User Manual

For the HG3-plus EXPRESS, PRO and QRO models Magnetic Loop Antenna

Roger M. Stenbock W1RMS

preciseRf
PRECISERF.COM ™

1 CONTENTS

2 TERMS AND CONDITIONS

The information contained in this document is subject to change without notice. PreciseRF makes no warranty of any kind with regard to this material, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. PreciseRF shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

2.1 15 DAY PRODUCT RETURN POLICY

1) PreciseRF factory assembled products and unassembled kits may be returned within 15 days after the date of shipment, subject to a restocking fee. If you have problems getting your PreciseRF kit to work, our support team will assist you. Contact us at preciserf.com for spare or missing parts. You can also reach us by phone at (503) 915-2490 Monday through Friday from 9:00 am to 4:00 pm PST.
2) Products must be returned in new and unused condition in their original packaging to qualify for a refund. On kits, all kit part's bags must be unopened, and the product manuals and boxes must be in a new, undamaged state. Note: Partially built and completed kits may not be returned for credit. PreciseRF reserves the right to make the final determination of returned product condition. Any refunds will be less the original shipping charges from PreciseRF to the customer. We also charge a 15% restocking fee on each returned product. The restocking fee is higher for assembled to order products. If a product arrives in a damaged state, we will either charge a higher return fee or return it to the customer.
3) You must contact PreciseRF for a return authorization form, instructions, and return address before returning any products. You will be responsible for paying for your own shipping costs for returning items. If you are returning an item, you should consider using a trackable shipping service or purchasing shipping insurance. We do not guarantee that we will receive the item that you are returning. Shipping costs are non-refundable. If you receive a refund, the cost of return shipping will be deducted from your refund. Email preciseRF.com or call (503) 915-2490 to authorize a return or if you have any questions.
4) Late or missing refunds. If you haven't received a refund, please contact your credit card company or financial institution. Your refund may take some time before it is posted to your account. If you still have not received your refund after contacting your financial institution or credit card company, please contact us at preciseRF.com.

2.2 WARRANTY

The material contained in this document is provided “as is,” and is subject to being changed, without notice, in future editions. Further, to the maximum extent permitted by applicable law, PreciseRF disclaims all warranties, either expressed or implied, with regard to this document and any information contained herein, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose.

The basic term of the warranty is twelve calendar months from the date of purchase. The duration and conditions of warranty for this product may be superseded when the product is integrated into (becomes a part of) other PreciseRF products. During the warranty period, PreciseRF will, at its option, either repair or replace products which prove to be defective. The warranty period begins on the date of delivery or on the date of installation, if installed by PreciseRF.

2.3 CERTIFICATION

PreciseRF certifies that this product met its published specifications at the time of shipment. PreciseRF further certifies that its calibration was accomplished with products in accordance with industry acceptable measurement and testing practices.

2.4 SERVICE

For warranty service or repair, this product must be returned to a service facility designated by PreciseRF. For products returned to PreciseRF for warranty service, the Buyer shall pre-pay shipping charges and PreciseRF shall pay shipping charges to return the product to the Buyer. However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to PreciseRF from another country.

2.5 REMEDIES

To the extent allowed by local law, the remedies provided herein are the Buyer’s sole and exclusive remedies. PreciseRF shall not be liable for any direct, indirect, special, incidental, or consequential damages (including lost profit or data), whether based on warranty, contract, tort, or any other legal theory. CAUTION! DAMAGE RESULTING FROM MISUSE, EXCESSIVE LOAD, WATER INCURSION AND USER FIRMWARE UPDATES, IS NOT COVERED BY THE WARRANTY.

2.6 LICENSES

The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

2.7 GENERAL SAFETY INFORMATION

Do not operate the product in an explosive atmosphere or in the presence of flammable gasses or fumes. For continued protection against fire, replace any fuse with the same voltage and current rating and type.

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.

Do not service or adjust the product alone. Under certain conditions, dangerous voltages may exist, even with the product switched off. Do not operate damaged products. Whenever it is possible that the safety protection features built into this product have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the product until safe operation can be verified by service-trained personnel. If necessary, return the product to PreciseRF for service and repair to ensure the safety features are maintained.

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.

3 INTRODUCTION

This manual covers the operation, description, and care of the preciseRF HG3 EXPRESS, PRO and QRO Magnetic Loop Antennas (MLA). It was created for amateur radio, military, and HF operators wanting the performance advantages of an MLA without its drawbacks.

This manual assumes a rudimentary understanding of radio and electronics typically acquired by amateur radio operators. For brevity, the HG3 is referred to as the HG3 EXPRESS, PRO or QRO 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 uses 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, capacitor value and more. The bottom line - count on topnotch receiving and transmitting performance!

3.1 TUNED CIRCUIT RADIATION

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 in parallel 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.

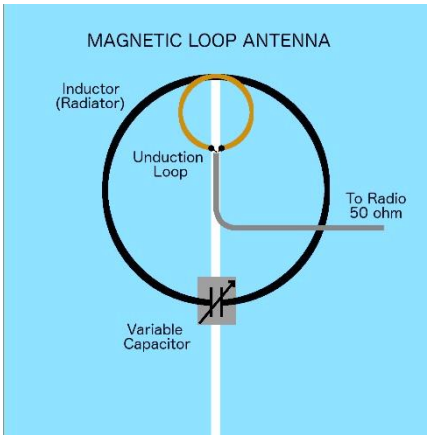


Figure 1 Magnetic Loop Antenna

3.2 MINIMIZING LOSSES

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.

3.3 DIRECTIVITY

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

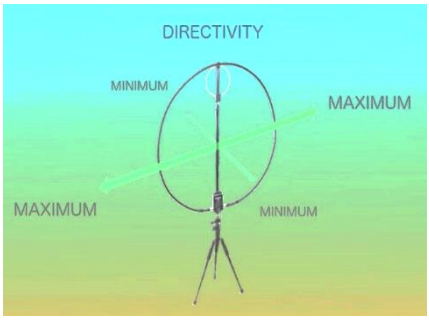


Figure 2 Directivity

3.4 CONVENIENT

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 Summit On The Air (SOTA) operations.

3.5 LOW NOISE

The MLA rejects locally generated background noise noise due to its inherent magnetic field coupling and its relative insensitivity to the electric field. That's valuable. Most interference sources with RF 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.

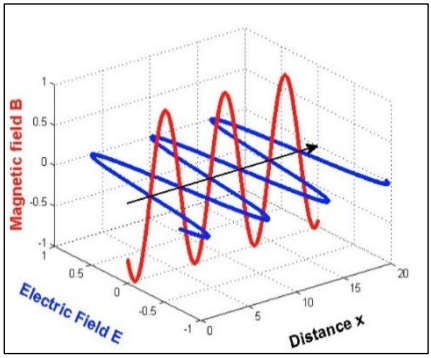


Figure 3 Near Field Radiation

3.6 EFFICIENCY

When designed and constructed properly, an MLA performs 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."*

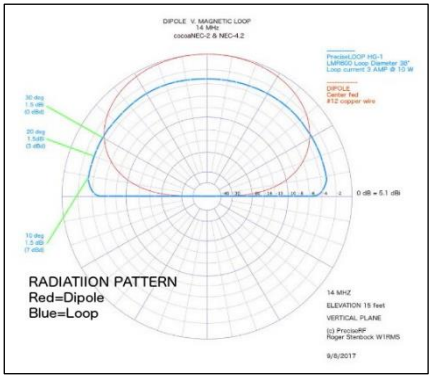


Figure 4 Dipole V Loop Radiation

3.7 LIMITATIONS

An MLA is not for every application and not for everyone. First, while desirable for selectivity and background noise rejection (note the loop's excellent Return Loss and SWR characteristics below) it can be challenging.

3.8 NARROW BANDWIDTH

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 HG3 MLA was designed

to overcome most of these limitations.

3.9 CAPACITOR 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

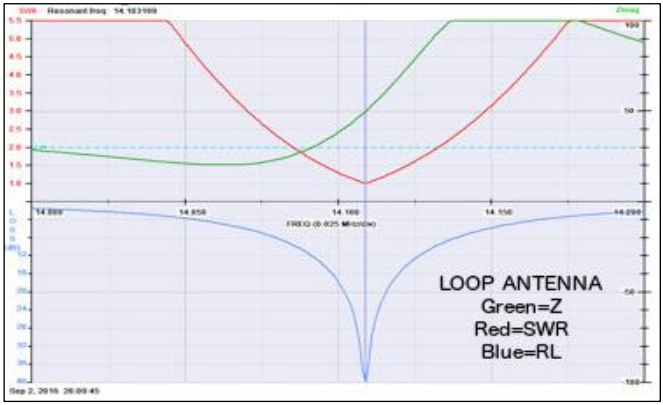


Figure 5 Hi Q of Loop Antenna

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 vacuum dielectric capacitor.

4 HG3 PLUS MODELS

The HG3 plus controller supports the EXPRESS, PRO and QRO models with the capability of additional options. (* See section 14 SPECIFICATIONS for greater detail.)

	EXPRESS	PRO	QRO
Resolution BW	13.5 KHz	13.5 KHz	600 Hz
Max Power*	100W	100W	1,500W
Bands*	40-10 meter	80-10 meter	80-10 meter
Tuning	Manual	Manual Auto	Manual Auto
SWR Bridge	No	YES	YES
Antenna Rotor	No	YES	YES

4.1 EXPRESS MODEL

The EXPRESS model is the basic model. It supports a high resolution 2000-step stepper motor and manual tuning.

4.2 PRO MODEL

The Pro model supports a high resolution 2000-step stepper motor, manual tuning, external resonator, auto-tuning, antenna rotation and includes the integrated SWR bridge and ERP functions.

4.3 QRO MODEL

This QRO model is our premium antenna. It uses a 45,000-step stepper motor to drive a vacuum capacitor. Its output shaft is connected to the vacuum capacitor via a 5:1 planetary gear. This provides increased torque, very low backlash, and excellent resolution.

The controller needs to be indexed to a known capacitance (step) of the vacuum capacitor in order to tune the MLA to the desired band and resonance. Traditionally, limit switches were used to detect that position. Because of the required gear train, they introduced additional backlash and complexity. The HG3 MLA uses optical sensors to detect the index position. Initializing, if required, needs only be done when the controller is turned on.

This allows for user programable band selection, *RapidTune*™ AUTO tuning and full power operation at 80 meters.

5 ASSEMBLY AND DEPLOYMENT

5.1 THE MAST

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

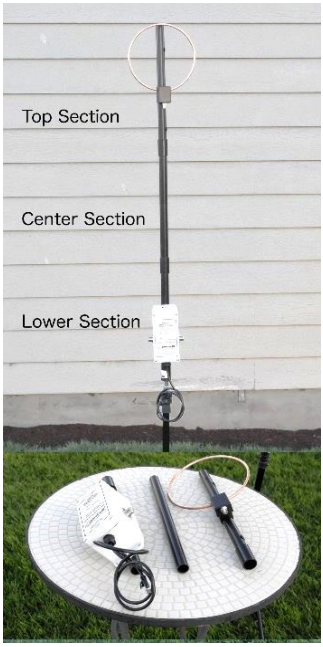


Figure 6 The PVC Mast

1) Find a level surface clear of any obstructions within an approximate 25-foot radius and 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.
2) 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.
3) 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.

Figure 7 Induction Loop

4) 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.

5) 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, onto the tuner's SO239 input connectors. Connect the supplied 50 Ω coaxial cable to the induction loop BNC connector.

Figure 8 U Bolts

6) Connect the other end of the 50 Ω coaxial cable to the radio's input/output for the EXPRESS model or to the controller as described for the PRO model.

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

Figure 9 Recommended 25-foot Distance

8) 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.

6 CONNECTIONS

6.1 CONTROLLER CONNECTIONS

The HG3 *plus* controller is compatible with the EXPRESS, PRO and QRO remotely tuned MLAs. Not all connections may be used. Refer to the figure:

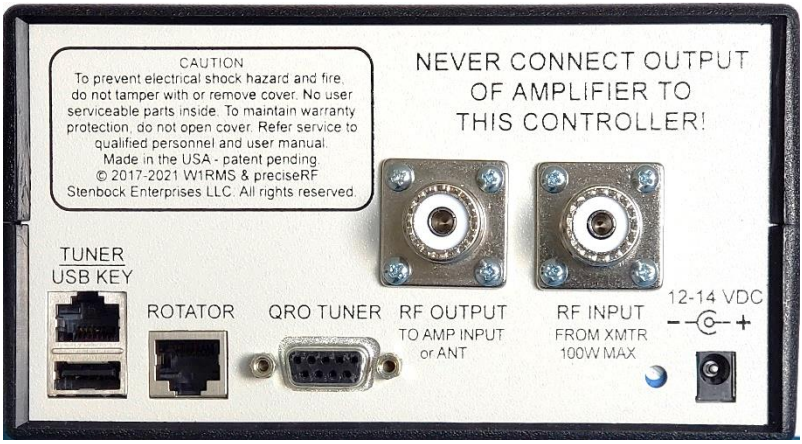


Figure 10 Rear Connections

CONNECTOR	PURPOSE
12-14 VDC input	Power input. Ensure it has adequate voltage and current for the model in use.
TUNER	CAT6 controller cable to the loop tuner for the EXPRESS and PRO model.
USB	Factory used only for programming.
ROTATOR	CAT6 cable to control the AR1 Rotator.
QRO tuner	DB9 controller cable to the loop tuner for the QRO model.
RF output	RF output for antenna or to drive an external linear amplifier.
RF input	RF input from the transceiver.

6.2 RF INTERCONNECTIONS

Depending on the model and your setup, the RF output from your HF radio will loop though the HG3 *plus* controller to be used to reference the SWR during tuning operations. Normal tuning is done using AM/CW modes between 1 and 5 Watts. Normal operational power is up to 100 Watts maximum. The RF output will then drive your linear amplifier or MLA antenna. Use only quality 50 Ω interconnect cables.

6.3 CONNECTING THE EXPRESS AND PRO

The MLA can be manually tuned. For manual tuning, connect the transceiver RF directly to the tuner and the controller to the tuner. See below:

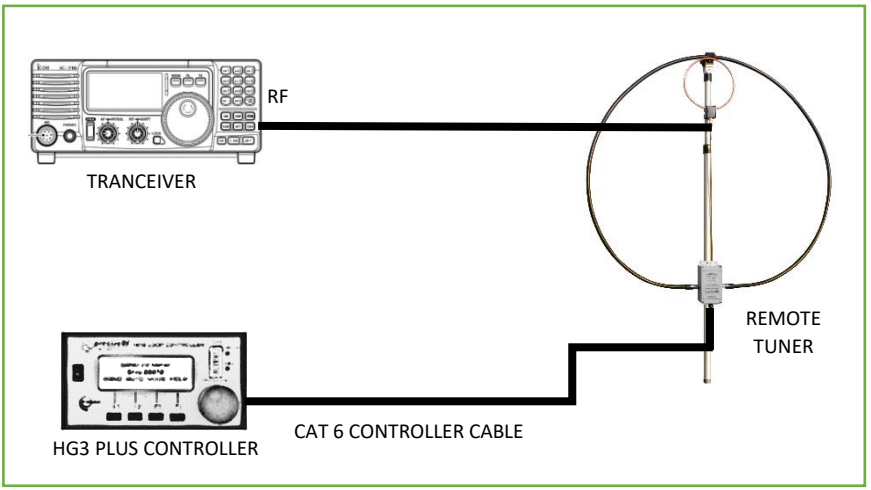


Figure 11 EXPRESS Model Connections

When automatic tuning is desired, the transceiver's RF output must be connected to the controller's RF INPUT and the controller's RF OUTPUT connects directly to the tuner. See below:

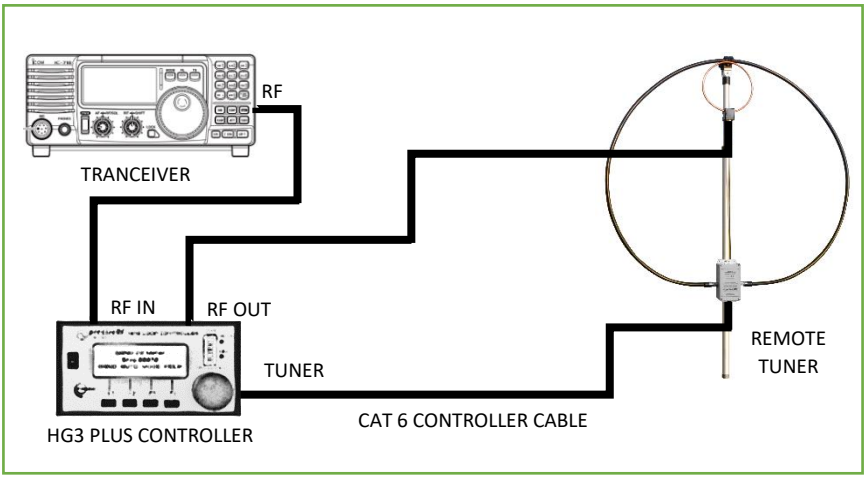


Figure 12 PRO Model Connections

6.4 CONNECTING THE HIGH POWER QRO

The MLA can be manually tuned. For manual tuning, connect the transceiver RF directly to the linear amplifier's RF input and the controller to the tuner. Connect the linear amplifier's RF output directly to the REMOTE TUNER SO239 input. See below:

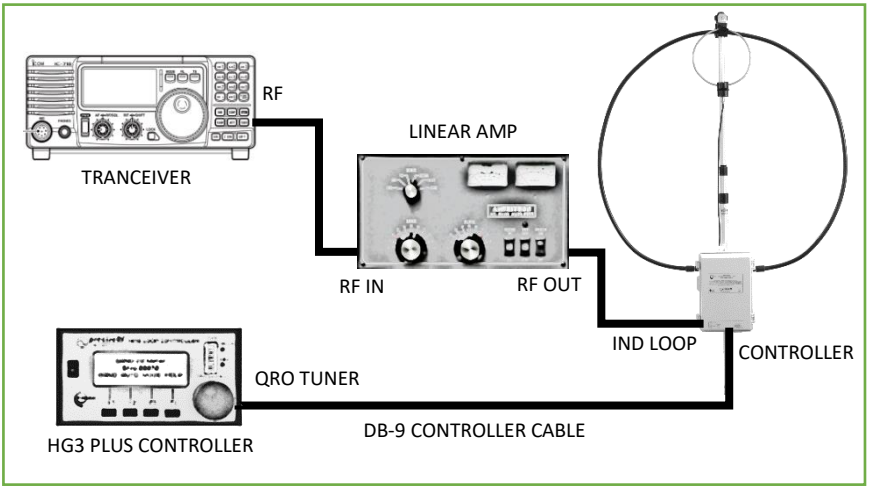


Figure 13 QRO High Power - Manual Tune

When automatic tuning is desired, the transceiver's RF output must be connected to the controller's RF INPUT and the controller's RF OUTPUT connects directly to the linear amplifier's RF input. Connect the linear amplifier's output directly to the REMOTE TUNER SO239 input. See below:

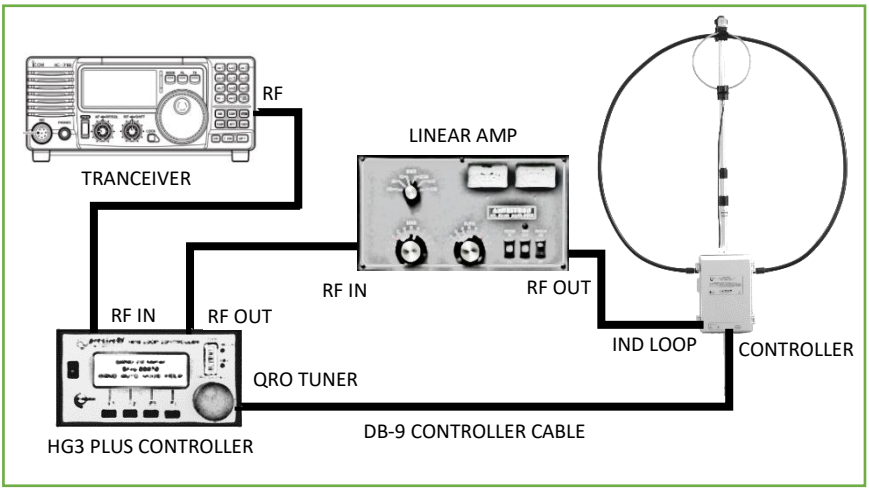


Figure 14 QRO High Power - Auto Tune

7 CONTROLS

7.1 FRONT PANEL

Remote loop tuning, band selection and the usual setup procedure are accomplished via the front panel controls. The LCD provide the current tuning and performance status at a glance. See the figure below:

Figure 13 Front Panel

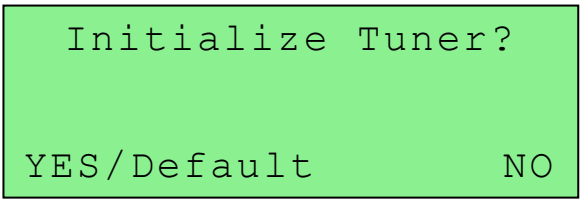
CONTROL	PURPOSE
Power switch	The power switch turns the controller on/off. Most operators use their shack's 13.5V power supply. For the EXPRESS and PRO models, a common 9 VDC 200 mA will work well. The QRO model requires more power because of the vacuum capacitor. It requires 12.5 to 14.5 volts at a maximum current of 1,500 mA when tuning and 200mA when at idle.
Function keys	The F1 to F4 keys are soft keys which change functions based on the required operation.
Tuning knob	The encoder knob is used to adjust the tuning for best SWR. The mechanical detents do not necessarily represent the encoded pulses. Pushing the knob in toggles it between normal and fine sensitivity. The FINE LED indicates its status.
SWR bar graph	The ten segment, green, yellow, and red segment bar graph is not calibrated. It provides only a relative indication of the SWR during tuning when used with power levels from 1 to 5 Watts. Any level in the green segment range is acceptable.

8 OPERATION - EXPRESS AND PRO

8.1 INITIALIZING THE TUNER

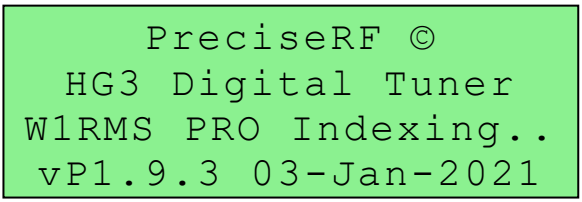
Indexing is the step which positions the tuning capacitor to a known capacitance. It takes just a few seconds. For the EXPRESS and PRO models, it is set to 40 meters. Ensure you have assembled and connected the MLA as described previously to the configuration of your choice. Follow these steps:

1) Turn the controller on. The initialize page appears.



2) Select YES/Default (F1)

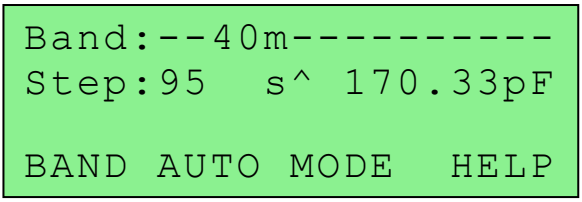
3) The tuner will now index. Note that the MOTOR LED is illuminated, and the indexing page appears.



4) If you wish to use the last saved tuner setting, press NO (F4).

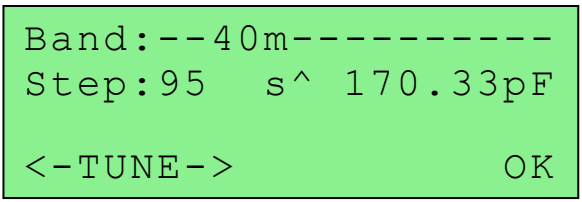
8.2 THE HOME PAGE

5) The home page appears after Initialization is complete.



8.3 BAND SELECTION

1) Press the BAND (F1) button. The band page appears.



Use the F1 and F2 buttons to select the band you wish to use. Default bands are 40m, 30m, 20m, 17m, 15m, 12m and 10m.
In this example, we'll select the 20-meter band. If you have not done so, initialize the controller. This will set the band to the default 40-meter band.

2) Use the F1 <-tune-> F2 to increase or decrease the band selection.
3) Press -> (F2). Note, the motor LED illuminates, and the band is now set to 30-meter. Press the **->** (F1) again. The band is now set to 20-meter. The **^** is the cursor. It indicates the approximate band position. The little **s** indicates that the current tuning position has been saved. The controller will return to this value when it is turned on again and not indexed.

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 page.

8.4 MODE

The operating mode is selected with the MODE (F3) key. It cycles between the home, Rotator, External Resonator pages by repeatedly pressing the MODE (F3) key. Try it.

8.5 HELP

Help is available with the HELP (F4) key. It supports most functions. Six help pages cover most of the HG3 functions. Explore the help pages by repeatedly pressing the PREV (previous) (F1) and or the NEXT (F2) keys. To exit, press CANCEL (F4).

8.6 TUNING FOR MAXIMUM NOISE

This method uses your radio and your ears. It gives you a close match quickly. Follow these steps (For this demo, we'll set the controller initially to the 20-meter band):

1) Turn the controller ON.
2) Set the controller to the 20-meter band.
3) Set the radio to the 40-meter band. Tune it to approximately 7.15 MHz.
4) 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.
5) Now select the 40-meter band on the controller. You should notice an increase in the background noise from your radio.
6) Use the TUNE knob to 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.

8.7 CHECKING THE SWR

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.
2) Transmit a low power carrier of about 1 to 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.

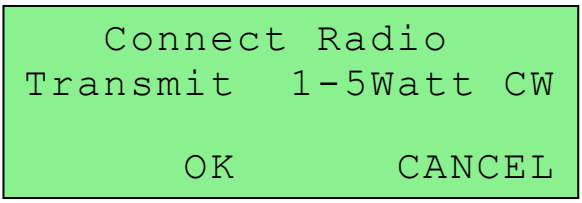
Figure 16 SWR Meter Reading

8.8 AUTO-TUNING PRO MODEL ONLY

Auto-tuning uses the HG3 PRO integrated SWR bridge and bar graph display. The controller automatically scans for a low SWR from slightly below the tuned frequency. The capacitor turns incrementally, in small steps. In this example, we will use the 20-meter band. 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 prompts displayed:



4) Transmit a low power AM/CW carrier of about 1 to 5 Watts. Note the high SWR prior to tuning for minimum.
5) Press OK (F2) to start auto-tuning.
6) If the power levels are not correct, you'll get these prompts:
   No Signal Transmit 1-5 Watt CW
   (If the signal is too low)
7) Reduce Power Transmit 1-5 Watt CW (If the signal is too high)
   Adjust the power level accordingly and press OK (F2).
8) After finding an acceptable SWR solution, auto-tuning ends.

The home page will show the SWR and Equivalent Radiated Power (ERP). Note: The slight SWR discrepancy is normal. While a perfect SWR of 1.0 is often desired, it is not necessary. Any SWR lower than 2.0 will give you better than 88% ERP. 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-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.

8.9 THE SWR BAR GRAPH

The SWR Bar Graph consists of ten segments. They are red, yellow and green. It is not calibrated and only provides a relative indication of the SWR during tuning, when used with power levels from 1 to 5 Watts. When transmitting at

higher power levels, the displayed bar graph SWR is not accurate and will read higher than the actual SWR. This is normal. It was designed that way to allow for low power auto-tuning. After tuning, any level in the green segment range is acceptable.

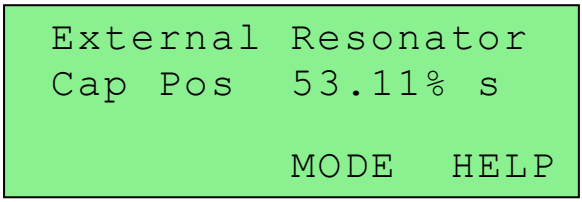
8.10 80 AND 60 METER TUNING

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. There is a solder jumper labeled 60/80M JUMPER JP1. See the figure at right:

Figure 17 Interface Jumper

2) Bridge the jumper with solder. This connects the main tuning capacitor to the external banana jack. 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 jack. It is located on the top end of the tuner case.
4) Press the `MODE` (F3) key repeatedly until the external resonator



page is displayed.
5) Using the TUNE knob, manually tune the antenna. The capacitor position displays the cap value as a percentage of total capacitance to aid with your tuning.

9 THE AR-1 ROTOR

The AR-1 ROTOR rotates the HG3 Pro MLA Model. It is intended for portable light duty only. 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:

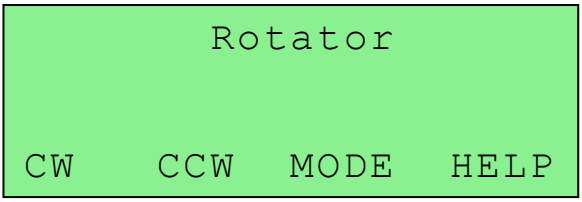
Figure 14 AR1 Rotator

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. IT MUST BE GUYED! Thread the AR-1 Rotator onto 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 or antenna mast.
4) Connect the CAT 6 cable from the controller's output labeled ROTATR to the AR-1 CAT 6 input.

9.1 TURNING THE AR-1 ROTOR

The EXPRESS model does not support the AR-1 antenna rotator.

1) Press the `MODE` (F3) key repeatedly until the Rotator page is displayed.



2) The choices are `CW` (F1) for clockwise, `CCW` (F2) for counter clockwise, `MODE` (F3) and `HELP` (F4).
3) Press either the `CW` (F1) for clockwise, or `CCW` (F2) for counterclockwise buttons to rotate the antenna. During rotation, the LCD indicates `Turning....`
4) Reverse direction once the rotation limits are reached when the LCD displays:
   `Limit reached Reverse direction`

   Note: It is normal for the limit reached message to flash occasionally. A slight adjustment of (R15) may be required. It is located on the main circuit board and is accessible from the rear panel.

5) Press the `MODE` (F3) button repeatedly to exit and select the desired mode.

10 OPERATION – QRO HIGH POWER

10.1 COMPONENTS

The HG3 QRO MLA is the high-power model MLA. It is shipped with all the components you need for 40-meter through 10-meter operation. It consists of the following components:

- HG3 plus controller
- Tuner (the variable capacitor)
- Radiation loop
- Induction loop
- Aluminum mast
- DB-9 control cable
- 50Ω coax transmission cable

10.2 PERMANENT AND PORTABLE MOUNTING CONSIDERATIONS

You must provide a suitable MLA location and mounting fixture. This could be a sturdy tripod or an antenna mast such as one used for a TV antenna when mounting it to an external structure. Because of the potentially high power, and the resultant intense RF field, exercise RF safety measures and remain clear by at least 25 feet during transmission.

10.3 ATTACHING THE HG3 QRO TUNER CASE TO THE MAST

1) Locate the tuner case and the tuner mast brackets.
2) Attach the tuner case as shown at right approximately 10-12 inches from the bottom of the mast using the brackets. This allows the mast to be mounted to a commercial antenna rotator.
3) Extend the mast sections to obtain a circular and symmetrical shape. (The shape is not critical.)
4) Attach the radiation loop to the top of the mast using the snap bracket.

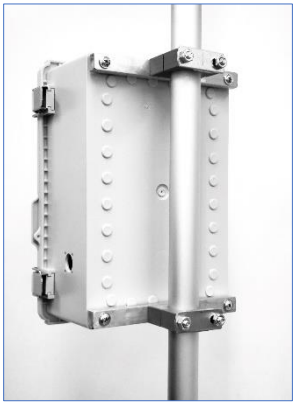


Figure 15 QRO tuner mast attachment

5) Attach the induction loop to the top of the mast.
6) Connect the 50Ω BNC cable from the induction loop to the tuner (labeled IND LOOP).
7) Connect the radiation loop to each of the two SO239 connectors located on each side of the tuner case.

Figure 16 Tuner

10.4 INITIALIZING THE TUNER

Ensure you have assembled and connected the MLA as described previously to the configuration of your choice.

1) Turn the controller on. The initialize page appears.

```
  Initialize Tuner?


YES/Default        NO
```

2) Select `YES/Default` (F1)
   (If the Loop is not connected to the controller, it will display an error message to connect the cable).
3) The tuner will now index. You will note that the motor LED is illuminated, and the indexing page appears.

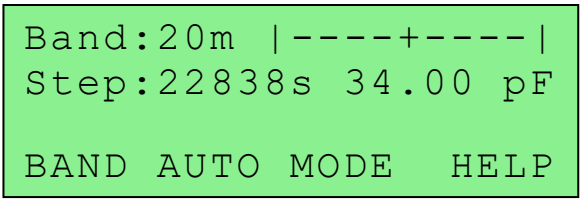
```
     PreciseRF ©
  HG3 Digital Tuner
W1RMS QRO Indexing..
 vP1.9.3 03-Jan-2021
```

Figure 17 Indexing page

4) If you wish to use the last saved tuner setting when the controller was turned off, do not initialize the tuner and press `NO` (F4).

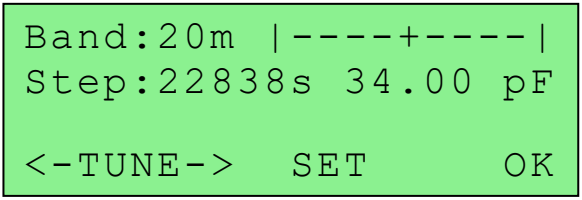
10.5 THE HOME PAGE

The home page appears after initialization is complete.



10.6 BAND SELECTION

1) Band selection is done with the `BAND` (F1) key. You can select the individual bands, set the default band positions, or exit the band mode with the `OK` key.
2) Press the `BAND` (F1) button. The band page appears.



3) In this example, we'll select the 40-meter band. If you have not done so, initialize the controller. This will set the band to the default 20-meter band.
4) Use the F1 `<-tune->` F2 to increase or decrease the band selection.
5) Press the `<-` (F1). Note, while the motor is running the message: `Tuning. Please wait` is displayed. The motor LED illuminates, and the band is now set to 30-meter. Press the `<-` (F1) again. The band is now set to 40-meter. Press `OK` (F4) to exit the band selection page.
6) The first line indicates:
   `Band:40m |----+----|`
7) The step and pF are also updated.
8) The + index is set to the selected band center position. The selected position can be the factory default or the user programmed position. The step number represents the step count used by the stepper

motor. It may be a different number than illustrated, depending on the actual tuning. The little s indicates that the current tuning position has been saved. The controller will return to this value on power up unless the tuner is initialized. The value indicated in pF (pico Farad) represents the approximate tuning capacitance.

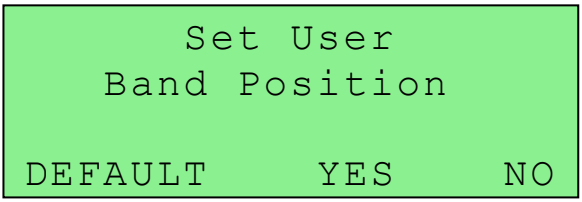
10.7 FACTORY DEFAULT BANDS

As bands are selected, the controller sets the capacitance for that band. These are the initial values used in that band to tune the loop. The controller is shipped from the factory with all bands set to their default band positions. The user can change these band positions.

10.8 USER BANDS

You may wish to set different initial band positions. To do this, follow these steps:

1) From the home page, press the BAND (F1) key. The band page appears.
2) Press the SET (F3) key. The set user band position page appears.
3) From here, your choices are:



4) DEFAULT Sets the band to the factory defaults.
5) YES Sets the band to position last tuned and centers the + cursor.
6) NO Exits the SET page.

10.9 TUNING WITH A LINEAR AMPLIFIER CONNECTED

Because the SWR bridge is connected to the input side of any connected external linear amplifier, when tuning a loop antenna, the linear amplifier circuitry will interfere with the tuning. Thus, it results in unreliable tuning. For that reason, all tunings should be made when the linear amplifier is bypassed. On most linear amplifiers, bypassing is done with the XMT switch. It must be set to STBY (standby).

Figure 18 Standby

10.10 TUNING FOR MAXIMUM NOISE

This method uses your radio and your ears. It gives you a close match quickly. Follow these steps (For this demo, we'll initially set the controller to the 40-meter band):

1) Bypass any linear amplifier connected by setting it to the STBY (standby) position.
2) Turn the controller on.
3) Initialize the tuner. This sets the band to 20-meter.
4) Set the radio to the 40-meter band. Tune it to approximately 7.15 MHz.
5) 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.
6) Now select the 40-meter band on the controller. You should notice an increase in the background noise from your radio.
7) Use the TUNE knob to 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. After tuning the loop, you can turn the bypass off. You are now ready for a QSO.

10.11 CHECKING THE SWR

1) Bypass any linear amplifier connected by setting to it to the STBY (standby) position.
2) Connect an SWR (Standing Wave Ratio) meter either in-line or on the radio.
3) Transmit a low power carrier of about 1 to 5 Watt.
4) 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.
5) 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.

Figure 19 SWR Meter Reading

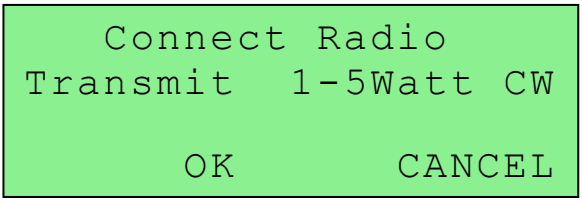
10.12 AUTO-TUNING FOR LOW SWR

Auto-tuning uses the HG3 QRO integrated SWR bridge and bar graph display. The controller automatically scans for a low SWR beginning at slightly below the tuned frequency. The capacitor turns incrementally, in small steps. In this example, we will use the 20-meter band. Follow these steps:

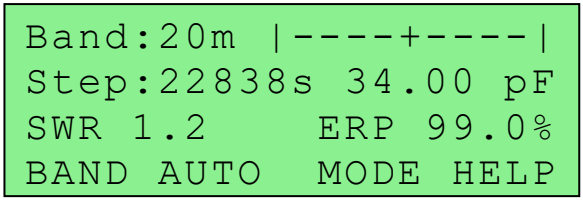
1) Bypass any linear amplifier connected by setting it to the STBY (standby) position.
2) Set the controller to the 20-meter band. Tune your radio to approximately 14.15 MHz. Set the radio's modulation mode to SSB

and increase the volume to hear some background noise. If necessary, turn the radio's pre-amp on.

3) Ensure the controller is set to the home page.
4) Adjust the controller TUNE knob to obtain the strongest background noise from the radio.
5) Press AUTO (F2) for auto-assist. The prompts displayed:



6) Transmit a low power carrier of about 1 to 5 Watt. Note the high SWR prior to tuning for minimum.
7) Press OK (F2) to start auto-tuning.
8) If the power levels are not correct, you'll get these prompts:
   No Signal Transmit 1-5 Watt CW
   (If the signal is too low)
9) Reduce Power Transmit 1-5 Watt CW (If the signal is too high)
   Adjust the power level accordingly and press OK (F2).
10) After finding an acceptable SWR solution, auto-tuning ends.



The home page will show the SWR and Equivalent Radiated Power (ERP). Note, the slight SWR discrepancy is normal. While a perfect SWR of 1.0 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-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-tuning by pressing the AUTO (F2) key. If the tuning is still not successful, use the manual tuning method. After auto-tuning, you can take the amplifier out of the standby mode. You are now ready for a QSO.

10.13 THE SWR BAR GRAPH

The SWR Bar Graph consists of ten segments. They are red, yellow and green. It is not calibrated and only provides a relative indication of the SWR during tuning, when used with power levels from 1 to 5 Watt. When transmitting at higher power levels, the displayed bar graph SWR is not accurate and will read higher than the actual SWR. This is normal. It was designed that way to allow for low power auto-tuning. After tuning, any level in the green segment range is acceptable.

11 IN CASE OF DIFFICULTY

If, after installing your MLA loop, you are not receiving any signals or are having tuning difficulties, make sure you have read this user guide and watched the demo video. 90% of all problems are the result of not having the correct connections, bad or intermittent cables, cables not completely seated, or not understanding the radio or controller controls.

11.1 CONFIRM THE RADIO IS RECEIVING

1) Set your radio to a 40-meter frequency, such as 7.15 MHz and select the SSB mode.
2) Connect a known good antenna (a length of 10' piece of wire will also work) to the radio's RF input.
3) You should note an increase in the background noise. This indicates that the radio is receiving something and most likely working correctly.

11.2 CONTROLLER CHECK - EXPRESS AND PRO MODEL

For this test, you do not need to assemble the MLA in its operating configuration. We'll just use the controller and the tuner (the light gray case). Refer to the figure.

1) For the EXPRESS & PRO model, connect the CAT6 cable from the controller output to the tuner's CAT 6 connection. This cable must be pushed in completely and securely seated.
2) Carefully open the tuner's cover. Apply power to the controller and turn it on. You should see the initialization page:
   `Initialize Tuner`
   `YES/Default NO`
3) Select `YES/Default` (F1). The stepper motor should turn the capacitor to the fully closed (in the 40-meter) position.

Figure 20 EXPRESS and PRO Tuner

11.3 CONTROLLER CHECK - QRO MODEL

1) For the QRO model, connect the DB-9 cable from the controller output (labeled QRO TUNER) to the tuner's DB-9 input. This cable must be pushed in completely and securely seated.
2) Carefully open the tuner's cover. Apply power to the controller and turn it on. You should see the initialization page:
   `Initialize Tuner`
   `YES/Default NO`
3) Select `YES/Default` (F1). The stepper motor should turn (either CW or CCW depending on its initial state) and stop with the bellows exposed to about one inch (the 20-meter position).
4) It is normal for the green LED to illuminate briefly. If the red LED illuminates, it indicates the capacitor has reached its fail-safe limit. <u>In that case, immediately shut the controller off</u> and manually reset the capacitor as described further in this section, and perform the initialization cycle again. If unsuccessful, return the tuner for factory service.

Figure 21 QRO Tuner Connections

Figure 22 Vac Cap at 20-meter

IMMEDIATELY SHUT THE CONTROLLER OFF IF AT ANY TIME THE TUNER MAKES AN ABNORMALLY LOUD NOISE.

The loud noise is an indication that the vacuum capacitor has reached either the CW or CCW limits. Further operation may damage the capacitor permanently. You must return the entire tuner to the factory for service.

5) Using the BAND (F1) button and < – – > buttons, change the band from 40-meter to 20-meter, then back to 40-meter. You should notice the capacitor is opening and closing accordingly (at 40-meter it is mostly closed).
6) If the capacitor is not opening or closing as the band is changed, then the controller, the DB-9 cable, or the connectors, may be lose or defective. The controller, or the tuner driver, may also be the cause.
7) Using your ohm meter, make sure that the capacitor connections are properly soldered.
8) Re-install the cover.

11.4 MANUALLY RESETTING THE VACUUM CAPACITOR

In the unlikely event that the capacitor continues to turn in the opening direction (past 10-meter), the fail-safe circuit will protect the capacitor and the red LED will illuminate. This prevents the motor from turning any further. The only way to clear this fault is as follows:

1) Turn the controller completely off and wait for 5 seconds.
2) Open the tuner case and locate the coupler, which connects the motor to the capacitor.
3) Manually turn the coupler 10 revolution clockwise (looking down at the motor). This closes the capacitor past the point of the fail-safe sensor.
4) Turn the controller on again and initialize the tuner.

11.5 RF LOOP CONNECTIONS CHECK

1) Assemble the MLA and connect the radiation loop (LMR600) to the tuner's HF connectors, located on each side of the tuner case. Ensure that they are securely fastened.
2) Connect a known good 50 Ω BNC cable from the copper induction loop to the tuner's 50 Ω BNC output labeled IND LOOP on the tuner case. (On the EXPRESS or PRO models, the cable goes directly from the copper induction loop to the radio's RF connector.)
3) Connect a known good 50 Ω cable from the tuner labeled XMTR to the radio's RF connector. They could be intermittent, so jiggle them to check them.

4) You should notice an increase in the background noise. This indicates that the connections from the radio to the induction loop are good.
5) You may have to initialize the controller and set the band on the controller and radio to 20-meter.
6) Use the TUNE knob to obtain maximum background noise.
7) If you do not hear an increase in the background background noise, then any of the following may be bad: cable/connector, induction loop, radiation loop or the tuner.
8) To check the induction loop, use an ohm meter and check that it reads a DC short at the BNC input (it is just a one turn copper loop). If it is open, the induction loop is defective. Use an ohm meter to check the cables and all connectors.

11.6 AUTO TUNE CHECK - PRO MODELS

1) Connect the controller as shown below with known good 50 Ω BNC cables.

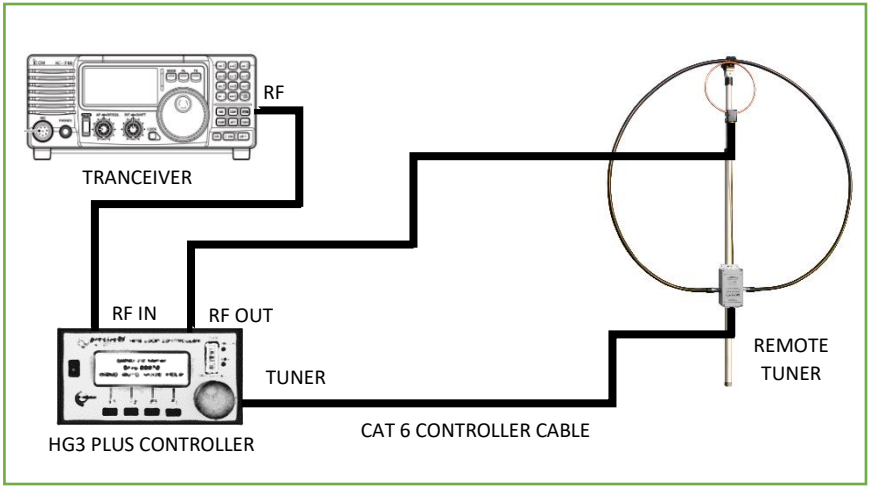
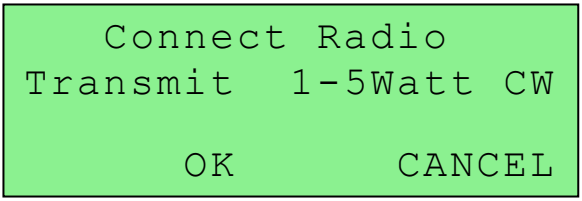


Figure 23 EXPRESS and PRO Model Controller Check

2) Set the radio to 40-meter (7.15MHz will work).
3) For this test, apply power to the controller and turn it on. You should see the initialization page:

```
Initialize Tuner
YES/Default      NO
```

4) Select `YES/Default` (F1). This sets the controller to the 40-meter band.
5) You should notice an increase in the background noise. (You may have to use the tuning knob for the greatest signal.) This indicates that the connections from the radio to the induction loop are good. If you do not get an increase in background noise, the RF cable connection may be defective. (You may need to adjust the TUNE knob for peak background noise.)
6) Ensure the radio is still set to the 40-meter band, (7.15Mz will work).
7) Press `AUTO` (F2) for auto-assist. The prompts displayed:



8) Transmit a low power carrier of about 1-5 Watt. Note, the high SWR prior to tuning for minimum.
9) Press `OK` (F2) to start auto-tuning.
10) If the power levels are not correct, you'll get these prompts:
    `No Signal Transmit 1-5 Watt CW`
    (If the signal is too low)
11) `Reduce Power Transmit 1-5 Watt CW` (If the signal is too high)
    Adjust the power level accordingly and press `OK` (F2).
12) After finding an acceptable SWR solution, auto-tuning ends, confirming that the controller is working correctly.

11.7 AUTO TUNE CHECK – QRO MODEL

1) Connect the controller as shown below with known good 50 Ω BNC cables.

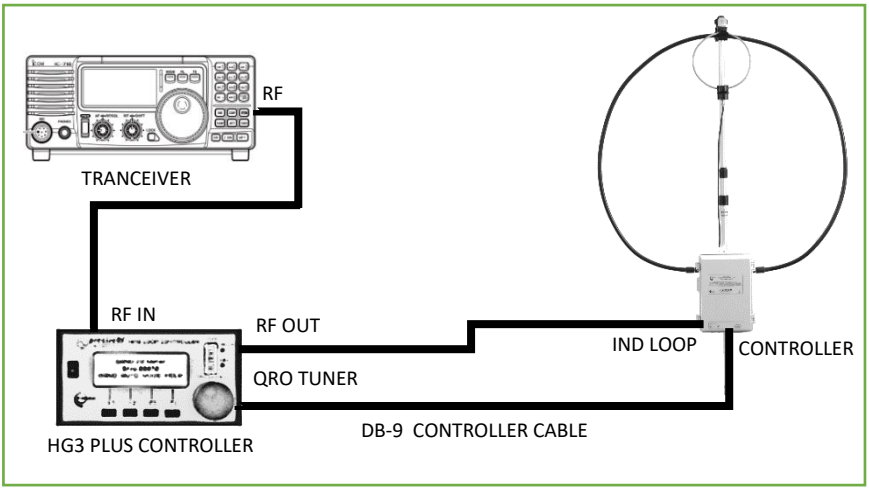
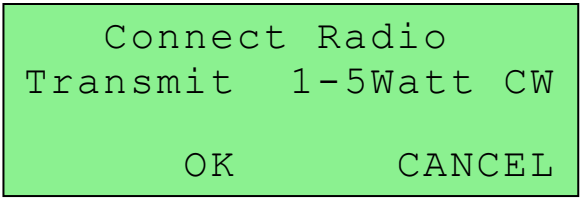


Figure 24 QRO Controller Check

2) Set the radio to 20-meter (14.15MHz will work).
3) For this test, apply power to the controller and turn it on. You should see the initialization page:
`Initialize Tuner`
`YES/Default NO`
4) Select `YES/Default` (F1). This sets the controller to the 20-meter band.
5) You should notice an increase in the background noise. (You may have to use the tuning knob for the greatest signal.) This indicates that the connections from the radio to the induction loop are good. If you do not get an increase in background noise, the RF cable connection may be defective.
6) Ensure the radio is still set to the 20-meter band (14.15Mz will work).

7) Press AUTO (F2) for auto-assist. The prompts displayed:
Transmit a low power carrier of about 1-5 Watt. Note, the high SWR prior to tuning for minimum.



8) Press OK (F2) to start auto-tuning.
9) If the power levels are not correct, you'll get these prompts:
No Signal Transmit 1-5 Watt CW
(If the signal is too low)
10) Reduce Power Transmit 1-5 Watt CW (If the signal is too high)
Adjust the power level accordingly and press OK (F2).
11) After finding an acceptable SWR solution, auto-tuning ends, confirming that the controller is working correctly.

12 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 make 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 25 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 background noise increase, indicating a tuning peak.	Turn pre-amp on and use the SSB mode on the radio. Repeat the troubleshooting steps.
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. Usually as close to the LMR600 radiator as possible is best.
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 or feedline cable or other connections are defective.	Replace coax or 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 power supply is defective.	Check the power supply and or replace it.

13 PRECAUTIONS

The AR-1 ROTOR is not waterproof. It is intended, primarily, for portable deployment or use in 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 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:

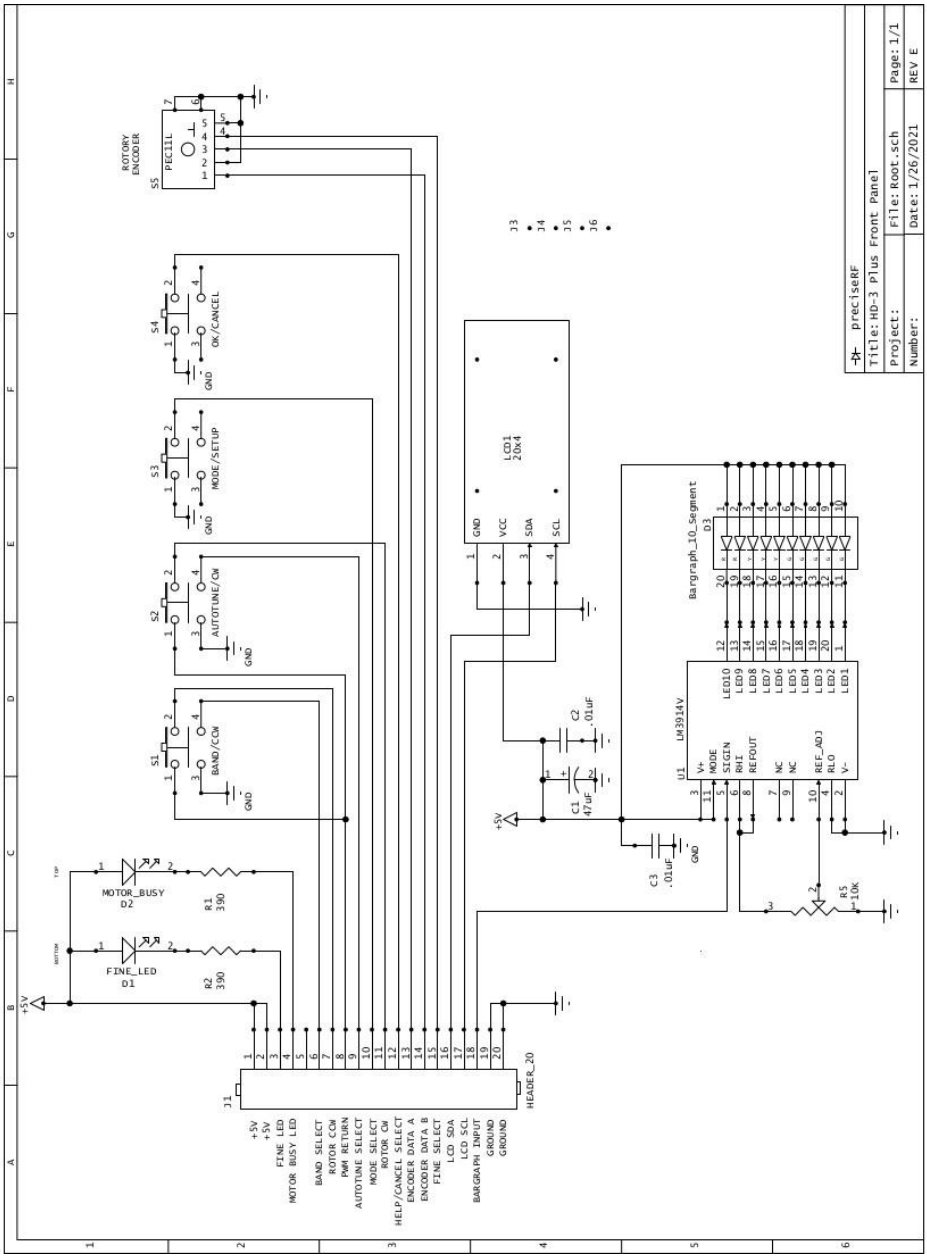
Check all fasteners for a tight fit. If needed, apply a small amount of silicone sealant to each connector. Protect the antenna at all times from extreme weather conditions. The PVC mast is not intended for unattended outdoor use. Use the optional metal antenna mast and attach guy wires to the two guying ears at the top of the mast..

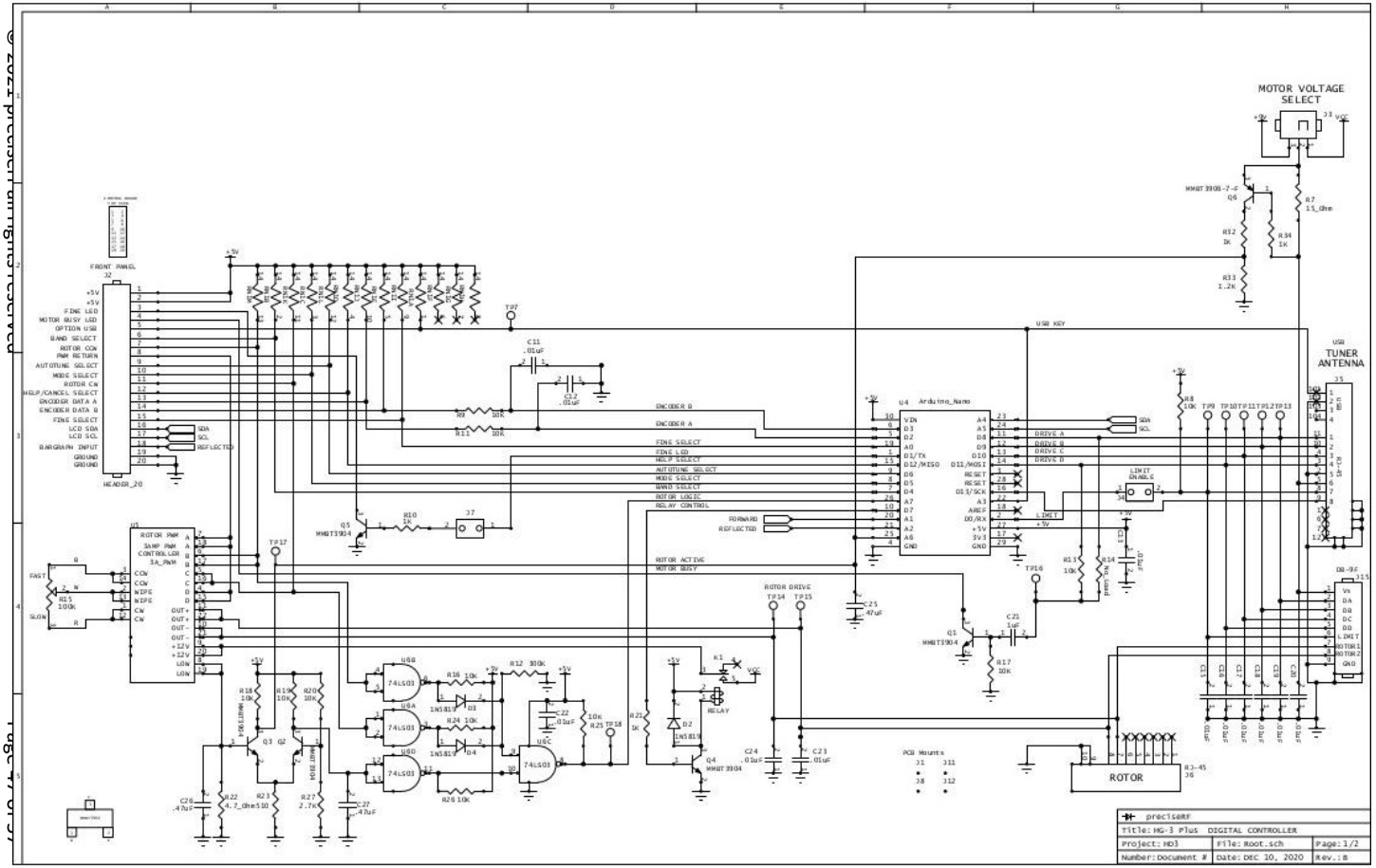
14 SPECIFICATIONS

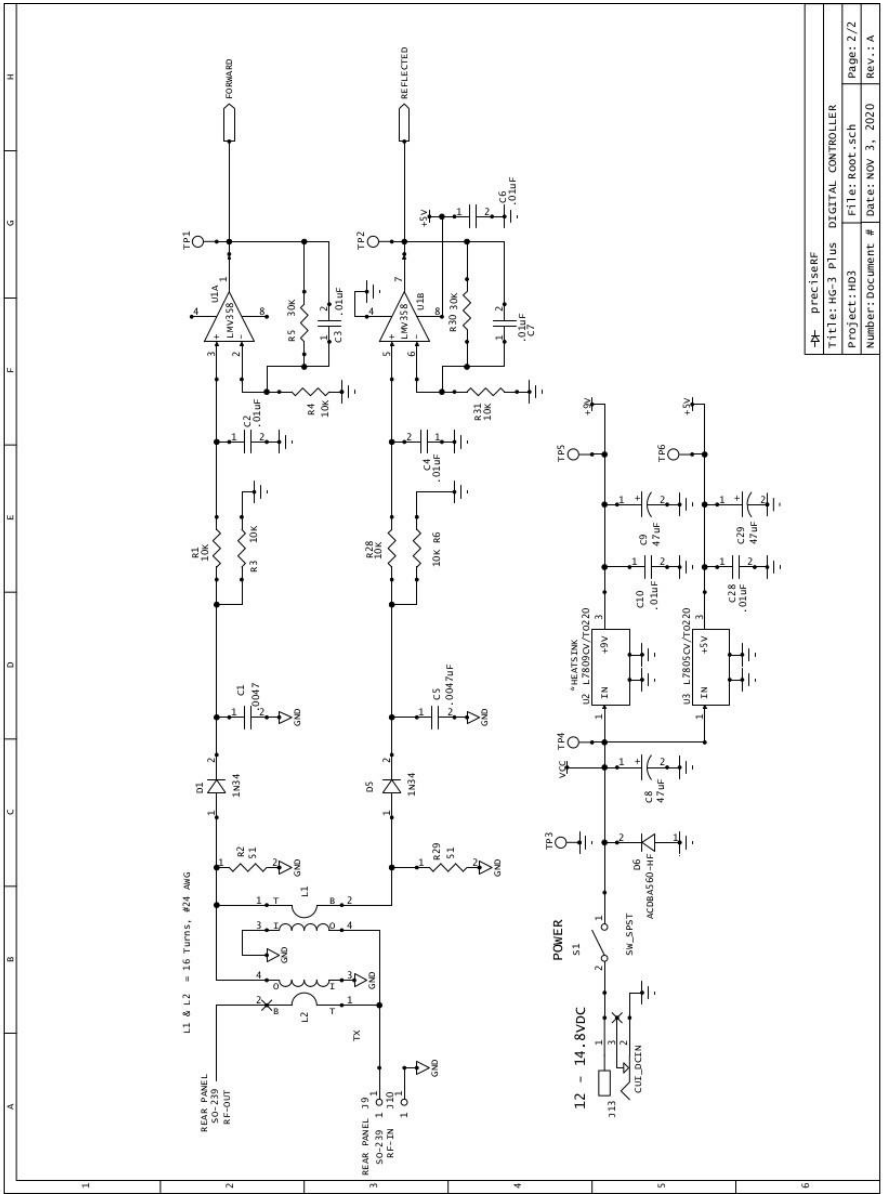
Item	HG3 EXPRESS/PRO		HG3 QRO	
SWR/RL	1.2 / 20 dB		1.01 / 41.1 dB	
Resolution BW	13.5 KHz		600 Hz	
Continuous tuning Range	7MHz – 28.5MHz		6MHz – 30MHz	
Impedance	59.2 Ω		59.2 Ω	
Stepper Motor	28BYJ-48 Unipolar		NEMA 17 Unipolar	
Tuning	EXPRESS Manual only	PRO Manual-Auto	Manual-Auto	
SW tuning Bridge (5W Max)	EXPRESS No	PRO Yes	Yes	
AR1 rotator interface	No	Yes	Yes	
Radiation Loop	MLR600 113 sq. in		MLR600 113 sq. in	
Tuning Capacitor	Dual Stator Air Variable		High Voltage Vacuum	
Tuning method	2K step stepper motor		45K step stepper motor	
Quality factor Q	625		1765	
	14MHz	30MHz	14MHz	30MHz
Rrad	.054Ω	1.15Ω	.054Ω	1.15Ω
ESR	60mΩ		12.5mΩ	
Efficiency %	44%	98.2%	84.5%	98.4%
Power loss	7.13dB	.17dB	1.46dB	.14dB
Max Power PEP with 50’ feedline	Direct	w/1:1 Balun	Direct	w/1:1 Balun
	55W	75W	800W	1.5KW
Duty Cycle	100% SSB 50% CW 30% Digital	75% SSB 25% CW 15% Digital	100% SSB 50% CW 30% Digital	75% SSB 25% CW 15% Digital
Processor	ATmega328 P Nano V3 C++		ATmega328 P Nano V3 C++	
Power Supply	9VDC 250ma		12.5 VDC 2A	
Environmental	0-35C <70% humidity water resistant NOT WATER PROOF			
Specifications are subject to change without notice and are provided under typical operating conditions.				

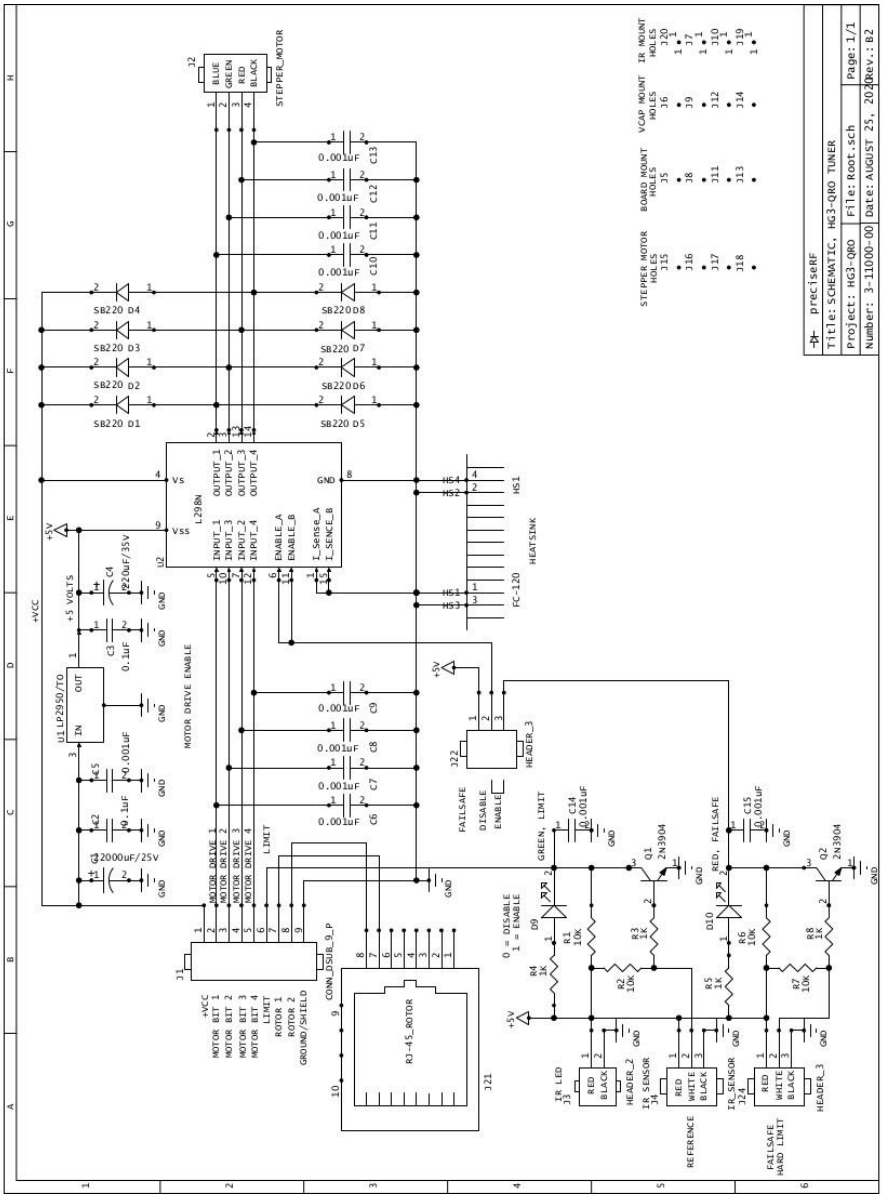
15 REFERENCE

15.1 SCHEMATICS




MOTOR VOLTAGE SELECT
TUNER ANTENNA
ROTOR
U4 Arduino_Nano
FRONT PANEL
HEADER_20
ROTOR PWM &AMP PWM CONTROLLER 3A_PWM
precisRF
Title: HG-3 Plus DIGITAL CONTROLLER
Project: HD3
File: Root.sch
Page: 1/2
Number: Document #
Date: DEC 10, 2020
Rev.: B





15.2 BILL OF MATERIAL

PCB Hardware Assembly

QTY	Product/Value	Reference Designators	P/N	Supplier
2	2-11000-00C	VCAP Bracket	2-11000-00C	BBC Steel
2	2-11002-00C	I/R Sensor Bracket	2-11002-00C	BBC Steel
1	Stepper Motor Bracket	ST-M1, OSM Tech, LTD		Amazon - Setpperonline
1	STEPPER_MOTOR	Stepper Motor w/5.18-1	17HS3401S-PG	usa.banggood.com
1	Motor Coupler		Roger	
1	Vacuum Capacitor	VCAP	Roger	
4	#8-32 x 3/4" PHPS	Motor		Olander 8C75PPMZR
8	#8-32 Kep Nut	Motor, Vcap		Olander 8CKNTZR
4	#8 x 3/8 Round Spacer	Motor		Olander 8N37RS5N
2	#6-32 x 1" PHPS	Vcap		Olander 6C100PPMZR
2	#6-32 Kep Nut (Small)	Vcap		Olander 6CSKNZR
4	#4-40 x 5/16" PHPS	I/R Bracket		Olander 4C31PPMZR
4	#4-40 Kep NUT	I/R Bracket		Olander 4CKTZR
4	#8-32 x 7/16: PHPS	Vcap		Olander 8C43PPMZR
2	#6-32 x 1/4" FHPS	Center Conductor		Olander 6C25PFMZR
2	M2.0-0.4 x 10MM PHFS	I/R Sensor		Olander .2C10PFMZR
2	M2.0-0.4 Nut	I/R Sensor		Olander .2HNTZR
1	#4-24 x1/4" STPFPS	Heatsink		Olander 4N25PPAZR

Final Assembly

QTY	Product/Value	Reference Designators	P/N	Supplier
1	Case	Case	2-11003-00A	Polycase
3	SO-239 Connector			367-1082-ND
1	Panel Mount BNC Female			ARFX1062-ND
4	#4-40x1/2" PHPS			Olander
4	#4-40 Kep NUT			Olander 4CKTZR
4	M5-0.8 x 10mm PHPS	PCB/Case		Olander .5C10PPMZR
12	#4-40 x 1/2" PHPS	PL-239 Connector		
12	#4-40 Kep Nut (Small)	Vcap		
1	5" #14 AWG Copper Wire			
2	HG-1 Interface Boards			preciseRF
1	HG-3 Antenna Coupler PCB			preciseRF
1	9 Pin Sub-D Gasket			1798-1143-ND

PCB Electronics Assembly

QTY	Product/Value	Reference Designators	preciseRF P/N	Digikey/Supplier
1	HG3-QRO 4-11000-00 B	PCB Revision B	PCBWay	preciseRF
11	0.001uF / 100V	C5-C15	P10-30-0101	BC2660CT-ND
2	0.1uF	C2-C3	P10-30-0103	445-5303-ND
1	220uF/35V	C4	P11-42-0200	P12411-ND
1	22000uF /25V	C1	P11-42-2203	338-1597-ND
8	SB220 Diode	D1-D8	A26-13-0200	SB220-E3/54GICT-ND
1	DB-9 RT ANG, Male	J21	C17-18-0002	AE10968-ND
1	RJ-45 RT ANG Female	J27	C10-16-0003	AE10387-ND
2	Header, 2 Pin	J22, J23	C13-13-0005	A31112-ND
1	Header, 3 Pin	J1	C13-13-0006	A31113-ND
3	Header Jumper	J1, J22, J23		S9337-ND
2	2N3904	Q1 , Q2	A20-25-0001	2N3904FS-ND
4	1K	R3, R4, R5, r8	P28-12-1001	RNF18FTD1K00CT-ND
4	10K	R1, R2, R6, R7	P28-12-1002	RNF18FTD10K0CT-ND
1	L298N	U2	A12-11-0064	497-1395-5-ND
1	LD1085/TO-220 Voltage Regulat	U1	A12-11-0066	497-3436-5-ND
1	Green LED	D10	A33-15- 0020	160-1142-ND
1	Red LED	D9	A33-15-0024	160-1139-ND
2	IR Sensor Kit	J3, J4, J24, J25	A99-18-0062	1528-2526-ND
1	Heatsink 25x30.3x25mm	HS1	M22-11-0005	e-Bay modulefans

16 CIRCUIT DESCRIPTION

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. An DB-9 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 /DB-9 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.

16.1 STEPPER MOTOR

Refer to the “HG-3 DIGITAL CONTROLLER” (two pages) and “HD-3 Front Panel” schematics. U2 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 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. Refer to the “HG-QRO tuner” schematic. The tuner receives the controller signal via the DB-9 cable and applies it to L298N 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 NMEA17 1.6 deg 5:1 reduction stepper motor providing 45K steps of resolution. U1LP2950/TO is the 5V regulator driving

the vacuum capacitor. D1 -D8 provide protection for LM298 when high EMF is generated by the stepper motor. Optical sensors detect the index and fail-safe positions. Q1 turns on and drives D9 to indicate when the Index position has been reached. Q2 turns on and drives D10 to indicate a fails-safe condition. The bar graph is comprised of 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. U1A and U1B comprise two noninverting 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. The bridge is optimized for low level SWR levels to allow for auto-tuning (1-10W maximum). At higher power levels U1A and U1B will saturate, and erroneous readings will be displayed.

16.2 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.

16.3 SWR BRIDGE

Refer to the “HG-3 DIGITAL CONTROLLER page 2” schematic. The optional SWR bridge employs the RF transformer-based topology and uses two RF transformers. SO-239 RF-IN is the RF in from the radio transmitter and SO-239 RF-OU 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.

16.4 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 COVERED BY THE WARRANTY.

Patent pending

DEVELOPMENT TEAM

- System Design
  Roger Stenbock W1RMS
- Firmware:
  Travis Cannon, Roger Stenbock W1RMS
- 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.

Roger M. Stenbock W1RMS - HG3 plus manual 2.1 - 3/22/2021

Size 5.83x8.27 (A5)

www.peciserf.com
13690 Wisteria Dr, Aurora, OR 97002 ph. (503) 915-2490

