HELI-CODER™ 4 TRANSMITTER
Operation Manual

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Add Additional Figures and Software Installation Section.	December 2012	Rev A
Amend DO-160 compliance table	July 2013	Rev B
Amend for references to encryption options	December 2013	Rev C
Amend FCC & Channel Bandwidth	June 2014	Rev C1

Conventions Used in This Manual

1.

NOTE: Notes provide supplementary information. They are highlighted for emphasis, as in this example, and are placed immediately after the relevant text.

CAUTION: Cautions give information which, if strictly followed, will prevent damage to equipment or other goods. They are boxed for emphasis, as in this example, and are placed immediately preceding the point at which the reader requires them.

WARNING: Warnings give information which, if strictly observed, will prevent personal injury or death, or damage to personal property or the environment. They are boxed and shaded for emphasis, as in this example, and are placed immediately preceding the point at which the reader requires them.

2. ATTENTION!

DO NOT use right-angle connectors or adapters on the RF Power Out cable assemblies. Right-angle connectors may have significant RF power loss at the operating frequencies of this system.

3.

FOR ALL BMS TRANSMITTERS – Operation of a BMS transmitter product generally requires a license. It is the responsibility of the user to obtain all required operating licenses.

4.

ONLY FOR PRODUCTS AWAITING FCC CERTIFICATION – This device has not been authorized as required by the rules of the US Federal Communications Commission. This device is not, and may not be, offered for sale or lease, or sold or leased, in the US until authorization is obtained.

Acceptance Test Procedure (ATP) test data results by product serial number are typically shipped with all units and indicate the equipment to be operating within advertised specifications. Contact BMS to request this data.

Read and Follow Instructions! All safety and operating instructions should be read before this product is operated. All operating and use instructions should be followed. This manual should be retained for future reference.

EMC Compliance – This equipment is certified to the EMC requirements detailed in the technical specifications. To maintain this certification, only use the cables supplied or if in doubt contact BMS Customer Service.

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1   INTRODUCTION

This document provides instructions for installation, operation and maintenance of the Heli-Coder 4 (HC4) COFDM Transmitter controlled by a DLC50 Downlink Control Panel.

BMS offers a wide selection of airborne products to meet the video and data requirements of today's real world applications. The Heli-Coder™ 4 (HC4) together with the DLC50 controller provides a simple, powerful solution containing everything needed for high-quality, reliable transmission. This includes the video encoder, modulator, up-converter and high-power amplifier and an intuitive powerful control interface (see Figure 1.).

Standard COFDM modulation offers excellent performance in urban and non-line of sight environments with significant multipath. The HC4 also provides an integrated GPS data interface that reduces the components needed to integrate location data into tracking systems. The HC4 provides everything required to achieve 10 W output power in an ultra-compact case. The DLC50 control panel allows the HC4 unit to be mounted remotely within the avionics bay while providing full control from the flight deck.

With the flexibility of MPEG-2 and H.264 compression, the HC4 efficiently handles SD or HD video and can be configured to deliver high speed data as an ethernet radio. The HC4 is also Geo-Point™ capable. Geo-Point™ uses metadata supplied by the equipment serving as the video source and allows the display of bearing and distance to the location shown on the screen in real time. (Geo-Point™ requires a compatible receiver.)

NOTE: The standard version of the HC 4 is configured to be controlled by a DLC50 Control Panel. Custom configurations and control schemes may be supported. Contact BMS regarding your operational requirements and the range of solutions BMS offers.

Broadcast Microwave Services (BMS) is a leader in wireless digital microwave technology providing innovative products for the television broadcast, video, telemetry and surveillance industries. A wholly owned subsidiary of Cohu, Inc., BMS designs and manufactures a comprehensive line of microwave communications equipment for broadcasting sports venues, law enforcement and military applications. BMS also builds and integrates the command and control centers to provide fully functioning, complex, end to end digital systems.

For the latest product and system information please visit www.bms-inc.com.

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2   SAFETY

⚠️   **WARNING- RF Hazard: Non-Ionizing RF Emission**

Operators of this equipment should be familiar with basic RF equipment operation and safety concepts. Users must consider many unique factors to maintain RF safety. We offer the following guidelines with the recommendation that each individual and organization establish an RF Safety and Awareness program based on their combination of hardware and usage environment.

Radiation Exposure

The frequencies present in BMS equipment produce non-Ionizing radiation. The FCC reference document regarding RF exposure limits is OET Bulletin 65 and can be viewed by visiting the FCC web site (www.fcc.gov) or by clicking here;

http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf

(Link valid as of 6/25/2012)

We also reference EU Standard EN 50392 (02-2004). BMS references these standards as reasonable guidelines.

The OET 65 document sets maximum permitted exposure (MPE) and is widely cited within the U. S. and Canada. Exposure is divided into two categories, "controlled" and "uncontrolled" environment. The uncontrolled environment is the harshest criteria and applies to exposure where you may not be aware and/or cannot control the exposure. Examples are where a residence is located near a cell site or other radio tower. You live there, cannot remove yourself from the field and cannot control the RF. Exposure is long term and not in your control.

The "controlled environment" applies to most professional radio users. It is assumed they are trained in RF Safety, they are aware there is an RF field, exposure is limited by transmission duty cycles, the flight or testing ends, hang up the cell phone, put up the walkie-talkie, etc.

BMS recommends that operators use the uncontrolled exposure category from OET 65 as it applies to an uncontrolled environment; *a maximum power density limit of 1mW/cm².*

The limit table from Bulletin 65 is reproduced below. X axis is frequency and y axis is mW/cm².

Figure 1.   *FCC Limits for Maximum Permissible Exposure (MPE)*

Plane-wave Equivalent Power Density
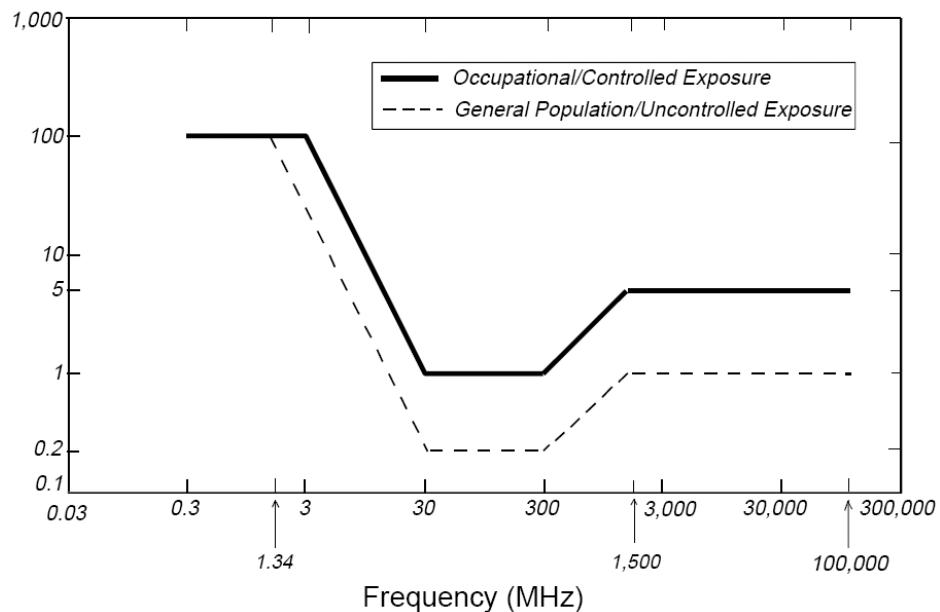
Use the formula from OET65 to determine the minimum recommended distance according to your individual usage circumstances.

Your organization should develop an understanding of its unique RF usage and create a plan to train personnel regarding recommended exposure limits according to the FCC and EU recommendations.

General Safety Rules;

a) Do not operate the transmitter or power amplifier with covers removed.

b) Never walk in front of directional antennas when radiating.

c) Switch off supplies before removing covers or disconnecting any RF cables, and before inspecting damaged cables or antennas.

d) BMS recommends returning the HC4 to the factory for service or repair.

In addition you can limit your exposure by raising awareness and using some common sense rules.

- Default to low power if available using hi-power only as required.

- Never stand in front of a transmitting directional antenna.

- Limit transmission duty cycles (turn on/off as needed).

Table 1 MPE per FCC OET65 (1.5 GHz to 100 GHz)

TRANSMITTER OUTPUT (w)	10							
ANTENNA GAIN dBi	0	2	4	6	9	11	14	22
UNCONTROLLED ENVIRONMENT: MINIMUM PERMISSABLE DISTANCE INCHES 1.005 mW/cm2	11.08	13.95	17.56	22.10	31.22	39.31	55.52	139.47
CONTROLLED ENVIRONMENT: MINIMUM PERMISSABLE DISTANCE INCHES (5.005 mW/cm2)	4.96	6.25	7.87	9.91	13.99	17.61	24.88	62.50

NOTE: Calculations do not factor reflections

3   PRODUCT DEFINITION

Figure 1. Heli-Coder 4 Transmitter

Table 2. Product connector descriptions in Figure 1

1	GPS Antenna Input	13	USB 2.0 port
2	28VDC Power	14	Mounting bracket (x2)
3	Ethernet port	15	Ethernet Status Indicators: Yellow SPEED LED: ON=100BaseT, OFF=10BaseT Green LINK LED: Flashing=Valid Ethernet Link, Off=NO Valid Ethernet Link
4	Communications Port Connector – RS-232		
5	RF Output (N-type)	16	**Power LED**: YELLOW when power cable plugged in; GREEN when unit turned on via DLC50 Control Panel **Alarm LED**: YELLOW indicates a transmit problem **TxEn LED (Transmit Enabled)**: YELLOW means Standby mode; GREEN means transmitter active
6	Audio Input		
7	Control cable Input (from DLC50 Control Panel)		
8	ARINC Connector (Reserved for future use)		
9	Analog Video Input (CVBS composite video)		
10	ASI (Asynchronous Serial Interface) video out		
11	ASI (Asynchronous Serial Interface) video in		
12	HD/SDI (Digital –uncompressed) video in		

3.1   Product Specifications

Frequency	6425-6525 MHz
Channel Bandwidth	6/7/8 MHz
RF Output Power	5W/10 W switchable
Modulation	• COFDM 2k • QPSK, 16/64 QAM • FEC 1/2, 2/3, 3/4, 5/6, 7/8 • Guard 1/4, 1/8, 1/16, 1/32 Other modulation available; consult factory
Video Encoding	H.264 (MPEG2 option)
Audio Encoding	MPEG 1, Layer II
Channels	Two audios, multiple wayside data channels up to 115kbit/s
Internal Test Generator	Video/Audio Test pattern
Local Control	External Control Panel*
Power Input	24 to 32 VDC (3 A @ 28 VDC)
Consumption	85 W @ RF-Output 10 W
Compliance	CE marked in accordance with EU Low Voltage and EMC Directives EMC Compliance: EN55022, EN55024
Operating Temp.	-15 to +55° C (5 to +131° F)
Storage Temp.	-55 to +85° C (-67 to +185° F)
Dimensions	5" W x 9" D x 6" H; 270 in.^{2} (127 x 229 x 153) mm
Weight	6 lbs. (2.73 kg)
FCC	This device has not been authorized as required by the rules of the Federal Communications Commission. This device is not, and may not be, offered for sale or lease, or sold or leased, until authorization is obtained. FCC (Part 74) product certification pending.
Regulatory (See section 10)	• FCC Parts 74, 90, 101 • RTCA DO-160, designed to be compliant • CE Mark

3.2   Model Information

PART NO.	MODEL	PROFILE
HC4-(xx)-H	H.264, SD/HD	SD=MP@L4 | HD=MP@L4; HP@L4
HC4-(xx)-M	MPEG2, SD/HD	SD=SP@ML; 422@ML | HD=SP@HL
HC4-(xx)-MH	MPEG2/H.264, SD/HD	MPEG2: SD=SP@ML; 422@ML | HD=SP@HL H.264: SD=SP@L4; HI422@L4 | HD=SP@L4

* where (xx) is center frequency in MHz

4   CONNECTORS AND PINOUTS
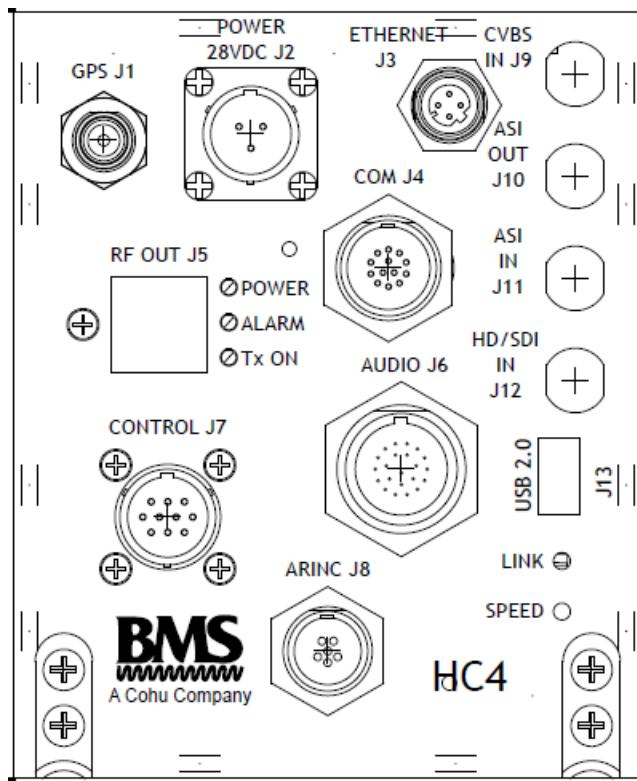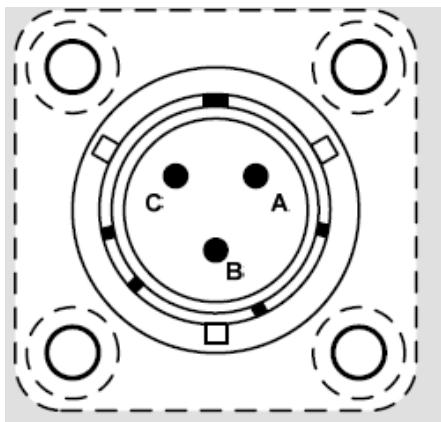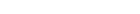
Figure 2 HC4 Front Panel Labels

Table 3. HC4 connectors

J1	GPS In (with optional DC Bias Out)	TNC(f), 50 ohm
J2	Power In	Souriau 3-pin male 851-02R12-3P50
J3	Ethernet	M12-4 Socket (early model used RJ45)
J4	COMM RS232 External GPS RS232 External AAAP RS232 KLV or Camera Metadata	Tri-Start, Size 11, 13 Socket
J5	RF Out	N(f), 50 ohm
J6	Analog Audio In (2 channels)	D38999-26WC, 35 pin
J7	Control Panel	Souriau (male) 10-pin
J8	ARINC 429 (reserved for future use)	D38999-26 WA355N socket
J9	CVBS In (NTSC, PAL)	BNC(f), 75 ohm
J10	ASI Out	BNC(f), 75 ohm
J11	ASI In	BNC(f), 75 ohm
J12	SDI, HD-SDI In	BNC(f), 75 ohm
J13	USB 2.0	Type A (Host)

Table 4. Connector pin outs

GPS

GPS J1

610006040, TNC(f), 50 ohm

GPS ANTENNA INPUT TNC CONN (FEMALE) 50 OHM	HC4
Provides variable DC bias or none.	SIGNAL
	SHIELDING GND

Power Input J2

3-pin SOURIAU (m)	HC 4
A	28VDC
B	GND
C	N/C

ETHERNET

ETHERNET J3

M12-4, 4 pin socket

USB 2.0 SERIAL DATA	HC4
SOCKET 1	TD+
SOCKET 2	RD+
SOCKET 3	TD-
SOCKET 4	RD-
	SHIELDING GROUND

COM J4

210069751, Connector Tri-start, Size 11, 13 Socket, PCB Tail

COM	HC4
1	GND
2	AERO RS232 TX
3	AERO RS232 RX
4	GND
5	TGT DATA RS232 TX, (KLV Data Tx)
6	TGT DATA RS232 RX (KLV Data Rx)
7-13	DO NOT USE

RF OUTPUTJ5

RF OUTPUT N-CONN(FEMALE) 50 OHM	HC4
UP TO 10W RF OUT COFDM	SIGNAL
	SHIELDING GND

Audio J6
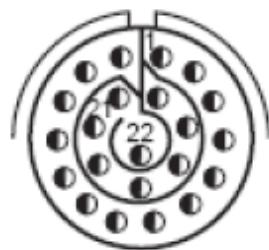
210069752, Connector Tristart size 13, 22Pin PC-tails

AUDIO	HC4
1	AUDIO 1 L GND
2	AUDIO 1 L+
3	AUDIO 1 L-
4	AUDIO 1 R GND
5	AUDIO 1 R+
6	AUDIO 1 R-
7-12	N.C.
13-22	DO NOT USE
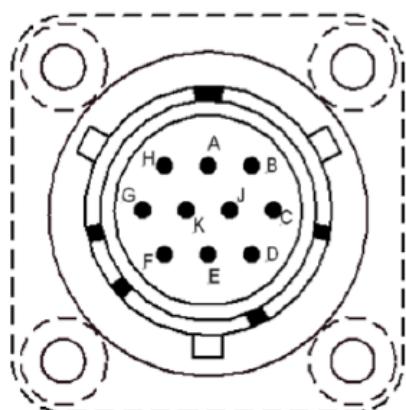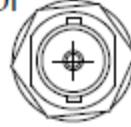
CONTROL J7

210004408, Connector Size 12, 10 Pins, PCB Tails

CONTROL PANEL	HC4
A	LOOP_OUT (RAW 28V OUT)
B	LOOP_IN (28V FROM DLC50)
C	NC
D	Remote control Rx
E	GND
F	Remote control TX
G	GND
H	NC
J	NC
K	NC

ARINC_J8

210069750,Connector, Tri_Start, Size 9, 6 Socket, PCB tail

ARINC	HC4
1	AOUT (ARINC 429 bus Tx)
2	BOUT (ARINC 429 bus Tx)
3	RIN A (ARINC 429 bus Rx)
4	RIN B (ARINC 429 bus Rx)
5	GND
6	GPS DATA Rs232RX

CVBS INPUT J9

BNC(f), 75 ohm

COMPOSITE VIDEO INPUT BNC CONN(FEMALE) 75 OHM	HC4
May be NTSC or PAL	SIGNAL
	SHIELDING GROUND

ASI OUTPUT J10

BNC(f), 75 ohm

ASI SERIAL DATA OUTPUT BNC CONN(FEMALE) 75 OHM	HC4
DVB-ASI SIGNAL	SIGNAL
	SHIELDING GROUND

ASI INPUT J11

BNC(f), 75 ohm

ASI SERIAL DATA INPUT BNC CONN(FEMALE) 75 OHM	HC4
DVB-ASI SIGNAL	SIGNAL
	SHIELDING GROUND

SDI INPUT J12

BNC(f), 75 ohm

HD OR SD SDI INPUT BNC CONN(FEMALE) 75 OHM	HC4
SERIAL DIGITAL VIDEO SIGNAL	SIGNAL
	SHIELDING GROUND

USB 2.0 J13

USB Type A socket

USB 2.0 SERIAL DATA	HC4
SOCKET 1	+5 VDC
SOCKET 2	Data -
SOCKET 3	Data +
SOCKET 4	Ground
	SHIELDING GROUND

5 INSTALLATION

Installation should only be performed by an FAA Certified A/P or Avionics Technician.

The HC4 and associated equipment should be installed in compliance with FAA regulations and accepted industry practices.

Other than allowing adequate air circulation above and below the transmitter, there are no set standards for placement of the HC4 equipment. The information in Table 5 is a guide for choosing the best placement for each component. Every aircraft installation is different, with unique interior space requirements to meet the needs of the pilot, operator and passengers. It is left to the customer to review the size, space, cable and ergonomic needs to best determine where the components should be installed.

The HC4 may be ordered with the HC4-CONN-KIT which contains all mating connectors except those locally available (BNC, N, and USB). Alternatively BMS will supply a partially assembled wiring harness upon order request.

Consult BMS regarding custom cable requirements

5.1 Locating the Components

Table 5. HC4 Component Placement Planning

Component	Space Requirement	Wt	Suggested Location	Connecting Component
DLC50 Primary Airborne Control Panel	4.9 in. x 5.75 in. x 1.5 in. 12.4 cm x 14.6 cm x 3.8 cm	<1 lb <.45 kg	Cabin, near operator	HC4
				2 AMP BREAKER
				(IF SUPPLIED) TAA-101
HC4 TRANSMITTER (with CT-A-MP mounting tray)	5" W x 9" D x 6" H (127 x 229 x 153 mm)	6 lb 2.72 kg	Usually baggage compartment but varies. Allow ventilation space above and below transmitter	DLC50
				Video-in
				Audio-in
				10 AMP BREAKER
				GA-35
				MAIN ANTENNA
				RS-232 DATA IN
				KLV DATA IN
GA-35 GPS Antenna	Unobstructed View 5 in. x 3 in. footprint 12.7 cm x 7. 6cm	.25 lb 0.11 kg	Top Exterior Tail (Varies)	HC4
Bulkhead Feed-Thru	Customer Furnished	Varies	Exterior Location (Varies)	RF Antenna

5.2   Fasteners

Installation of the HC4 is unique to every aircraft. It is left to the installer to provide the properly certified fasteners for the application.

5.3   Mounting the Transmitter

The HC4 transmitter should be mounted in aircraft or other craft using the BMS-supplied mounting bracket (BMS P/N 4414414000). The transmitter/bracket assembly must have adequate space above and below the unit to allow free air flow. Three thermostatically controlled fans contained within the HC4 chassis keep the unit at operating temperature.

1. Place the transmitter so that the two holes on its rear side fit the pins on the mounting bracket.

2. Tighten the mounting screw fasteners. Ensure the round nut captures the mounting bracket on the transmitter.

Figure 3 Transmitter mounting bracket

Figure 4 HC4 positioned in aircraft mounting bracket
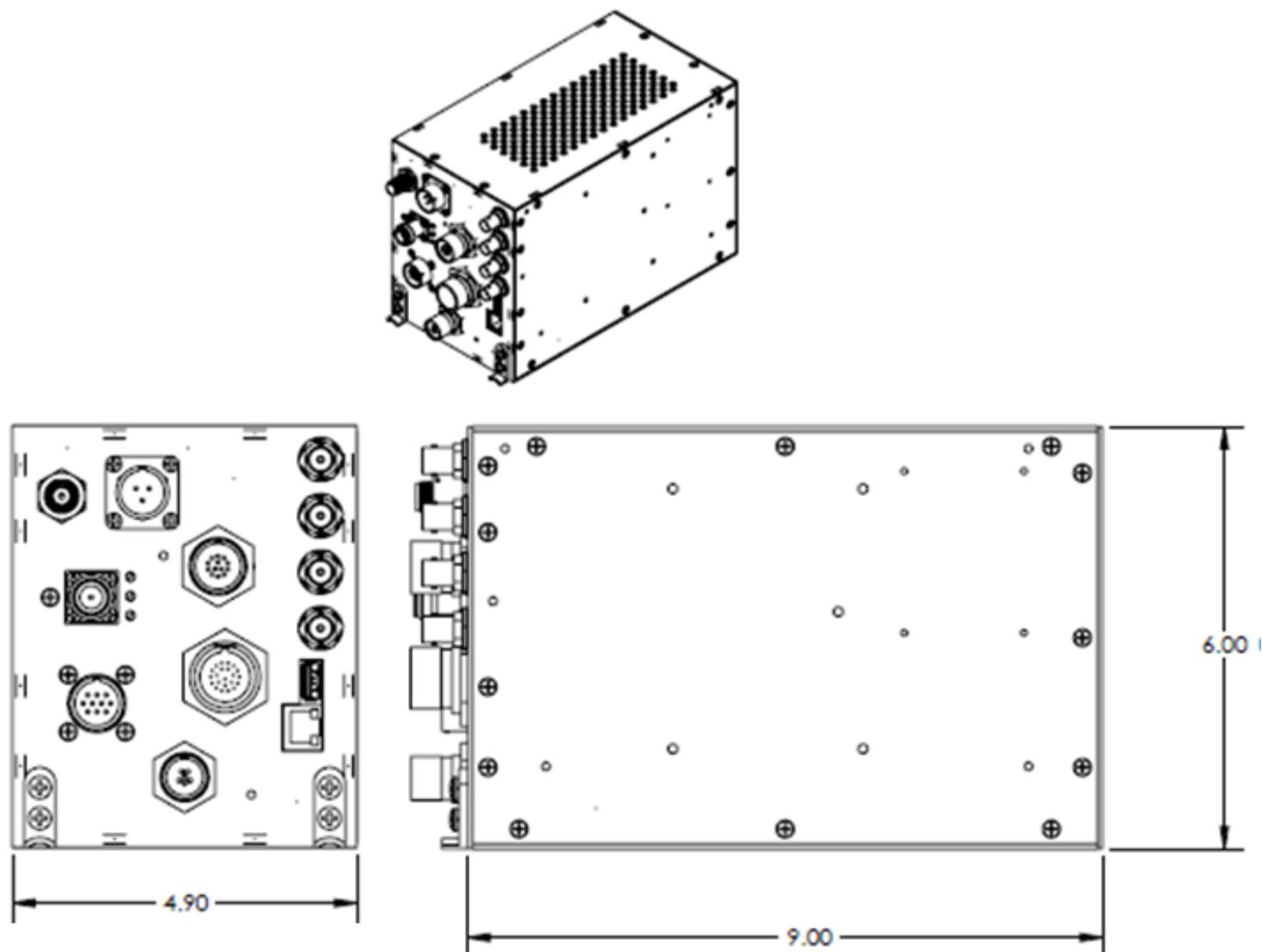
Figure 5 HC4 Outline Drawing
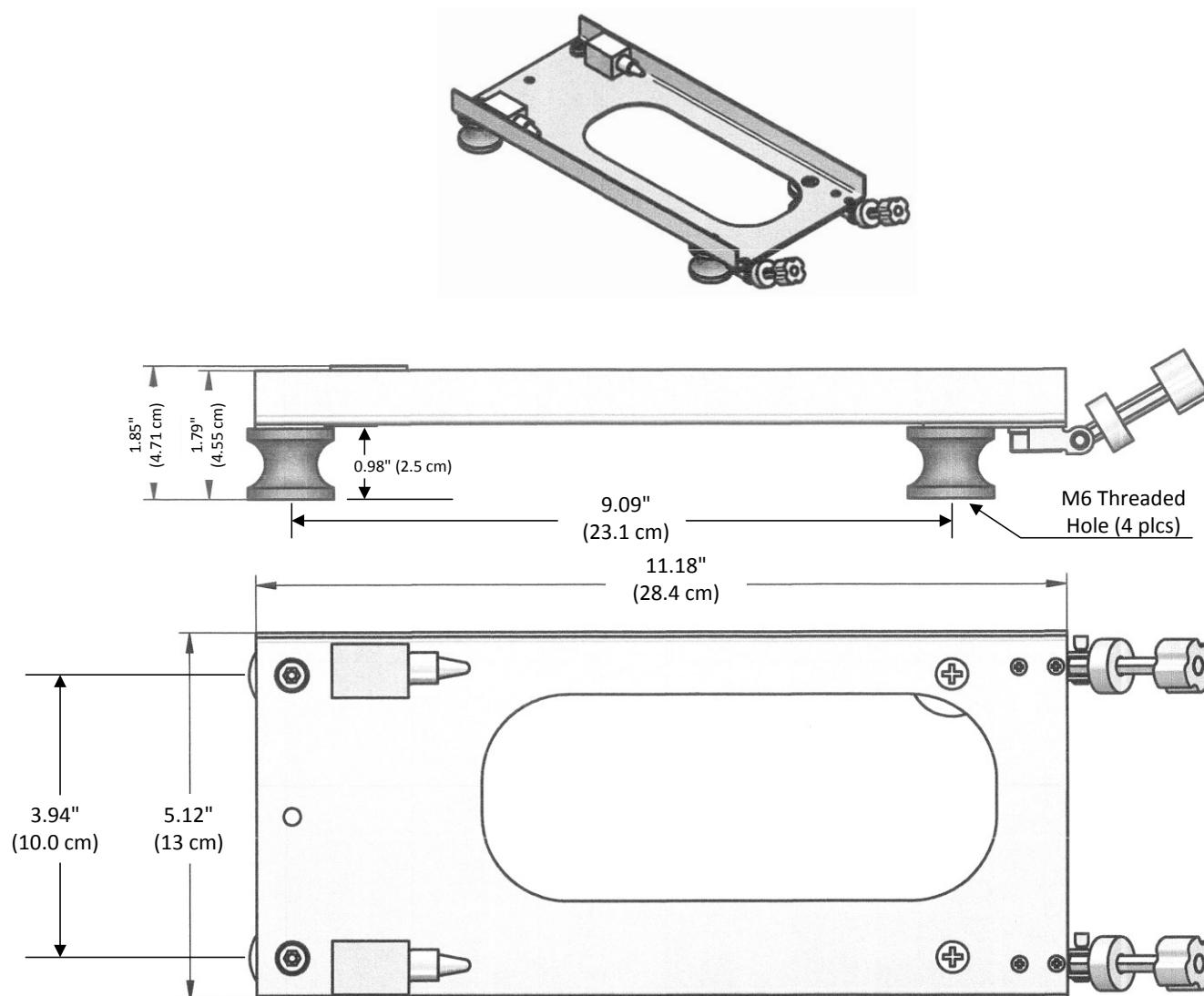
Figure 6 CT-A-MP HC4 Mounting Plate - Dimensioned Drawing

5.4   Wiring Connections and Signal Interfaces

Reference Figure 12 Typical airborne installation diagram (*without TAA-101 Antenna Actuator*)" and Figure 13 Wire Hook-Up Diagram for HC4 System" shown later in this document. Also reference section 16 of this manual titled "CONNECTION AND WIRING DIAGRAMS" during installation for detail related to a typical installation.

Contact BMS regarding issues related to custom or modified installations if applicable. Additional service or fees may apply.

5.4.1   Power Input (J2)

J2 connects aircraft 28VDC from an available 5 AMP breaker. Use AWG 20 gauge wire or larger.

5.4.2   Radio Frequency Output (RF Out) (J5)

⚠️   J5 conducts the radio frequency energy out to a transmit antenna. Achieving optimum link performance includes assuring a maximum RF energy is delivered to the antenna assembly via properly mated connector assemblies and well installed cables. RF cable should be 50Ω foam dielectric coaxial cable. Belden type FSJ-50A or equal is recommended. Cable lengths should be as short as practical in the installation to reduce RF loss. Observe the cable manufacturer's minimum "bend radius" recommendation during installation. Kinks, pinches, or sharp bends in high frequency cable will cause significant power losses.   Check all connections for proper termination and use high-quality type N connectors. Hand-tighten connectors; do not use a wrench or pliers as over-tightening will damage a connector and reduce the system performance by introducing RF loss in the transmission line. Seal mated exterior connections with self-vulcanizing rubber tape in order to avoid moisture in the connection joint which may also introduce RF loss or physically damage the connector over time.

It is good practice to avoid the use of 90° elbow adaptors within the RF coax cable run.

5.4.3   Serial Digital Video Input (J12)

J12 is a standard 75Ω BNC jack that is for a Serial Digital Interface. This is the digital video signal that comes out of most modern video cameras. The signal may be standard definition SDI (SMPTE-270) or high definition HD-SDI (SMPTE-292). A high quality, double shielded coaxial video cable should be used such as Belden 8281 or equal. Take care to terminate the cable with a 75Ω BNC plug.

5.4.4   Composite Video (CVBS) Input (J9)

J9 accepts a standard definition composite video signal (PAL or NTSC). Follow the same cabling instructions as in 5.4.3.

5.4.5   ASI Input

J11 accepts an asynchronous serial input (ASI) also known as DVB-ASI (digital video broadcasting). The signal consists of a compressed MPEG transport stream. The input by-passes the internal encoder built into the HC4 and goes right into the modulator. This allows use of external video or data encoders whose outputs are an ASI transport stream. **The input must conform to the ISO/IEC 13818-1 standard**. Follow the same cabling instructions described in section 5.4.3.

5.4.6   ASI Output

J10 ports out an ASI transport stream consisting of the encoded video currently being transmitted by the HC4. This output allows external monitoring of the compressed signal and the use of a backup transmitter or other configurations. Follow the same cabling instructions described in section 5.4.3.

5.4.7   Audio Input

J6 is a multi-pin connector where pins 1-6 are dedicated to two balanced audio channels, each 600Ω impedance. Use a high quality shielded twisted pair audio cable.

5.4.8   GPS

J1 is an input connector for an external GPS antenna. The recommended antenna is a Garmin GA 35 but other antennas will work. The output connector is a TNC(f) and should be cabled with a good quality 50Ω coax. Follow the antenna manufacturer's instructions for cable/ connector type and cable length.

A switchable (on/off) and adjustable (0-10VDC) DC voltage bias is supplied on the center pin of the connector to power the amplifier in the GPS antenna. The DC bias voltage is adjustable during the HC4 set-up operation.

5.4.9   Data Wayside Input

J4 is a multi-pin connector for interfacing data to be transmitted with the video transport stream. The data wayside interface is RS-232 from between 1.2 to 115 kb/s.

5.4.10   KLV Data

J4 has a second channel for KLV data transmission. The interface is RS-232 from between 1.2 to 115 kb/s.

5.4.11   Auxiliary Data

J4 offers an auxiliary data interface for RS-232 data for speeds from 1.2 to 115 kb/s.

5.4.12   Ethernet

Field installation of the connector is difficult so no standalone mating connector is available. Instead, a 10-meter M12 to RJ45 cable assembly is available that may be used as-is or cut to length and re-terminated as required.

Ordering information for the cable;

P/N 610000411   Cable Assembly, M12 Male to RJ45 plug, 4 Pin Ethernet, 10m (32.8 FT)

Contact the factory for price and availability.

J3 is associated with two LED's on the lower right of the HC4 labeled SPEED and LINK. The LED's mirror those found on a standard RJ45 LAN port and indicate the following;

SPEED   Yellow LED:
   ON=100BaseT
   OFF=10BaseT

LINK   Green LED:
   Flashing=Valid Ethernet Link
   Off=NO Valid Ethernet Link

The Ethernet port can be used for command and control of the HC4 in a standard LAN configuration. This may be desired where the mission hardware must be controlled from a central operator's console running a custom PC application. A detailed discussion for this configuration is beyond the scope of this document. BMS will provide instructions, a command set, and reasonable support to any customer desiring this type of control ability.

In addition to Ethernet for command and control, an extension of the Ethernet port capabilities includes routing and data streaming capabilities in a unidirectional fashion. The HC-4 is interfaced to a local area network in the aircraft. The HC-4 can then be either controlled via the network interface, or forward unidirectional IP packets such as UDP over the radio link, or receive a data payload from an IP packet (either TCP or UDP) and convert that data into a format to be sent in the MPEG transport stream. A companion receiver (like the BMS SPRITE-PRO Series) recovers the packets and ports them out of an Ethernet connection.

5.4.13   USB

J13 is a standard USB 2.0 type A jack. It is normally left open and is used for software updates to the HC4. The jack accepts a USB drive or may be connected to a PC via a commonly available USB cable.

5.4.14   ARINC

J8 <Reserved for future use>

5.4.15   Control

J7 provides interconnection between the DLC50 control panel and HC4 transmitter.

6 TRANSMITTER OPERATION

6.1 Operating the Transmitter with the DLC50 Control Panel

The HC4 is designed for standard operation via a BMS DLC50 Control Panel. After wiring the transmitter according to the wiring diagram shown in the wiring and connection section the transmitter may be turned on via the power switch (PWR) located on the front face of the DLC50 Control Panel. All transmit channel selection, receive channel control, relay operation, and link configuration can be managed through the DLC50 menu structure and operated via the simple dual ring control knob, Basic control panel commands used with the transmitter are shown in Figure 9 DLC50 Commands" on the following page. See "Figure 10 DLC50 Outline" for outline dimensions for the DLC50.

For a full description of control panel operation and custom configuration instructions, consult the DLC50 control panel manual, BMS P/N 6051439500.

Figure 7 DLC50-A AVIONICS CONTROL PANEL (FRONT)

Figure 8 DLC50-A AVIONICS CONTROL PANEL (BACK)

6.2   DLC50 Menu Structure*
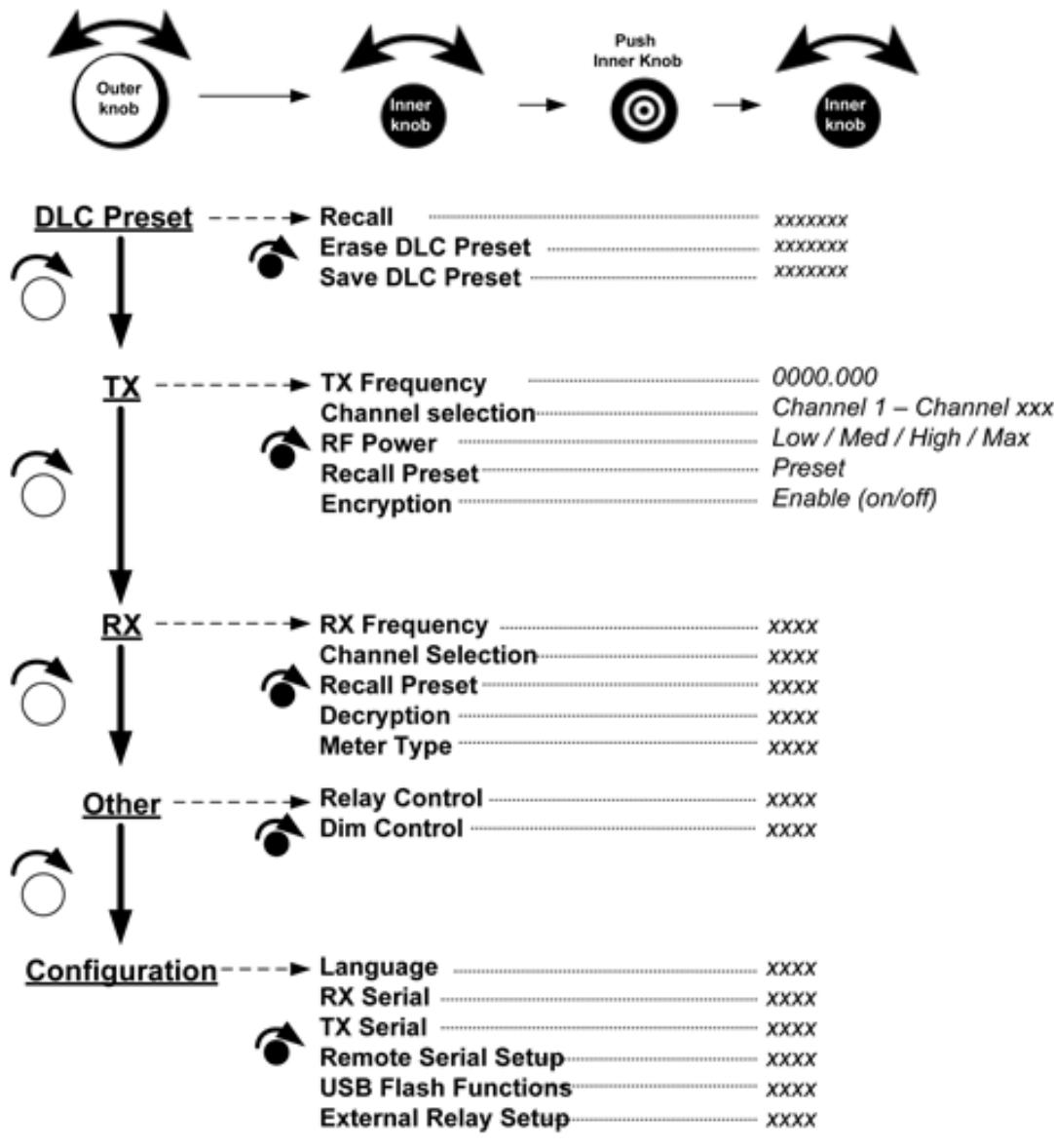
Figure 9 DLC50 Commands

*   For full DLC50 operation see BMS document 6051439500 "DLC50 Operating Manual"
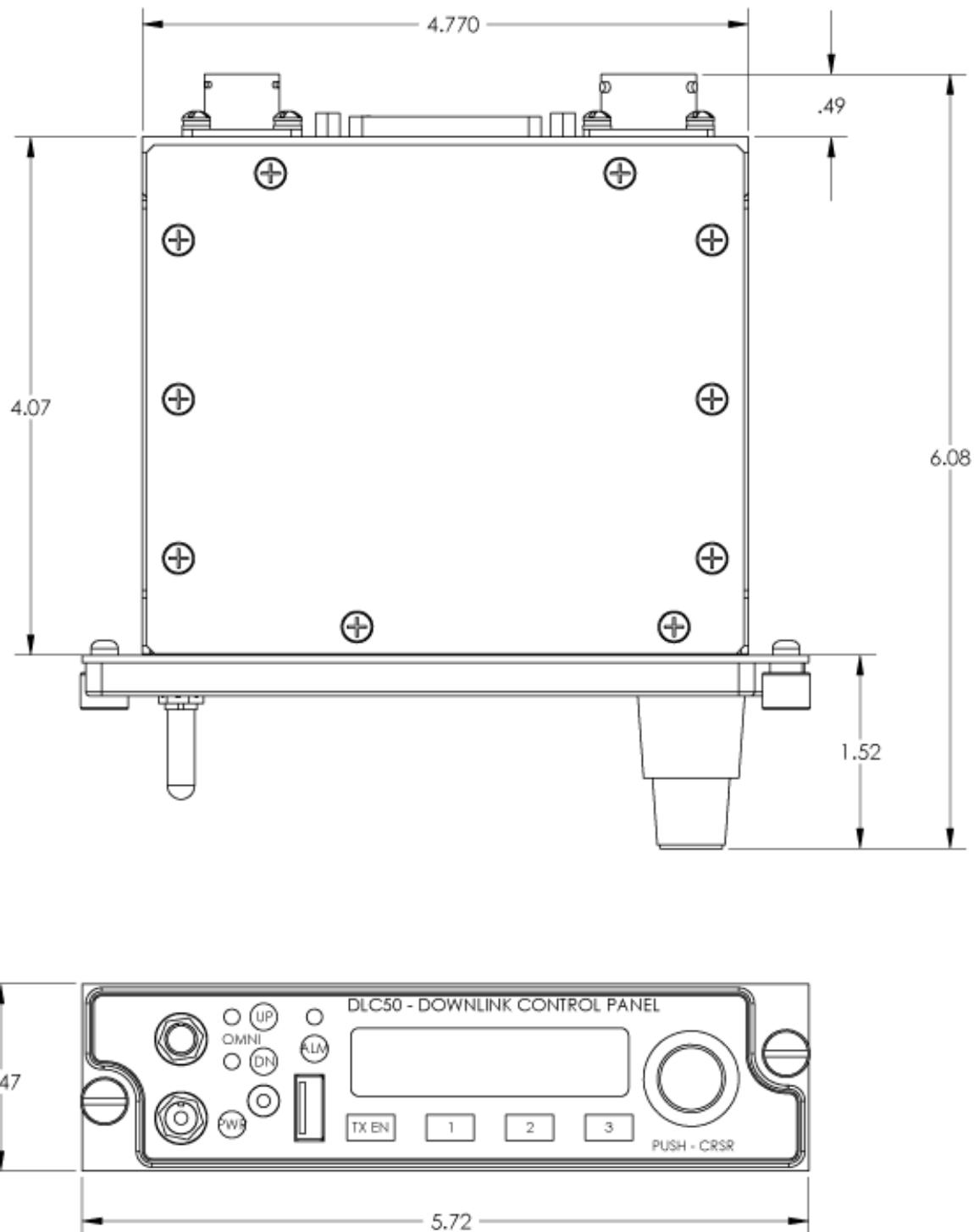
Figure 10 DLC50 Outline

7   BMS Geo-Point™ System

7.1   Geo-Point System Description

The Geo-Point System provides a method for ground personnel to instantly know the range and direction to the center point of live video they are viewing. Using information received from the camera sensor or on-board moving map, the CVIII+ hand-held receiver/monitor displays both real-time video and an easy to interpret compass "rose" that shows direction and distance information. Unlike other tactical systems that rely on external processors, Geo-Point direction information is developed within the handheld receiver.

The Plus model CVIII contains an integral compass and GPS receiver. Geo-Point software looks for a special word in the NMEA 0183 data stream known as Target Lat Long (TLL). Using the TLL data received from the aircraft the receiver displays direction and distance to where the airborne camera is pointed.

Geo-Point is a proprietary feature of BMS products.

7.2   Enabling Geo-Point™

A GPS receiver is built into the HC4. J4 (COM PORT) pins 5 and 6 accept NMEA 0183 serial data containing the "stare point" (SP) information from an external source (usually the camera or a moving map). This function is enabled all the time. The GPS source will be external if there is valid NMEA data on pins 5/6. If an input on pins 5/6 is missing or corrupt, the HC4 will revert to its internal GPS source to maintain sync with the tracking sites. Lacking the SP information the Geo-Point enabled device will report the aircraft range and position.

The SP info must be added to the NMEA stream in the TLL word (Target Lat/Long) position. The RX site will track by reading the aircraft position LAT/LONG from the NMEA stream while Geo-Pont enabled display, (e.g. a BMS CVIII+, or CVIII+-HD) will use the TLL info to develop the range/distance report for the Geo-Point display overlay. BMS has worked with several manufacturers to assure compatibility and support for the Geo-Point function. The addition of the TLL word to the GPS message is supported by several interfacing equipment manufactures or may involve a simple set-up process.

To learn more about how adoption of Geo-Point can benefit your agency contact the BMS.

8   SOFTWARE INSTALLATION

The DLC50 and HC4 both come completely loaded with the software required to operate the unit. However field installation of software can easily be accomplished by the user in order to Update, Upgrade, or even reinstall the system software. The process to install software on either the DLC50 or the HC4 involves loading a file via the USB port on each device from a USB mass storage device. A USB memory stick will be recognized by both the DCL50 and the HC4 and is a recommended device for providing the software update.

General Notes:

1. Control of the Installation process is accomplished via the control interface provided on the DLC50, however the USB port on each unit must be used to perform the installation on that unit.
    a. If you are loading an update into the DLC50, then the USB stick is inserted into the USB port of the DLC50.
    b. If you are loading an update into the HC4, then the USB stick is inserted into the USB port of the HC4.
    c. A device inserted into the USB port of the DLC50 WILL NOT be able to update the software in a connected HC4.
2. Software files for installation MUST be stored in the root directory of the USB storage device or USB memory stick.
3. The file type for the DLC50 is DLCsoft.hex
4. The file type for the HC4 is hc4_app.xxxxxxxxx.bin

Installation Procedure for the DLC50

1. Prior to starting the procedure, ensure the file for theDLC50 update is in the root level directory of the USB device
2. Ensure that the DLC50 is powered ON.
3. Insert the USB device into the USB port on the front of the DLC50 control panel.
4. Wait 10 seconds (typically) for the system to recognize the file on the USB device.
5. Using the DLC50 front panel controls:
    a. Rotate the OUTER knob to "Config."
    b. Rotate the INNER knob to "Config: USB Flash".
    c. Press the INNER Knob, or "OK" to select. The DLC50 will ask for confirmation.
    d. Press the INNER knob, or "OK" to select "yes" to initiate the update.

Installation Procedure for the HC4

1. Prior to starting the procedure, ensure the file for the HC4 update is in the root level directory of the USB device
2. Ensure that both the DLC50 and HC4 are powered ON and that the DLC50 is controlling the HC4.
3. Insert the USB device into the USB port of the HC4.
4. Wait 10 seconds (typically) for the system to recognize the file on the USB device.
5. Using the DLC50 front panel controls:
    a. Rotate the OUTER knob to "TX".
    b. Rotate the INNER knob to "Software Update".
    c. Press the INNER Knob, or "OK" to select. The DLC50 will ask for confirmation.
    d. Rotate INNER knob to highlight "yes".
    e. Press the INNER knob, or "OK" to select "yes" to initiate the update.

9 ACCESSORIES

Item	Description	Part Number
CT-A-MP Mounting Plate	Mounting plate for transmitter	4414414000
HC4-CONN-KIT	Kit; Mating Connectors for HC4 Includes all PTO type connectors required for full HC4 installation. Does not include USB, BNC, or N-Type connectors (all commonly available).	7614521100
DLC50	Aviation control panel. Available in following configurations; DLC50 Transmitter control DLC50-A Transmitter and actuator control DLC50-N Transmitter control, NVIS-B compliant DLC50-AN Transmitter and actuator control, NVIS-B compliant	8714395002 8714395000 8714395003 8714395001
TAA-101	Skid mounted antenna actuator for microwave downlink. Left Side Mount Right Side Mount	870169302 870169304
GA-35	Garmin GPS antenna	120410017
Wiring Harness	Contact BMS regarding custom system wiring harness	Contact Factory
Manual	HC4 Operation and Installation Manual	6051452100
GCA-11	Directional Antenna Pod with belly mount	Contact Factory
AES ENCRYPTION	AUTHORIZATION KEY (Bcrypt1 and Bcrypt2)	(AES 128) 8710000128 (AES 128/256) 8710000256
BISS ENCRYPTION	AUTHORIZATION KEY (BISS1, E)	8710000100
Consult BMS for information about these products.		

10 ADDITIONAL REFERENCES

The following documentation is recommended to further aid the installation of the HC4.

DLC50   Manual   BMS # 6051439500

TAA-101 Actuator Manual (if used)   BMS # 605169301

GA 35 Antenna Installation Instructions (if used)   Garmin 190-00848-00

11 REGULATORY

11.1 Electromagnetic Compliance

CE marked in accordance with EU Low Voltage and EMC Directives

EN55022

EN55024

11.2 FCC

The HC4 is an intentional radiator and is authorized by the Federal Communications Commission (FCC) to comply with the following parts of CFR 47 (grant pending);

Part 74

Part 90

11.3 Environmental Qualifications

The HC4 transmitter and DLC50 control panel have been designed to meet the following sections of RTCA DO-160G;

Section	Category	Description
Section 4	Category A1	Temperature and Altitude
Section 5	Category B	Temperature Variation
Section 6	Category A	Humidity
Section 8	Category R,U2, (8.8.3)	Vibration
Section 16	Category B, Designation I	Power Input
Section 17	Category A	Voltage Spike
Section 20.4		Radio Susceptibility - Conducted
Section 20.5		Radio Susceptibility - Radiated
Section 25		Electrostatic Discharge (ESD)

12 PREVENTIVE MAINTENANCE

In order to ensure system longevity it is highly recommended that the following preventive maintenance procedures be done at the appropriate time.

12.1 Maintenance Schedule

Procedure	Yearly	Quarterly	Monthly	Prior Each Use
Inspect Mounting Hardware		☑		
Inspect Wiring (connection, chafing)		☑		
Inspect control and RF cables				☑
Inspect TAA-101 Antenna Actuator				☑

12.2 Maintenance Procedures

There are no required maintenance procedures for the HC4.

Include the following with preflight inspection:

Inspect mounting hardware to ensure all components are secure.

Inspect cables and connections.

12.3 Spare Parts

The HC4 has no user replaceable parts. Contact BMS for all service and repair inquiries. Factory contact information is provided in section 20"REPAIR SERVICE AND WARRANTY"

Note: Any attempts to service individual components may void the warranty.

13 REPAIR SERVICE AND WARRANTY

BMS warrants that, at time of delivery, this product will be free from defects in materials and workmanship, provided the equipment or system is installed, operated and maintained in accordance with the Operation and Maintenance manual or such other BMS documentation as may be applicable. Any such defect reported to BMS within two years, BMS will take reasonable and prompt action to repair or replace such equipment.

Should any of the components be defective, please contact BMS immediately. Please have the following information available so we can best serve you.

- Customer Name
- Contract Number
- BMS Model Number
- Serial Number
- Detailed Description of Problem
- Name of Contact Person.
- Contact Information such as phone number and/or email address.
- Return Information

Much of this information can be found on the product label found on the component.
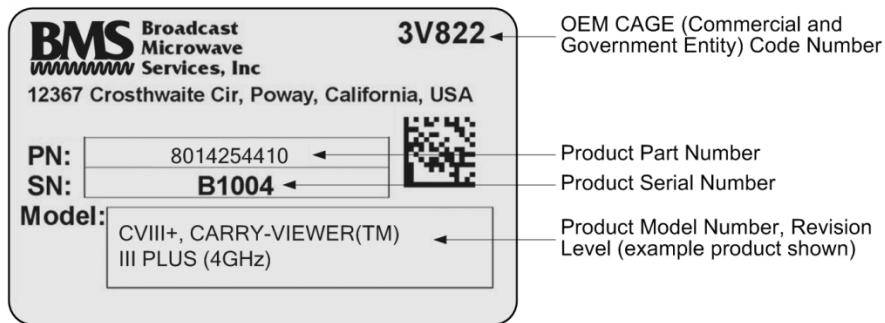
Figure 11 Product Label

Defective components under BMS warranty will be repaired/replaced promptly at the discretion of BMS. Items no longer under warranty will require a PO before repairs can proceed.

> **NOTE**: All goods returned for service require an RMA #. Any goods received without an RMA# may not be processed in a timely manner. Please contact BMS for an RMA#.

13.1 Customer Service

Broadcast Microwave Services, Inc.
12367 Crosthwaite Circle, Dock 10 • Poway, CA 92064 • U.S.A.
Tel: +1-858-391-3050 • Toll Free (U.S.): 800-669-9667 • Fax: +1-858-391-3049
Website: www.bms-inc.com • E-mail: sales@bms-inc.com

Broadcast Microwave Services Europe
Schwalbacher Str. 12 • 65321 Heidenrod • Germany
Tel: +49-6124-72 39-00 • Fax: +49-6124-72 39-29
Website: www.bms-inc.com • E-mail: saleseurope@bms-inc.com

14 GLOSSARY

AES	Advanced Encryption System. Optional encryption system available for signal privacy
Analog Transmission	Frequency Modulated (FM) method of sending information with radio waves. An older, dependable method of transmission. (See Digital Transmission)
Antenna Actuator	The mechanism which deploys or retracts the antenna radio operation or for landing and take-off.
ASI: Asynchronous Serial Interface.	Transmission standard used to connect video delivery equipment within a cable, satellite or terrestrial plant.
BISS	Basic Interoperable Scrambling System, optional method of signal privacy
BNC Connector	The Bayonet Neill-Concelman connector is a type of RF connector used for terminating coaxial cable. (See TNC connector)
BTP:	BMS Transmission Privacy. BMS proprietary PIN encryption system, standard on most BMS digital products
COFDM: Coded Orthogonal Frequency Division Multiplex	A digital modulation method that divides a single digital signal across multiple (1000+) signal carriers simultaneously. BMS Coder II family products use COFDM digital modulation.
Composite Video	The format of an analog television (picture only) signal before it is combined with a sound signal and modulated onto an RF carrier.
CVIII	Carry-Viewer™ III Handheld Receiver Microwave downlink receiver with color monitor
CVIII+	Carry-Viewer™ III+ (includes Geo-Point) Handheld Receiver Microwave downlink receiver with color monitor
Data Wayside	The data side channel on a microwave downlink
dB: Decibel	A unit for expressing the ratio of two amounts of electric or acoustic signal power equal to 10 times the common logarithm of this ratio.
dBm	A unit for expressing the power ratio in decibel (dB) of the measured power referenced to one milliwatt (mW).
Digital Transmission	Digitally Modulated (COFDM and others) method of sending information with radio waves. Newer more reliable method of transmission. (See Analog Transmission)
Directional Antenna	The final transmit element of a microwave system that radiates the signal one direction, in a directed or focused narrow beam. This requires aiming of the antenna toward the receive site.
DVB-T: Digital Video Broadcasting-Terrestrial	An international digital television (DTV) standard that defines digital COFDM modulation using MPEG2 compression.
DO-160	RTSC standard; Environmental Conditions and Test Procedures for Airborne Equipment
Downlink	Microwave transmission from air to ground
Geo-Point	BMS Proprietary direction and ranging system
GPS: Global Positioning System	A navigational system using satellite signals to fix the location of a receiver on or above the earth's surface
MPEG-2	A compression standard for digital video, audio, and data
H.264	A compression standard for digital video, audio, and data conforming to MPEG-4, Section 10 AVC (Advanced Compression Standard)
HD-SDI	High Definition Serial Digital Interface - A digitized video format for high definition video

KLV	Key Length Value. A method of encoding data into video streams. Defined in standard SMPTE 336M-2007
Multipath	The radio wave propagation phenomenon that results in the transmitted signals ft. reaching the receiving antenna by two or more paths. This condition is not desirable and usually results in signal fading and interference.
NMEA 0183	National Marine Electronics Association electrical and data standard for communication between systems
NTSC	The standard analog television system in use in the United States Analog television encodes television picture information as an analog signal, that is, by varying the voltages and/or frequencies of the signal.
Omni-Directional Antenna	The final transmit element of the microwave system that radiates the signal approximately equally throughout a 360 degree circle. Does not require aiming of the antenna.
PAL phase-alternating line	A color encoding used in broadcast television systems in large parts of the world.
RF: Radio Frequency	That portion of the Electromagnetic Spectrum that is used for radio and television transmission.
SDI: Serial Digital Interface	Serial Digital Interface - A digitized video format for standard definition
Stand-by	The condition of an RF system where all but the transmit circuits are energized. In this status the system may be switched into transmit mode instantaneously. (See Transmit)
Stare-Point (SP)	Stare-Point or SP refers to the center of a video camera picture
Symbology	System of defined symbols
TLL	Target Latitude Longitude
TNC Connector	Threaded version of the BNC connector (See BNC connector)
Transmit	The condition of an RF system where it is sending out signal. (See Stand-by)

15 CONNECTION AND WIRING DIAGRAMS

This section contains system and hook-up wiring diagrams.
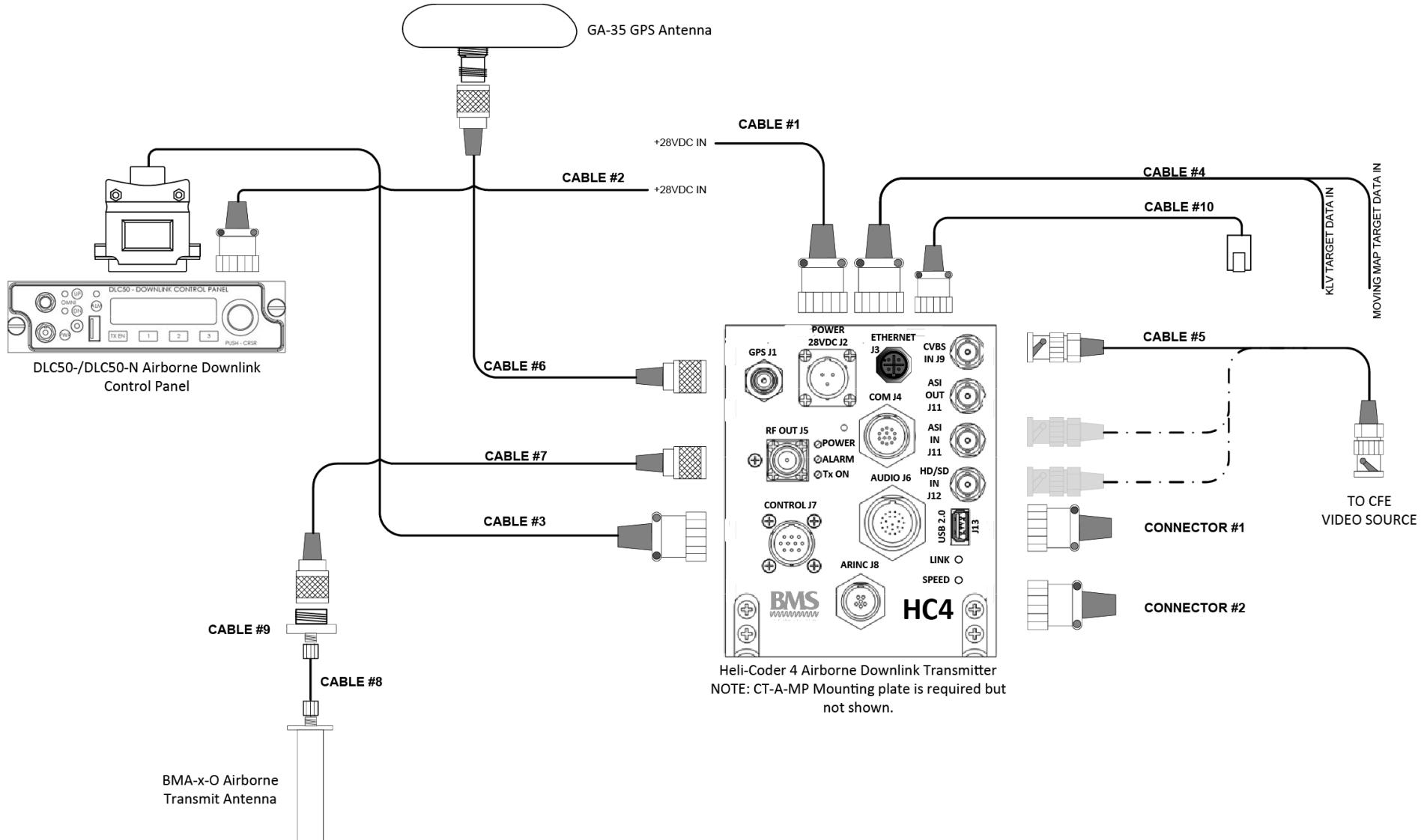
GA-35 GPS Antenna

CABLE #1

+28VDC IN

CABLE #2

+28VDC IN

CABLE #4

CABLE #10

KLV TARGET DATA IN

MOVING MAP TARGET DATA IN

DLC50-/DLC50-N Airborne Downlink Control Panel

CABLE #6

CABLE #7

CABLE #3

CABLE #9

CABLE #8

BMA-x-O Airborne Transmit Antenna

POWER 28VDC J2

ETHERNET J3

GPS J1

CVBS IN J9

COM J4

ASI OUT J11

RF OUT J5

POWER
ALARM
Tx ON

ASI IN J11

AUDIO J6

HD/SD IN J12

CONTROL J7

USB 2.0 J13

ARINC J8

LINK

SPEED

BMS

HC4

Heli-Coder 4 Airborne Downlink Transmitter
NOTE: CT-A-MP Mounting plate is required but not shown.

CABLE #5

CONNECTOR #1

CONNECTOR #2

TO CFE VIDEO SOURCE

Figure 12 Typical airborne installation diagram (*without TAA-101 Antenna Actuator*)

NOTES: UNLESS OTHERWISE SPECIFIED

△3 FLAG NOTE 3 INDICATES A CONNECTOR TO BE INSTALLED AFTER THE CABLE IS ROUTED THRU THE AIRCRAFT AND CUT TO LENGTH.

△4 APPROPRIATE VIDEO INPUT VARIES. CONSULT YOUR VIDEO OUTPUT DEVICE MANUAL TO DETERMINE APPROPRIATE VIDEO CONNECTION.

5. SEE SHEET 3 FOR AVAILABLE PART NUMBERS OF HELICODER II COMPONENTS.

CABLE#	PART NUMBER	DESCRIPTION	LENGTH
1	7314521000	HELI-CODER 4 Vdc POWER INPUT	30'
2	7314395010	DLC50 Vdc POWER INPUT	30'
3	7314395020	HELI-CODER 4 CONTROL FROM DLC50	30'
4	7314521010	HELI-CODER 4 TGT/KLV DATA INPUT	3'
5	CFE	VIDEO INPUT	
6	7314521020	HELI-CODER 4 GPS INPUT	30'
7	7314189100	HELI-CODER 4 RF OUTPUT	15'
8	730805000	ACTUATOR RF CABLE	16"
9	210008501	TYPE "N" (F) TO SMA (F) BULKHEAD ADAPTER	1 EACH
10	610000411	HELI-CODER 4 ETHERNET CABLE	32.8'
CONNECTOR	PART NUMBER	DESCRIPTION	
1	210069725	AUDIO MATING CONNECTOR & BACKSHELL	1 EACH
2	210069712	ARINC MATING CONNECTOR & BACKSHELL	1 EACH
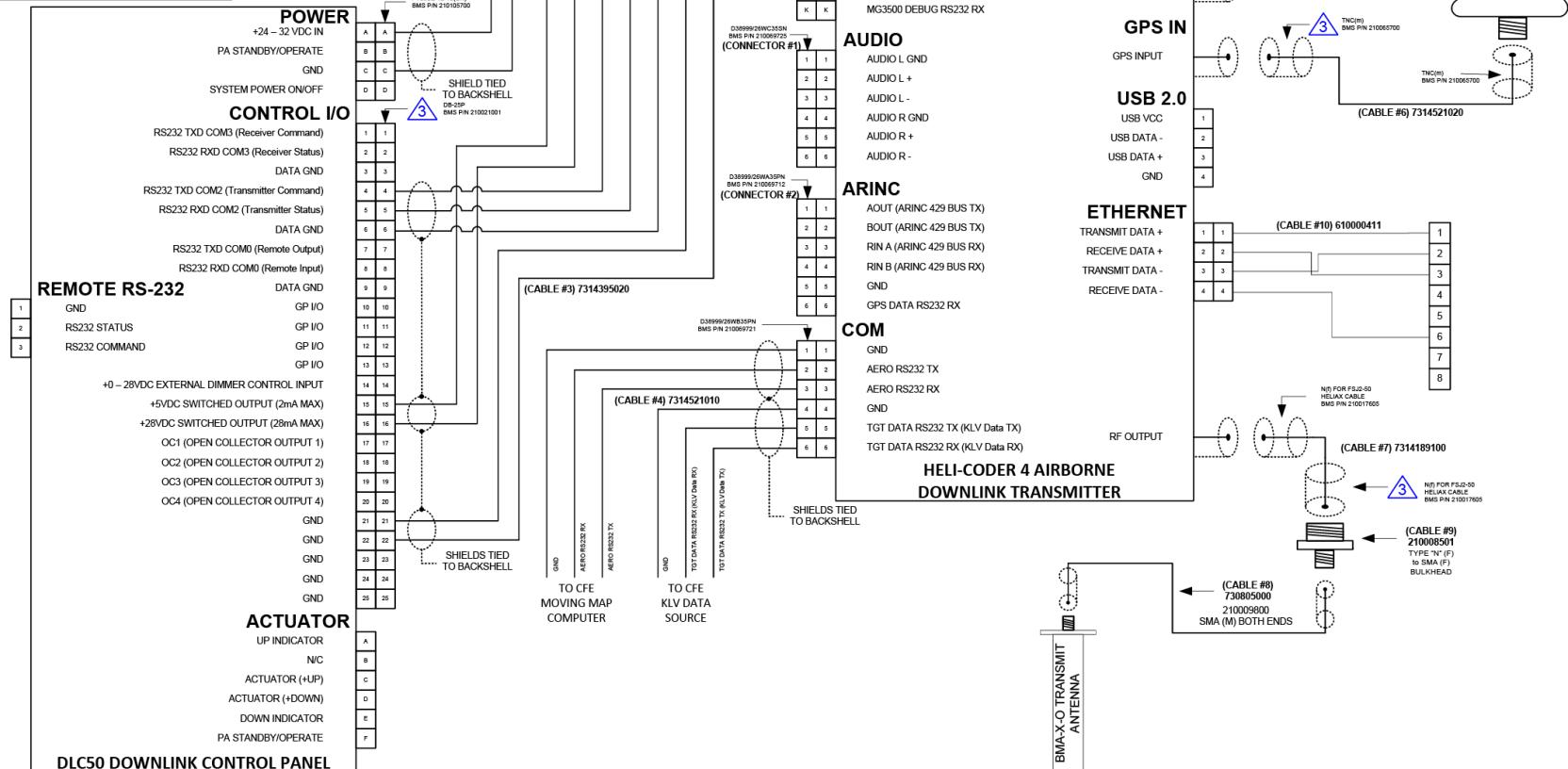
Figure 13 Wire Hook-Up Diagram for HC4 System (without *TAA-101 Antenna Actuator*)

1. SEE SHEET 2 FOR CABLE PART NUMBERS, CONNECTOR PINOUTS AND LENGTHS.

2. SEE SHEET 3 FOR SPECIFIC BMS PART NUMBERS.

GA-35 GPS Antenna

CABLE #1

+28VDC IN

CABLE #2

+28VDC IN

CABLE #4

CABLE #8

KLV TARGET DATA IN

MOVING MAP TARGET DATA IN

DLC50-A/DLC50-AN Airborne Downlink Control Panel

CABLE #6

CABLE #9

CABLE #5

POWER 28VDC J2

ETHERNET J3

GPS J1

CVBS IN J9

COM J4

ASI OUT J11

RF OUT J5

POWER
ALARM
Tx ON

ASI IN J11

AUDIO J6

HD/SD IN J12

CONTROL J7

USB 2.0 J13

BMS

ARINC J8

LINK

SPEED

HC4

TO CFE VIDEO SOURCE

CONNECTOR #1

CONNECTOR #2

CABLE #7

CABLE #3

TAA-101/TAA-101S Antenna Actuator System

Heli-Coder 4 Airborne Downlink Transmitter
NOTE: CT-A-MP Mounting plate is required but not shown.

CABLE #10

BMA-x-O Airborne Transmit Antenna

Figure 14 Typical airborne installation diagram (*including TAA-101 Antenna Actuator*)

NOTES: UNLESS OTHERWISE SPECIFIED

3. FLAG NOTE 3 INDICATES A CONNECTOR TO BE INSTALLED AFTER THE CABLE IS ROUTED THRU THE AIRCRAFT AND CUT TO LENGTH.

4. APPROPRIATE VIDEO INPUT VARIES. CONSULT YOUR VIDEO OUTPUT DEVICE MANUAL TO DETERMINE APPROPRIATE VIDEO CONNECTION.

5. APPROPRIATE TAA-SM SKID MOUNT VARIES PER HELICOPTER MODEL AND IS ORDERED SEPERATELY. CONSULT THE FACTORY FOR PROPER MODEL AND P/N.

6. SEE SHEET 3 FOR AVAILABLE PART NUMBERS OF HELICODER II COMPONENTS.

CABLE#	PART NUMBER	DESCRIPTION	LENGTH
1	7314521000	HELI-CODER 4 Vdc POWER INPUT	30'
2	7314395010	DLC50 Vdc POWER INPUT	30'
3	7314395020	HELI-CODER 4 CONTROL FROM DLC50	30'
4	7314521010	HELI-CODER 4 TGT/KLV DATA INPUT	3'
5	CFE	VIDEO INPUT	
6	7314521020	HELI-CODER 4 GPS INPUT	30'
7	7314189100	HELI-CODER 4 RF OUTPUT	15'
8	610000411	HELI-CODER 4 ETHERNET CABLE	32.8'
9	7314189070	ACTUATOR CONTROL CABLE	30'
10	730805000	ACTUATOR RF CABLE	16"

CONNECTOR	PART NUMBER	DESCRIPTION	
1	210069725	AUDIO MATING CONNECTOR & BACKSHELL	1 EACH
2	210069712	ARINC MATING CONNECTOR & BACKSHELL	1 EACH

AIRCRAFT GROUND RETURN
AIRCRAFT 24 - 32 Vdc 10 AMP IN
(CABLE #1) 7314521000
PT06SE-12-3S(SR) BMS P/N 210105000

AIRCRAFT GROUND RETURN
AIRCRAFT 24 - 32 Vdc 2 AMP IN
(CABLE #2) 7314395010
PT06SE-12-10S(SR) BMS P/N 210105900

SHIELDS TIED TO BACKSHELL

POWER 28VDC
+28VDC
GND
N/C

CONTROL
+28VDC OUT (LOOP OUTPUT)
+28VDC IN (LOOP INPUT)
N/C
RS232 WDTS RX
DATA GND
RS232 WDTS TX
GND
N/C
MG3500 DEBUG RS232 TX
MG3500 DEBUG RS232 RX

AUDIO
AUDIO L GND
AUDIO L +
AUDIO L -
AUDIO R GND
AUDIO R +
AUDIO R -
D38999/26WC35SN BMS P/N 210069725 (CONNECTOR #1)

ARINC
AOUT (ARINC 429 BUS TX)
BOUT (ARINC 429 BUS TX)
RIN A (ARINC 429 BUS RX)
RIN B (ARINC 429 BUS RX)
GND
GPS DATA RS232 RX
D38999/26WA35PN BMS P/N 210069712 (CONNECTOR #2)

COM
GND
AERO RS232 TX
AERO RS232 RX
GND
TGT DATA RS232 TX (KLV Data TX)
TGT DATA RS232 RX (KLV Data RX)
D38999/26WB35PN BMS P/N 210069721

CVBS IN
CVBS INPUT

ASI IN
ASI INPUT

HD/SDI IN
HD/SDI INPUT

ASI OUT
ASI OUTPUT

GPS IN
GPS INPUT

USB 2.0
USB VCC
USB DATA -
USB DATA +
GND

ETHERNET
TRANSMIT DATA +
RECEIVE DATA +
TRANSMIT DATA -
RECEIVE DATA -

RF OUTPUT

HELI-CODER 4 AIRBORNE DOWNLINK TRANSMITTER

(CABLE #5) CFE
TNC(m) BMS P/N 210065700
TNC(m) BMS P/N 210065700
(CABLE #6) 7314521020

(CABLE #8) 610000411

N(f) FOR FSJ2-50 HELIAX CABLE BMS P/N 210017605
N(f) FOR FSJ2-50 HELIAX CABLE BMS P/N 210017605
(CABLE #7) 7314189100

POWER
+24 – 32 VDC IN
PA STANDBY/OPERATE
GND
SYSTEM POWER ON/OFF
PT06SE-12-4S(SR) BMS P/N 210105700

SHIELD TIED TO BACKSHELL
DB-25P BMS P/N 210021001

CONTROL I/O
RS232 TXD COM3 (Receiver Command)
RS232 RXD COM3 (Receiver Status)
DATA GND
RS232 TXD COM2 (Transmitter Command)
RS232 RXD COM2 (Transmitter Status)
DATA GND
RS232 TXD COM0 (Remote Output)
RS232 RXD COM0 (Remote Input)
DATA GND
GP I/O
GP I/O
GP I/O
GP I/O
+0 – 28VDC EXTERNAL DIMMER CONTROL INPUT
+5VDC SWITCHED OUTPUT (2mA MAX)
+28VDC SWITCHED OUTPUT (28mA MAX)
OC1 (OPEN COLLECTOR OUTPUT 1)
OC2 (OPEN COLLECTOR OUTPUT 2)
OC3 (OPEN COLLECTOR OUTPUT 3)
OC4 (OPEN COLLECTOR OUTPUT 4)
GND
GND
GND
GND
GND

REMOTE RS-232
GND
RS232 STATUS
RS232 COMMAND

(CABLE #3) 7314395020

(CABLE #4) 7314521010

ACTUATOR
UP INDICATOR
N/C
ACTUATOR (+UP)
ACTUATOR (+DOWN)
DOWN INDICATOR
PA STANDBY/OPERATE

DLC50 DOWNLINK CONTROL PANEL

TO CFE MOVING MAP COMPUTER
TO CFE KLV DATA SOURCE

SHIELDS TIED TO BACKSHELL

TAA-101/TAA-101S ANTENNA ACTUATOR SYSTEM
UP INDICATOR
N/C
ACTUATOR (+UP)
ACTUATOR (+DOWN)
DOWN INDICATOR
N/C
PT06SE-10-98P(SR) BMS P/N 210105000
PT06SE-10-98S(SR) BMS P/N 210105301

TAA-SM ACTUATOR SKID MOUNT
210008501 TYPE "N" (F) to SMA (F) BULKHEAD (PART OF THE MOUNT)
210009800 SMA (M) BOTH ENDS

(CABLE #9) 7314189070
(CABLE #10) 730805000 FOR TAA-101, USE 610805025 FOR TAA-101S.

BMA-X-O TRANSMIT ANTENNA

Figure 15 Wire Hook-Up Diagram for HC4 System (including *TAA-101 Antenna Actuator*)

16 COFDM Characteristics

The main COFDM modulation parameters are:

- Number of sub-carriers (about 2000 for DVB-T)
- Guard interval (GI) duration between COFDM symbols
- Constellation scheme used for individual sub-carrier modulation
- Data redundancy code rate used for error correction

The transmission robustness depends on constellation and code rate.

The following table gives the useful transmission bit rate for each COFDM mode. It also specifies the Carrier-to-Noise operation limit in the case of a perfect line-of-sight (Gaussian) channel and in the case of a typical multipath terrestrial (Rayleigh) channel.

Constellation	Code Rate	Useful Bitrate (Mb/s)				C/N for perfect channel (dB)	C/N for typical channel (dB)
		GI=1/4	GI=1/8	GI=1/16	GI=1/32		
QPSK	1/2	4,98	5,53	5,85	6,03	3.1	5.4
	2/3	6,64	7,37	7,81	8,04	4.9	8.4
	3/4	7,46	8,29	8,78	9,05	5.9	10.7
	5/6	8,29	9,22	9,76	10,05	6.9	13.1
	7/8	8,71	9,68	10,25	10,56	7.7	16.3
16-QAM	1/2	9,95	11,06	11,71	12,06	8.8	11.2
	2/3	13,27	14,75	15,61	16,09	11.1	14.2
	3/4	14,93	16,59	17,56	17,10	12.5	16.7
	5/6	16,59	18,43	19,52	20,11	13.5	19.3
	7/8	17,42	19,35	20,49	21,11	13.9	22.8
64-QAM	1/2	14,93	16,59	17,56	18,10	14.4	16.0
	2/3	19,91	22,12	23,42	24,13	16.5	19.3
	3/4	22,39	24,88	26,35	27,14	18.0	21.7
	5/6	24,88	27,65	29,27	30,16	19.3	25.3
	7/8	26,13	29,03	30,74	31,67	20.1	27.9

Notice that a low code rate (high data redundancy) is necessary to insure a good efficiency in a multipath environment.

The guard interval determines the maximum echoes length dispersion that the system can tolerate. From this figure, we can estimate the maximum transmission range that the system might offer for a typical terrestrial channel (with adequate RF power).

The following table summarizes the results of the 4 possible guard interval values:

Guard Interval Ratio	Guard Interval Duration (us)	Maximum echoes dispersion (km)	Maximum transmission distance (km)
1/32	7	2.1	2-6
1/16	14	4.2	4-12
1/8	28	8.4	8-24
1/4	56	16.8	16-48

Transmission distances can be increased when using directional antennas, but signal break-ups can still occur if long echoes enter the receiving antenna beam width.

END