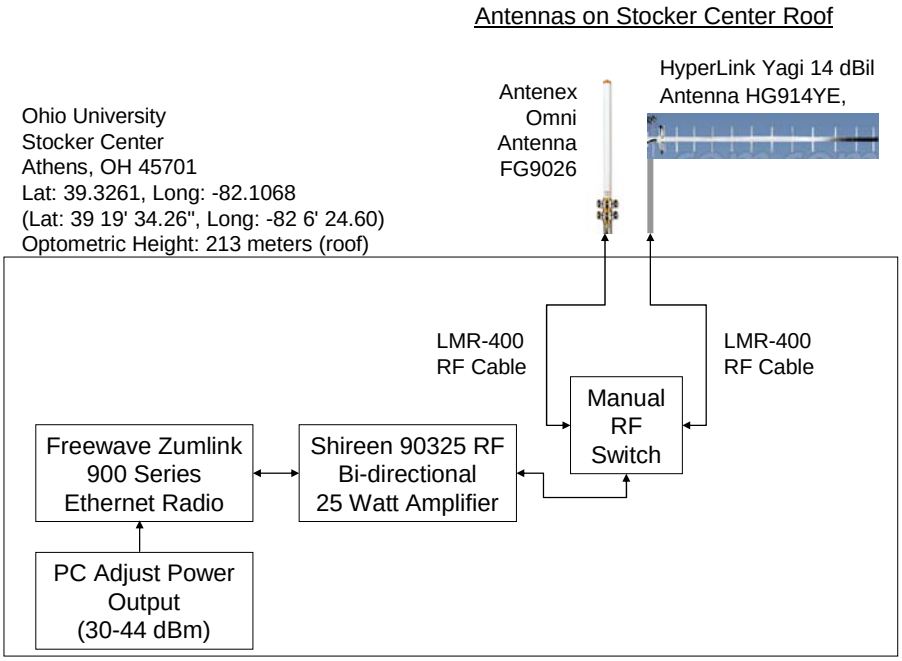
Administrative Portion Information:
Confirmation Number: EL410180
Application File Number: 0022-EX-PN-2018
Date of Submission: 2018-04-15 14:19:41.443

Ohio University 902-928 MHz 25 Watt Radio Link

Ohio University, School of Electrical Engineering, Professor Chris G. Bartone, Ph.D., P.E., (FRN 0025370479) wishes to operate a communications link between a fixed grounds station and a mobile airborne S-3 Aircraft in the southeastern Ohio area. The ground station will be located on the campus of Ohio University, Stocker Center, Athens, OH 45701, at a location: Lat: 39.3261, Long: -82.1068 (Lat: 39 19' 34.26", Long: -82 6' 24.60), Optometric Height: 213 meters (roof); transmission antennas will be located on the roof of the Stocker Center building at an Othrometric height of 213 meters.
The radio is planned to transmit in the 902-928 MHz band using a Freewave Ethernet radio with a maximum output power amplifier of 25 Watts (44 dBm), via an omni-directional antenna (gain=6dBd, i.e., 8dBil) or a 14-element Yagi directional antenna (gain-14dBil). The output power is adjustable from 30 to 44 dBm in 1 dB steps. Antenna selection will be via a manual RF switch. Figure 1 below illustrates the ground radio station configuration.



Additional details on the components that make up the radio station are provided below, and the attached pdf pages.

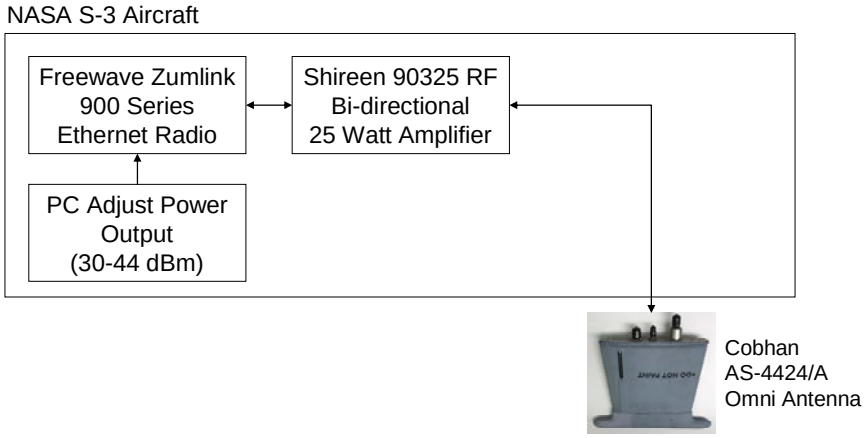
[1] Freewave, Zumlink, 900 Series Ethernet Radio operating in the Frequency Range 902 to 928 MHz, see; http://www.freewave.com/products/zumlink-900-series/

[2] Shireen, Item # 90325 RF Bi-directional amplifier with Operating Range 902 - 928 MHz Transmit Power 44 dBm, 25 Watt, see; http://www.shireeninc.com/wp-content/uploads/2011/01/Specs-90325.pdf

[3] Antenex, OMNI-DIRECTIONAL ANTENNAS, FG9026 (902 - 928 MHz), see; https://www.arcantenna.com/laird-fg9026-65-inch-outdoor-rated-900mhz-fiberglass-omni-antenna-with-fixed-n-female-connector.html?gclid=Cj0KCQjw8MvWBRC8ARIsAOFSVBUNC2F6TasVjsgxeEX6ULLquZC1RzHzzEQe3lzjLmT-VKdHeo-YEOkaAsovEALw_wcB

[4] HyperLink Wireless 900MHz (824-960MHz) 14 dBi High Performance Yagi Antenna for ISM, GSM and Wireless LAN Systems, Model: HG914YE, see; http://www.l-com.com/wireless-antenna-900-mhz-14-dbi-al-yagi-antenna-n-female-connector

The ground radio station will communicate to a mobile airborne S-3 Aircraft that is comparably equipped with the Freewave Ethernet Radio, 25 Watt amplifies, but will transmit via a omni-directional antenna that is mounted on the bottom of the aircraft. The aircraft will communicate with the radio grounds station while it operates in and around the Athens, OH ground stations within the operational polygon identified. This mobile S-3 Aircraft configuration is illustrated below.



Antennas on Bottom of S-3

Additional details on the omni antenna used on the mobile aircraft is shown below and the attached pdf pages.

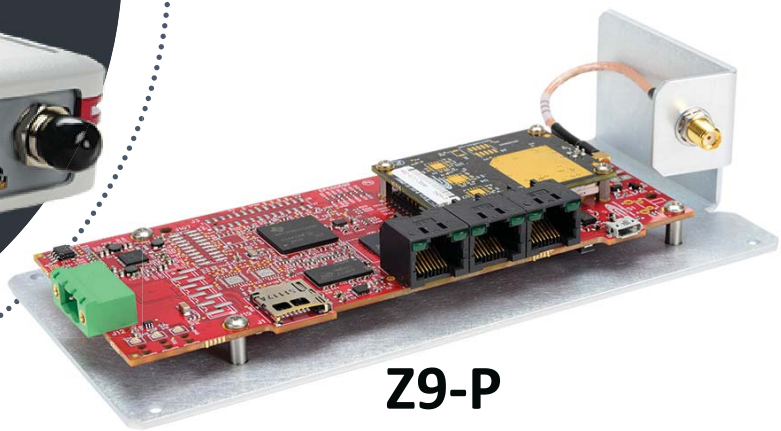
[5] Cobham, Chelton, AS-4424/A Type 12-190-6 antenna with a gain estimated to be 0 dBi in the frequency band of 902-928 MHz.

POC: Chris G. Bartone, Ph.D., P.E., (FRN 0025370479) Professor, School of EECS, 349 Stocker Center, Athens, OH 45701, 740-591-1660 (m), bartone@ohio.edu

ZUMLINK™

900 Series Ethernet Radio

Z9-PE



Z9-P

KEY FEATURES

Multi-High Speed Data Rates™:
Five RF Link Rates supporting throughputs from 80 kbps to 4 Mbps.

Programmability:
Flexible user configuration along with acceptance of 3rd party applications.

ZumBoost™ Network Acceleration Pack:

- Packet Compression: Minimizes packet transmission
- Packet Aggregation: Maximizes network efficiency
- Forward Error Correction: Improves network reliability
- Adaptive Spectrum Learning: Reduces the impact of interferences

Security: 128-bit and 256-bit AES counter mode encryption.

Long Range: Up to 60 miles line of sight.

User Selectable Channels:
Manipulate channel settings to assure highest performance.

Low Current Consumption:
355 mA @ 12V in transmit
100 mA @ 12V in receive

Reliable Communication:
CRC, FEC, and ARQ

OVERVIEW

FreeWave's new ZumLink™ 900 series platform, part of our Sensor-2-Server™ solution delivers secure collection, transport and control of data. The ZumLink 900 Series currently operates in the unlicensed 900 MHz spectrum supporting link rates up to 4 Mbps and is user configurable.

This cost effective, high-speed, rugged communication platform is specifically designed for outdoor industrial locations and is reliable under extreme environmental conditions. Its advanced technology makes it ideal in field area networks for oil and gas, utilities, mining, facility automation, municipalities, disaster recovery, or any industrial application that needs extremely reliable communications.

ZumLink's flexible, high speed, low power consumption radios also leverages FreeWave's ZumBoost™ Network Acceleration Pack to assure the most efficient network platform possible. ZumBoost introduces techniques such as compression, packet aggregation, forward error correction, and patent-pending Adaptive Spectrum Learning technology to ensure maximum throughput to meet the demands of today's wireless applications.

Virtually any M2M, SCADA, or Industrial IoT application can benefit from the enhanced features provided by our ZumLink products. The products support SSH, SNMP, and AES encryption.

Industry's 1st Programmable Radio

A very powerful new break-through technology – ZumLink includes the ZumIQ Application Environment which allows the development and deployment of third-party applications and puts intelligence at the edge. ZumIQ provides a Linux-based Debian operating system and storage for applications built in Node-RED, JavaScript, Java, Python and C++.

FreeWave's ZumLink 900 Series and Sensor-2-Server communication solutions have been designed to provide the performance, reliability, and quality that our customers have come to know and expect in our products.

All radios are designed, manufactured, and tested in Boulder, CO.

TECHNICAL SPECIFICATIONS

TRANSMITTER

Frequency Range	902 to 928 MHz
Output Power	Up to 1W; user selectable
Data Link Range	60 miles
Modulation	GFSK and 8-ary FSK
Channel Sizes	230.4, 345.6, 691.2, 1382.4, 3225.6 kHz
RF Data Rates	115.2, 250, 500 kbps, 1 & 4 Mbps
Hopping Channels	Up to 112; RF Data Rate Dependent
Hopping Patterns	Up to 16, RF Data Rate Dependent
Hopping Rates	400ms, 200ms, 100ms, 50ms, 25ms
Protocol	Adaptive Spectrum Learning

RECEIVER

IF Selectivity	> 40 dB
System Gain	136 dB

Sensitivity

RF Data Rate	Without FEC	With FEC
115.2 kbps	-105 dBm	-108 dBm
250 kbps	-102 dBm	-105 dBm
500 kbps	-99 dBm	-102 dBm
1 Mbps	-95 dBm	-98 dBm
4 Mbps	-83 dBm	-86 dBm

DATA TRANSMISSION

Error Detection	CRC, FEC, and ARQ
Link Throughput	Up to 1.6 Mbps; 4 Mbps with Compression
User Interface Rates	Ethernet Rate 10/100 Mbps Serial Rate up to 250 kbps
Data Encryption	128-bit and 256-bit AES CCM
Advanced Features	Packet Compression and Packet Aggregation

THIRD PARTY APPLICATIONS

Storage	1 GB
RAM	512 MB

INTERFACES

Data Connectors	Three RJ-45 (1 Ethernet, 2 Serial)
USB Connector	Micro USB
RF Connector	**Z9-P**: SMA **Z9-PE**: TNC
Power Connectors	**Z9-P**: Phoenix (#1776692) **Z9-PE**: Circular (#CRD-021717-02-A)

POWER REQUIREMENTS

Operating Voltage	+6 to +30 VDC (± 10%)
Transmit Current	355 mA @ 12 VDC
Receive/Idle Current	100 mA @ 12 VDC

GENERAL INFORMATION

Operating Temperature

Z9-P:	-40°C to +85°C
Z9-PE:	-40°C to +75°C

Dimensions

Z9-P:	177.29mm L x 83.06mm W x 40.89mm H
Z9-PE:	191.04mm L x 109.47mm W x 41.91mm H

Weight

Z9-P:	172.37g
Z9-PE:	750g

Humidity	0 to 95%, non-condensing
Reliability	62,000 hour MTBF
Safety	Class 1 Div 2 Groups A-D

UL — **Z9-P** — **Z9-PE**

INFORMATION TO ORDER

Model Number	Description
Z9-P	Board Level Unit, 902-928 MHz
Z9-PE	Enclosed Unit, 902-928 MHz
Z9-PE-AUS	Enclosed Unit – Australia, 915-928 MHz
Z9-PE-DEV	Enclosed Unit for lab/development
Z9-PE-DEVKIT	Includes 2 Z9-PE-DEV units and accessories

SOLUTIONS

DRONES & ROBOTICS · EARTH MONITORING · GOV & DEFENSE · IRRIGATION & PRECISION · ASSET TRACKING · OIL & GAS · WATER & WASTEWATER · SMART CITIES · UTILITIES

CONTACT US

5395 Pearl Parkway, Boulder, CO 80301
TF: 866-923-6168 T: (303) 381-9200
For more information, visit www.freewave.com

900 MHz, 25Watt Amplifier
Outdoor unit

This high power, bi-directional amplifier is designed for 902~928 MHz radio products. Works equally well with all types of radios.

Designed in a completely weatherproof housing for all outdoor applications. The unit is powered over coax with DC injector.

Item # 90325

Salient Features:

1. **Transmit Gain**: The unit provides 20 dB of gain which can be reduced at factory.
2. **LNA:** The built-in Low Noise Amplifier with signal gain of 19 dB with a ultra low noise figure of only 1.2dB. Improves the receive sensitivity of remote equipment, while keeping noise level very low.
3. **Receive Filtering**: All radio equipment contain filter for receive path. The band pass filter on this amplifier gives added protection against out of band noise.
4. **Enclosure**: The unit is housed in machined, Anodized Aluminum enclosure, designed according to the location of critical components. With appropriate cavities and contacts the PCB performs optimally and **NO heat sink** is needed.
5. **DC Injector**: With only 0.8dB insertion loss, this DC injector is the lowest loss available anywhere. Enclosed in a specially designed machined aluminum housing.
6. **Warranty**: All Shireen's products come with 2-year warranty.

The complete set includes:

1. The Outdoor Amplifier,
2. DC injector, and
3. Universal power supply (110~240VAC to 28 V DC)

Specifications

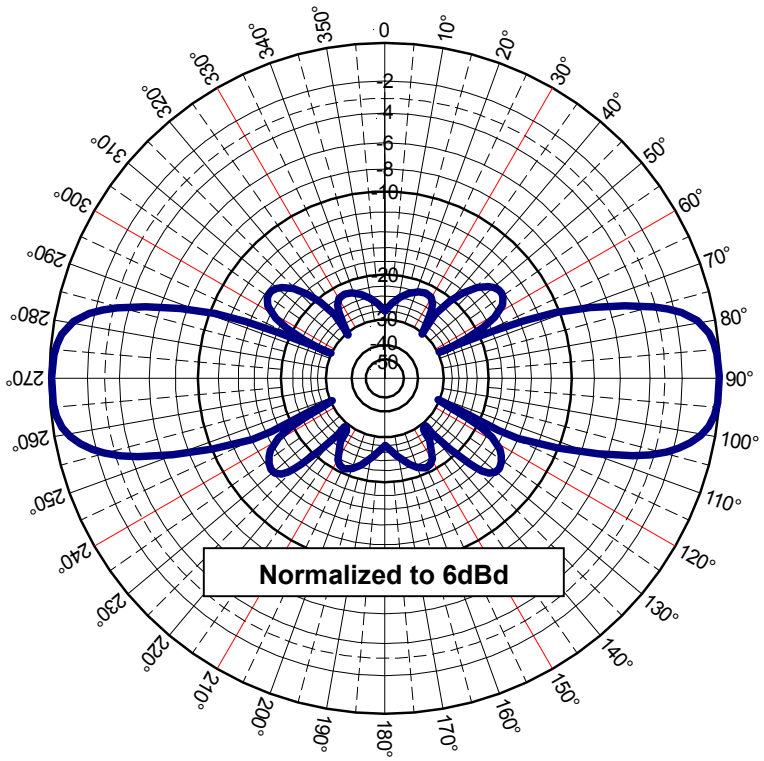
Electrical:

Operating Range	902 - 928 MHz
Operating Mode	TDD, Time Division duplex,
Transmit Power	44 dBm, 25 Watt
Transmit Gain	20 dB max
Transmit input Power	0 dBm min 24 dBm max
Receive Gain	26 dB
Noise Figure	1.2 dB
LED indicators	Red for Receive (Default mode) Green for Transmit
Power Consumption	260mA Rx, 1300 mA Tx @ 28VDC
Operating Temp	-40 °C to + 70 °C

Mechanical:

	Amplifier	**DC Injector**
Dimension:	6" x 3.5" x 1.2" (152.4mm x 88.9mm x 41.91mm)	1.4" x 3.5" x 1.0" (35.5mm x 88.9mm x 25.4)
Enclosure:	Watertight machined aluminum housing with Anodized finish	Machined aluminum housing with Anodized finish
Connectors:	Type N female	Type N female
Weight:	1.51 lb (685 g)	2 Oz. (134 g)

OMNI-DIRECTIONAL ANTENNAS
FG9026 (902 - 928 MHz)



Elevation Pattern (Y, Z or H-plane)

FEATURES

- **High Performance**
- **Easy installation /w optional FM2**
- **Special UV treated radome, resists sun damage**
- **N Female industry standard connector**
- **100% tested on a network analyzer**

ELECTRICAL SPECIFICATIONS

Frequency Range:	902 - 928 MHz
VSWR:	< 1.5:1 Max
Nominal Gain:	6dBd
Maximum Power:	100 W
Nominal Impedance:	50Ω
Polarization:	Vertical
Pattern:	Omni-Directional
Half-Power Beamwidth: (Elevation° x Azimuth°)	30° x 360°
Coaxial Cable Length & Type:	None
Termination:	N-Female connector
Lightning Protection:	Lightning Arrestor LABH350NN (Sold Separately)

MECHANICAL SPECIFICATIONS

Height:	61”
Diameter:	1.310”
Weight:	0.5 lb
Rated Wind Velocity:	125mph (210kph)
Rated Wind Velocity (with 0.5” radial ice)	85mph (137kph)
Lateral Thrust @ 125mph WIND VELOCITY	57 lbs. (26kg)
Wind Resistance in Sq. Feet:	0.5549
Mounting Information:	FM2 Mounting Kit (Sold separately)

2000-205 Bloomingdale Road • Glendale Heights, Illinois 60139 U.S.A. • Web Site: Http://www.antenex.com
630-351-9007 • Fax: 630-351-9009 • Order line: 800-323-3757

HyperLink Wireless 900MHz (824-960MHz) 14 dBi High Performance Yagi Antenna for ISM, GSM and Wireless LAN Systems

Model: HG914YE

Applications and Features

Applications:

- 900MHz ISM Band
- Wireless LAN systems
- Point to multipoint applications
- Non Line of Sight (NLOS)
- GSM
- RFID
- SCADA
- Wireless Video Links
- 900MHz Cellular

Features:

- Superior performance
- 30° beam-width
- Heavy-duty Anodized Aluminum boom
- Heavy-duty Anodized Aluminum elements
- Solid 1/4" mounting plate
- 15 inch Low Loss Coax lead
- Includes mount kit

Product Description

Superior Performance

The HyperGain® HG914YE High-Performance Yagi Antenna combines high gain with a wide 30° beam-width. It is ideally suited for directional applications in the 900 GHz ISM and GSM bands as well as Non Line of Sight (NLOS) and Point to Multi-Point installations. Typical applications include 900 MHz Wireless LAN, SCADA, Wireless Video Links, 900 MHz Cellular, Non Line of sight (NLOS) applications and point to multi-point systems. External interference of this antenna is minimized due to the excellent front to back ratio. The antenna comes with a 15" Low Loss coax lead terminated with one of these standard connectors (N-Female, N-Male, RP-SMA Plug, SMA Male), others are available. The antenna can be installed for either vertical or horizontal polarization applications.

Rugged and Weatherproof

This antenna features a heavy-duty Anodized Aluminum boom and elements. Secure mounting is assured by a solid 1/4" mounting plate and two stainless steel U-bolts.

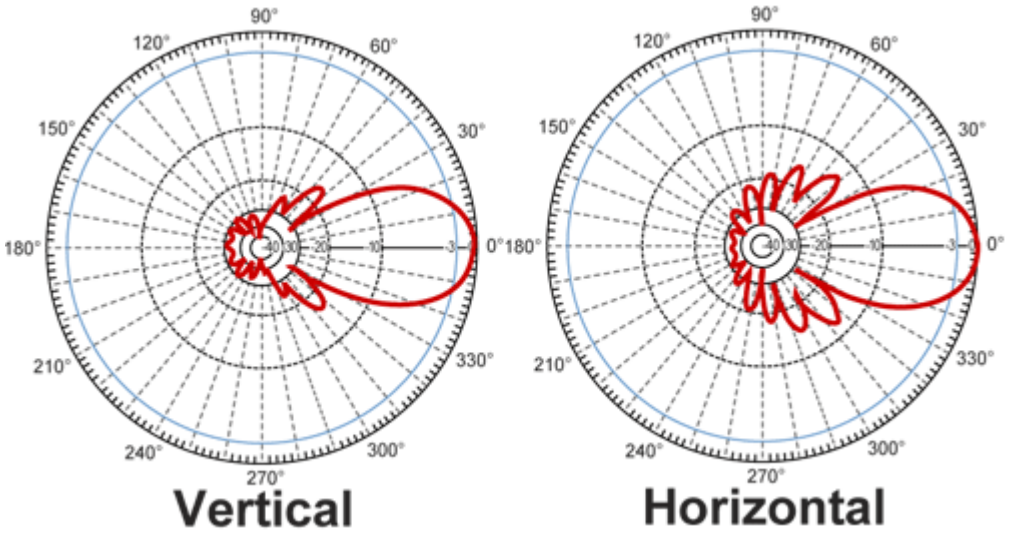
Model: HG914YE

Specifications

Electrical Specifications

Model	HG914YE
Frequency	824-960 MHz
Gain	14 dBi
Polarization	Horizontal or Vertical
Horizontal Beam Width	31°
Vertical Beam Width	26°
Front to Back Ratio	15 dB
Impedance	50 Ohm
Max. Input Power	100 Watts
VSWR	< 1.5:1 avg.
Elements	14
Weight	2.7 lbs. (1.22 kg)
Length	55.1 in. (1.40 m)
Mounting	2 in. (51 mm) diameter mast max.
Operating Temperature	-40° C to 85° C (-40° F to 185° F)
Lightning Protection	DC Short
Connector	N-Female, N-Male, RP-SMA Plug, or SMA Male
Wind Survival	135 MPH
RoHS Compliant	Yes

RF Antenna Gain Patterns

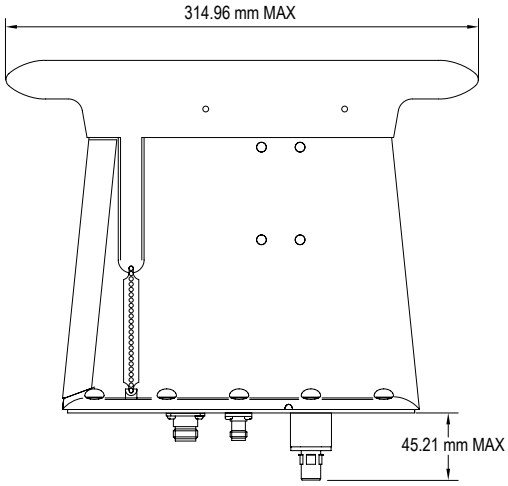


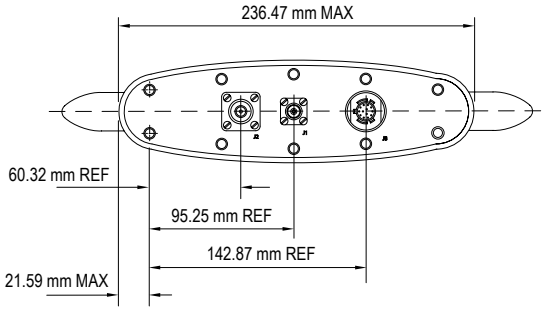
Type 12-190-6/1

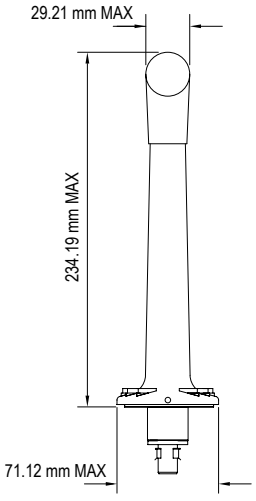
Low Profile Tuned Antenna
30 MHz - 400 MHz / 960 MHz - 1220 MHz

12-190-6#1-DS Issue 1

The most important thing we build is trust







The **12-190-6/1 Low Profile Tuned Antenna** is a high efficiency PIN diode tuned antenna operating over the frequency ranges 30 MHz to 400 MHz and 960 MHz to 1220 MHz, and intended for general airborne application.

The antenna offers a guard facility whereby performance is maintained at 121.5 MHz and 243 MHz when switched to any frequency within specified operating bands.

The antenna is configured as an electrically short monopole in which, at VHF and UHF frequencies, the capacitance between the top tube and ground is tuned out by a series of binary related PIN diode switched inductors in accordance with encoded data from the transmitter. Radiation resistance compensation is provided by a capacitive transformer.

Guard performance is provided by a separate radiating element, internally diplexed via a 243 MHz tuned circuit.

The L-band antenna is configured as a co-phased couplet of folded monopoles. Transmission line techniques are incorporated to provide decoupling from the VHF and UHF circuitry

The **12-190-6/1** comprises a pressure moulded grp shell housing the electronics assembly and enclosed by an aluminium alloy baseplate carrying the connectors. At the top of the shell is fitted a double tube arrangement in a coaxial configuration. The inner is connected to the radiating structure and the outer aluminium alloy sheath is connected to a diverter strip, thereby providing a lightning strike protection system. A polyurethane leading edge strip is fitted as standard.

Type 12-190-6/1

Low Profile Tuned Antenna

Electrical Specification

Frequency	30 MHz - 88 MHz 108 MHz - 174 MHz 225 MHz - 400 MHz 960 MHz - 1220 MHz	
Gain	Gain (dBi)	Frequency (MHz)
	≥-14.5	30 rising to 88
	≥-4.5	88
	≥-3*	108 - 174
	≥ 0*	225 - 400
	≥ 0*	960 -1220
	* average	
Polarisation	Essentially vertical when mounted vertically	

Power Rating	Rating	Frequency (MHz)
	FM 23 W	30 - 88
	FM 23 W	108 - 174
	FM 23 W	225 - 400
	AM 15 W + 100% modulation	118 - 156
	AM 15 W + 100% modulation	225 - 400
	1.5 kW peak, 0.4% duty cycle	240 - 400

Impedance	50 ohm (nominal)	
VSWR	VSWR	Frequency (MHz)
	≤ 2.5:1	30 - 88
	≤ 2.5:1	108 - 174
	≤ 2.3:1	225 - 299.9
	≤ 2.0:1	300 - 400
	≤ 2.0:1	960 - 1000
	≤ 1.8:1	1000 - 1100
	≤ 2.0:1	1100 - 1220
Connectors	TNC Type Female N Type Female	30 MHz - 400 MHz 960 MHz - 1220 MHz

Mechanical Specification

Dimensions (mm)	234.19 x 314.96 x 71.12
Weight (kg)	1.59
Mounting	10 holes fixed location

Environmental Specification

High Temperature	Operational: Storage:	+71°C +95°C
Low Temperature	Operational: Storage:	-54°C -62°C
Altitude	70,000 feet	
Acceleration	13.5 g all axes	
Shock	15 g, 11 ms, functional	
Vibration	MIL-STD-810D, Method 514.3, Procedure I MIL-STD-810E, Method 514.4, Procedure I, Cat 6 (modified) RTCA DO-160C Section 8 Cat L Fixed Wing Cat Y Helicopter	
Temperature Shock	10°C per minute between operational limits	
Humidity	Normal operation with relative humidity up to 95% at 60°C	
Rain	Normal operation when exposed to driving rain	
Salt Fog	The antenna will not be degraded by salt exposure up to 48 hours at 5% salinity.	
Magnetic Effect	The compass safe distance will not be more than 300 mm	

For further information please contact:

Cobham Antenna Systems
The Cobham Centre
Fourth Avenue, Marlow,
Buckinghamshire, SL7 1TF England
Tel: +44 (0)1628 472072
Fax: +44 (0)1628 482255
Email: antennasystems.marlow.marketing@cobham.com