Aspen™ AEVK-01 User Manual
Ultra Wideband Transceiver

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Regulatory Notice

This device does not comply with any RF emissions regulations in any country. Users should consult their spectrum management authorities before use.

U.S. Operation: This device complies with the Part 15 of the FCC rules. Operation is subject to the following conditions: (1) this device may not cause harmful interference; (2) this device must accept any interference received, including interference that may cause undesired operation; (3) this device must be operated indoors; and (4) the emissions from equipment operated under this section shall not be intentionally directed outside of a building where the equipment is located, such as through a window or doorway, to perform an outside function, and (5) the use of outdoor mounted antennas or any other outdoor antenna infrastructure is prohibited. Operation in disregard of these conditions is a violation of 47 U.S.C. 301 and could subject the operator to serious legal penalties.

Outside U.S. Operation: This Aspen™ UWB transceiver technology has not been authorized for use or commercial exploitation under the regulations on any non-U.S. government agency. Please consult with your government's local regulatory agency to ensure proper authorizations are obtained.

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Revision History

Revision Date	Author	Comments
November 1st, 2005	L. Chow	Initial creation.
March 25th, 2005	R. Erman	Added instructions on RF Test Mode
March 31st, 2005	R. Erman	Moved programming portion Tech Note 4001.
April 5th, 2005	R. Erman	Added Information regarding AEVK companion CD.

Introduction

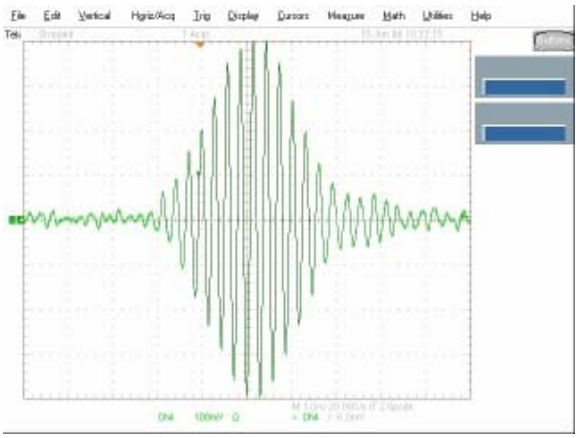
Congratulations on your purchase of the General Atomics AEVK-01 ultra wideband (UWB) transceiver evaluation kit! This evaluation kit contains all of the hardware, software and documentation necessary to evaluate an FCC-compatible high data rate UWB transmission system. As the first generation of the Aspen™ family of UWB radios, the AEVK-01 is a discrete implementation of the Aspen™ 2000 UWB multi-chip module (MCM) based chipset, including the physical layer, baseband, and the embedded media access control (MAC) functions necessary to accomplish low-power wireless multimedia streaming.

This User's Guide describes the functional capabilities of the Aspen system, the advantages of the Spectral Keying® (SK) modulation technique employed in the radio, its operational characteristics, and application interfaces. The AEVK-01 is designed to provide product development OEMs and ODMs confidence in the robust RF performance of the SK-based UWB radio and provides all of information necessary to develop and test applications.

Detailed timing and interface specifications are provided separately with General Atomics developer's agreement.

Spectral Keying® Ultra Wideband Modulation

SK modulation is fundamentally different from other UWB approaches, optimized for robust long-range operation in high multipath application environments. The SK modulation approach divides the allocated UWB spectrum into multiple sub-bands, each with 500 MHz minimum bandwidth. This provides flexibility in selecting suitable bands (spectral agility) based on the presence of interference or regulatory constraints. In the SK modulation architecture used in the AEVK-01, information symbols are made up of 5 pulses, each sent in a different UWB sub-band. The combination of the five sub bands creates a symbol, where information is encoded in the sequence of the bands used for each pulse. Each frequency is used only once in a symbol. An individual sub band sample is shown below:



Using 5 bands, the allowable symbol set is 5!=120 unique symbols. Hence the number of possible bits per symbol is $\log_2(120)$ = 6.9 bits. Figure 1 illustrates the advantage of SK its capability to carry a large number of bits per symbol showing two typical SK symbols. The first symbol uses the sequence of sub-bands F_1, F_2, F_3, F_4, F_5 to create a unique symbol, while the second F_2, F_5, F_1, F_3, F_4 to a different another symbol. The result is a symbol set with great spectral agility, but with sufficient time between symbols to effectively capture multipath energy.

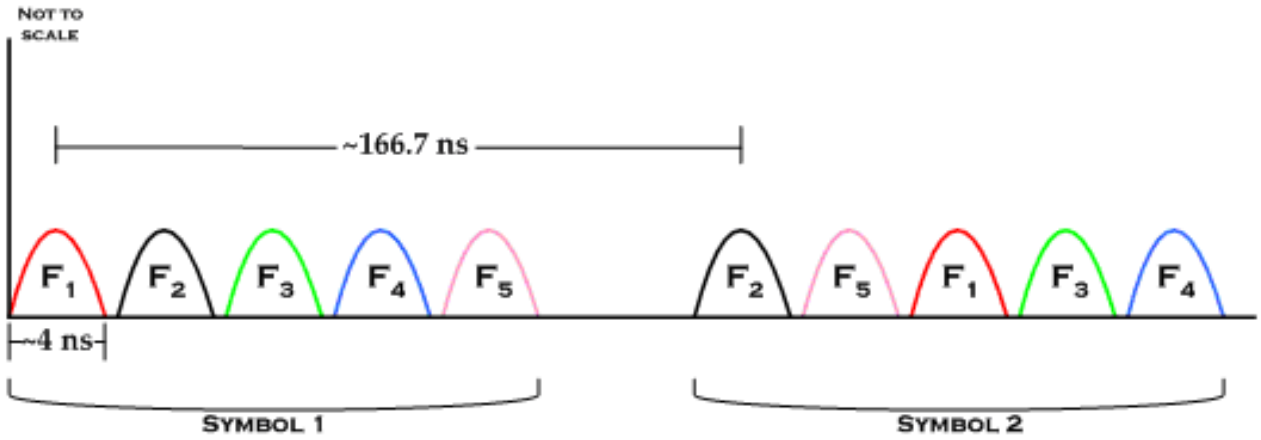


Figure 1: Typical SK symbols

The following are the key parameters employed in the AEVK-01:

Parameter	Value
Symbol repetition frequency	6 MHz
No of pulses per symbol	5
Bandwidth per pulse	>500 MHz
No of frequency sub-bands	5
Nominal Center Frequency of sub-bands (GHz)	3.48, 4.02, 4.56, 6.12, 6.96 GHz

Note: all five sub-bands must transmit in each symbol period. No information is contained in any single sub-band, and Aspen has no ability to dwell on any single sub-band.

Interference Potential of SK:

To a victim narrowband receiver (BW < 500 MHz), SK waveform will look like an impulse radio waveform, that has ~ 4 ns pulse length, ~ 500 MHz BW and 6 MHz PRF. Such signal has been anticipated in the FCC R&O and its

interference impact analyzed before issuing the rules. Therefore interference from an SK transmitter will be very low.

Applications

Since February 2002, when the FCC opened the door to unlicensed communication systems based on UWB technology, industry has been anticipating high bandwidth (>10 Mbps), short range (<30m) wireless solutions based on this technology. The Aspen solution meets this promise by offering data rates up to 80 Mbps at ranges of 10 meters and beyond. Robust in both data rate and performance in high multipath indoor applications, Aspen is ideal for streaming video, streaming audio, and in the future, data exchange applications such as USB and 1394.

Applications for the Aspen UWB radio include video cable replacement (real-time streaming of content from DVD/DVR/satellite receivers/security cameras to television monitors), audio entertainment systems (file transfer or streaming between PC-based platforms and audio receivers, and portable music systems), and more.

The General Atomics Aspen family of UWB transceivers was developed specifically to address these types of demanding application environments – indoor operation, effective operation through walls and other home construction material, and peaceful co-existence with other wireless home networking solutions such as garage door openers, 802.11a/b/g networks, microwaves, and other RF interferers. Most importantly, Aspen's SK-based UWB has been proven to operate effectively in dynamic multipath environments, defined as the presence of people moving between transmit and receive antennas.

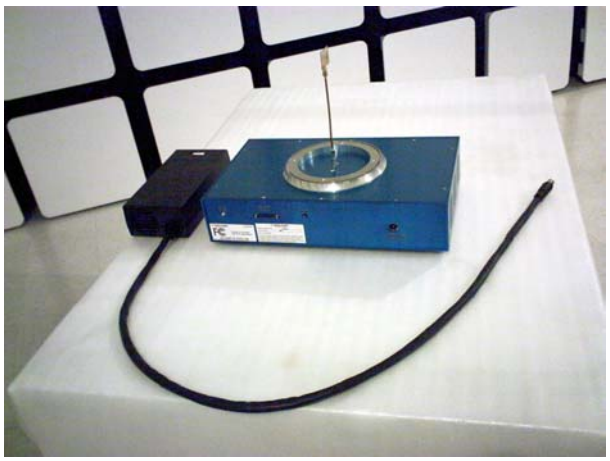
AEVK-01 accepts data into a general purpose FIFO through Serial Parallel Interface (SPI) port. Any type of data source can be connected on the transmit side and sent to an AEVK-01 receiver. Data rates vary depending on the radio settings and forward error correction (FEC) coding employed. A typical scenario would use a 2/3 FEC coding, allowing for up to 50 Mbps of (application) data to be transmitted over a single transmitter. In this configuration, one transmitter could carry up to two high-definition (HD) or four standard definition (SD) video streams.

The AEVK-01 is designed to be used with a customer supplied external codec. The codec inputs data into the AEVK-01 radio in accordance with the provided interface and timing specification document. No external drivers are needed to operate the AEVK-01 in its operational mode, although drivers and external hardware may be required to interface and monitor specific applications over the radios. When an external application is attached to the AEVK-01, the radio will operate in its basic streaming mode, point to multipoint broadcast. All

AEVK-01 units are shipped in this configuration unless otherwise specified by the customer.

In cases where an external application is not available, the AEVK-01 can also be configured into an RF Test Mode that streams representative video data through the UWB transmitter. The RF Test Mode can be utilized without a required external application, and even when an Aspen receiver is not present. This mode provides an RF output signal consistent with an external video codec. Instructions for configuring the RF Test Mode are included in the companion CD that is shipped with all AEVK01 units from General Atomics.

The elements of the AEVK-01 are shown in the accompanying photo, including the radio transceiver with antenna, and power supply. This photo shows the antenna exposed without the accompanying antenna cover. A knob at the top of the antenna cover allows the user to point the antenna for fine tuning link quality.

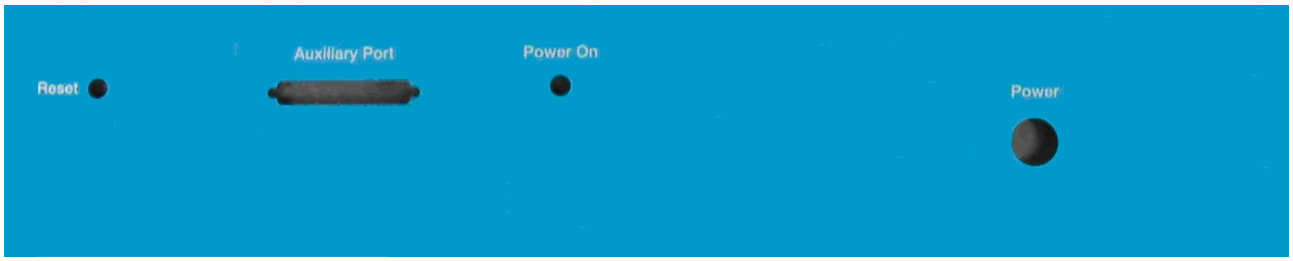


Getting Started

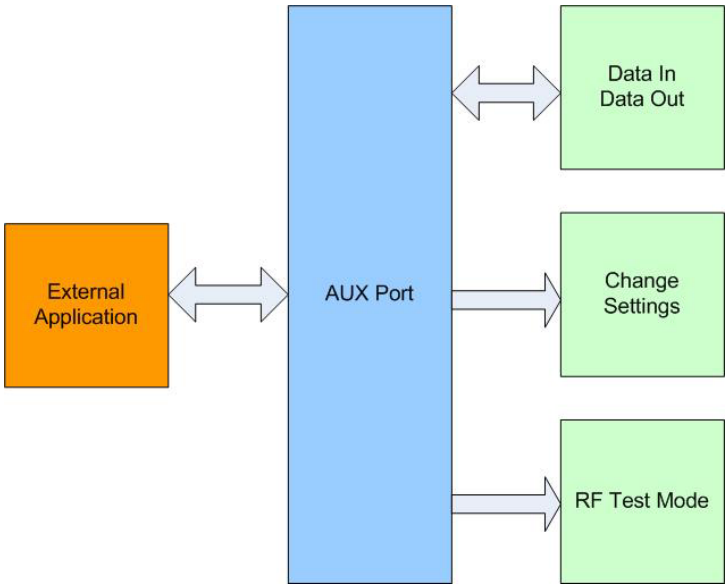
First, please check the contents of the package. Each AEVK-01 should contain the following items:

Qty	Item
2	AEVK -01 Transceivers
2	Power supplies with cords
2	Integrated UWB antennas
2	SCSI to DB9 cables
1	Interface and Timing Specification Document
1	RF Test Mode Connector
1	Companion CD

Each connector and switch on the AEVK-01 transceiver's back panel is labeled as to its function.



Starting from the far left, the reset button performs an overall soft reset of the radio, forcing it to purge all data currently in the system and reestablishing either transmit or receive functions. Reset is useful in situations when the radio doesn't respond properly due to faulty data from an external application.



The Auxiliary Port has two main functions. At start-up, the Aux port can be used to program radio operational features such as data rate and FEC rate. It is also used as the interface to configure the radio between normal and RF Test modes.

Once the radio is configured, the Aux port acts as the main data interface into the transmitter and out of the receiver. Details on normal operation and RF Test Mode programming and interface methods are addressed in their respective sections.

The Power-On LED in the center of the panel illuminates when the radio is active. A solidly lit LED indicates that the unit is active. A blinking LED means that the power supplied to the unit is insufficient.

In compliance with the FCC rules for UWB, the UWB antenna is permanently mounted to the top of the transceiver box, covered by an opaque, but RF transparent acrylic radome. This radome, and the antenna it protects, are permanently attached to the transceiver and cannot be removed or modified.

Note: Removing or modifying the AEVK-01 UWB antenna in any way is a violation of the FCC rules governing the transmission of UWB signals.

Included in the AEVK-01 kit is a companion CD. This CD contains tools for programming the digital chips, specifications, tech notes, firmware, and other UWB related materials. The CD is designed to be operated from a standard PC, allowing the user to program the radio through a PC Parallel Port connection to the AEVK-01's AUX port.

For the latest information, firmware, and documents please visit our website http://photonics.ga.com/uwb

Basic Connection

After verifying the contents and familiarizing yourself with the major elements of the transceiver, the basic radio can be configured. The AEVK-01 boxes supplied come preloaded with streaming mode firmware. This firmware has been preconfigured to run at 40mbps, 2/3 FEC encoding, and uses a packet of 188 bytes. The customer has the option to change any of these parameters by following the instructions below along with the companion CD.

Each transceiver has a power supply that connects to a standard 110 Volt outlet. Once the power supply cable is connected to the AEVK-01 radio, the radio can be turned on via the on/off switch on the power supply. With the switch flipped to the 'on' position, the power supply fan should be audibly recognized and the blue LED on the transceiver's front panel will illuminate.

Note: The power supply should be placed such that the air vents are not blocked; blocking the air vents will lead to the power supply overheating and may cause permanent damage.

Connecting The System For Data Streaming Operation

If the preloaded configuration meets the customer application requirements, the customer application board can be connected directly to the Aux Port on the transmitter. Once data flows into the Aux Port, the AEVK-01 will transmit the data automatically, if it senses a receiver present. If the preloaded configuration is not sufficient the default configuration values can be changed. There are two ways to change these values: programming the EEPROM as specified by the Aspen Interface and Timing Document, or by loading a different FPGA code into the system as described by Tech Note 4001.

By programming the GA transceivers, the user can:

- Change the data rate to either 12, 24, 40 Mbps
- Change the FEC rate to either 1/3, 1/2, 2/3
- Change the packet size to either 36, 188, 204 bytes

To utilize the transceivers in streaming mode, a customer-provided external application must be configured to stream digital data into the AEVK-01 in accordance with the Aspen Auxiliary port interface definition.

- Connect the customer-provided transmitter application hardware to the GA transceiver box via the parallel cable provided.
- Connect the receive side of the customer-provided application to the second transceiver box.

Unless overridden in RF Test Mode, the AEVK-01 will transmit only when an associated receiver is detected. In normal streaming mode, the system will transmit only for 10 seconds without an associated receiver present.

RF Test Mode

A RF Test Mode has been included with the AEVK-01 to allow Spectral Keying UWB waveform to be evaluated when an external customer-provided application is not available. In this mode, actual video streaming data captured and stored in the AEVK-01 is processed exactly as it would be if it were coming from an external source. This mode allows the user to measure RF Spectrum of the AEVK-01 transmitter without an application. It also provides the ability to measure individual sub-bands to confirm 500Mhz minimum bandwidth.

The first step to utilize the RF Test Mode involves reloading firmware onto the AEVK-01, since the default configuration is standard streaming mode. Please refer to Tech Note 4001 for instructions on loading new firmware onto the AEVK-01. When using the RF Test Mode, a special DIP switch connector, provided separately, must be attached to the Aux Port on the AEVK-01 to control different modes of the radio. The following table lists the DIP switch positions on the external connector that alter the behavior of the AEVK-01:

Switch #	1	2	3	4	5	6	7	8
ON Position	Disable Freq1	Disable Freq2	Disable Freq3	Disable Freq4	Disable Freq5	Video	Pseudo Random Symbols	Continuous mode
OFF position	Enable Freq1	Enable Freq2	Enable Freq3	Enable Freq4	Enable Freq5		Repeat Same Symbol	Burst mode ~ 1 second

Note: Once a change has been made to the DIP Switch, the AEVK-01 reset button must be pressed for the change to become effective.

Switches 1-5 control the individual sub-bands, allowing for verification of each band's 500 MHz bandwidth compliance. Switch 6 activates the embedded sample video data to be transmitted. Switch 7 changes the mode between pseudo-random symbols (normal mode) to a mode which repeats a single symbol. Switch 8 allows an override of the receiver-sense function, allowing a continuous streaming of the video data even when a receiver is not present.

Two sets of files are included in the AEVK-01 CD in the RF Test Mode firmware folder, one that programs the RF control, and one that configures the baseband modem.

FPGA	Digital RF	Digital BB
MCS files	Mogul.mcs	fcc_top_0.mcs fcc_top_1.mcs
BIT files	Mogul.bit	Fcc_top.bit

The MCS file loads the devices' EEPROM, which maintains that version of firmware even through power cycling. BIT files are also included that load into a devices' RAM, allowing mode changes that remain in effect until the device is powered off.

Questions

Answers to most question regarding the setup and operation of your AEVK-01 can be found on GA's UWB support website:

http://photonics.ga.com/uwb/support

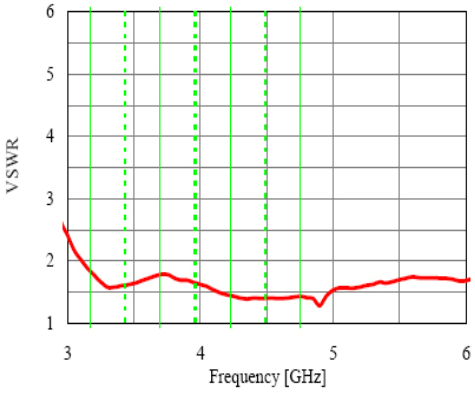
Questions not addressed here can be submitted to uwbsupport@ga.com or contact your sales representative.

Antenna Characteristics

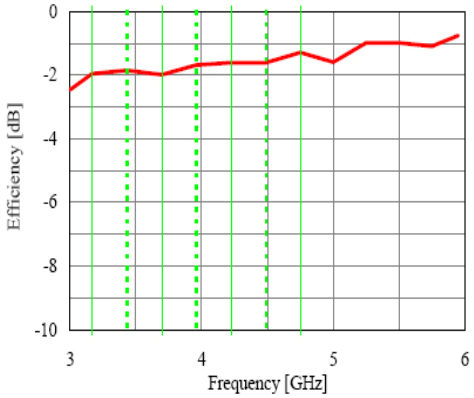
This section covers the antenna characteristic that is used in the AEVK-01 kit. The antenna is roughly omni in nature, and provides nearly uniform gain over the frequency range of operation. System performance can be affected by factors such as room configuration, construction, and antenna pointing. Information on optimal performance considerations can be found on the General Atomics UWB Customer Support website.

Frequency [GHz]		3.168	3.432	3.696	3.96	4.224	4.488	4.752
XY-plane	TX-V	-6.0	-5.1	-5.9	-5.9	-4.6	-4.3	-3.2
	TX-H	-4.2	-5.1	-5.2	-5.4	-7.2	-7.6	-8.2
YZ-plane	TX-V	-3.9	-3.1	-3.4	-3.0	-2.4	-2.4	-2.2
	TX-H	-19.0	-17.7	-17.1	-18.0	-17.6	-19.0	-19.5
ZX-plane	TX-V	-8.2	-6.8	-6.5	-7.0	-6.1	-6.3	-6.9
	TX-H	-2.1	-3.1	-3.1	-1.4	-1.1	-1.0	-0.5

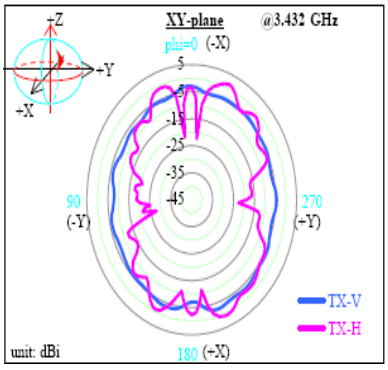
Average gain data (dBi)

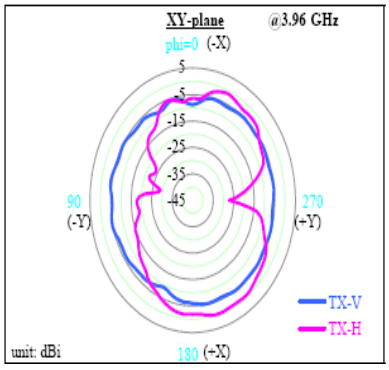


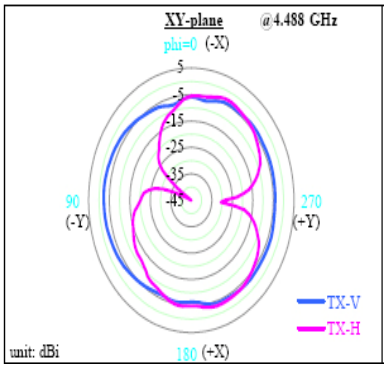
VSWR Data



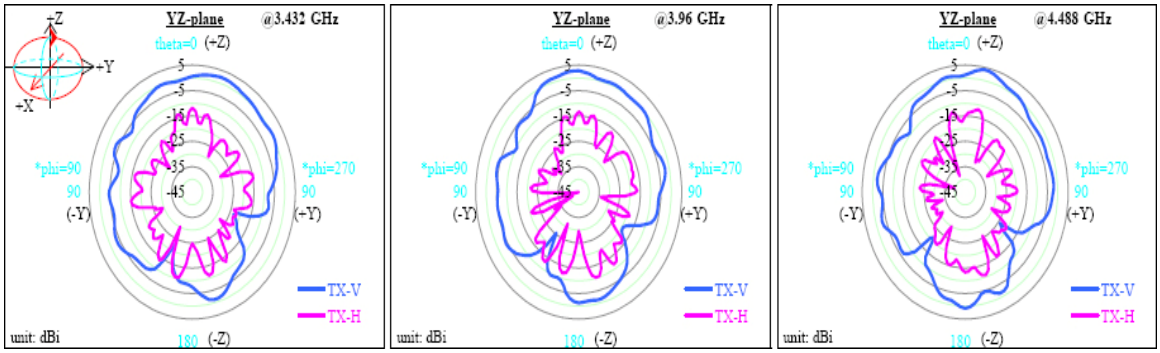
Efficiency Data



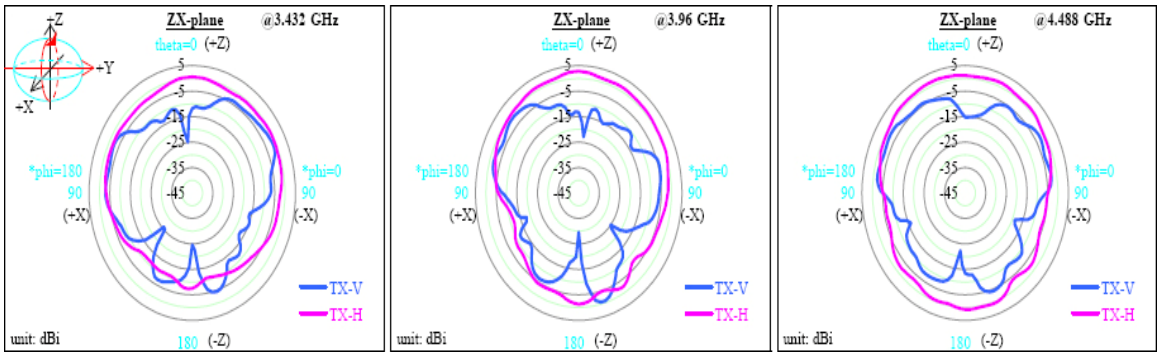




XY Radiation Pattern



YZ Radiation Pattern



ZX Radiation Pattern