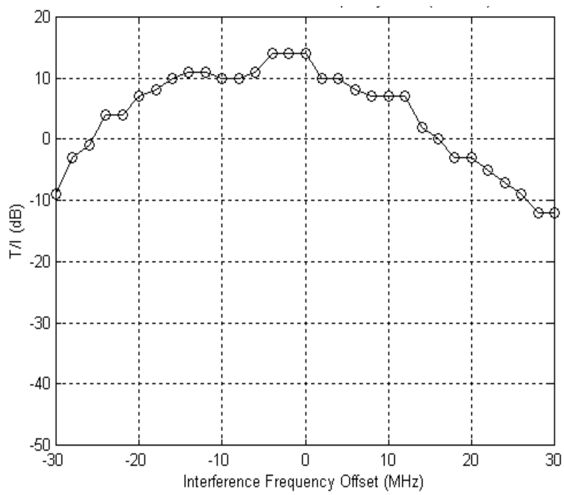
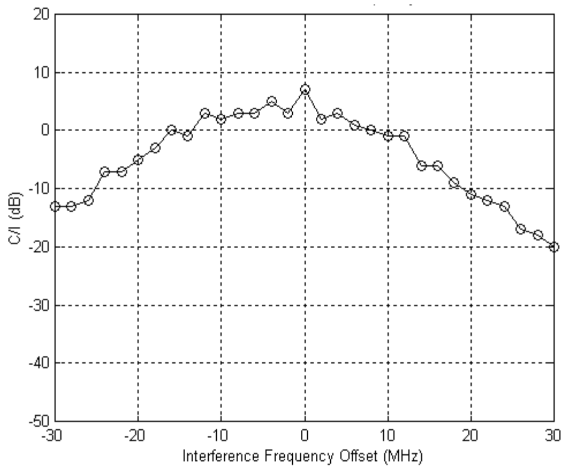


Figure E-11 C/I versus wideband interference frequency offset



Jitter Performance

Input Jitter Tolerance

HDB3 input ports were tested according to ITU-T Rec. G.823, Table 2 (2^{15} -1 pseudorandom test signal used).

Table E-8 ***Test results, input jitter tolerance***

Test Frequency	Jitter Frequency (Hz)	Tolerable Input Jitter (UI_{p-p})	G.823 Lower Limit (UI_{p-p})
f_0	1.2×10^{-5}	> 40	36.9
f_1	20	10	1.5
f_2	2.4 k	10	1.5
f_3	18 k	3.6	0.2
f_4	100 k	0.7	0.2

The input jitter tolerance complies with Figure 3/G.823 and Table 2/G.823 requirements.

Output Jitter

The output jitter complies with Figure 4/G.823 and Table 3/G.921 (same pseudorandom test signal used as in preceding test). The output jitter in the absence of input jitter frequency in the range f_0 to f_4, is less than 0.1 UI_{p-p}; Table 3/G.921 allows for 0.2 UI_{p-p}.

Jitter Gain

The jitter gain in the frequency range, f_0 to f_4, is far below (worst case, –4 dB) the limit of 3 dB specified in Section 1.3.2.3/G.921.

Jitter Transfer Characteristic

Table E-9 shows that test results exceeded the standards of Figure 4/G.823 and AT&T 62411.

Table E-9 Test results, jitter transfer characteristic

Test Frequency	Jitter Frequency (Hz)	Jitter Attenuation (dB)	AT&T 62411 Upper Limit (dB)
f_0	1.2×10^{-5}	4.0	0
f_5	20	28.0	0
f_6	2 k	45.0	40
	> 2 k	> 45.0	40

Environmental Performance

Temperature Performance

Temperature (°C)	Tx Power (dBm)	Rx Threshold (dBm)
0	19.2	–89
25	19.0	–88
50	18.7	–87.5

Long-Term Error Performance

Receiver input level is set at the nominal –40 dBm at room temperature. Both transmitter and receiver achieved error-free performance over temperature cycling for 0^{o}C to $+50^{o}$C for continuous 8-hour testing.

Appendix F
Forms

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Harris Microwave Communications Division
Service Registration Form

To facilitate warranty support and to receive product update information, please complete and return this form to our customer service department.

By fax: 514-421-3555

By e-mail: crcmtl@harris.com

By mail: Harris Corporation
Microwave Communications Division
3 Hotel de Ville
Dollard-des-Ormeaux, Quebec
CANADA H9B 3G4

Attention: Customer Resource Center

The Customer Resource Center is available on the internet at http://www.microwave.harris.com/cservice/.

Please print:

Company Name: ______________________________________

Requester's Name: ____________________________________

Title____ **Dept.** ______________________________

Address

City ____ **State/Province**______________________________

ZIP/Postal Code _______________________________ **Country**___________________________________

Telephone Number _____________________________ **Fax Number** ______________________________

E-mail____

Original Sales Order/PO Number________________

(Sales order number is found in your documentation and on the equipment rack base plate.)

Harris Microwave Communications Division
Rapid Request for Return Material Authorization (RMA)

Service Locations:

5727 Farinon Drive **or** **3, Hotel de Ville, Dollard-des-Ormeaux**
San Antonio, TX 78249, USA **Quebec, CANADA H9B 3G4**

Tel: 1-800-227-8332 **or** **1-800-465-4654, (+1) 514-421-8333**
Fax: (+1) 514-421-3555

The Customer Resource Center is available on the internet at http://www.microwave.harris.com/cservice/.

Company Name:______________________________ **Phone**: ______________________________________

Requester's Name: __________________________ **Fax**:____

Billing Address **Shipping Address**

____ ____

____ ____

____ ____

Service Requested: [ ] Repair [ ] Exchange

Requested Repair Urgency: [ ] Standard [ ] Expedite

Warranty Status: [ ] IN-WARR (Provide Sales Order No.) ________________________________

[ ] NON-WARR (Provide Purchase Order No.) __________________________

Requested Mode of Shipment: [ ] Standard Service [ ] 2nd Day Air [ ] Overnight

NOTE: IN-WARRANTY UNITS are returned via STANDARD SERVICE only. Please provide COURIER ACCOUNT NUMBER if faster delivery is required.____

SD Number and Options	**Part Description**	**Problem/Service Required**
_________________________	______________________________	_________________________________
_________________________	______________________________	_________________________________
_________________________	______________________________	_________________________________
_________________________	______________________________	_________________________________
_________________________	______________________________	_________________________________

Special Instructions

____

____

____

Please do not write below this space

Date Form Received: _____________________ Rec by: __________________________ Your RMA # is: ________

Repair/Exchange Price: Item 1________________________ Item 4 ________________________

Item 2________________________ Item 5 ________________________

Item 3________________________ Item 6 ________________________

Harris MCD Instruction Manual Survey

1. Overall, taking everything into account, how would you rate this Harris MCD instruction manual (IM)? *(check one box)*

☐ Excellent ☐ Fair
☐ Very Good ☐ Poor
☐ Good

2. How do you think this Harris MCD IM compares with the instruction manuals provided by other manufacturers of microwave radio assemblies? *(check one box)*

☐ Better than other instruction manuals.
☐ About the same as other instruction manuals.
☐ Worse than other instruction manuals.

3. If you have the printed version of the Harris MCD IM, please rate the following characteristics. *(check one box per characteristic)*

	Excellent	Very Good	Good	Fair	Poor
Binding	☐	☐	☐	☐	☐
Section tabs	☐	☐	☐	☐	☐
Printing	☐	☐	☐	☐	☐
Type style	☐	☐	☐	☐	☐
Text format	☐	☐	☐	☐	☐
Page layout	☐	☐	☐	☐	☐

4. If you have the CD-ROM version of the Harris MCD IM, please rate the following characteristics. *(check one box per characteristic)*

	Excellent	Very Good	Good	Fair	Poor
Ease of installation	☐	☐	☐	☐	☐
Hypertext links	☐	☐	☐	☐	☐
Legibility	☐	☐	☐	☐	☐
Text format	☐	☐	☐	☐	☐
Page layout	☐	☐	☐	☐	☐

5. Using the same scale as in question 3 or 4, please rate each of the following characteristics as they relate to the context of this Harris MCD IM. *(check one box per characteristic)*

	Excellent	Very Good	Good	Fair	Poor
Organization	☐	☐	☐	☐	☐
Clarity	☐	☐	☐	☐	☐
Completeness	☐	☐	☐	☐	☐
Correctness	☐	☐	☐	☐	☐

6. Using the same scale once again, please rate each of the following characteristics as they relate to the diagrams, illustrations, charts, graphs, tables, and figures in this Harris MCD IM. *(check one box per characteristic)*

	Excellent	Very Good	Good	Fair	Poor
Organization	☐	☐	☐	☐	☐
Clarity	☐	☐	☐	☐	☐
Completeness	☐	☐	☐	☐	☐
Correctness	☐	☐	☐	☐	☐

7. Please rate the following sections of this Harris MCD IM. *(check one box per characteristic)*

	Excellent	Very Good	Good	Fair	Poor
Table of contents	☐	☐	☐	☐	☐
General information	☐	☐	☐	☐	☐
Installation section	☐	☐	☐	☐	☐
Operation procedure	☐	☐	☐	☐	☐
Alignment section	☐	☐	☐	☐	☐
Routine maintenance	☐	☐	☐	☐	☐
Trouble isolation	☐	☐	☐	☐	☐
Unit replacement	☐	☐	☐	☐	☐
Appendixes	☐	☐	☐	☐	☐
Index	☐	☐	☐	☐	☐

8. What is there about this Harris MCD IM that you like? *(please be specific)*

____

____

9. On the other hand, what is there about this Harris MCD IM that you dislike? *(please be specific)*

____

____

10. Which of the following comes closest to describing your title? *(check one box)*

☐ Technician ☐ Communications Tech
☐ Engineer ☐ Operations Manager
☐ Other (specify): __________________________

Please complete the following information.

IM Part No.: **Issue:**

Product:

Your Name:

Your Title:

Company:

Address:

After completing this form, fold (see reverse side), seal, and mail to Harris MCD. No postage required if mailed in the United States.

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Glossary

AC

Alternating Current.

ACU

Antenna Coupling Unit.

A/D

Analog to Digital.

ADPCM

Adaptive Differential Pulse Code Modulation.

AGC

Automatic Gain Control; automatic gain adjustment of a varying input signal level to produce a constant output signal level.

AIS

Alarm Indication Signal.

ALC

Automatic Level Control.

AMI

Alternate Mark Inversion.

ANSI

American National Standards Institute.

antenna feed system

A system that transports signals from the output terminal of the transmitter to the antenna or to the antenna radiator. It usually consists of the transmitter-antenna feed connector, the antenna feed, and the antenna mechanical structure, such as a tower, mast, and radiator support, and does not include the antenna or the radiator and reflector, if any.

B8ZS

Bipolar with Eight Zero Substitution.

baseband

A frequency band occupied by a modulating information signal.

Bellcore

Bell Communications Research, Inc. (source of telephony standards in the U.S.A.).

BER

Bit Error Ratio.

BERT

Bit Error Ratio Tester.

BPF

BandPass Filter.

BSC

Base Station Controller.

BW

BandWidth.

CAN

Controller Area Network, an interface standard (ISO 11898) for interconnecting microcontrollers.

CEPT

Conference Européen des Administrations des Postes et des Télécommunications.

C/I

Carrier-to-Interference (ratio).

CIT

Craft Interface Terminal.

CRC

Customer Resource Center.

CW

Continuous Wave.

DC

Direct Current.

demux

demultiplexer.

DFM

Dispersive Fade Margin.

DIP

Dual In-line Package (switch).

directivity

The distribution in space of the energy radiated by an antenna.

DMM

Digital MultiMeter.

DQPSK

Differential Quadrature Phase-Shift Keying.

DSSS

Direct Sequence Spread Spectrum.

D-subminiature connectors

The size of the D-subminiature connector is specified by the standard shell size and the number of connectors. For example, a 15-pin connector is referred to as a DA-15. See the following table.

Standard Shell Size	No. of Connectors
E	9
A	15
B	25
C	37
D	50

DTE

Data Terminal Equipment.

EEPROM

Electronically Erasable Programmable Read-Only Memory.

EIA

Electronic Industries Association.

EIRP

Effective Isotropic Radiated Power.

ETSI

European Telecommunications Standards Institute.

FarScan

Harris' network management system software.

FCC

Federal Communications Commission (U.S.).

FM

Fade Margin; Frequency Modulation.

FPGA

Field-Programmable Gate Array.

hop

The span between a transmitter and a receiver.

IF

Intermediate Frequency; frequency below the radio frequency.

IM

Instruction Manual.

ISM

Industrial, Scientific, and Medical.

ISO

International Organization for Standardization.

ITU

International Telecommunication Union.

J/S

Jamming-to-Signal (ratio).

LAN

Local Area Network.

LED

Light-Emitting Diode.

LNA

Low-Noise Amplifier.

LO

Local Oscillator.

LOS

Loss Of input data Signal.

MCD

Microwave Communications Division, formerly Farinon Division.

MCU

MicroController Unit.

MMIC

Microwave Monolithic Integrated Circuit.

MSC

Mobile Switch Center.

MTBF

Mean Time Between Failures.

mux

multiplexer.

NC

Normally Closed.

NCO

Numerically Controlled Oscillator.

NMS

Network Management System.

NO

Normally Open.

NRZ

NonReturn to Zero (coding).

OEM

Original Equipment Manufacturer.

PA

Power Amplifier.

PCB

Printed Circuit Board.

PCN

Personal Communications Network.

PCS

Personal Communications Service.

PLL

Phase-Locked Loop.

PN

Pseudo-random Number.

QPSK

Quadrature Phase-Shift Keying.

RF

Radio Frequency.

RMA

Return Material Authorization.

RMS

Rack-Mounting Space.

ROM

Read-Only Memory.

RSL

Received Signal Level.

RSSI

Receive Signal Strength Indicator.

RX

Receiver.

SAW

Surface Acoustic Wave.

SCAN

System Control And Alarm Network. Harris' proprietary standard for sending alarm/status/control messages over a serial port.

SD

Schematic Drawing.

SESR

Severe Errored-Second Ratio.

SNMP

Simple Network Management Protocol.

SPSC

Spare Products Support Center.

TCXO

Temperature-Compensated Crystal Oscillator.

T/I

Threshold-to Interference (ratio).

TIA

Telecommunication Industries Association.

TX

Transmitter.

VCO

Voltage-Controlled Oscillator.

VGA

Variable Gain Amplifier.

WAN

Wide Area Network.

XO

Crystal Oscillator.

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