Applied Radar, Inc.
www.appliedradar.com

AR1012
SWORD™ DREX

User's Manual

Revision 1.0.0, May 2011

Notices

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A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

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Safety Notices

CAUTION

A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

WARNING

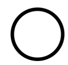
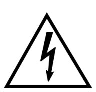
A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the likes that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Personal Safety Considerations

This is a Safety Class I product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor, inside or outside the product, is likely to make the product dangerous. Intentional interruption is prohibited. If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means of protection are intact) only.

No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers. For continued protection against fire hazard, replace the line fuse(s) only with fuses of the same type and rating (for example, normal blow, time delay, etc.). The use of other fuses or material is prohibited.

Safety Symbols

	Direct current		On (supply)
	Alternating current		Off (supply)
	Both direct and alternating current		Three-phase alternating current
	Earth (ground) terminal		Protective conductor terminal
	Chassis terminal		Protective conductor terminal
	Temperature		Caution, risk of danger
	Caution, risk of electric shock		Caution, hot surface
	Microwave radiation hazard		

Markings
The following markings may appear on the equipment or in any related documentation.

Marking	Description
ESD Sensitive	This marking indicates that a device, or part of a device, may be susceptible to electrostatic discharges (ESD) which can result in damage to the product. Observed ESD precautions given on the product, or in its user documentation, when handling equipment bearing this mark.
FC Part 15	This marking indicates that the device complies with applicable sections of part 15 of the FCC rules.
VISA	This marking indicates that the device complies with the Virtual Instrument Software Architecture (VISA) specification.
SCPI	This marking indicates that the device complies with the Standard Commands for Programmable Instrumentation (SCPI) specification.
USBTMC *USB488*	This marking indicates that the device complies with the USB Test & Measurement Class (USBTMC) and the USB 488 subclass specifications.
VXI bus	This marking indicates that the device complies with the VME eXtensions for Instrumentation (VXI) specification.
LXI™ LAN eXtensions for Instrumentation	This marking indicates that the device complies with the LAN eXtensions for Instrumentation (LXI) specification.
IOIOI	This marking indicates that the device communicates over the RS232 Serial Bus.

This marking indicates that the device communicates over the Universal Serial Bus (USB).

This marking indicates that the device communicates over Ethernet.

This marking indicates that the device is USB Low Speed and Full Speed certified.

This marking indicates that the device is USB On The Go (OTG) Low Speed and Full Speed certified.

This marking indicates that the device is USB High Speed certified.

This marking indicates that the device is USB On The Go (OTG) High Speed certified.

This marking indicates that the device communicates over the proprietary Applied Radar Expansion Bus. This expansion bus allows multiple Applied Radar products to be connected to a common host board to provide a single connection to the control computer.

Equipment Disposal

Do not dispose in domestic household waste

To dispose of this equipment, check your local or state regulations for proper disposal instructions.

General Safety Information

The following general safety precautions must be observed during all phases of operation of this product. Failure to comply with these precautions or with specific warnings elsewhere in this manual or any manual associated with this product violates safety standards of design, manufacture, and intended use of the product. Applied Radar, Inc. assumes no liability for the customer's failure to comply with these requirements.

WARNING

BEFORE APPLYING POWER TO THIS PRODUCT OR MAKING ANY CONNECTIONS TO THIS PRODUCT ensure that all instruments are connected to the protective (earth) ground. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in personal injury or death.

CAUTION

- Use this device with the cables provided.
- Do not attempt to service this device. This device should be returned to Applied Radar, Inc. for any service or repairs.
- Do not open the device.

Environmental Conditions

This product is designed for *indoor* use only. Table i shows the general environmental requirements for this product.

Table i: Environmental Conditions

Condition	Requirements
Temperature	0 °C to +40 °C (operating) -30 °C to +70 °C (non-operating)
Humidity	Operating up to 96% at 70 °C (non-condensing) Operating up to 90% at 65 °C (non-condensing)
Altitude	Operating up to 4,600 meters (15,000 feet) Non-Operating up to 4,600 meters (15,000 feet)

Revision Control

Revision	Description of Changes	Date
1.0.0	Initial Creation	01/06/2011

Acronyms

ARI Applied Radar, Inc.

AROSA Applied Radar Open Source Architecture

BMD Ballistic Missile Defense

CPG Coherent Pulse Group

CPI Coherent Pulse Interval

DREX Digital Receiver EXciter

ECU Embedded Controller Unit

GUI Graphical User Interface

OSA Open Systems Architecture

ROSA Radar Open Systems Architecture

SBC Single Board Computer

SWORD Scalable Wideband Open Systems Architecture Radar

VVA Voltage Variable Attenuator

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1 Introduction

In This Chapter

The following markings apply to the SWORD™ DREX

ESD Sensitive

SCPI **VISA** **USBTMC** **USB488**

1. Overview

The SWORD™ DREX is a four channel Scalable Wideband Open Systems Architecture Radar (SWORD) Digital Receiver EXciter (DREX) system which is based on the Applied Radar Open Source Architecture (AROSA) model. The AR1012 is comprised of several Applied Radar, Inc. (ARI) products. For a complete list of the products and options in your SWORD™ DREX system, please reference the *Product Configuration Sheet* which shipped with the SWORD™ DREX system.

The AR1012 SWORD™ DREX is available in different factory configurations, optimized for operation at different radar bands and with up to 500 MHz of instantaneous bandwidth. The configured frequency band and instantaneous bandwidth can be found on the front panel of the SWORD™ DREX on the Product Identification Panel and is in the format SWORD™-*RBBB*, where *R* is the frequency band designator (i.e. L, C, S, X, etc.) and *BBB* is the instantaneous bandwidth in MHz. For example, a SWORD™ DREX factory configured to operate at X-Band with 400 MHz of instantaneous bandwidth will be designated as a SWORD™-X400.

2. Part Number

The part number for the SWORD™ DREX is in the format *AR1012-WW-XX-YY*, where *WW* is the lower operating frequency limit in GHz, *XX* is the upper operating frequency limit in GHz and *YY* is the number of channels. For example, *AR1012-7-11-4* identifies the SWORD™ DREX as having four channels with an operating range of 7 GHz to 11 GHz.

3. Options

The AR1012 SWORD™ DREX is available with factory installed options, which are listed in Table 1.1. To determine which options are installed in your AR1012, please refer to either the *Product Configuration Sheet* that came with your product or the *Part Identification Label* located on the rear of the AR1012.

Table 1.1: Factory installed options

001	Single Board Computer
002	4 port Gigabit Ethernet switch installed
100	VME Slot 0 MXI-Bus Controller installed (deletes Options 001 and 002)
110	Processing/Control computer installed (requires Option 100)

4. Included Components

The AR1012 SWORD™ DREX is a complete system which is comprised the following components:

- 16U 19-inch Rack, black in color
  - Product identification panel with master power switch
  - 4U, five slot VME chassis
    - VME Power Supply
    - Custom I/O panel integrated into the VME chassis
    - AR1006 Dual Mezzanine FPGA Processor with AR8006 DAC and AR8005 ADC mezzanines installed

    - AR1004-2-18-4 Four Channel RF Downconverter, 2 to 18 GHz
    - (Option 001) VME Single Board Computer
    - (Option 100) VME Slot 0 MXI-Bus Controller
  - (Option 110) 2U Processing and Control computer
  - AR1001 LO Synthesizer Distribution Unit
    - Integrated touchscreen LCD
    - AR2006 GPS Timing & Reference module with integrated 10 MHz OCXO and holdover mode
  - AR1002 Single Channel Upconverter (Quantity 4)
  - Circulator Patch Panel

- Monitor
- Keyboard and mouse (USB)
- Server software, installed on the VME Single Board or Processing and Control computer
- Client software (Requires Fedora 13 or higher)

5. Getting Started

5.1 Initial Inspection

In order to prevent damage to the system components, the AR1012 SWORD™ DREX is shipped unassembled in several shipping containers. Inspect each shipping container for damages immediately upon arrival. If any of the shipping containers or packing material is damaged, they should be kept until the contents of the shipment have been checked mechanically and electrically. If there is any mechanical or electrical damage, notify Applied Radar within 3 days of receiving the shipment. Keep the damaged shipping materials (if any) for inspection by the carrier.

5.2 Package Contents

The following items are included in the shipment. If any items are missing, contact Applied Radar immediately.

- ❑ SWORD™ DREX (AR1012)
  - ❑ 16U 19-inch Rack
  - ❑ Product identification panel with master power switch
  - ❑ 4U, 5 slot VME chassis with custom I/O panel and power supply
  - ❑ AR1006 Dual Mezzanine VME FPGA Processor board
  - ❑ AR8005 ADC Mezzanine card
  - ❑ AR8006 DAC Mezzanine card
  - ❑ AR1004 Four channel RF Downconverter VME module
  - ❑ (Option 001) VME Single Board Computer
  - ❑ (Option 100) VME Slot 0 MXI-Bus controller card
  - ❑ (Option 110) Processing and control computer
  - ❑ AR1001 LO Synthesizer Distribution Unit
  - ❑ AR1002 Single Channel RF Upconveter x4

- ❑ Circulator patch panel

- ❑ Custom formed RF cables x28 (AR1012-92-0-1 through AR1012-92-0-28)
- ❑ Power cable (AR1012-92-1) x6
- ❑ USB A-B cable (AR1012-92-2)
- ❑ BNC cable (AR1012-92-5) x2
- ❑ Cat-5 Ethernet cable, 10 ft (AR1012-92-6-120)
- ❑ User's Manual (AR1012-99-6)
- ❑ Client GUI Disk (AR1012-91-1)
- ❑ Documentation Disk (AR1012-91-2)
- ❑ Server Recovery Disk (AR1012-91-3)
- ❑ (Option 001) Windows XP™ Installation Disk (AR1012-91-4)
- ❑ (Option 100) Windows 7™ Installation Disk (AR1012-91-5)
- ❑ (Option 100) Fedora 14™ Installation Disk (AR1012-91-7)
- ❑ National Instruments NI-488 Disk (AR1012-91-8)

2 Specifications

In This Chapter

1. Electrical

The operating specifications of the AR1012 SWORD™ DREX are given in the table below. Please note that the exact Frequency Range, Number of Channels, and Instantaneous Bandwidth will be determined by the how the SWORD™ DREX has been configured by the factory. For a complete list of operating specifications for your AR1012 SWORD™ DREX, please reference the *Product Configuration Sheet* that shipped with your system.

Electrical Specifications

Parameter	Min.	Typ.	Max.	Units
Frequency Range	2		18	GHz
Number of Channels	4		16	
IF center frequency		1.125		GHz
Instantaneous 3 dB bandwidth	100		500	MHz
RF output P1dB		10.5		dBm
Saturated RF output power		12		dBm
Upconverter Gain		48		dBm
Downconverter Gain		35		dBm
DAC 2nd Nyquist output power at 1125 MHz		-42		dBm
Receive spurious-free dynamic range		50		dB
Noise Figure	4.5	5	6	dB
Tuning Speed		20		ms
Minimum Pulse repetition interval (PRI)		81		μs
LO 1 frequency range	23.63		39.63	GHz
LO 1 input power		0		dBm
LO 2 frequency		22.755		GHz
LO 2 input power		0		dBm

1.1 Connectors

The AR1012 SWORD™ DREX utilizes different connector types for the various input and output connections, depending on the operating frequency of the connection being made. The different connector types, along with their associated operating frequency range, are given in Table 2.2.

CAUTION

The RF connectors deteriorate when contacted with hydrocarbon compounds such as acetone, trichloroethylene, carbon tetrachloride, and benzene. Applied Radar recommends only using isopropyl alcohol to clean the RF connectors.

Table 2.2: Connector Type

Frequency Range	Connector
Timing and Control Signals	BNC, MMCX
RF<18 GHz	SMA
18 GHz ≤RF≤27 GHz	Super SMA
27 GHz ≤RF≤35 GHz	3.5 mm
35 GHz ≤RF≤40 GHz	2.9 mm
40 GHz ≤RF≤50 GHz	2.4 mm

CAUTION

Clean the connector only at a static free workstation. Electrostatic discharge to the center pin of the connector will render the AR1012 SWORD™ DREX inoperative and void the warranty.

1.2 Absolute Maximums

Operating Temperature	40°C
RF Input Power	20 dBm

ELECTROSTATIC SENSITIVE DEVICE
OBSERVE HANDELING PRECAUTIONS

2. Physical

2.1 AR1012 SWORD™ DREX

The AR1012 SWORD™ DREX is a 19-inch rack based system. The SWORD™ DREX includes a 16U 19-inch rack for mounting of all components. The dimensions for the system as well as the individual components are given in Table 2.4 and outline drawings are shown in Fig. 2.1.

Table 2.4: Physical dimensions (all units in inches)

Part	Width	Height	Depth	Drawing (Fig. 2.1)
AR1012 SWORD™ DREX	21.00	30.00	24.50	A
Product Identification Panel	19.00	1.72	0.125	E
VME Rack	19.00	7.00	11.00	B
AR1006 Dual Mezzanine FPGA Processor	9.25	0.785	6.299	C
AR1004 Four Channel RF Downconverter	9.25	0.785	6.299	C
AR1001 LO Synthesizer Distribution Unit	19.00	3.48	17.00	D

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Part	Width	Height	Depth	Drawing (Fig. 2.1)
AR1002 Single Channel Upconverter	19.00	3.48	17.00	D
Circulator Panel	19.00	1.72	0.125	E

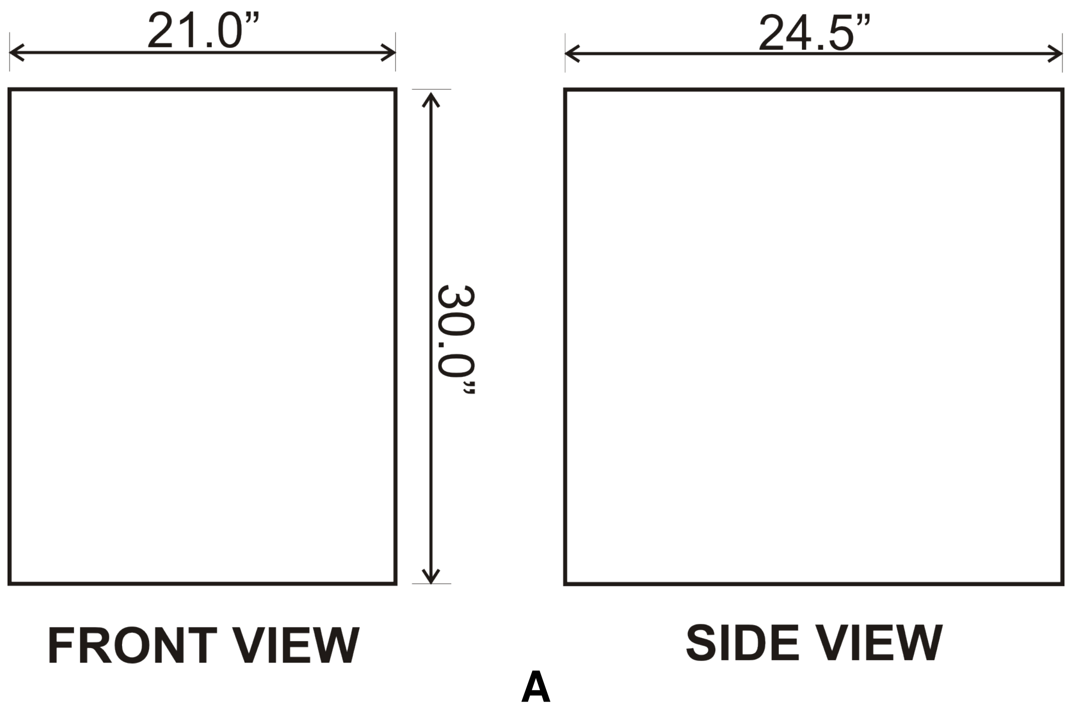
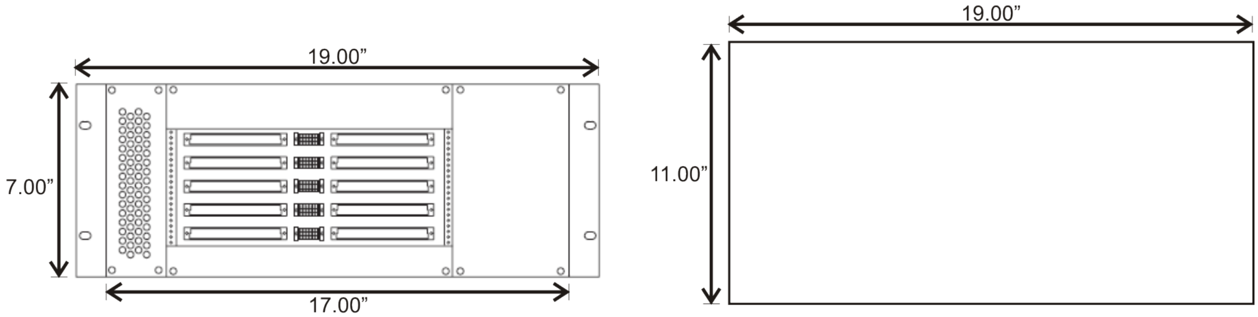
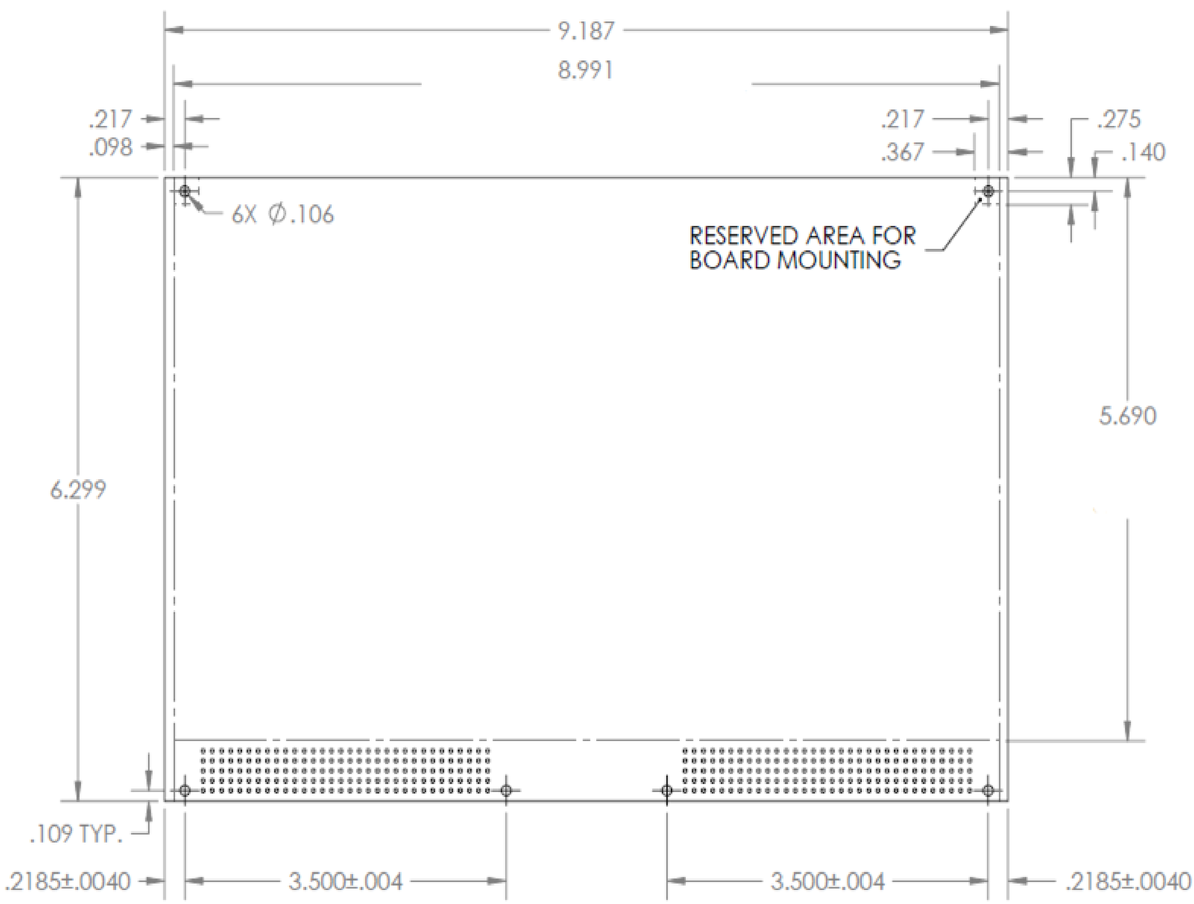


Figure 2.1: Outline drawings for Table 2.4



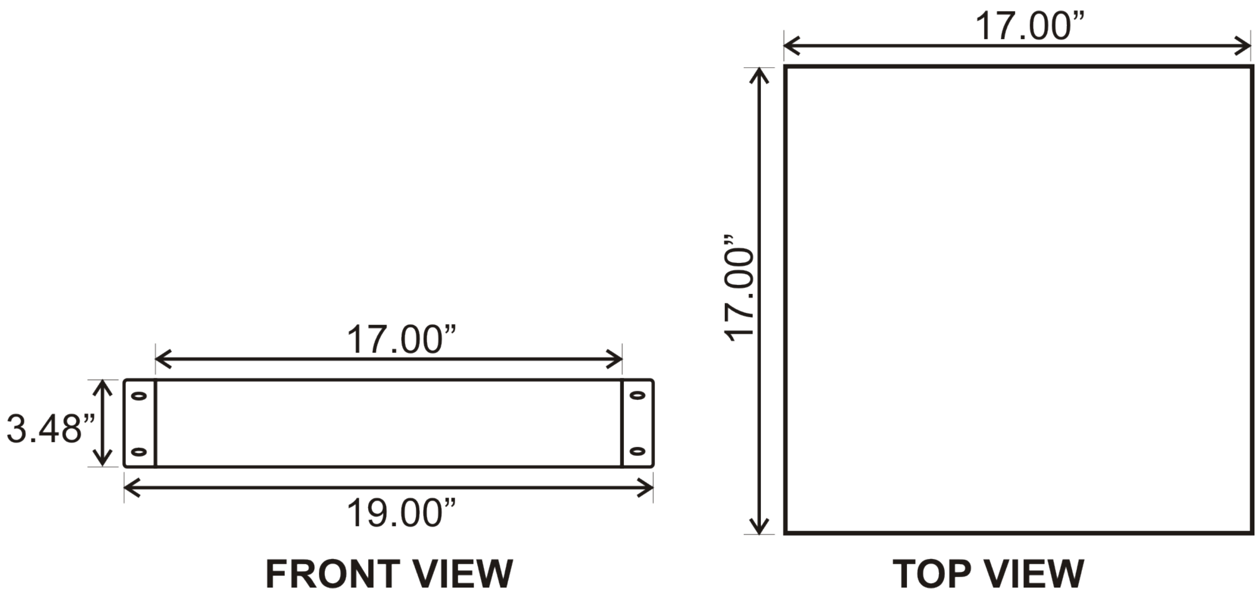
FRONT VIEW **Top VIEW**

B

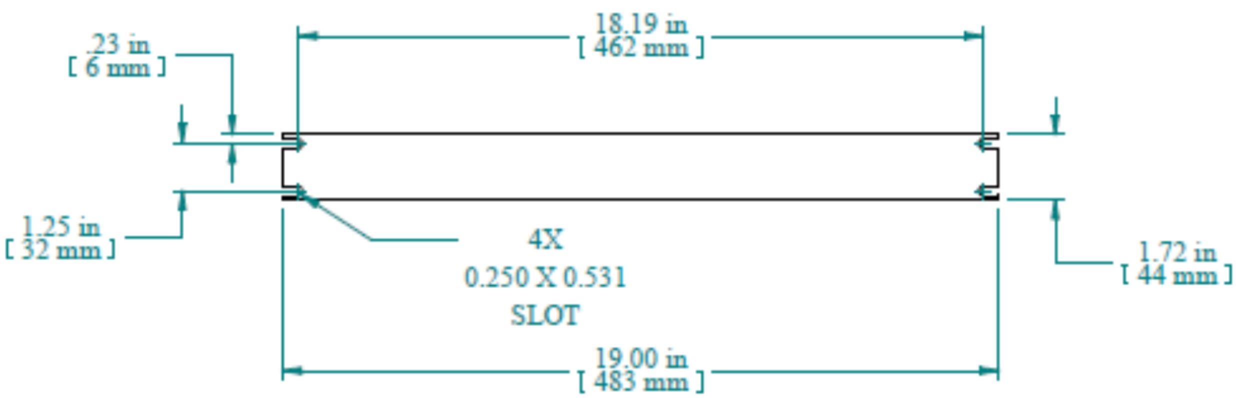


C

Figure 2.1: Continued



D



E

Figure 2.1: Continued

3 Maintenance

In This Chapter

1. General Information

This chapter contains information about the general maintenance of the AR1012 SWORD™ DREX.

NOTICE

There are no user serviceable parts in the AR1012 SWORD™ DREX. For service or repair, return the AR1012 to Applied Radar. Opening of any of the AR1012 SWORD™ DREX components will void the warranty.

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2. Cleaning

Use a clean, damp cloth or sponge to clean the chassis of the AR1012 SWORD™ DREX. Do not use any cleaner, including rubbing alcohol, as doing so may result in damage to the printing on the panels.

3. Connector Cleaning

CAUTION

The RF connectors deteriorate when contacted with hydrocarbon compounds such as acetone, trichloroethylene, carbon tetrachloride, and benzene. Applied Radar recommends only using isopropyl alcohol to clean the RF connectors.

Keeping in mind its flammable nature, a solution of pure isopropyl or ethyl alcohol can be used to clean the connector.

Clean the connector face using a cotton swab dipped in isopropyl alcohol. If the swab is too big, use a round wooden toothpick wrapped in a lint-free cotton cloth in place of the cotton swab.

CAUTION

Clean the connector only at a static free workstation. Electrostatic discharge to the center pin of the connector will render the AR1012 SWORD™ DREX inoperative and will void the warranty.

Part I

Hardware

4
AR1012 SWORD-X400

In This Chapter

1. Overview

The AR1012 SWORD™ DREX, shown in Fig. 4.1, is a four channel Digital Receiver EXciter (DREX) system based on the Applied Radar Open Systems Architecture (AROSA) model. The Applied Radar Open Systems Architecture is a derivative of the MIT-LL and MDA Radar Open Systems Architecture (ROSA) (see Chapter 10) and is therefore compatible with ROSA without access to the advanced features of AROSA. The AR1012 SWORD™ DREX is an all inclusive system, containing all of the necessary hardware and software to generate a waveform at the IF frequency and upconvert it to the desired output frequency and take the returned RF signal and downconvert it to the IF baseband and digitally sample the returned signal. The AR1012 utilizes either a VME Single Board Computer running Linux or a VME slot 0 MXI-Bus controller (Option 100) connected to an external computer running Linux. Using Linux provides the system with a real-time operating system environment.

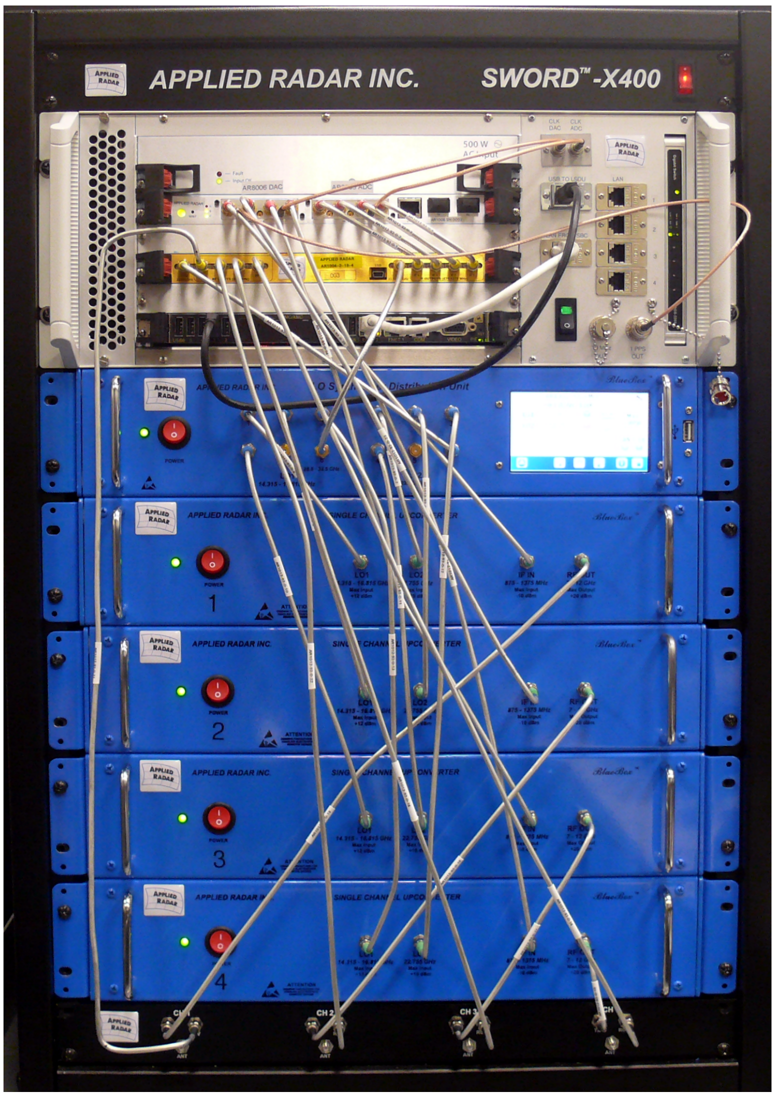

Figure 4.1: AR1012 SWORD™ DREX

2. Hardware Configuration

A typical representation of the AR1012 SWORD™ DREX is shown in Fig. 4.2. The actual configuration may vary based on the number of channels and factory installed options.

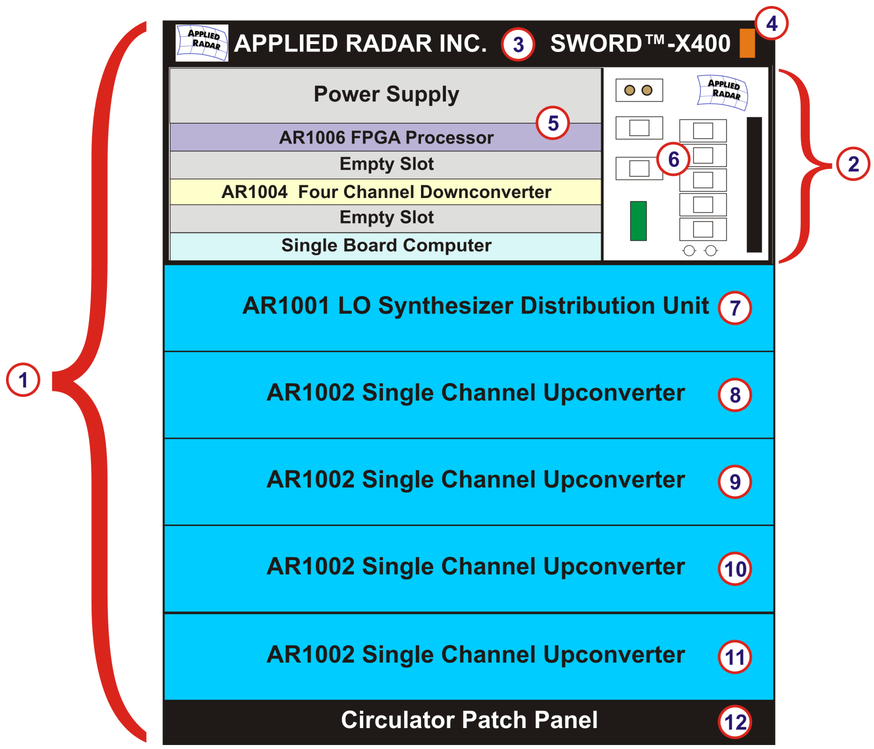

Figure 4.2: AR1012 SWORD™ DREX

No.	Part	Functions
1	Rack	16U 19-inch rack
2	VME Chassis	Five slot VME chassis mounted in the 19-inch rack.
3	Name plate	Identification plate
4	Master power switch	Controls AC power to the rack.
5	I/O Interface panel	Provides I/O connectors to and from the SWORD™ DREX.
6	VME Slots	This area is part of the VME chassis and houses the power supply for the VME chassis, AR1006 Dual Mezzanine FPGA processor, AR1004 Four Channel RF Downconverter, and Single Board Computer (Option 001) or VME slot 0 MXI-Bus controller (Option 100)
7	AR1001 LO Synthesizer Distribution Unit (LSDU)	Provides LO1, LO2, ADC Clock, DAC Clock, and timing signals

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No.	Part	Functions
8	AR1002 Single Channel Upconverter	Upconverter for Channel 1
9	AR1002 Single Channel Upconverter	Upconverter for Channel 2
10	AR1002 Single Channel Upconverter	Upconverter for Channel 3
11	AR1002 Single Channel Upconverter	Upconverter for Channel 4
12	Circulator Patch Panel	Contains the RF circulators and connections for the TX, RCV, and Antenna ports.

2.1 VME Chassis

Every AR1012 SWORD™ DREX system includes a VME chassis to support the AR1006 Dual Mezzanine FPGA Processor, AR1004 Four Channel RF Downconverter, and either a VME Single Board Computer (Option 001) or VME Slot 0 MXI-Bus Controller (Option 100). A custom I/O panel has been added to the VME chassis to provide additional I/O connections. When Option 002 is installed, a five port Gigabit Ethernet switch is added to the custom I/O panels to provide an additional four LAN connections to the server to support multiple user environments and/or control of supported antennas.

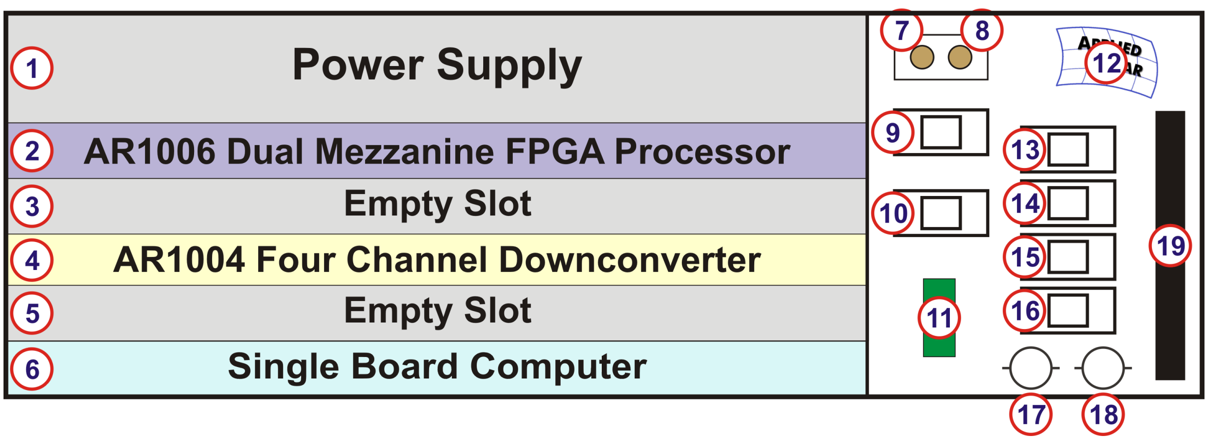

Figure 4.3: SWORD™ DREX

No.	Part	Functions
1	Power Supply	Provides DC Power to the VME chassis
2	AR1006	VME Dual Mezzanine FPGA Processor with DAC and ADC mezzanine cards installed
3	Empty Slot	Intentionally left blank for airflow
4	AR1004	VME Four Channel RF Downconverter
5	Empty Slot	Intentionally left blank for airflow

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No.	Part	Functions
6	Controller/Computer	VME Single Board Computer (Option 001) or VME Slot 0 MXI-Bus Controller (Option 100)
7	DAC Clock	700 MHz reference output for clocking the DAC, SMA connector
8	ADC Clock	1.4 GHz reference output for clocking the ADC, SMA connector
9	USB-B Connector	USB connection to AR1001 LSDU
10	Cat-5 Connector	LAN from the VME Single Board Computer. *Requires Option 002*
11	Power Switch	Power switch for the VME chassis
12	Logo	Applied Radar, Inc. Logo
13-16	Cat-5 Connectors	LAN Connections from Ethernet Switch (18). *Requires Option 002*
17	10 MHz output	Provides a copy of the 10 MHz reference signal generated by the AR1001 for synchronizing purposes, BNC connector
18	1 PPS output	Provides a 1 Pulse-Per-Second (PPS) signal derived from the GPS unit in the AR1001, BNC connector
19	Ethernet switch	Provides four additional Cat-5 connections to the SBC. *Requires Option 002*

2.2 Server Computer

A server computer is required to operate the AR1012 SWORD™ DREX. The server computer can be configured in any of the following three ways.

1. VME Single Board Computer (Option 001)
2. VME Slot 0 Controller (Option 100) and integrated 2U server computer (Option 110)
3. VME Slot 0 Controller (Option 100) and a user supplied server computer

In order to ensure driver compatibility, it is highly recommended that the server computer be integrated into the system by Applied Radar. If the customer chooses to supply their own computer, Applied Radar assumes no liability nor provides any assurance that the AR1012 will be compatible with the chosen computer system. Operation of the AR1012 is only guaranteed with a computer integrated and tested by Applied Radar

The VME Slot 0 MXI-Bus Controller utilizes the MXI bus from National Instruments. There are two major advantages which utilizing the VME Slot 0 MXI-Bus Controller provides to the user; additional AR1012 systems can be easily added to expand the number of DREX channels using the MXI daisy-chain capability (up to eight total systems can be daisy-chained together) and the server computer can be configured using standard COTS components to optimize the performance for the needs of the end application and allows for the server computer to be upgraded as newer components become available.

2.2.1 Operating System

For AR1012 SWORD™ DREX systems that ship with Option 001 or Option 110 installed, the system includes a server computer for controlling the AR1012. For systems with a VME Single Board Computer (Option 001), the server computer comes Fedora 8 installed. For systems with a separate rack mounted server computer (Options 100 and 110), the control computer comes with Fedora 14 installed.

NOTICE

Systems with Option 100 and 110 installed will always ship with the latest version of Fedora which has been verified to work with the AR1012.

2.3 Circulator Patch Panel

Connections between the AR1012 SWORD™ DREX and the antenna are made through the Circulator Patch Panel, which is located at the bottom of the 19-inch rack. A circulator for each channel of the DREX has been mounted to the back of the patch panel and the receive, transmit, and common (antenna) ports are brought to the front of the panel through SMA bulkheads. The transmit (*TX*) and receive (*RCV*) ports are connected to the AR1002 Single Channel Upconverter RF output port and the AR1004 Four Channel Downconverter RF input port, respectively. The antenna being used with the AR1012 SWORD™ DREX (antenna is not included) is attached to the system through the antenna (*ANT*) port.

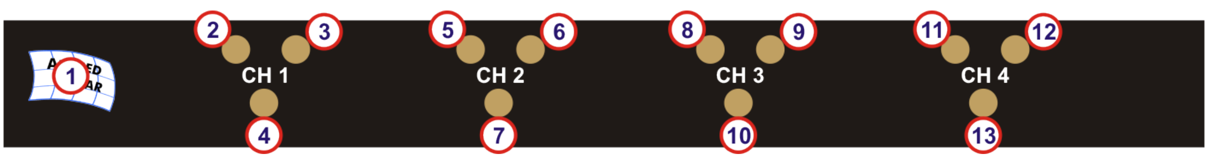

Figure 4.4: Circulator Patch Panel

No.	Part	Functions
1	Logo	Applied Radar, Inc. Logo
2,5,8,11	TX	Transmit Connectors for channels 1, 2, 3 and 4 respectively. Connected to the RF output of the respective AR1002 Single Channel Upconverter.
3,6,9,12	RCV	Receive Connectors for channels 1, 2, 3 and 4 respectively. Connected to the RF input of the respective channel on the AR1004 Four Channel RF Downconverter.
4,7,10,13	ANT	Antenna Connectors for channels 1, 2, 3 and 4 respectively.

2.4 RF Cables

The AR1012 comes with custom formed RF cables for interconnecting the RF components of the AR1012. Each cable is custom formed and is marked with a part number of AR1012-92-0-X, where X is the cable number. To aide with assembly, each end of the cable has been color coded to indicate which device that end connects to. The color coding for the AR1012 is listed in Table 4.1.

Table 4.1: Cable color coding

Color	Connects To
Red	AR1006 Dual Mezzanine FPGA Processor
Yellow	AR1004 Four Channel RF Downconverter
Blue	AR1001 LO Synthesizer Distribution Unit
Green	AR1002 Single Channel Upconverter
Black	Circulator Patch Panel

2.4.1 RF Cable Wiring Guide

The wiring guide for the RF cables for a four channel version of the AR1012 SWORD™ DREX is given in Table 4.2. Please refer to the documentation that came with your AR1012 system for the RF cable wiring guide applicable to your system.

As there are four AR1002 Single Channel Upconverters in the example system, they will be referred to as AR1002 #1 through AR1002 #4, with #1 being the topmost AR1002 and #4 being the bottommost AR1002.

Table 4.2: RF Cable Wiring Diagram

Cable #	End 1	End 2	Connection
1	Yellow	Red	Downconverter, IF1 to ADC Port 1
2	Yellow	Red	Downconverter, IF2 to ADC Port 2
3	Yellow	Red	Downconverter, IF3 to ADC Port 3
4	Yellow	Red	Downconverter, IF4 to ADC Port 4
5	Blue	Yellow	LSDU, LO1, Port 6 to Downconverter, LO1
6	Blue	Green	LSDU, LO1, Port 1 to Upconverter 1, LO1
7	Blue	Green	LSDU, LO2, Port 1 to Upconverter 1, LO2
8	Blue	Green	LSDU, LO2, Port 2 to Upconverter 2, LO2
9	Blue	Green	LSDU, LO1, Port 2 to Upconverter 2, LO1
10	Blue	Green	LSDU, LO1, Port 4 to Upconverter 3, LO1
11	Blue	Green	LSDU, LO2, Port 4 to Upconverter 3, LO2
12	Blue	Green	LSDU, LO2, Port 3 to Upconverter 4, LO2
13	Blue	Green	LSDU, LO1, Port 3 to Upconverter 4, LO1
14	Black	Yellow	Circulator 4, Port 2 to Downconverter, RF4

Continued on Next Page. . .

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Cable #	End 1	End 2	Connection
15	Green	Black	Upconverter 4, Port 4 to Circulator 4, Port 1
16	Black	Yellow	Circulator 3, Port 2 to Downconverter, RF3
17	Green	Black	Upconverter 3, Port 4 to Circulator 3, Port 1
18	Green	Black	Upconverter 2, Port 4 to Circulator 2, Port 1
19	Green	Black	Upconverter 1, Port 4 to Circulator 1, Port 1
20	Blue	Yellow	LSDU 2, Port 6 to Downconverter, LO2
21	Black	Yellow	Circulator 1, Port 2 to Downconverter, RF1
22	Black	Yellow	Circulator 2, Port 2 to Downconverter, RF2
23	Red	Green	DAC, Port 2 to Upconverter 2, Port 3
24	Red	Green	DAC, Port 3 to Upconverter 3, Port 3
25	Red	Green	DAC, Port 1 to Upconverter 1, Port 3
26	Red	Green	DAC, Port 4 to Upconverter 4, Port 3
27	Blue	Black	LSDU, DAC to DAC, CLK
28	Blue	Black	LSDU, ADC to ADC, CLK

3. Principles of Operation

The AR1012 is a mulit-channel DREX which is operates using the AROSA interface. The AR1012 accepts messages from the ARI AROSA client software, or a user supplied AROSA compliant client, and handles the waveform generation and capture. The waveforms are generated and captured at baseband (875-1375 MHz) and the baseband signals are translated to and from the desired operating frequency through the RF upconverters and downconverters. Timing for the waveform generation is provided by a GPS Timing signal, which is supplied by the AR1001 LO Synthesizer Distribution Unit (LSDU). Connection to the antenna (not included) is performed through the included circulator, allowing for monostatic operation.

3.1 GPS

The AR1012 comes with an AR2006 GPS Timing & Reference Module with an ultra-stable 10 MHz output installed in the AR1001 LO Synthesizer Distribution Unit (LSDU). In addition to providing the common 10 MHz reference signal and the 1 PPS signal for the AR1006 Dual Mezzanine FGPA Processor, the AR2006 provides the GPS timing messages used in the AROSA command schema.

An antenna connection for the AR2006 has been provided on the rear panel of the AR1001. The use of an antenna with a view of a sufficient number of satellites will allow the GPS unit to use the obtained GPS signal to output the correct absolute time and to correct for the drift in the 10 MHz OCXO. The GPS unit is capable of running in holdover mode which allows the GPS unit to function without being able to lock onto a GPS signal. When running in holdover mode, the drift in the 10 MHz signal is not corrected and the time reported will be relative to when the GPS unit was switched on. Since the 10 MHz OCXO used in the system has very low drift (daily aging is 2 ppb and yearly aging is 80 ppb) and the server and client software synchronize their time base, it is acceptable to operate the AR1012 in a lab environment which does not have receive a GPS signal.

3.2 Waveform Generation

Waveform generation is performed by the AR1006 Dual Mezzanine FPGA Processor and the installed AR8006 Four Channel 1.2 GSPS 14-Bit DAC mezzanine card. The generated waveforms are capable of supporting up to 500 MHz of bandwidth with an output frequency between 25 MHz and 525 MHz (see Fig. 4.5).

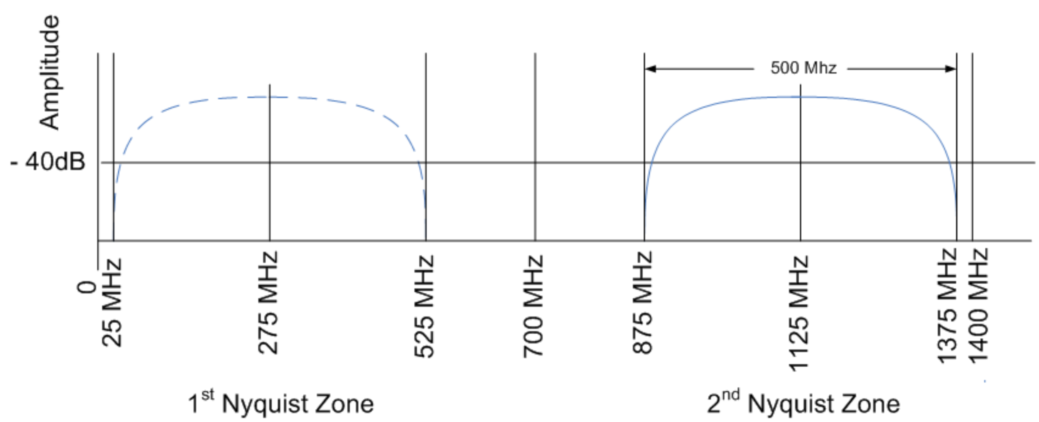


Figure 4.5: AR8006 outputted Waveform spectrum

In order to shift the spectrum of the outputted waveform to the desired RF carrier frequency, an AR1002 Single Channel Upconverter is used. The input frequency range of the AR1002 is 875 MHz to 1375 MHz, which requires using the 2^{nd} Nyquist zone of the generated waveform, as shown in Fig. 4.5. Additional amplification stages have been added to the AR1002 to compensate for the lower signal output level of the AR8006 when operated in the 2^{nd} Nyquist zone.

3.3 Circulators

The AR1012 is equipped with a Circulator Panel, allowing for monostatic operation. The *TX* (transmit) output of the circulator is connected via a RF cable to the output of the associated AR1002 RF Upconverter. The *RCV* (receive) port of the circulator is connected via a RF cable to the associated RF input port of the AR1004 RF Downconverter. The *ANT* (common) port of the circulator is provided as a SMA bulkhead connection.

3.4 Received Waveform Capture

Waveform capture is performed by the AR1006 Dual Mezzanine FPGA Processor and the installed AR8005 Four Channel 1.5 GHz 8-Bit ADC mezzanine card. The received waveforms are first routed through the AR1004 Four Channel RF Downconverter to shift the spectrum to baseband which can be directly sampled by the ADC. The captured waveform is then sent to the client where all processing is performed.

3.5 Processing

The operator can selectively apply different processing algorithms on the captured data through the ARI Client software.

3.5.1 Coherent Integration

All components of the AR1012 are locked to the common 10 MHz output of the AR2006 GPS Timing & Reference module, allowing the system to coherently integrate the received waveforms. The ARI Client software allows the operator to set the coherent integration factor (a factor of one is equivalent to turning off coherent integration). Coherent integration is applied before any other processing.

3.5.2 Matched Filtering

Matched filtering is used to recover a known waveform from the returned signal, reducing the effect of noise and other undesired signals. Matched filtering involves correlating the returned signal with a copy of the transmitted waveform.

3.5.3 Calibration

In order to perform the matched filtering operation, the transmitted waveform must be known. A calibration must be performed in order to account for any variations from the theoretical waveform due to the effects of the digital and RF hardware. For more information regarding calibration, please see the calibration discussion in Section 13.5..

3.5.4 Clutter Filter

In order to reduce the effect of clutter on the received data, the client has two clutter filter modes which can be activated by the user, *Subtraction* and *Doppler*. The *Subtraction* mode is used to remove the returns from known stationary objects so that only changes (additions, subtractions, or position changes) to the scene are recorded and presented to the user. The *Doppler* mode is used to remove returns from the scene that have not changed in Doppler, highlighting to the user any changes in motion in the scene.

3.5.5 Incoherent Integration

After matched filtering has been performed, incoherent integration can be applied to smooth out the noise variance. The ARI Client software allows the operator to set the incoherent integration factor (a factor of one is equivalent to turning off incoherent integration). Incoherent integration is applied after all other processing.

4. Typical Performance

Typical performance results of the AR1012 SWORD™ DREX are shown in Figures 4.6 to 4.8.

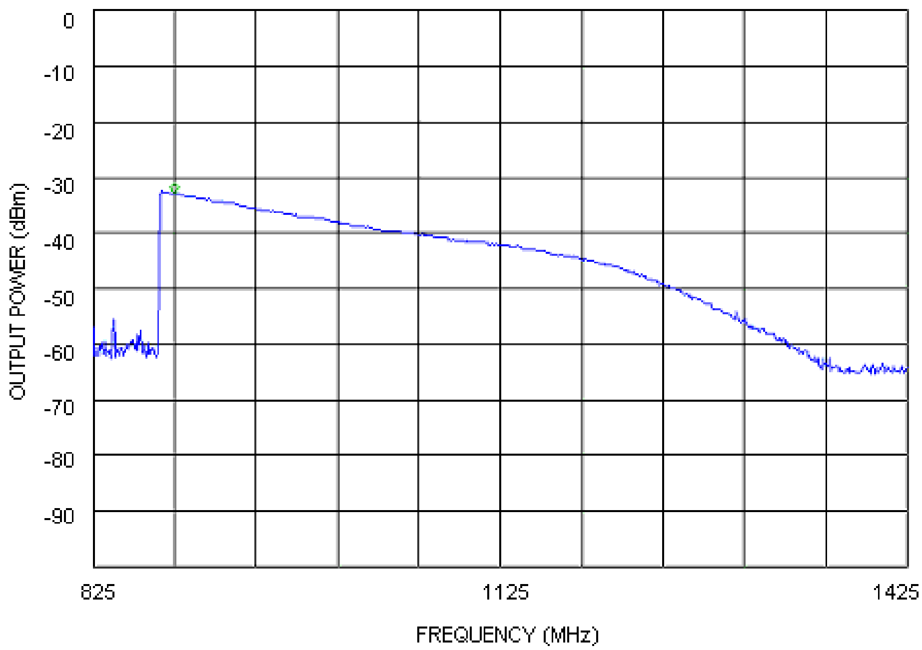


Figure 4.6: Typical DAC output sweep at IF Baseband (2^{nd} Nyquist). Rolloff is due to the 2^{nd} Nyquist performance of the DACs.

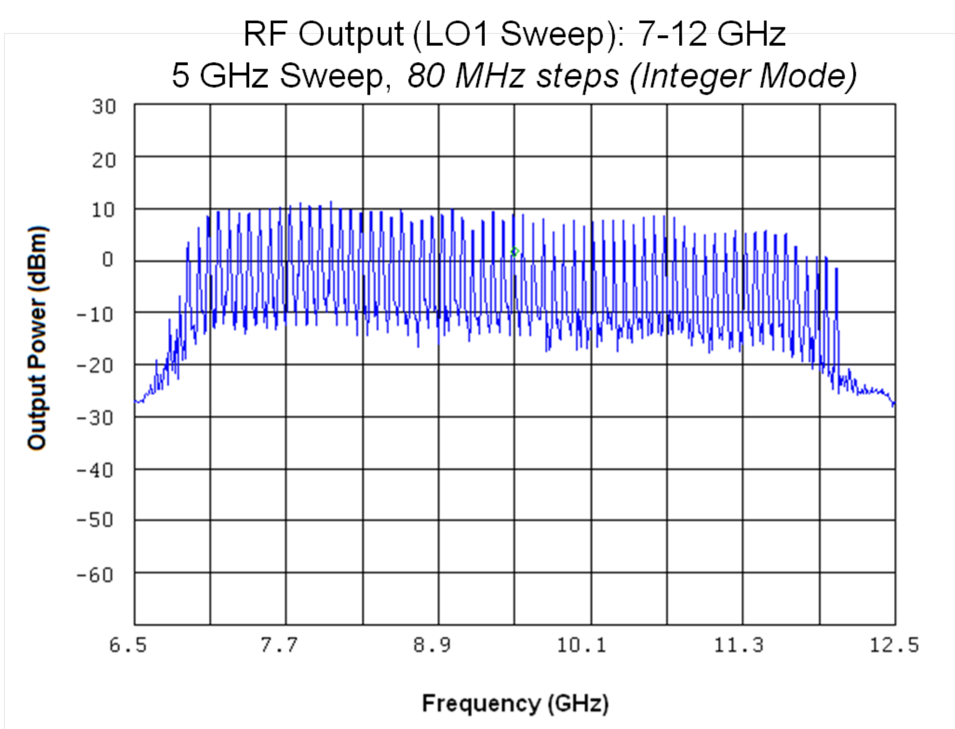


Figure 4.7: Typical RF output after upconversion, 80 MHz RF output steps, LO1 in integer mode.

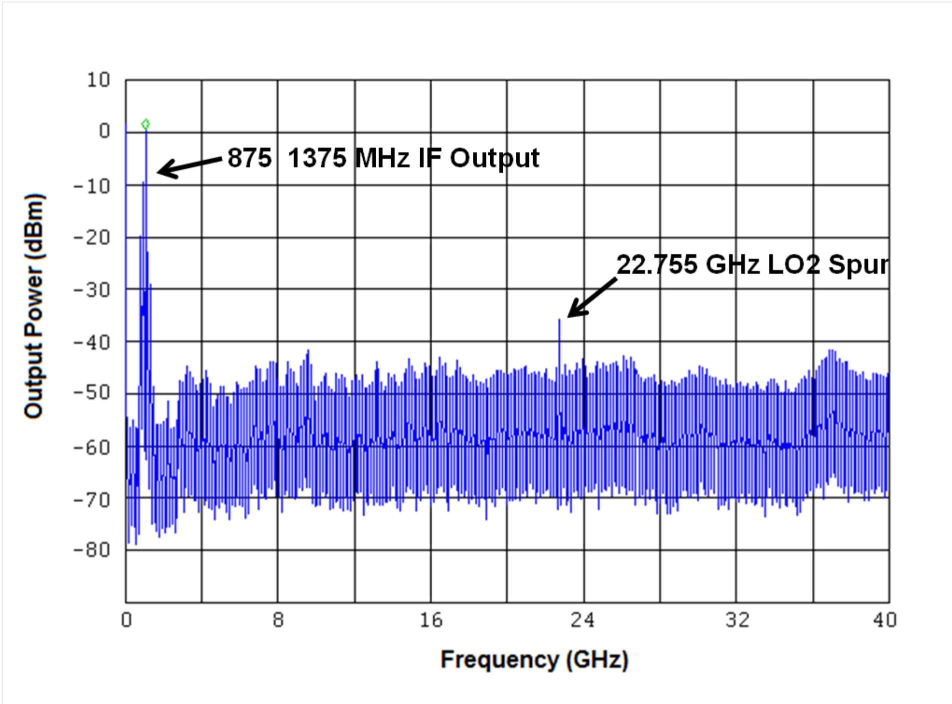


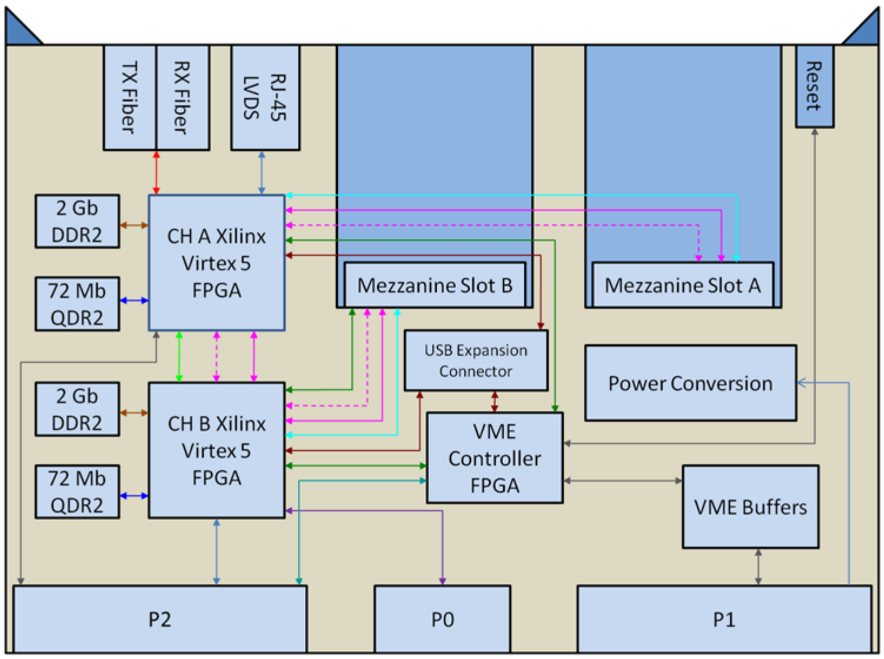
Figure 4.8: RF Loopback frequency spectrum

5
AR1006 Dual Mezzanine FPGA Processor

In This Chapter

1. Overview

The AR1006 Dual Mezzanine FPGA Processor is a VME FGPA processing board which utilizes two Xilinx Viretx-5 FPGAs to provide logic and DSP processing capabilities. The AR1006 features two custom mezzanine interface sites, allowing for a variety of analog and digital mezzanine cards to be used. When used with the AR1012 SWORD™ DREX, the AR1006 Dual Mezzanine FPGA Processor is equipped with one four channel ADC mezzanine card and one four channel DAC mezzanine card, allowing the AR1006 to function as both the waveform generator and the received signal digitizer.



Color Code	Description	Type	Speed	Mode
	Front Panel Fiber Multi-Gigabit links	CML	31.25 Gb/s	Full-Duplex
	DDR2 Interface	SSTL	1.6 Gb/s	X16
	QDR2 Interface	SSTL	1.125 Gb/s	4Mb x 18
	FPGA to FPGA Multi-Gigabits Links	CML	12.5 Gb/s	Full-Duplex
	FPGA to FPGA and Mezzanine Connection Buses	LVDS	40 Gb/s	Half-Duplex
	Multi-Gigabit Links	CML	6.25 Gb/s	Full-Duplex
	USB Expansion Interface	LVTTL		Half-Duplex
	Mezzanine Control Bus	LVTTL		Half-Duplex
	VXS Multi-Gigabit Links	CML	25 Gb/s	Full-Duplex

Figure 5.1: AR1006 Dual Mezzanine FPGA Processor block diagram

The AR1006 is a VME size C (6U) board and is installed in the top slot of the VME chassis. The outputs of the DAC mezzanine card are fed into the AR1002 Single Channel RF Upconverters and the IF outputs of the AR1004 Four Channel RF Downconverter are fed into the inputs of the ADC mezzanine.

2. Front Panel

A typical representation of the AR1006 Dual Mezzanine FPGA Processor front panel with one AR8006 DAC mezzanine and one AR8005 ADC mezzanine installed is shown in Fig. 5.2. The actual configuration may vary based on the number of channels and factory installed options.

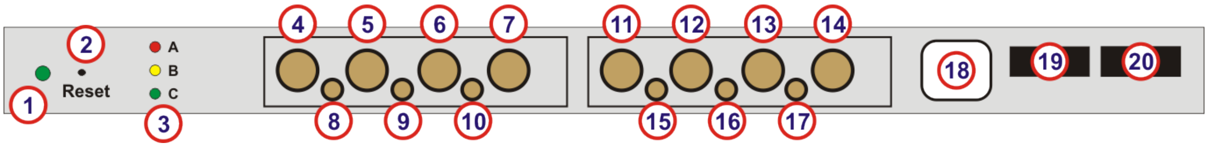


Figure 5.2: AR1006 Dual Mezzanine FPGA Processor front panel

No.	Part	Functions
1	LED	LED indicator
2	Reset	Used to force a hard reset of the AR1006
3	LEDs	Indicator LEDs (See the AR1006 Operating Manual for meaning)
4-7	DAC output	Output connectors of the DAC mezzanine
8	Trigger	External trigger input
9	Clock out	Clock output for daisy-chaining
10	Clock in	External clock input
11-14	ADC input connector	Input connectors for the ADC mezzanine
15	Trigger	External trigger input
16	Clock out	Clock output for daisy-chaining
17	Clock in	External clock input
18	Cat-5 SYNC	Provides synchronizing capability when multiple AR1006s are used
19	TX Fiber Connector	Transmit multi-gigabit fiber connection for high speed output
20	RCV Fiber Connector	Receive multi-gigabit fiber connection for high speed input

3. AR8005 Four Channel ADC Mezzanine

The AR8005 is a four channel, 8-bit 1.5 Giga-Sample Per Second (GSPS) analog-to-digital converter (ADC) mezzanine card compatible with the AR1006 Dual Mezzanine FPGA Processor. The AR8005 ADC chipset allows for either baseband or second Nyquist band real-time sampling of analog IF or RF signals with over 500 MHz of instantaneous bandwidth and 7.5 effective bits. A single onboard PLL clock is used to clock all four ADC channels. The AR8005 has the option for an external clock input signal, through a MMCX connector, which may be used to clock the four ADC input channels, allowing for a common clock to be used for multiple mezzanine cards. The AR8005 contains an external input trigger signal which is used to synchronize data collection of multiple AR8005 modules. The single external input trigger signal initializes data sampling across all four ADC channels and can be used to synchronize multiple AR8005 mezzanine cards.

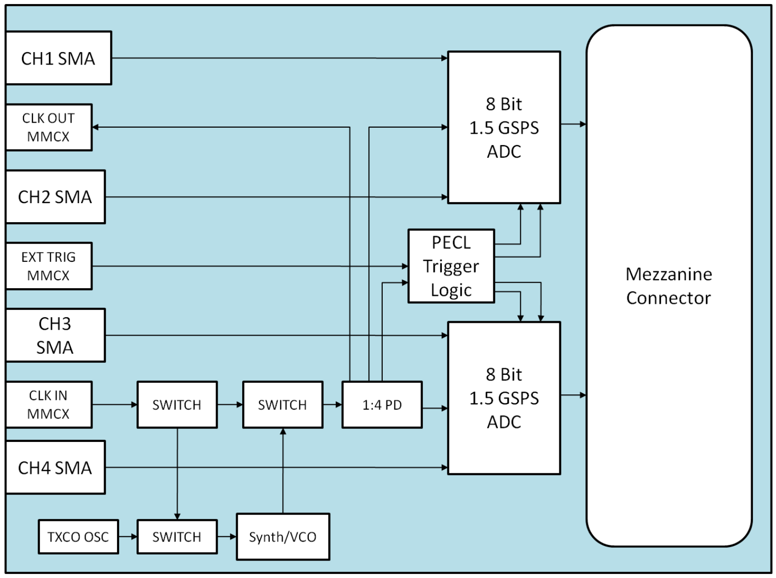


Figure 5.3: AR8005 block diagram

4. AR8006 Four Channel DAC Mezzanine

The AR8006 is a four channel 1 Giga-Sample Per Second (GSPS) 14-bit digital-to-analog converter (DAC) mezzanine card which is compatible with the AR1006 Dual Mezzanine FPGA Processor. The AR8006 contains four 14-bit DAC output channels, each sampled at 1 GSPS. The AR8006 utilizes a single onboard PLL clock to clock all four DAC channels and has the option for an external input clock signal through the use of a front panel MMCX input connector. The AR8006 has four SMA output connectors which are transformer-coupled to four 14-bit, 1 GSPS DAC channel outputs. An onboard switch network allows for selection of either an onboard VCO generated clock configured with an onboard phase-locked-loop (PLL) circuit, or an external clock input which may be optionally fed to the onboard PLL. An external clock output is provided for phase-aligning multiple mezzanine modules. An external trigger I/O is provided for synchronizing all four DAC channel outputs between multiple mezzanine modules.

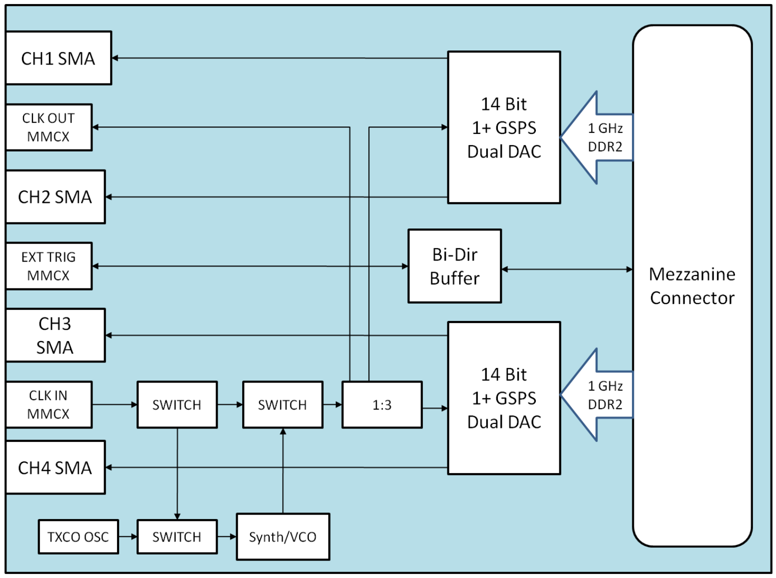


Figure 5.4: AR8006 block diagram

An example of the output spectrum of the AR1006 with an AR8006 mezzanine card installed is shown in Fig. 5.5.

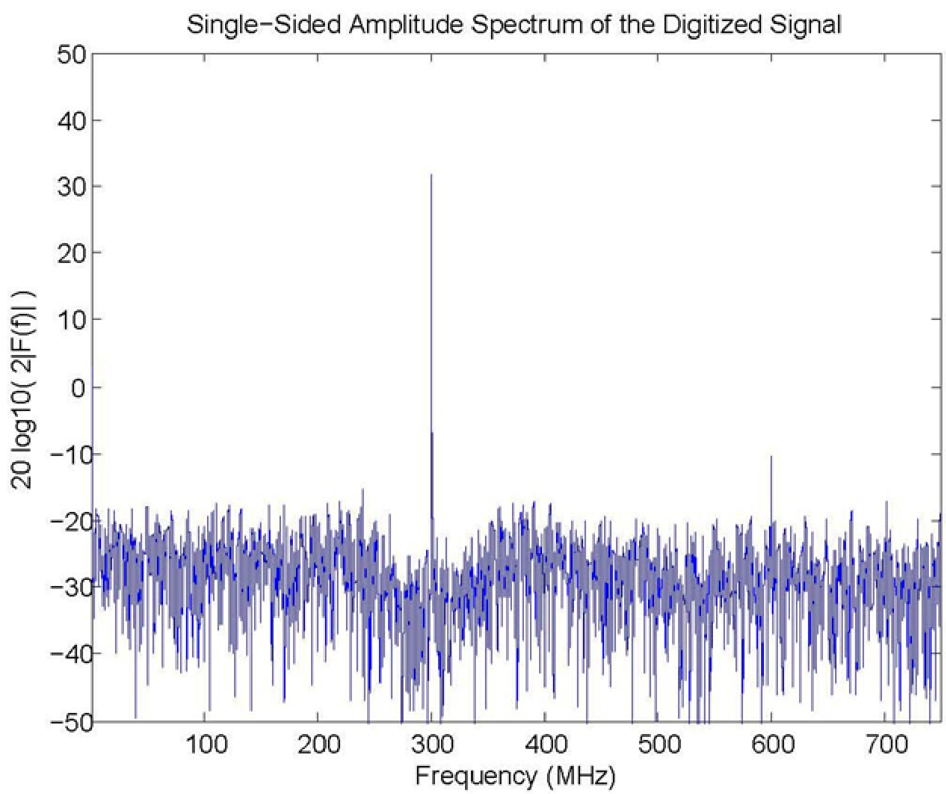


Figure 5.5: Output spectrum of the AR1006

6
AR1004 Four Channel RF Downconverter

In This Chapter

1. Overview

The AR1004 Four Channel RF Downconverter provides four channels of RF downconversion with an RF input frequency range of 2 to 18 GHz. The IF output is centered at 1125 MHz with a 500 MHz bandwidth (875 - 1375 MHz). The AR1004 provides typical gains of 42 dB at 2 GHz and 27 dB at 18 GHz. There is 25 dB of gain control with four bit resolution (approximately 1.6 dB steps). The form-factor is a single-slot VME size C (6U) card.

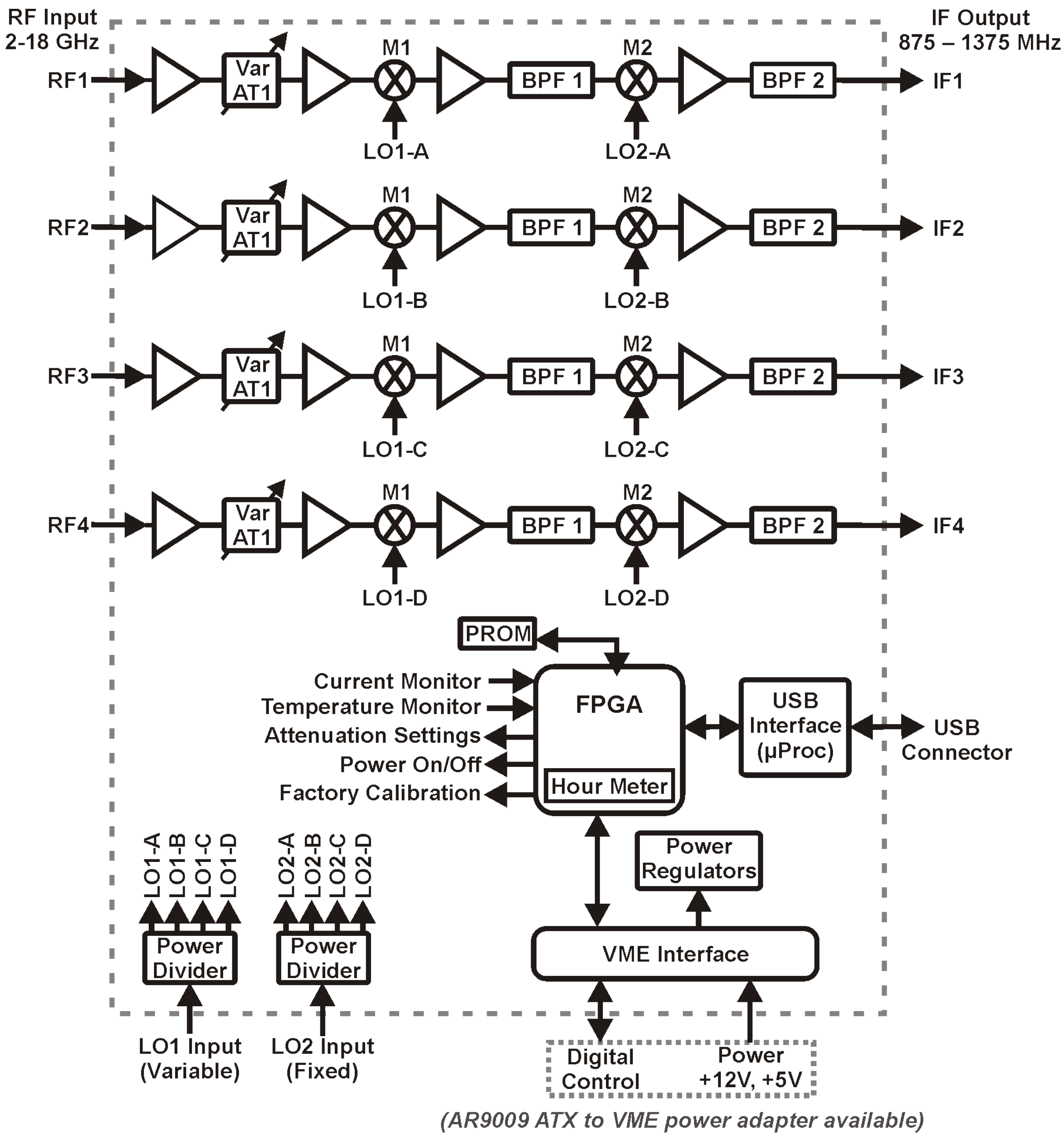


Figure 6.1: AR1004 Four Channel RF Downconverter block diagram

The AR1004 is a dual conversion downconverter with four parallel channels, as shown in Fig. 6.1. The first LO (LO1) is tunable over 23.63 GHz to 39.63 GHz to select the RF input frequency desired (LO1 (GHz) = 21.63 GHz + RF (GHz)). The second LO (LO2) is fixed at 22.755 GHz. Both LOs are a single input for all four channels and is supplied in the AR1012 SWORD™ DREX by the AR1001 LO Synthesizer Distribution Unit.

Digital control and status is available through the VME bus or through the front panel USB port. The digital control board provides power up and power down sequencing, control of variable attenuators, temperature monitoring, monitoring of all amplifier bias currents, and total hours the module has been powered on. This temperature and current monitoring capability provides a built-in-test (BIT) capability for diagnostic purposes.

2. Front Panel

All connections are made through the front panel of the AR1004. The RF and IF connectors are SMA while the LO1 and LO2 connectors are 2.92mm and Super SMA (27 GHz), respectively. When installed in a VME rack, the USB port is for factory use only, all communications with the AR1004 in the AR1012 SWORD™ DREX system are performed through the VME backplane.

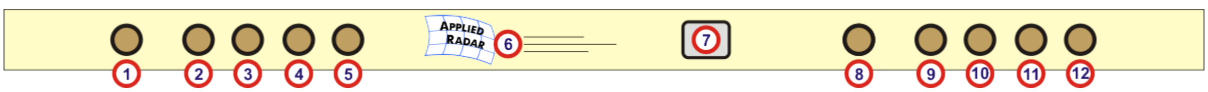


Figure 6.2: AR1004 Four Channel RF Downconverter front panel

No.	Part	Functions
1	LO2	LO2 input, 2.92mm connector
2	RF 1	RF input, channel 1, SMA connector
3	RF 2	RF input, channel 2, SMA connector
4	RF 3	RF input, channel 3, SMA connector
5	RF 4	RF input, channel 4, SMA connector
6	Markings	Logo badge and text markings
7	USB	USB port, *factory use only*
8	LO1	LO1 input, Super SMA connector
9	IF 4	IF outputs, channel 4, SMA connector
10	IF 3	IF outputs, channel 3, SMA connector
11	IF 2	IF outputs, channel 2, SMA connector
12	IF 1	IF outputs, channel 1, SMA connector

3. Electrical Specifications

The electrical specifications for the AR1004 Four Channel RF Downconverter are given in Table 6.1 and the nominal current values are given in Table 6.2. Typical gain performance as a function of frequency is shown in Fig. 6.3. Fig. 6.4 shows the flatness of the IF output with a fixed LO1 and sweeping RF. The typical Noise Figure performance of the AR1004 is shown in Fig. 6.5.

Table 6.1: AR1004 Four Channel RF Downconverter Electrical Specifications

Parameter	**Min**	**Typical**	**Max.**	**Units**
RF input frequency range	2		18	GHz
IF output center frequency	1.125			GHz
Instantaneous 3 dB bandwidth		500		MHz
Gain @ 2 GHz		40		dB
Gain @ 6 GHz		40		dB
Gain @ 10 GHz		35		dB
Gain @ 14 GHz		30		dB
Gain @ 18 GHz		25		dB
Noise Figure, 2 - 12 GHz (at maximum gain)			5	dB
Noise Figure, 12 - 18 GHz (at maximum gain)			10	dB
IF output 1 dB compression point (OP1dB)		+15		dBm
Output third order intercept point (OIP3)		+25		dBm
Group delay distortion (over 80% 500 MHz BW)	-5		5	ns
Gain control range	25			dB
Gain control step		1.6		dB
LO 1 frequency range	23.63		39.63	GHz
LO 1 input power	+17	+19	+23	dBm
LO 2 frequency		22.755		GHz
LO 2 input power		0		dBm

Table 6.2: AR1004 amplifier nominal current values

Amplifier	**Channel 1**	**Channel 2**	**Channel 3**	**Channel 4**
LO2 Common	250 mA			
RF Out Amp	85 mA	85 mA	85 mA	85 mA
RF In Amp	150 mA	150 mA	150 mA	150 mA
IF1 Amp	250 mA	250 mA	250 mA	250 mA
LO1 Amp	140 mA	140 mA	140 mA	140 mA

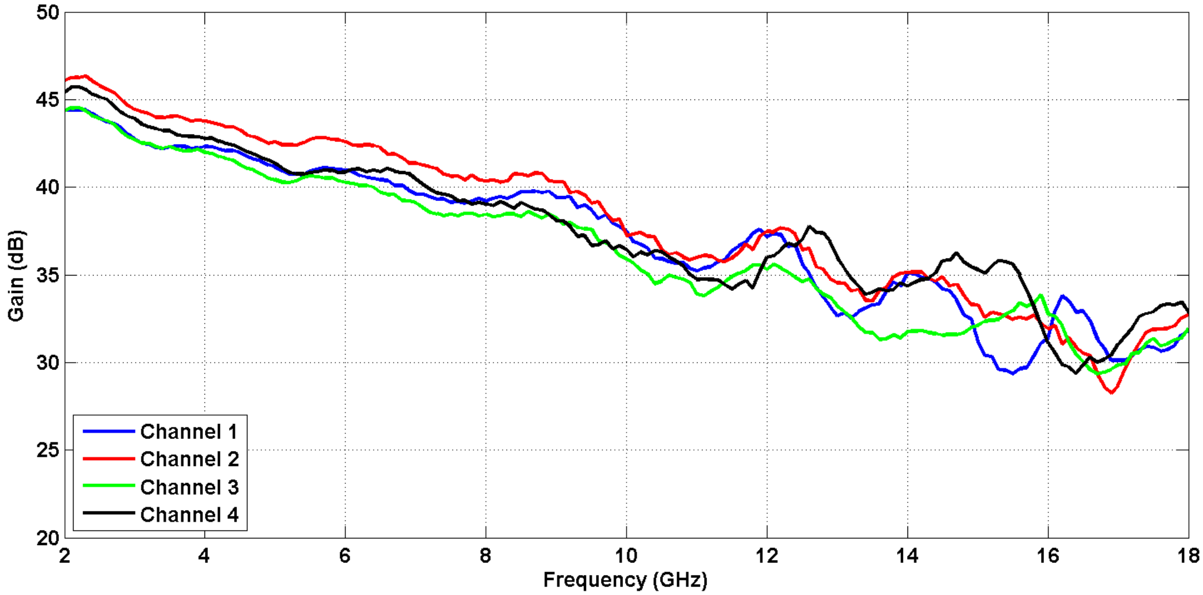


Figure 6.3: Typical Gain response over the RF input range of 2 to 18 GHz

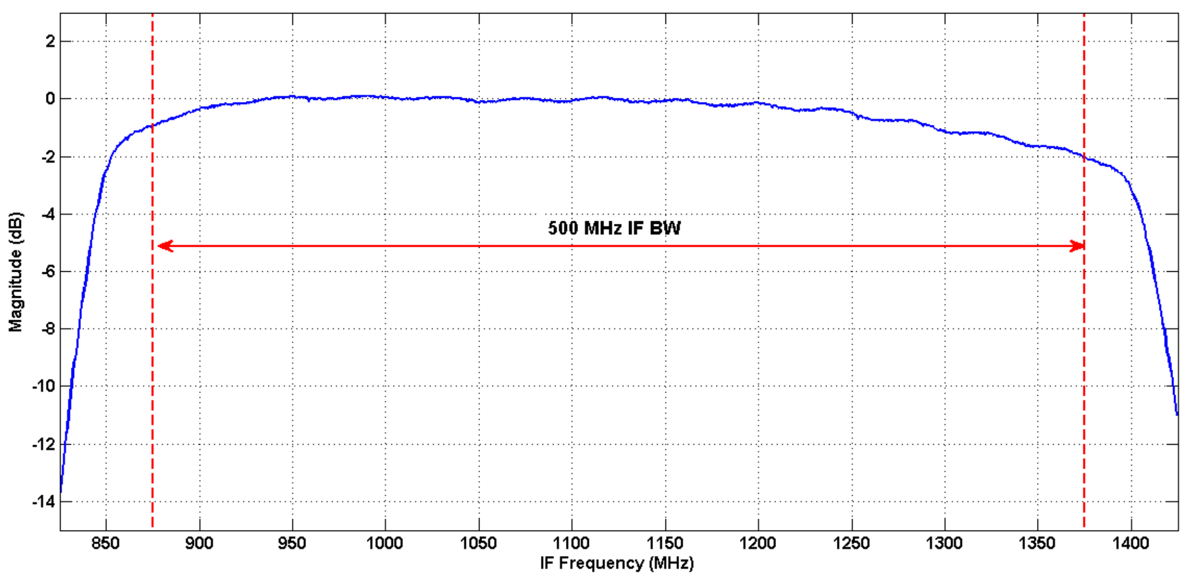


Figure 6.4: Typical IF output response over a 500 MHz IF bandwidth (LO1 held constant and RF swept)

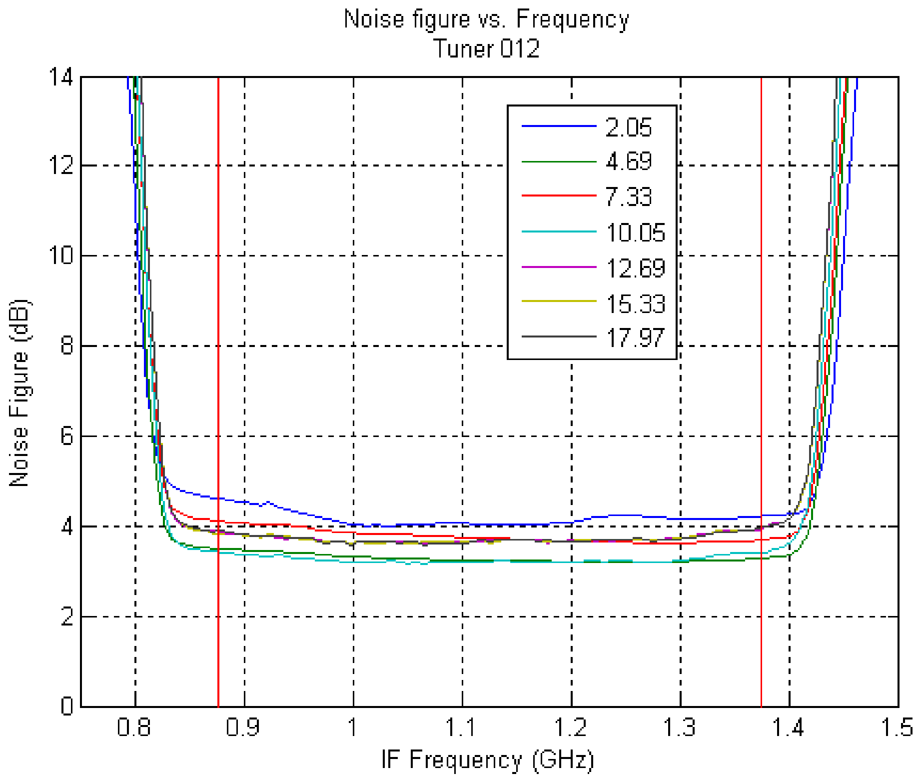


Figure 6.5: Typical Noise Figure performance of the AR1004

7
AR1001 LO Synthesizer Distribution Unit

In This Chapter

1. Overview

The AR1001 LO Synthesizer Distribution Unit (LSDU) functions as an LO source for the Applied Radar frequency converter product line. The LSDU can be configured with up to four independently controlled RF synthesizers with up to eight outputs per synthesizer. With the ability to tune over frequency and adjust the output power level, the LSDU can be used as an LO source for the Applied Radar frequency converter line or to provide multiple RF signals to other systems.

The AR1001 LO Synthesizer Distribution Unit is available with factory installed options. The available options for this product are listed in Table 7.1. To determine which options are installed in your AR1001, please refer to either the *Product Configuration Sheet* that came with your product or the Part Identification Label located on the rear of the AR1001.

Table 7.1: Factory installed options

001	LCD interface
002	Internal 10 MHz reference installed
003	70 MHz reference frequency
004	Frequency doublers installed
005	ADC/DAC clock reference installed
006	Hardware TTL reset input on rear panel
100	GPS timing & reference installed
200	Sweeping

For units with Option 001 installed, the LSDU can be controlled through the front panel touchscreen LCD, which allows for control of the LSDU without requiring connection to a computer. Through the LCD interface, the user can change the frequency and configure the operating mode of the RF synthesizers, configure sweeping modes, determine the status of the LSDU, and save/recall up to 10 user states. When connected to a computer, commands received over the USB or LAN connection will override any commands entered through the LCD.

A general block diagram of the AR1001 LO Synthesizer Distribution Unit is shown in Fig. 7.1. Computer control of the LSDU is perfromed through the USB or LAN connection provided by the Embedded Controller Unit (ECU) in the LSDU. The ECU is an embedded processor running the Linux operating system and provides a conduit for sending commands and retrieving information from the connected synthesizers. The ECU also communicates with the reference oscillator, the LCD, and temperature sensors mounted in the LSDU chassis.

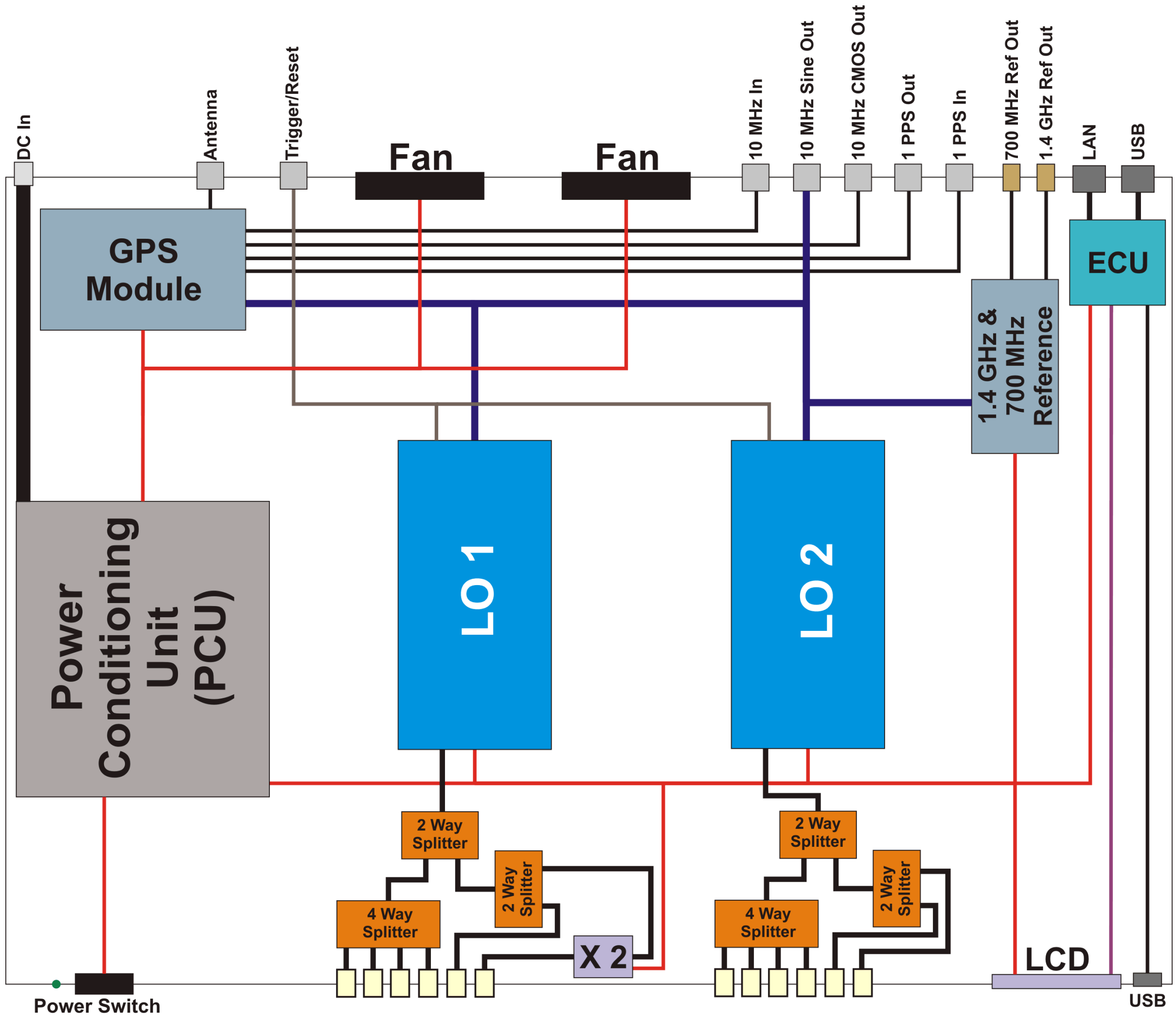
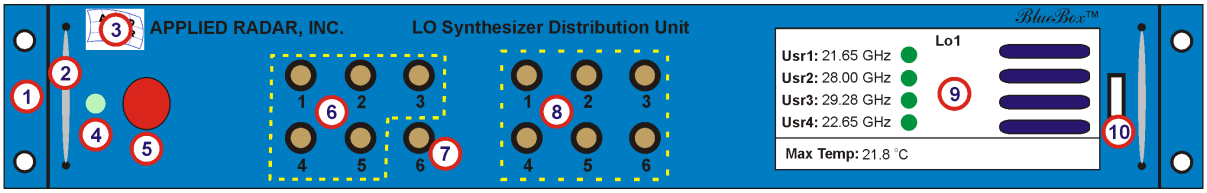
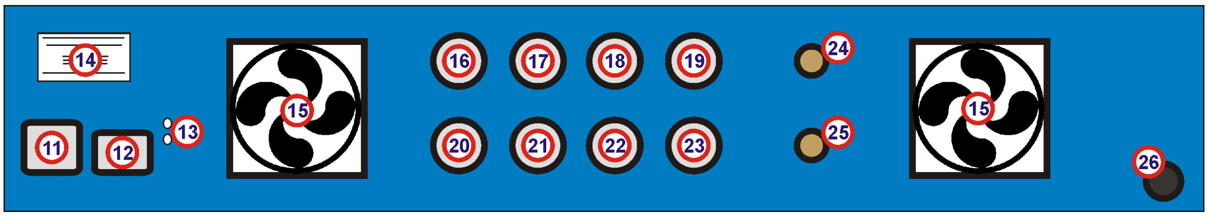


Figure 7.1: General block diagram of the AR1001 LO Synthesizer Distribution Unit used in the AR1012 SWORD™ DREX



Front Panel



Rear Panel

Figure 7.2: AR1001 LO Synthesizer Distribution Unit front (a) and rear (b) panels

No.	Part	Function
1	"Dog Ears"	For mounting to a 19-inch rack
2	Handle	Handle to assist in removal of unit from a 19-inch rack
3	Logo	Applied Radar, Inc. Logo
4	LED	Power indicator
5	Power Switch	Turns On/Off the AR1001
6	LO1	LO1 outputs to the AR1002 Single Channel Upconverters (plus extra output which must be terminated in 50 Ω if unused), SMA connectors
7	LO1	LO1 output to the AR1004 Four Channel RF Downconverter, 2.92mm
8	LO2	LO2 outputs to all units(plus extra output which must be terminated in 50 Ω if unused), Super SMA connector
9	LCD	Touchscreen LCD
10	USB Host	Provides a USB connector for USB drives and other Applied Radar, Inc. USB instruments. This USB port is connected to the ECU.
11	LAN	Cat-5 Ethernet connection
12	USB Device	USB connection from control computer to the AR1001
13	LEDs	Status LEDs *Factory use only*
14	ID Label	Part identification label including product number, options, serial number, and date code
15	Fan	Cooling fans

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No.	Part	Function
16	10 MHz In	10 MHz input for locking the RF synthesizers to an externally supplied 10 MHz reference signal, BNC connector
17	10 MHz Out	10 MHz output for daisy chaining, BNC connector
18	1 PPS Out	1 Pulse-Per-Second (PPS) output, BNC connector
19	GPS Antenna	Connection to GPS antenna, BNC connector. For maximum stability and accuracy, a GPS antenna should be used with a view of a sufficient number of satellites to obtain a GPS lock.
20	1 PPS In	1 Pulse-Per-Second (PPS) input for locking the RF synthesizers to an externally supplied 1 PPS signal, BNC connector
21	10 MHz CMOS out	10 MHz CMOS output signal, BNC connector
22	Not Used	*Reserved for future use*
23	Trigger input	Trigger input, BNC connector *Reserved for future use*
24	DAC clock	700 MHz DAC clock output, SMA connector
25	ADC clock	1.4 GHz ADC clock output, SMA connector
26	DC in	DC power input connector, +12V @ 8A maximum

2. RF Synthesizer

Each AR1001 LO Synthesizer Distribution Unit comes with up to four AR2001 RF synthesizer modules installed. The RF synthesizers are PLL based synthesizers and are available in a variety of frequency ranges. For details regarding the specific RF synthesizers installed in your AR1001 LO Synthesizer Distribution Unit, refer to the *Product Configuration Sheet* that came with your system.

2.1 Configuration

The AR2001 RF Synthesizer is a phase lock loop (PLL) based tunable RF synthesizer. A block diagram is shown in Fig. 7.3. A voltage controlled oscillator (VCO) is used to generate the RF carrier output. A sample of the VCO output is fed back to the PLL, where it is compared to a reference signal. This comparison is carried out by passing the VCO signal through a *Divide-By-N* (which is part of the PLL) and dividing the VCO signal by an integer value, as set in a PLL register, to produce the signal which is compared to the reference signal. The tuning voltage applied to the VCO by the PLL is adjusted until the frequency of the VCO is at the desired frequency. This condition is known as the *locked* state. In order to reduce noise on the tuning voltage line, which can cause degradation in the output spectrum of the VCO, a loop filter is placed on the tuning voltage line between the PLL and the VCO.

Some ARI RF synthesizer models are available with an on board frequency doubler and a VVA. The frequency doubler extends the output frequency of a single RF synthesizer while the VVA allows for amplitude control of the RF output. A generic block diagram of a typical RF synthesizer with an on board doubler and VVA is shown in Fig. 7.4.

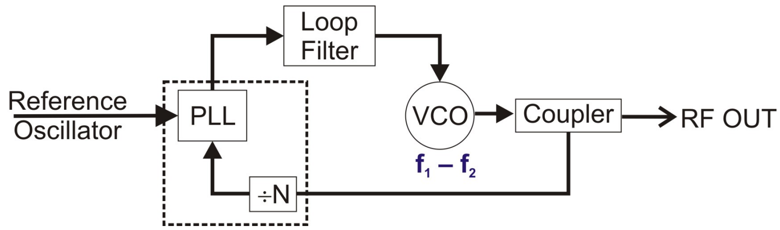


Figure 7.3: General block diagram of the RF Synthesizer

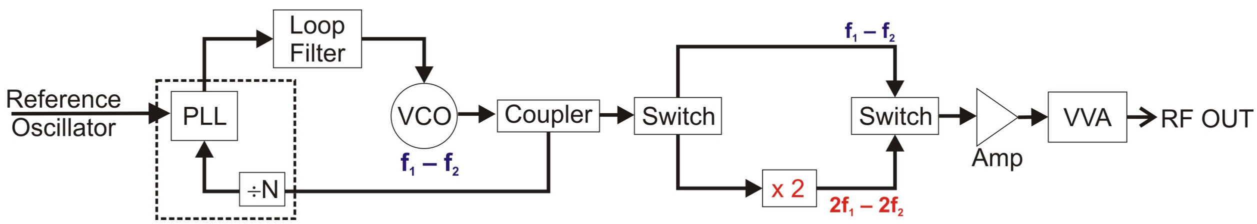


Figure 7.4: General block diagram of the RF Synthesizer with on-board doubler and VVA

2.2 Operating Modes

The PLLs used in the RF Synthesizers are capable of operating in two modes; *Integer* (also referred to as *Integer-N* mode) and *Fractional* (also referred to as *Fractional-N* mode). The choice of operating mode affects the phase noise performance and tuning step capabilities of the RF synthesizer. When the synthesizer is placed in *Integer* mode, the output frequency is an integer multiple of the reference oscillator frequency. For RF synthesizers that do not include any doublers, the frequency resolution is an integer multiple of two times the reference factor (the factor of two is due to an internal multiplication factor of two in the PLL). For each doubler installed in the signal path, the output frequency step resolution increases by a factor of two. For example, if the AR2001-05-20 synthesizer is installed along with AR1001 Option 004, the output frequency step resolution is 80 MHz (10 MHz Reference x2 for the PLL, x2 for the doubler on the AR2001-05-20, x2 for the doubler installed in the AR1001). *Integer* mode operation has the best output phase noise performance of the two modes. When the synthesizer is placed in *Fractional* mode, the output frequency of the RF synthesizer can be any integer or non-integer multiple of the reference frequency. While Fractional mode allows you to achieve any desired output frequency (limited to a 1 MHz resolution for the AR1001), it comes with the price of increased phase noise.

NOTICE

When operating in *integer* mode, if the frequency entered falls between two valid output frequencies, the lower of the frequencies is outputted. For example, if the system frequency step resolution is 100 MHz and 1.195 GHz is entered, the output frequency would be 1.1 GHz.

A compromise between the limited output frequency lower phase noise *Integer* mode and the higher phase noise *Fractional* mode can be achieved by placing the RF synthesizer in *Integer* mode and using the internal reference divider to divide down the 10 MHz reference to a lower frequency. By dividing down the reference frequency, the RF synthesizer can achieve smaller frequency steps while remaining in Integer mode. In the previous example of an RF synthesizer with two doublers, if the reference divider is set to 4, the output frequency step would be 20 MHz rather than 80 MHz. The larger the reference divider factor the greater the impact to the output signals phase noise. However, the impact to the phase noise while using the reference divider is less severe than operating in *Fractional* mode for small values of the reference divider factor (assuming proper optimization of the PLL parameters). As the reference divider factor is increased, the degradation in the output phase noise approaches the phase noise of operation in the *Fractional* mode. For very large reference divider factors, the output phase noise can become worse than operating in *Fractional* mode.

The trade offs between operating in *Integer*, *Fractional*, and *Integer* using a reference divider are summarized in the Table 7.2.

Table 7.2: Advantages and disadvantages of the various RF synthesizer operating modes

Mode	**Advantage**	**Disadvantage**
Integer	• Lowest Phase Noise • Phase Coherency among multiple RF synthesizers	• Larger frequency steps
Fractional	• Any output frequency step (limited to a 1 MHz resolution) can be achieved	• Higher Phase Noise • Phase coherency among multiple RF synthesizers cannot be guaranteed
Integer w/Reference Divider	• For small reference divider factors, smaller frequency steps can be achieved with minimal impact to phase noise • Phase Coherency among multiple RF synthesizers	• Output frequency step is limited to integer steps of the divided reference frequency • Phase noise is degraded versus Integer mode • For large reference divider factors, the phase noise degradation can be worse than Fractional mode

For more information regarding the operating modes of the RF Synthesizers, please see the AR2001 Operating Manual.

2.3 Typical Performance

The typical performance of the LO1 RF Synthesizer is shown in Figures 7.5 through 7.10. The typical performance of LO2 is shown in Figures 7.11 through 7.14.

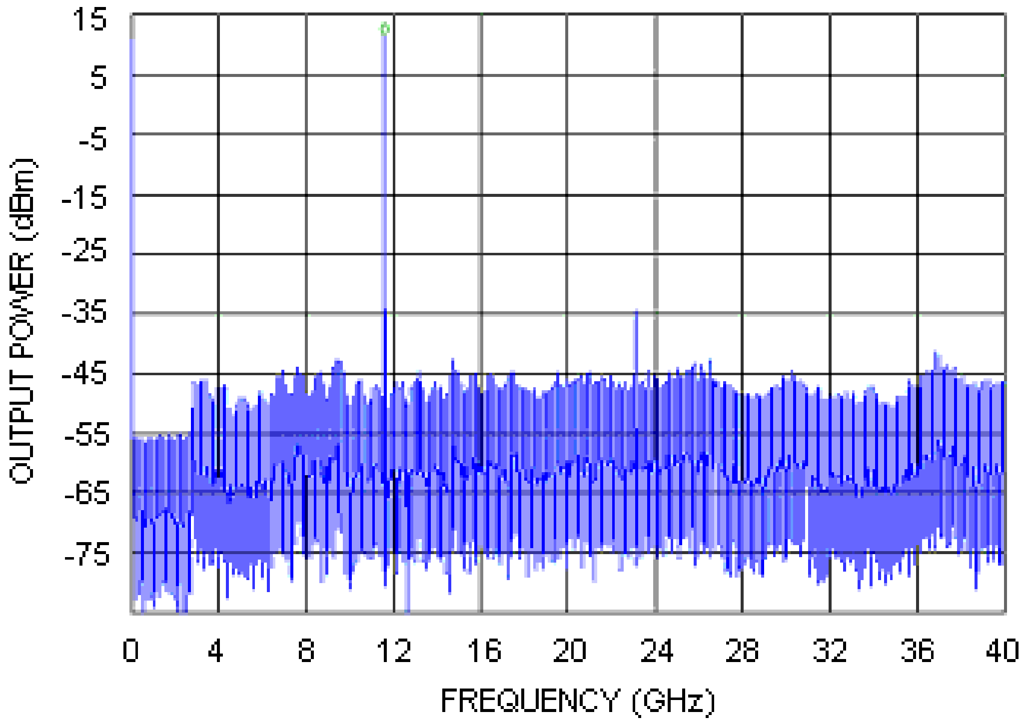


Figure 7.5: LO1 output spectrum with F_{out} = 11.6 GHz with a 40 GHz span.

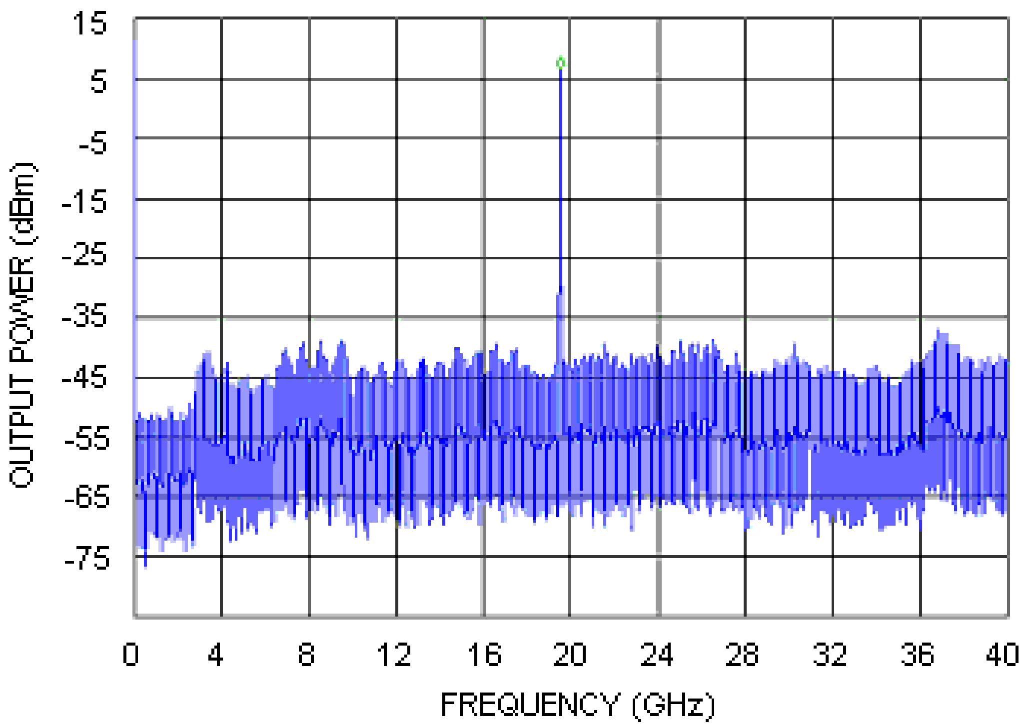


Figure 7.6: LO1 output spectrum with F_{out} = 19.6 GHz with a 40 GHz span.

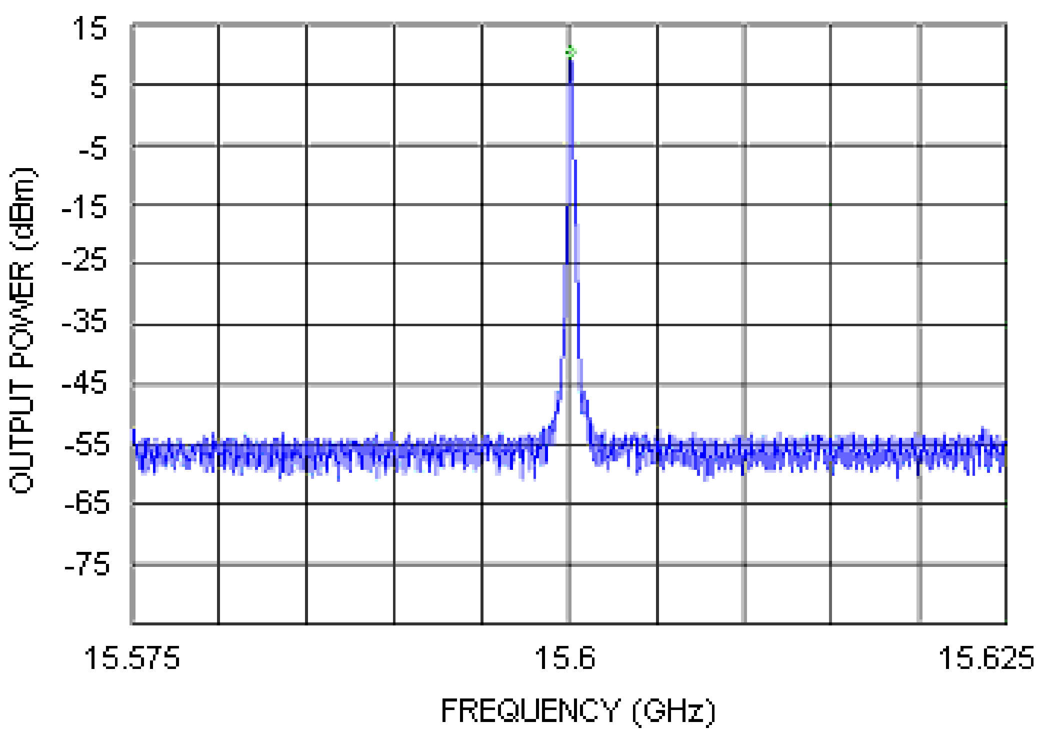


Figure 7.7: LO1 output spectrum with F_{out} = 15.6 GHz with a 50 MHz span.

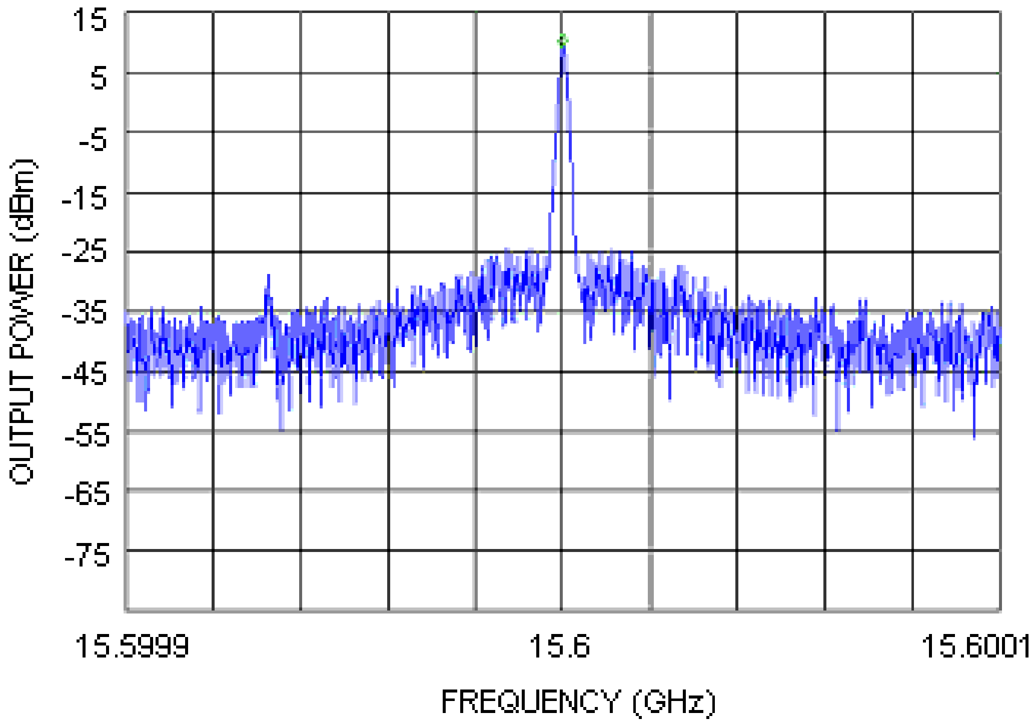


Figure 7.8: LO1 output spectrum with F_{out} = 15.6 GHz with a 200 kHz span.

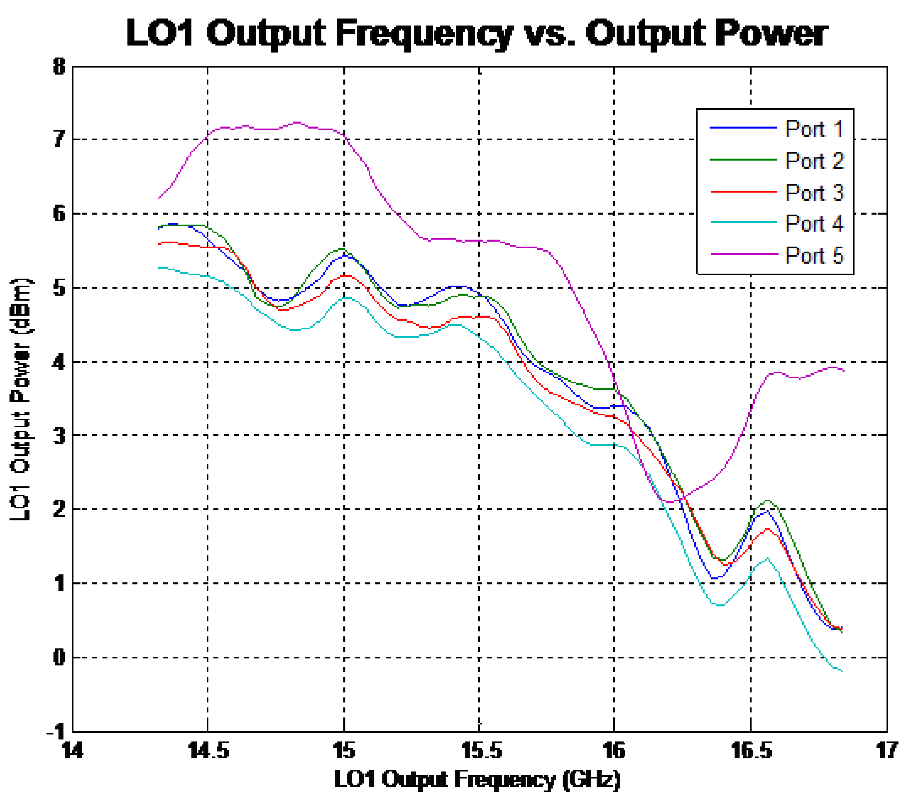
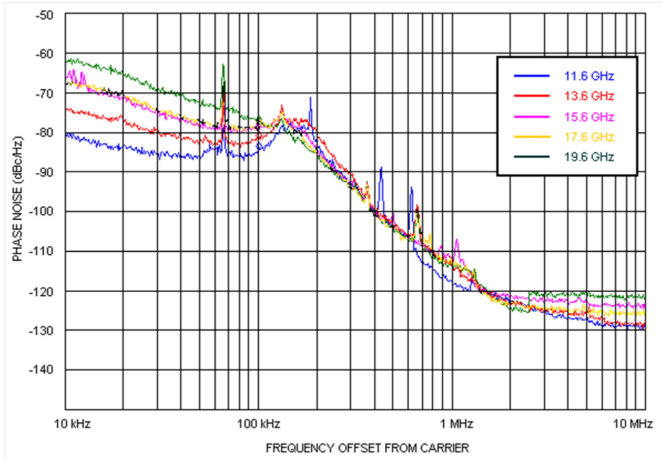


Figure 7.9: LO1 output power



Spectral Purity

Frequency (GHz)	2^{nd} Harmonic (dBc)	3^{rd} Harmonic (dBc)	Spurious (dBc)
11.63	-40	-71	-67
13.63	-42	-	-60
15.63	-50	-	-65
17.63	-74	-	-60
19.63	-44	-	-60

SSB Phase Noise

Frequency (GHz)	Offset From Carrier		
	10 kHz (dBc/Hz)	100 kHz (dBc/Hz)	1 MHz (dBc/Hz)
11.63	-80	-85	-118
13.63	-75	-82	-112
15.63	-65	-78	-112
17.63	-65	-78	-111
19.63	-62	-76	-112

Figure 7.10: LO1 Phase Noise performance

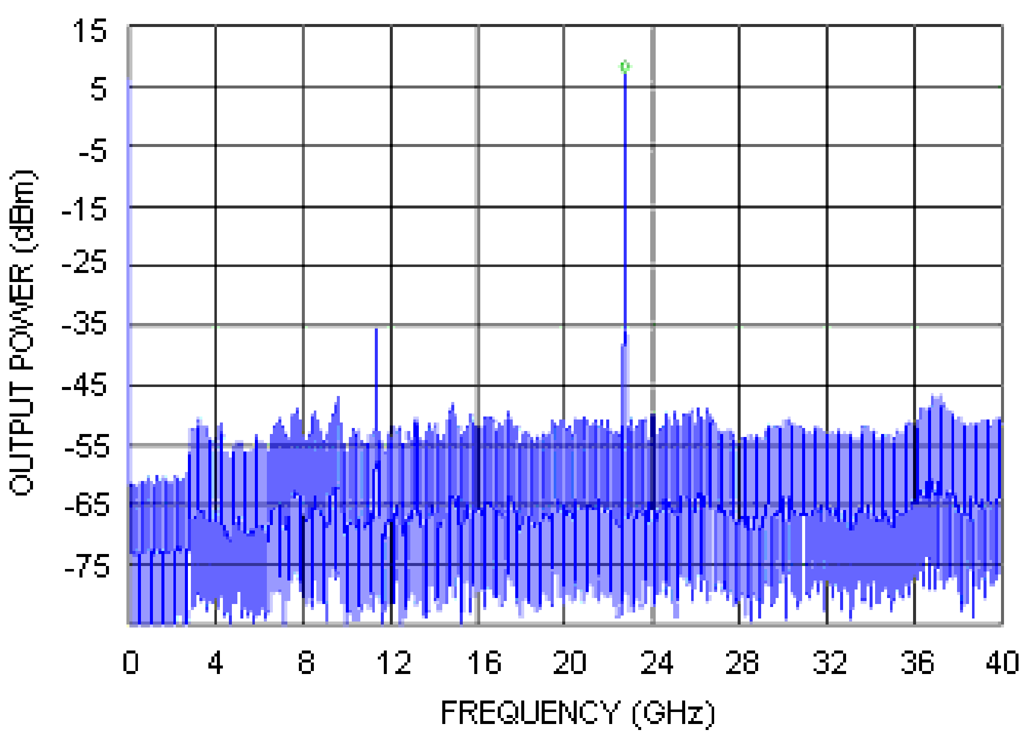


Figure 7.11: LO2 output spectrum with F_{out} = 22.755 GHz with a 40 GHz span.

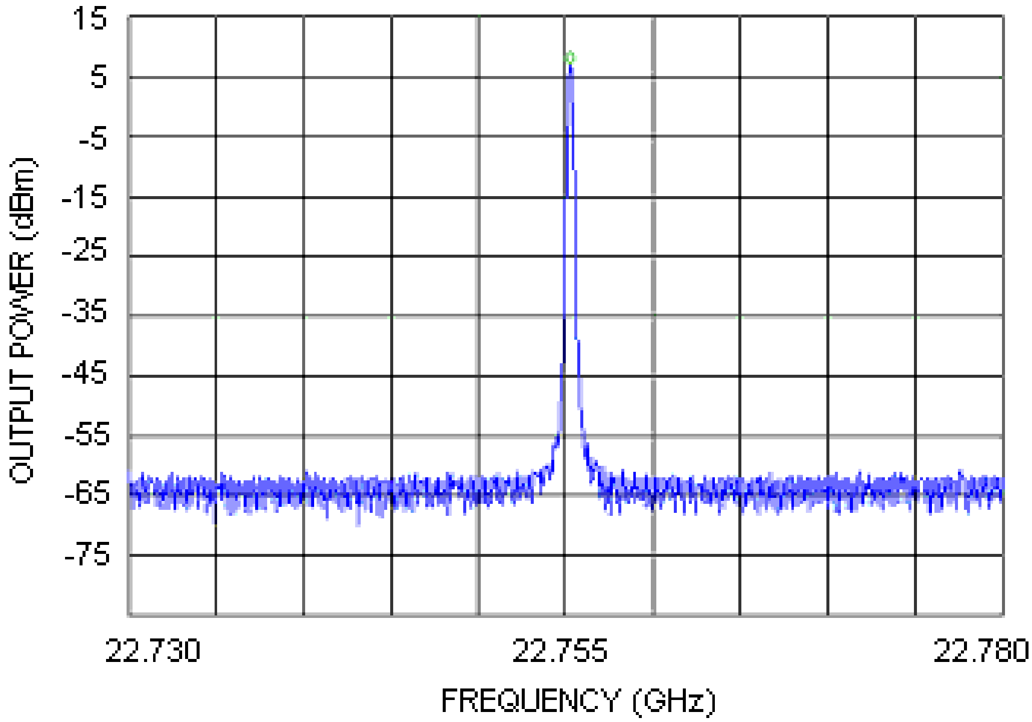


Figure 7.12: LO2 output spectrum with F_{out} = 22.755 GHz with a 50 MHz span.

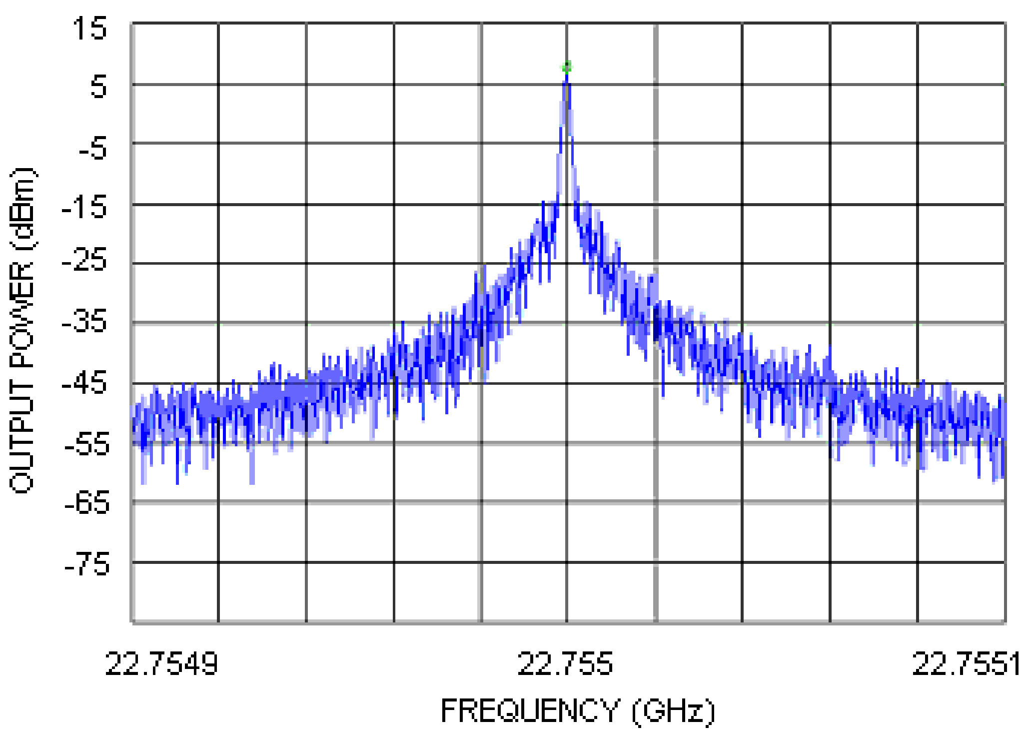
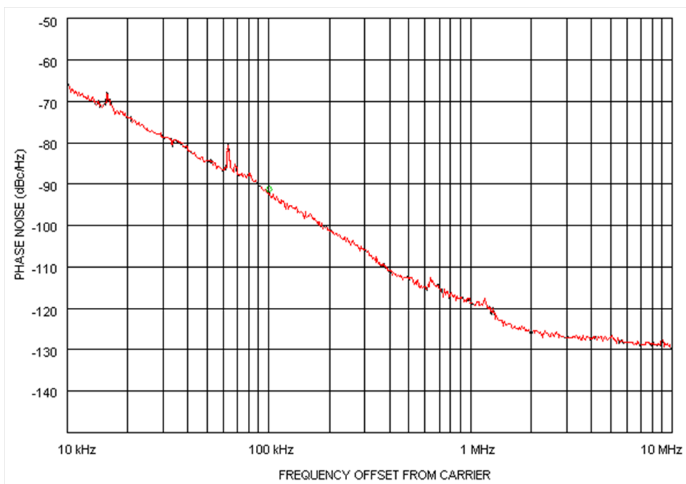


Figure 7.13: LO2 output spectrum with F_{out} = 22.755 GHz with a 200 kHz span.



Spectral Purity

Frequency (GHz)	½ f0 (dBc)	Spurious (dBc)
22.755	-45	-62

SSB Phase Noise

Frequency (GHz)	Offset From Carrier		
	10 kHz (dBc/Hz)	100 kHz (dBc/Hz)	1 MHz (dBc/Hz)
22.755	-66	-92	-118

Figure 7.14: LO2 Phase Noise performance

2.4 Phase Coherence Among Multiple RF Synthesizers

With multiple independently tuned RF synthesizers in the AR1001 LO Synthesizer Distribution Unit, phase coherency among the RF synthesizers will depend on the operating mode of the RF synthesizers. When operating in *Integer* mode (with or without reference division), assuming that the RF synthesizers have been locked for several cycles of the reference oscillator, the RF synthesizers are guaranteed to be phase coherent. When operating in *Fractional* mode, the RF synthesizers are not guaranteed to be phase coherent.

NOTICE

If phase coherency among the synthesizers is a requirement, Integer or Integer with reference divider mode must be used.

3. Embedded Controller Unit

Every AR1001 unit comes with an Embedded Controller Unit (ECU) installed. The ECU provides a central connection point between the control computer and all of the installed modules in the AR1001. The ECU can be connected to a computer through either the USB port or LAN port. Communication with the ECU is performed through the VISA libraries. The command format and structure is identical for USB and LAN connections.

Programming of the synthesizers and other modules is performed by sending commands to and from the ECU. *See the AR1001 Programming Manual for a list of programming commands.*

4. GPS Timing & Reference Module

For systems with Option 100 installed, the standard AR3003 Reference Distribution Unit is replaced by the the AR2006 GPS Timing & Reference module. The AR2006 is a GPS driven, mixed-signal phase lock loop, providing 1 PPS CMOS, 10 MHz CMOS, and 10 MHz Sine outputs from an intrinsically low jitter voltage controlled oscillator. The AR2006 can be locked to a 10 MHz reference derived from the on-board GPS receiver or to an externally supplied 10 MHZ or 1 PPS signal.

The AR2006 incorporates a high precision 10 MHz OCXO which is disciplined by the GPS signal. When the AR2006 is unable to lock onto a sufficient number of GPS satellites, the AR2006 operates in *Holdover* mode, which uses the 10 MHz OCXO to directly derive the output 1 PPS and 10 MHz signals. The AR2006 is also capable of locking to an externally applied 1 PPS or 10 MHz signal. The reference source used by the AR2006 is specified either through VISA commands from the host computer or through the LCD (when the AR1001 is equipped with Option 001).

The AR2006 provides four 10 MHz reference signal outputs for driving up to four RF Synthesizers. A fifth amplified output is provided and connected to the reference output connector on the rear panel of the AR1001, permitting one reference unit to drive multiple products. In addition to the 10 MHz reference output, a 10 MHz CMOS and a 1 PPS output are provided on the rear panel to allow the AR1001 to supply timing signals for time critical applications, such as Applied Radar's DREX (Digital Receiver EXciter) product line.

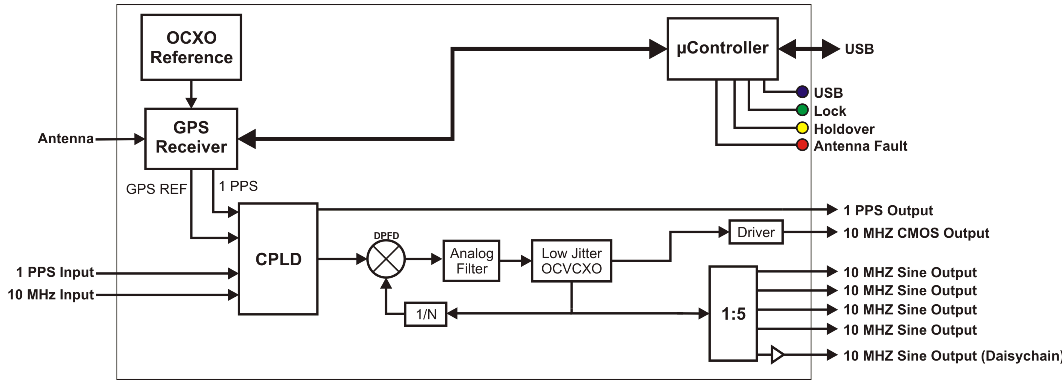


Figure 7.15: Block diagram of the AR2006 GPS Timing & Reference Module

In order to provide the most accurate reference and timing signals, the AR2006 needs to acquire a GPS signal. A BNC antenna connector is provided on the rear panel of the AR1001. The AR2006 supports a variety of antenna types, both active an passive (*for best performance, an active antenna with a minimum of 10 dB of gain (including cable loss) should be used*). For active antennas, the bias voltage is provided by the AR2006. The bias voltage is user selectable between passive (0), 3.3 V, 5 V, and 12 V. The antenna voltage is selected through programming the AR1001 or through the GPS Setup and Status screen of the LCD.

NOTICE

The performance of the AR1001 is affected by the quality of the reference signal supplied to its internal synthesizers. Care must be taken to ensure that a clean and stable reference signal is provided to the AR1001 when using the external reference. All supplied data with your system was collected with the AR1001 using the AR2006 GPS Timing & Reference module with a GPS lock.

The 10 MHz output signal of the AR2006 is shown in Figures 7.16 through 7.18.

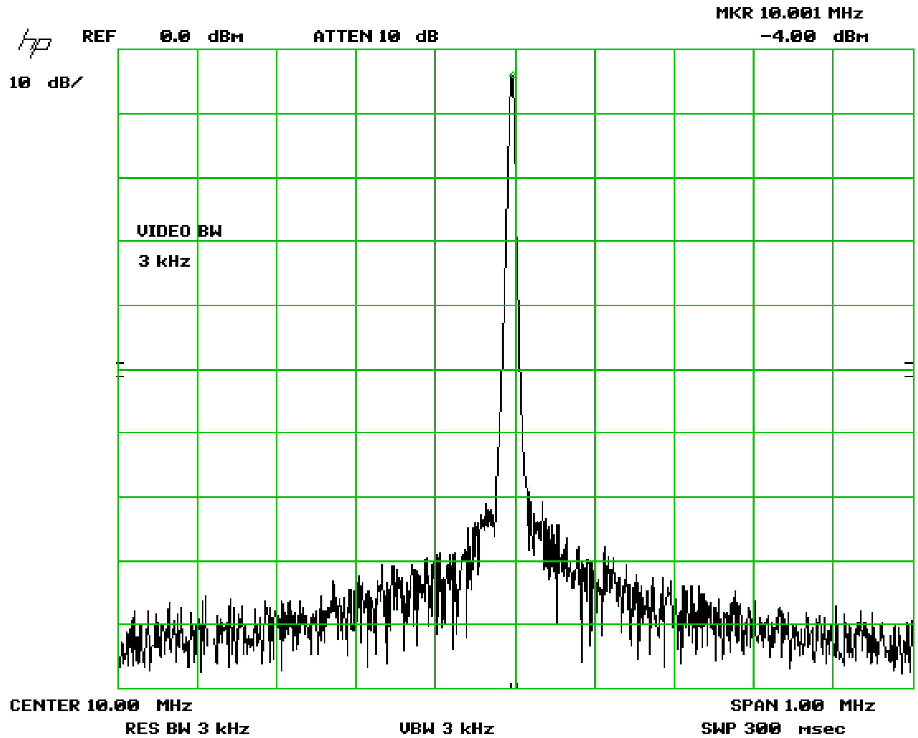


Figure 7.16: 10 MHz output from the AR2006, 1 MHz span

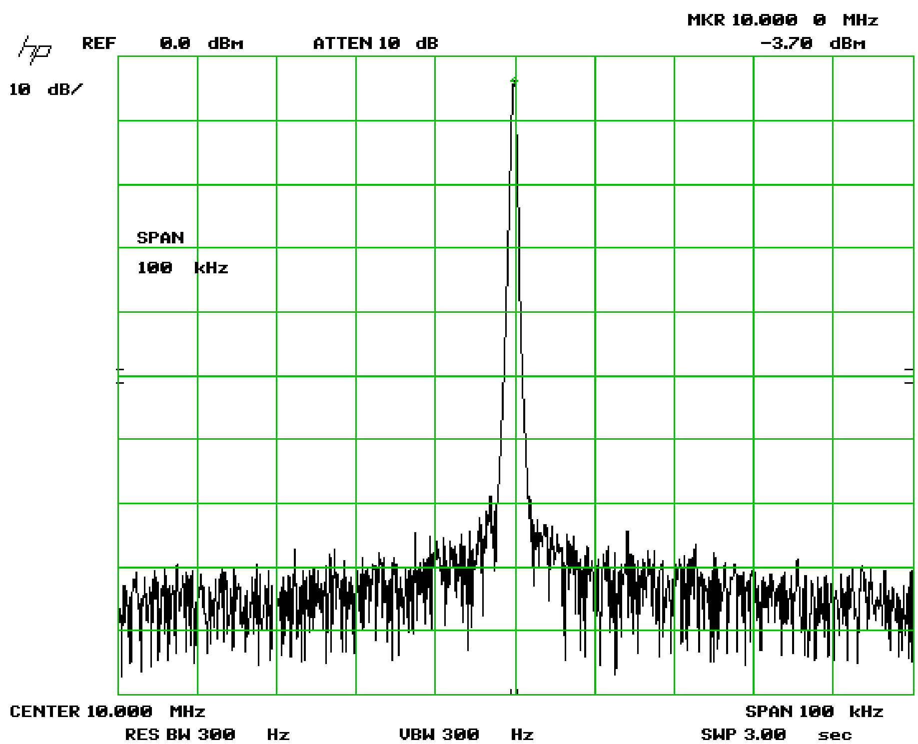


Figure 7.17: 10 MHz output from the AR2006, 100 kHz span

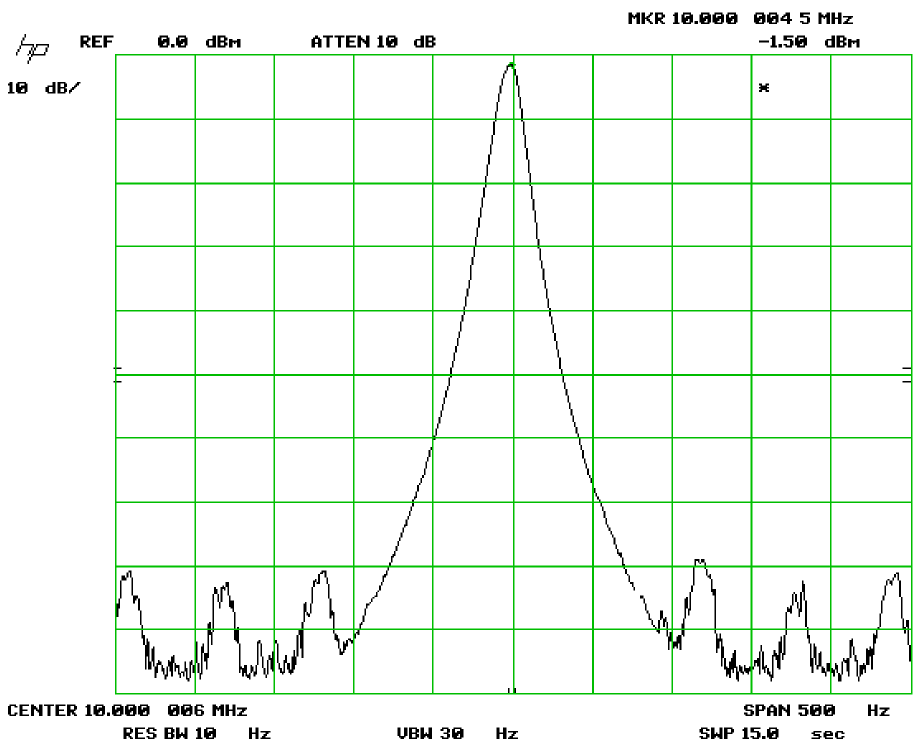


Figure 7.18: 10 MHz output from the AR2006, 500 Hz span

5. Power Supply and Conditioning

The AR1001 requires a +12 V DC input voltage capable of providing up to 8 A to operate. In order to provide a clean voltage supply to the RF components, all power is routed through the AR9004 Power Supply Conditioning board. This board uses linear regulators and filtering to condition the power lines from the external DC power supply and removes the noise due to any switching in the power supply. This board is crucial for low phase noise operation and the AR1001 should never be operated without the AR9004 Power Supply Conditioning Board installed.

CAUTION

Use only the supplied AC-DC 12V, 8.5A Switching Power Adapter. Do not replace or modify the AR9004 Power Conditioning Unit. Doing so will result in degraded RF performance and will void the warranty. Should the AR1001 need repair, please return it to Applied Radar for service.

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6. LCD Operation

For systems with Option 001 installed, a touch screen LCD is added to the front panel of the AR1001 LO Synthesizer Distribution Unit. The LCD interface allows the user to not only receive visual feedback of the state of the system, it also allows the AR1001 to be operated in the absence of a computer. Through the LCD, the user can verify the USB and LAN connections, the lock status of the RF synthesizers and GPS, change the GPS configuration, modify the LAN parameters, change the frequency and power settings of each of the installed RF synthesizer individually, save and recall to/from any of the 10 memory locations (recalling from memory location 0 is the same as presetting the unit), and monitor the maximum temperature of the LO Synthesizer Distribution Unit and RF synthesizers. The user may also customize the title (max 25 characters) and the 4 character ID string of each RF synthesizer through the LCD.

NOTICE

The LCD must communicate with the ECU in order to capture user inputs and update the display. Please allow 1-2 seconds for changes made to be updated on the LCD display

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6.1 Splash Screen

When power is applied to the AR1001 LO Synthesizer Distribution Unit the *Splash* screen will appear. A sample *Spash* screen is shown in Fig. 7.19. The *Splash* screen displays the LO Synthesizer Distribution Unit system information including the product part number and description, serial number, installed options, and firmware version. While the AR1001 is in the initialization process, a spinning icon indicator will appear on the *Splash* screen in place of the system information. After the AR1001 has finished initializing, the *Splash* screen will remain visible for 10 seconds. To dismiss the *Splash* screen before the 10 seconds has expired, press anywhere on the display.

In the event that the LCD is unable to communicate with the LO Synthesizer Distribution Unit's ECU, the screen in Fig. 7.20 will appear. Press the *Reconnect* button to try to connect to the ECU. The LCD will not operate without the ECU being present and operational in the system.

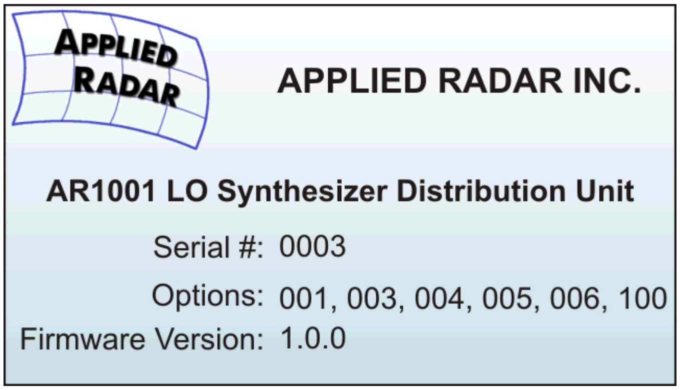


Figure 7.19: Splash Screen

Figure 7.20: Indicates that the single board controller did not respond to attempts to connect

6.2 Home Screen

The *Home* screen, shown in Fig. 7.21, acts as the status display screen for the system. The *Home* screen is divided into five parts, the title, the RF Synthesizer panel, GPS lock status, maximum temperature, and computer connectivity status.

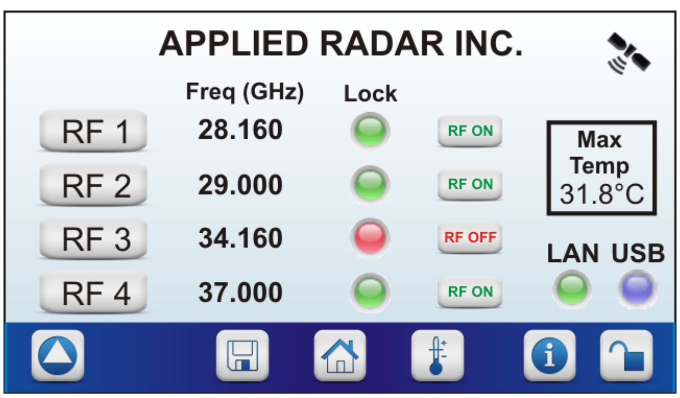


Figure 7.21: The Home Screen

Title String

The title string identifying the LO Synthesizer Distribution Unit unit is shown on the top of the *Home* Screen. The displayed title can be customized through the *LCD Setup* menu.

RF Synthesizer Panel

The RF synthesizer panel displays the four character synthesizer id strings, synthesizer frequency, lock status, and RF power state (*On* or *Off*) for up to four AR2001 RF Synthesizers in the AR1001. The RF synthesizer button, located on the far left hand side of the LCD, displays the currently assigned ID string for up to four RF synthesizer modules in the system. The RF Synthesizer ID string is a customizable four character string which can be customized through the *LCD Setup* menu. Pressing the RF Synthesizer button will take you to the RF Synthesizer Control panel screen (Fig. 7.37).

The output frequency of each RF synthesizer is shown in the column adjacent to the RF Synthesizer button. The PLL lock status is displayed next to the frequency. The status is displayed as an indicator LED. A Red LED signifies that the RF synthesizer is unlocked, while a green LED signifies that the RF synthesizer is locked.

The RF power state is shown in the last column. When *RF OFF* is displayed, the RF signal output is disabled. Pressing the RF power state button toggles the state of the RF output.

GPS Icon

(For systems with Option 100 installed) If the GPS Icon appears in the upper right corner of the LCD, the integrated GPS Timing & Reference module is locked to the GPS signal. If the icon appears in a red circle with a line through it, then a sufficient number of satellites are not in view and a lock to the GPS signal could not be established.

Maximum Temperature

The maximum temperature observed in the AR1001 unit is displayed on the right side of the Home Screen. To see the temperature readings for the individual RF Synthesizers, press the temperature icon on the LCD Menu bar.

LAN Connection

The status of the LAN connection is displayed on the lower right of the Home Screen. The status is displayed as an indicator LED. If the LED is green, then the computer is connected to the AR1001 through the LAN port.

USB Connection

The status of the USB connection is displayed on the lower right of the Home Screen. The status is displayed as an indicator LED. If the LED is blue, then the computer is connected to the AR1001 through the USB.

6.3 Toolbar

The toolbar, shown in Fig. 7.22, is located at the bottom the LCD screen. The toolbar contains icons that allow you to navigate through the various functions of the LCD. For a description of the icons, see Table 7.3.

Figure 7.22: LCD Toolbar

Table 7.3: Toolbar icons

Icon	Description
	Provides access to the LCD Setup and System Setup menus
	Provides access to the Save/Recall screen
	Press this icon to return to the Home screen
	Provides access to the Temperatures screen
	Provides access to the System Information screen
	This icon indicates that the LCD is *unlocked*. Press to Lock
	This icon indicates that the LCD is *locked*. Press to Unlock

When a command is received by the AR1001 through either the USB or LAN connection, the LCD is automatically returned to the *Home* screen and placed in the locked state. To unlock the LCD, simply press the *Locked* icon in the lower right corner of the LCD. The LCD may be locked at anytime by pressing the *Unlocked* icon. When locked, the LCD display will continue to update the status of the RF synthesizers, but will not accept any user input.

6.4 System Menus

The *System Menu*, shown in Fig. 7.23, is accessed by pressing the *System Menu* icon on the *Toolbar*.

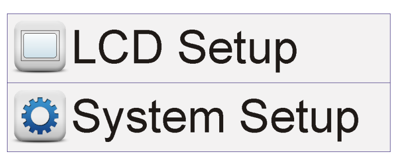


Figure 7.23: System Menu accessed by pressing *System Menu*.

Table 7.4: System Menu icons

Icon	Description
	Provides access to the LCD Setup menu

	Provides access to the System Setup menu

6.4.1 System Setup Menu

The *System Setup Menu*, shown in Fig. 7.24, allows the operator to access the *GPS Setup and Status* screen, the *LAN Setup* screen and the *Reference* configuration screen.

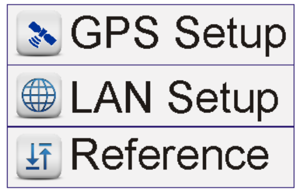


Figure 7.24: Configuration Menu

Table 7.5: Configuration Menu icons

Icon	Description
	Provides access to the GPS Setup and Status screen
	Provides access to the LAN Configuration screen
	Provides access to the Reference configuration screen

6.4.2 GPS Setup

NOTICE

Only applies to systems with Option 100 installed

To access the *GPS Setup and Status* screen, press the *GPS Setup* option from the *System Setup* menu. The *GPS Setup and Status* screen provides the current status of the GPS unit as well as allowing the operator to configure the Antenna bias voltage. The *GPS Setup and Status* screen, shown in Fig. 7.25, is divided into two sections. The GPS status is shown on the left side of the screen and allows the operator to determine if an antenna fault has been detected, if the GPS unit is in holdover mode, if the GPS unit has achieved lock, and the number of satellites currently in view. The right side of the *GPS Setup and Status* screen allows the user to select the bias voltage applied to the antenna port. The system is capable of providing 0 Volts, 3.3 Volts, 5 Volts, and 12 Volts to the antenna. The selected antenna voltage is indicated with an orange LED. To change the antenna voltage, simply push the desired antenna voltage.

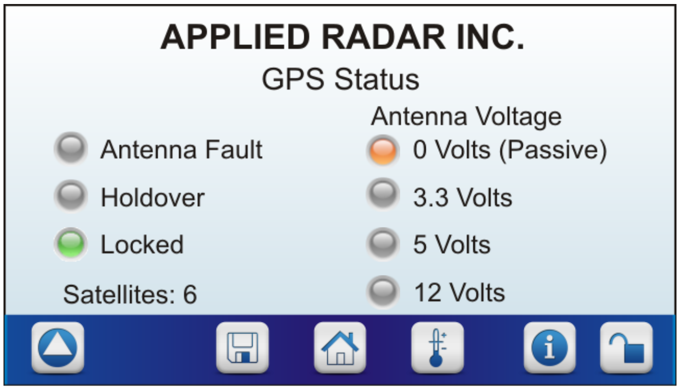


Figure 7.25: GPS Setup and Status screen

CAUTION

The GPS unit is unable to detect the required antenna voltage and it is left up to the operator to select the appropriate antenna voltage level. Consult the operating manual that came with your GPS antenna to determine the proper antenna voltage. Always ensure that the proper antenna voltage has been selected prior to attaching the antenna to the system. Failure to do so may result in damage to the GPS antenna.

6.4.3 LAN Setup Menu

The AR1001 is a LAN capable device, allowing the AR1001 to be controlled remotely through a local area network. The AR1001's LAN settings can be automatically configured by the network through DHCP/Auto IP and Auto DNS or manually configured. When the *LAN Setup* menu is selected, the *LAN Status* screen, shown in Fig. 7.26, appears. The current LAN settings, including MAC address, IP Address, Subnet Mask, Gateway, and DNS are displayed. The current status of the LAN connection is displayed through two LEDs, the *Power* LED indicating if a cable is connected and the *Status* LED indicating if the network is configured. The operator is presented with two buttons, *LAN RESET* and *Setup*. Pressing the *LAN RESET* button will result in the LAN settings being reset to the default settings which is for everything to be automatically configured by the network. Upon pressing this button, the user will be prompted to confirm their action prior to the LAN being reset. Pressing the *Setup* button will bring the operator to the *LAN Setup* screen where the operator can access and configure the LAN settings. To return to the *Home* screen, press the *Home* icon on the toolbar.

Figure 7.26: LAN Status screen

6.4.4 LAN Setup Screen

NOTICE

When manually configuring the IP or DNS settings, see your network administrator for the appropriate settings.

The *LAN Setup Screen*, shown in Fig. 7.27, allows the operator to select between dynamic configuration (DHCP/Auto IP and Auto DNS) and manual configuration. The *LAN Setup* screen has two rows of checkboxes, the first row allows the operator to choose between a dynamically assigned IP address and a manually entered IP address, while the second row allows the operator to choose between Auto DNS and manually configuring the DNS. To return to the *LAN Status* screen, press the *Back* button.

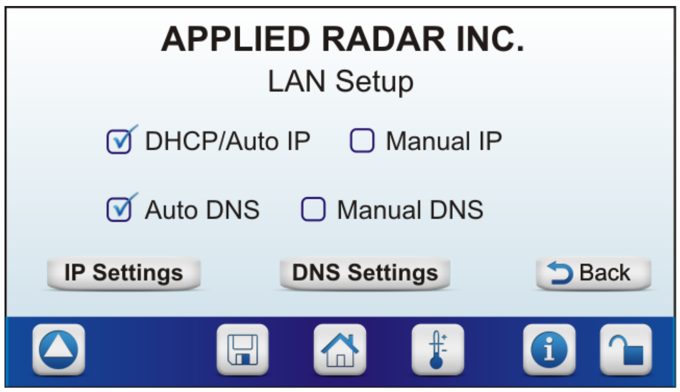


Figure 7.27: LAN Setup screen

To manually configure the IP settings, the operator should select the *Manual IP* checkbox and then press the *IP Settings* button, which will take the operator to the *IP Settings* screen, shown in Fig. 7.28. From this screen, the operator can enter the desired IP address, Subnet Mask, and Gateway. Once all entries have been made, press the *Back* button to return to the *LAN Setup* screen.

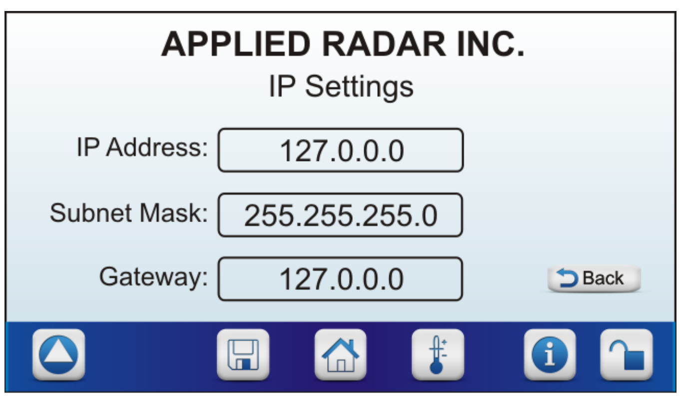


Figure 7.28: IP Settings screen

To manually configure the DNS settings, the operator should select the *Manual DNS* checkbox and then press the *DNS Settings* button, which will take the operator to the *DNS Settings* screen, shown in Fig. 7.29. From this screen, the operator can enter the desired primary and secondary DNS addresses. Once all entries have been made, press the *Back* button to return to the *LAN Setup* screen.

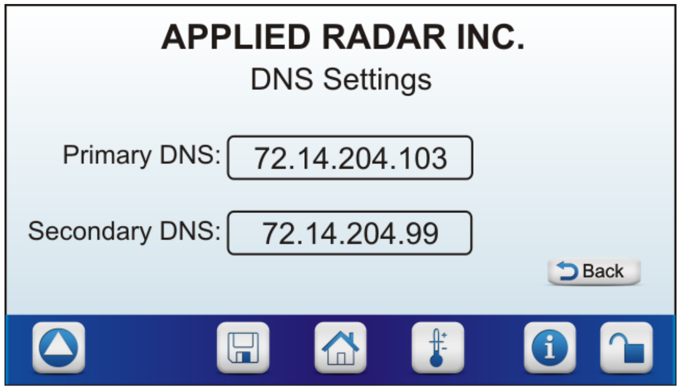


Figure 7.29: DNS Settings screen

6.4.5 Reference Configuration Screen

NOTICE

Only applies to systems with Option 002 or Option 100 installed

The *Reference Configuration* screen, shown in Fig. 7.30, allows the operator to choose between the internal 10 MHz reference source, an externally applied 10 MHz source, or an externally applied 1 pps (Option 100 required). The currently selected reference source is indicated by an orange LED. To select the desired reference source, press the corresponding radio button. To return to the *Home* screen, press the *Home* icon on the toolbar.

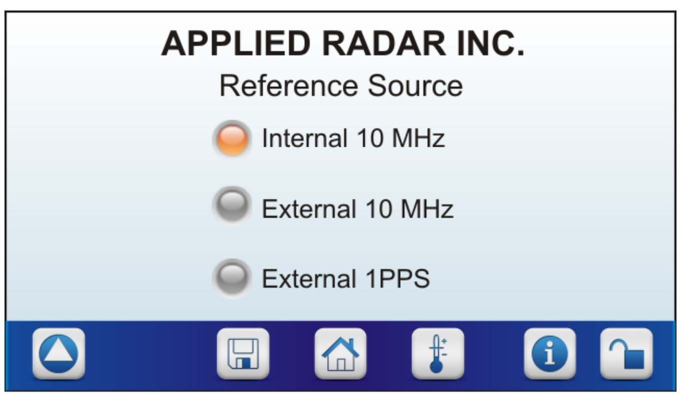


Figure 7.30: Reference Source Configuration screen

6.4.6 LCD Setup Menu

The *LCD Setup Menu*, shown in Fig. 7.31, allows the operator to access the *Backlight* screen, run the touch screen calibration, access the *RF Synthesizer ID* screen, and access the *Title* screen.

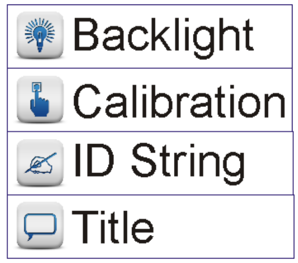


Figure 7.31: Configuration Menu

Table 7.6: Configuration Menu icons

Icon	Description
	Provides access to the Backlight screen
	Provides access to the touch screen calibration screen
	Provides access to the RF Synthesizer ID string screen
	Provides access to the Title screen

6.4.7 Backlight Intensity Screen

The *Backlight Intensity* screen allows the operator to adjust the brightness of the LCD display.

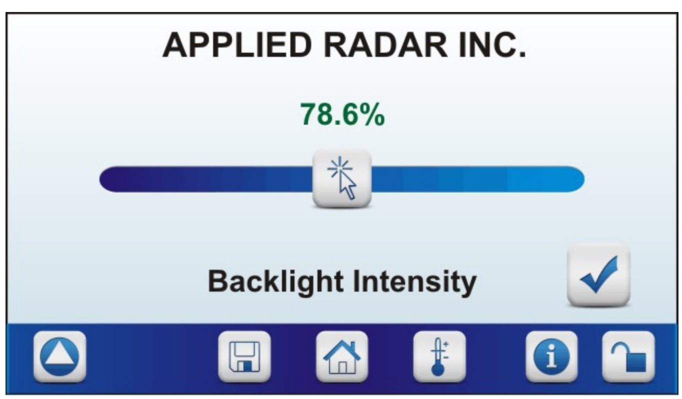


Figure 7.32: Backlight screen

Table 7.7: Backlight screen icons

Icon	Description
	Press to adjust the backlight intensity
	When this icon shows, slide you finger to adjust the backlight intensity
	Press to accept

6.4.8 Touchscreen Calibration

Selecting the *Touch Screen Calibration* icon launches the LCD's built in touch calibration routine. Follow the on screen instructions to complete the calibration.

6.4.9 RF Synthesizer ID String Screen

The *RF Synthesizer ID String* screen, shown in Fig. 7.33, allows the operator to change the 4 character on-screen display label for each of the RF synthesizers in the system. To change the display label, press the button corresponding to that synthesizer (the current label is displayed on the button). The *QWERTY Keyboard* screen will appear where the operator will be able to enter a new 4 character ID label.

Figure 7.33: RF Synthesizer ID String screen

6.4.10 Title String Screen

Pressing the *Title Screen* icon will take the operator to the *QWERTY Keyboard* screen where the new title can be entered. The title string is limited to 25 characters in length.

6.5 Save/Recall Screen

The *Save/Recall* screen, shown in Fig. 7.34, allows the operator to save or recall the current system settings to/from any of the 10 registers on the LO Synthesizer Distribution Unit. Register 0 is a special register, as it contains the default settings loaded upon power up. In addition to the Save and Recall functions, the operator may also *Preset* the instrument (which is the same as recalling from Register 0) or restore the factory defaults. When restoring the factory defaults, the default settings at the time of shipping are written into Register 0 and all other registers are cleared. Use this feature to attempt to recover from a system malfunction.

To save or recall from a register, press the register in the table on the right side of the screen and then either press the *Save* or *Recall* button. If a register has settings stored in it, an asterisks (*) will appear next to the register number. When saving to a register which already contains saved settings, the user will be prompted to overwrite the register. When recalling from a register or restoring the factory defaults, the user will be prompted to confirm the action before the requested action is executed.

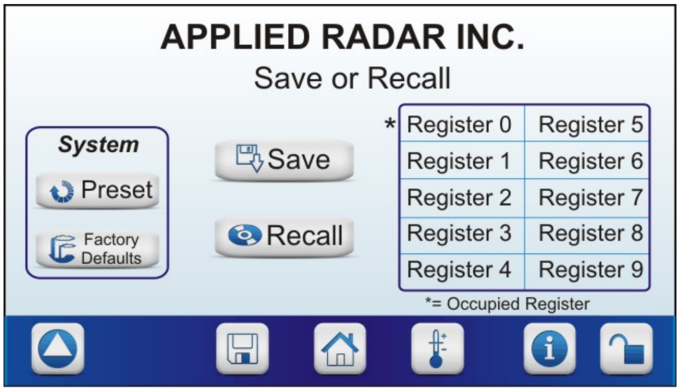


Figure 7.34: The Save\Recall Screen

Table 7.8: Save/Recall icons

Icon	Description
	Recalls settings from the selected register
	Saves settings to the selected register
	Presets the LO Synthesizer Distribution Unit
	Restores the factory defaults

6.6 Temperature Screen

The *Temperature* screen, shown in Fig. 7.35, displays the maximum temperature of up to four connected RF synthesizers as well as the overall maximum temperature reading of the LO Synthesizer Distribution Unit. All temperature readings are displayed in °C .

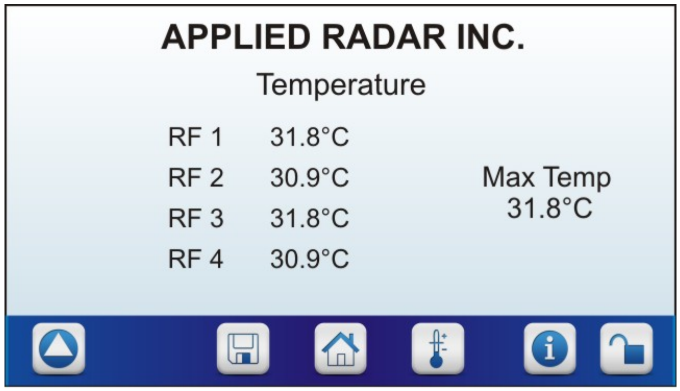


Figure 7.35: The Temperature Screen

6.7 System Information Screen

The *System Information* screen, shown in Fig. 7.36, displays the serial number, installed options, and firmware version of the LO Synthesizer Distribution Unit. The product number, serial number, and firmware version of each of the RF synthesizers is also displayed.

Figure 7.36: The Information Screen

NOTICE

The units for the frequency are displayed as Gz rather than the conventional GHz. This is due to internal string size constraints in the LCD module

.

6.8 Synthesizer Control Panel Screen

The *Synthesizer Control Panel* screen is accessed by pressing the corresponding synthesizer button on the *Home* screen. From the *Synthesizer Control Panel* screen, the user can select the operating mode (*Integer* or *Fractional*), set the output frequency, and set the reference divider value. The frequency of the synthesizer is displayed at the bottom of the screen.

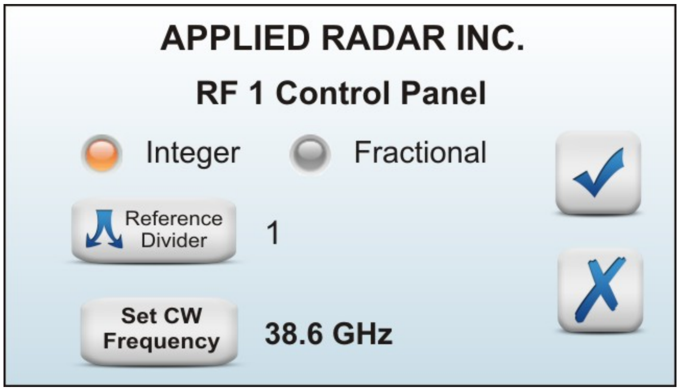
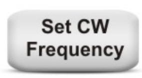


Figure 7.37: The Synthesizer Control Panel Screen

Table 7.9: Synthesizer Control Panel icons

Icon	Description
	Press to enter the reference divider value
	Press to enter the CW frequency
	Press to accept
	Press to cancel
	Indicated operating mode is active
	Indicated operating mode is inactive

In order for any of the changes made in the *Synthesizer Control Panel* to take effect, the user must press the *Accept* button. To discard any changes made, press the *Cancel* button. The operator will be prompted to verify that they want to discard the changes.

6.9 Keypad

For entering numeric data, the LCD will take you to the Keypad screen, as shown in Fig. 7.38. Enter the desired number by pressing the numeric keys. To accept the entry, press the *Accept* icon. To cancel the entry without saving the changes, press the *Cancel* icon. If a key is pressed in error, use the *Back Arrow* icon.

NOTICE

When you press the *Accept* icon, the entry is sent to the ECU for validation. If the entered value is deemed invalid by the ECU, the LCD will return to the Keypad screen where another numeric value can be entered.

Figure 7.38: The numeric Keypad

Table 7.10: Keypad icons

Icon	Description
	Press to erase the last character entered
	Press to accept
	Press to cancel
	Press to clear entry

6.10 QWERTY Keyboard

For entering alphanumeric data, the LCD will take you to the QWERTY Keyboard screen, as shown in Fig. 7.39. Enter the desired string. To accept the entry, press the *Accept* icon. To cancel the entry without saving the changes, press the *Cancel* icon. If a key is pressed in error, use the *Back Arrow* icon.

NOTICE

The text displayed on the LCD screen is always displayed in uppercase letters. As such, all text can only be entered as a combination of numeric values, uppercase letters and the symbols \ . : -

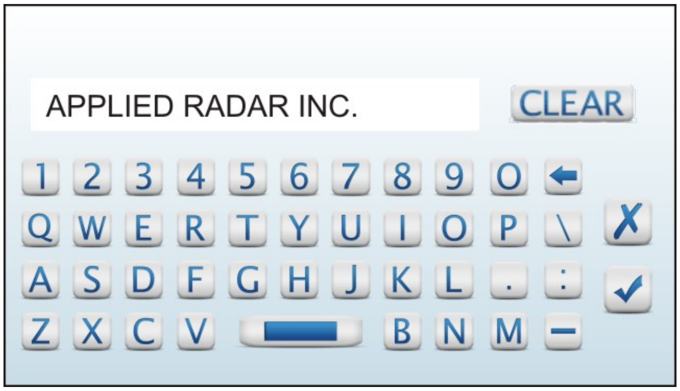


Figure 7.39: The QWERTY Keyboard

Table 7.11: Keypad icons

Icon	Description
	Press to erase the last character entered
	Press to accept
	Press to cancel

8
AR1002 Single Channel Upconverter

In This Chapter

1. Overview

The AR1002 Single Channel Upconverter is part of Applied Radar's 19-inch rack BlueBox™ product line. The AR1002 measures 2U in height and 17.5 inches in depth. The AR1002 is a single channel upconverter which accepts an IF frequency between 875 MHz and 1375 MHz and outputs an RF frequency between 7 GHz and 12 GHz, depending on the LO1 frequency applied. The AR1002 utilizes a dual stage upconversion and is capable of upconverting up to 500 MHz of IF bandwidth at one time. A block diagram of the AR1002 is shown in Fig. 8.1. A bandpass filter has been added to the output of the second upconverter stage to suppress spurious signals. The AR1002 is capable of outputting an RF signal between 2 GHz and 18 GHz and it's usable output frequency range is only limited by the final bandpass filter. A typical output gain versus offset frequency from the carrier for a range of output frequencies is shown in Fig. 8.2.

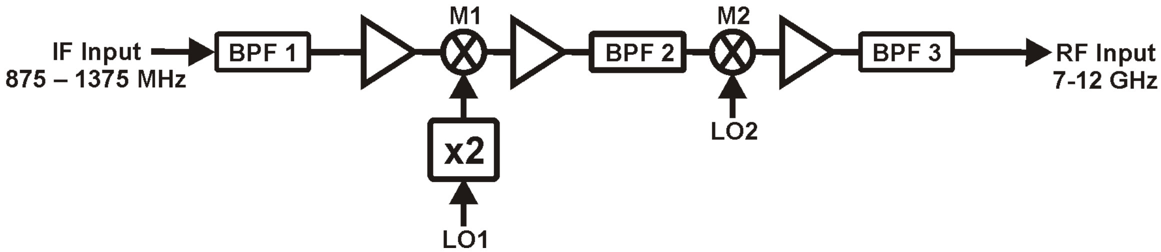


Figure 8.1: AR1002 Single Channel Upconverter block diagram

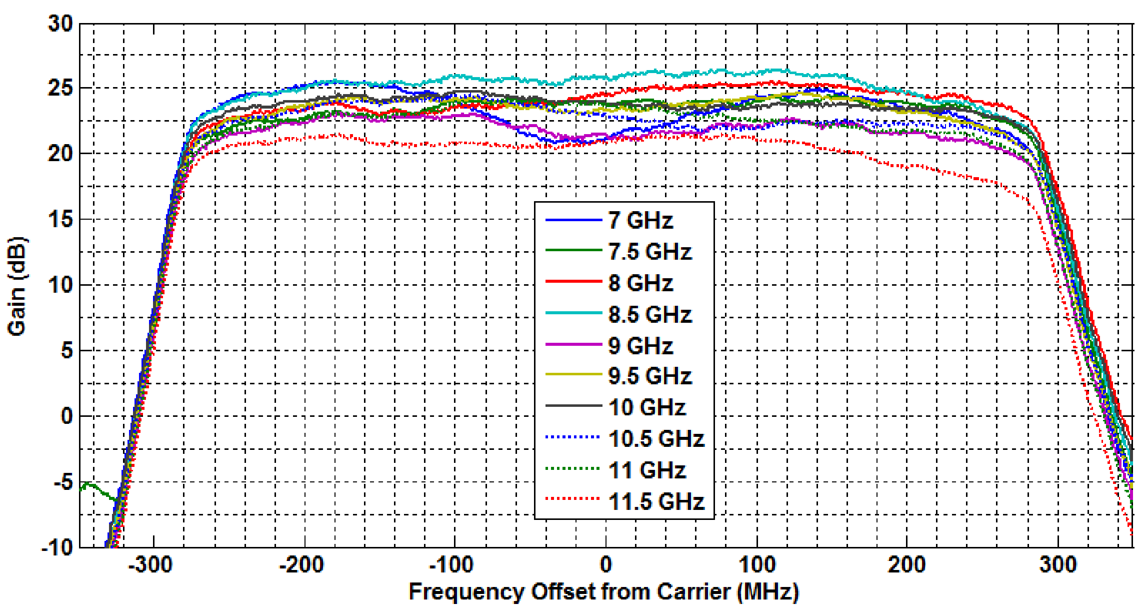


Figure 8.2: Typical AR1002 Single Channel Upconverter output gain as a function of output frequency.

2. Front Panel

A typical representation of the AR1002 Single Channel Upconverter front panel is shown in Fig. 8.3.

Figure 8.3: AR1002 Single Channel Upconverter front panel

No.	Part	Functions
1	"Dog Ears"	For mounting to a 19-inch rack
2	Handle	Handle to assist in removal of unit from a 19-inch rack
3	Logo	Applied Radar, Inc. Logo
4	LED	Power indicator
5	Power Switch	Turns On/Off the AR1002
6	LO1	LO1 input, SMA connector
7	LO2	LO2 input, Super SMA connector
8	IF in	IF input, SMA connector
9	RF out	RF output, SMA connector

Part II

Applied Radar Open Source Architecture

9
AROSA Messages

In This Chapter

1. Introduction

The implementation of the AR1012 SWORD™ DREX server is derived from the Radar Open Systems Architecture (ROSA) model developed by MIT-LL (described in Chapter 10). The ROSA model decomposes the radar-processing-control architecture into individual loosely coupled systems[1]. These subsytems communicate to the main computer through the use of a high-level control message based schema. The original MIT/LL ROSA structure was developed with Ballistic Missile Defense (BMD) and tracking radars as the end use product. The AR1012 SWORD™ DREX has been designed to be a general purpose Digital Receiver EXciter and Radar. As such, the ROSA structure does not easily lend itself to all modes of operation of the AR1012. In order to give complete flexibility in regards to the transmitted waveforms, Applied Radar has developed a supplemental message architecture, the AROSA which is an Open Systems Architecture (OSA) based around the MIT-LL ROSA. The AR1012 maintains its comparability with the ROSA structure without access to the advanced features and waveform sequences afforded by the ARI AROSA message structure.

2. ARI Timing Control Messages

The ARI_TCM message format allows the user to easily modify AR1012 SWORD™ DREX waveform parameters while taking advantage of Applied Radar's independent multi-channel transmission capabilities. It is structured such that multiple coherent pulse groups (CPGs), each with its own number of pulses and pulse repetition interval (PRI), can be queued internally on the server. Inside of a CPG, the user can also specify the waveform output on each of 4 channels. As a result, one can queue a near unlimited number of pulses on the server for transmission, reception, and client-side analysis. The ARI Timing Control Message structure is shown in Table 9.1.

Table 9.1: ARI_TCM Message Structure

Var Name	Description	Location	Data Type	Size (Bytes)	Units	Type	Value
Applied Radar Timing Control Message (ARI_TCM) Header							
msg_name	ASCII, null-terminated message name	ATM Header	char[4]	4	N/A	MSG-ID	'A"T"M"\0'
atmnum	ARI TCM sequential timing message index	ATM Header	unsigned int32	4	index	Global index	ATM Index
txstart	Transmit time of first CPG described in message	ATM Header	double	8	sec	UTC SSM	Abs. time
rxoffset	Sampling time offset	ATM Header	double	8	sec	Time delta	Rel. time
dwellPeriod	Time in ms between CPG transmission	ATM Header	double	8	sec	Time delta	Rel. time
ARI_TCM Header Size				32	bytes		
Applied Radar Timing Control Message (ARI_TCM) Timing Interval Data Array							
pri	Pulse repetition interval (PRI) for a specific CPG	ARI TCM Data	double	8	msec	Time delta	Time between pulses
num	Number of pulses in the CPG	ARI TCM Data	unsigned int32	4	count	Num. pulses	Integer value ≥ 0
wvfm	Waveform type index for a specific pulse group	ARI TCM Data	unsigned int32[4]	16	index	Code	WF Code
ARI_TCM Timing Interval Data Array				28	bytes		
Max Entries				128	bytes		
Max Size				3584	bytes		
Max Total ARI_TCM Size				**3616**	**bytes**		

typedef struct { uint8_t msg_name[4]; uint32_t atmnum; uint32_t cpg_total; double txstart; double rxoffset; double dwellPeriod; } ARI_TCM_Header_t;	The first structure is defined as the ARI_TCM Header. It contains all static information for an ARI_TCM message. The **cpg_total** variable refers to the number of used entries in the ARI_TCM_Data_t structure. **txstart** refers to the initial start time for waveform transmission. For messages with multiple CPGs, transmission start time for additional groups is calculated based on the total transmission time of the preceding CPGs and the **dwellPeriod**. The **dwellPeriod** is constant across all CPGs within an ARI_TCM message. **rxoffset** specifies delay time from transmission to reception for all pulses within the ARI_TCM message. This allows the user to shift the ADC sampling window in time.
typedef struct { double pri; uint32_t num; uint32_t wvfm[4]; } ARI_TCM_Data_t;	The ARI_TCM_Data_t structure is an array containing the timing interval and waveform information for each CPG. Using the **pri** and **num** variables, as well as the **txstart** and **dwellPeriod** variables from the header, the DREX calculates the transmit and receive time for each pulse, programming the timing information into the FPGA. **txstart** and **dwellPeriod** only affect the start time for a particular ARI_TCM_Data_t entry.
typedef struct { ARI_TCM_Header_t hdr; ARI_TCM_Data_t ti[MAX_PULSE_GROUP]; } ARI_TCM_Msg_t;	The ARI_TCM_Msg_t structure is simply the inclusion of both the ARI_TCM_Header and ARI_TCM_Data_t structures. In each ARI_TCM_Msg_t there is one header entry and up to 128 timing interval entries.

2.1 Examples

The following scenarios demonstrate the ARI TCM structure.

Scenario 1

- Starting at 560.11 seconds, output 50 pulses separated at a PRI of 100 μs.
- The system is in digital loopback (DAC straight to ADC).
- Output waveform code 1150 on channels 1 and 3, and waveform code 1151 on channels 2 and 4.

Table 9.2: ARI_TCM Structure for Scenario 1

ARI TCM Header	

msg_name[4] = "ATM";
atmnum = 1;
cpg_total = 1;
txstart = 560.11;
rxoffset = 0;
dwellPeriod = 0;
	The message name will always be "ATM". The atmnum is set to 1, although it could be any number, as it is user defined and not used in timing calculation.
	The cpg_total is 1, since there are 50 pulses at a single PRI.
	The txstart is the time at which the first of 50 pulses will be transmitted.
	Since the system is in digital loopback, no rxoffset is necessary.
	With a single CPG, the dwell period is unnecessary. The value is ignored.

ARI TCM Timing Interval Data	
Entry 1	

pri = 0.100;
num = 50;
wvfm[0] = 1150;
wvfm[1] = 1151;
wvfm[2] = 1150;
wvfm[3] = 1151;
	The PRI is set to 100us.
	The number of pulses is set to 50.
	In the array, numbering starts at 0. Therefore then channel number that the wvfm array refers to is actually the index + 1.

Entries 2 - 128	
NULL	Any data inside of these entries is ignored because the cpg_total variable in the header is set to 1.

Code equivalent (loosley based on C/C++, but not correct syntax)

```
typedef struct
{
   uint8_t  msg_name[4];
```

```
   uint32_t atmnum;
   uint32_t cpg_total;
   double   txstart;
   double   rxoffset;
   double   dwellPeriod;
} ARI_TCM_Header_t;


typedef struct
{
  double   pri;
  uint32_t num;
  uint32_t wvfm[4];
} ARI_TCM_Data_t;

typedef struct
{
  ARI_TCM_Header_t hdr;
  ARI_TCM_Data_t ti[MAX_PULSE_GROUP];
} ARI_TCM_Msg_t;

ARI_TCM_Msg_t ariMsg;

ariMsg.hdr.msg_name = "ATM"
ariMsg.hdr.atmnum = 1
ariMsg.hdr.cpg_total = 1;
ariMsg.hdr.txstart = 560.11;
ariMsg.hdr.rxoffset = 0;
ariMsg.hdr.dwellPeriod = 0;

ariMsg.ti[0].pri = 0.100;
ariMsg.ti[0].num = 50;
ariMsg.ti[0].wvfm[0] = 1150;
ariMsg.ti[0].wvfm[1] = 1151;
ariMsg.ti[0].wvfm[2] = 1150;
ariMsg.ti[0].wvfm[3] = 1151;
```

Scenario 2

- Starting at 32560.950 seconds, output 100 pulses separated at a PRI of 200us.
- Wait 100ms after the second pulse group.
- Output 20 pulses at a PRI of 150us.
- Wait 100ms after the first pulse group.
- Output 500 pulses at a PRI of 80us.
- Start the sampling window 20us after transmission time for each pulse.
- Output waveform code 1150 on channel 1. Do not output a waveform on the other channels.

Table 9.3: ARI_TCM Structure for Scenario 2

ARI TCM Header			

msg_name[4] = "ATM";
atmnum = 51;
cpg_total = 3;
txstart = 32560.950;
rxoffset = 20.0e-6;
dwellPeriod = 0.100;
		The message name will always be "ATM".
		
		The rxoffset is set to 20us. The ADC will be programmed to start its sample window 20us after each pulse is transmitted.
		The dwell period is set to 100ms between each CPG.	

ARI TCM Timing Interval Data			
Entry 1	Entry 2	Entry 3	Entries 4 - 128

pri = 0.200;
num = 100;
wvfm[0] = 1150;
wvfm[1] = 0;
wvfm[2] = 0;
wvfm[3] = 0;
	pri = 0.150;
	num = 20;
	wvfm[0] = 1150;
	wvfm[1] = 0;
	wvfm[2] = 0;
	wvfm[3] = 0;
		pri = 0.080;
		num = 500;
		wvfm[0] = 1150;
		wvfm[1] = 0;
		wvfm[2] = 0;
		wvfm[3] = 0;
			NULL

3. ARI Status Messages

The ARI status structure contains critical system information concerning the LSDU and Downconverter. It is a one-directional message, sent from the AR1012 to the client once every 5 seconds in the absence of any TCM related message or processing. If an ARI_TCM or TCM message is currently being processed, ARI status messages stop transmitting until all pulses are received, processed, and sent back to the client. The ARI Status Message structure is shown in Table 9.4.

Table 9.4: ARI Status Message Structure

Var Name	Description	Location	Data Type	Size (Bytes)	Units	Type	Value
Applied Radar Status Message (ARI_Status)							
msg_name	ASCII, null-terminated message name	ARI Status	char[4]	4	N/A	MSG-ID	'A"R"S"\0'
Applied Radar Status Message, RF Status							
lo1Lock	Lock status of LO1	ARI RF Status	unsigned int8	1	num	bool	0 = unlock 1 = lock
lo2Lock	Lock status of LO2	ARI RF Status	unsigned int8	1	num	bool	0 = unlock 1 = lock
maxTemp	Maximum temperature inside the LSDU	ARI RF Status	double	8	°C	temp	Any
Applied Radar Status Message, RF Status Structure Size				10	bytes		
Applied Radar Status Message, Downconverter Status							
dcCurrent	Downconverter current readings	ARI D/C Status	double[17]	128	mA	current	Any
dcTemp	Downconverter temperature readings on each channel	ARI D/C Status	double[4]	24	°C	temp	Any
Applied Radar Status Message, Downconverter Status				152	bytes		
Total Applied Radar Status Message Size				**166**	**bytes**		

typedef struct { uint8_t lo1Lock; uint8_t lo2lock; double maxTemp; } RF_Status_t;	The ARI_TCM_Data_t structure is an array containing the timing interval and waveform information for each CPG. Using the **pri** and **num** variables, as well as the **txstart** and **dwellPeriod** variables from the header, the DREX calculates the transmit and receive time for each pulse, programming the timing information into the FPGA. **txstart** and **dwellPeriod** only affect the start time for a particular ARI_TCM_Data_t entry.
typedef struct { double dcCurrent[17]; double dcTemp[4]; } DC_Status_t;	The DC_Status_t structure contains critical status information concerning the AR1004 RF Downconverter. Downconverter current and temperature sensor readings are represented in double arrays, with normal operating conditions for both variables shown in Table 6.2.
typedef struct { uint8_t msg_name[4]; RF_Status_t rf; DC_Status_t dc; } ARI_Status_t;	The ARI_TCM_Msg_t structure is simply the inclusion of both the ARI_TCM_Header and ARI_TCM_Data_t structures. In each ARI_TCM_Msg_t there is one header entry and up to 128 timing interval entries

4. ARI Command Messages

The ARI command structure serves as a bi-directional communication link between the AR1012 and the client, providing additional control and feedback from Applied Radar devices. Messages will always originate from the client to the AR1012, with the AR1012 performing the action specified in the command message and responding to the client appropriately. Messages and their respective arguments are outlined in Chapter 11. The ARI Command Message structure is shown in Table 9.5.

Table 9.5: ARI Command Message Structure

Var Name	Description	Location	Data Type	Size (Bytes)	Units	Type	Value
Applied Radar Command Message							
msg_name	ASCII, null-terminated message name	ARI Cmd	char[4]	4	N/A	Msg-ID	'A"R"C"\0'
cmd_name	ASCII, null-terminated command name	ARI Cmd	char[30]	30	N/A	Msg-Cmd	String
arg	Message argument	ARI Cmd	double[4]	8	N/A	num	Any
Total Applied Radar Command Message Size				**42**	**bytes**		

typedef struct { uint8_t msg_name[4]; uint8_t cmd_name[30]; double arg[4]; } ARI_Command_t;	The ARI_Command_t structure is will always contain information in the **msg_name** and **cmd_name** variables. The **arg** from client-to-server will always be empty, but from server-to-client, it will contain either the requested information or a success (1) / fail (-1) variable in **arg[0]**.

4.1 Examples

The following scenarios demonstrate the ARI_TCM structure.

Scenario 1

- Turn the RF Downconverter Off

Table 9.6: ARI Command Structure for Scenario 1

Client - to - Server: Send request	

msg_name[4] = "ARC";
cmd_name[30] = "SYST:DOWN:POWEROFF"
arg[0] = 0;
arg[1] = 0;
arg[2] = 0;
arg[3] = 0;
	The client sends the ASCII **cmd_name** string as specified in Chapter 11. The **arg** array is irrelevant because the command has no argument, and is therefore packed with 0s.

Server - to - Client: Respond to request	

msg_name[4] = "ARC";
cmd_name[30] = "SYST:DOWN:POWEROFF"
arg[0] = 1;
arg[1] = 0;
arg[2] = 0;
arg[3] = 0;
	The server responds to the client's request with the same **msg_name** and **cmd_name**. The **arg[0]** variable is packed with 1, meaning that the command was a success and the Downconverter module is now powered off. If it failed, the **arg[0]** value would have been -1.

Scenario 2

- Get the actual frequency of LO2

Table 9.7: ARI Command Structure for Scenario 2

Client - to - Server: Send request	

msg_name[4] = "ARC";
cmd_name[30] = "SYST:RF:getLO2"
arg[0] = 0;
arg[1] = 0;
arg[2] = 0;
arg[3] = 0;
	The client sends the ASCII **cmd_name** string as specified in Chapter 11. The **arg** array is irrelevant because the command has no argument, and is therefore packed with 0s.

Server - to - Client: Respond to request	

msg_name[4] = "ARC";
cmd_name[30] = "SYST:RF:getLO2"
arg[0] = 22.755;
arg[1] = 0;
arg[2] = 0;
arg[3] = 0;
	The server responds to the client's request with the same **msg_name** and **cmd_name**. The **arg[0]** variable is packed with 22.755 (GHz).

Scenario 3

- Get the attenuation of all four channels of the Rf Downconverter

Table 9.8: ARI Command Structure for Scenario 3

Client - to - Server: Send request	

msg_name[4] = "ARC";
cmd_name[30] = "SYST:DOWN:getATTEN:0"
arg[0] = 0;
arg[1] = 0;
arg[2] = 0;
arg[3] = 0;
	The client sends the ASCII **cmd_name** string as specified in Chapter 11. The **arg** array is irrelevant because the command has no argument, and is therefore packed with 0s.

Server - to - Client: Respond to request	

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msg_name[4] = "ARC";
cmd_name[30] = "SYST:DOWN:getATTEN:0"
arg[0] = 0;
arg[1] = 5;
arg[2] = 3;
arg[3] = 8;
	The server responds to the client's request with the same **msg_name** and **cmd_name**. As described in the Chapter 11 Section 6.3, **arg[0]** through **arg[3]** correspond to different attenuation states on channels 1 through 4. This is one of the few requests that actually returns values on **arg[1]** through **arg[3]**.

10
MIT-LL ROSA Messages

In This Chapter

1. Introduction

The implementation of the AR1012 SWORD™ DREX server is backwards compatible with the Radar Open Systems Architecture (ROSA) model developed by MIT-LL. The ROSA model decomposes the radar-processing-control architecture into individual loosely coupled systems[1]. These subsytems communicate to the main computer through the use of a high-level control message based schema.

2. ROSA Socket Messages

The AR1012 SWORD™ DREX supports UDP sockets in compliance with ROSA. The messages supported are described in Table 10.1.

Table 10.1: DREX Socket Message Types

Message Type	Description
TCM	ROSA Transmit Control Message (TCM) –initiates a pulse transmission and capture
BCM	ROSA Beam Control Message (BCM) –these are presently ignored
RES	ROSA captured sample result Message results from TCM
WF	Waveform message, enables downloading of WF.cnf file to be used for SWORD™ DREX waveform generation. *Note: In ROSA, the mechanism for distribution of this file is not explicitly specified. Use of this message enables custom waveforms to be downloaded. All waveforms are referenced off from the WF waveform index. WFR Waveform Request message, causes the AR1006 system to send the current WF.cnf file to the requestor using a WF message.*

2.1 TCM Messages

The ROSA TCM message is converted into a AR1006 GEN message internally and inserted into the DREX waveform generator/capture queue. The DREX state machine then generates the waveform and captures the samples requested, and returns a RES message.

Table 10.2: ROSA TCM binary message (courtesy MIT-LL ROSA simulator manual).

Var Name	Description	Location	Data Type	Size (Bytes)	Units	Type	Value
TCM Header							
MSG_NAME	ASCII, null-terminated message name	TCM Header	char[4]	4	N/A	Msg-ID	'T"C"M"\0'
MSG_SIZE	Size of TCM Message	TCM Header	unsigned long	4	bytes	Calculation	Msg Size
MSG_TIME	Message composition time	TCM Header	double	8	sec	Time Format 1	Abs. Time
TCMNUM	Sequential timing message index	TCM Header	unsigned long	4	indx	Global Index	TCM-Index
UCMNUM	Associated UCM index	TCM Header	unsigned long	4	indx	Global Index	UCM-Index
CPIBEG	CPI start strobe time	TCM Header	double	8	sec	Time Format 1	Abs. Time

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Var Name	Description	Location	Data Type	Size (Bytes)	Units	Type	Value
CPILEN	Length of CPI	TCM Header	double	8	sec	Time Format 1	Abs. Time
TCM Header Size				40	bytes		
State Vector Table Header							
ST1_TOM	State vector table 1 time stamp	SVT Header	double	8	sec	Time Format 1	Abs. Time
ST1_TYPE	Table type code	SVT Header	unsigned long	4	code	Unique Code 1	1
ST1_NUM	Count of valid table entries	SVT Header	unsigned long	4	cnt	Num. Entries	1-8
SVT Header Size				16	bytes		
State Vector Table							
SV1_UCMIDX_	Associated UCM Index	State Vector	unsigned long	4	indx	Global Index	UCMNUM
SV1_IDX_	Index into local state vector table	State Vector	unsigned long	4	indx	Table Index	1-8
SV1_TOV_	Time of validity for state vector 1 values	State Vector	double	8	sec	Time Format 1	Abs. Time
SV1_RNG_	Target range at SV1_TOV_1	State Vector	single	4	m	State Vector	>=0
SV1_RDOT_	Target range rate at SV1_TOV_1	State Vector	single	4	m/sec	State Vector	Any
SVT Vector Size				24	bytes		
Max Entries				8	bytes		
Max Size				192	bytes		
Timing Interval Table Header							
IT1_TOM	Timing interval table 1 time of message	TIT Header	double	8	sec	Time Format 1	Abs. Time
IT1_TYPE	Table type code	TIT Header	unsigned long	4	code	Unique Code 1	2
IT1_NUM	Count of valid table entries	TIT Header	unsigned long	4	cnt	Num. Entries	2-16
TIT Header Size				16	bytes		
Timing Interval Table							
TI1_IDX_	Sequential timing interval index	Timing Inter.	unsigned long	4	indx	Table Index	1-16
TI1_SVIDX_	Associated local state vector index	Timing Inter.	unsigned long	4	indx	Table Index	SV1_IDX_
TI1_TXRX_	Timing interval type code	Timing Inter.	unsigned long	4	code	TX/RX	1,101
TI1_WVFRM_	Waveform table index	Timing Inter.	unsigned long	4	indx	Code	WF Code
TI1_STRT_	Timing interval 1 start time	Timing Inter.	double	8	time	Time Format 1	Abs. Time
TI1_DUR_	Timing interval 1 duration	Timing Inter.	double	8	sec	Timing Format 2	Rel. Time
TI1_TOT_	Timing interval 1 time on target	Timing Inter.	double	8	sec	Time Format 1	Abs. Time
Timing Inter. Size				40	bytes		
Max Entries				16	bytes		
Max Size				640	bytes		
Max Total TCM Size				904	bytes		

Note 1:
Time Format 1: Seconds since midnight UTC. Nanosecond precision (at least 14 sig-figs required).
Time Format 2: Relative time delta in seconds. Nanosecond precision.
Note 2: All floating point numbers follow IEEE 754-1985 standards.
Note 3: This is a variable sized message, the entries with the word Table can be different sizes.

2.2 BCM Messages

The Beam Control Message is designed to steer the antenna beam to point at the target, whether the beam is mechanically or electronically steered. *This message is presently accepted from the ROSA Simulator, but no action/command is performed or executed.* Eventually, this message will drive a 3rd party or ARI transmit antenna or beamformer to the appropriate azimuth/elevation at the appropriate time and beamwidth.

Table 10.3: ROSA BCM binary message (courtesy MIT-LL ROSA simulator manual).

Var Name	Description	Location	Data Type	Size (Bytes)	Units	Type	Value
			BCM Header				
MSG_NAME	ASCII, null-terminated message name	BCM Header	char[4]	4	N/A	Msg-ID	'B"C"M"\0'
MSG_SIZE	Size of BCM Message	BCM Header	unsigned long	4	bytes	Calculation	Msg Size
MSG_TIME	Message composition time	BCM Header	double	8	sec	Time Format 1	Abs. Time
BCMNUM	Sequential beam message index	BCM Header	unsigned long	4	indx	Global Index	BCM-Index
TCMNUM	Associated TCM index	BCM Header	unsigned long	4	indx	Global Index	TCMNUM
UCMNUM	Associated UCM index	BCM Header	unsigned long	4	indx	Global Index	UCMNUM
SPARE	Data alignment spare	BCM Header	unsigned long	4	N/A	N/A	Null
	BCM Header Size			32	bytes		
			Beam Vector Table Header				
BT1_TOM	Beam table 1 time stamp	BT Header	double	8	sec	Time Format 1	Abs. Time
BT1_TYPE	Table type code	BT Header	unsigned long	4	code	Unique Code 1	3
BT1_NUM	Count of valid table entries	BT Header	unsigned long	4	cnt	Num. Entries	1-8
	BT Header Size			16	bytes		
			Beam Vector Table				
BV1_DAZ_1	Target azimuth at SV1_TOV_1	Beam Vector	single	4	rad	State Vector	$-\pi/2$ to $\pi/2$
BV1_DEL_1	Target elevation at SV1_TOV_1	Beam Vector	single	4	rad	State Vector	$-\pi/2$ to $\pi/2$
BV1_AZRT_1	Target azimuth rate at SV1_TOV_1	Beam Vector	single	4	rad/sec	State Vector	Any
BV1_ELRT_1	Target elevation rate at SV1_TOV_1	Beam Vector	single	4	rad/sec	State Vector	Any
	Beam Vector Size			16	bytes		
	Max Entries			8	bytes		
	Max Size			128	bytes		
			Beam Command Table Header				
BC1_TOM	Beam command table 1 time of message	BCT Header	double	8	sec	Time Format 1	Abs. Time
BC1_TYPE	Table type code	BCT Header	unsigned long	4	code	Unique Code 1	4
BC1_NUM	Count of valid table entries	BCT Header	unsigned long	4	cnt	Num. Entries	2-16
	BCT Header Size			16	bytes		
			Beam Command Table				
BA1_TYPE_1	Beam action type code	Beam Cont.	unsigned long	4	code	TX/RX	1,101
BA1_TIDX_1	Associated timing interval index	Beam Cont.	unsigned long	4	indx	Table Index	TI1_IDX_
BA1_AZTPR_1	Azimuth taper code	Beam Cont.	unsigned long	4	code	Code	uniform/taper
BA1_ELTPR_1	Elevation taper code	Beam Cont.	unsigned long	4	code	Code	uniform/taper

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Var Name	Description	Location	Data Type	Size (Bytes)	Units	Type	Value
BA1_AZOFF_1	Azimuth angular offset	Beam Cont.	single	4	rad	Offset	Any
BA1_ELOFF_1	Elevation angular offset	Beam Cont.	single	4	rad	Offset	Any
BA1_DLY_1	Delay offset	Beam Cont.	single	4	sec	Offset	Any
BA1_PHS_1	Phase offset	Beam Cont.	single	4	rad	Offset	Any
BA1_ATTEN_1	Attenuation offset/gain control	Beam Cont.	single	4	dB	Gain	Any
BA1_POL_1	Polarization code	Beam Cont.	unsigned long	4	code	Code	Any
Beam Control Size				40	bytes		
Max Entries				16	bytes		
Max Size				640	bytes		
Max Total BCM Size				832	bytes		

Note: This is a variable sized message, the entries with the word Table can be different sizes

2.3 RES Messages

The SWORD™ DREX RES message is used to return samples from the TCM request or GEN request. The RES message is not specified by ROSA, but rather is vendor defined. ARI chose this specific format to be compliant with the minimum input requirements of ROSA so that the samples could be properly interpreted by the ROSA system. The TCM header, state vector table (SVT) and timing interval table (TIT) headers from the original TCM message are repeated so that the ROSA system can properly associate the RES message with the original TCM message.

Table 10.4: ROSA RES binary message (vendor specific, ARI originated).

TCM Header (same as TCM Message)							
SVT Header (same as TCM Message)							
TIT Header (same as TCM Message)							
Var Name	**Description**	**Location**	**Data Type**	**Size (Bytes)**	**Units**	**Type**	**Value**
type	type: 1 = 8-bit data real 2 = 16 bit data real	Pulse_Data	unsigned long	4	Indx	Enum	0 = 8-bit 1 = 16-bit
numsamples	Number of samples	Pulse_Data	unsigned long	4	Samples	Integer count	1 to 65447 for 8-bit, 1 to 323723 for 16-bit UDP, TCP/IP 1 Msamples
samplerate	Sampling rate (Fs) in samples/sec, e.g., 1.5 Gsamples/sec	Pulse_Data	double	8	Hz	samples/sec	100 MSamples/sec to 5 Gsamples/sec
data	Array of samples, variable length	Pulse_Data	uchar[]	1*# of samples (8-bit) or 2*# (16-bit)	ADC Int	Returned Samples	-128 to 127 (8-bit), -32768 to 32767 (16-bit)

Note: The TCM header is given a type field with 'RES' filled in.

2.4 WFC Waveform Table Message

When either a TCM or GEN message is executed by the DREX, they reference a waveform (WF) index, which is an index into the currently loaded WF.cnf file. This file specifies all of the parameters required to generate a ROSA or ROSA-compatible pulse waveform. The WF.cnf format is described in section 2.4.1.

Note: If the WFC message is not sent, the DREX system will default to using /opt/ari/cfg/wf.cnf as the default waveform file.

Table 10.5: WFC binary message (ARI originated).

Var Name	Description	Location	Data Type	Size (Bytes)	Units	Type	Value
type	type of message, ASCII null terminated string	WFC_Data	char[4]	4	chars	'WFC'	'WFC'

2.4.1 WF.cnf Format

```
typedef struct
{
  char   wf_name[40];              /* waveform name */
  int    wf_code;                  /* waveform code */
  char   wf_type[40];              /* waveform type: CW,LFM,LFMB,PCW,PSK */
  int    narrow;                   /* narrow 0=Off,1=On  */
  int    wide;                     /* wide   0=Off,1=On  */
  char   freq_band[8];             /* frequency band: S,X,K */
  char   waveband[8];              /* waveband */
  char   weighting[40];            /* weighting used to generate waveform: Hamming */
  double freq_center;              /* center frequency in Hz */
  double freq_min;                 /* minimum frequency in Hz  */
  double freq_max;                 /* maximum frequency in Hz  */
  double pulse_width_tx;           /* pulse width tx in seconds */
  double pulse_width_rx;           /* pulse width rx in seconds */
  double pulse_bw;                 /* pulse bandwidth in Hz */

  /* post-processing parameters */
  char   samp_chans[40];           /* sample channels: PP1,OP,AZ,EL */
  char   dsp_filter[40];           /* DSP filter, THRU */
  char   dsp_type[40];             /* DSP type: COMPRESS, STRETCH */
  double dsp_output_bw;            /* DSP output BW in Hz */
  int    decim_ratio;              /* decimation ratio */
  char   corr_type[40];            /* corr type: REF_LO, REF_RAMP, means correction */
  int    discard_filter_edges;     /* discard filter edges 0=Off,1=On */
  int    num_signal_gates;         /* number of signal gates */
  int    oversample;               /* over sampling rate */
  double prf_min;                  /* PRF minimum in Hz */
  double prf_max;                  /* PRF maximum in Hz */
  double sim_tx_pwr;               /* simulated tx power (not dB) */
  int    enable_random;            /* enable random: 0=Off,1=On */
  int    priband;                  /* PRI band: 0 */
  double band_rec_window;          /* band rec window in seconds */
  double band_prf_min;             /* band minimum prf Hz */
  double band_prf_max;             /* band maximum prf Hz */
  int    band_num_ffts_dpcs;       /* band DPCs number of FFTs */
  int    band_fft_size_dpcs;       /* band DPCs FFT size */
```

```
  int    band_samps_per_ch;          /* band samples per channel */
  int    band_display_gates;         /* band display number of gates */
  int    band_display_gates_offset; /* band display gates offset */
  double band_scale;                 /* band scale factor */
} Waveform_t
```

11
Remote Commands

In This Chapter

1. Introduction

A set of remote commands for the AR1012 SWORD™ DREX has been developed, allowing the client software to interact, through the server software, with the system hardware. In addition to providing commands to safely power on and off the system, device specific commands are provided for the AR1004 RF Downconverter and the AR1001 LSDU. Through these device specific commands, the user can check the status of the device, turn on and off the device, and in some cases, set certain operating parameters of the device.

2. Command Syntax

A parameter enclosed in square brackets ([ ]) indicates an optional parameter.

NOTICE

All commands are case insensitive

---

3. System Commands

3.1 SYST:IP

The SYST:IP command provides the AR1012 server computer with a client IP address for server-to-client communication. Upon reception of a SYST:IP command, the server computer will reinitialize the UDP transmit socket and will send all status and response messages to the given client IP. In its current implementation, the AR1012 server computer will only send data to one client at a time. Whenever a new client sends a SYST:IP command to the AR1012 server computer, the server will immediately begin communication with the new client PC and cease communication with the previous.

The client IP and server transmit and receive ports are stored locally in a configuration file. Upon startup, the most recent UDP configuration will be loaded by default.

Command Syntax: **SYST:IP:<IPv4String>**

Parameters

None	
Default:	The most recent UDP configuration will be used

Returns: 1 if command executed successfully, -1 otherwise

Example:

1. SYST:IP:192.168.1.110 sets the client IP address to 192.168.1.110

4. Power Commands

4.1 SYST:PWRON

The SYST:PWRON command safely powers on the AR1004 Four Channel Downconverter and the AR1001 LSDU.

Command Syntax: **SYST:PWRON**

Parameters

None
Default: The default system power up state is powered off

Returns: 1 if command executed successfully, -1 otherwise

4.2 SYST:PWROFF

The SYST:PWROFF command safely powers off the AR1004 Four Channel Downconverter and the AR1001 LSDU.

Command Syntax: **SYST:PWROFF**

Parameters

None
Default: The default system power state is powered off

Returns: 1 if command executed successfully, -1 otherwise

5. RF Commands

5.1 SYST:RF:POWERON

The SYST:RF:POWERON command turns on LO1 and LO2.

Command Syntax: **SYST:RF:POWERON**

Parameters

None	
Default:	The default system power up state is LO1 and LO2 powered off

Returns: 1 if command executed successfully, -1 otherwise

5.2 SYST:RF:POWEROFF

The SYST:RF:POWEROFF command turns off LO1 and LO2.

Command Syntax: **SYST:RF:POWEROFF**

Parameters

None	
Default:	The default system power up state is LO1 and LO2 powered off

Returns: 1 if command executed successfully, -1 otherwise

5.3 SYST:RF:getLO1

The SYST:RF:getLO1 command returns the frequency of LO1 for the specified user in GHz.

Command Syntax: **SYST:RF:getLO1**

Parameters

None

Returns: LO1 frequency in GHz

5.4 SYST:RF:getLO2

The SYST:RF:getLO2 command returns the frequency of LO2 for the specified user in GHz.

Command Syntax: **SYST:RF:getLO2**

Parameters

None

Returns: LO2 frequency in GHz

6. Downconverter Commands

6.1 SYST:DOWN:POWERON

The SYST:DOWN:POWERON command powers on the AR1004 downconverter.

Command Syntax: **SYST:DOWN:POWERON**

Parameters

None	
Default:	The default system power up state is powered off

Returns: 1 if command executed successfully, -1 otherwise

6.2 SYST:DOWN:POWEROFF

The SYST:DOWN:POWEROFF command powers down the AR1004 downconverter.

Command Syntax: **SYST:DOWN:POWEROFF**

Parameters

None	
Default:	The default system power up state is powered off

Returns: 1 if command executed successfully, -1 otherwise

When executing this command, if LO1 and/or LO2 is on, the system will power off the LOs prior to powering off the AR1004.

6.3 SYST:DOWN:getATTEN

The SYST:DOWN:getATTEN command retrieves the current attenuation value for the specified channel in dB.

Command Syntax: **SYST:DOWN:getATTEN:*channel***

Parameters

channel:	Specifies the desired channel number (1-4). A channel value of 0 returns the attenuation for the specified module on all 4 channels.

Returns: Attenuation state of the specified channel

Attenuation state	Attenuation (dB)
0	0
1	1.8
2	3.6
3	5.4
4	7.2
5	9.0
6	10.8
7	12.6

Attenuation state	Attenuation (dB)
8	14.4
9	16.2
10	18.0
11	19.8
12	21.6
13	23.4
14	25.2
15	27.0

Multiple attenuation states, requested by setting *channel* to 0, shall be returned as a string of states separated by commas.

6.4 SYST:DOWN:setATTEN

The SYST:DOWN:setATTEN command sets the attenuation value of the specified channel.

Command Syntax: **SYST:DOWN:setATTEN:*channel*:*attenuation***

Parameters

channel:	Specifies the desired channel number (1-4). Multiple *channels* can be addressed by separating the channel numbers with a comma. When addressing multiple *channels*, separate the attenuation values with commas. If a single attenuation value is supplied, all channels being addressed will be set to that value. A *channel* value of 0 is equivalent to specifying 1,2,3,4 for the channel value
attenuation:	Desired attenuation state. When specifying multiple *channels*, the attenuation state shall be either in the form of a single value or a string of values separated by a comma. When specifying multiple attenuation states, a state must be supplied for every channel.

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Attenuation state	**Attenuation (dB)**	**Attenuation state**	**Attenuation (dB)**
0	0	8	14.4
1	1.8	9	16.2
2	3.6	10	18.0
3	5.4	11	19.8
4	7.2	12	21.6
5	9.0	13	23.4
6	10.8	14	25.2
7	12.6	15	27.0

Default: 0 dB

Returns: 1 if command executed successfully, -1 otherwise

Example:

1. SYST:DOWN:setATTEN:2:0 sets channel #2 attenuation to 0 dB
2. SYST:DOWN:setATTEN:2:6 sets channel #2 attenuation to 10.8 dB
3. SYST:DOWN:setATTEN:0:1 sets the attenuation of all channels to 1.8 dB
4. SYST:DOWN:setATTEN:1,2,3:0,4,6 sets channel #1 attenuation to 0 dB, channel #2 attenuation to 7.2 dB, channel #3 attenuation to 10.8 dB

Part III

Software

The AR1012 SWORD™ DREX software is divided into two components, the server and the client software. The server software resides on the VME Single Board Computer (SBC) for systems with Option 001 or on the Processing/Control computer for systems with Options 100 and 110. The server software is responsible for processing AROSA and ROSA messages received from the client computer, interacting with the hardware, and sending the received data to the client. The client software provides the Graphical User Interface (GUI) interface between the end user and the server computer. Any ROSA back end client can be used in place of the Applied Radar (ARI) supplied client software. When using client software other than the one supplied by ARI, the user must add the system specific messages for powering on and off the system and performing routine diagnostics on the hardware as well as support for the AROSA message schema in order to access the advanced featurs of the AR1012. ARI only provides support for the client software supplied with the AR1012.

NOTICE

When using a ROSA Client other than the ARI supplied Client, care must be taken to follow the proper initialization and shutdown procedures, as outlined in Chapter 11. Failure to do so may result in permanent damage to the AR1012 SWORD™ DREX.

12
Server Software

In This Chapter

1. Overview

The AR1012 server software resides on the server computer and is launched automatically when the system is powered on. The server computer runs Linux Fedora Version 8 for systems with Option 001 installed and Fedora Version 14 for systems with Option 100 installed.

The server software provides the interface between the client computer and the AR1012 hardware. The server software communicates with the client using the UDP protocol. The server computer interprets the AROSA and ROSA messages and communicates with the system hardware. The client software may either reside on a physically separate computer or may be installed on the server computer. When installed on the server computer, the client and server communicate through the local loopback port, 127.0.0.1.

The server software requires no end user interaction; however, a simple GUI window is included in order to provide visual feedback of the status of the AR1012. The server GUI also allows authorized service personnel to access diagnostic tools contained in the server GUI. These diagnostic tools should be accessed by authorized repair personnel only. Any attempts to modify the server software will result in voiding the warranty.

2. Server GUI Window

The Server GUI Window, shown in Fig. 12.1, provides the user with visual feedback regarding the status of the AR1012 SWORD™ DREX. In addition to the DREX System Status, the current uptime of the DREX, LO lock statuses, IP addresses and ports, and the Error Code of any errors encountered are displayed. To shutdown the server, select "Exit" from the *File* menu.

Under the *Test* menu, the user can issue a reset command to the AR1006 Dual Mezzanine FPGA Processor board and send the string "SWORD Test Message" via the UDP connection to the client to verify that communication has been established.

NOTICE

The "Debug Window", found under the *File* menu, is only accessible by authorized personnel and requires a password to open.

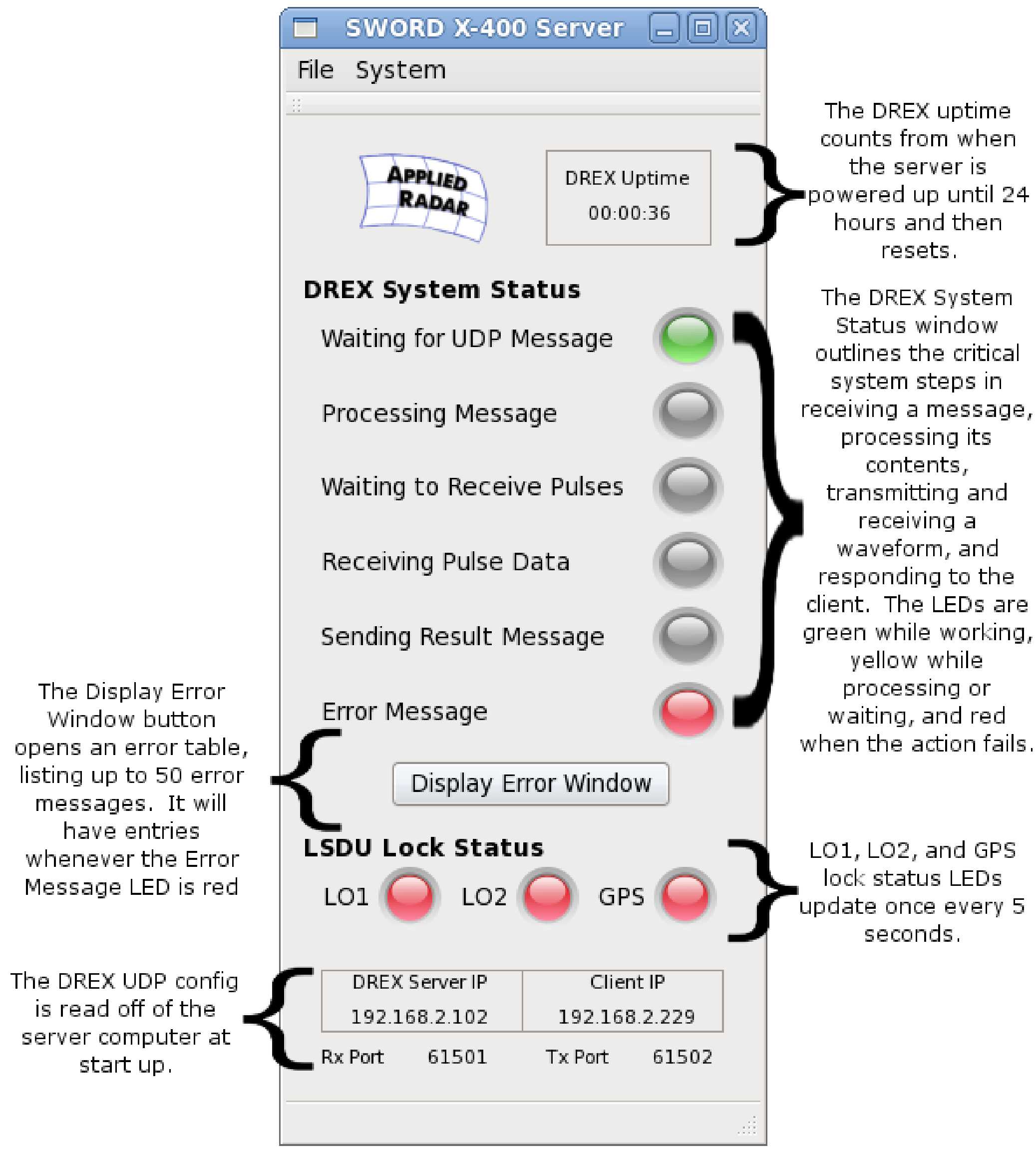

Figure 12.1: Server GUI window

2.1 Error Reporting

The ARI error table logs and displays a number of errors encountered by the AR1012. A brief description is shown in the Fig. 12.2, and the Error Codes / Error Messages are listed in Table 12.1.

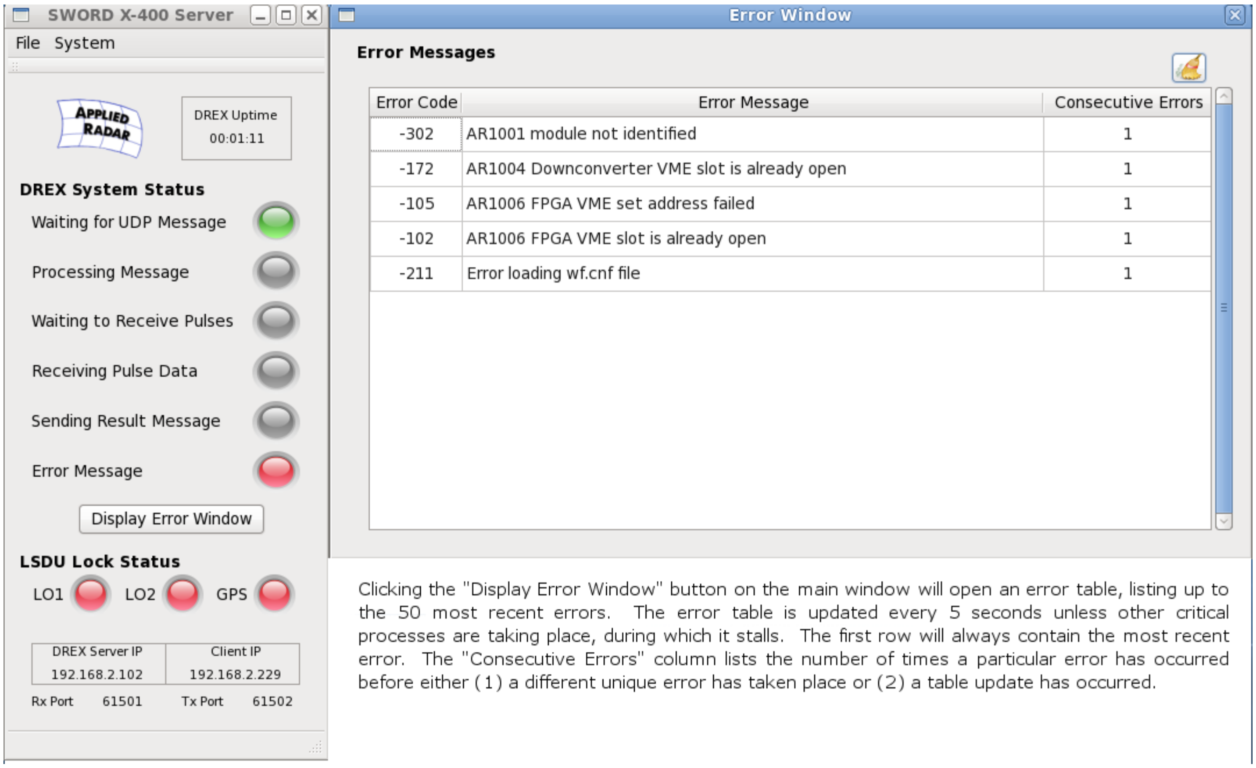

Figure 12.2: Server GUI Error window

Table 12.1: AR1012 Error Codes and Messages

AR1006 FPGA Error Messages	
-101	AR1006 FPGA failed to open a VME slot
-102	AR1006 FPGA VME slot is already open
-103	AR1006 FPGA VME slot is invalid
-104	AR1006 FPGA VME IMG set mapping error
-105	AR1006 FPGA VME set address failed
-106	AR1006 FPGA VME get address failed
-107	AR1006 FPGA VME get granularity failed
-121	AR1006 ADC sample data not ready
-122	AR1006 ADC read incorrect index
-123	AR1006 ADC time expired before read could finish

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-124	AR1006 FPGA FIFO is greater than half full, dropping samples
AR1004 Downconverter Error Messages	
-171	AR1004 Downconverter failed to open a VME slot
-172	AR1004 Downconverter VME slot is already open
-173	AR1004 Downconverter VME slot is invalid
-174	AR1004 Downconverter VME IMG set mapping error
-175	AR1004 Downconverter VME set address failed
-176	AR1004 Downconverter VME get address failed
-177	AR1004 Downconverter VME get granularity failed
-181	AR1004 Downconverter invalid gate voltage entry
-182	AR1004 Downconverter error reading from PIC
-183	AR1004 Downconverter error writing to PIC
AR1012 System Command Error Messages	
-211	Error loading wf.cnf file
-212	Error unzipping wf.cnf file
-213	Error opening wf.cnf file
-222	Bad character in ARI command string
-223	Unknown command in ARI command string
AR1012 Memory Allocation Error Messages	
-231	Failed to allocate ADC data array
-232	Failed to allocate queue data array
-233	Failed to allocate waveform data array
AR1012 Waveform Parameter Error Messages	
-242	Pulsewidth is too big for AR1012 waveform gen core, forced to 11.7us
-243	Invalid center frequency, sample rate too low
-244	Unknown waveform type requested
-245	Invalid waveform parameter entered

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AR1004 VISA Error Messages	
-301	AR1004 module failed to open
-302	AR1004 module not identified
-303	AR1004 error during write of command
-304	AR1004 error during read of result
LSDU AR2001-10-20 VISA Error Messages	
-321	AR2001-10-20 LO1 module failed to open
-322	AR2001-10-20 LO1 module not identified
-323	AR2001-10-20 LO1 module error during write of command
-324	AR2001-10-20 LO1 error during read of result
LSDU AR2001-21-24 VISA Error Messages	
-341	AR2001-21-24 LO2 module failed to open
-342	AR2001-21-24 LO2 module not identified
-343	AR2001-21-24 LO2 module error during write of command
-344	AR2001-21-24 LO2 error during read of result
LSDU AR2006 VISA Error Messages	
-361	AR2006 GPS module failed to open
-362	AR2006 GPS module not identified
-363	AR2006 GPS module error during write of command
-364	AR2006 GPS error during read of result
UDP Transmit Error Messages	
-401	Failed to initialize UDP server transmit socket
-402	Failed to send UDP message
UDP Receive Error Messages	
-421	Failed to initialize UDP server receive socket
-422	Failed to bind to UDP receive socket
-423	Partial or ill-formed UDP message received
-424	UDP receive busy, ignoring request

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-425	Failed to receive UDP message
AR1012 General Error Messages	
+0	No errors in the error queue. Device is operating normally.

13
Client Software

In This Chapter

1. Overview

The AR1012 SWORD™ DREX ships with a fully functional client GUI, shown in Fig. 13.1. The user may choose, at his or her discretion, to use the supplied client GUI or to supply their own. The ARI client GUI is a fully functional GUI which integrates the system control and data processing aspects of the AR1012 into one easy to use program. Through the ARI client GUI, the user can configure the waveforms for each of the four channels in the AR1012, configure the Coherent Pulse Interval (CPI) and Coherent Pulse Group (CPG), schedule the CPGs for transmission at a specific time in the future, start and stop the AR1012, monitor the status of the AR1012, stream the received data to a storage device, and process the received data. The client GUI is subdivided into three sections: *Transmission Configuration*, *Control Panel*, and *Processing and Plotting Tools*. These sections are described in detail in Section 4., Section 5. and Section 6. respectively.

In the discussion that follows, it is assumed that the AR1012 SWORD™ DREX has been configured with four channels. The concepts discussed apply for any system, regardless of the number of channels installed. The client GUI that ships with your system may appear different from the screenshots shown in this manual, depending on the number of channels in your system.

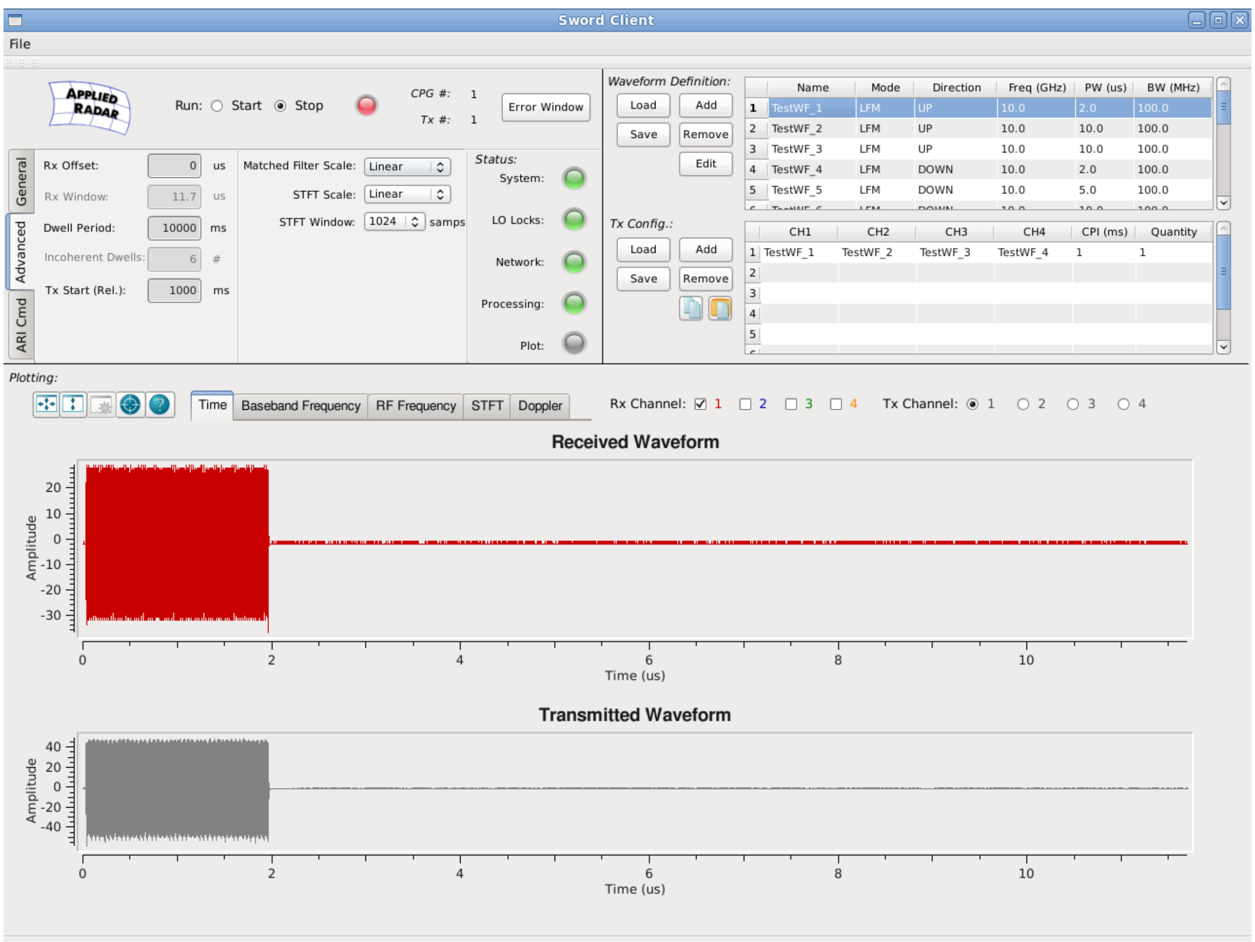

Figure 13.1: Applied Radar's Client GUI

2. Flow Diagram

The flow diagram in Fig. 13.2 illustrates the typical procedural flow of the AR1012 SWORD™ DREX. For definitions for the terminology used in the flow diagram, please see Section 3.

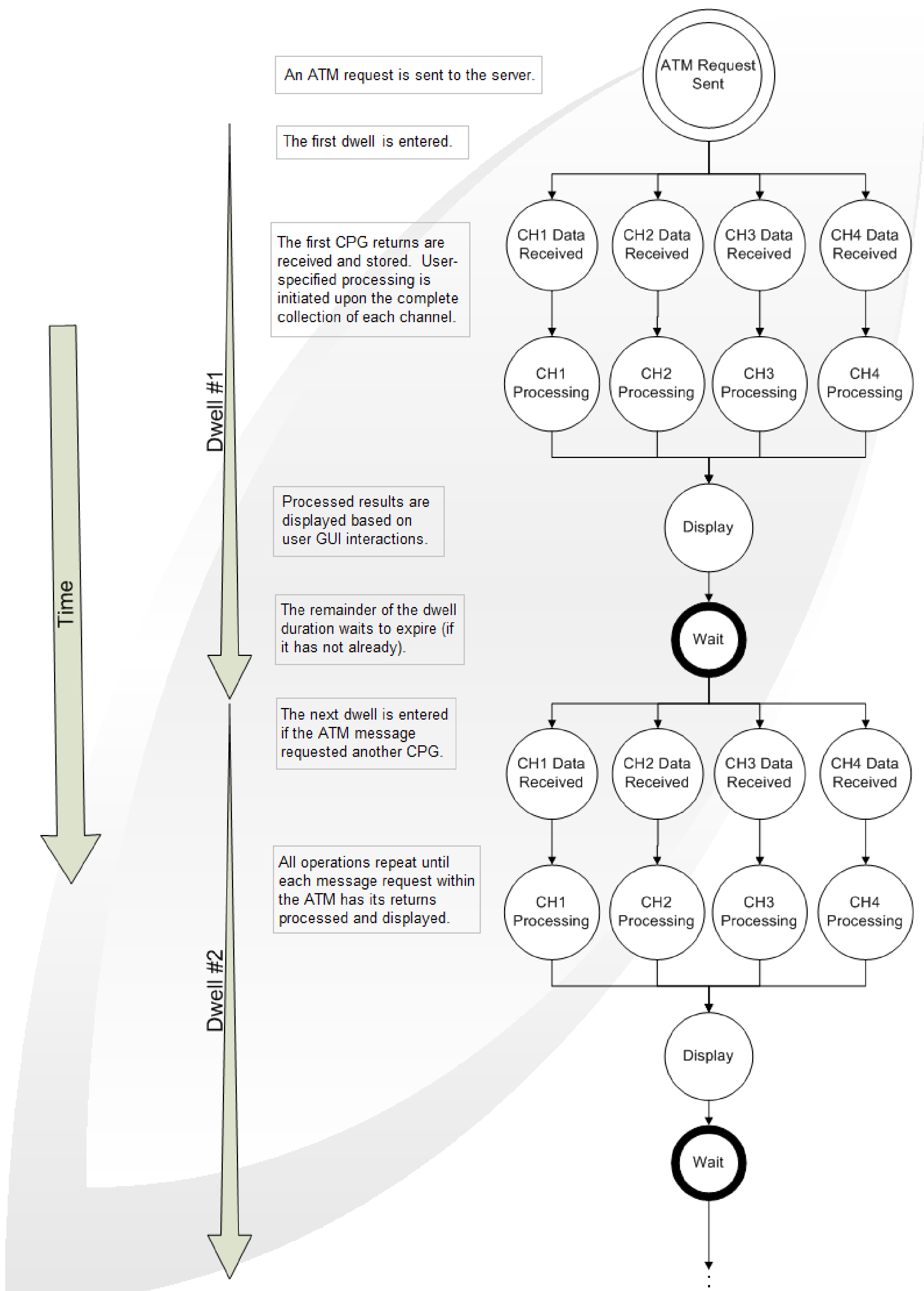

Figure 13.2: Process flow of the AR1012 SWORD™ DREX

3. Definitions

The following terminology is used when describing transmitted waveform. These concepts are illustrated graphically in Fig. 13.3.

ATM (ARI_TCM Message)
Unique structure sent to the server that contains up to 128 unique message requests characterizing a quantity of exclusive waveforms to be generated at a chosen PRI for all individual channels. Each individual request may be referred to as a CPG pattern.

CPG (Coherent Pulse Group)
One of up to 128 sets of returns for all four channels. A CPG corresponds to a quantity of pulses (user-specified) received for all four channels within a dwell.

Dwell
Duration allowed for reception and processing of radar returns for a CPG.

PRI (Pulse Repetition Interval)
Time between pulses within a CPG shared for all channels.

CPI (Coherent Pulse Interval)
See PRI. Used to exemplify the capability to associate a unique PRI with each CPG.

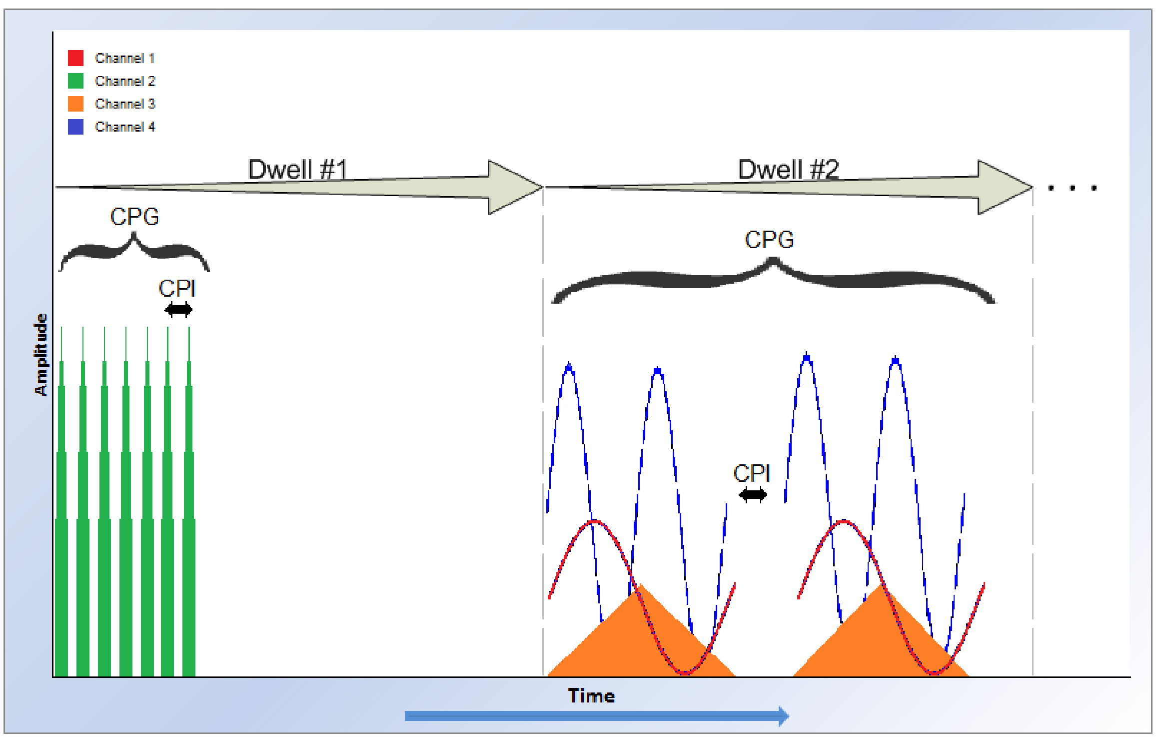

Figure 13.3: Graphical representation of the transmitted waveform definitions

4. Transmission Configuration

Through the *Transmission Configuration* panel of the GUI, the user is able to specify the waveforms to be transmitted on each of the four channels of the AR1012 SWORD™ DREX. The AR1012 has been designed to support different waveforms on each channel for each pulse, allowing for complete flexibility in the selection of transmitted waveforms. The transmitted waveforms are controlled through two tables located in the *Transmission Configuration Panel*, the *Waveform Table* and the *Transmit Configuration Table*. Through these two tables, the user can set the parameters of the desired waveforms and specify the transmission sequence for all four channels. A single CPG can consist of a transmission sequence of up to 128 different waveforms, allowing for the transmission of complicated waveform sequences.

4.1 Waveform Table

Through the *Waveform Table*, the user can specify the characteristics of individual waveforms. The waveforms are stored in a waveform configuration file (.cnf). The user can save different waveforms to different waveform configuration files and load them as needed. The *Waveform Table* consists of six columns: Name, Mode, Direction, Freq (GHz), PW (μs), and BW (MHz).

Waveform Name
The Waveform Name is a unique identifier name assigned to the waveform by the user.

Mode
The Mode allows the user to select between the type of waveform. The AR1012 ships configured to transmit CW and Linear FM (LFM) waveforms. Support of additional waveforms can be added by the factory upon request.

Direction
The Direction parameter selects the direction of the LFM, either increasing in frequency (up) or decreasing in frequency (down). When operating in the CW mode, the direction parameter is ignored.

Frequency
The FREQ column specifies the CW frequency or the starting frequency of the LFM waveform in GHz, depending on the selected Mode.

Pulse Width
The PW column specifies the pulse width of the waveform in microseconds (μs)

Bandwidth
The BW column specifies the bandwidth of the waveform in MHz. When configured for operation in the CW mode, the bandwidth parameter is ignored.

To load a previously saved waveform configuration file, press the "Load" button and select the desired .cnf file from the browser dialog. To save the current *Waveform Table* for later use, press the "Save" button and enter the desired filename. The waveform configuration file will be saved with a .cnf extension. To add an entry to the *Waveform Table*, press the "Add" button. A new window will appear where the user can enter the parameters of the waveform to be added to the *Waveform Table*. To remove a waveform, select the waveform to remove and press the "Remove" button. To edit an existing waveform, select the waveform in the table by clicking on the waveform's row and press the "Edit" button. A window will appear where the user can edit the waveform parameters.

When using the supplied ARI client GUI, the client will automatically synchronize the *Waveform Configuration Table* with the server, no user interaction is required.

4.2 Transmit Configuration Table

The *Transmit Configuration Table* allows the user to specify the waveforms to be outputted on each channel of the AR1012. The *Transmit Configuration Table* allows the user to configure up to 128 CPGs to be outputted by the AR1012. Each row in the *Transmit Configuration Table* represents a single CPG. Each CPG designates which waveform to be produced on each channel, how many times to replicate this set of waveforms (QTY) and the time interval by which to space each repeated pulse (CPI). Note that successive CPGs are repeated by the *Dwell Period* and the first CPG is delayed by the *Tx Start* parameter, both of which are specified in the *Control Panel* (see Section 5.).

The *Transmit Configuration Table* consists of six columns: CH1, CH2, CH3, CH4, QTY, CPI (ms).

CH1
The CH1 column contains the waveform name, from the *Waveform Table*, that will be outputted on CH1 of the AR1012.

CH2
The CH2 column contains the waveform name, from the *Waveform Table*, that will be outputted on CH2 of the AR1012.

CH3
The CH3 column contains the waveform name, from the *Waveform Table*, that will be outputted on CH3 of the AR1012.

CH4
The CH4 column contains the waveform name, from the *Waveform Table*, that will be outputted on CH4 of the AR1012.

Quantity
Number of pulses to be generated for the waveforms specified in the "CH1" through "CH4" column. The "Quantity" value must be an integer number greater than zero.

CPI
The non-zero time interval in milliseconds (ms) between successive pulses within the CPG.

To load a previously saved transmit configuration file, press the "Load" button and select the desired .txc file from the browser dialog. To save the current *Transmit Configuration Table* for later use, press the "Save" button and enter the desired filename. The transmit configuration file will be saved with a .txc extension. To add an entry to the *Transmit Configuration Table*, press the "Add" button and a new row will be added to the table. To remove a row from the table, select the row to remove and press the "Remove" button. To edit an entry on the *Transmit Configuration Table*, simply double click the desired element and enter the new values. "Copy" and "Paste" buttons are also provided for ease of replicating entries in the table. To specify the waveform name in the "CH1" through "CH4" columns, the user may either type the waveform name or drag and drop the waveform name from the *Waveform Table*.

NOTICE

The waveform names entered in the "CH1" through "CH4" columns must match a waveform name in the *Waveform Table*

---

5. Control Panel

The *Control Panel* contains interactive input widgets for managing execution of the *Transmit Configuration Table*, manipulation of returns, and status display indicators. The *Control Panel* consists of the "Start" and "Stop" radio buttons and a tab widget which contains the *General*, *Advanced*, and *ARI Cmd panels* along with the system status LEDs.

5.1 Start/Stop

The "Start" and "Stop" buttons control sending requests for waveforms to the server. If "Start" is pressed when there is at least one valid entry in the *Transmit Configuration Table*, a TCM message will be sent to the server. If "Stop" is pressed, the client will finish processing the current CPG if a request was sent to the server before "STOP" was pressed and then stops sending future transmission requests.

5.2 Error Window

When the *Status Panel* indicates that an error has occurred, pressing the "Error Window" button will bring up the client error reporting window, shown in Fig. 13.4. For a list of error codes and their meaning, please see Table 12.1 in Section 2.1 of Chapter 12.

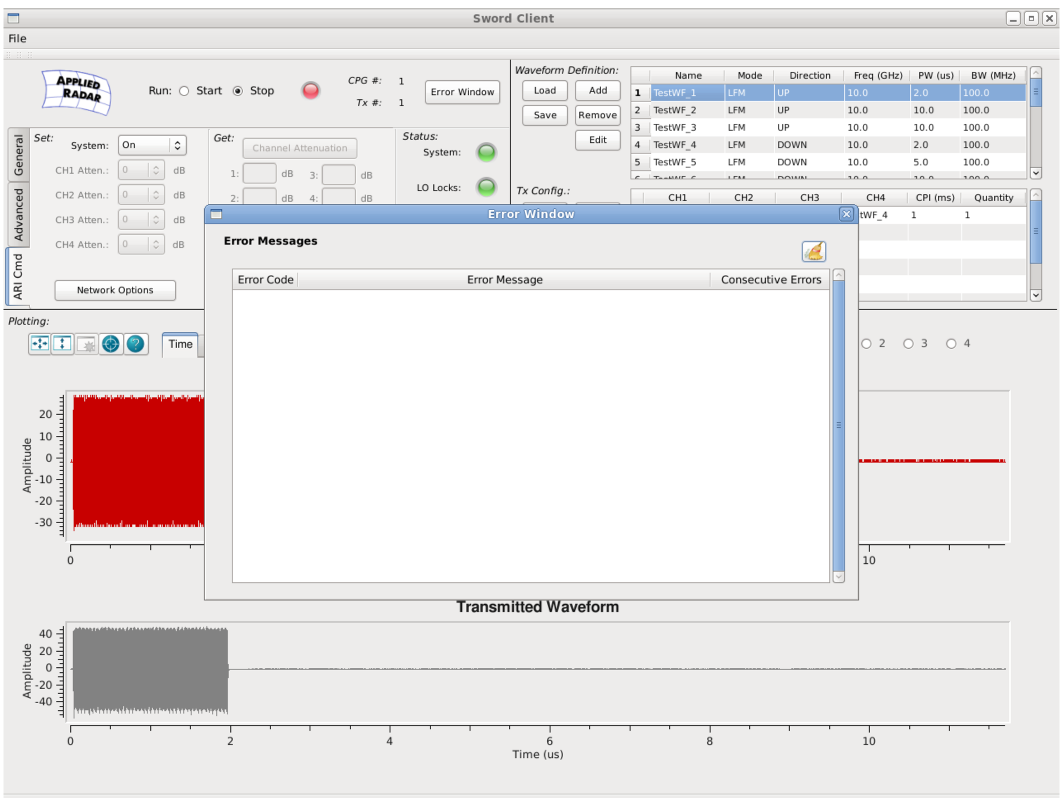

Figure 13.4: Client Error Reporting Window

5.3 General Pane

The *General* tab pane, shown in Fig. 13.5, allows the user to perform configuration of the AR1012 and the return waveform processing.

Active Channels

By default, all four channels of the AR1012 are active. The user can select which channels are active

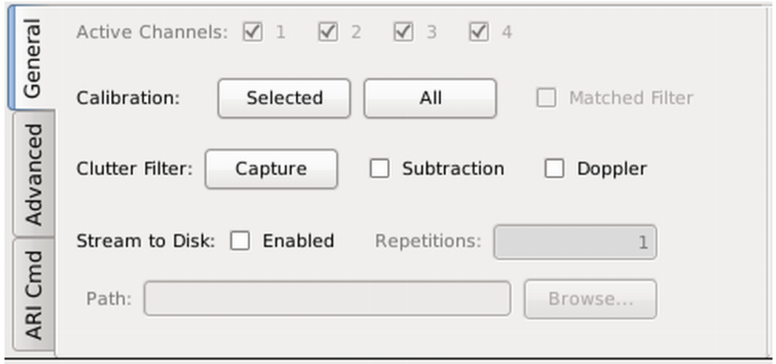

Figure 13.5: General tab pane

and which are configure to output a null waveform. Please note that the active status only determines if entries from the *Transmit Configuration Table* or a null waveform are outputted. The RF upconverters and downconverters will still be powered on and active, even if a channel is made inactive.

Calibration
In order to perform matched filtering on the received signal, the AR1012 must be calibrated to accurately describe the transmitted waveform. This need arises for imbalances in the RF channels and imperfections in the transmitted waveform. When calibrating, a copy of the transmitted waveform is recorded and stored. The calibration can be performed in either digital loopback, RF loopback, at the antenna port, or at an arbitrary location.

Digital Loopback
When performing a Digital loopback calibration, the output of the DAC is direct wired to the ADC input, bypassing the RF hardware and antenna. This is the least accurate method for calibration as the modifications to the waveform due to being passed through the RF hardware are not accounted for.

RF Loopback
When performing a RF loopback calibration, the antenna is disconnected from the AR1012 and the antenna port is terminated in a matched load. The transmitted signal will leak into the receive path due to the circulator having approximately 24 dB of isolation. The resultant received waveform after upconversion and downconversion has been performed is recorded. If the received waveform is saturating the ADC, it may be required to add additional attenuation between the receive port and the input to the RF downconverter.

Antenna Port
When performing a calibration at the antenna port, the cable attached to the antenna is removed and an attenuator is placed at the end of the cable. The transmitted signal is reflected back to the AR1012, attenuated by traversing the attenuator twice, and the received waveform recorded.

Arbitrary Location
The AR1012 can be calibrated at any arbitrary location, for example at the face of the antenna. When performing any calibration, the user must ensure that a signal of sufficient strength, without saturating the ADC, is received. If the received signal saturates the ADC, then a true representation of the transmitted waveform is not captured and will impact the ability to perform matched filtering. If the received signal strength is too low and close to the noise floor, then the calibration waveform will contain noise artifacts which may hamper the ability to perform matched filtering.

There are two options for calibration, "Selected" and "All". When the "Selected" button is pressed, the client will perform the calibration for the waveform that is currently highlighted in the *Waveform Table*. When the "ALL" button is pressed, a calibration is performed for all waveforms in the *Waveform Table*. The calibration data is written into a file with the naming convention of *waveform.cal*, where *waveform* is the name of the waveform, found in the *Transmit Configuration Table* or *Waveform Table*. The Fourier Transform of the calibrated data is also stored for analytical purposes.

Matched Filtering
To activate matched filtering, click on the "Matched Filter" checkbox. When matched filtering is activated, the software will automatically search through the *Transmit Configuration Table* to determine if each waveform in the table has an associated calibration file. If a calibration file is found, the user will be prompted to use that file or to perform a new calibration. If the user chooses to perform a new calibration or if any waveforms are found to be missing their corresponding calibration file, the client will automatically perform the required calibrations.

Upon pressing the "Start" button and for every new dwell, stored calibration data is loaded and passed to each individual channel processing unit based on the *Transmit Configuration Table* entry for the current CPG.

Clutter Filter
In order to reduce the effect of clutter on the received data, the client has two clutter filter modes which can be activated by the user, "Subtraction" and "Doppler". When the "Subtraction" mode is used, the user captures the received signal that corresponds to the background by pressing the "Capture" button. When the "Doppler" mode is used, the previous returned data is subtracted from the current received data. "Subtraction" is used to remove the returns from known stationary objects so that only changes (additions, subtractions, or position changes) to the scene are recorded and presented to the user. "Doppler" is used to remove returns from the scene that have not changed in Doppler, highlighting to the user any changes in motion in the scene.

Stream to Disk
In the standard mode of operation, all of the data is processed and displayed within the client GUI. In order to stream the received data for all channels to disk for later processing and analysis, click the "Stream to Disk" checkbox. Data will be streamed to disk according to the *Transmit Configuration Table*. The number of times that the *Transmit Configuration Table* is repeated is controlled by the entered "Repetitions" value. The path to where the data is stored is set by clicking on the "Browse" button and selected the desired folder name to store all returns. The streamed data will be stored in a subfolder in the selected path with a unique name that is date/time stamped. This folder will contain five files, "CH1.dat", "CH2.dat", "CH3.dat", "CH4.dat" and "HDR.dat". The "HDR.dat" file contains the setup and configuration information for the test.

When using the "Stream to Disk" option, the "Clutter Filter" and "Calibration" options are not available.

5.4 Advanced Pane

The *Advanced* tab pane, shown in Fig. 13.6, allows the user to setup the timing intervals and select advanced plotting options.

RX Offset
The *RX Offset* parameter controls the ADC sampling delay time in milliseconds.

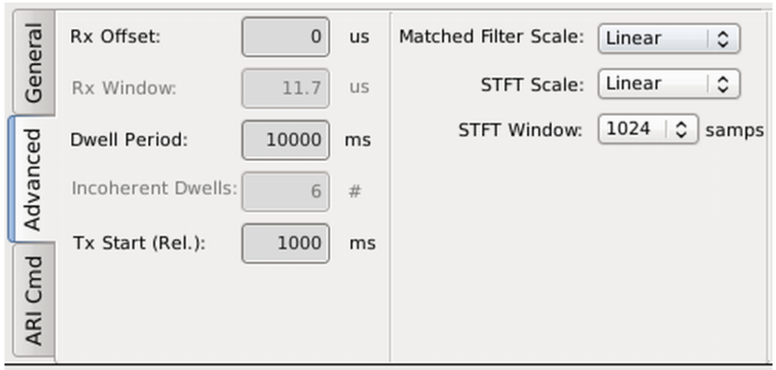

Figure 13.6: Advanced tab pane

Dwell Period
The *Dwell Period* sets the time between dwells in milliseconds. All processing occurs between dwells, so if the dwell period is too short and returns are not processed, an error message will be displayed indicating that the *Dwell Period* needs to be increased.

TX Start (REl.)
The *TX Start (Rel.)* parameter is the time in milliseconds relative to that of the message request time that indicates when to begin generating the *Transmit Configuration Table* requests.

Matched Filter Scale
The user can choose between linear, absolute value, and dB plot scales for the matched filter results graph.

STFT Scale
The user can choose between linear and db scales for the Short-Time-Fourier-Transform (STFT) graph.

STFT Window
The *STFT Window* parameter determines the number of Fourier Transform samples, up to a maximum of 1024, which comprise the STFT window. The higher the number of samples, the better the resolution. The default for the *STFT Window* is 1024 samples.

5.5 ARI Command pane

The *ARI Cmd* tab pane, shown in Fig. 13.7, allows the user to configure and determine the status of the individual ARI hardware components in the AR1012 SWORD™ DREX. The *ARI Cmd* pane is divided into two subpanes, *Set* and *Get*. The *Set* pane allows the user to set ARI hardware parameters while the *Get* subpane allows the user to view the status of the ARI hardware.

5.5.1 Set Subpane

Within the *Set* subpane, the user can turn on or off the system and set the attenuation value of each channel of the AR1004 RF Downconverter.

System
Selecting "On" from the dropdown menu will safely power on the AR1012, ensuring that the AR1004 is biased before applying an LO signal. Selecting "Off" will safely power down the AR1012, ensuring that the LO signals are turned off before turning off the AR1004.

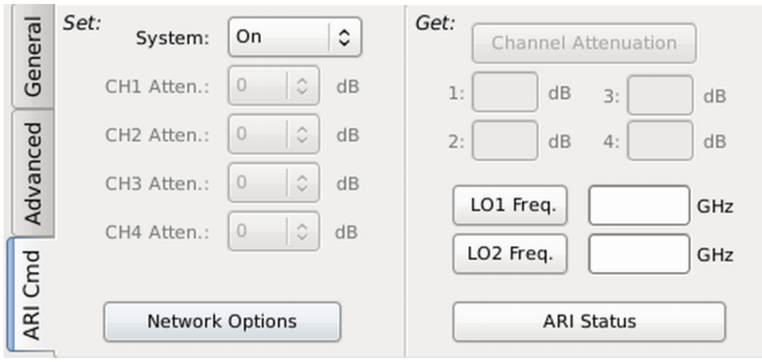

Figure 13.7: ARI tab pane

CHx Atten
The CHx Atten dropdown box allows the user to select the attenuation value for the channel x (where x is 1 to 4).

Network Options
Clicking the "Network Options" button will launch the *Network Options* window, shown in Fig. 13.8. Through the *Network Options* window, the user can enter the IP address of the server computer and specify the TX and RCV ports. The IP address of the client is displayed in the window for reference.

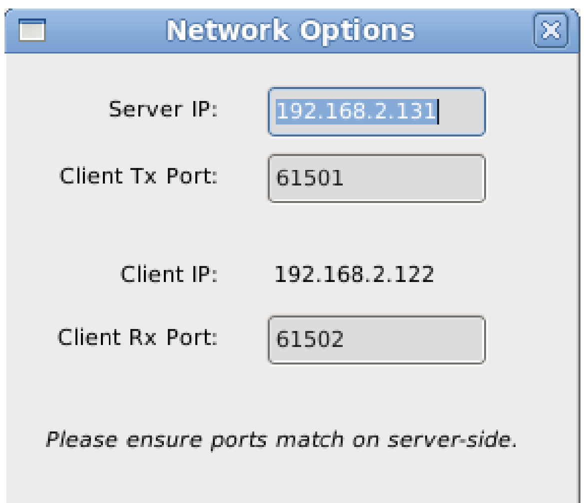

Figure 13.8: Network Options window

NOTICE

The *Client TX Port* must match the *Server RCV Port* and the *Client RCV Port* must match the *Server TX Port* in order for communication to be established

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5.5.2 Get Subpane

Within the *Get* subpane, the user can read and display the attenuation settings for each channel of the AR1004 RF Downconverter, read and display the LO1 and LO2 frequencies and display the ARI Status window.

Channel Attenuation Button
Clicking the "Channel Attenuation" button will read and display the current attenuation setting for each of the four channels of the AR1004 RF Downconverter.

LO1 Freq. Button
Clicking the "LO1 Freq." button will read and display the current output frequency of the LO1 synthesizer in the AR1001 LSDU.

LO2 Freq. Button
Clicking the "LO2 Freq." button will read and display the current output frequency of the LO2 synthesizer in the AR1001 LSDU.

ARI Status Button
Clicking the "ARI Status" button will show the *ARI Status* window, shown in Fig. 13.9, which displays the lock status of LO1 and LO2, the reading of the four temperature sensors onboard the AR1004 RF Down Converter, and the currents for each of the amplifiers on the AR1004 RF Downconverter (for the nominal current values, please see Table 6.2).

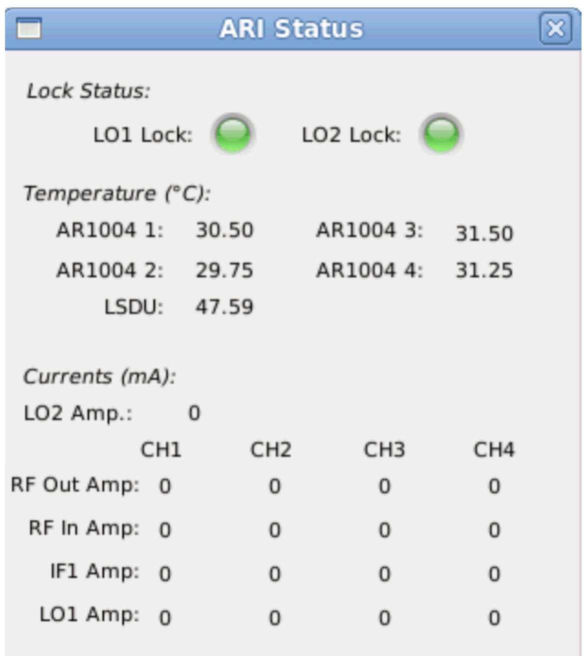


Figure 13.9: ARI Status window

5.6 Status LEDs

The Status LEDs, shown in Fig. 13.10, provide visual feedback on the status of the AR1012 to the user. The five LEDs provide the visual status of the System, LO Lock, Network, Processing, and Plotting.

System
Indicates the system health of the AR1012. If the LED turns Red, check the wiring and "ARI Status" for abnormalities.

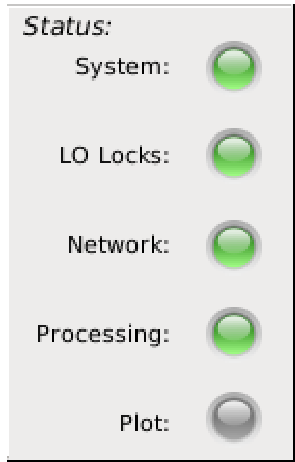


Figure 13.10: Status LEDs

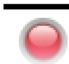
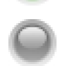
LO Locks
Indicates the lock status of LO1 and LO2. A Green LED indicates that both LO1 and LO2 are locked, while a Red LED indicates the one or both of the LOs are unlocked. To determine which LO(s) is unlocked, click on the "ARI Status" button located in the *Get* subpane of the *ARI Cmd* pane.

Network
Indicates if the bi-directional UDP connection with the server is active. A Green LED indicates that a UDP connection has been established and verified. A Red LED indicates that UDP connection cannot be established. If this should occur, verify that you can manually connect to your network.

Processing
Indicates if your Dwell Period is too small for your current processing load. If the LED turns Red, All returns were not able to be processed within the dwell. Verify that your network LED is not also showing red. If it is, then check your connection to your network. If your network LED is green, reduce your dwell period until it is long enough to allow processing of all returns.

Plot
Indicates that the returns have been processed and plotted. The Blue LED will flash twice when data has been received and plotted. When data is not being plotted, the LED will appear Gray.

The LEDs color indicates the current status according to the following color scheme:

	An Error condition exists
	Functioning Properly
	Inactive

6. Processing and Plotting Tools

The *Plotting* section of the client, shown in Fig. 13.11, allows the user to examine the received waveform and the results of the various built-in processing options. The *Plotting* section consists of *Tool Buttons* to allow the user to interact with the plots, *Rx Channel* checkboxes to allow the user to control which channels are displayed in the plots, *TX Channel Display* radio button to choose which channel the transmitted waveform is displayed in the bottom graph and the *Plot Tabs* which allows the user to choose between the different processing and data display options.

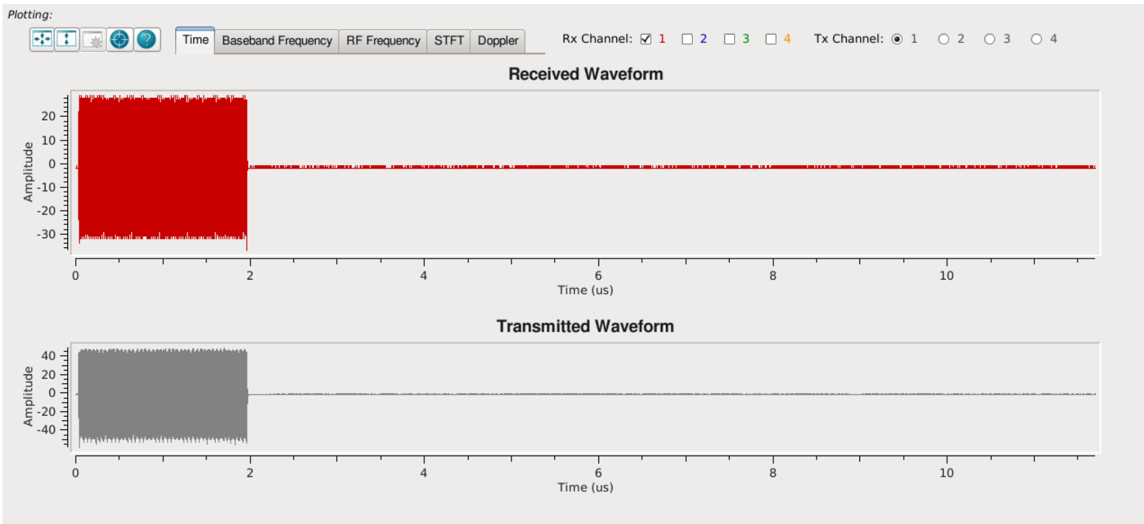


Figure 13.11: Plotting section of the Client GUI

When interacting with the plots, the user may use the mouse to help navigate the plots.

Table 13.1: Mouse gestures for the plotting window

Action	Mouse Gesture
Zoom in	Hold down the Left mouse button and drag the mouse to select the rectangular area to zoom
Zoom Out	Right click to return to the previous point of view
Pan	Hold down the Middle mouse button and drag in the desired direction to pan the view

6.1 Rx Channel Checkboxes

The *RX Channel* checkboxes allow the user to control which channels are displayed on the plot. The color of the checkbox corresponds to the color displayed in the plot. The user can choose to display from one up to four channels at a time.

6.2 TX Channel Display Radio Buttons

The *TX Channel Display* radio buttons allow the user to select which channel the transmitted waveform for is displayed in the bottom graph. Only one TX may be selected at a time.

6.3 Tool Buttons

Five Tool Buttons have been provided for the user to interact with the plots.

Table 13.2: Plot tool buttons

Button	Mouse Gesture
	Autoscales the displayed plot
	Autoscales the Y axis
	Undocks the currently displayed plot from the *Plotting* window and opens it in its own window
	Displays a tooltip which holds the current x and y value of the cursor position
	Displays a Help window summarizing the mouse gestures for interacting with the plots

6.4 Plot Tabs

The *Plot Tabs* allow the user to select between the five available processing and data display options.

Table 13.3: Plot tabs

Action	Mouse Gesture
Time	Shows the received data as a function of time
Baseband Frequency	Performs and FFT on the received data and displays the baseband frequency components
RF Frequency	Translates the Baseband Frequency plot to the RF output frequency band
STFT	Displays the two-dimensional Short-Time-Fourier-Transform plot of the selected channel
Doppler	Displays the Range-Doppler map of the most currently processed CPG of the selected channel

7. Example Scenarios

The following examples walk the user through configuring the client software for different scenarios.

Scenario 1

To view a 10 GHz pulsed CW tone with a 2 μs pulse width for each channel with a PRI of 10 seconds.

Approach

1. Setup your *Waveform Table* to contain the described waveform. To do this, click the "Add" button. In the popup window, enter the following to define your waveform

Name	Give your waveform a unique name
Mode	Set the mode to CW
Direction	Ignore, does not apply
Freq	Enter 10
PW	Enter 2
BW	Ignore, does not apply

   The values in "Direction" and "BW" have no effect on a pulsed CW tone.

2. Save the *Waveform Table* so it can be recalled in the future (Optional)
3. Click the name of the waveform you made in step 1 and while holding down the mouse button, drag it over to the *Transmit Configuration* table and drop it in the "CH1" column. Repeat for all four channels. Alternatively, you can double click each channel column and type the name of the waveform exactly as it appears in the *Waveform Table*. Double click and enter 1 in the "CPI" column. Double click and enter 1 in the "Quantity" column. Ensure that this is the only entry in the table.
4. Save the *Transmit Configuration Table* so it can be recalled in the future (Optional)
5. Click on the "Advanced" tab of the *Control Panel* and enter 10000 in the "Dwell Period" textbox. This will cause the *Transmit Configuration Table* to be repeated every 10 s until told to stop.
6. Check all of the "Rx Channel" checkboxes in the plotting area to display the results of all four channels.
7. Click the "Start" radio button to start the AR1012
8. When finished, click the "Stop" radio button to stop the AR1012.

Scenario 2

Stream the return of all four channels to disk for 10 repetitions of the *Transmit Configuration Table*. Schedule the first pulse to happen five seconds in the future.

Approach

1. Setup your *Waveform Table* to contain the desired waveform.
2. Save the *Waveform Table* so it can be recalled in the future (Optional)
3. Setup the *Transmit Configuration Table* with the desired values
4. Save the *Transmit Configuration Table* so it can be recalled in the future (Optional)
5. Set the "TX Start (Rel.)" parameter, located in the "Advanced" pane of the *Control Panel*, to 5000 to set the 5 s delay.
6. Set your "Dwell Period" for your time between CPGs to the desired value
7. Check the "Stream to Disk" checkbox, located in the "Basic" pane of the *Control Panel*.
8. Enter 10 into the "Repetitions" textbox and press enter (the textbox will now be grayed out signifying that the value is now locked)
9. Click "Browse..." to set the path and enter the folder name to store data.
10. Click the "Start" radio button and wait until the system is done (it will stop automatically).

Scenario 3

View the return on Channel 1 and see if the time delay measured matches the known distance to a target. Configure the system to use an LFM up-chirp at 10 GHz with a pulse width of 10 μs and a bandwidth of 300 MHz. Enable matched filtering.

Approach

1. Setup your *Waveform Table* to contain the desired waveform.
2. Save the *Waveform Table* so it can be recalled in the future (Optional)
3. Setup the *Transmit Configuration Table* with the desired values. Be sure to set "Quantity" to a value of 1.
4. Save the *Transmit Configuration Table* so it can be recalled in the future (Optional)
5. Remove the connection from the antenna on channel 1 and leave the terminate the cable with a 10 dB attenuator.
6. Check the "Matched Filter" box, choosing to overwrite the existing file if prompted. The system will now calibrate the transmitted waveform. The calibration will account for everything up to the antenna.
7. Reconnect the antenna
8. Configure the "Dwell Period" and "Tx Start (Rel.)" parameters to the desired values

9. Check the "Rx Channel 1" checkbox on the plotting section.
10. Click the "Start" radio button to start the measurement cycle.
11. Click the "Stop" button to end the measurement cycle.

Note: Under the "Advanced" pane in the *Control Panel*, the "Matched Filter Scale" can be set to Absolute Value, Linear, or dB.

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Bibliography

[1] S. Rejto. Radar open systems architecture and applications. In *Radar Conference, 2000. The Record of the IEEE 2000 International*, 2000.

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