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Laufer Wind
Aircraft Detection System (ADS)
Model C Pulse Doppler Radar

User Manual

March 25, 2015

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Document Change History

Document Title: Model C Pulse Doppler Radar Product Manual **Document No:**			
Date	**Revision**	**Detail**	**Author**
10-20-14	1	Initial Release	HMS
2-2-15	2	Model C Radar	RP
2-3-15	3	Model C Radar	AKH
3-25-15	4	FCC Considerations	AKH

1. Manufacturer

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2. Safety Information

The purpose of this manual is to provide safety and operating information for persons using the Laufer Wind Pulse Doppler Radar. The Pulse Doppler Radar is designed to operate unattended for long periods of time. Periodic maintenance or service should only be performed by Laufer Wind-approved service personnel.

The following symbols and terms may be found on the product or used in this manual.

2.1 Warning Label and Safety Marking Explanation

	This symbol indicates general warning or caution.
	This symbol indicates the presence of high voltages in or around the unit.
	This symbol indicates the presence of microwave or RF radiation in or around the unit.
	This symbol indicates the presence of x-radiation in or around the unit.
	This symbol indicates the presence of rotating equipment in or around the unit.
	This symbol indicates the presence of magnets in or around the unit.
	This symbol indicates the presence of automatic equipment that could start without warning.
	This symbol indicates a protective earth ground connection point.
	This symbol indicates that one should read the user manual before operating or servicing.

2.2 General Safety Instructions

**FIX THIS FIRST

READ SAFETY INSTRUCTIONS

Servicing: This radar product is not customer serviceable. Only Laufer Wind and their trained and authorized agents are permitted to remove the cover or attempt repairs.

Product Usage: This radar product is designed to use within the Aircraft Detection Solution System, which restricts access to authorized competent personnel.

Environmental: This radar product is rated IP56, and chemical, solvents and cleaning agents should be used sparingly.

Input Parameters: This radar product must be operated with the input parameters stated in the product limitation in this manual.

End of Life Disposal: This radar product contains components that require special disposal. Make sure the unit is properly disposed of at the end of its service life and in accordance with local regulations.

Lifting Instructions: This radar product is heavy (65lbs for the radar housing, plus another 45lbs for the antenna.) Only users that are knowledgeable and capable of lifting such weight safely should attempt to lift or move the radar assembly.

Safety Protection Impairment: This radar product is designed to operate safely with its control computer and communication links to the radar in an active (operational) state. Electrical power should be turned off to the Pulse Doppler Radar if the control computer or communications links become inoperable. A service call should be placed with Laufer Wind to insure user safety.

RISK OF ELECTRICAL SHOCK

High Voltage Warning: Dangerous voltages are present within the radar product. A professional installer must protect service personnel from inadvertent contact with these dangerous voltages. This radar product must be reliably earthed and professionally installed in accordance with the prevailing local electrical wiring regulations and safety standards.

RISK OF MICROWAVE RADIATION

Microwave Warning: Dangerous microwave radiation is emitted by this radar product when connected to its microwave antenna. Personnel must stay at least 10 meters away from the radar when it is radiating with the antenna attached. There no restrictions when the dummy load is attached.

RISK OF X-RAY RADIATION

X-Ray Warning: X-Radiation may be present if the radar is operated with its sides off. Only Laufer Wind and their authorized agents are permitted to operate the radar with sides removed.

RISK OF CRUSH and CLOTHES HAZARD

Crush and Clothes Hazard Warning: The radar operates with an exposed rotating antenna that can pose crush and clothes entanglement hazards.

AUTOMATIC EQUIPMENT

Automatic Equipment: This equipment may start without warning.

3. Radar Description and Specifications

The purpose of the ADS Pulse Doppler Radar is to detect and track aircraft and other objects that are flying within specified ranges of the Radar. Doppler Radar measurements are used by the ADS Central Controller to determine if aircraft are approaching, and to turn-on Obstruction Light Modules to warn off incoming aircraft that are approaching within a specified range.

The Laufer Wind Pulse Doppler Radar can be supplied in two package variants. Figure 1 shows the Radar fitted with a conformal radome/antenna assembly that offers the lowest weight (~50 kg) and smallest mechanical footprint. The Radar can also be packaged with a hemispherical radome like that shown in Figure 2 that has a larger weight (~82 kg) and mechanical footprint, and hides the rotating antenna from view. The conformal radome is the preferred solution where icing is a concern. Both Radar and antenna/radome package variants are designed to mount on meteorological towers, wind turbine towers, or stand-alone lattice towers.

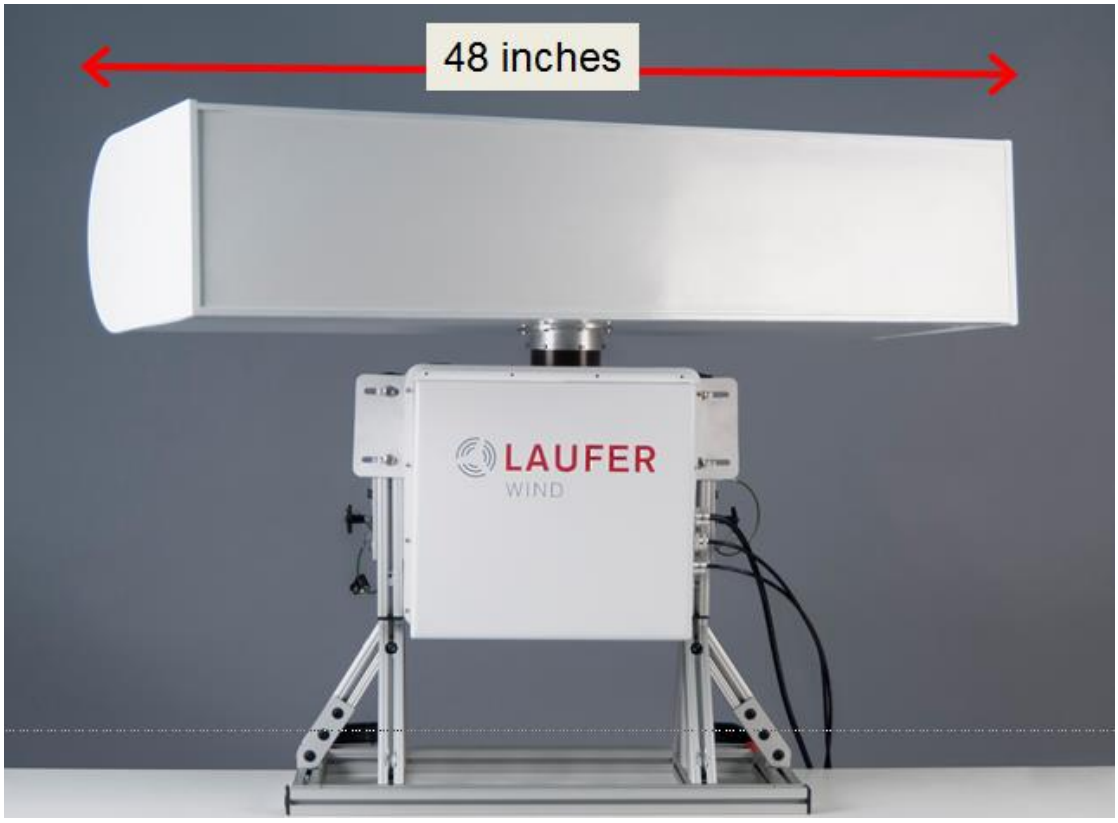

Figure 1. Photograph of the Laufer Wind Doppler Radar configured with a conformal radome/antenna.

Figure 2. Photograph of the Laufer Wind Doppler Radar configured with a hemispherical radome. This Radar is mounted on the side of a meteorological tower.

3.1 Radar Electrical Specifications

Description	Specifications
AC input voltage	100-240, single phase, neutral with ground
AC line frequency	50/60 Hz (nominal)
AC input power	550VA/500W (maximum)
Microwave output power	12 kW (peak)
Microwave pulse duration	500 nanoseconds
Microwave pulse recurrent frequency	2000 pulses per second (nominal)
Microwave average power	12 W (nominal)
Microwave frequency	9410 MHz +/- 30MHz (X-Band)
Detection range (1 sq-m radar cross-section)	12 km (bad weather, rain and/or ice and snow) 16 km (clear weather)

3.2 Control Signal and Electrical Connections

Description	Specifications
Ethernet control cable	Cat6, outdoor/UV-rated cable
AC input power	The radar is hardwired in accordance with local codes using 3 conductor, 16 AWG (or heavier gauge) outdoor/UV rated cable

3.3 Mechanical Specifications

3.3.1 Radar with Conformal Radome Antenna Configuration

Description	Specifications
Radar Size	15 in wide x 15 in deep x 20 in high (38 cm x 38 cm x 51 cm)
Weight	Radar: 60 lbs (27.2 kg) Antenna: 45 lbs (20.4 kg) Total: 105 lbs (47.6 kg)
Antenna Size	48.6 in wide x 12 in deep x 12 in high (123 cm x 31cm x 31cm)
Mounting	Vertical
Cooling	Ambient air cooling
Warning labels:	• General warning or caution • Hazardous voltage • Hazardous microwave radiation • Hazardous X-radiation • Crush and clothes hazard • Presence of magnets • Automatic equipment / May operate without warning • Read manual • Ground connection point

3.3.2 Radar with Hemisphere Radome Configuration

Description	Specifications
Radar Size	15 in wide x 15 in deep x 20 in high (38 cm x 38 cm x 51 cm)
Weight	Radar: 60 lbs (27.2 kg) Antenna (bare): 20 lbs (9.1 kg) Mounting Ring: 65 lbs (29.5 kg) Radome: 34 lbs (15.4 kg) Total: 179 lbs (81.2 kg)
Antenna Size	48.6 in wide x 12 in deep x 12 in high (123 cm x 31 cm x 31 cm)
Mounting	Vertical in radome ring assembly
Cooling	Ambient air cooling
Radome	59 in dia x 45 in high (hemisphere) (150 cm dia x 114 cm high)
Warning labels:	• General warning or caution • Hazardous voltage • Hazardous microwave radiation • Hazardous X-radiation • Crush and clothes hazard • Presence of magnets • Automatic equipment / May operate without warning • Read manual • Ground connection point

3.4 Environmental Specifications

Description	Specifications
Operating ambient temperature	-40 °C to +55 °C
Operating air pressure	75 to 105 kPa (-1000 ft to 8000 ft MSL)
Operating wind velocity	0 to 55 m/sec (0 to 125 mph)
Environment rating	IP56
Storage and transport temperature	-40 °C to +70 °C
Storage and transport pressure	75 to 105 kPa (-1000 ft to 8000 ft MSL)

3.5 FCC Siting Considerations

The Pulse Doppler Radar must comply with Federal Communications Commission (FCC) requirements if installed in the United States. These requirements include:

(1) The Radar must operate under individual FCC licenses that are specific to each installation site.
(2) Radar installations should be coordinated with the Government Meteorological Aids Service
(3) The non-Government Radiolocation Service for the Radar frequency band (FCC Part 90F operating at 9.3-9.5 GHz) is secondary to the Maritime Radionavigation Stations (part 80) the Aeronautical Radionavigation Service (part 87) and the Government Radiolocation Service.

4. Maintenance

The Pulse Doppler Radar is designed to operate unattended for long periods of time. Periodic maintenance or service should only be performed by Laufer Wind-approved service personnel.

5. Operating Instructions

The instructions below describe how to connect AC power and communications to the Pulse Doppler Radar, turn the Radar on and off, and control Radar operation through a Central Controller computer and software.

5.1 Radar Setup and Power and Ethernet Connections

The Laufer Wind Radar should be set up and tested on the ground before it is installed on the radar platform. The Radar is powered through a single-phase (line-neutral-ground) 100-240V, 500W AC power source and cable, and is controlled by a shielded Cat6 Ethernet communication cable.

Figure 3 shows a photograph of the Pulse Doppler Radar housing with its input AC power cable and Cat6 Ethernet cable connections near the bottom of the radar housing. Power and Ethernet cables are passed into the radar body through bulkhead gland seals. Only one Ethernet cable is needed to control the Radar. A spare bulkhead gland seal is provided for a second Ethernet cable, in case additional data transfer is desired. The AC power cable wires are connected to an EMI filter (line and neutral) and a chassis stud (ground). Ethernet cables are plugged directly into lightning arrestor filter boards. It is necessary to remove the radar cover to connect these cables. Once AC power and Ethernet are connected, the Radar can be controlled by an ADS Central Controller computer.

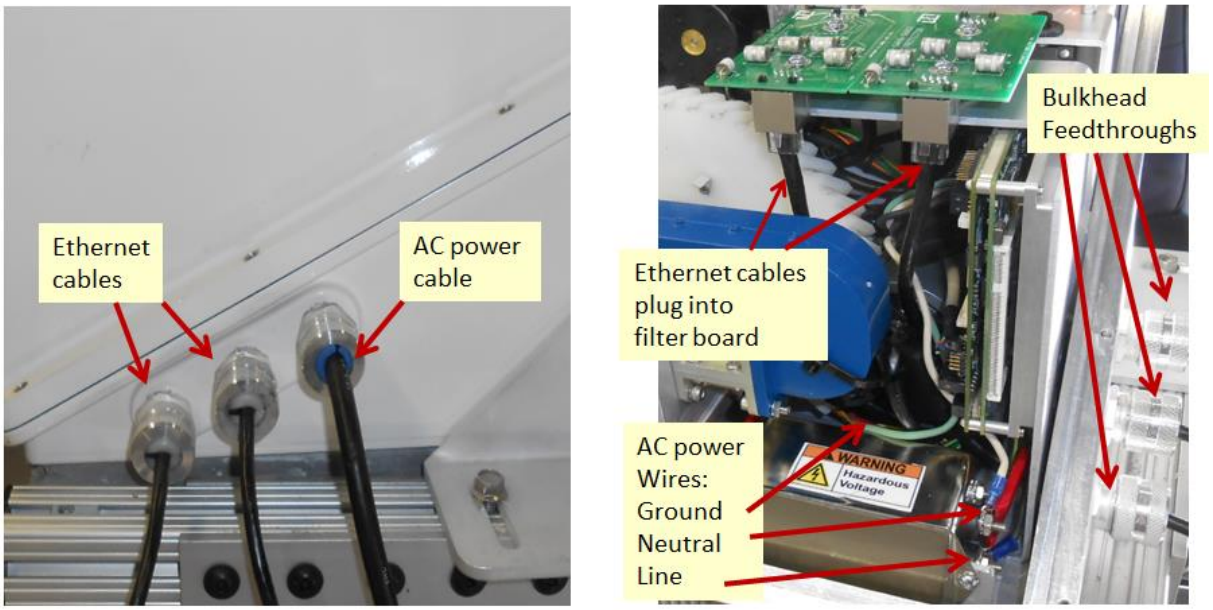

Figure 3. Left: Photograph showing Radar power and Ethernet cables and bulkhead gland feedthroughs. Right: Photograph showing how Ethernet cables connect to the filter board and AC power wires connect to the EMI filter and chassis ground stud.

A laptop computer with Central Controller software tests and controls the Radar during checkout. The Figure 4 block diagram shows how the Pulse Doppler Radar and Central Controller computer can be connected, either (a) directly via a shielded Cat6 Ethernet communication cable, or (b) remotely via a wireless Ethernet bridge. Table 1 provides guidance on the suggested wire gauge for the AC power cable as a function of cable length.

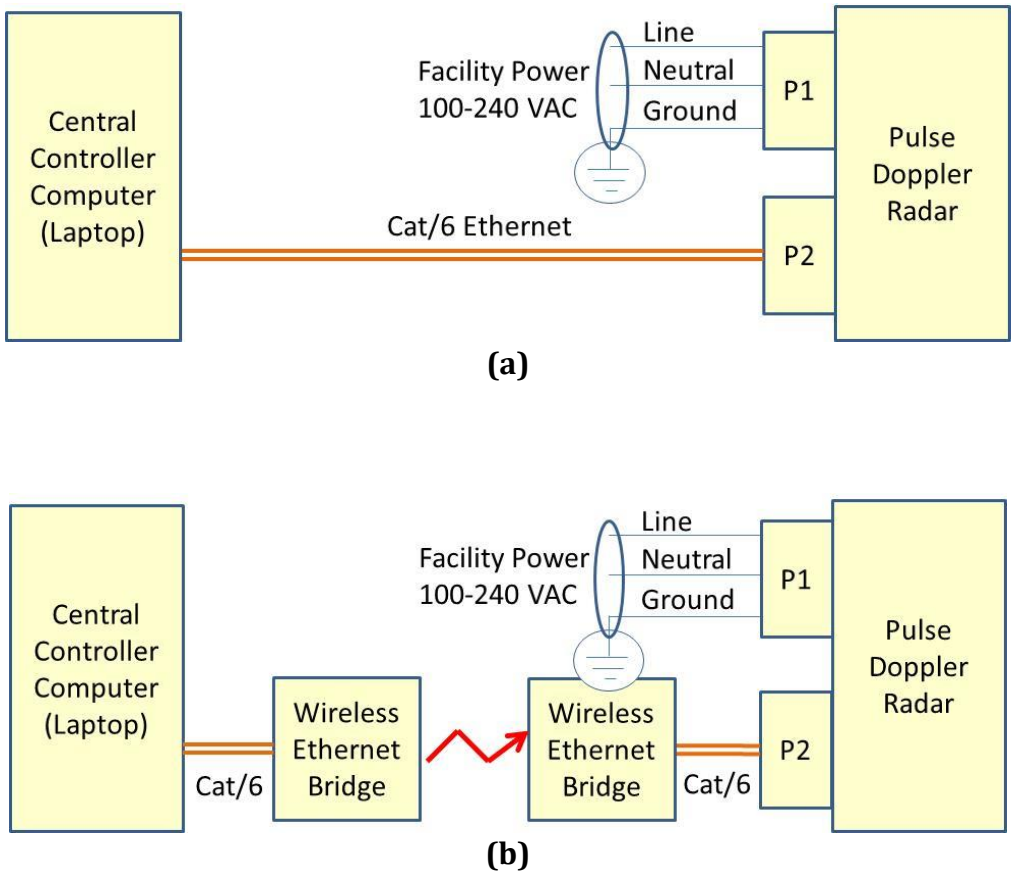

Figure 4. Block diagram showing AC power and Ethernet connections needed to operate the Pulse Doppler Radar with a Central Controller computer. (a) Central Controller can communicate directly with the Radar through a Cat6 Ethernet cable, or (b) remotely using a wireless Ethernet bridge.

Table 1: Suggested Doppler Radar power cable wire gauge versus cable length.

Cable Length	AWG Wire Gauge
1m-10 m	18
10m-100m	14
100m-300 m	10

5.2 Radar Operation

These instructions cover the steps needed to operate the Pulse Doppler Radar system with a Central Controller computer. These are general, user-oriented instructions, and it is assumed that the system has been correctly configured for network communications.

System Requirements

1. One Central Controller computer
2. One or more Pulse Doppler Radars

5.2.1 Radar Checkout into Dummy Load with Installation Laptop

Once the Radar has been wired properly, the Radar front cover should be re-installed. The 50-ohm dummy load assembly supplied with the installation kit should be attached to the rotary joint at the top of the Radar, as shown in Figure 5. The Ethernet cable can now be connected to the installation laptop, and AC power can be turned on to the Radar. A green LED will illuminate an indicator lens on the bottom of the radar cover, indicating that the Radar is correctly powered up.

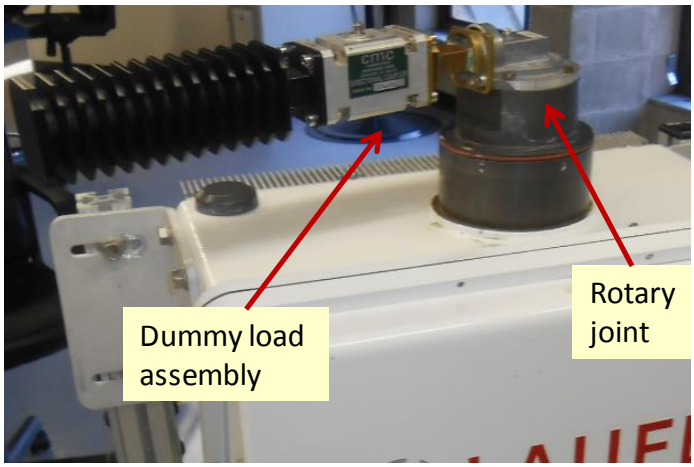

Figure 5. Photograph of Radar with dummy load assembly.

The Radar is now ready for functional checkout with the Central Controller setup laptop.

5.2.2 Radar Control GUI Operation Procedure

Below is a step-by-step procedure for launching the Central Controller software for controlling the Radar.

1. Power up and log into the Central Controller computer.
    a. User name: *radar*
    b. Password: *radar*
2. For hard-wired network interface connections (similar to Figure 4a):

a. If only one Radar is used, an Ethernet communication link can be connected directly to the Central Controller network interface.

b. If multiple Radars are used, individual Radars will be configured with unique IP addresses. The Ethernet cables to the Radars and the Central Controller should be connected to a network switch.

3. For wireless network interfaces (similar to Figure 4b), the Central Controller can control multiple Radars remotely through a wireless Ethernet bridge. The network configuration will support multiple Radar IP addresses through the wireless Ethernet bridge, and the Central Controller will be able to communicate with individual Radars by select their respective IP addresses.

4. Start the Radar Control GUI.

a. On the Central Radar Controller desktop screen shown in Figure 6, double click the icon labeled ***"CentralCon."***

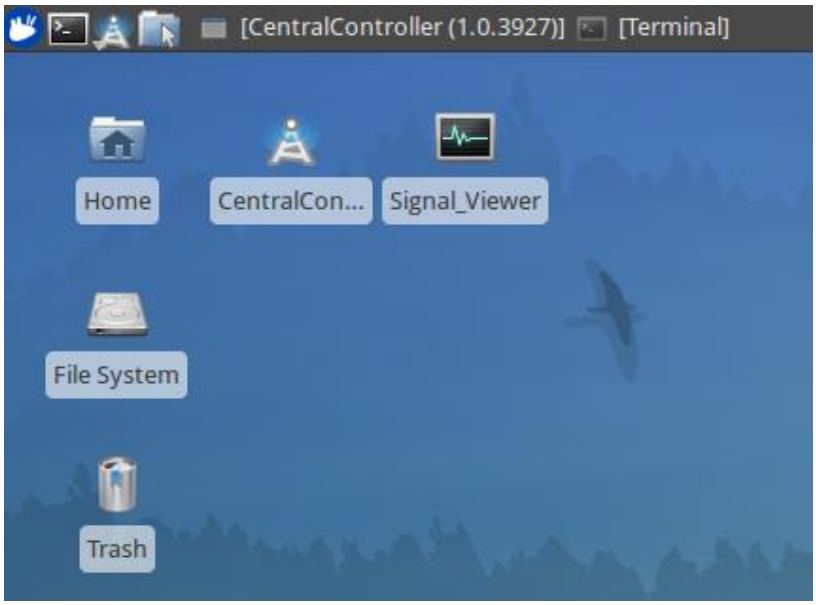

Figure 6. Central Controller desktop screenshot.

b. The program will initially display a new Radar Control GUI screen similar to Figure 7, with status as "***Not Connected"*** until a Radar Processor connects.

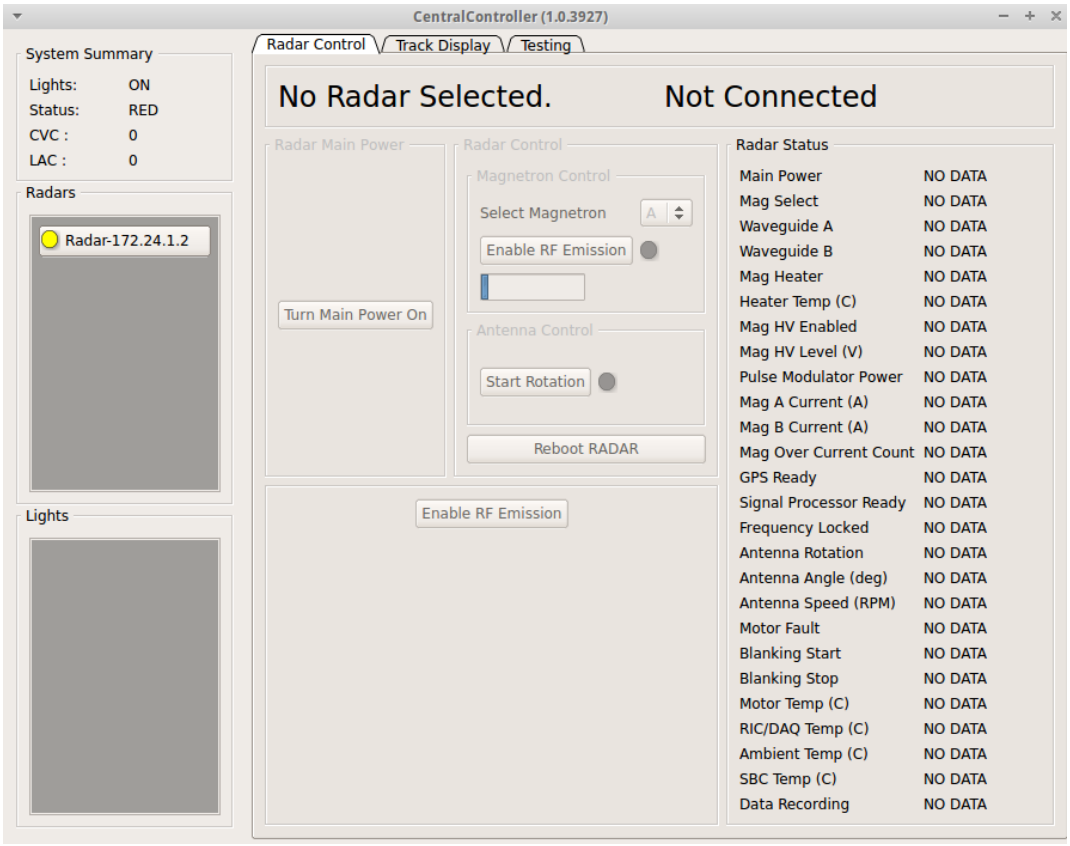

Figure 7. Screenshot showing the Radar Control GUI before it makes a communications connection with a Radar.

5. When the Radar Control GUI has connected to the Radar Processor and the "Main Power On" has been selected, the GUI should resemble that shown in Figure 8. Note that the Radar Status values in the right-hand column are updated periodically.

IMPORTANT: If it is necessary to quickly shut down the Radar, clicking the big, red STOP button will shut it down, as long as the communication status is connected. Otherwise, remove AC power to the Radar.

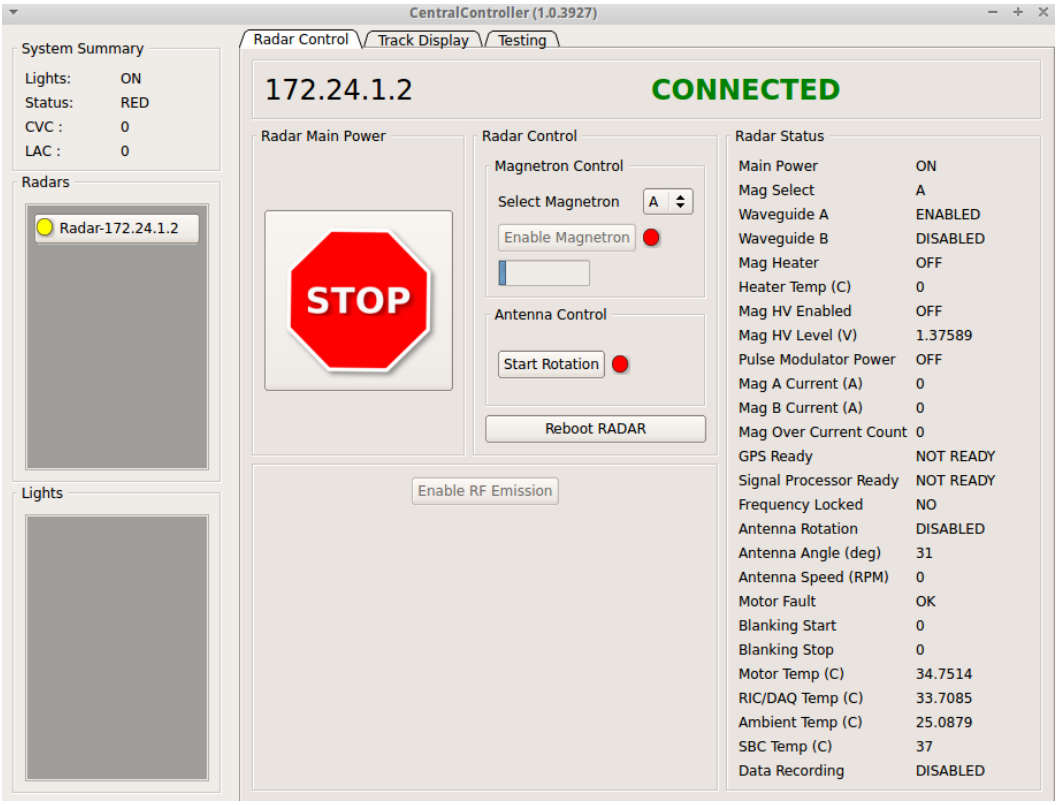

Figure 8. Radar Control GUI when connected to a Pulse Doppler Radar.

6. Once the Radar Control GUI has connected, select the Radar to use by choosing its IP address in the "Radar" box. If only one Radar Processor is connected to the Central Controller, it will be selected by default.

NOTE: The IP address shown in the screen shots herein are examples and may not be that of the actual radar(s) attached to the Central Controller. The actual IP address of the Radar(s) is 172.24.1.x, where "x" is the serial number of the Radar.

7. Once the Radar is connected, it can be initialized as follows:
   a. Select Magnetron A or B using the pull-down indicated by Icon 1 on Figure 9.
   b. Enable the Magnetron by clicking the "Enable Magnetron" indicated by Icon 2 on Figure 9. Once "Enable Magnetron" is selected the magnetron heater will begin heating (90 seconds heating time).
   c. The antenna (or dummy load if attached) can be made to rotate (or turned off) at any time by selecting the "Start Rotation" button indicated by Icon 3 on Figure 9.

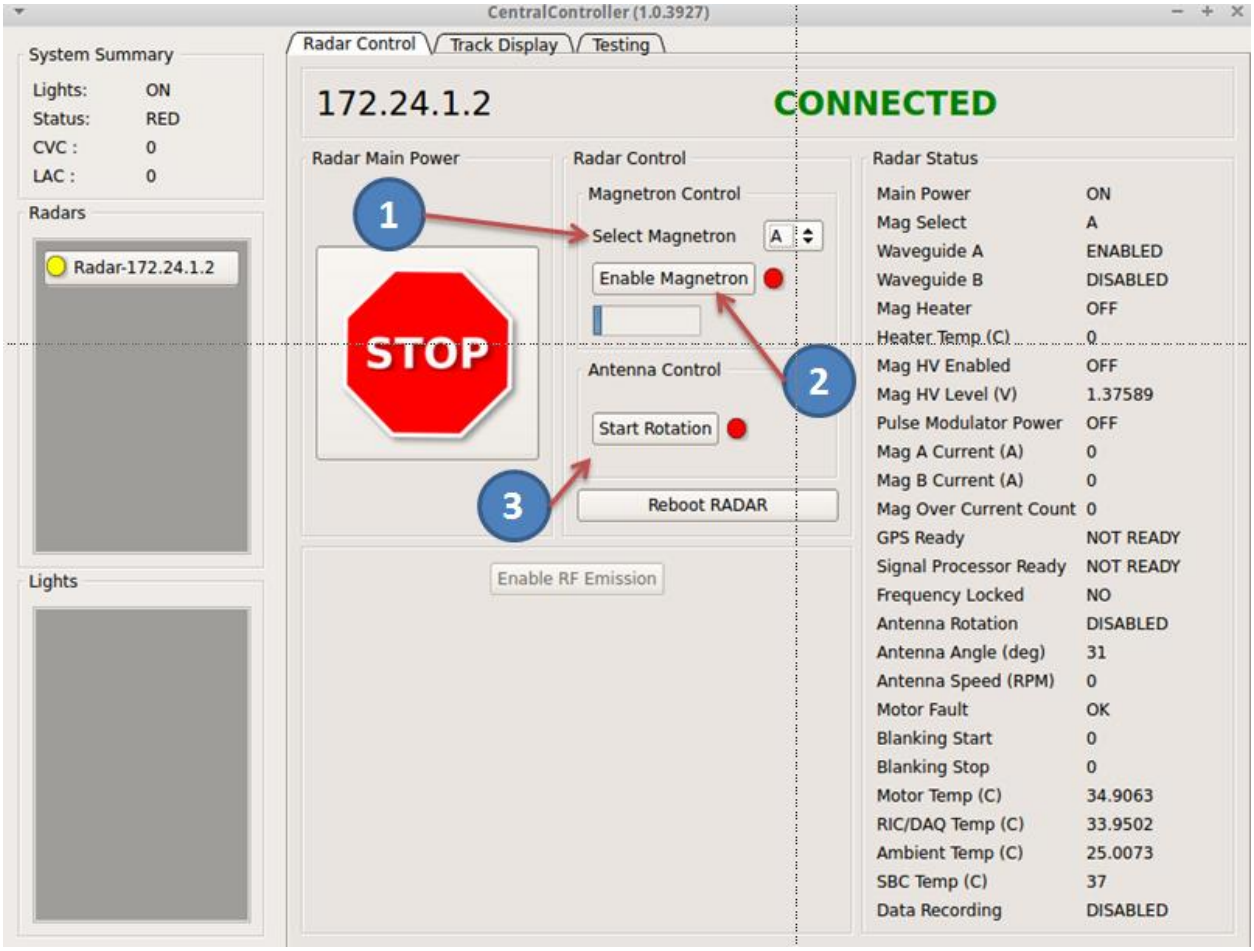

Figure 9. Radar Control GUI showing Magnetron Select feature.

8. Once "Heating" has reached 100%, the "Enable RF Emission" button indicated by Icon 4 on Figure 10 will no longer be grayed out. **WARNING!!! When "Enable RF Emission" is selected, *HIGH POWER RF WILL BE GENERATED***. To prevent radiation exposure, be sure that a dummy load is on the Radar for testing. If testing with an antenna, be sure that all personnel are in a safe area before Enabling RF Emission. The minimum safe distance from the antenna while it is radiating is 10 meters.

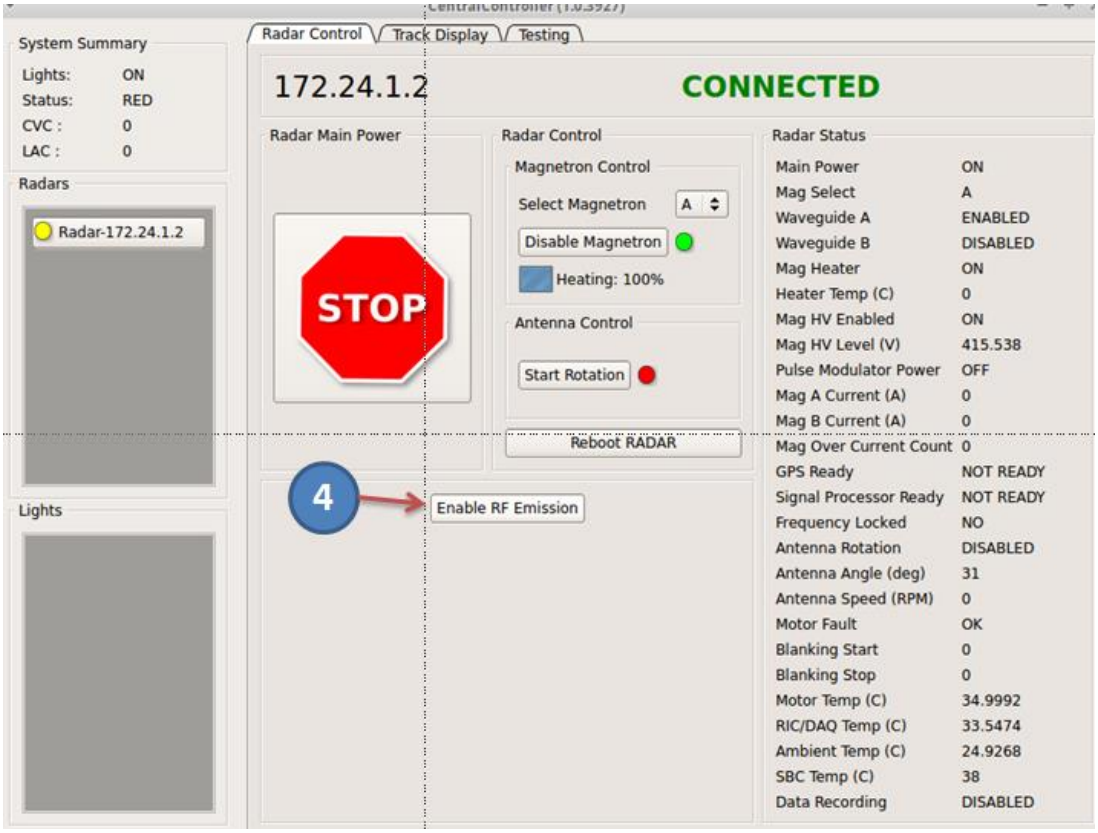

Figure 10. Radar Control GUI showing "Enable RF Emission" feature.

WARNING!!! The magnetron should never be enabled without either an antenna or a dummy load attached, otherwise serious damage will occur to the Radar.

9. Once "Enable RF Emission" is selected, the GUI will indicate Radiating and Radar Status will display several key operating parameters as shown in Figure 11:

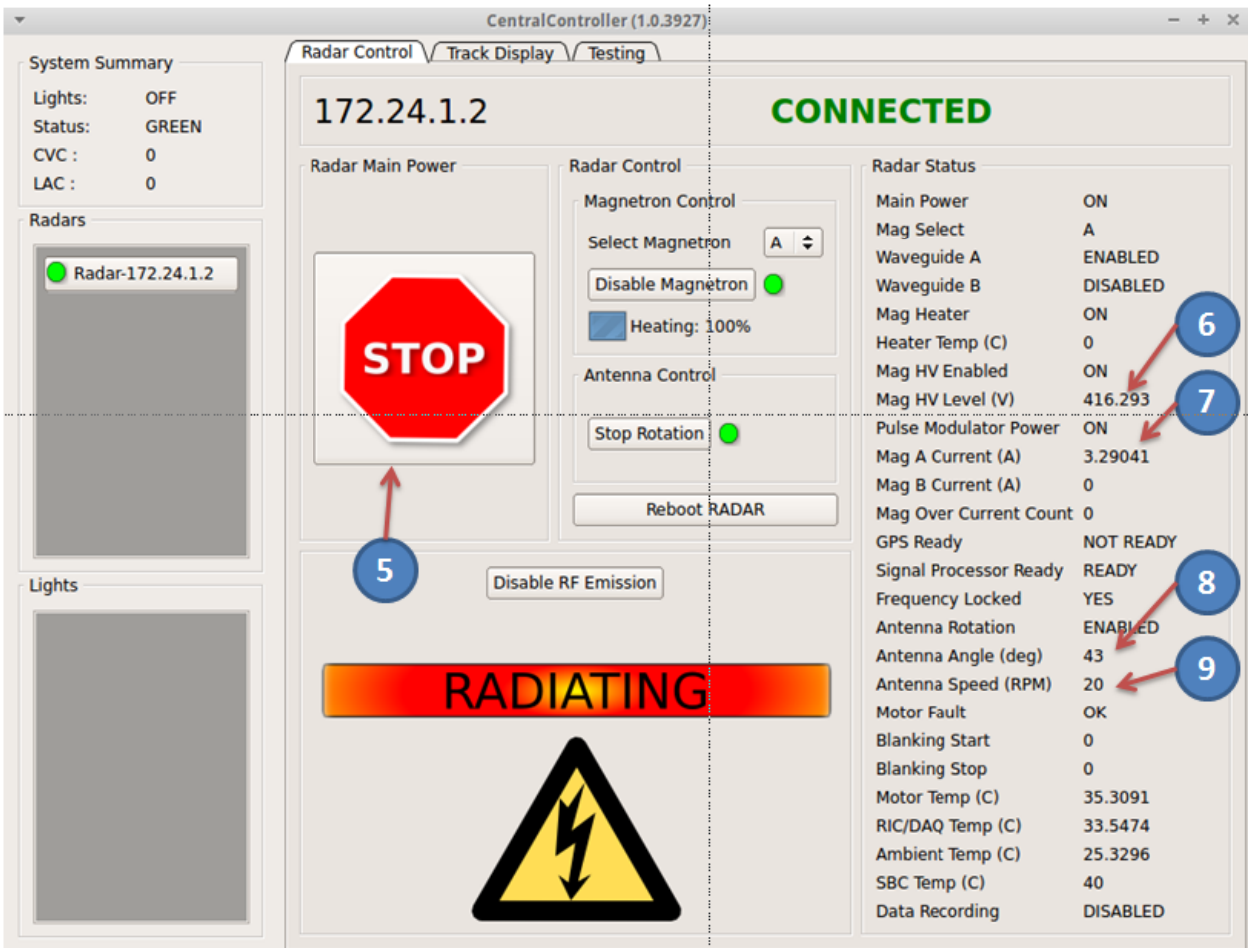

Figure 11. Radar Control GUI showing High Voltage ready feature.

Several important features are shown in Figure 11 as follows:

Icon 5: The STOP button can be used to quickly stop RF radiation and rotation. Selecting the large red *Stop* button will deactivate the Radar. This will put the system in a state described in Step 6, and the magnetron will have to go through another heating cycle before the Radar can produce microwave radiation.
Icon 6: The magnetron high voltage level should be in the range of 400V to 480V. **Icon 7:** The magnetron current should in the range of 3.2 A and 5.6 A. **Icons 8 & 9:** If the antenna (or dummy load if used) is rotating the Antenna Angle should be changing and the Antenna Speed should be 18 to 22 RPM.

10. The Radar will stop radiating when the "Disable RF Emission" button is selected. Selecting the large red *Stop* button will deactivate the Radar. This will put the system in a state described in Step 6. To restart the Radar, a complete cycle starting with magnetron selection and including the magnetron heating must be executed before the Radar can produce microwave radiation.

11. ***Optional Signal Viewer Application***. Once the Radar Processor application has launched, it is possible to view the microwave pulse waveforms from the Radar. This is done by double-clicking the ***"Signal_Viewer"*** icon on the Central Controller desktop screen as indicated by Icon 10 in Figure 12a and entering the password *radar* in the pop-up terminal as shown in Figure 12b.

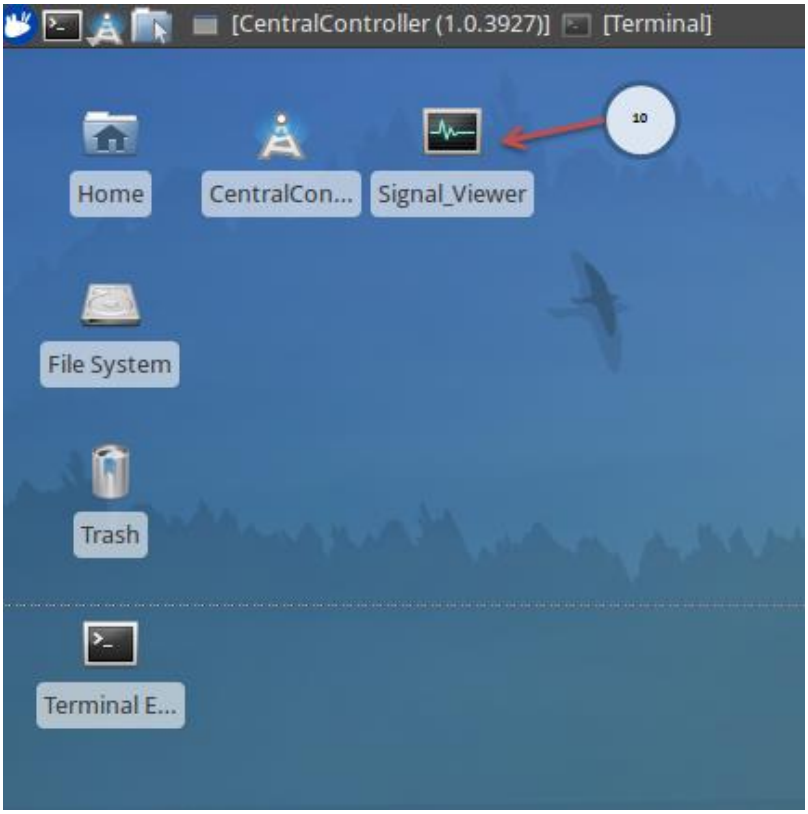

Figure 12a. Clicking the Signal_Viewer icon starts the Signal Viewer.

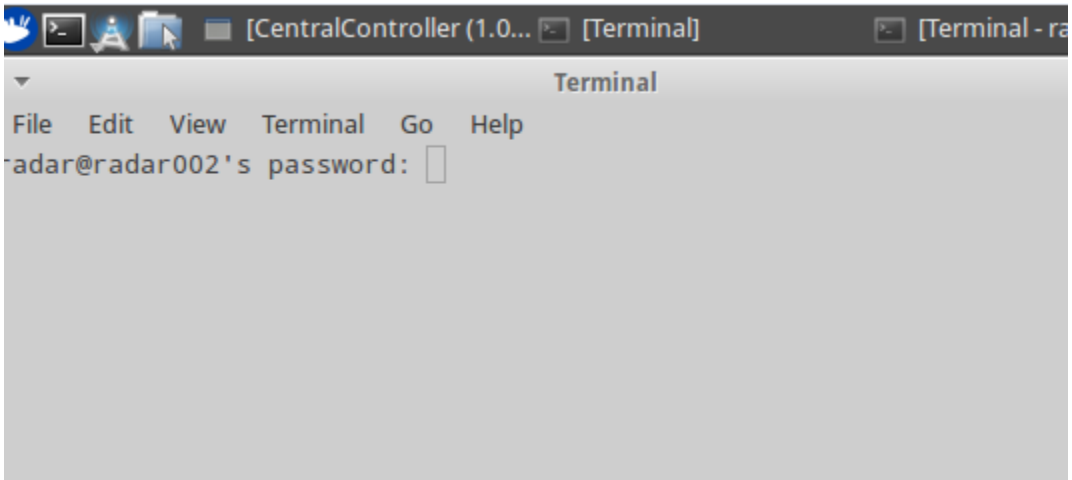

Figure 12b. Log-in terminal for the Signal Viewer.

The Signal Viewer's signal graph will initially be a flat line. Later, when the magnetron high voltage is turned on, the signal should appear similar to that shown in Figure 13.

NOTE: The Signal Viewer is only provided as a test diagnostic and is not run during the normal operation of the Radar. Running the Signal Viewer uses significant processor resources, resulting in increased power dissipation and thermal load within the Radar. **Therefore the Signal Viewer should only be used for short periods to confirm Radar operation and never be left running longer than necessary.**

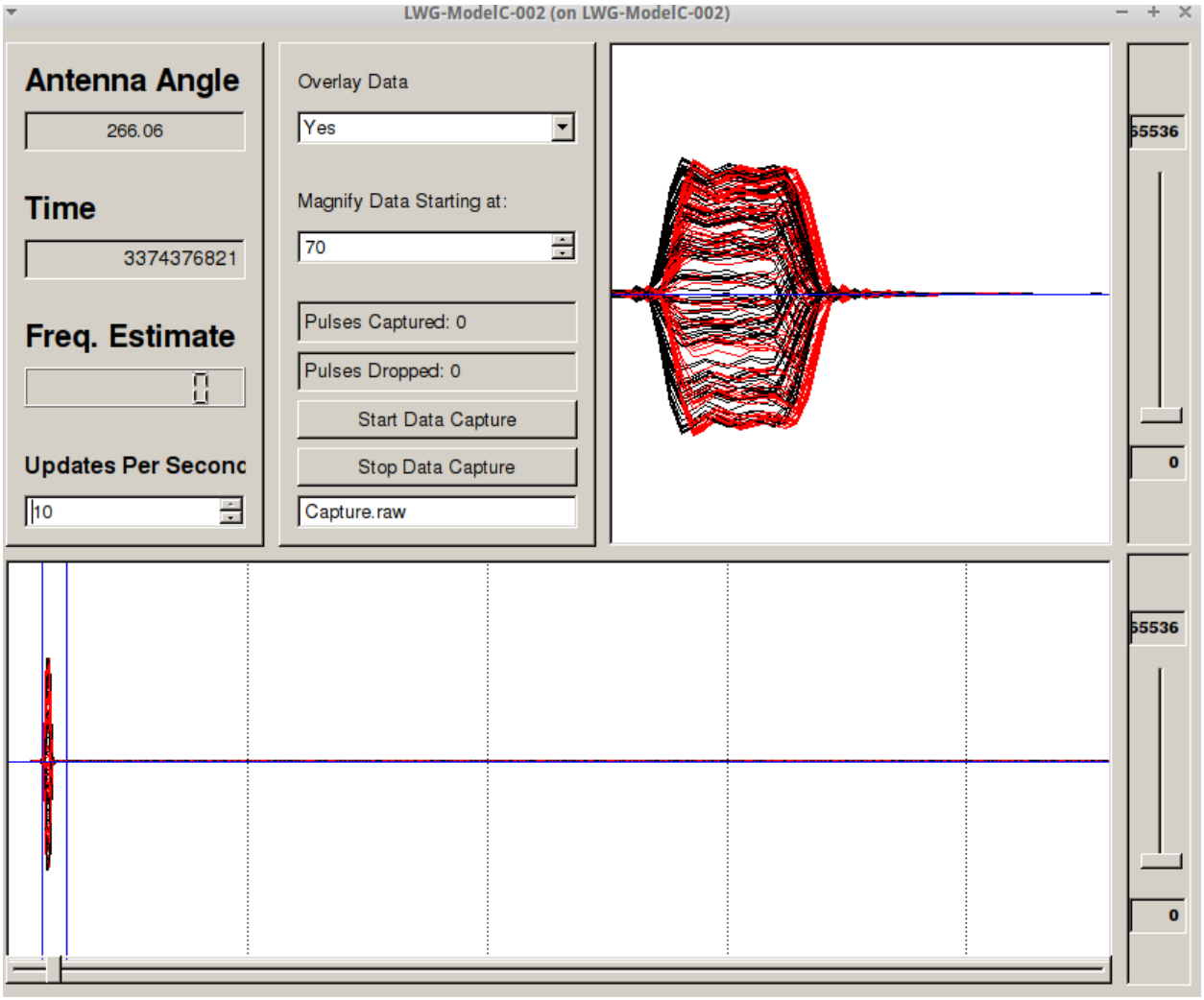

Figure 13. Screenshot of the Signal Viewer GUI displaying Radar microwave pulse waveforms.

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