HG3 STEPPER MAG LOOP™

REMOTELY TUNED HF MAGNETIC LOOP ANTENNA

USER GUIDE

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INTRODUCTION

This manual covers the operation, description and care of the preciseRF HG3 Stepper Mag Loop Antenna. It was created for the amateur radio, military, and HF operator wanting the performance advantages of an MLA without some of its drawbacks. This manual assumes a rudimentary understanding of radio and electronics. For brevity, the HG3 stepper tuned Mag Loop Antenna (MLA) is referred to as the HG3 MLA in this manual.

A magnet loop is not a new antenna. What sets the HG3 MLA apart is how it addresses many of the magnetic loop antenna's shortcomings. The result is the HG3 MLA. It delivers unprecedented capability, performance and convenience for a remotely tuned MLA. It employs a proven, accurate and repeatable stepper motor design.

Band selection, remote tuning, including optional loop rotation, is controlled by a microcontroller driving a high-resolution stepper motor. An integrated digital SWR bridge allows auto-tuning based on an SWR scan. This ensures compatibility with most radios. Manual tuning uses a convenient rotary encoder knob - no more finicky push buttons. The four-line LCD shows the band selected, SWR, ERP, Cap value and more. The bottom line - count on topnotch receiving and transmitting performance!

DESCRIPTION

An MLA is just an inductor formed by a wire loop with a circumference limited to less than 10% of a wavelength and a capacitor tuned to resonance. Electrically, it behaves as an inductor that inductively couples the radio wave (electromagnetic wave) magnetic field in the antenna's near region. In contrast, conventional monopole and dipole antennas couple to the radio wave's electric field.

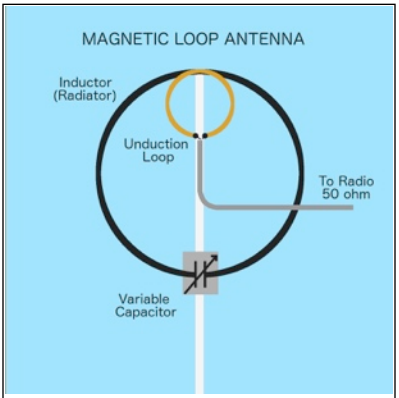


Fig. 1 Magnetic Loop Antenna

To work efficiently, losses must be minimized. Because of skin effect, the inductor forming the radiation loop's (L) surface area should be high. This decreases series resistive losses. The tuning capacitor (C), should have a low loss dielectric for low Equivalent Series Resistance (ESR). This LC circuit must be tuned to resonance at the desired frequency. At resonance, the MLA exhibits very high Q. As a result, it exhibits very narrow bandwidth and high voltage (in the kilovolts) across the capacitor.

The MLA has its maximum signal gain in the plane of its radiation loop, with nulls broadside to the loop.

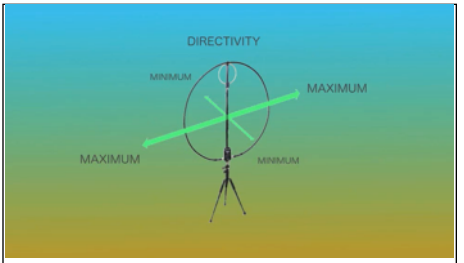


Fig. 2 Loop directionality

CHARACTERISTICS

CONVENIENCE

It is a compact, lightweight efficient antenna that's quickly deployable. It is ideal where an HOA restricts full-size wire antennas, or where there just is not enough room to erect a conventional antenna. Many operators favor the MLA for field day and SOTA (Summit On The Air) operations.

LOW NOISE

The MLA rejects locally generated noise due to its inherent magnetic field coupling and its relative insensitivity to the electric field. That's fortuitous. Most interference sources with radio-frequency content, directly radiate in the near electric fields. That's a big advantage for using an antenna that's insensitive to the main interference sources present in that frequency range.

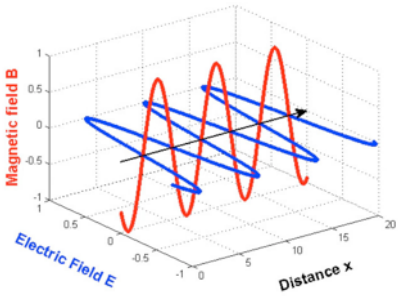


Fig. 3 Near field propagation, magnetic field (blue) versus electric field (red)

EFFICIENCY

When designed and constructed properly, an MLA performs as as well or even better than a dipole antenna. According to the American Radio Relay League (ARRL) technical editor, Jerry Hall K1TD, in describing MLA gain, concluded: “in fact, it (MLA) considerably exceeds the gain of a dipole when the MLA is mounted close to the ground”.

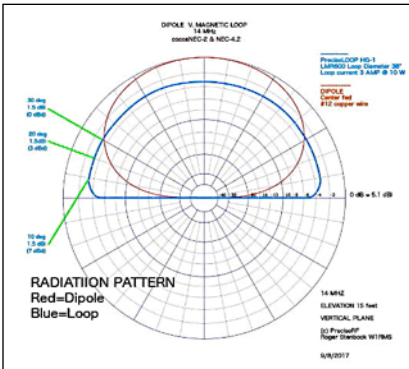


Fig. 4 Dipole v. Mag loop radiation patterns, note superior low angle for loop

HIGH SELECTIVITY

An MLA is not for every application and not for everyone. First, while desirable for selectivity and noise rejection (note the loop's excellent Return Loss and SWR characteristics below) it can be challenging. Because of this narrow bandwidth, it must be retuned when making any significant frequency changes. This was especially annoying with first-generation tuning control methods. They lacked a clear indication of the tuning capacitor position, quick band switching and convenient incremental tuning. So, it is not recommended for quick band scanning, unless the MLA has addressed these shortcomings. Fortunately, the preciseRF HG3 MLA was designed to overcome some of these limitations.

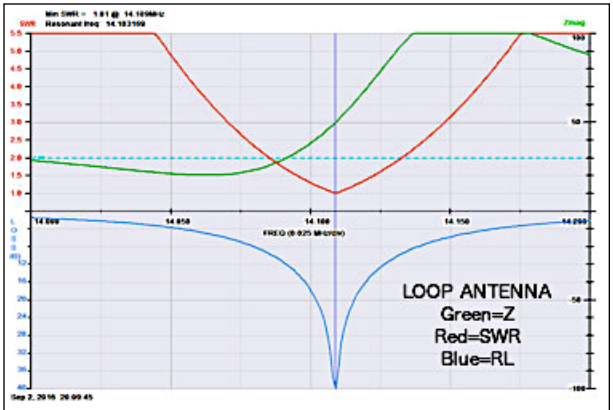


Fig. 5 Excellent SWR and high Q

CAPACITOR HIGH VOLTAGE

The capacitor is at a high voltage ranging in the kilovolts. It is at high impedance and can't deliver much current, so any contact will load it and rapidly reduce the voltage. There is still enough charge stored in the tuning capacitor to cause an RF-burn. At higher power settings, the tuning capacitor can break down and cause arcing. For that reason, high power operation requires a special and more costly capacitor, such as a high voltage air dielectric butterfly or vacuum dielectric capacitor.

DEPLOYMENT

Proper deployment is crucial for any antenna, especially for an MLA. Begin with the mast and tuner. Follow these steps:

1. Find a level surface clear of any obstructions within an approximate 15-foot radius.
2. Extend your tripod to a convenient height. Use either the supplied tripod or your own. The MLA works well from two feet or higher above the ground. After approximately a six to ten foot height, little performance is gained.
3. Assemble the mast. The HG3 is available with either an optional aluminum or PVC mast. When properly guyed, the aluminum mast is suitable for more permanent deployment. When using the aluminum mast, other than attaching the tuner and placing it on the tripod, no further mast assembly is required.
4. Assemble the PVC mast. The PVC mast is made up of three sections. It's intended for portable use. It should never be left unattended. It takes just slight pressure to fit the mast sections securely together. The tuner attaches to the lower section, which attaches to the center section. The center section attaches to the top section. The top section includes the induction loop.
5. Note, this step applies to the AR1 Antenna Rotator only. When using the optional AR1 Antenna Rotator, its base must first be securely attached to the tripod using the tripod adaptor. Then thread the mast onto the rotator's output shaft.

Fig. 6 The PVC mast

6. Spread the radiation loop and fit it to the top of the mast using the snap clamps. Orient the induction loop to face forward over the radiation loop. Locate the tuner and attach it to the mast's lower section using the supplied hardware. Next, securely thread the PL239 connectors, located at the radiation loop's ends, on to the tuner's SO239 input connectors. Connect the supplied 50-ohm coaxial cable to the induction loop BNC connector.

Fig. 7 Induction loop

7. Connect the other end of the 50 ohm coaxial cable to the radio's input/output for the EXPRESS model or to the controller as described for the PRO or LAB versions.

8. NOTE, TRIPOD USE IS INTENDED FOR TEMPORARY PORTABLE DEPLOYMENT ONLY. ITS MUST BE GUYED! For a more secure installation, clamp the mast to a solid object, such as a TV antenna mast as shown at right. Use U bolts available at most hardware stores.

Fig. 8 U-bolts

9. Locate the antenna at least 25 feet from the controller and people. CAUTION: The antenna's radiator is at a high voltage level and emits a high RF field.

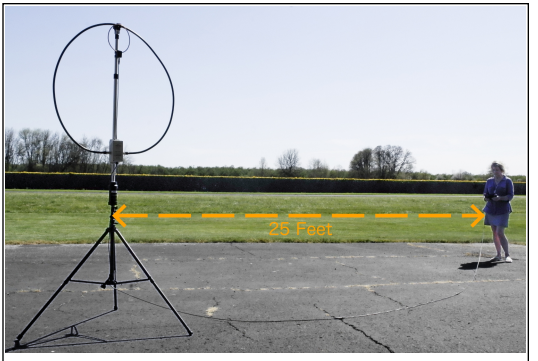


Fig. 9 Recommended 25 foot distance

CONTROLLER

The HG3 controller supports a wide range of options. The initial offering includes the EXPRESS, PRO and LAB options, with the capability of additional options (see the table below). A USB key determines which options are installed. The controller reads the USB key and automatically sets it to the correct option/ version on startup.

Fig. 10 The USB key

	EXPRESS	PRO	LAB	QRO
Processor Language	ATmega328 P Nano V3 C++	ATmega328 P Nano V3 C++	ATmega328 P Nano V3 C++	ATmega328P Nano V3 C++
Stepper Motor	28BYJ-48 Unipolar 2K Steps	28BYJ-48 Unipolar 2K Steps	NENA 17 Unipolar 8K Steps	NENA 21 Unipolar 8K Steps
Resolution	.08pF	.08pF	.02pF	.02pF
Power Supply	9 VDC 1A	9 VDC 1A	9 VDC 1A	12 VDC 2A
Option Key	none	PRO	LAB	QRO
Manual Tuning	√	√	√	√
Auto Assist Tuning		√	√	√
External Resonators	√	√	√	√
SWR Bridge		√	√	√
Antenna Rotator		√	√	√

- EXPRESS MODEL
  It is the standard model and requires no USB key. It supports a high resolution 2000 position stepper motor, manual tuning and an external resonator.

- PRO OPTION
  This version requires the PRO USB key. It supports a high resolution 2000 position stepper motor, manual tuning, external resonator, auto-tuning, antenna rotation and includes the integrated SWR bridge and ERP functions.
- LAB OPTION
  This version requires the LAB USB key. It is intended for advanced users wanting the controller in the lab for experimental use. It is available in a kit form requiring some technical assembly and soldering skills. It supports a NEMA 17 ultra-resolution 8000 position stepper motor, manual tuning, external resonator, auto-tuning, antenna rotation and includes the integrated SWR bridge and ERP functions.
- QRO OPTION
  This version requires the QRO USB key. It is intended for higher power. It supports a NEMA 21 ultra-resolution 8000 position stepper motor, manual tuning, external resonator, auto-tuning, antenna rotation and includes the integrated SWR bridge & ERP functions.

Fig. 11 Display at startup

The front panel includes the LCD, SWR bar-graph, motor and FINE LEDs, the tuning knob and the four soft keys.

CONNECTIONS

The HG3 controller requires a 9-12 Volt power supply (12 Volt for the AR-1 Rotator). The back has the antenna input labeled ANT, the transmitter input labeled XMTR, the CAT6 tuner output, labeled TUNE and the CAT6 rotator output labeled ROTATR. On the left side is the USB input jack setting the options.

Fig. 12 Connectors at rear

CONNECTIONS - EXPRESS MODEL

1. Note, the USB key is not required for EXPRESS tuning. Connect the power supply.
2. Connect the CAT 6 cable (it's an ordinary ethernet cable), from the controller's TUNE output to the tuner's CAT 6 input.
3. Connect the 50 ohm coaxial cable from the antenna copper loop BNC to the radio's input/output. Use adaptors, if necessary, to mate the BNC cable to the radio. You are now ready to tune the antenna.

STARTUP - ALL VERSIONS

Insert any required USB key. Turn the controller from OFF to ON (required to read the option).

The LCD opening screen shows the version and installed options. During startup, the capacitor indexes to the 40-meter position, noted by the MOTOR LED illuminating.

Fig. 13 After startup PRO version

The four row LCD indicates:

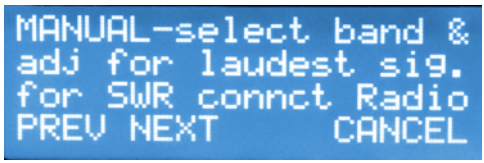
- Top row, the BAND information
- Second row, the triangle-shaped cursor and the Cap value in picoFarads
- Third row, the AUTO tuning status
- Fourth row, the four soft function keys, depending on the options installed, F1 through F4. The initial soft key choices are BAND (F1) AUTO (F2), MODE (F3) and HELP (F4).

The BAND (F1) key selects the band. Check it out. Press the BAND (F1) key. The choices now are tune down (F1) in frequency, indicated by the left arrow and tune-up (F2) in

frequency, indicated by the right arrow. The OK (F4) accepts the band selected and exits the band mode.

Experiment with these selections by pressing the band up or down keys (F1 and F2). Each time these keys are pressed, the BAND indication updates and the motor LED illuminates. Press OK (F4) to accept the frequency and to exit the band mode.

Help is available with the HELP (F4) key. It supports most functions. Six HELP pages cover most of the HG-3 functions. Explore the help pages by repeatedly pressing the PREV (say previous) (F1) and or the NEXT (F2) keys. To exit HELP, press CANCEL (F4).



TUNING FOR MAXIMUM NOISE - EXPRESS MODEL

This method uses your radio and your ears. It gives you a close match quickly. Follow these steps:

1. Turn the controller from the OFF position to ON. This sets the correct option and initializes the Controller. During initialization, the LCD displays the “Express” mode and indexes the capacitor to the 40-meter band.
2. For this demo, set the controller to the 20-meter band. Then, set the radio to the 40-meter band. Tune it to approximately 7.5 MHz.
3. Set the radio’s modulation mode to SSB, and increase the volume to hear some background static. If necessary, turn the radio’s pre-amp on.
4. Now set the controller to the 40-meters band. You should notice an increase in the background noise from your radio.

5. Lastly, using the TUNE knob, adjust it for the strongest background noise from the radio. If needed, push the knob in, to alternate between fine and coarse adjustment. The increase in background noise is a direct indication of the tuning match. Higher noise equals a better tuning match. You are now ready for a QSO.

CHECKING THE SWR - EXPRESS MODEL

1. Connect an SWR (Standing Wave Ratio) meter either in-line or on the radio. This step requires an external SWR meter, which is not standard on the EXPRESS model.

Fig. 14 EXPRESS version after adjusting to minimum SWR

2. Transmit a low power carrier of about 2-5 Watt.
3. Using the controller's TUNE knob, adjust it for a low SWR value. This will take a little bit of practice. If needed, push the knob in to alternate between fine and coarse adjustment. In a little while you'll get the hang of it.
4. Note, while a perfect SWR of 1.0 is often desired, it is not necessary. Once you achieve anything under 2.0, you've got better than 88% ERP (Equivalent Radiated Power), or about 0.1dB loss. That minor loss is virtually undetectable by the receiving station. You are now ready for a QSO.

CONNECTIONS - PRO AND LAB OPTIONS

The PRO and LAB versions come with an integrated SWR bridge. So, an external SWR meter is not needed. Configure the HG3 Controller as follows:

1. Insert the PRO or LAB option required USB key. Connect the power supply.
2. Connect the CAT6 cable (an ordinary ethernet cable) from the controller's TUNE output to the tuner's CAT6 input.
3. Connect the 50 ohm coaxial cable from the antenna's copper loop BNC to the controller's antenna input labeled ANT.
4. Connect another 50 ohm coaxial cable from the radio's output/input to the controller's transmitter input, labeled XMTR. Use adaptors, if necessary, to mate the BNC cable to the radio. You are now ready to tune the antenna.

TUNING FOR MAXIMUM NOISE - PRO AND LAB MODEL

This method uses your radio and your ears. It gives you a close match quickly. Follow these steps:

1. Turn your radio on. Turn the HG3 Controller from the OFF position to ON. This sets the correct option and initializes the controller. During the initialization, the LCD displays the Pro option and indexes the capacitor to the 40-meter band.
2. For this demo, set the controller to the 40-meter band. Set the Radio to the 20-meter band. Tune your radio to approximately 14.15 MHz.
3. Set the radio's modulation mode to SSB and increase the volume to hear some background noise. If necessary, turn the radio's pre-amp on.
4. Set the controller to the 20-meter band. You should notice an increase in the background static from your radio. If you don't notice much of an increase, adjust the TUNE knob to obtain the strongest background noise from the radio. Push the knob in to alternate between Fine and Coarse adjustment. The increase in background

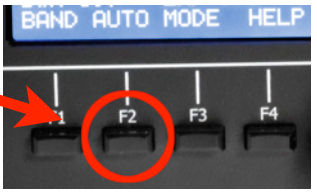
noise is a direct indication of the tuning match. Higher noise equals a better tuning match. You are now ready for a QSO.

AUTO TUNING FOR LOW SWR - PRO AND LAB MODELS

Fig. 15 PRO option. Note high SWR prior to tuning for minimum

Auto-tuning uses the HG3 integrated SWR bridge and bar graph display. The controller automatically scans for a low SWR at slightly below the tuned frequency. The capacitor turns incrementally, in small steps, while continuously updating the Cap value, SWR, ERP and bar graph. Follow these steps:

1. Set the controller to the 20-meter band. Tune your radio to approximately 14.15 MHz. Set the radio's modulation mode to SSB and increase the volume to hear some background noise. If necessary, turn the radio's pre-amp on.
2. Adjust the controller TUNE knob to obtain the strongest background noise from the radio.
3. Press AUTO (F2) for auto-assist. The LCD prompts "Connect Radio Transmit 1-3 Watt CW".
4. Transmit a low power carrier of about 2-3 Watt and press OK. If the power is not correct, it prompts to adjust the power level accordingly.



5. After the required power levels are met, auto-tuning starts. After finding an acceptable SWR, auto-tuning ends.

6. Check the bar graph SWR. The bar graph ranges from a minimum of 1.0, indicated by one or no segment on, to a maximum of 10.0 or greater, with all segments on. Any level in the green segment range is acceptable. Note, the slight SWR discrepancy (below) is normal.

Fig. 16 PRO option. Note low SWR after tuning for minimum SWR

While, a perfect SWR of 1.0, as in this example, is often desired, it is not necessary. Any SWR lower than 2.0 will give you better than

88% ERP (Equivalent Radiated Power). That equates to a loss of less than 0.1dB. That minimal loss is virtually undetectable by the receiving station. Auto tuning can be canceled at any time by pressing the CANCEL (F4) key.

Auto assist tuning usually takes only a few seconds. Occasionally, it repeats the tuning cycle up to three times. If you are still not satisfied with the results, repeat auto assist tuning by pressing the AUTO (F2) key. If the tuning is still not successful, use the manual tuning method. You are now ready for a QSO.

TUNING TIPS

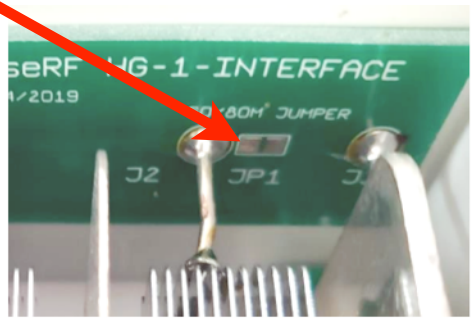
Like all antennas, the HG3 MLA is not a miracle antenna. It is subject to the solar cycle, propagation and ionospheric conditions, as well as QRM, QRN and other factors. Proper deployment and operating practices makes all the difference. Unexpected tuning results are usually traced to antenna deployment, local conditions and occasionally, operator error or antenna adjustments.

Cause	Remedy
The antenna is too close to the controller. It must be at least 20 feet away from the controller.	Move the antenna. The antenna has been tested for reliable operation with a 50-foot coax.
Common mode current may be interfering with the controller or radio.	Attach a common-mode balun at the antenna such as the CMB-300 1:1 Common Mode Balun from preciseRF.
Unable to hear a background noise increase, indicating a tuning peak.	Turn pre-amp on and use SSB mode on the radio.
The antenna is too close to a metal object.	Move the antenna away from any metal object.
The copper induction loop is not correctly positioned.	Reposition the induction loop up or down on the mast.
The tuner is defective, such as a short in the capacitor, the stepper motor or driver circuit.	Correct the defect and try again. This may require factory service.
The coaxial cable or other connections is defective.	Replace the feed line and or correct the bad connection.
The copper induction loop is defective.	Check to make sure the loop has continuity from the BNC center pin to the shield.
The controller does not have the correct USB key.	Insert the correct USB Key.
The power supply is defective.	Check the power supply and or replace it.

80 AND 60 METER TUNING

The HG3 is capable of 60m and 80m operation. Because of 10 meter performance optimization, the circuit boards are made with isolation jumpers for connection to the optional external 60m and 80m resonators. This reduces stray capacitance. To enable the 60 or 80 meter bands follow these steps:

1. Locate the 60/80m jumpers. They are located on the circuit board on each side of the case. These boards are identical. On these boards there is a solder jumper labeled 60/80M JUMPER JP1. See the figure at right:



2. Bridge the jumper with solder. This connects the main tuning capacitor to the external banana jacks. If you find that it is difficult to tune the upper portion of the 10 meter band, open the solder bridge to restore the tuning range.

3. Insert the optional external resonator into the banana jacks. They are located on the top end of the tuner case.

4. Press the MODE key repeatedly until “External Resonator” is displayed on the LCD. Using the TUNE knob, manually tune the antenna. The LCD will display the cap value as a percentage of total capacitance to aid your tuning.

THE AR-1 ROTOR

The AR-1 ROTOR rotates the HG-3 MLA. Given that an MLA has the maximum signal in the plane of its radiation loop with nulls broadside to the wires, rotating the loop for best signal or least noise is desirable. For deployment, follow these steps:

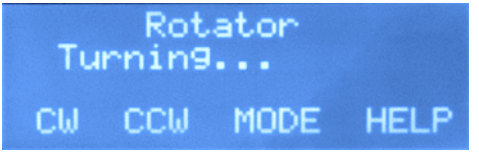
1. Ensure that a 12V power supply is connected for AR-1 Rotator option.
2. CAUTION! THE ROTATOR AND TRIPOD ARE INTENDED FOR TEMPORARY PORTABLE DEPLOYMENT ONLY. ITS MUST BE GUYED! Thread the AR-1 Rotator on to the tripod and attach the antenna to the top of the rotator using the appropriate adaptor available from preciseRF.
3. ENSURE THE TRIPOD IS MOUNTED SECURELY!For a more robust mounting method, secure the rotator to a sturdy fixed object using strong U bolts, such as a steel antenna mast, as shown at right.

Fig. 17 Rotator U-bolt

4. Connect the CAT 6 cable from the controller's output labeled ROTATR to the AR-1 CAT 6 input.

TURNING THE AR-1 ROTOR

1. Ensure you have the correct option installed. The EXPRESS model does not support the AR-1 antenna rotator. Press the MODE (F3) key repeatedly until "Rotator" is displayed on the top LCD line. The bottom line presents four choices. They are CW (F1) for clockwise, CCW (F2) for counter clockwise and Help (F4).
2. Press either the CW (F1) for clockwise, or CCW (F2) for counter clockwise buttons to rotate the antenna. During rotation, the LCD indicates "Turning...".



3. Reverse direction once the rotation limits are reached, when the LCD displays “Limit reached Reverse direction”.
4. Press the MODE (F3) button repeatedly to exit and select the desired mode.

PRECAUTIONS

THE AR-1 ROTOR IS NOT WATERPROOF. IT IS INTENDED FOR TEMPORARY PORTABLE DEPLOYMENT OR SHELTERED AREAS. Under extreme conditions, water can enter the rotator and render it permanently unusable. Excessive weight can damage the rotator. Rotating a guyed loop antenna is difficult. The use of the AR1 Rotator in windy conditions must be done with caution. After establishing the desired direction, ensure the antenna is again guyed. Never leave the antenna unattended when not guyed. CAUTION! EXCESSIVE LOAD AND WATER DAMAGE IS NOT COVERED BY THE WARRANTY!

The tuner is housed in a premium water-resistant case with a silicone rubber gasket, made in the USA by Polycase. It is made to UL Listed to UL508-4x specifications, constructed of durable, impact-resistant UV Stabilized Polycarbonate material and is water-resistant. It is not waterproof. Under extreme conditions, water can enter the tuner and render it permanently unusable. Before use, ensure that all connections are secure from possible water incursion. This includes the sealed o-ring protected cover, the CAT 6 cable gland, PL239 connectors and the banana connectors. If, after inspection, there is any doubt of the water resistance integrity, follow these maintenance guidelines: Check all fasteners for a tight fit. If needed, apply a small amount of silicone sealant to each connector. Protect the antenna at all times from extreme weather conditions. The PVC mast is not intended for unattended outdoor use. Use the optional metal antenna mast and attach guy wires to the two guying ears at the top of the mast. CAUTION! EXCESSIVE LOAD AND WATER DAMAGE IS NOT COVERED BY THE WARRANTY.

SPECIFICATIONS

	14 MHz @ 10 W		29 MHz @ 10 W	
SWR / RL	1.01 / 41.09 dB		1.14 / 23.40 dB	
Bandwidth	31.2 kHz		279 kHz	
Impedance (Ω)	59.17 Ω		56.85 Ω	
Induction loop	Copper tube 26”			
Radiation loop	MLR600 120”			
Conductor surface area	113 sq. in		113 sq. in	
Tuning capacitor	Air variable dual stator		Air variable dual stator	
Tuning method	Remote Stepper200 steps (Express&Pro) 8000 steps (Lab)			
Quality Factor (Q)	448		104	
Rrad	0.074 Ω		1.36 Ω	
Rloss	0.093 Ω		0.134 Ω	
Current loop Imp	3.5 A		3.0 A	
Current Irad	1.54 A		2.73 A	
Current I loss	1.96 A		0.297 A	
Power rad	4.44 W		9.10 W	
Efficiency %	44% -3.5 dB		91% -0.4 dB	
Gain dBi / dBd	1.5dBi 3-7 dBd (		1.5dBi 3-7 dBd	
Max input power at feed-line	25’ RG8 feed-line	+ CBM-300 Common mode 1:1 Balun	50’ RG8 feed-line	+ CBM-300 Common mode 1:1 Balun
PEP (SSB)	55 W	75W	75W	100 W
CW 50% Duty cycle	35W	35W	50W	50W
RTTY(digital) & AM	25W	25W	35W	35W
Environmental	0-35C < 80% humidity water resistant NOT WATERPROOF			

Specifications based on actual measurements and/or computer models. All products are calibrated and tested to meet or exceed published specifications. Please contact PreciseRF and arrange for a return or repair authorization. Manufacture’s Suggested Retail Price (MSRP). Prices and specifications subject to change without notice. (c) 2017 all rights reserved preciseRF.

SYSTEM REFERENCE

This reference provides the user/operator a better understanding of the capability and limitations of the HG3 MLA. CAUTION! Non-factory repair, alterations or adjustments are not covered by the warranty.

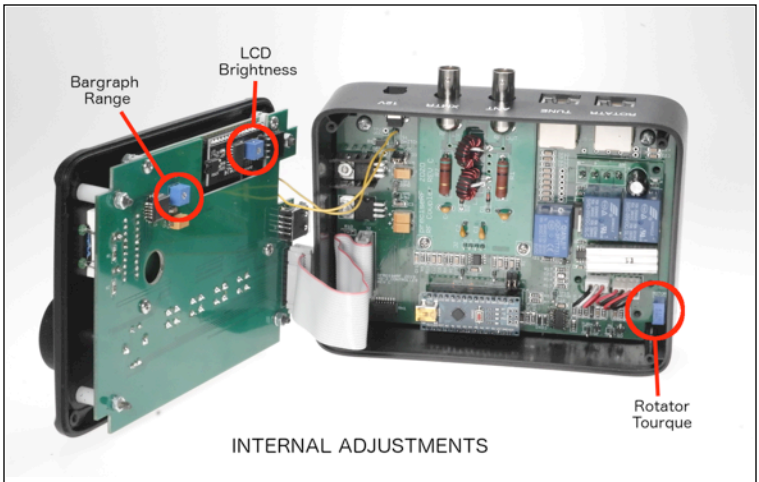


Fig. 18 The HG3 Controller with case open

Fig. 19 Tuners with cover removed

CIRCUIT DESCRIPTION

OVERVIEW

The HG3 Stepper Mag Loop Antenna (MLA) is made up of the tuner, rotator and controller. The tuner and its components are housed in an enclosure attached to the antenna mast. The components are the tuning capacitor, the stepper motor driver and the stepper motor, which turns the tuning capacitor. A CAT6 cable connects it to the controller. The AR1 Rotator is in a PVC housing. It contains the pulse width controlled motor, limit switches and rotational logic. The antenna is supported by a polyformaldehyde (thermoplastic) thrust bearing. A CAT6 cable connects it to the controller. The controller provides the necessary user interface and control voltages for the driver and the pulse width signal for the antenna rotator. The controller firmware is written in C++ and provides the necessary functionality and logic for MLA operation.

STEPPER MOTOR

Refer to the “HG-3 DIGITAL CONTROLLER” and “HD-3 Front Panel” schematics. U1 provides +9VDC for the stepper motors. U3 provides +5VDC for the logic and controller. U4 is an ATmega328P Nano V3 micro controller (controller). S5 is a rotary encoder which sends rotation, fine and coarse commands to the controller. S1 and S2 serve dual purposes, sending F1 key, CCW and F2 key, and CW commands to the controller. D1 and D2 provide knob fine/course and motor status indication. LCD1 is a serial data 20x4 display. It provides the various user messages and prompts. The controller’s digital output pins D8, D9, D10 and D11 serve as the control signal for the stepper motor driver. The driver is located in the tuner enclosure. These control signals are comprised of square waves, phased according to the stepper’s motor driver logic. They can be either full steps or micro steps. Q1 samples D8 and D11 phases. With a driver signal is present, Q1 turns on and subsequently turns on LED D2, the motor busy signal. J5 is the CAT6 output for the tuner.

SWR BAR GRAPH

The LM3914, along with a 10 segment bar graph, provide a relative indication of SWR, based on the voltages from the U28B output. R5 sets the bar graph threshold. J2 is a USB jack. It sets the available options. U28A and U28B comprise two non-inverting operational amplifiers which serve as buffers and signal conditioners of the SWR bridge. Their outputs serve as control signals for the analog input, A1 and A2, of the controller.

AR1 ANTENNA ROTATOR

The optional antenna rotator AR1 circuit, is implemented as follows: U5 is the pulse width control module. It powers the AR1 rotator. It is enabled by the controller D7 relay logic. Q4 turns on and activates relay K1. Pins 8 and 9 of U5 are the ground return current sources for the pulse width control module through R22. This serves as a current sensor. Q3 and Q2 are configured as a differential amplifier. Normally, Q2 is on and Q3 is off. When U5 powers the rotator motor, the voltage across R22 increases. It, in turn, saturates Q3 and turns off Q2. Simultaneously, Q3 collector goes low and sends a control signal to A6 of the controller. This indicates that the rotator is turning, sending a message “Turning” to the display. To detect whether either the rotator’s CCW or CW limit switches have been tripped, a quad 2-Input NAND gate with open-collector outputs is used (U6). U6A, U6B and U6D compare the state of Q2 and the CW and CCW switches. When either the CCW or CW switches are depressed and Q2 is on (low), this logic indicates the limits have been reached. Subsequently, the inputs of pin 9 and 10 of U6C toggle high and its output goes low. This sends a rotor logic signal to pin A7 of the controller. As a result, the controller sends a message “Limit Reached Reverse direction”. J6 is the CAT6 output for the rotator.

SWR BRIDGE

Refer to the “HF coupler Shield” schematic. The optional SWR bridge employs the RF transformer-based topology and uses two RF transformers. J3 is the RF in from the radio transmitter and J1

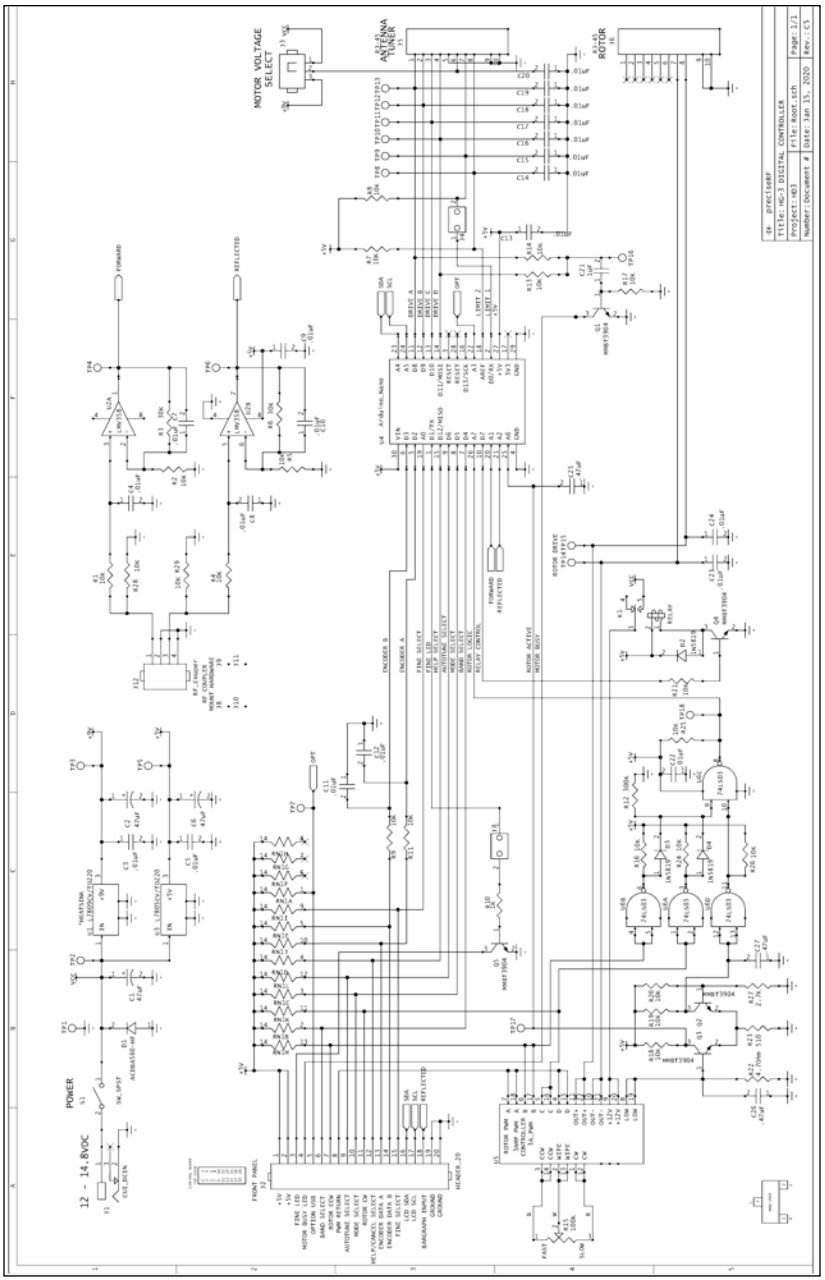
is the RF output to the antenna. The transformer's primary, L1, senses the main line current between the input and the load. A second transformer, L2, senses the voltage on the main line relative to ground. The coupling coefficient is at a nominal -30dB level. Under ideal conditions, when the SWR (Standing Wave Ratio) is 1.0:1, the forward voltage is maximum across R1 D1 and the reflected voltage is zero across R2 D2 (pun not intended). D1 and D2 rectify the RF voltage. C3, C1, C4 and C2 filter the resultant RF to a DC voltage proportional to the forward and reflected power. J2 provides the output for U28 and U28B for further conditioning.

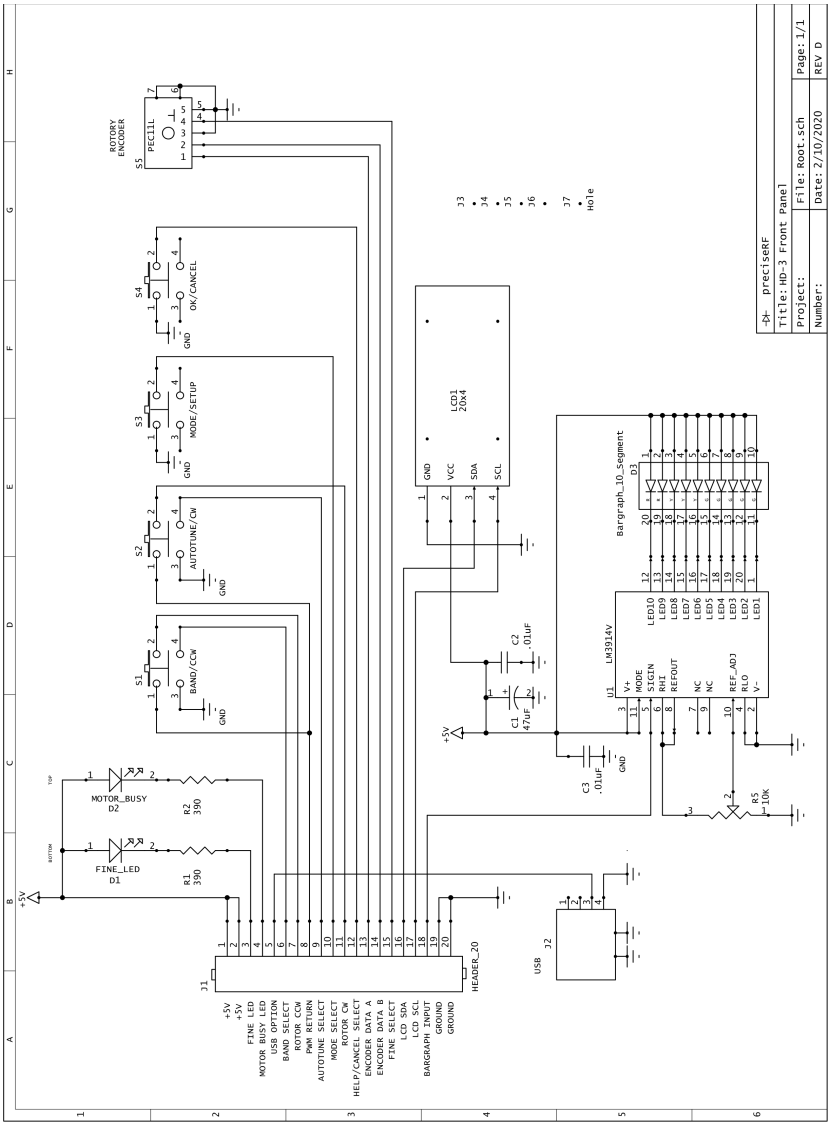
STEPPER MOTOR DRIVER

Refer to the "MG3 MLA" schematic. The tuner receives the controller signal via the CAT6 cable and applies it to U1. U1 is a ULN2003 stepper motor driver. The outputs from this driver are routed to J1 and J2. They power the stepper motor with the required phased square-waves. The HG3 is compatible with 28BYJ-48 Unipolar 2K stepper motors, but may turn in opposite directions of otherwise identical stepper motors, thus the purpose of the two connectors.

FIRMWARE

The HD3 MLS uses an Arduino nano micro-controller. The firmware is written in C++ and can be updated by the end user or by the factory. Check preciseRF.com for more info. We cannot provide telephone product support to help end users upgrades their firmware. Please contact preciseRF to make shipping arrangement prior to sending your unit to us. CAUTION! DAMAGE RESULTING FROM USER FIRMWARE UPDATE IS NOT COVERD BY THE WARRANTY.




preciseRF
Title: HD-3 Front Panel
Project: File: Root.sch Page: 1/1
Number: Date: 2/10/2020 REV D
ROTORY ENCODER
S5 PEC11L
S4 OK/CANCEL
S3 MODE/SETUP
S2 AUTOTUNE/CW
S1 BAND/CCW
LCD1 20x4
Bargraph_10_Segment
D3
U1 LM3914V
C1 47uF
C2 .01uF
C3 .01uF
R5 10K
R1 390
R2 390
MOTOR_BUSY D2
FINE_LED D1
USB J2
J1 HEADER_20
+5V
GND
J3
J4
J5
J6
J7 Hole
+5V
+5V
FINE LED
MOTOR BUSY LED
USB OPTION
BAND SELECT
ROTOR CCW
PWM RETURN
AUTOTUNE SELECT
MODE SELECT
ROTOR CW
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ENCODER DATA B
FINE SELECT
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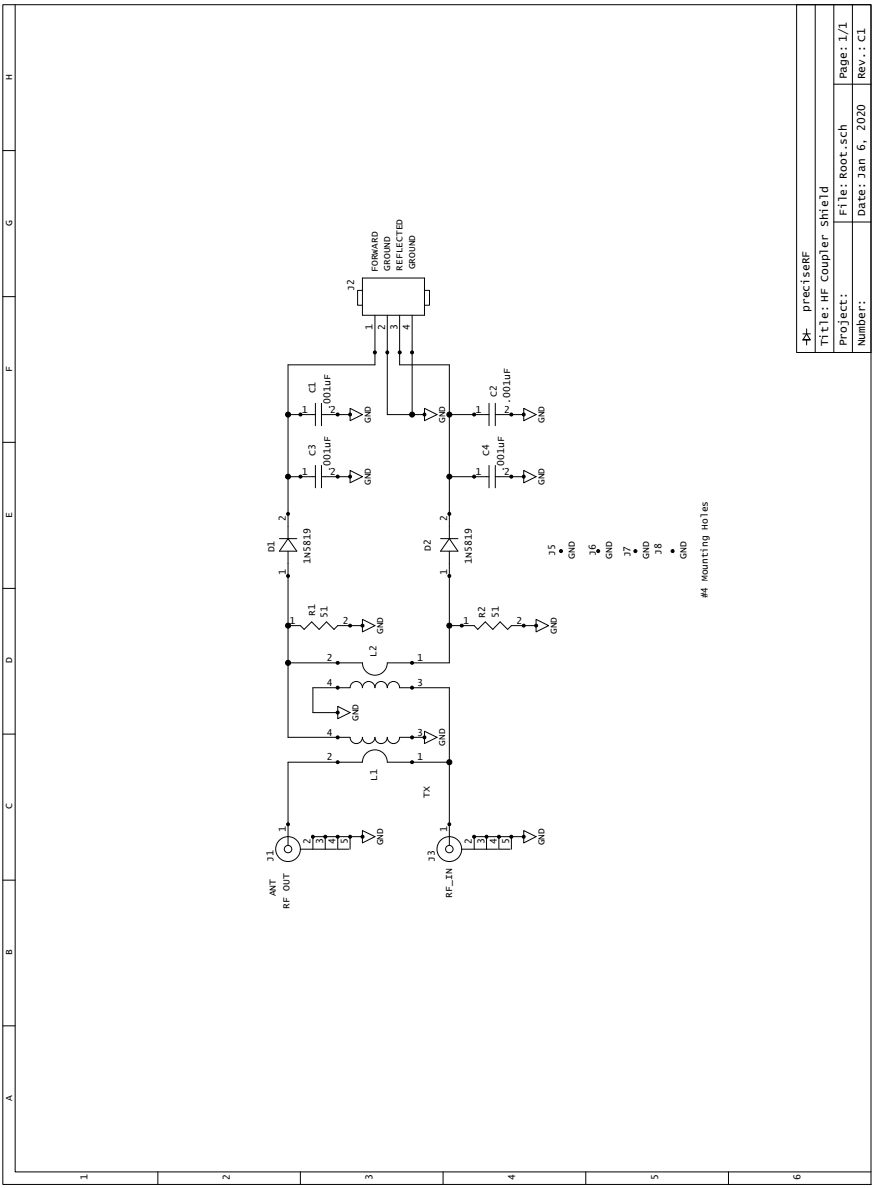
LCD SCL
BARGRAPH INPUT
GROUND
GROUND


preciseRF
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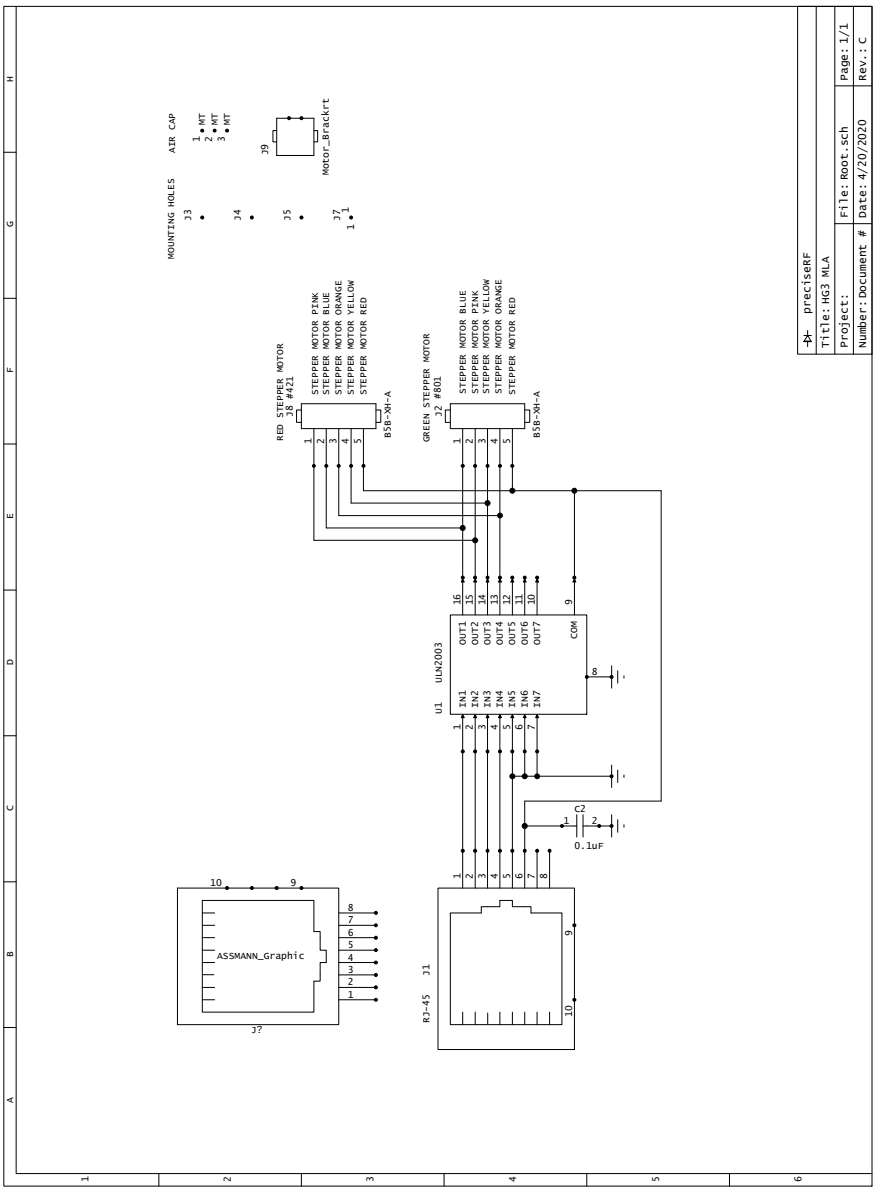
Project:
File: Root.sch
Page: 1/1
Number:
Date: Jan 6, 2020
Rev.: C1
J2
FORWARD
GROUND
REFLECTED
GROUND
C1 .001uF
C2 .001uF
C3 001uF
C4 001uF
D1 1N5819
D2 1N5819
R1 51
R2 51
L2
L1
TX
J1
ANT
RF OUT
J3
RF_IN
J5
J6
J7
J8
GND
#4 Mounting Holes


MOUNTING HOLES
J3
AIR CAP
1 MT
2 MT
3 MT
J4
J5
J9
Motor_Brackrt
J7
1
RED STEPPER MOTOR
J8 #421
STEPPER MOTOR PINK
STEPPER MOTOR BLUE
STEPPER MOTOR ORANGE
STEPPER MOTOR YELLOW
STEPPER MOTOR RED
B5B-XH-A
GREEN STEPPER MOTOR
J2 #601
STEPPER MOTOR BLUE
STEPPER MOTOR PINK
STEPPER MOTOR YELLOW
STEPPER MOTOR ORANGE
STEPPER MOTOR RED
B5B-XH-A
U1 ULN2003
IN1
IN2
IN3
IN4
IN5
IN6
IN7
OUT1
OUT2
OUT3
OUT4
OUT5
OUT6
OUT7
COM
C2
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RJ-45 J1
preciseRF
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File: Root.sch
Page: 1/1
Number: Document #
Date: 4/20/2020
Rev.: C

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   8.2. Do not perform procedures involving cover or shield removal unless you are qualified to do so. Procedures involving the removal of covers and shields are for use by service-trained personnel only.

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8.4. Do not substitute parts or modify the product. Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the product. For service, return the product to PreciseRF.

<end>

Roger M.Stenbock W1RMS - HG3manualV1.1 - 4/24/2020

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Industrial Design: Roger Stenbock W1RMS

Tuner Design: Rob Kirkpatrick KI6HNA

Rotator Design: Robert Kirkpatrick KI6HNA

Manufacturing: Audrie Crane

Model Shop and Fabrication: Harold Crane

Word Smithing: Florene Stenbock

About the Author

The PreciseRF HG3 Stepper Mag Loop was created by retired Tektronix engineer, Roger M. Stenbock (W1RMS). He has a life-long passion for electronics. At Tektronix, he worked on a number of 7000 series oscilloscopes and was on the development team for the 7A22 differential amplifier. He was a design engineer for the 2200 series oscilloscopes FG501, FG502, FG503 and FG504 function generators and PG 501 pulse generator. He holds four US Patents covering oscilloscope trigger circuits and on-line flight planning software. Besides his ham radio activities, he enjoys working in his electronic lab, motorcycling and glider flying.

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