



Pole/Zero 2019 Applications & New Product Overview



BSC | DOW-KEY MICROWAVE | K&L MICROWAVE | POLE/ZERO



Corporate Overview

- ▶ **Growing since 1989 in West Chester, OH (near Cincinnati, Ohio)**
- ▶ **Acquired 2007 by Dover Corp. (NYSE: DOV).**
 - ◆ Pole/Zero is one of 4 companies in the Dover Corp. Microwave Products Group (MPG) division: **BSC Filters, Dow-Key Microwave, K&L Microwave**
- ▶ **Full capabilities**
 - ◆ **World leader** in solutions for cosite interference reduction
 - ◆ ISO-9001/AS9100 certified
 - ◆ Complete engineering & test facilities
 - ◆ 190 Employees



Pole/Zero – Cosite Mitigation at All Levels

Tunable Filters



Integrated Cosite Equipment (ICE)

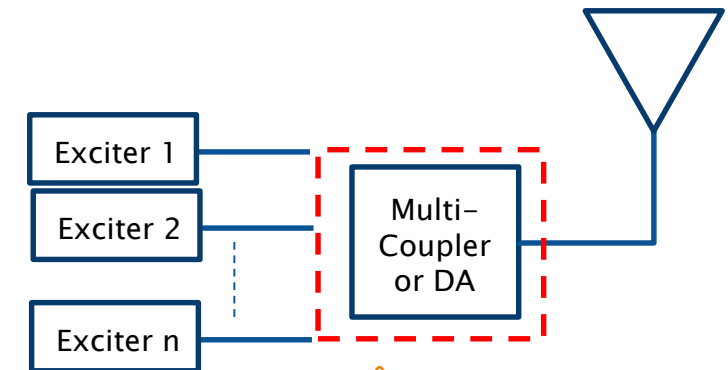
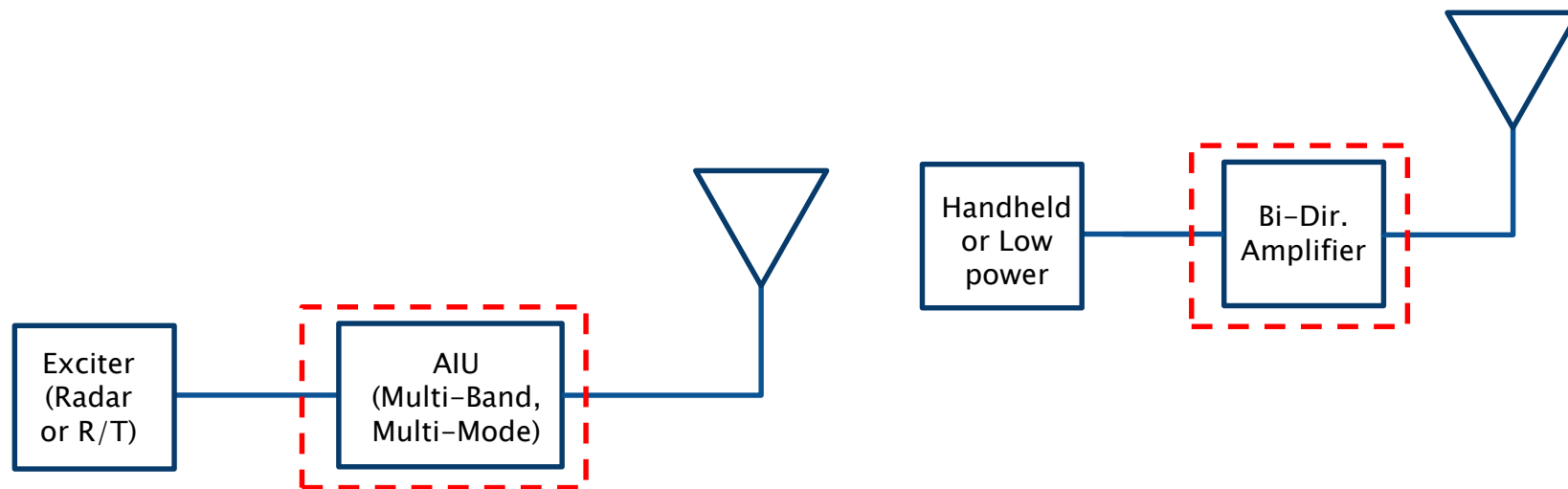
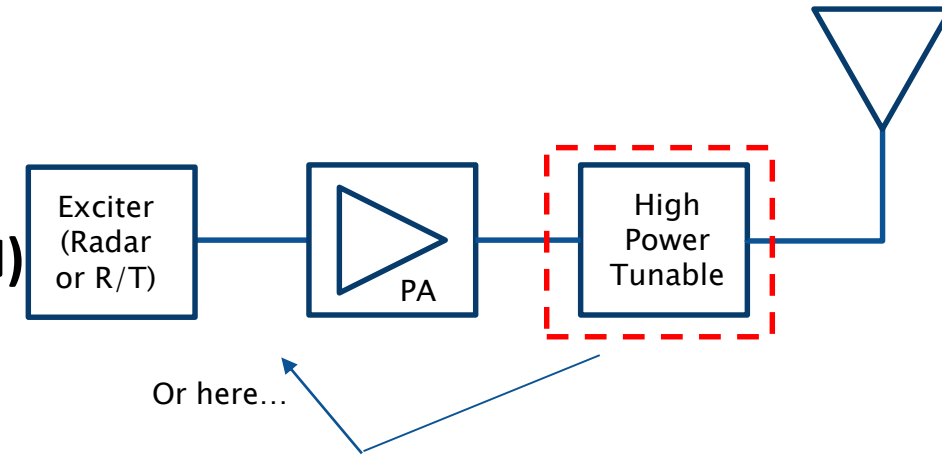


Cosite Analysis & System Integration



Not just RF filters!

- Pre/Post-selectors
- Antenna Interface Units, Bi-Directional Amplifiers
- Fast hopping waveforms (SINGARS, HAVEQUICK, SATURN)
- Cancelers
- High Intercept LNAs, Power Amplifiers
- Multi-Couplers and Distribution Amplifiers



Applications

- ▶ **Tunable Filters (TF) and Integrated Cosite Equipment (ICE) are installed in military communication systems around the world:**
 - ♦ *Software Defined Radios (SDR)*
 - ♦ *Vehicle Amplifier Adapters (VAA)*
 - ♦ *RADAR and Electronic Warfare (EW) systems*
 - ♦ *Command and Control platforms (Ground, Naval, Airborne)*



Custom Filter Designs – Guided by Design Trade-Offs

Our Engineering Team can Pull Multiple Design Levers to Achieve an Almost Endless Variety of Filter Performance:

- Bandwidth % (3dB)
- Tuning Range
- Tuning Speed
- Input Power
- Selectivity
- Size
- Insertion Loss



NEW PRODUCT: MINI-ERF-S11[®]

The MN-90-520-X-S11 tunable filter was designed to have the best power handling and Q in the smallest package possible.



Parameter	HF-ERF
Tuning Range	90 MHz to 520 MHz
Insertion Loss:	3.2 dB typical: 7% BW (3dB) 5.5 dB typical: 4% BW (3dB)
Inband RF Power Handling (input):	2 Watts: 7% BW (3dB) 1 Watt: 4% BW (3dB)
Inband IIP3 (input)	+40 dBm typical
Tuning Control:	Parallel or Serial (SPI)
Tuning Speed:	12 μ sec typical @ 0 dBm input
DC Power Consumption (Static):	+3.3 VDC @ 75 mA typical +100 VDC @ 1.2 mA typical
Dimensions:	2.0 x 2.0 x 0.293 in. 50.8 x 50.8 x 7.4 mm
Mounting	SMT castellation

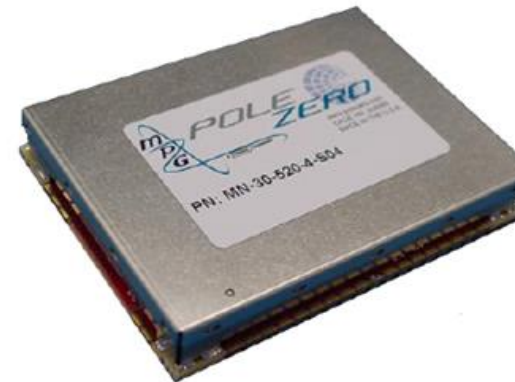
30–520 MHz Tunable Filter in SDRs & VVAs

❖ 30-520 MHz Tunable Filter in Software Defined Radio and Vehicular Amplifier Adapter Applications

- ◆ Out of band rejection provides necessary filtering of undesired signals.
- ◆ Ruggedized, Surface Mount Filters are well suited for demanding environmental applications.

❖ Bottom line:

- ◆ Increased Quality & Range of Communications in Tactical Mobile Networks



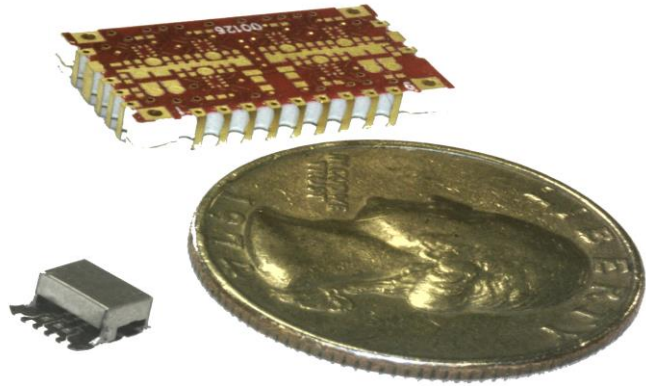
HF-ERF[®] Tunable Filter

The HF-ERF tunable filter integrates the function of three HF MINI-POLE filters, along with all control and RF path switching, into one compact and cost-effective SMT unit.



Parameter	HF-ERF
Tuning Range (one pkg.)	1.5 MHz to 30 MHz
IL-BW metric	20
Inband RF Power Handling (input):	+17 dBm (1.5 to 4 MHz) +25 dBm (4 to 10 MHz) +27 dBm (10 to 30 MHz)
Inband IIP3 (input)	+27 to +37 dBm
Tuning Control:	Parallel or Serial (SPI)
Tuning Speed:	200 µsec max., +10 dBm input
DC Power:	+5 VDC - 400 mA, max +100 VDC – 3 mA, max.
Dimensions:	2.75 x 2.0 x 0.60 in. 70 x 51 x 15 mm
Mounting	SMT – Solder ball pin

Pole/Zero Tunable Filters Roadmap



2018-2019

- Release Microwave, 3-Pole, VTF with tuning speeds < 200 ns
- Release +30 dBm, 20 mm x 12 mm Gen 2 Nano
- Development of RFIC design capability within Pole/Zero
- 3rd party custom tuning element partnership
- 30 to 200 MHz Size/Performance Improvement SMIRAD
- Begin RFIC designs in Cadence and AWR

2019-2020

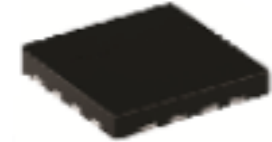
- Develop Foundry relationships
- Begin RFIC prototyping with industry partner(s)
- Implement Wafer level test station
- Develop > 3 GHz, Simultaneous Automated Test Set-up

2020+

- Digitally-tuned, +30 dBm Integrated Microwave filter line
- ASIC containing custom digital circuitry incorporated with RF switching

2020+ +30 dBm, Digital Tuning Control

High-Power – Digital Tuning Control	Target
Frequency Coverage	0.25 octave bands from 1 – 8 GHz 0.125 octave bands from 8 – 18 GHz
ILxBW	30
IL (Average)	3 dB
Selectivity	40 dBc @ $f_c \pm 10\%$
Inband Power Handling	+30 dBm
IIP3	+40 dBm
Tuning Control	< 3 dB bandwidth step size Options 1. SPI with internal decoding 2. SPI/Parallel inputs with ROM for customer decoding 3. SPI/Parallel inputs with no lookup
Tuning Speed	< 30 μ s
DC Power	+3.3 V < 100 mA
Interface characteristics	3.3 V LVCMOS
Operating Temperature	-40 to +85 °C
Size	7 x 7 x 4 mm



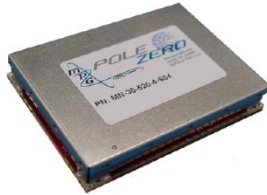
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P/Z is Innovating in New Areas

High Dynamic Range – Wide Bandwidth



Broadband Surface Mount



Wideband 30-512 MHz



High Power, Small Form Factor

Filter/Amplifiers



UAV Re-Transmission



Multi-Band, High Power, High Selectivity

Cancellation



Referenced Cancelling



Referenceless Cancelling

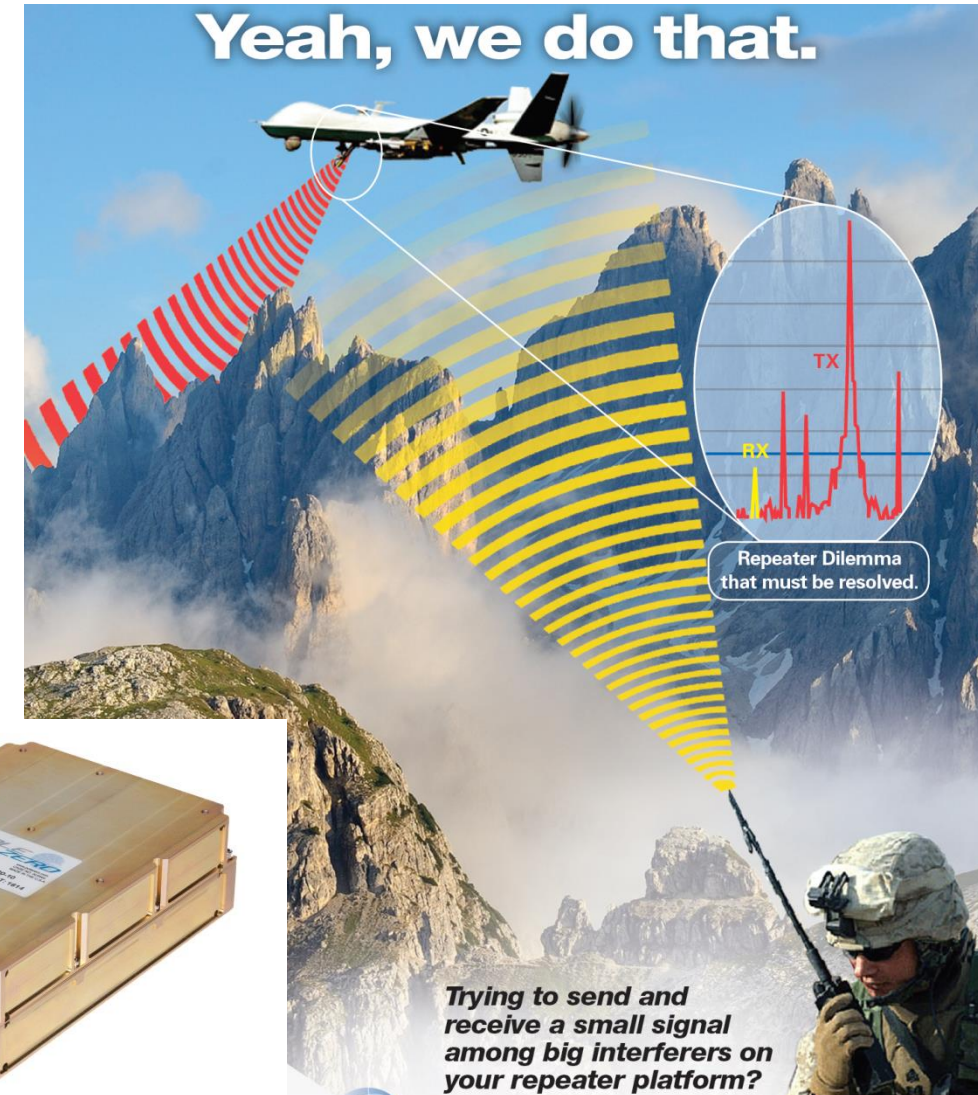
30-520 MHz Tunable Filter

❖ 5 Watt, 30-520 MHz Tunable Filter in UAV Comms Relay Payload (CRP) Application

- ◆ Provides necessary filtering of undesired signals.
- ◆ Ruggedized, high reliability Filters are well suited for demanding environmental applications.

❖ Bottom line:

- ◆ Increased range of Communications in Tactical UAV Mobile Network



High Power Tunable Filters

MEGA-POLE Filter

Input/Output Impedance:	50 Ω
In-band RF Power Handling:	50 W average 100 W peak
In-band Third Order Intercept:	> +60 dBm
Tuning Control:	Flexible control design for ARC-210 and VHF-4000. Standard options available.
Tuning Speed:	< 25 μ s typical Supports frequency hopping waveforms
DC Power:	+28 VDC, < 1A, MIL-STD-704
Center Frequency Stability:	Internally compensated
Shape Factor (30 dB / 3 dB):	3.3 to 3.75 typical
Operating Temperature Range:	-40°C to +55°C
Size:	6 x 7.55 x 3.6 (in.) / 152 x 190 x 91 (mm.)



High Power Hopping Filters

ICE3009 Filter/Amplifier

Part Number:	ICE3009-TR-30-400		
Operation:	Half duplex transmit and receive		
Frequency Coverage:	VHFL: 30 to 88 MHz		
	VHFH: 108 to 174 MHz		
	UHF: 225 to 400 MHz		
Receive Gain (Typical):	5.0 to 10.0 dB		
Receive Noise Figure (Typical):	9.0 dB		
Receive Input IP3:	+52 dBm @ 5 & 10% offset		
Transmit RF Output Power:	20 W (AM) to 100 W (FM) depending on frequency band configuration		
Selectivity (Typical):	-35 dB @ > $\pm 3.0\%$		
	-55 dB @ > $\pm 5.0\%$		
Broadband Noise:	-140 dBm/Hz @ > 5%		
Tuning Speed:	UHF: < 50 μ s		
	VHF: < 100 μ s		
Power:	+28 VDC	Tx:	386 W
		Rx:	125 W
		Bypass:	80 W
Operating Temperature Range:	-20°C to +55°C		
Size:	6 x 7 x 15.7 (in.) / 152 x 178 x 398 (mm.)		
Weight:	20 lbs. / 9.07 kg.		



ICE4003 Dual Channel Filter/Amp with Combiner

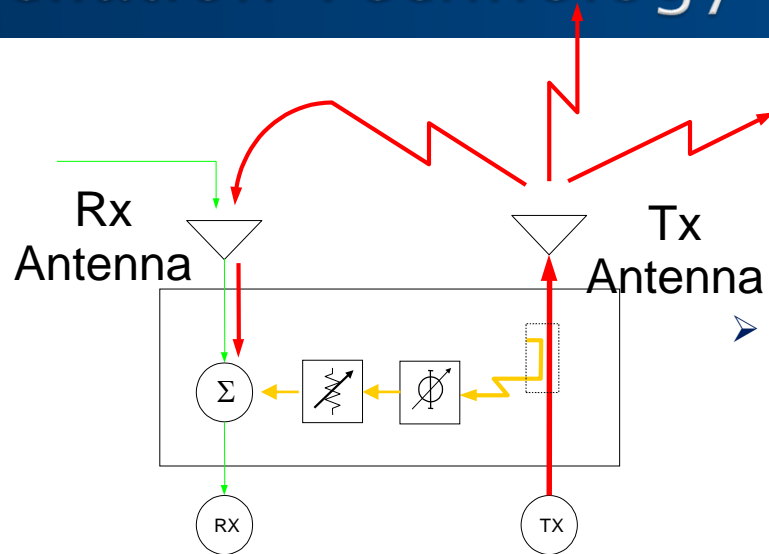
Part Number:	ICE4003-2TR-225-400
Operation:	Dual channel Tx & Rx filter/amplifier
Frequency Coverage:	225 to 400 MHz (2 channels)
Receive Gain (Typical):	1.0 to 5.0 dB
Receive Noise Figure (Typical):	10 dB*
Receive Input IP3:	+55 dBm @ 4 & 8 MHz offset
Transmit RF Output Power:	25 W per channel
Selectivity (Typical):	Transmit or Receive: -8 dBc @ ± 1.0 MHz -40 dBc @ ± 2.0 MHz -60 dBc @ ± 3.0 MHz
Tuning Speed:	200 μ S
Power:	115 VAC, 400 Hz @ 6.3 A
Operating Temperature Range:	0°C to +40°C
Size:	8.3 \times 11.3 \times 20 (in.) / 211 \times 287 \times 505 (mm.)
Weight:	71 lbs. / 32.2 kg.

* Performance varies around guard band (243 MHz).

Includes a UHF
combiner for
antenna
reduction



Cancellation Technology for Undesired Signals



➤ **Referenced:** Interferer signal couples to receiver and is conditioned for canceling

- **Referenceless:** Intelligently identifies interferer signals and cancels them
- Highly integrated complex design with extensive digital signal processing (DSP) and RF manipulation
- Ideal for SIGINT & COMINT applications, aboard ships and ISR aircraft, DF (direction finding) systems and other sensitive RF systems



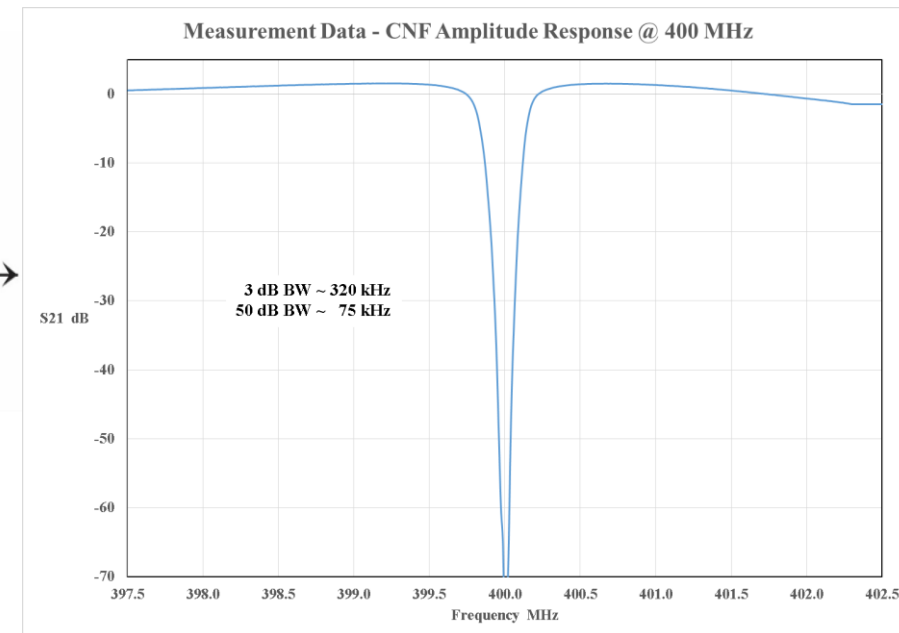
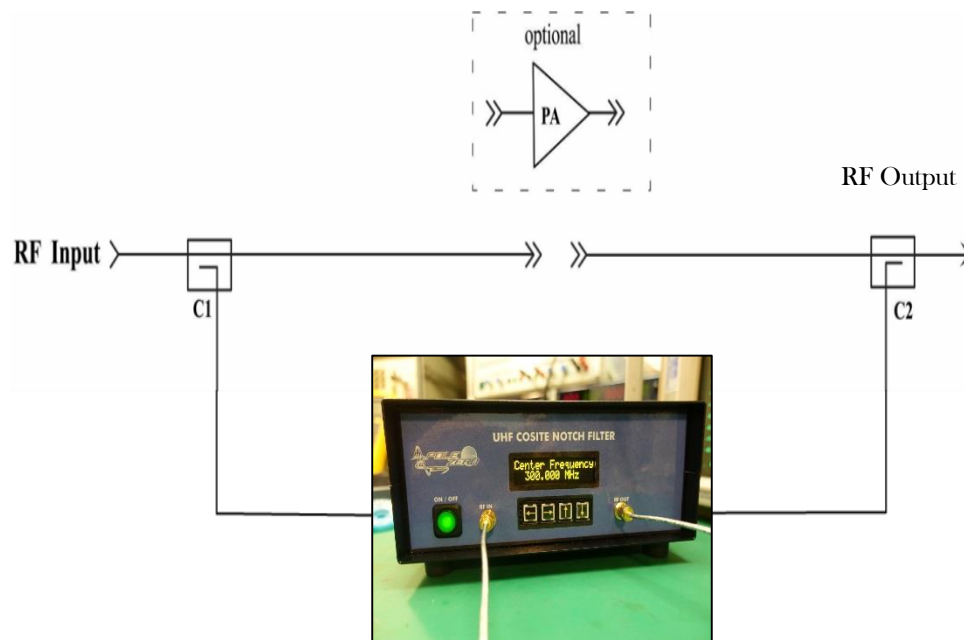
Cosite Notch Filter Ideal for High Power Applications

Functions:

- Cosite Notch Filter (CNF) inserts a low loss tunable notch into your high power devices!
- Ideal for solving interoperability issues between systems

Features:

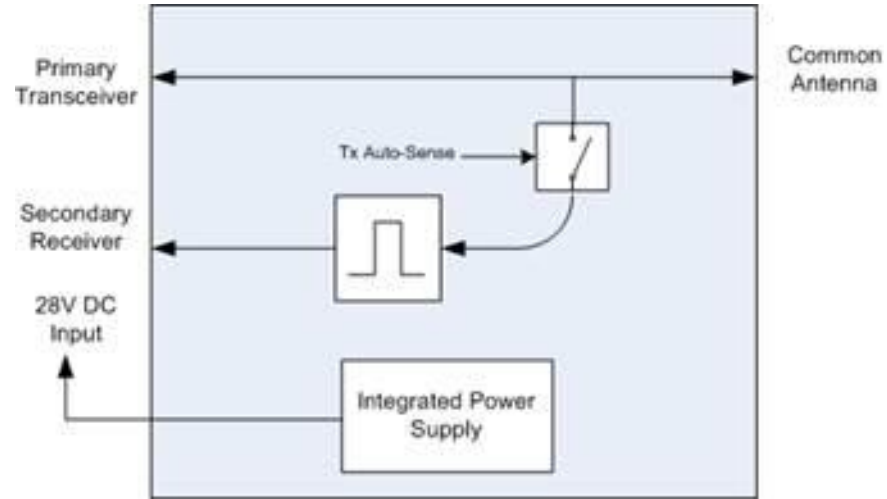
- < 0.5 dB post-HPA insertion loss
 - Multiple notches w/same IL
 - Narrow (~75 kHz) and Wide (~2 MHz) options; Constant BW across frequency
- Architecture scales to other frequency ranges
- Extremely high effective Q in a small form factor



Splitter for Antenna Reduction

➤ Enables the addition of a dedicated receive path using an existing antenna

- Taps path of existing transceiver
- Automatically blanks the RX path during high power TX near RX band
- Protects the RX Receiver from cosite antenna transients
- Unbalanced split for negligible impact to transceiver path
- Available in various guard band or AIS frequencies
- Accommodations included for mounting various AIS Receivers



Summary



Continuous
Improvement

Technology
Innovation



New
Opportunities

