University of Hawai'i at Mānoa
School of Ocean and Earth Science and Technology
Radio Oceanography Laboratory

Generic High Frequency Doppler Radar Synthesizer-Transmitter Unit Model MK3-PW-PA-TX Operational Description

April 2022
v. 10

radlab@satlab.hawaii.edu
Marine Sciences Building
1000 Pope road
Honolulu Hawai'i 96822

FCC Supplier’s Declaration of Conformity

University of Hawai'i Generic High Frequency Doppler Radar Synthesizer-Transmitter Unit, model *MK3-PW-PA-TX.*

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference, and

(2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by University of Hawai'i could void the user's authority to operate the equipment.

University of Hawai'i at Mānoa
School of Ocean and Earth Science and Technology
Radio Oceanography Laboratory
radlab@satlab.hawaii.edu
1000 Pope road
Honolulu, HI 96822, U.S.A
Phone (808) 956 7098

Warnings

This device contains potentially dangerous high voltages and high frequency radiation. Operation and servicing is restricted to properly trained and certified personnel.

Maximum output power is 50 W (+0.5dB) for frequencies 8 MHz and below and 30 W (+0.5dB) for frequencies 12 MHz and above.

The user’s authority to operate this device if connected to any radiating antenna or structure in the United States is contingent on applying for and being awarded a valid license through the FCC Universal Licensing System before transmitting. This device may not be powered up for testing unless connected to a non-radiating resistive load.

Table of Contents

Generic High Frequency Doppler Radar (G-HFDR)

1. Physical principles

The G-HFDR is an Oceanographic High Frequency Doppler radar designed with bare minimum features to ensure low production cost, low power requirement, and easy maintenance.

The operation of the G-HFDR consists of transmitting frequency-modulated continuous radio waves that are channeled along the surface of the conducting ocean as ground waves, in the wavelength range of 10 to 100 m (frequency 3 to 30 MHz).

These radio waves are coherently back-scattered by the ocean's surface gravity waves at half the radio wavelength (5 to 50 m), and captured by an array of receive antennas. The back-scattered radio waves are shifted in frequency by the Doppler effect due to the sum of the surface wave velocities and the surface current. The velocity of the radial currents in the direction of the G-HFDR is estimated from this Doppler shift.

For "Region 2", the Americas, the International Telecommunication Union (ITU) has recommended and the Federal Communication Commission has allocated dedicated secondary frequency bands for operating High Frequency Doppler radars (Table 1).

Table 1. Allocation for Oceanographic High Frequency Doppler radars in Region 2.

Center	*Occupied bandwidth*
(MHz)	*(kHz)*
4.463	50
5.2625	25
13.500	100
16.150	100
24.550	200
26.310	220

The G-HFDR consists of two units or subsystems: the Synthesizer-Transmitter Unit, and an optional Receiver-Digitizer Unit.

The Synthesizer-Transmitter Unit is based on commercial off-the-shelf modules and contains: (i) an ultra-low phase noise reference oscillator (OCXO), (ii) direct digital signal synthesizers (DDS-FPGA), (iii) a power amplifier (PA), (iv) an anti-harmonic filter (LPF), (v) power supplies (PS) and power line filters (RFI). This unit is the subject of the present technical document.

The optional Receiver-Digitizer Unit is based on schematics and engineering drawings published by the Radio Oceanography Laboratory and released in the public domain as Open Design/Open Source. It is a passive homodyne quadrature demodulator to baseband and does not contain any oscillator, frequency synthesizer or RF power amplifier. This unit is the subject of a separate technical document.

The units exchange information with the outside world through ethernet links. Absolute timing, if required, can be provided by the precision network time protocol (*ptp*), encompassing master network-based GPS clocks or atomic clocks.

2. System description and schematics

The following modules are integrated to form the Synthesizer-Transmitter Unit (Figure 1):

1. an ultra-low phase noise oven-controlled crystal oscillator (OCXO) fitted with a thermal-inertia bell, providing the clock signal to the digital synthesizer. Features: 100 MHz frequency, single side-band phase noise -148dBc/Hz. Manufacturer: Bliley (United States), model N79A-optA. The technical specification are found in appendix 1.

2. a clock-remapping direct digital synthesizer (DDS-C) to correct for frequency offset, aging and drift of the OCXO with a precision of 1 mHz, based on initial factory-calibration against a rubidium clock or optional real-time calibration against network clocks.

3. a two-channel quadrature (I, Q) direct digital synthesizer (DDS-A/B) providing frequency-modulated (chirped) signals. Features: internal frequency 300MHz after base clock multiplication, 48-bit phase register yielding 1 µHz tunability, 12-bit digital-to-analog converter, 80 dB SFDR, 27MHz analog low-pass filters resulting in an operating frequency extending to 27MHz. Both the clock-remapping DDS-C and the chirping DDS-A/B are based on Analog Devices' model AD9854 CMOS DDS, integrated by D-Tacq Solutions (Scotland/UK), model RAD-CELF. The technical specifications of this triple DDS radar controller are found in appendix 2 and its schematics are shown in Figure 2 and 3.

4. an embedded processor, combining on the same integrated circuit, a programmable logic gate array (FPGA) and a dual-core sequential processor operating under Linux (ARM Cortex-A9) based on Xilinx' model Zynq-7000. Mother-board integrated by D-Tacq Solutions (Scotland/UK), model ACQ-1001Q.

5. a solid state Class AB MOSFET RF power amplifier (PA) operated in continuous mode (CW). Features: input signal level -10dBm, Maximum output power is 50 W (+0.5dB) for frequencies 8 MHz and below and 30 W (+0.5dB) for frequencies 12 MHz and above. Stable operating range from 0.5 to 150 MHz. Manufacturer: Tomco Technologies (Australia), Model BTM00250-AlphaSA. The technical specifications are found in appendix 3.

6. a 9th order Butterworth power low-pass filter to cancel spurious signal harmonics and aliases. Manufacturer: DLW associates (Missouri, USA). The low-pass filter is built to the specific operating frequency and factory-fit at time of manufacture. The technical specifications are found in appendix 4.

7. switching power supplies manufactured by Traco, including 12V model for the digital electronics (TSP-070-112) and 26V model for the RF power amplifier (TSP-360-124 coupled with TSP–BCM24 battery controller module). The Traco power supplies are rated for an input voltage range 85V to 260V. They feature oscillator dithering to reduce spurious radiated peaks. The technical specifications are found in appendix 5. AC and DC power line filters (RFI) are inserted to mitigate spurious radiated emissions. Standard circuit breakers are added for protection.

8. a custom-built enclosure rated IP65 in white lacquered aluminum 20x60x75 cm protecting all electronic modules from weather and electromagnetic interference, including 6-point grounding harness for the door. The Synthesizer-Transmitter Unit operates without an active cooling device over an ambient temperature range of -30C to +50C.

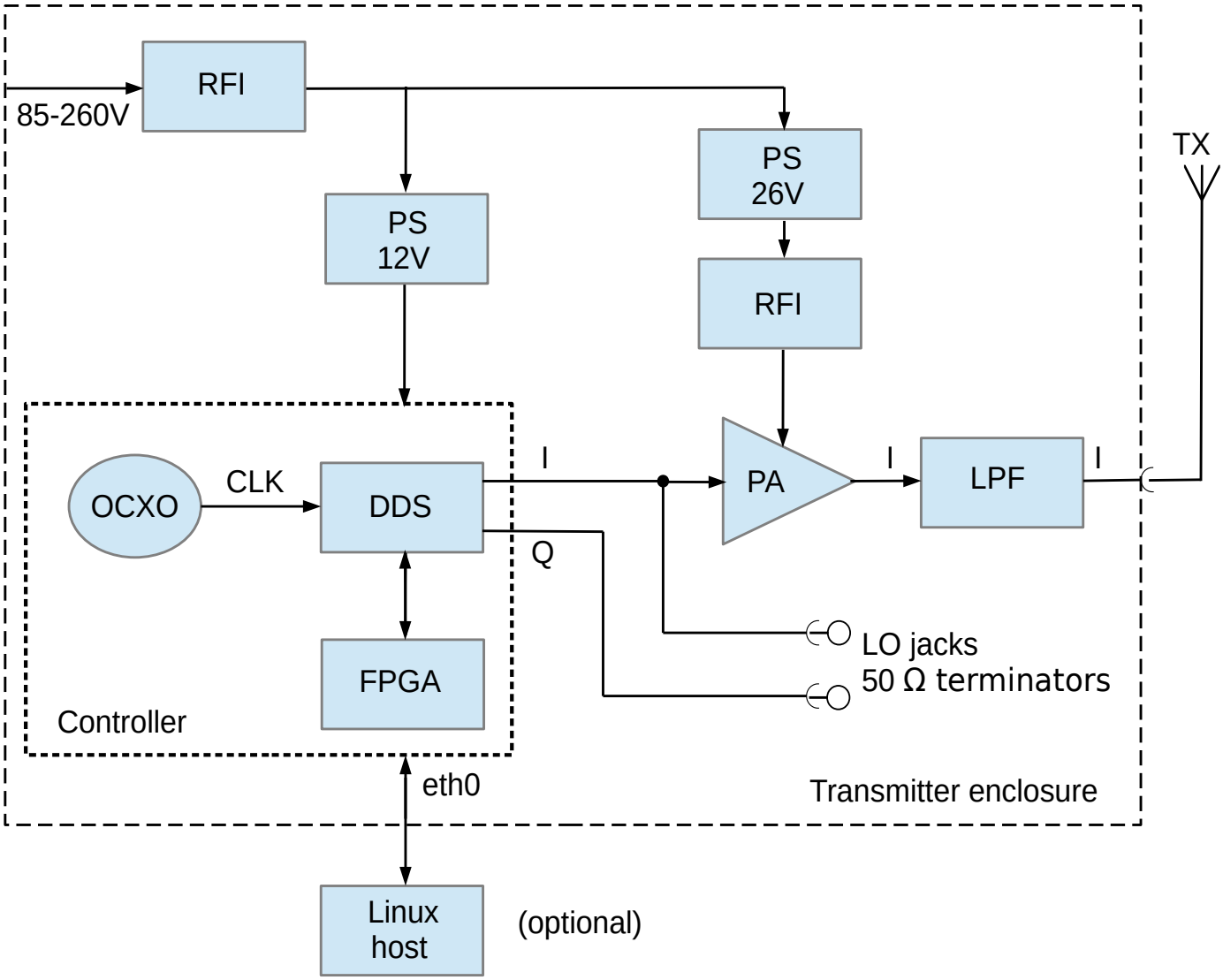


Figure 1. Schematics of the Synthesizer-Transmitter Unit.
See Table 2 for list of components and references.

Table 2. List of commercial modules incorporated in the Synthesizer-Transmitter Unit

Tag	*Description*	*Reference*	*Manufacturer*
OCXO	Oven-controlled crystal oscillator, 100 MHz	N79A-optA	Bliley Technologies Inc. 2545 W Grandview Blvd, Erie PA 16506 USA
FPGA	Carrier with embedded FPGA&ARM processors	ACQ1001	D-TACQ Solutions Ltd., International House Stanley Blvd, Blantyre G72 0BN Scotland UK
DDS	Triple DDS Radar Controller	RAD-CELF	*id.*
PA	Radio-frequency power amplifier	BTM00250-AlphaSA	Tomco Technologies 38 Payneham Rd, Stepney, Australia 5069
LPF	Power low-pass filter	FLxxMLP-HFDR	DLW Associates 6 Woodford place, St. Charles MO 63301 USA
PS12V	Industrial power supply	TSP-070–112	Traco Electronic AG Sihlbruggstrasse 111, CH-6340 Baar
PS26V	Industrial power supply	TSP-360–124	*id.*
RFI-DC	EMI Filter with High Attenuation Performance	FN2030M-Z-20-06	Schaffner Holding AG Nordstrasse 11, CH-4542 Luterbach
RFI-AC	EMI Filter with High Attenuation Performance	FN9266-10-06	*id.*

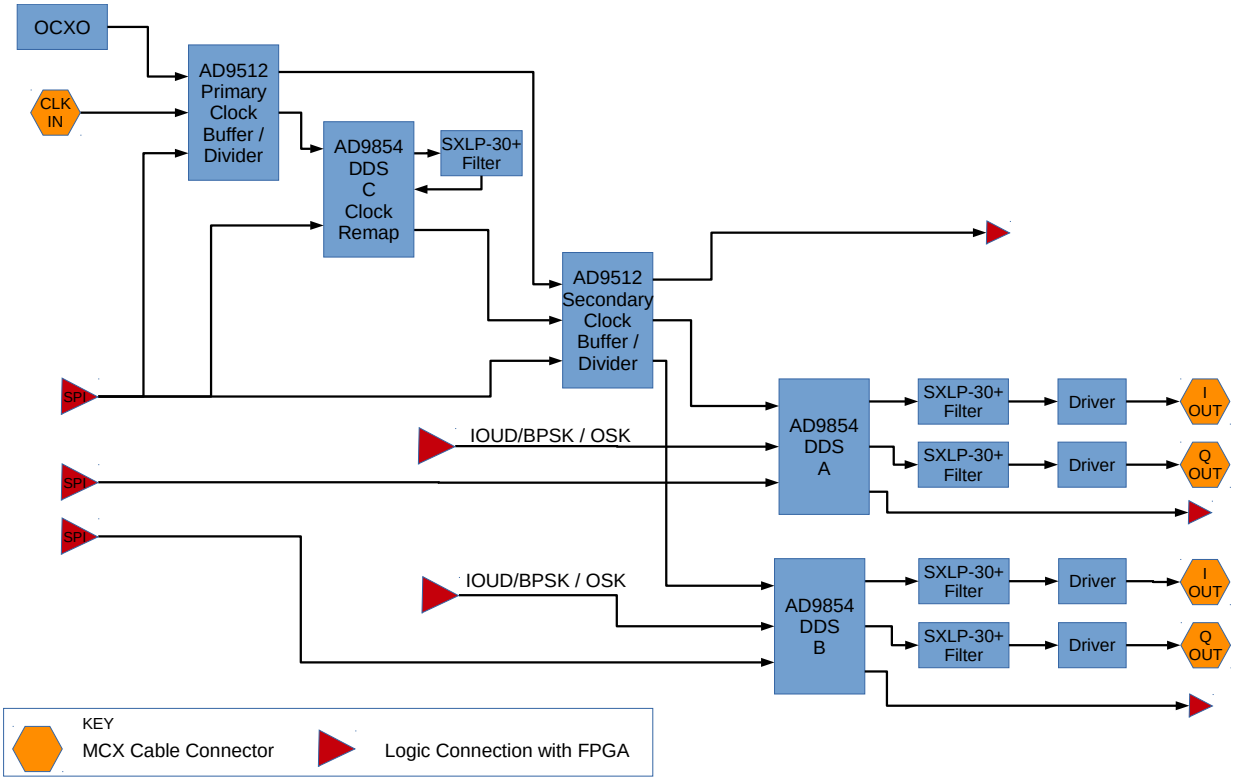


Figure 2. Schematics of the Triple DDS Radar Controller.
See Table 3 for list of components and references.

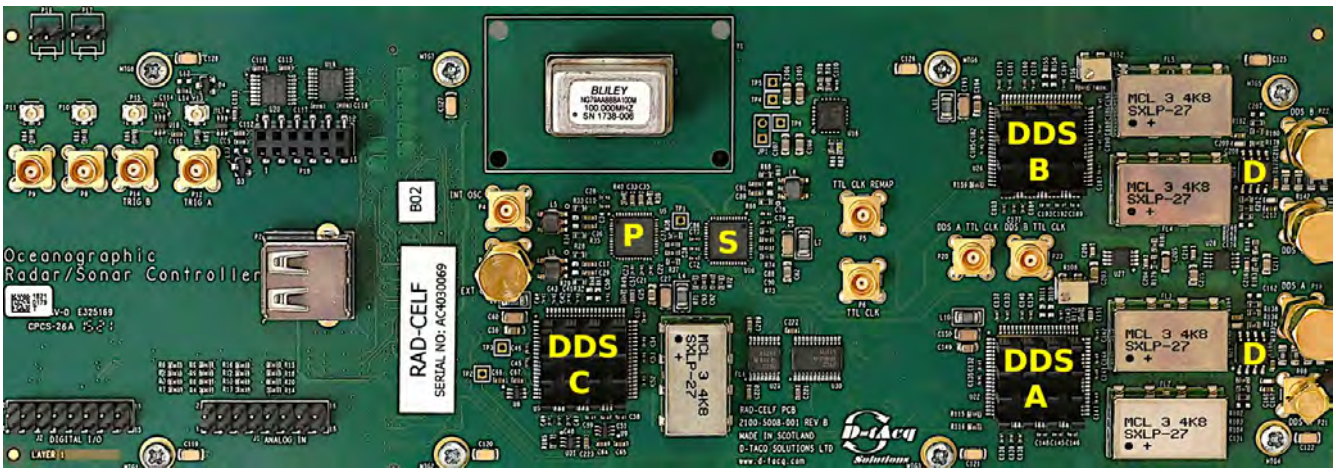


Figure 3a. Photo of the Triple DDS Radar Controller board (top face).

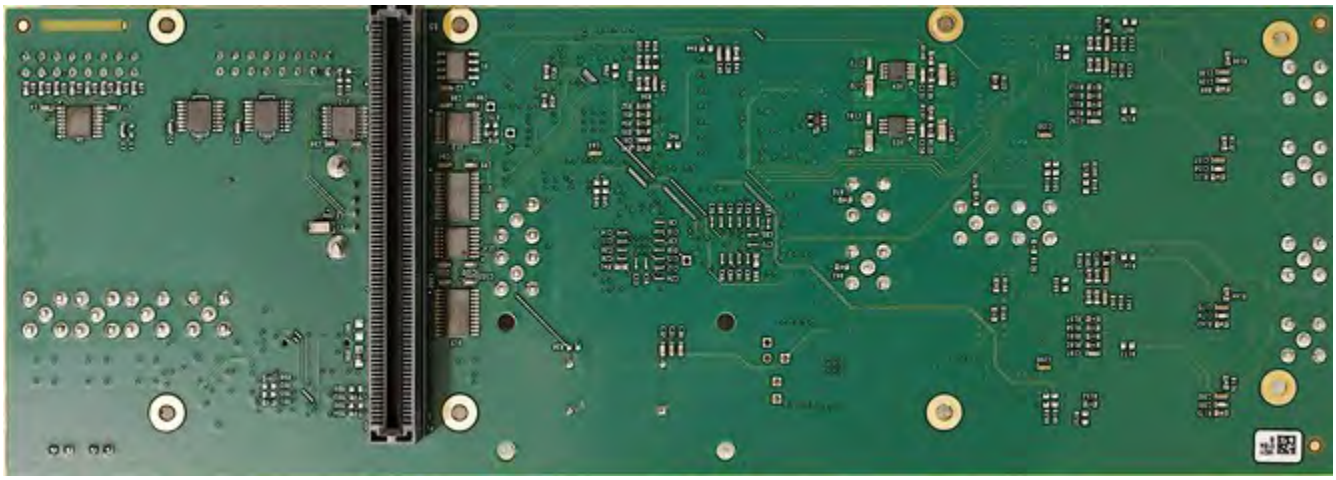


Figure 3b. Photo of the Triple DDS Radar Controller board (bottom face).

Figure 3c. Photo of the carrier board with FPGA (top face; bottom face not accessible).

Table 3. List of functional integrated circuits used in the Triple DDS Radar Controller

Tag	*Description*	*Reference*	*Manufacturer*
Primary	Clock/buffer divider	AD9512BCPZ	Analog Devices One Analog Way, Wilmington MA 01887 USA
Secondary	Clock/buffer divider	AD9512BCPZ	*id.*
DDS-A	Direct digital synthesizer	AD9854ASVZ	*id.*
DDS-B	Direct digital synthesizer	AD9854ASVZ	*id.*
DDS-C	Direct digital synthesizer	AD9854ASVZ	*id.*
Filter	Lumped LC low-pass filter	**SXLP-27**+	Mini-Ciruits 13 Neptune Ave, Brooklyn NY 11235 USA
Driver	Operational amplifier	OPA2694D	Texas Instruments 12500 TI Blvd., Dallas TX 75243 USA

Note: commodity components (inductors, capacitors, resistors, regulators) used on the Radar controller board have passive functions and do not contribute to the signal generation.

3. Summary of specifications

Signal characteristics:	FMCW linear sweep (chirp)
Emission designation:	F1N
Design operating frequencies:	3 MHz to 27 MHz
Modulation bandwidth:	Max. 2% of operating frequency
Restricted operating frequencies/bandwidth:	firmware-restricted to FCC/ITU allocations
Sweep (chirp) rate, radar mode:	1-5 Hz
Sweep (chirp) rate, call-sign mode:	1 kHz
Master reference clock:	OCXO 100 MHz SC-cut
Single side-band phase noise:	148 dBc/Hz @ 1 kHz or better
Clock frequency stability:	300 ppb or better (1-year, full temp. range)
Conducted output power < 10 MHz:	50 W
Conducted output power > 10 MHz:	30 W
Harmonics at rated power:	2**f0* < -70 dB; 3**f0* < -80 dB
Supply voltage range:	85 V to 260 V AC, 50-60 Hz
Supply power:	250 W AC
Operating temperature range:	-30°C to +50°C

4. Tune-up procedure

This device has no adjustments to tune output power and reference frequency because these are digitally programmed during the manufacture of the system and drifts are non-existent within the precision of measurements.

Programming the unit is password-protected and reserved to factory-authorized personnel. There are no user-accessible controls to modify the programming of the unit.

5. Configuration and operation

The unit is programmed to emit a repetition of frequency sweeps (chirps), typically at a rate of 1Hz to 4Hz and an occupied bandwidth of 25 to 220kHz determined by the ITU frequency allocation (see Table 1), resulting in a frequency-modulated continuous wave (FMCW mode, emission designation F1N).

The unit is factory-programmed to start transmitting automatically upon power up at the ITU frequency for which a low-pass filter is factory-fitted. To avoid any erroneous operation that could damage the power amplifier and/or the low-pass filter, or result in unlicensed transmissions, all frequencies are factory-disabled, except the ITU frequency for which a low-pass filter is actually factory-fitted to the unit. Programming the unit to other frequencies is password-protected and reserved to factory-authorized personnel.

If a FCC call sign has been provided at the time of factory-configuration, a full-bandwidth broadcast of the call sign is automatically scheduled every 20 min. Chirps at a rate of 1 kHz are transmitted over the same occupied bandwidth, for short periods corresponding to the dots and dashes of the Morse code, resulting in a similar frequency-modulated continuous wave (emission designation F1N).

The unit can be powered-up in two modes of operation: (a) a test mode, for which the output is connected to a 50Ω non-radiating resistive load, or (b), a live mode, for which the output is connected to a radiating antenna or structure. The user's authority to operate this device in the live mode (b) from a location within the United States is contingent on being awarded a license through the FCC Universal Licensing System. In the absence of a valid FCC license, the device may only be operated in the test mode (a).

The firmware allows programming all operations of the digital synthesizer, including chirping, calibration tones and full-bandwidth call-sign broadcast, using a single ethernet web server interface, configured through the Dynamic Host Configuration Protocol (DHCP; Figure 4). The actual settings of the digital synthesizers are continuously read back from the DDS registers and displayed on a separate diagnostic web page (Figure 5).

5.1. Start-up procedure

The following steps must be performed in the order given:

1. open enclosure and verify that the frequency of the low-pass unit fitted (figure 9) corresponds to the factory-configured frequency marked on the label (figure 8).
2. verify that all breakers are off in the down positions (figure 9).
3. for mode (a), connect a power attenuator such as a a Bird 100-SA-FFN-30 to the N-type RF output of the unit (figure 12).
4. for mode (b), connect the cable to the TX antenna, with a minimum attenuation of 5 dB (figure 12).
5. connect a CAT-6e cable from a local network to the RJ45 jack of the unit (figure 12);
6. connect a grounded power cable to the IEC-C13/C14 power inlet (figure 12) and plug into a 120 or 240V outlet (the unit auto-detects the voltage).
7. connect the power adapter of the heat-exchanger shown in figure 5 into a 120 or 240V outlet (the unit auto-detects the voltage).
8. power up the unit and the heat exchanger.

9. enable the power surge suppressor by flipping its breaker to the up position (lower DIN rail, figure 9).
10. enable the power supplies by flipping all remaining breakers in sequence from right to left to the up position (middle DIN rails, figure 9).
11. tie the 6 grounding connections of the door and close the enclosure.
12. verify that the network router has provided an IP address through DHCP (waiting 2-3 minutes may be necessary to let the boot sequence complete).
13. open browser on this IP address, verify that a screen similar to figure 4 is obtained.
14. click on “Status”, verify that a popup screen similar to figure 5 is obtained and that the entry shown for ---DDS-A--- under /FREQ displays the expected factory-configured frequency.

The unit is now operating and transmitting the required signal.

5.2. Toggling between signal types

Two signal types are allowed: standard frequency-modulated continuous wave chirp for normal radar operation, and continuous tones for calibration. Continuous tones can be programmed at three distinct frequencies: at the lower limit of the allocated bandwidth *f0-bw/2*, at the center frequency *f0* and at the upper limit of the allocated bandwidth *f0+bw/2.*

To toggle between signal types:

1. open a browser on the unit’s IP address, obtain a screen similar to figure 4.
2. to change between signal types, click on the appropriate button.
3. wait 15 sec for the command to execute.
4. verify with the “Status” screen that the frequency has been updated.

The unit is now transmitting the required signal.

5.3. Power-down procedure

The following steps must be performed in the order given:

1. open a browser on the unit’s IP address, obtain a screen similar to figure 4.
2. click on the “Stop” button.
3. wait 15 sec for the command to execute.
4. verify with the “Status” screen that the frequency has been updated to 0.
5. open enclosure.
6. disable the power supplies by flipping all breakers in sequence from left to right to the down position (middle DIN rails, figure 9).
7. power down the unit and the heat exchanger.
8. close enclosure and stow unit.

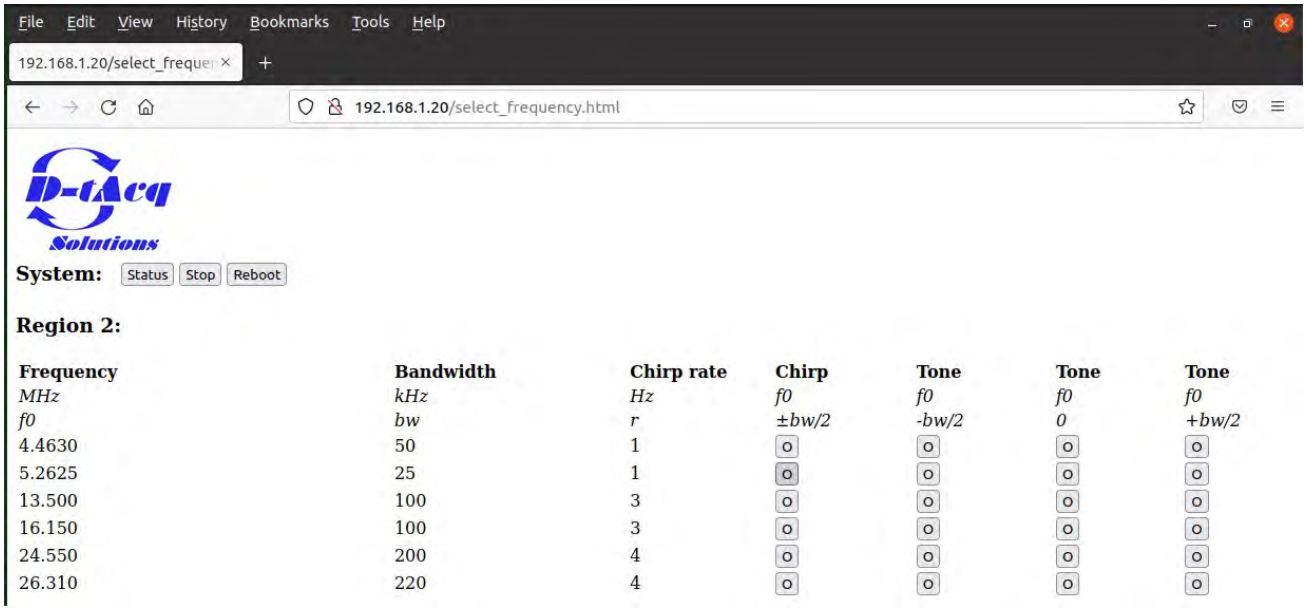


Figure 4. Web interface for programming the synthesizer/transmitter.

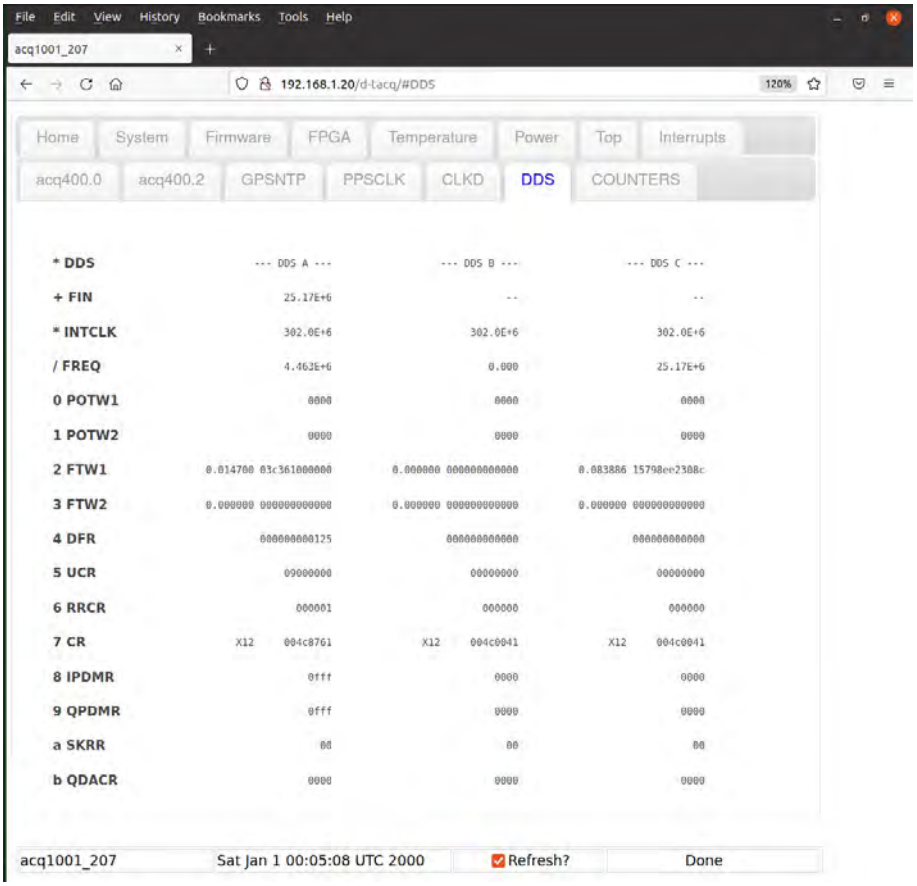


Figure 5. Diagnostic page with DDS registers read-back.

6. Antenna design

The transmit antennas are normal-mode helical monopoles (Kraus, J.D., “The Helical Antenna”, *Proc. I.R.E.* 1949 pp. 263-272). They consist of an AWG-16 vertical wire of length λ/4 wound over a mast of height λ/8 and diameter λ/300, a 3-loop tuning air-coil, and a network of 4 underground radials of length λ/4 (λ is the electromagnetic wavelength). The air-coil diameter is adjusted to achieve resonance using a standard commercial VSWR meter.

The customer-provided mast may be built of any non-conductive material, such as fiberglass, PVC, bamboo, wood. The typical gain of a normal-mode helical monopole is approximately 2 dBi.

Figure 6. Normal-mode helical monopole with air-coil on a fiberglass mast (8 MHz).

Figure 7. Normal-mode helical monopole with air-coil on a PVC mast (16 MHz).

Table 5. Dimensions of the antenna components as function of ITU frequency (metric)

F	*Wavelength*	*Vertical wire*	*Radial wires*	*Pole height*	*Diameter*
(MHz)	*(m)*	*(m)*	*(m)*	*(m)*	*(cm)*
4.4630	67.22	16.80	16.80	8.40	22.4
5.2625	56.01	14.00	14.00	7.00	18.7
13.500	22.22	5.55	5.55	2.78	7.4
16.150	18.58	4.64	4.64	2.32	6.2
24.550	12.22	3.05	3.05	1.53	4.1
26.310	11.40	2.85	2.85	1.43	3.8

The coaxial cable connecting the synthesizer/transmitter unit in the shack to the remote antenna, preferably deployed at the water edge, is specified as standard RG-213U, with a typical attenuation of at least 5 dB, depending on the frequency.

To comply with FCC RF exposure requirements, the antennas must be installed to ensure a minimum separation distance from persons while operating:

Table 6. Minimum separation distance to comply with FCC RF exposure requirements

Operating Frequency	*Minimum Separation Distance*
(MHz)	*(m)*
4.463	10.66
5.2625	10.66
13.500	3.55
16.150	3.55
24.550	2.30
26.310	2.30

7. Photos of unit

University of Hawai'i at Mānoa
Radio Oceanography Laboratory
1000 Pope road
Honolulu Hawai'i 96822

Generic High Frequency Doppler Radar
Synthesizer–Transmitter Unit

Model: MK3–PW–PA–TX
Serial number: 3–003
Input voltage: 85–260 V
Input power: 250 W AC
FCC ID: 2A562–MK3–PW–PA–TX
Modulation: FMCW mode F1N

Operating frequency / Bandwidth / RF power:

☐ 4.4630 MHz / 50 kHz / 50 W	☐ 5.6250 MHz / 25 kHz / 50 W
☐ 13.500 MHz / 100 kHz / 30 W	■ 16.150 MHz / 100 kHz / 30 W
☐ 24.550 MHz / 200 kHz / 30 W	☐ 26.310 MHz / 220 kHz / 30 W

Figure 8. Above: Synthesizer-Transmitter Unit model MK3-PW-PA-TX, serial 3-003 (March 2022), door closed. Below: device identification label, affixed to the top right of the enclosure door. The factory-programmed operating frequency and output power are marked, here 16.150 MHz/30W.

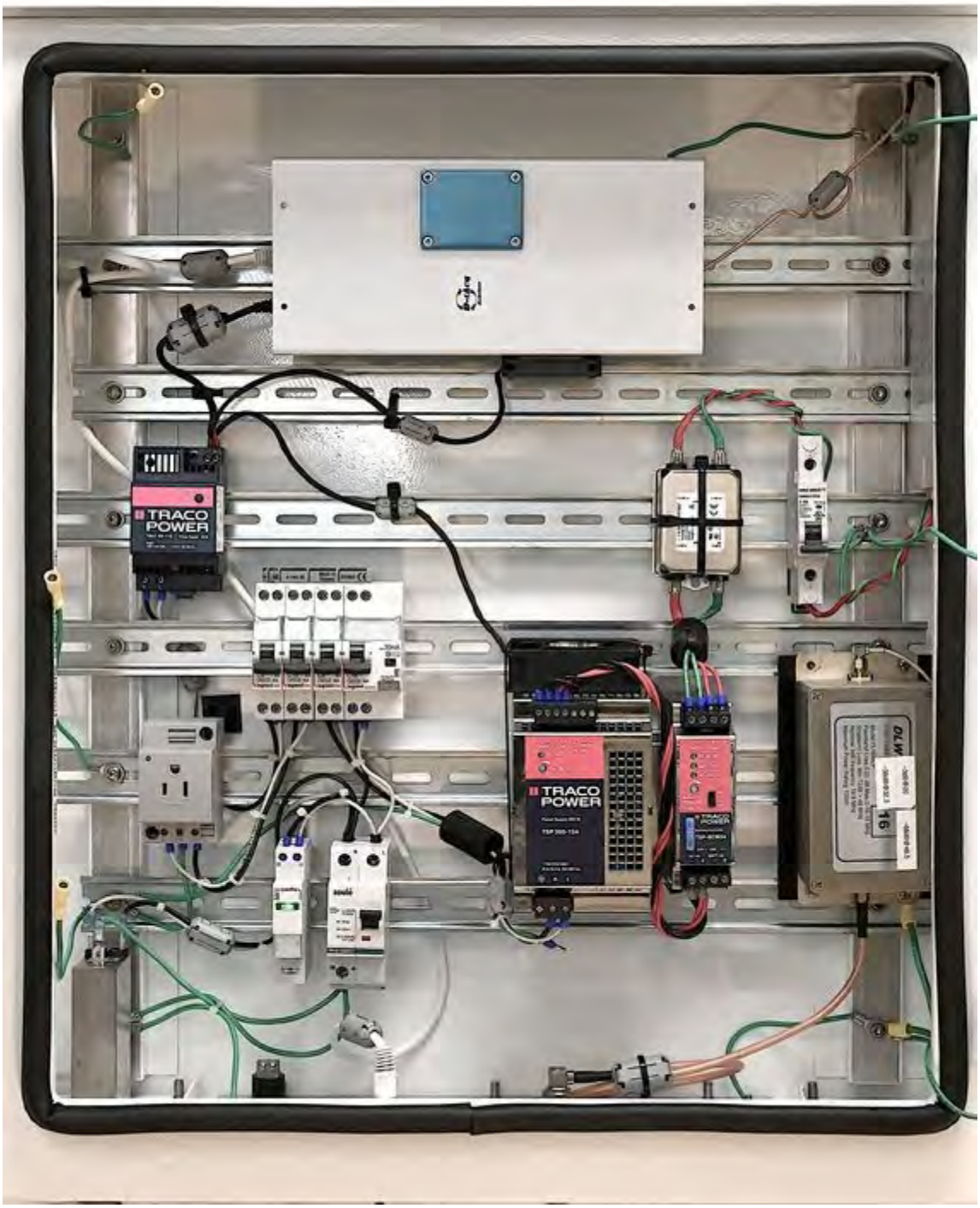


Figure 9. Synthesizer-Transmitter Unit, door open.
Bottom rails: power supplies with circuit breakers.
Upper rail: digital synthesizer and controller with blue thermal bell.
On the right wall: the power amplifier module and the low-pass filter.

Figure 10. Synthesizer-Transmitter Unit, door open, slanted view. The power amplifier module (top) and the low-pass filter (bottom) are seen on the right inner wall.

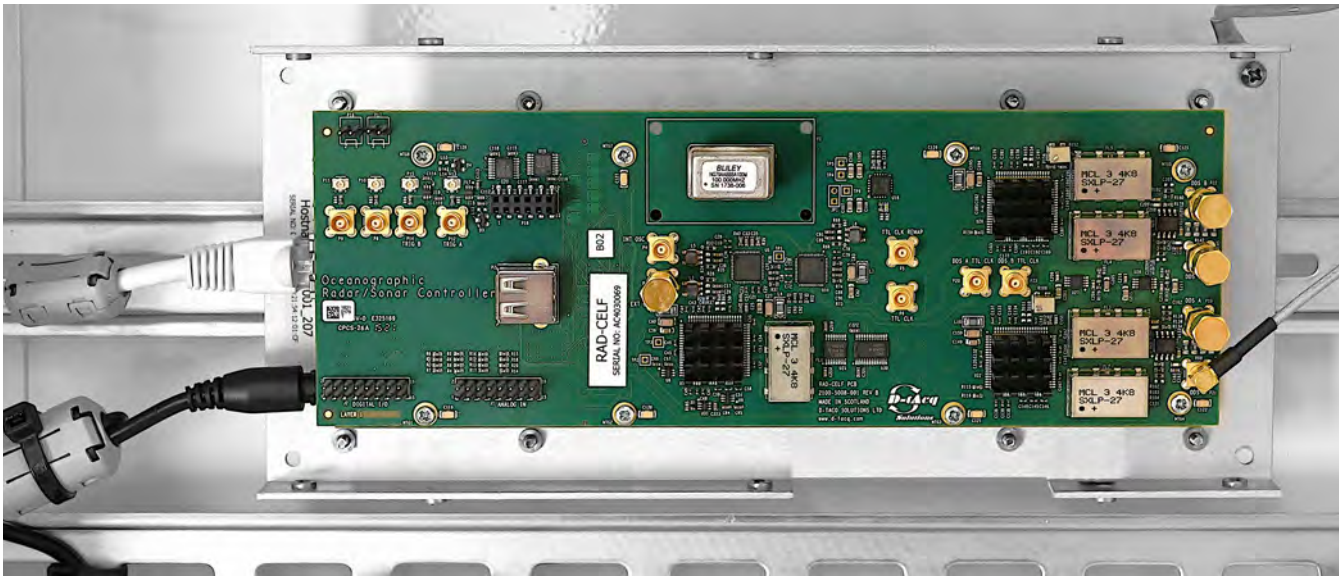


Figure 11. Upper rail enlarged from Figure 9 and 10, after removal of the aluminum lid and thermal bell, showing the Triple DDS Radar Controller board.

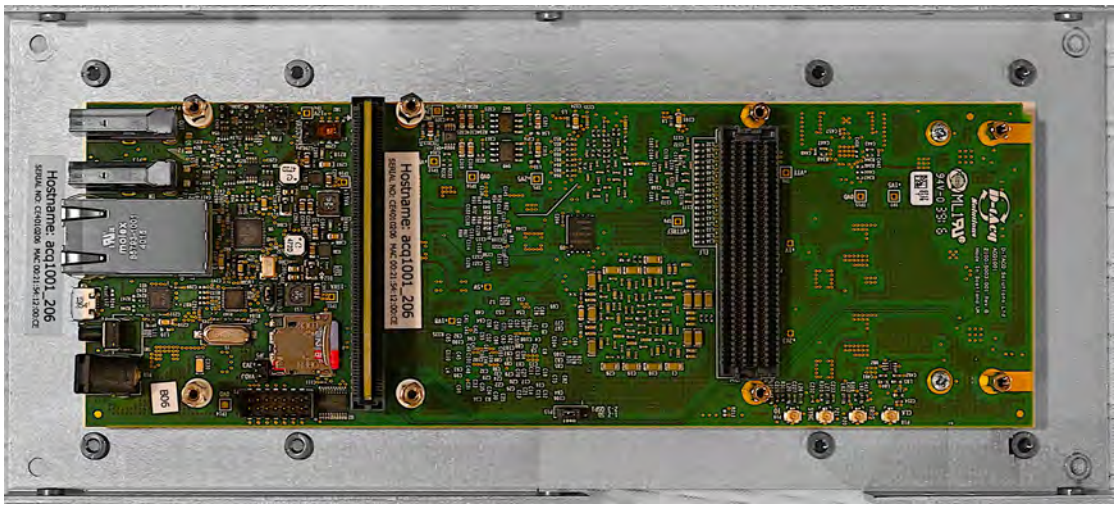


Figure 12. Carrier board with FPGA, after removal of the Triple DDS Radar Controller board (top face; bottom face not accessible).

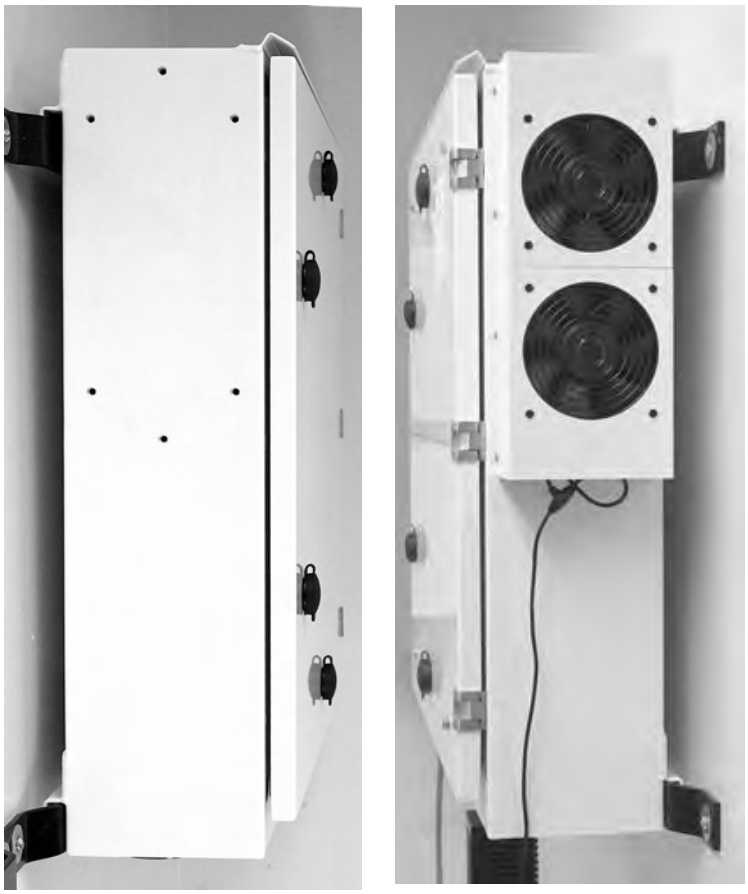


Figure 13. Synthesizer-Transmitter Unit, left and right side views.
The twin-fan forced air flow heat exchanger unit is seen on the right side.

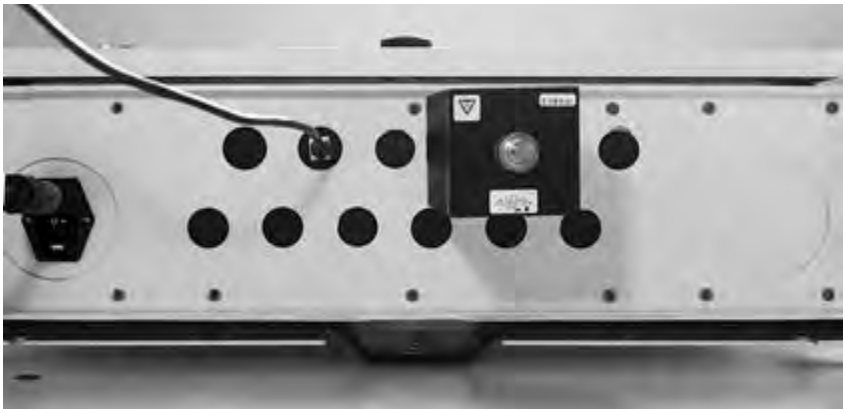
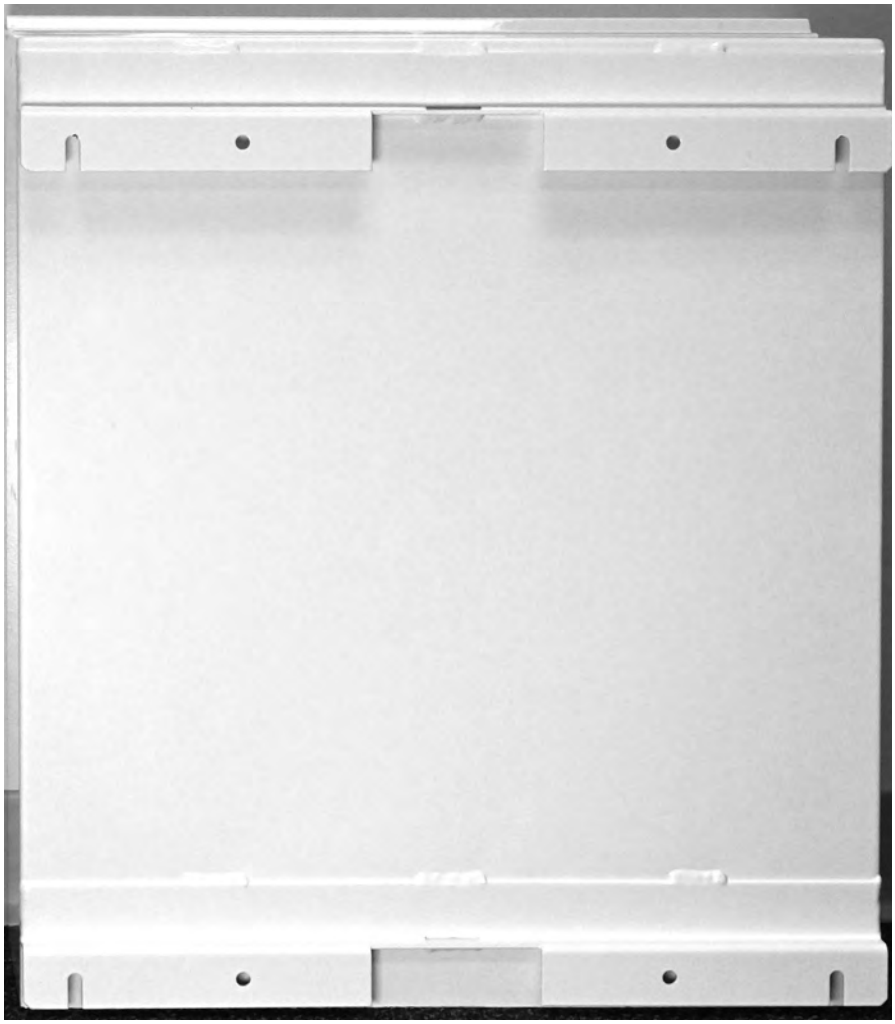


Figure 14. Synthesizer-Transmitter Unit, bottom view.
Connector plate with IEC-C13/C14 power inlet, RJ45 jack for CAT6 Ethernet, N-type bulkhead adapter for cable to antenna (a Bird 100-SA-FFN-30 power attenuator is attached).

Fig. 14. Synthesizer-Transmitter Unit, top view.
The twin-fan forced air flow heat exchanger unit is seen on the right side.

Fig. 15. Synthesizer-Transmitter Unit, back view
(after removing unit from wall supports).



Appendix 1 : specifications of the ultra-low phase noise oscillator (OCXO)

High Freq. 20x13mm NV79 DIP OCXO

Bliley Technologies Inc.
2545 W Grandview Blvd
Erie, Pa 16506
Factory +1-814-838-3571

Features:

- **50MHz to 120MHz Output Frequency's**
- **Standard Frequency of 100 MHz.**
- **Excellent Stability and Noise in a miniature size**
- **Options for Phase noise, and FVT**
- **Available in surface mount, through hole or gull wing package styles.**
- **RoHS-6/Lead free Compliant**
- **Storage Temperature Range of -55°C to +85°C**
- **Manufactured in Erie, Pa. USA**

Description:

The NV79 Series Ovenized Crystal Oscillator offers high stability Frequency vs. Temperature performance and SC Cut Crystal Phase Noise performance in a DIP configuration. It is ideally suited for base station, test equipment, synthesizers, and digital switching applications. It is available in three different package styles as well as custom frequencies between 50 to 120 Mhz. Standard frequency is 100 MHz.

Electrical Specifications

1. Output Characteristics

	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
1.1	Frequency Range	50		120	MHZ	
1.2	Initial Accuracy			±50	PPB	
1.3	Output Type					
	Sinusoidal					
	Output Level	3	5		dBm	
	Load Impedance ±5%	45	50	55	Ω	
	Harmonic Content		-25		dBc	
	Spurious Modulation			-60	dBc	
1.4	Acceleration Sensitivity*			1	PPB/g	@100MHz

***Please consult factory for acceleration sensitivity options regarding other frequencies.**

Bliley Technologies Inc.
2545 W Grandview Blvd
Erie, Pa 16506
Factory +1-814-838-3571

2. Frequency Stability

	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
2.1	Frequency vs. Temperature					Referenced to Frequency @+25˚C
	0°C to +50°C		±70		PPB	See Table 2 For Ordering Options
	-20°C to +70°C		±100		PPB	See Table 2 For Ordering Options
	-40°C to +85°C		±150		PPB	See Table 2 For Ordering Options
2.2	Aging	Typical for 100MHz after 30 days of continuous operation				
	Per day after 30 days			±5	PPB	Typical at 100MHz after 30 days of continuous operation
	1st Year**			±300	PPB	
	10 Years**			±650	PPB	
2.5	Short Term		8		10e-11	τ = 1 Second
2.6	Warm-up		±50		PPB	Within 3 minutes
2.7	Static Phase Noise	See Table 2 for Ordering Options				
		Option A	Option B	Option C		Tested @ +25˚C±1˚C Static Environment
	ℒ(f)@10Hz	-95	-90	-85	dBc/Hz	
	ℒ(f)@100Hz	-127	-120	-115	dBc/Hz	
	ℒ(f)@1KHz	-148	-145	-140	dBc/Hz	
	ℒ(f)@10KHz	-158	-155	-150	dBc/Hz	
	ℒ(f)@100KHz	-160	-155	-150	dBc/Hz	

Values listed above are typical performance of a (100.000) MHz Fo

**Long term aging projection is calculated per MIL-PRF 55310 f(t) = A(ln(Bt+1))+Fo

3. Input Characteristics

	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
3.1	Supply Voltage	4.75	5	5.25	Vdc	See Table 2 for Ordering Options
3.2	Power Dissipation					
	Warm-up			800	mA	@25°C ±1°C ambient
	Steady State			300	mA	@25°C ±1°C ambient

3. Input Characteristics (Continued)

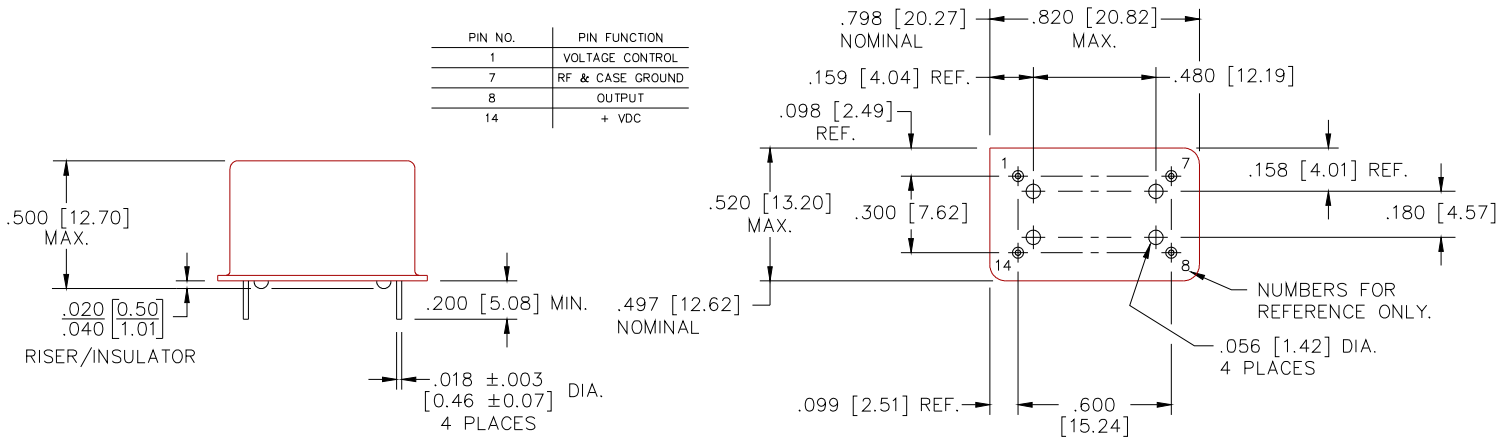
	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
3.3	Electronic Frequency Control					
	Voltage Range	0		5.0	Vdc	
	Center Voltage		2.5		Vdc	
	Frequency Range	±0.8			PPM	Consult Factory for Wide Pull Range
3.4	Slope		Positive			
3.5	Input Impedance	100K			Ω	
3.6	Linearity			10	%	

4. Environmental, Reliability and Mechanical Specifications

	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
4.1	Operational Temperature	-40		+85	˚C	See Table 2 For Ordering Options
4.2	Storage Temperature	-55		+85	˚C	
4.3	Shock Mil-Std 202G	Survive				1000 Single, 100 Repeated
4.4	Sinusoidal Vibration Mil-Std 202G	Survive				50G's rms 10 to 2000Hz

Mechanical Dimensions, and Pin Functions

Standard Package Style (79A):



Appendix 2 : specifications of the digital synthesizer (DDS) module

RADCELF

TRIPLE-DDS RADAR SIGNAL GENERATOR
Product Specification

High Performance Simultaneous Data Acquisition

Table of Contents

1 Product Description

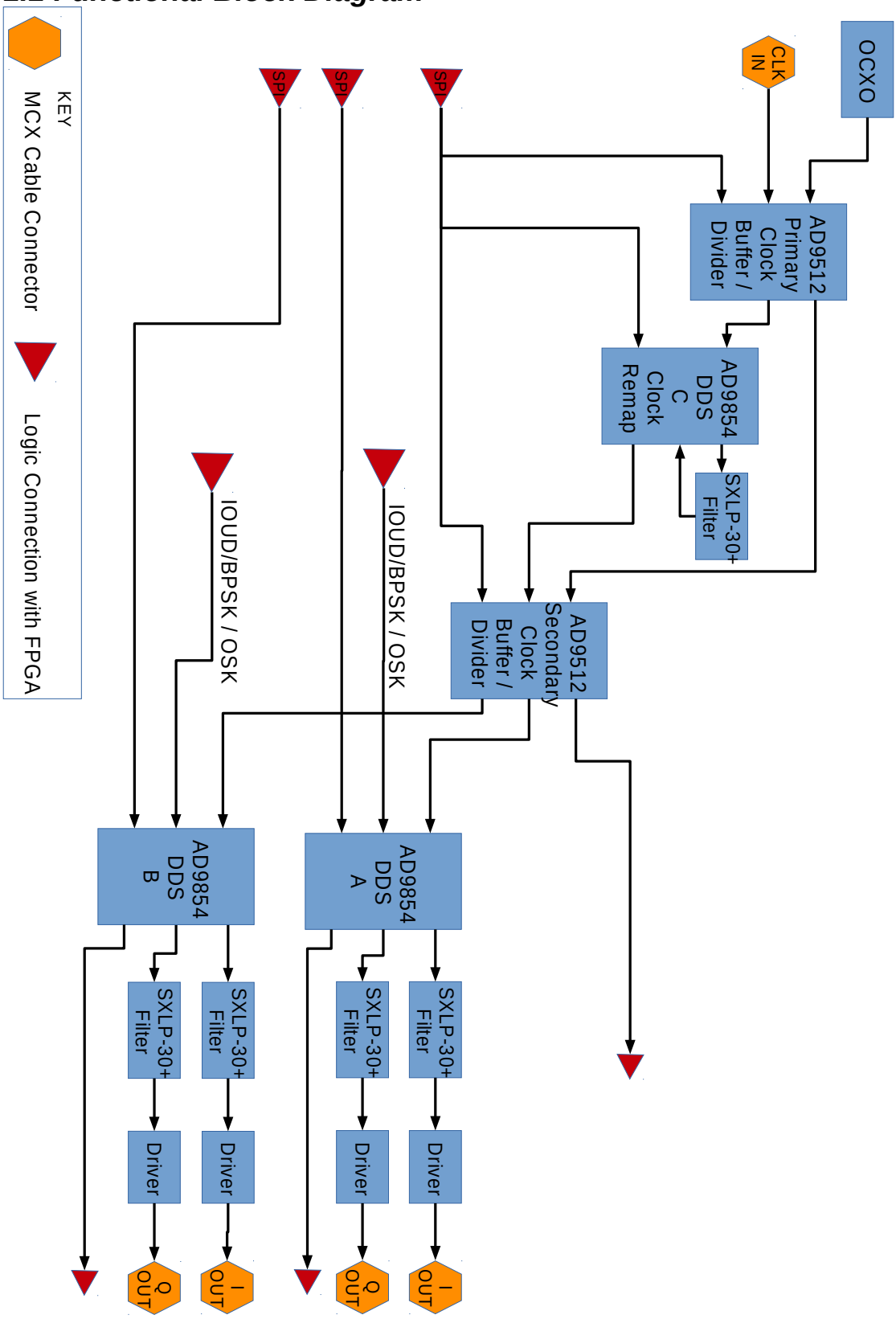
1. RADCELF is a complete clocking system suitable for HF RADAR and SONAR
2. Circuit board forms the top layer of a 3-layer stack comprising
    1. ACQ1001Q base unit with ZYNQ FPGA
    2. Optional digitizer module.
    3. RADCELF
3. Includes 3 x AD9854 DDS devices
    1. ddsA : I+Q outputs, for main system control.
    2. ddsB : I+Q outputs for system calibration.
    3. ddsC : I output for clock remapping
4. Includes 2 x AD9512 CLKD Clock divider/buffer devices
    1. clkdA : Select Oven Local Oscillator or CLK-IN
    2. clkdB : Select Clock source for ddsA, ddsB.
5. All 5 devices are controlled from SPI from the ACQ1001. Multiple SPI channels are used to potentially provide simultaneous register update.
6. Key signal inputs to DDS are provided from the FPGA. All output clocks feed back to the FPGA for monitoring.
7. Provision for Oven Local Oscillator (power supply, socket and space for thermal management) or external clock
8. Signal inputs and outputs on MCX connectors. ddsA, ddsB TRG inputs.
9. Outputs filtered by Minicircuits SXLP filters.
10. I/O expansion:
    1. P18: PMOD connector. (12 pin header with FPGA IO)
    2. J1: VMON (16 pin header, 8 x slow ADC channels, 1Hz, 10bit)
    3. J2: DIO (16 pin header, 8 slow DIO)
    4. USB 2.0, type A port, suitable for USB stick or remote devices.

RADCELF?

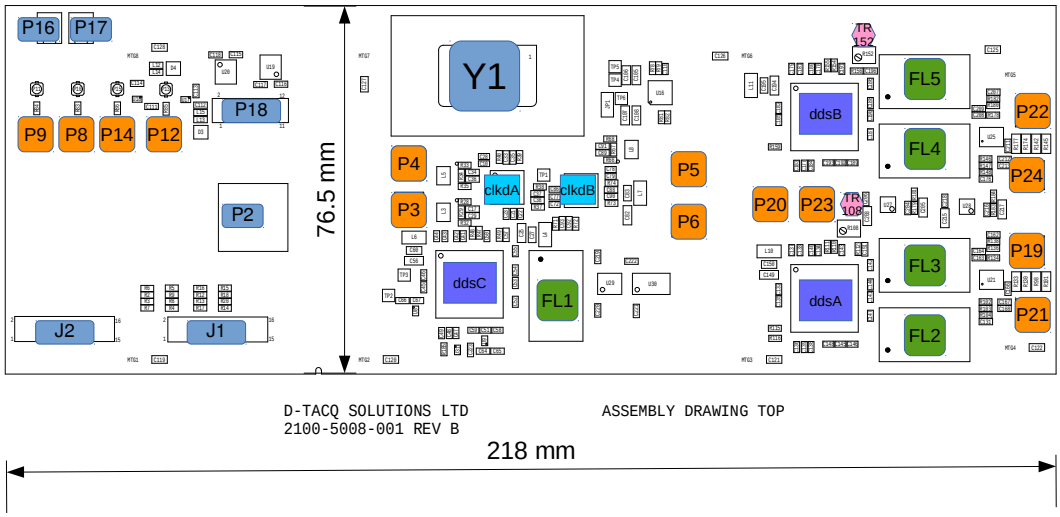
RAD : Radar

CELF : “Carrier Elf”, D-TACQ definition for 3 layer stacking board.

1.1 Functional Block Diagram



2 Physical



2.1 Devices

- ddsA, ddsB, ddsC : AD9854 DDS devices
- clkdA, clkdB: AD9512 CLK divider/distributors.
- FL1..FL5 DDS output filters
- Y1 DIL socket for LO
- TR152, TR108 : DDS output level match trimpots.

2.2 MCX Connectors

ID	*IO*	*Description*	*Opt?*
P3	I	EXT CLK INPUT	
P4	O	OCXO LO Monitor	
P5	O	REMAP CLK Monitor	X
P6	O	clkdB Monitor	X
P8	IO	Link tee with uFL P10	X
P9	IO	Link tee with uFL P11	X
P12	IO	DDS A Trigger tee with uFL P13	
P14	IO	DDS B Trigger tee with uFL P15	
P19	O	DDS A I output	
P20	O	DDS A monitor output	X
P21	O	DDS A Q output	
P22	O	DDS B I output	
P23	O	DDS B monitor output	X

ID	IO	Description	Opt?
P24	O	DDS B Q output	

2.2.1 Misc Connectors

ID	Type	Description	Opt?
P2	USB-A	USB 2.0 Master	
P16	2-pin HDR	3V3 external	X
P17	2-pin HDR	5V external	X
P18	12 pin HDR	PMOD Header	
J1	16 pin HDR	AI 8 slow monitor	
J2	16 pin HDR	DIO 8 slow control/monitor	

2.3 RADCELF Dimensions

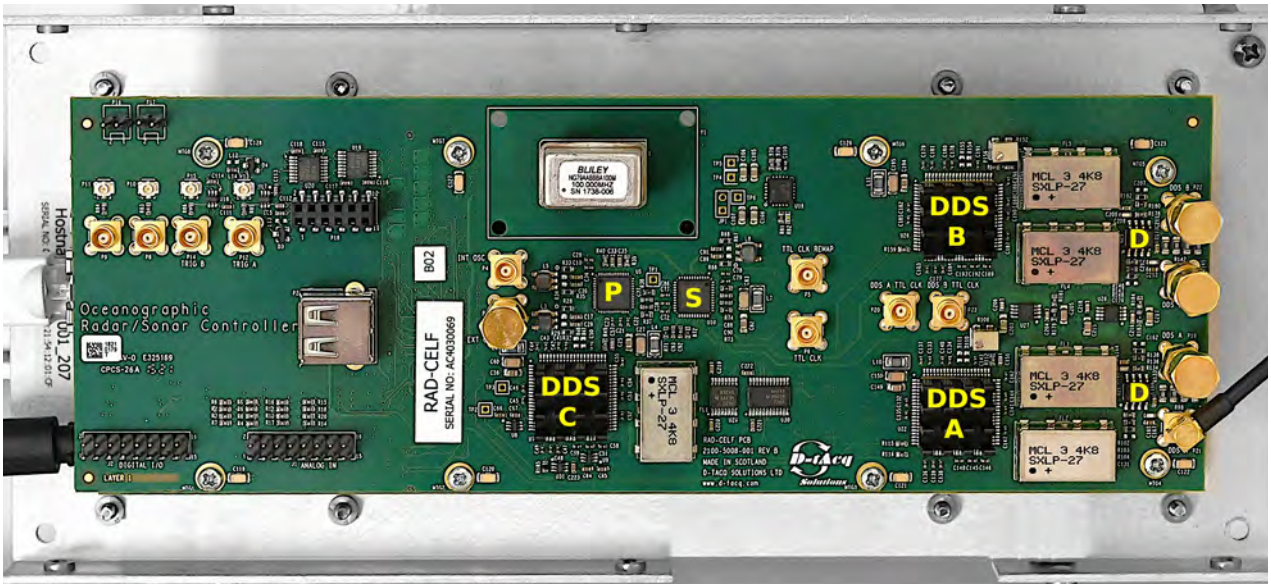
2.3.1 Length 218mm

2.3.2 Width 76.5mm

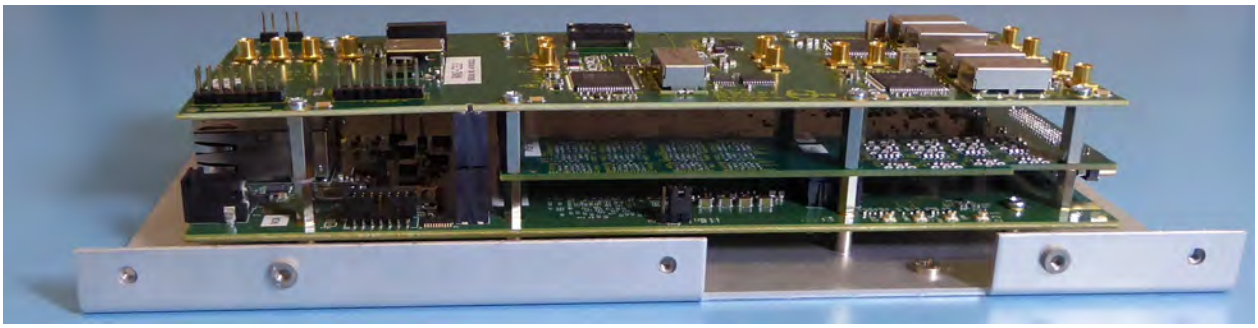
2.3.3 Stack Height 50mm

2.4 Appearance

2.4.1 Plan View



2.4.2 Side view of Stack up



Top to Bottom:

- RADCELF
- ACQ1001: FPGA/Computer control module.
- Plinth base.

3 Interface Specification

3.1 OCXO socket

Standard 14 pin socket is provided for a OCXO.

Linear regulated 5V power at up to 1A (warm up) and 500 mA (steady state)

Sine or Square Wave output 2-7 dBm

Tested with Bliley NV79A.

Physical separation with mounting holes to allow the OCXO to be encased for thermal separation

3.2 I/O Connectors

3.2.1 I& Q Output MCX Connectors

All outputs are a nominal 7dBm output with 50 Ohm impedance

3.2.2 Clock Input

Connector P3 transformer coupled 2-7dBm 50 Ohm input Square or Sine Wave input.

3.2.3 Trigger Inputs

The two trigger input functionality is application dependent. These are 5V TTL compatible inputs with optional output functionality.

3.3 Clock Monitors

P4 allows the oscillator to be monitored it is a direct connection to the output of the OCXO Oscillator

P5 is a TTL output monitor of the square wave frequency of the Clock Remapping DDS – DDS C. This is the square-wave produced by the AD9654 comparator.

P6 is a TTL output monitor of the input Clock to the two main DDS devices DDS A and DDS B. This signal is controlled from the secondary AD9512 device and can therefore be overridden under software control to produce a divide by N output if desired.

P20 and P23 are TTL monitors of the square wave frequency of DDS A and DDS B. This is the square-wave produced by the AD9654 comparator.

3.4 Misc Connectors

3.4.1 P16 3V3 External

Auxiliary 3V3 output 100 mA max.

3.4.2 P17 5V External

Auxiliary 5V output 100 mA max.

3.4.3 P18 PMOD Header

12 pin 0.1” box header socket for use with PMOD modules.

PMOD is a simple low-cost expansion standard.

Using the PMOD requires FPGA customization depending on PMOD chosen. Please contact D-TACQ with requirements.

3.4.4 J1 AI 8 Slow monitor

16 pin 0.1” box header plug for monitoring slow AI signals.

Input range: 0..5V, 10 bit conversion, 1Hz typical rate. 20K input impedance.

Access through Linux device driver.

2x LM7417 devices include temperature monitor.

Pin	***Channel***
2	AI1
4	AI2
6	AI3
8	AI4
10	AI5
12	AI6
14	AI7
16	AI8
1,3,5,15	GND

3.4.5 J2 DIO control

16 pin 0.1” box header plug for slow DIO control.

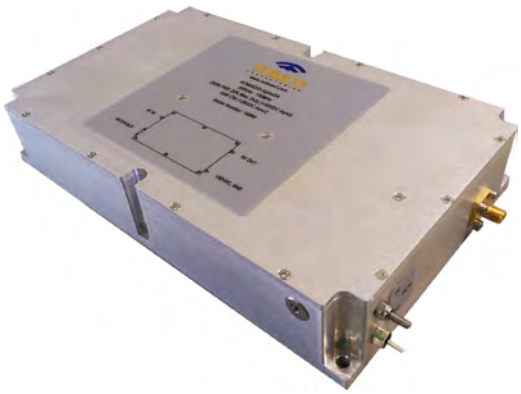
5V TTL. Access through Linux device driver.

Pin	***Channel***
2	DIO1
4	DIO2
6	DIO3
8	DIO4
10	DIO5
12	DIO6
14	DIO7
16	DIO8
1,3,5,15	GND

Appendix 3 : specifications of the power amplifier (PA) module

BTM00250-AlphaSA
500kHz-150MHz
250W Pulsed/50W CW

- Scientific and Industrial Applications



The BTM-AlphaSA series is a range of class AB RF power amplifier modules covering the 500kHz to 150MHz frequency range.

- Rugged, solid-state design - high reliability
- Extremely high phase and amplitude stability
- Very fast pulse rise/fall times
- High linearity
- Very low interpulse noise
- Competitively priced

Can be supplied as amplifier module only or with optional heatsink and cooling fans

RF Specifications

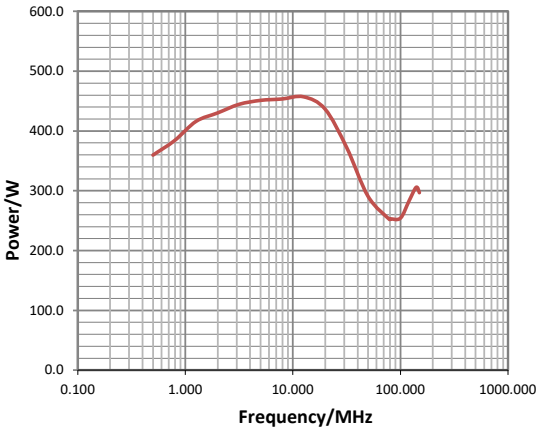
Rated Power	250W minimum in pulsed mode 50W minimum in CW mode PEP for input power of 0dBm
P1dB	200W minimum in pulsed mode 40W minimum in CW mode Minimum output power at P1dB compression
Gain	54dB minimum in pulsed mode 47dB minimum in CW mode
Type	Class AB MOSFET
Frequency	500kHz-150MHz
Gain flatness	±2dB maximum (measured at 1/10th rated output power)
Max. duty cycle	20% Maximum GATE duty cycle in pulsed mode
Max. pulse width	100ms Maximum GATE pulse width in pulsed mode
Pulse droop	0.5dB maximum Measured at max. pulse width at P1dB level
Pulse rise and fall times	Risetime: 200ns typical Falltime: 100ns typical using a pre-gated RF input signal
Gate rise and fall times	Risetime: 300ns typical Falltime: 150ns typical
Gate delay	Rising edge: 1µs typical Falling edge: 500ns typical Rising edge measured from rising edge of GATE pulse to 90% RF output voltage. Falling edge measured from falling edge of GATE pulse to 10% RF output voltage
Harmonics	Odd: -20dBc typical, -10dBc max. Even: -30dBc typical, -20dBc max. Measured at 1dB below rated output power
Spurious	<-70dBc maximum
Output noise (blanked)	<10dB above thermal (100kHz bandwidth)
Phase change/power	<10˚ from -40dB to full power
Phase stability	<1˚ across 100ms pulse
Input/output impedance	50 Ω nominal
Load VSWR	Tolerates at least 3:1 @ full rated power without damage External mismatch protection is recommended No internal mismatch protection included
Gain control range	10dB minimum for 0-5V control voltage Control via parallel interface
RF Input	0dBm nominal, +10dBm for no damage
GATE (blanking)	Logic low = Blank, logic high = unblank. CMOS and TTL compatible

Electrical Specifications

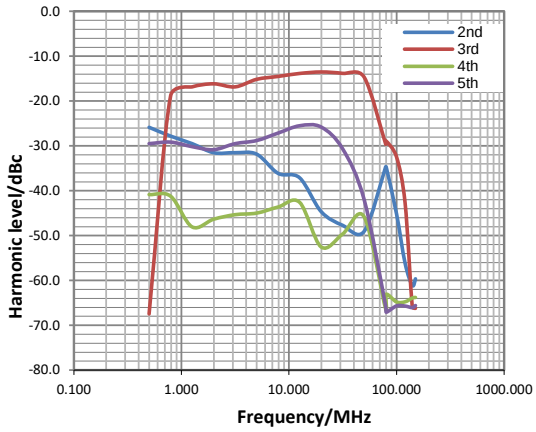
DC supply voltage	Pulsed mode: +50V at approx. 3.3A CW mode: +28V at approx. 8A
DC connection	Solder pin

Typical Performance Plots

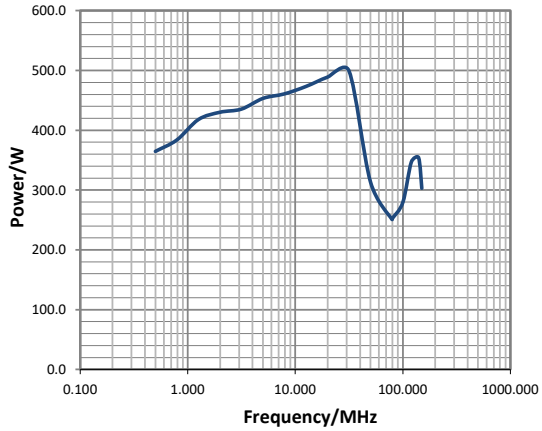
Peak input power for 0dBm RF drive



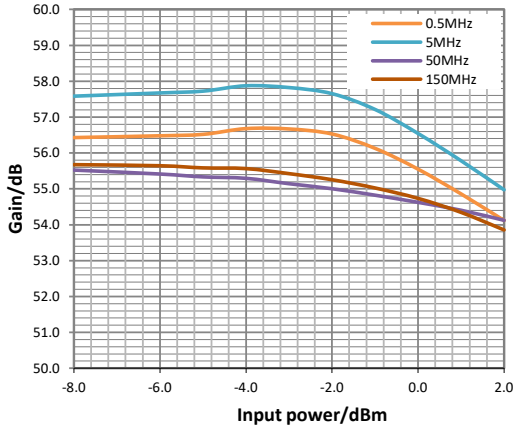
Harmonics



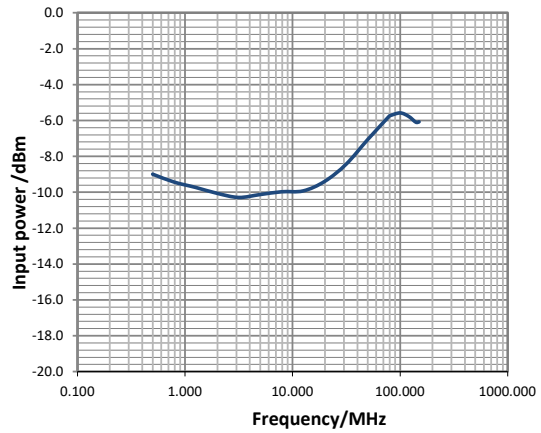
Peak output power at 1dB compression



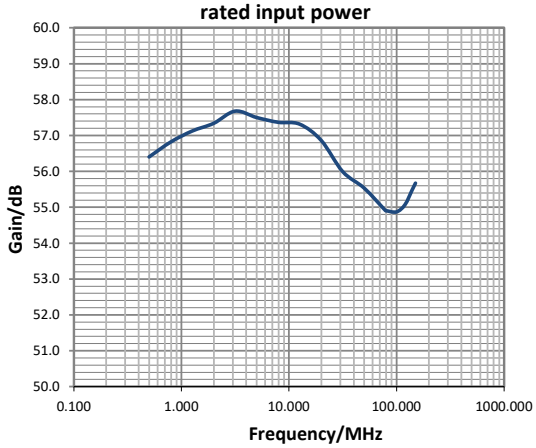
Gain as a function of input power



RF input for 50W CW out at +28V DC

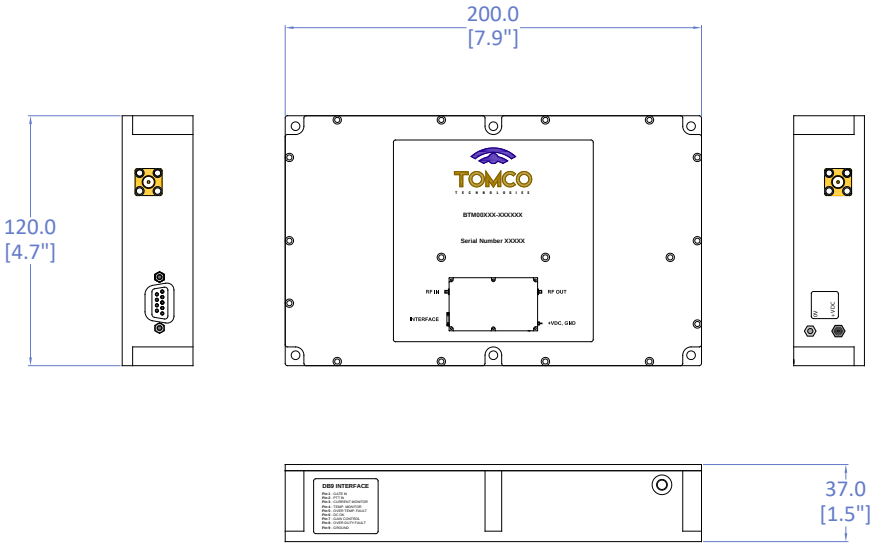


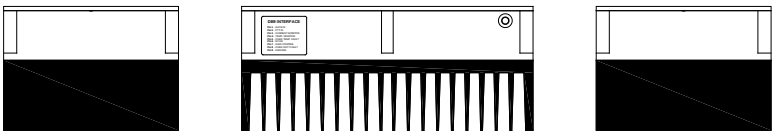
Small signal gain measured at 10% of maximum rated input power



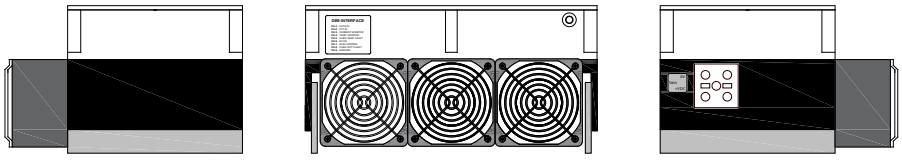
Mechanical Specifications

Connectors	RF IN: SMA RF OUT: SMA INTERFACE: DB9 female
Dimensions	Module only: 200mm (7.9”) x 120mm (4.7”) x 37mm (1.5”) Module with heatsink: 200mm (7.9”) x 120mm (4.7”) x 85mm (3.3”) Module with heatsink and fan assembly: 200mm (7.9”) x 168mm (6.6”) x 85mm (3.3”)
Weight	approx. 1.3kg (2.8lbs), module only
Enclosure classification	IP20





With optional heatsink



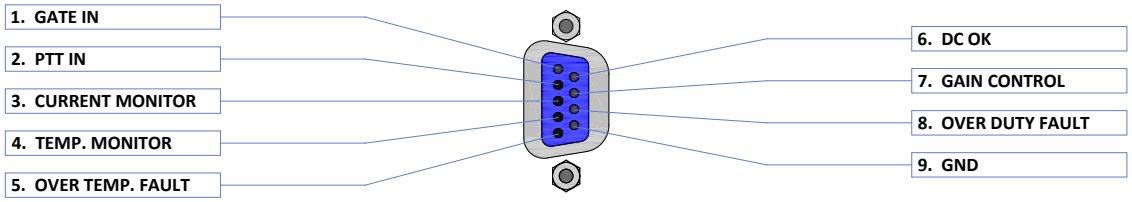
With optional heatsink and fan assembly

Protection

Over temperature	Self-resetting shutdown protection activates if thermal limits are exceeded
Reverse polarity	Reverse-current protection circuitry
Input/output transients	High voltage transient protection circuitry

Monitoring and Control

Parallel Interface	9-pin D-connector female



Environmental

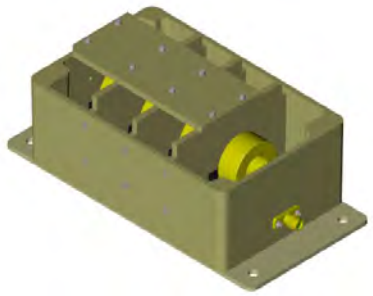
General	Intended for use only in controlled, indoor environment. Non-consumer product for industrial and scientific use
Cooling	Requires heatsink and/or external fan (optional extras)
Operating temperature	+5^{0}C to +40^{0}C
Storage temperature	-20^{0}C to +60^{0}C
Humidity	80% for temperature up to 31^{0}C, decreasing linearly to 50% relative humidity at 40^{0}C
Operating altitude	Up to 2000m
Pollution degree	2
Electromagnetic compatibility	In line with IEC61326-1:2012 ISM sub-assembly, Group 1, Class A
Safety	In line with IEC61010-1:2010
Electromagnetic field strength	In line with ICNIRP Guidelines: 1998, occupational limits

Tomco Technologies
38 Payneham Rd, Stepney, Australia 5069
Tel: +61 8 8362 2902, Fax: +61 8 8362 2912

www.tomcorf.com
sales@tomcorf.com
support@tomcorf.com

Appendix 4 : specifications of the low-pass filter (LPF) module

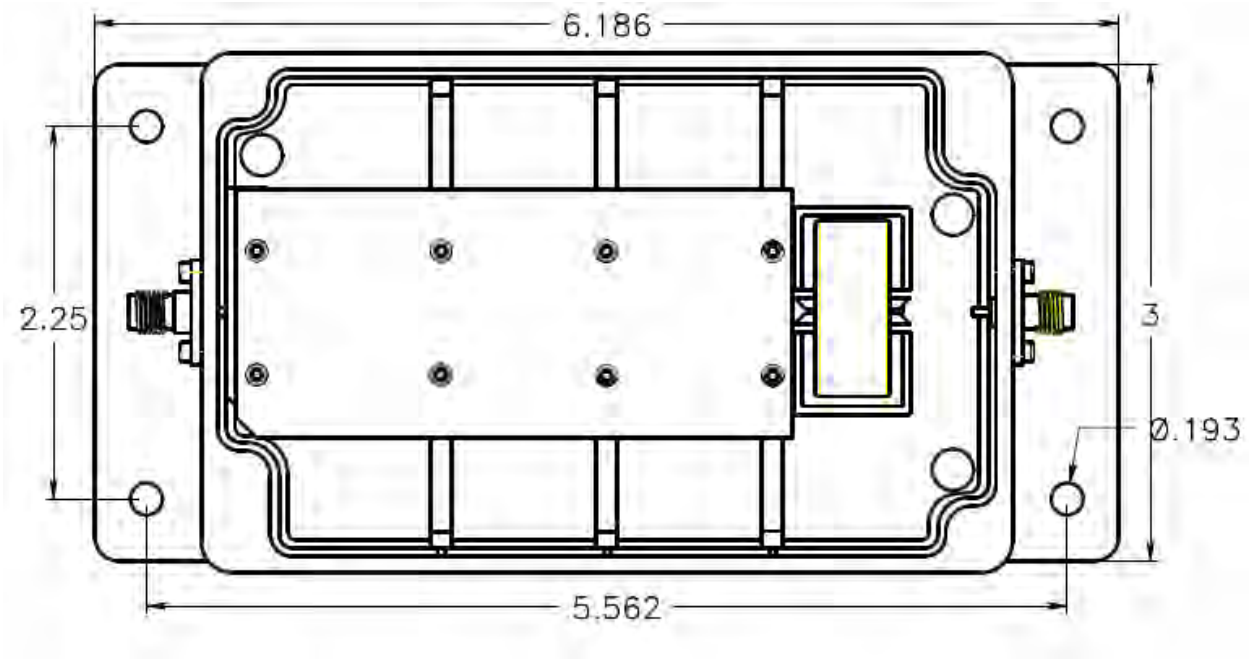
March 29, 2022



BASIC COMMON SPECIFICATIONS:

- Maximally Flat (Butterworth) 9th Order Response
- Return Loss 20 dB min over Passband
- Power Rating: 100W max Continuous
- Connectors: SMA, Gold Plated
- Mounting Bracket
- Impedance 50 Ohms
- Cast Aluminum NEMA 4 Rated Enclosure & Gasketed Cover
- Alodine Conversion Coat
- Coils Sealed with Q-Dope
- 18-8 Stainless Assembly Hardware
- Weight: 1.6 lbs

Part No	Insertion Loss dB	F-3dB (MHz)	F-60dB(MHZ)	F-100dB ()MHz)
FL5MLP-HFDR	0.25	6.4	13.8	23
FL9MLP-HFDR	0.29	11.25	24.25	40.6
FL13MLP-HFDR	0.3	16.25	35	58.7
FL16MLP-HFDR	0.3	19.7	42.5	71.3
FL25MLP-HFDR	0.3	30.5	65.7	110
FL26MLP-HFDR	0.53	31.7	67.8	114.5



Installation Drawing (Inches)

DLW ASSOCIATES
6 Woodford place
St. Charles, MO 63301 USA
PH: 314-537-6579
FX: 314-649-8989

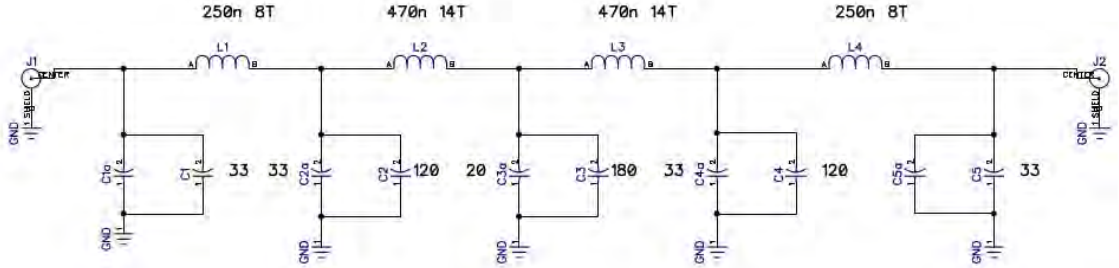
Notes:

Inductors wound on T106-0 toroidal cores

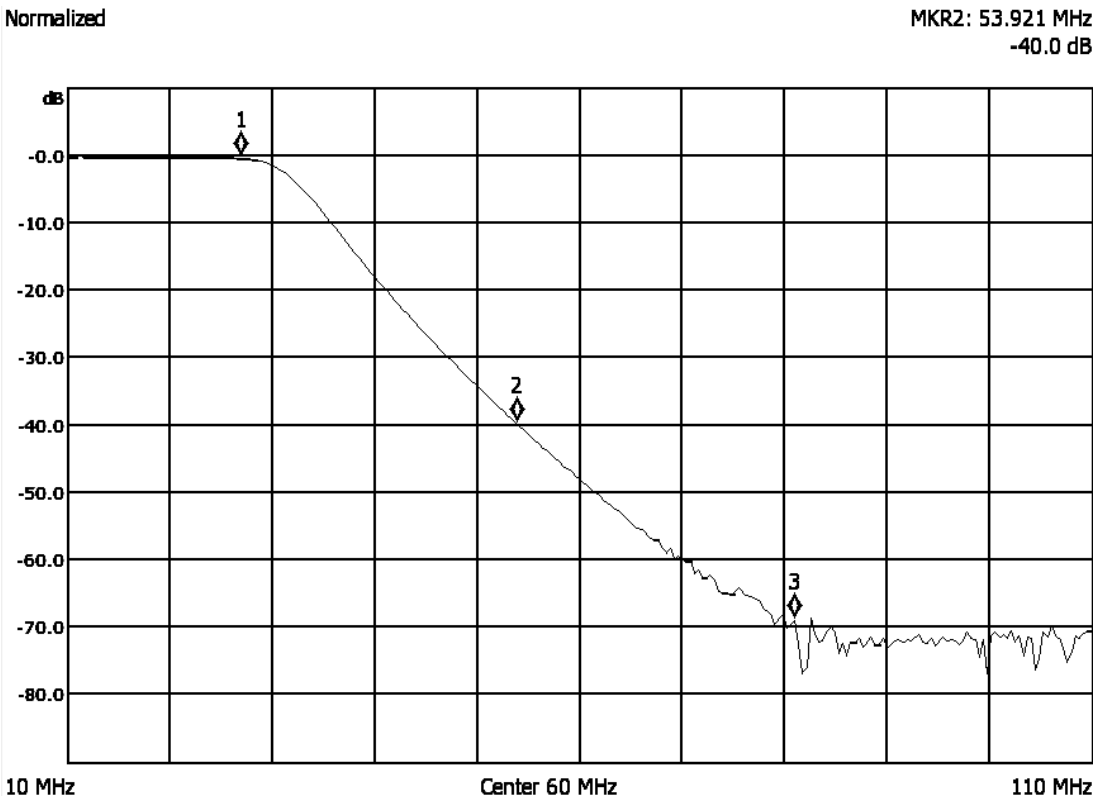
#18AWG magnet wire

Connectors are gold plated two hole flange mount sma with extended dialectric and solder post

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



DLW ASSOCIATES 6 WOODFORD PLACE ST. CHARLES MO 63301 PH 314-537-6579 FAX 314-649-8989	SCHEMATIC DIAGRAM		
	FILTER, LOW PASS 26 MHZ, BUTTERWORTH -3dB = 31.8 MHz		
	SIZE A	FSCM NO.	DWG NO. DSFL26MLP-HFDR	REVB
	SCALE none		Sheet 1	



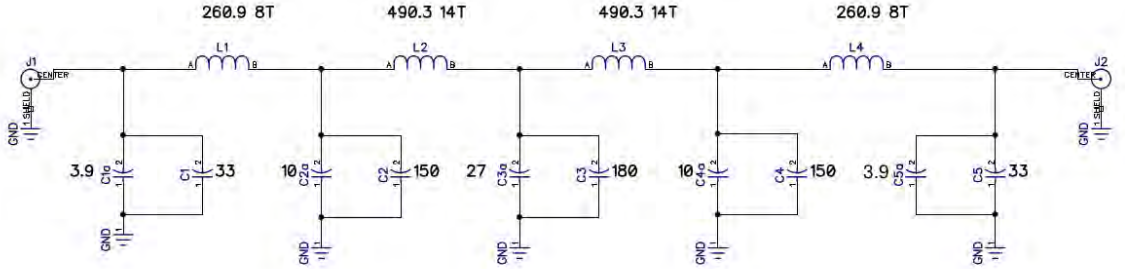
Notes:

Inductors wound on T106-0 toroidal cores

#18AWG magnet wire

Connectors are gold plated two hole flange mount sma with extended dialectric and solder post

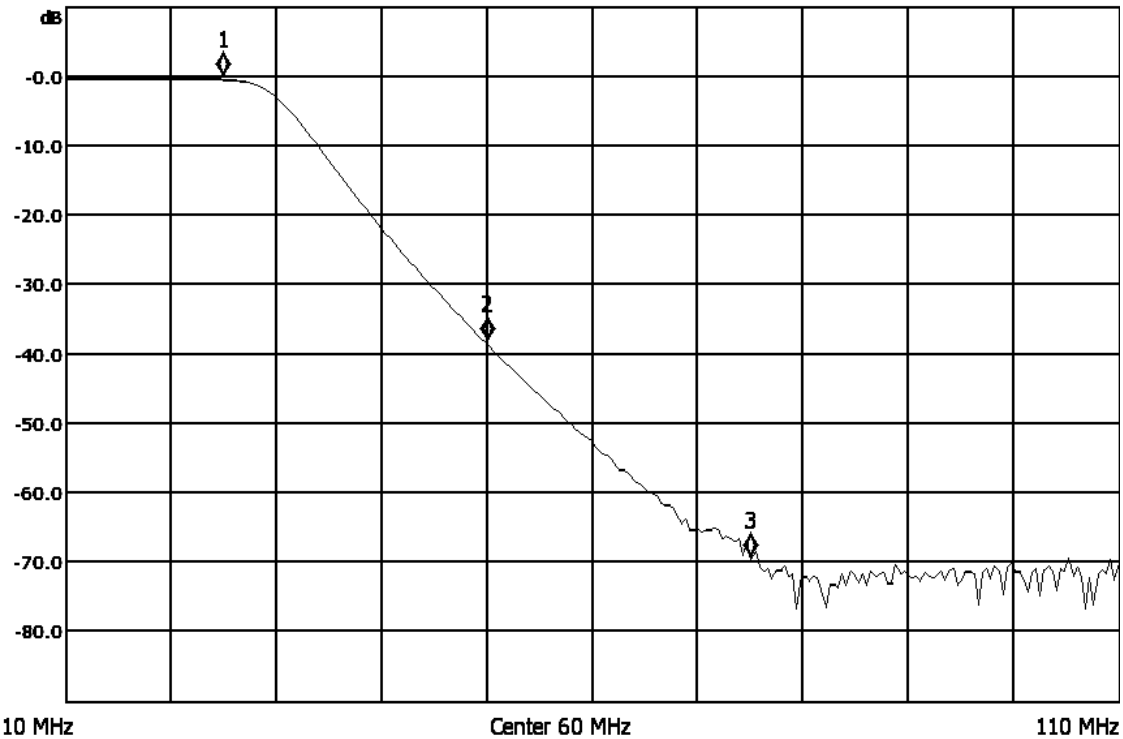
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



DLW ASSOCIATES 6 WOODFORD PLACE ST. CHARLES MO 63301 PH 314-537-6579 FAX 314-649-8989	SCHEMATIC DIAGRAM		
	FILTER, LOW PASS 25 MHZ, BUTTERWORTH -3dB = 30.5 MHz		
	SIZE A	FSCM NO.	DWG NO. DSFL25MLP-HFDR	REVB
	SCALE none		Sheet 1	

Normalized

MKR2: 50 MHz
-38.6 dB



10 MHz

Center 60 MHz

110 MHz

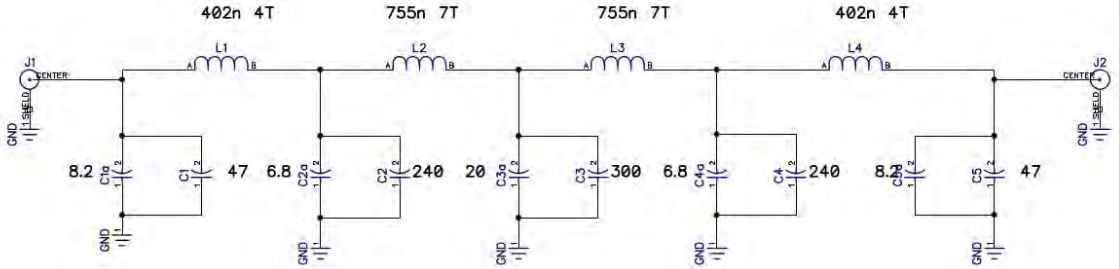
Notes:

Inductors wound on T106-6 toroidal cores

#18AWG magnet wire

Connectors are gold plated two hole flange mount sma with extended dialectric and solder post

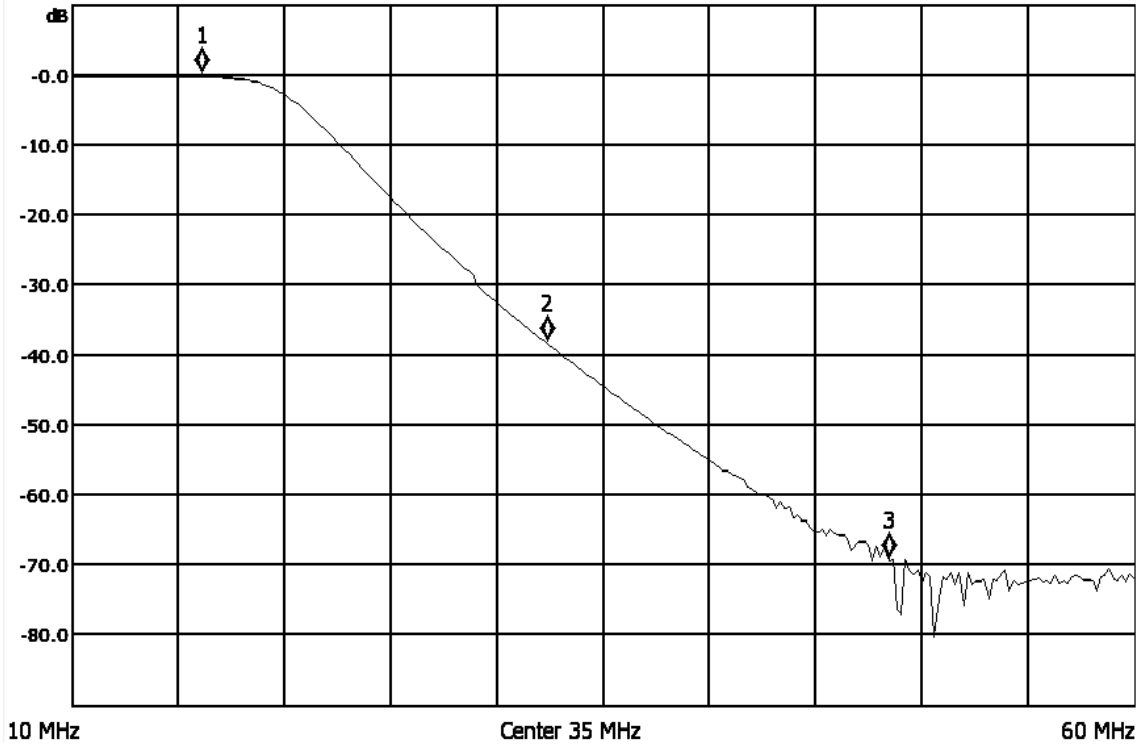
REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



DLW ASSOCIATES 6 WOODFORD PLACE ST. CHARLES MO 63301 PH 314-537-6579 FAX 314-649-8989	SCHEMATIC DIAGRAM		
	FILTER, LOW PASS 16 MHZ, BUTTERWORTH -3dB = 19.8 MHz		
	SIZE A	FSCM NO.	DWG NO. DSFL16LPUH / REV C
	SCALE none		Sheet 1

UnNormalized

MKR2: 32.352 MHz
-38.3 dB



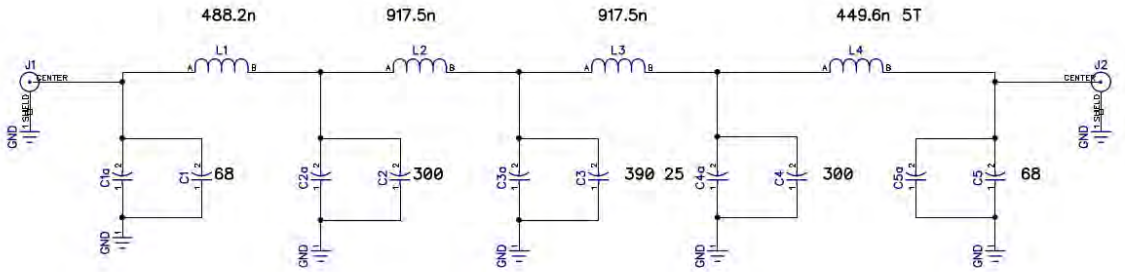
Notes:

Inductors wound on T106-6 toroidal cores

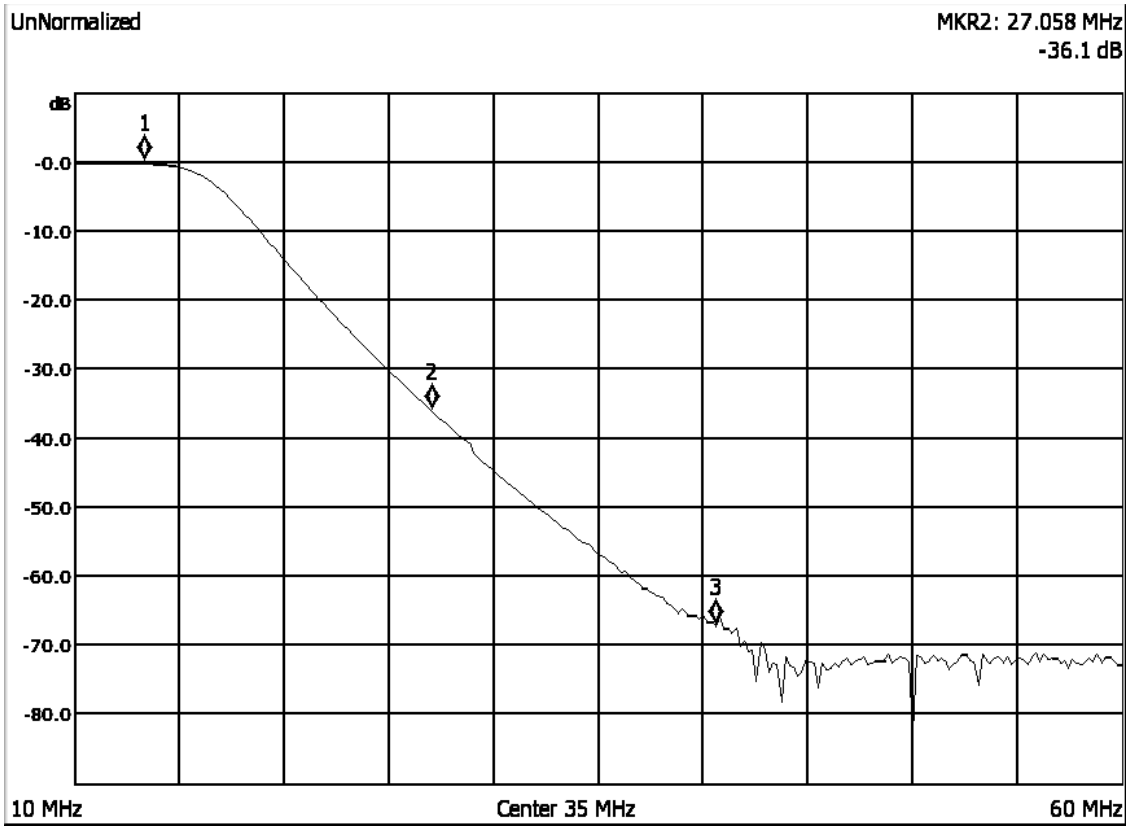
#18AWG magnet wire

Connectors are gold plated two hole flange mount sma with extended dialectric and solder post

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



DLW ASSOCIATES 6 WOODFORD PLACE ST. CHARLES MO 63301 PH 314-537-6579 FAX 314-649-8989	SCHEMATIC DIAGRAM		
	FILTER, LOW PASS 13 MHZ, BUTTERWORTH -3dB = 16.3 MHz		
	SIZE A	FSCM NO.	DWG NO. DSFL13MLP-HFDR / REV
	SCALE none		Sheet 1



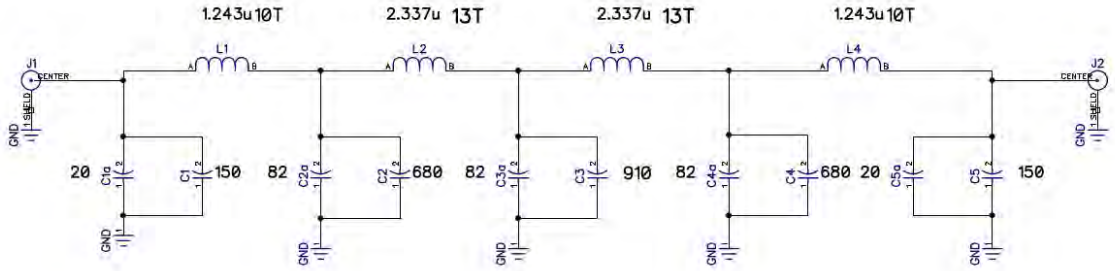
Notes:

Inductors wound on T106-2 toroidal cores

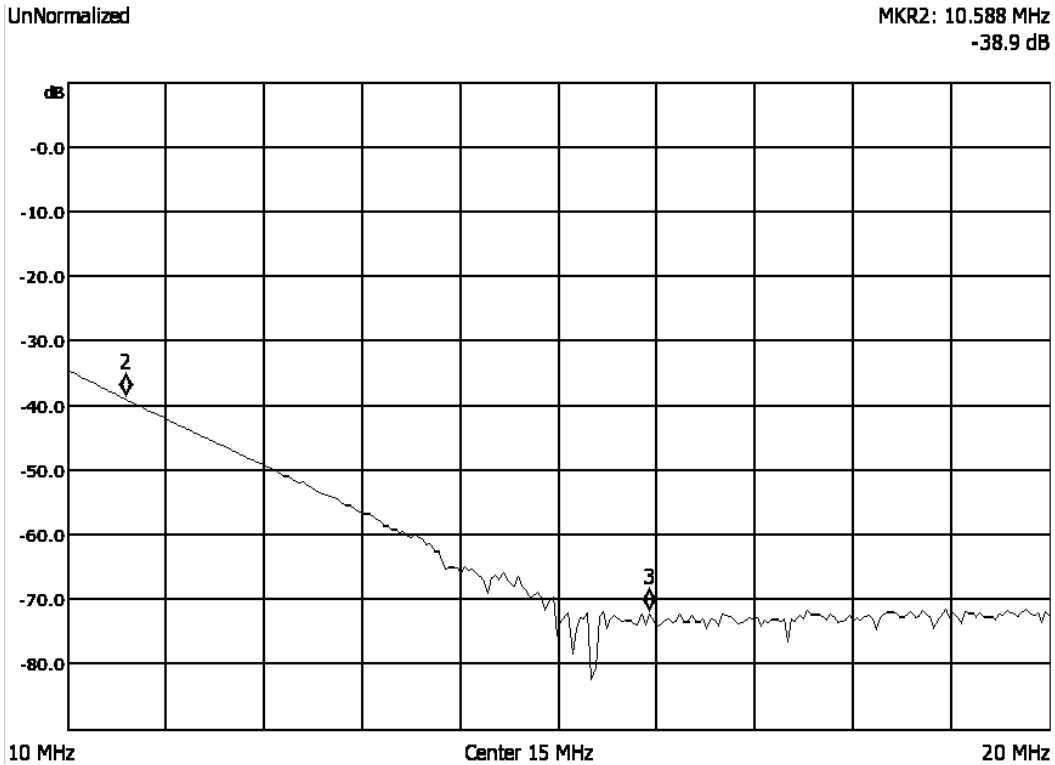
#18AWG magnet wire

Connectors are gold plated two hole flange mount sma with extended dialectric and solder post

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



DLW ASSOCIATES 6 WOODFORD PLACE ST. CHARLES MO 63301 PH 314-537-6579 FAX 314-649-8989	SCHEMATIC DIAGRAM		
	FILTER, LOW PASS 5 MHZ, BUTTERWORTH -3dB = 6.4 MHz		
	SIZE A	FSCM NO.	DWG NO. DSFL5MLP-HFDR / REV C
	SCALE none		Sheet 1



Appendix 5 : specifications of the power supply (PS) module

Industrial Power Supplies

TSP-Series

Innovative and Powerful Features!

- Rugged metal case for harsh industrial environments
- Shock and vibration proof
- Worlwide Safety approval package.
- ATEX certification tested in accordance to IECEX (opt. EX)
- Model TSP 090-124N meets NEC class 2
- Industrial operating temperature range: –25°C to +70°C
- Adjustable output voltage
- Protection against short-circuit, overvoltage and over-temperature
- Power OK signal, Remote On/Off
- Wall mounting (opt.)
- 3-year product warranty

EMC LVD | IEC 60950-1 | UL 60950-1 UL 508 UL 60079-15 | ATEX II3G

The TSP series comprises high performance DIN-rail mount power supplies designed for reliable operation under difficult factory floor conditions. High immunity against electrical disturbances and rugged metal casing make these modules the best choice to power sensitive loads in industrial process control systems, machine tools or other demanding industrial applications. They provide a DC-OK signal and external shut down function. Detachable screw terminal blocks make the connection easy.

This power supply line is accompanied by a wide range of function modules for reliable system solutions:

Redundancy modules for true current sharing in parallel operation and for redundant systems.
Battery controller modules to configure high reliable UPS systems for 12, 24 and 48 VDC. Selection of battery packs available.
Buffer modules for protection against short time AC power loss. Maintenance free! No batteries required.

Function Modules (see page 5)

Models

Order Code	Output Power (Pmax)	**Output Voltage (Vnom)	***Output Current (Imax)
TSP 070–112*	72 W	12 VDC	6.0 A
TSP 090–124*	90 W	24 VDC	3.75 A
TSP 090–124N	90 W	24 VDC	3.75 A
TSP 090–148*	96 W	48 VDC	2.0 A
TSP 140–112*	144 W	12 VDC	12.0 A
TSP 180–124*	180 W	24 VDC	7.5 A
TSP 180–148*	192 W	48 VDC	4.0 A
TSP 360–124*	360 W	24 VDC	15.0 A
TSP 360–148*		48 VDC	7.5 A
TSP 600–124*	600 W	24 VDC	25.0 A
TSP 600–136		36 VDC	16.5 A
TSP 600–148*		48 VDC	12.5 A

* For ATEX compliant models add appendix -EX to order code.
** Output voltage adjustable 12–14 VDC, 24–28 VDC and 48–56VDC
*** Max. current at nominal output voltage and operating temperature up to +40°C max.

Input Specifications

Input voltage range		TSP 070/090	85 – 264 VAC universal input
		other models:	85 – 132 / 187 – 264 VAC autoselect
		output current derating at operation below 100 VAC	see graph B, page 4
Input voltage frequency			47 – 63 Hz
Harmonic limits			EN 61000-3-2, Class A (for limited output power)
Holdup time		230 VAC	20 ms
		115 VAC	10 ms at full load, 20 ms at 66% load
Inrush current			115 VAC / 230 VAC
		TSP 070/090	< 12 A / < 20 A
		TSP 140/180	< 13 A / < 25 A
		TSP 360	< 16 A / < 25 A
		TSP 600	< 25 A / < 30 A
Recommended circuit breaker, characteristic B		TSP 070/090/140/180	6.0 – 16.0 A
		TSP 360	10.0 – 16.0 A
		TSP 600	16.0 – 25.0 A
Efficiency			87 % typ.

Output Specifications

Output voltage adj. range		12 VDC models:	12 – 14 VDC
		24 VDC models:	24 – 28 VDC
		36 VDC model:	36 – 42 VDC
		48 VDC models:	48 – 56 VDC
			At output voltage higher than nominal output voltage max. output current has to be reduced accordingly, in order not to exceed max. output power.
Regulation	– Input variation		0.5 % max.
	– Load variation (10–100 %)		0.5 % max.
Ripple and Noise (20MHz bandwidth)			100 mV pk-pk typ. (200 mV pk-pk max. at Imax)
Electronic short circuit protection			current limitation at Imax. constant current, automatic recovery
Output overvoltage protection		12 VDC models:	20 V
		24 VDC models:	35 V
		36 VDC model:	43 V
		48 VDC models:	60 V
Overload protection			electronic overload protection
Overtemperature protection			switch off at overtemperature, automatic restart
Power back immunity		12 VDC models:	16 V
		24 VDC models:	35 V
		36 VDC model:	48 V
		48 VDC models:	63 V
Status indicator			dual color LED (green: DC ok, red: DC off)
Power OK signal	– trigger threshold:	12 VDC models:	9 – 11 V
		24 VDC models:	18 – 22 V
		36 VDC model:	27 – 34 V
		48 VDC models:	36 – 46 V
	– active output signal: (reference to –Vout)	12 VDC models:	11.0 V ±1.0 V (20 mA max. for TSP 070, 40 mA max. for TSP 140)
		24 VDC models:	22.0 V ±2.0V / 20 mA max. (10 mA max. for TSP 090, 20mA max. for others)
		36 VDC model:	34.0 V ±2.0 V / 20 mA max.
		48 VDC models:	44.0 V ±4.0 V / 15 mA max.
	– relay output		DC OK = contact closed rated: 30 VDC/1.0 A for 12/24 VDC models rated: 30 VDC/2.0 A for 36 VDC model rated: 48 VDC/0.5 A for 48 VDC models

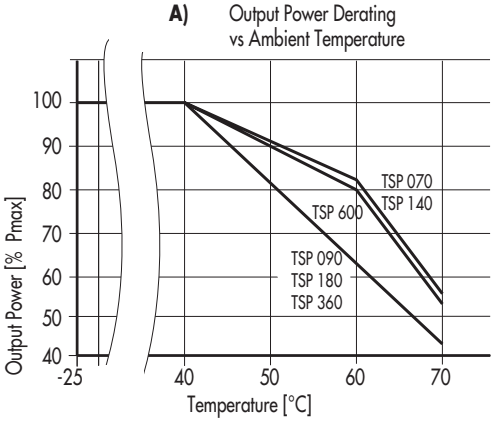
General Specifications

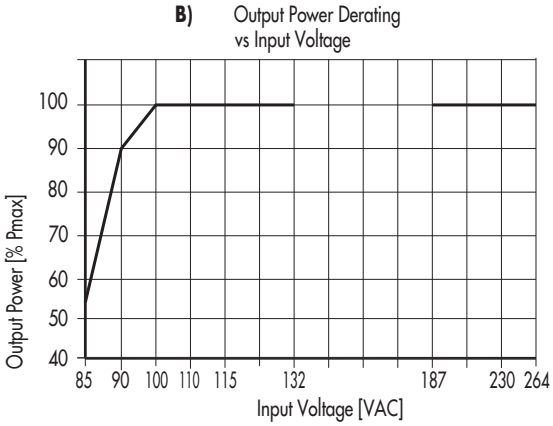
Max. capacitive load		unlimited
Temperature range	– Operating	–25°C to +60°C max. (with derating) (for derating see graph A on page 4)
	– Storage	–25°C to +85°C
Cooling		convection cooling, no internal fan
Humidity (non condensing)		95 % rel. H max.
Pollution degree		2
Altitude during operation		2'000 m max.
Temperature coefficient		0.02 %/K
Reliability, calculated MTBF (at +25°C acc. to IEC 61709)	– TSP 070/090	>1.8 Mio h
	– TSP 140	>1.2 Mio h
	– TSP 180/360/600	>0.9 Mio h
Remote On/Off		by ext. contact. DC on: -S contact open DC off: -S connectetd via 1Kohm to -Vout
Isolation (60 s)	– Input to output	3'000 VAC
	– Input to PE	1'500 VAC
	– Output to PE	500 VAC
Safety standards	– Information technology equipment	IEC/EN 60950-1, UL 60950-1, CSA-C22.2 No. 60950-1-03
	– Measurement, Control & Laboratory	IEC/EN 61010-1, IEC/EN 61010-2-201
	– Industrial control equipment	UL 508, CSA-C22.2 No. 107
	– Electrical equipment for machines	EN 60204
	– Electronic equipment for power installation	EN 50178
	– Safety transformers for SMPS	EN 61558-2-16
	– Limited power source **(model TSP 090-124N)**	EN 60950 sect. 2.5 and NEC Class 2
	– Control equipment for hazardous location	UL 60079-15 (Class I, Division 2, Groups A,B,C,D AEx n C II C T4 U) IEC/EN 60079-15 (Class I, Zone 2, EEx nC II C T4 U), (Ex) II3G EEX nAC IIC T4 (T3 with limited power)
Safety approvals and certifications	– CB report	for IEC/EN 60950-1, IEC/EN 61010-1 & 61010-2-201
	– UL approvals	UL 60950-1 rec. File: e181381, UL 508 listed File: e210002
	– CSA certification	(file no. 219759) for UL 60950-1, UL 508, UL 60079-15-02, ANSI/ISA 12.12.01, CSA-22.2 No. 60950-1-03, CSA C22.2 No. 107, CSA 60079-15-02
	– (Ex) II3G ATEX 94/9/EC	certificate no. EPS 12 ATEX 1 424 X (option -EX only)
	– BG certification	EN 60950-1, EN 60204-1, EN 61558-2-16, EN 50178
	– Certification documents	www.tracopower.com/overview/tsp
Class of protection		safety class I (IEC 536)
Degree of protection		IP 20 (IEC/EN 60529)
Electromagnetic compatibility (EMC), Emissions		EN 61000-6-3, EN 61204-3
	– Conducted RI suppression on input	EN 55011 class B, EN 55022 class B,
	– Radiated RI suppression	EN 55011 class B, EN 55022 class B,
Electromagnetic compatibility (EMC), Immunity		EN 61000-6-2, EN 61204-3
	– Electrostatic discharge (ESD)	IEC / EN 61000-4-2 4 kV / 8 kV criteria B
	– Radiated RF field immunity	
	TSP 070/140/360 models:	IEC / EN 61000-4-3 10 V / m criteria A
	TSP 090/180/600 models:	IEC / EN 61000-4-3 10 V / m criteria B
	– Electrical fast transient / burst immunity	IEC / EN 61000-4-4 2 kV criteria B
	– Surge immunity	IEC / EN 61000-4-5 1 kV / 2 kV criteria B
	– Immunity to conducted RF disturbances	IEC / EN 61000-4-6 10 V criteria A
	– Power frequency field immunity	IEC / EN 61000-4-8 30 A / m criteria A
	– Mains voltage dips and interruptions	IEC / EN 61000-4-11 criteria B/C
	– Voltage sag immunity	SEMI F47
		www.tracopower.com/overview/tsp

General Specifications

Environment	– Vibration acc. IEC 60068-2-6; – Shock acc. IEC 60068-2-27	3 axis, sine sweep, 10 – 55 Hz, 1 g, 1 oct/min 3 axis, 15 g half sine, 11 ms
Enclosure material		aluminium (chassis) / stainless steel (cover)
Mounting	– DIN-rail mounting – Wall mounting (option)	for DIN-rails as per EN 50022-35x15/7.5 (snap-on with self-locking spring) with wall mounting bracket - see page 9
Connection		detachable screw terminals (plugs included) 2 terminals per output
Remote On/Off connection	– 2 pin molex male terminal KK series	mating connector information (cable not included) www.tracopower.com/products/tsp-jc.pdf
Installation instructions		www.tracopower.com/overview/tsp

Output Power Derating





All specifications valid at nominal input voltage, full load and +25°C after warm-up time unless otherwise stated.

Function Modules Overview

Redundancy Module:

With this module and two power supplies of the TSP series a highly reliable, true redundant power system can be configured without any additional components. This module provides:

– Operation with true current sharing
– Alarm outputs and redundancy OK signal
– Hot swappable inputs can be loaded up to 15A each (resp. 25A with model TSP REM600)

TSP-REM360
TSP-REM600

Models

Order Code	Output Voltage adj.	Output Power
TSP–REM360	24 VDC (24 – 27 VDC)	360 W
TSP–REM600		600 W

TSP-REM datasheet: www.tracopower.com/products/tsp-rem.pdf

Battery Controller Modules + Batteries:

This module provides a professional battery controller to charge and monitor an external lead-acid battery. Together with a power supply of the TSP series and a battery pack a perfect DC-UPS system can be configured. This module provides:

- Battery protection for over voltage, deep discharge, short circuit and reverse connection
- Remote On/Off for battery and power supply
- Alarm outputs for input, output and battery condition
- Controlled end of charge voltage by temperature sensor
- Redundant inputs for two indepedant sources **(TSP-BCMU360 only)**

TSP-BCM12
TSP-BCM24
TSP-BCM48

TSP-BCM24A
TSP-BCM48A

TSP-BCMU360

Models

Order Code	Output Voltage	Output Power
TSP-BCM12	12 VDC	180 W
TSP–BCM24	24 VDC	360 W
TSP-BCM24A		600 W
TSP–BCM48	48 VDC	360 W
TSP-BCM48A		600 W
TSP-BCMU360	24/48 VDC	360 W

TSP-BCM datasheet: www.tracopower.com/products/tsp-bcm.pdf
TSP-BCMU datasheet: www.tracopower.com/products/tsp-bcmu.pdf

Buffer Module:

This module will maintain the output voltage of a 24VDC power supply during typical mains faults, short time blackouts or voltage dips of up to ten full 50Hz cycles. During this buffer period no deterioration of the 24VDC output voltage will occur. This module provides:

- Capacitor bank for energy storage, no battery needed!
- Maintenance free, long lifetime, high performance also at low temperature.
- Guaranteed Hold-up-time 200ms/25A to 4s/1.2A max.
- Output 24 to 28VDC, 600W max.
- Active ready and inhibit signals

TSP-BFM24

Models

Order Code	Output Voltage	Output Power
TSP–BFM24	24 – 28VDC	600 W

TSP-BFM datasheet: www.tracopower.com/products/tsp-bfm.pdf