POWER SYSTEM

FOR THE MOBILE RFI MONITORING SYSTEM

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ABBREVIATIONS

SARAO	South African Radio Astronomy Observatory
RFI	Radio Frequency Interference
RMS	RFI Monitoring System
SE	Shielded Enclosure
CFE	Customer Furnished Equipment
SM	Single Mode
LNA	Low Noise Amplifier
AC	Alternating Current
DC	Direct Current
RF	Radio Frequency
BMS	Battery management system

1 INTRODUCTION

SARAO is currently busy with the modification of a Toyota Hilux D4D D/C 4x4 vehicle into a Mobile RFI Monitoring System (RMS) that must be able to perform sensitive RFI measurements.

Due to an increase in activity at the SARAO South Africa Karoo Astronomy Reserve, a dedicated vehicle is required to make sensitive mobile RFI measurements on site and the surrounding areas. The Mobile RMS should be able to:

1. Provide a stable mobile platform for sensitive RFI measurements on different types of rugged terrain in the Karoo and in various types of weather conditions.
2. Perform both static point as well as mobile / drive-by measurements.

Figure 1: Vehicle used for Mobile RMS

2 EXISTING VEHICLE FEATURES

SARAO will provide the vehicle with the features described in Section 2.1.

2.1 VEHICLE

The 2012 Toyota Hilux 3.0 D-4D D/C 4x4 Raised Body Raider has the following specification / features:

1. Nudge bar and tow bar
2. Aluminium canopy with a roof rack and a telescopic access ladder
3. Fabricated 8 mm base plate for the load bay where all current equipment is mounted on
4. Nycoil cable management assembly with cable basket fitted to the canopy roof
5. Clark telescopic mast mounted to load bay base plate
6. Equipment rack mounted to load bay base plate
7. The equipment rack contains a Clark Model 40E compressor and a Yaesu G5500 rotator control unit
8. Yaesu G5500 rotator fitted to the top of the mast
9. Tait TM8115 Radio installed at the front passenger seat
10. Foldable tray for a laptop fitted at the front passenger
11. Back passenger seats removed and a storage bin fitted

Figure 2: Vehicle used for Mobile RMS

2.2 TELESCOPIC MAST

The telescopic mast mounts to the vehicle load bay base plate and protrudes through the roof of the canopy.

Table 1: Clark mast specifications

Manufacturer and Model	Clark PT16-6
Extended / Retracted Height	6.07 m / 1.73 m
Maximum Head load	30 Kg

2.3 MAST COMPRESSOR

The mast compressor mounts to the equipment rack in the vehicle load bay and extracts or retracts the 6 m telescopic mast.

Table 2: Mast compressor specifications

Manufacturer and Model	Clark Model 40E
Input Voltage	12 VDC
Current consumption	11 – 13 A
Dimensions (WxHxD)	131 x 265 x 232.5 mm
Weight	7 kg

Figure 3: Clark Model 40E compressor

2.4 ANTENNA ROTATOR AND CONTROLLER

The Rotator mounts to the top of the mast while the Controller mounts to the equipment rack in the load bay.

Table 3: Rotator and controller specifications

Manufacturer and Model		Yaesu G5500
Power consumption		120 VA
Power	Controller	220 - 240 VAC
	Rotator	24 VAC – Supplied by Controller
Dimensions (WxHxD)	Controller	200 x 130 x 193 (mm)
	Rotator	254 x 349.25 x 190.5 (mm)
Weight	Controller	3 kg
	Rotator	9 kg

Figure 4: Yaesu G550 Rotator and Controller

2.5 CABLE MANAGEMENT ASSEMBLY

The Nycoil cable management basket mounts to the roof of the canopy and holds a tube, which in turn contains all the cables.

Table 4: Nycoil cable management specifications

Manufacturer	Nycoil
Tube diameter	1” Inner Diameter
Tube length	12 m

Below are specifications of the cables contained in the Nycoil tube:

Table 5: Coaxial cable specifications

Manufacturer and Model	Times Microwave - LMR400
Connectors	N-type
Datasheet link	https://www.timesmicrowave.com/documents/resources/LMR-400.pdf
Length	± 15 meters
Cable quantity	1

Table 6: Fibre cable specifications

Manufacturer and Model	CBi electric - Field Deployable fibre cable
Datasheet number	FDC/03
Fibre type	SM 9/125 µm
Specification	ITU-T G. 652
Fibre connectors	SC
Fibre count	12
Length	± 15 meters
Quantity	1

Table 7: Rotator control / RF frontend power cables specifications

Manufacturer and Model	Jaycor – J0205044
Datasheet link	http://www.jaycor.co.za/PDF/J0205044.pdf
Number of cores	8 cores per cable
	6 cores per cable – Rotator Control / Motor power
	2 cores per cable – DC power for RF frontend

Current handling (max)	3 A
Length	± 15 meters
Cable quantity	2

2.6 RADIO

The radio installed inside the vehicle cabin at the front passenger seat.

Table 8: Radio specifications

Manufacturer and Model	Tait TM8115
Input Voltage	12 VDC – Supplied by vehicle starter battery
Dimensions (WxHxD)	175 x 51 x 160 mm
Weight	1.5 kg

Figure 5: Tait TM 8115 Radio

3 POWER SYSTEM REQUIREMENTS

Procurement / Manufacturing of the individual components and fitment of the Power System to vehicle must include the following:

1. Procure / Manufacture an aluminium Shielded Enclosure (Section 3.1).
2. Install the shielded enclosure. See Appendices for the proposed position.
3. Procure and install power filter/s for all the electrical interface/s.
4. Measure Shielded Enclosure Shielding Effectiveness (Section 3.2).
5. Procure and install a Pure Sine wave Inverter.
6. Procure and install the Battery charger.
7. Procure and install Inverter batteries.
8. Provide an inverter bypass capability.
9. Procure and install a Shunt and Battery monitor.
10. Procure and mount an AC electrical / Shore supply inlet socket.
11. Procure and mount an AC electrical outlet socket.
12. Distribute DC electrical power.
13. Distribute AC electrical power.
14. Procure and supply a Shore supply extension cord.
15. Procure and install the components to modify the vehicle charging system to charge the Inverter batteries while driving.
16. Demonstrate the complete Power system.

Appendix A shows a two-dimensional proposal for the load-bay layout and Appendix B shows a 3-dimensional representation of the former. Appendix C is a block diagram of the complete system, which serves as a recommendation for the integration strategy. Any changes made to these diagrams must be reviewed and approved by SARAO

3.1 POWER SYSTEM SHIELDED ENCLOSURE

Procure / Manufacture and install a custom sized shielded enclosure to fit to the available space of vehicle load bay, while accommodating the Receiver System SE. Generate a layout drawing of the load bay with the proposed shielded enclosure and upon approval by SARAO, manufacturing may commence.

1. The SE manufactured out of aluminium to minimise weight.
2. Procure and install the appropriate power filter/s required for all the electrical interface/s.
    a. DC input for the Inverter.
    b. AC input for the Battery Charger.

c. AC output for the Receiver System and Rotator controller.

3. The SE must have sufficient space for the following equipment:
    a. Pure Sine Wave Inverter
    b. Battery charger/s
    c. DC power supplies
    d. Power filters
4. The SE must have a removable lid.
5. Make provision on the SE housing for the mounting of the following:
    a. AC electrical inlet socket (shore supply)
    b. AC electrical outlet socket
6. Procure and install vibration support for the SE.
7. The SE must have sufficient ventilation. The air temperature inside the SE shall be less than the maximum operating temperature specifications of the equipment installed inside the SE.
8. The SE must have sufficient protection against dust, because the Mobile RMS vehicle will mainly conduct measurements in and around the SARAO site.

3.2 SHIELDING EFFICIENCY

The Power System shielded enclosure must provide the following effective shielding:

1. The SE must provide 80 dB of attenuation for frequencies from 70 MHz to 3 GHz.
2. The SE must provide 60 dB of attenuation for frequencies from 3 GHz to 18 GHz.

3.3 INVERTER

Procure and install an Inverter.

1. Procure a pure sine wave Inverter capable of driving the electrical load listed in Table 9.

Table 9: Total electrical load

Electrical Load					
Equipment	**Quantity**	**Supply**	**Load (W)**	**Usage Hr/Day**	**Watt Hr/Day**
MPS RTA-3 Receiver	1	220 VAC	100	8	800
Dell PowerEdge R330 Server	1	220 VAC	350	8	2 800
+12 VDC power supply	1	220 VAC	50	8	400
+32 VDC power supply	1	220 VAC	50	8	400
+15 VDC power supply	1	220 VAC	50	8	400
Yaesu G5500 Controller	1	220 VAC	108	1	108
Clark Model 40E compressor	1	12 VDC	156	1	156
Total Watt hours per day					**5 064**

2. All the electrical interfaces to the inverter must have in-line power filter/s

3.4 BATTERY CHARGER

Procure and install a battery charger.

1. Provide an inverter battery bank charging capability, with full charge-control management that charges the batteries via an external AC power source / Shore supply.
2. The battery charger must be compatible with Lithium batteries.
3. All the electrical interfaces to the battery charger must have in-line power filter/s.

3.5 INVERTER BATTERIES

Procure and install Inverter Batteries:

1. Procure the appropriate size / quantity of Lithium batteries to save on weight compared to the traditional deep cycle batteries.
2. Procure / manufacture the bracket/s to secure the inverter batteries to the vehicle load bay.
3. Procure and install in-line DC electrical fuses and removable fuse holders that will allow the User to isolate power between the battery bank and the inverter when required.
4. If necessary, procure and install a battery management system (BMS) for integration with the battery charger and monitor.

3.6 INVERTER BYPASS

Provide an Inverter bypass capability for the Power System:

1. Provide an inverter bypass capability that will provide AC electrical power directly to the System, but ONLY if Shore power is available.
2. The User must be able to isolate the Inverter in case it is faulty or malfunctions.

3.7 SHUNT AND BATTERY MONITOR

Procure and install a Shunt and a Battery monitor:

1. The Shunt and Battery monitor must allow the User to monitor the state of the Inverter Battery bank as well as the vehicle starter battery.
2. The battery monitor must give the User an indication of the battery voltage, current drawn / charge current and state of charge / depth of discharge of the battery bank.
3. The battery monitor must warn the user against faulty batteries or individual cells to ensure safe operation.

3.8 DC POWER SUPPLIES

Procure and install Low EMI DC electrical power supplies:

1. The following DC electrical power supply units are required:

a. +12 VDC @ 1A

b. +32 VDC @ 1 A

c. +15 VDC @ 1 A

3.9 DC ELECTRICAL DISTRIBUTION

Distribute DC electrical power via power filters to the following equipment:

1. Clark mast compressor:
    a. The vehicle starter battery currently supplies DC power to the mast compressor
    b. Disconnect the DC electrical lines for the mast compressor from the vehicle starter battery and reconnect it to an alternative DC electrical source.
2. Receiver System Shielded Enclosure. The following equipment inside the SE requires DC electrical power:
    a. Yaesu GS232 computer control interface unit
    b. Oring IMC-111FB-SS-SC Ethernet to Fibre converter
    c. Oring ISC-1310FB-SS-SC RS232 to Fibre converter
3. RF frontend located at the top of the mast.

3.10 AC ELECTRICAL DISTRIBUTION

Distribute AC electrical power via power filters to the following equipment:

1. Yaesu G5500 Controller unit
2. Receiver System Shielded Enclosure. The following equipment inside the SE requires AC electrical power:
    a. Receiver
    b. Server

3.11 VEHICLE DUAL BATTERY CHARGING SYSTEM

Procure and install the components to modify the vehicle battery charging system:

1. Provide an inverter battery bank charging capability that charges the batteries via the vehicle alternator while driving.
2. The components to modify the vehicle battery charging system must be suitable for Lithium batteries.
3. Install the components to modify the vehicle battery charging system.

3.12 AC ELECTRICAL OUTLET SOCKET

Procure and install a spare AC electrical outlet socket:

1. Procure an AC electrical outlet socket with an isolating switch that is also waterproof.

2. Mount the outlet socket on the Power System shielded enclosure.
3. Install an appropriate power filter.
4. Route all electrical wiring in a protective conduit.

3.13 AC ELECTRICAL INLET SOCKET

Procure and install an AC electrical inlet socket to charge the inverter battery bank when Mains power becomes available:

1. Procure an AC electrical inlet socket with an isolating switch that is also waterproof.
2. Mount the inlet socket on the Power System shielded enclosure.
3. Install an appropriate power filter.

3.14 SHORE SUPPLY EXTENSION CORD

Procure a Shore supply extension cord:

1. Procure and supply a 30-meter AC electrical / shore supply extension cord.
2. The extension cord is required for charging the inverter batteries when an external Mains power becomes available.

3.15 DEMONSTRATION

Demonstrate the operation of the Power System equipment:

1. Inverter operation
2. Battery Charger operation
3. Battery monitor operation

4 VERIFICATION

4.1 VERIFICATION DEFINITIONS

Table 10: Verification definitions

A	Analysis	An element of verification that uses established technical or mathematical models or simulations, algorithms, charts, graphs, circuit diagrams, or other scientific principles and procedures to provide evidence that stated requirements are met
D	Demonstration	An element of verification that involves the actual operation of an item to provide evidence that the required functions were accomplished under specific scenarios - The items may be instrumented and performance monitored
I	Inspection	An element of verification that is generally non-destructive and typically includes the use of sight, hearing, smell, touch, and taste; simple physical manipulation; and mechanical and electrical gauging and measurement
T	Test	An element of verification in which scientific principles and procedures are applied to determine the properties or functional capabilities of items

4.2 VERIFICATION CROSS REFERENCE

The traceability between the requirement in section 3 and the verification methods specified in section 4.1 listed in Table 11.

Table 11: Verification Cross Reference

Requirement Number & Name	Verified by:
3.1 Power System Shielded Enclosure	Inspection
3.2 Shielding Efficiency	Test
3.3 Inverter	Inspection
3.4 Battery charger	Inspection
3.5 Inverter Batteries	Inspection
3.6 Inverter bypass	Demonstration
3.7 Shunt and Battery monitor	Demonstration
3.8 DC power supplies	Inspection
3.9 DC electrical distribution	Inspection
3.10 AC electrical distribution	Inspection
3.11 Vehicle dual battery charging system	Demonstration
3.12 AC electrical outlet socket	Inspection
3.13 AC electrical inlet socket	Inspection
3.14 Shore supply extension cord	Inspection
3.15 Demonstration	Demonstration

5 APPENDICES

5.1 APPENDIX A

Proposed 2-dimensional layout for the Mobile RMS vehicle load bay

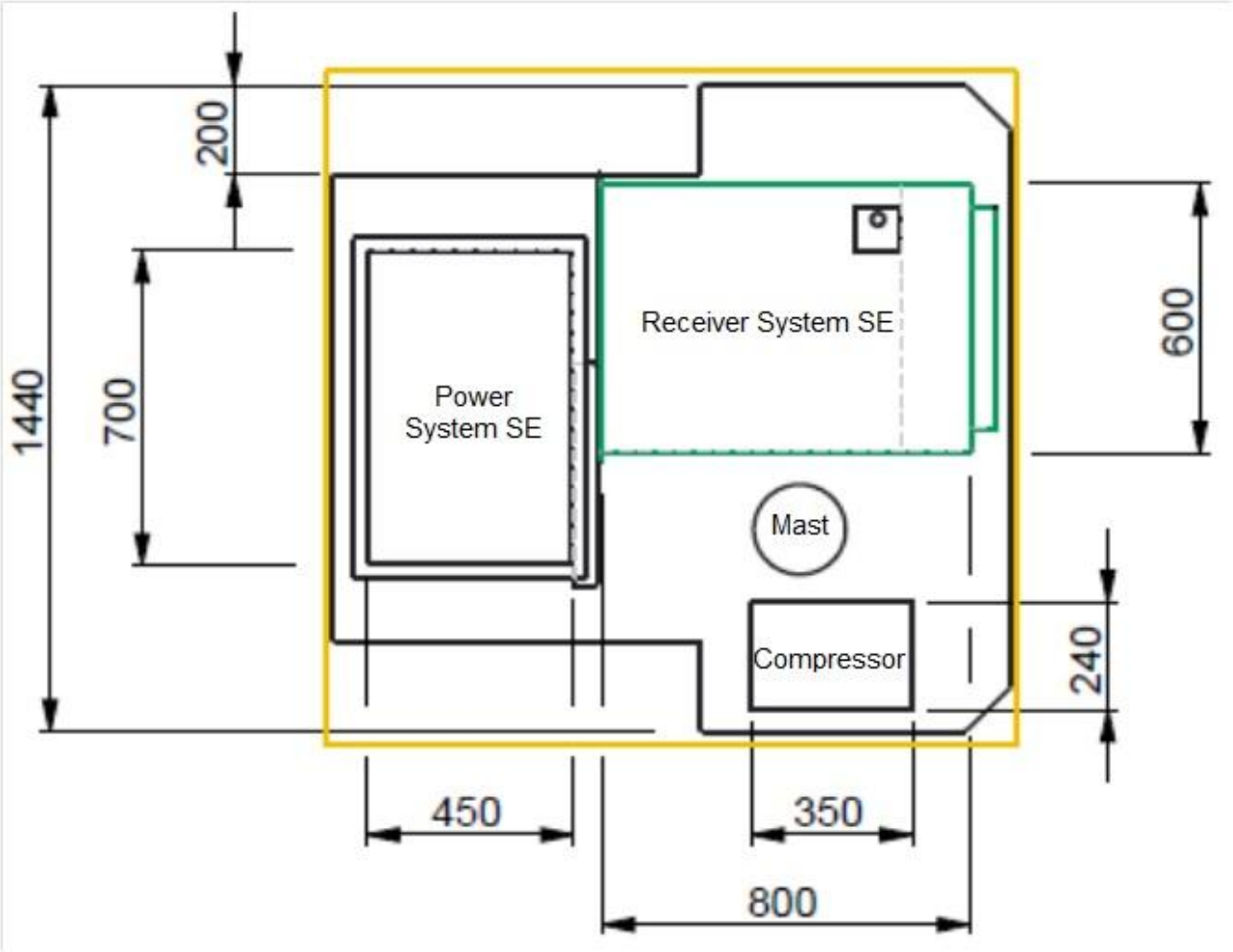

Figure 6: Proposed 2D layout

5.2 APPENDIX B

Proposed 3-dimensional layout for the Mobile RMS vehicle load bay, with the Receiver SE rail system extended to allow access to power-system SE.

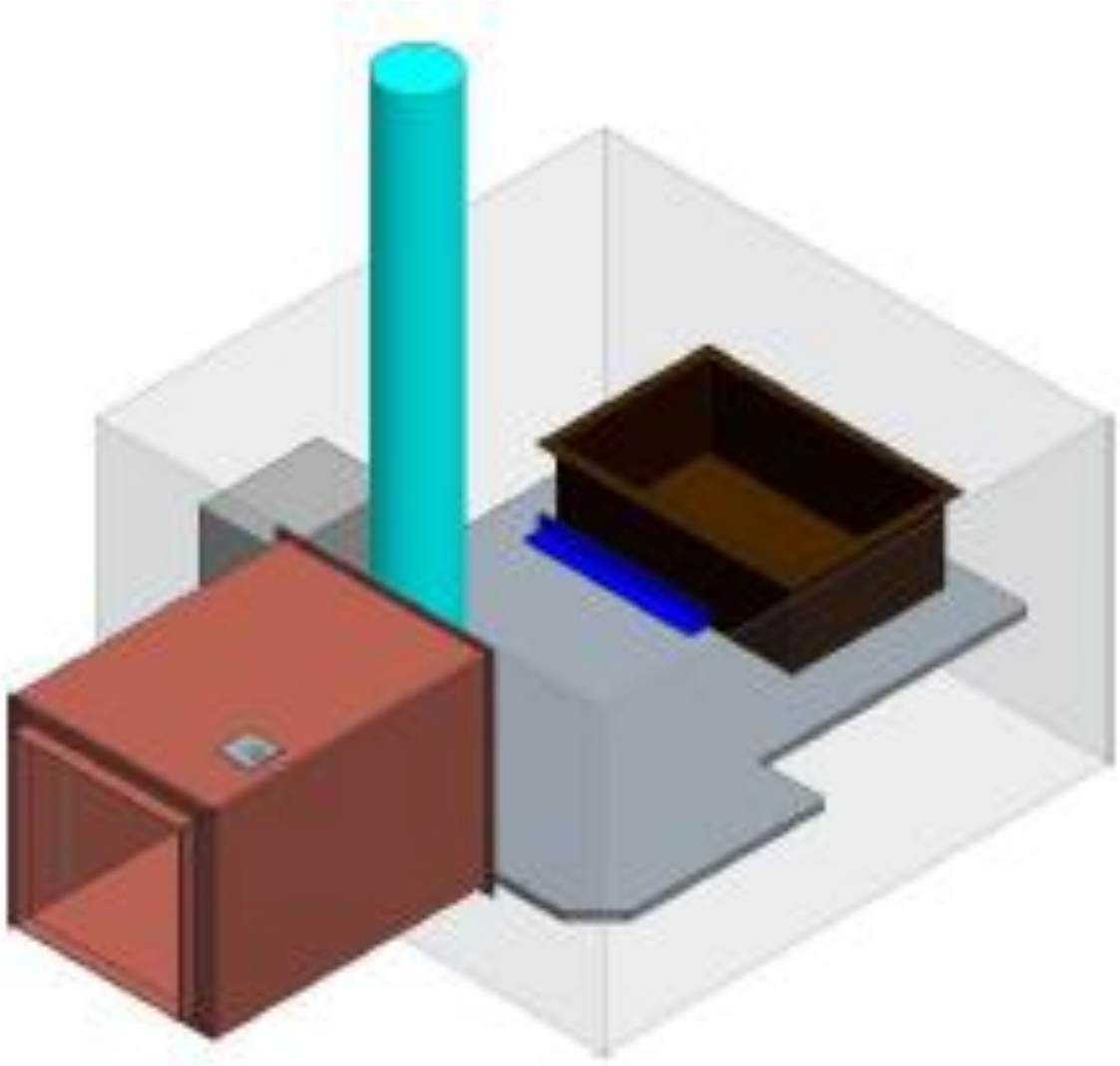

Figure 7: Proposed 3D layout

5.3 APPENDIX C

Mobile RFI Monitoring System Block diagram

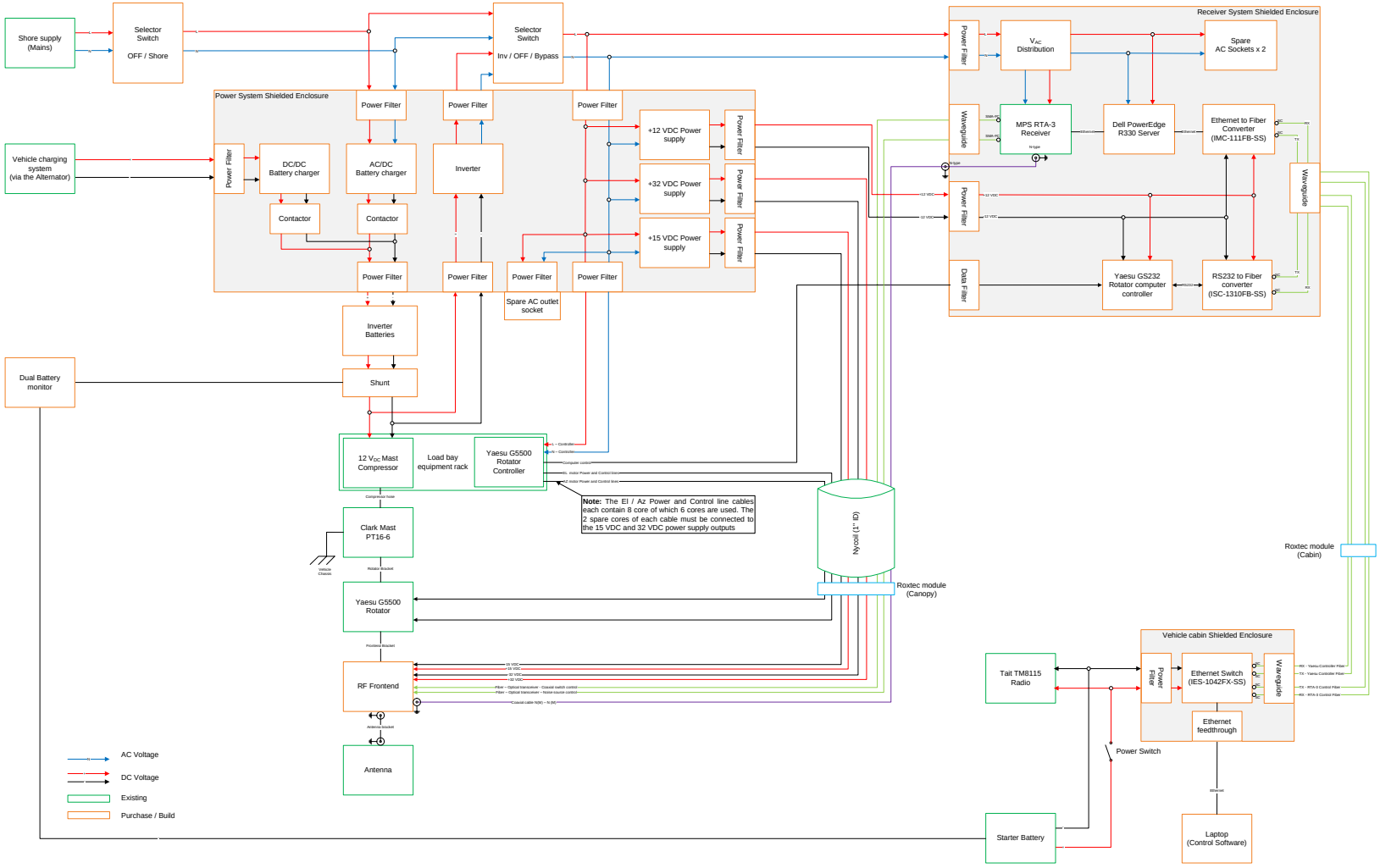

Figure 8: Block diagram of Mobile RMS

Specification - RFI Bakkie, Power system

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