Wideband Jammer Dynamic Frequency Notch Filter for Interference Reduction

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PROBLEM STATEMENT

Wideband jamming systems can interfere with blue force communication, navigation, and identification (CNI) systems over great distances. Modern CNI systems can be frequency agile using rapid frequency hopping to reduce susceptibility to narrow band jamming. Applying notch filters to the output of high power wideband jamming systems is not feasible because the reflected power can damage the jammer. Additionally, rapidly tunable notch filters are unavailable for high power application. Inserting conventional tunable filters between the driver and power amplifier (PA) stages of the jammer often does not result in the desired effect because the system is open loop and does not adjust for the unwanted effects of the nonlinear PA (spurious, intermodulation products, harmonics, etc.). Conventional filters also are not rapidly adjustable in bandwidth. A method to reduce the energy in defined bands, both static and dynamic (frequency hopping/agile) is required. A reduction of 30dB minimum within the notch is desired. The notch location and width should be rapidly tunable. Several tunable notches are required in order to address a normal complement of CNI equipment.

WHO CAN BENEFIT

In addition to airborne jammers other fixed wing aircraft and land vehicle systems could also benefit from ZA's CNF technology. It is not unusual for modern aircraft and ships to utilize dozens of radio and antenna systems. On smaller aircraft there is often insufficient distance to provide isolation between transmitting and receiving antennas to prevent receiver desensitization which reduces the useful range of radio communications. These systems often interfere with one another thus requiring elaborate frequency management schemes. However, frequency management alone may not protect cosited frequency

hopping (FH) receivers from co-spectral or wideband transmitters. Conventional resonating output notch filters applied to transmitter outputs cannot provide sufficiently narrow, dynamically tunable spectral notches with low passband insertion loss and can reflect energy back into the transmitter reducing power output.

BASELINE TECHNOLOGY

Presently several methods are utilized to overcome the interference from nearby transmitters to cosited comms receivers. They include: avoiding simultaneously transmitting while receiving; using a high-insertion loss filter on transmitter output or on the receiver antenna input; using just an interference canceller alone.

TECHNOLOGY DESCRIPTION

The objective of this SBIR effort is to develop a method for notching out (reducing RF energy within) tunable frequency bands from the output of a high power wideband (VHF through Lband) jammer or transmitter. It addresses the development of two sub-band prototype models of ZA's Cosite Notch Filter (CNF), one covering V/UHF band and the other UHF through S band. Each CNF will filter out selected narrow spectral portions from the output of a transmitter's power amplifier (PA) while allowing it to pass the rest of its designated frequency range with very low loss.

The CNF is a critical and enabling technology for interoperability with a wideband jammer PA which offers significant enhanced performance over existing filter and other related technology. The CNF will substantially reduce radio frequency interference (RFI) to cosited and nearby off board blue force communications receivers, providing a new tool to provide interoperability between transmitters and receivers.

The CNF provides a bank of notch filters that are independently and dynamically tunable in notch center frequency (f_c) and notch width (NW). These parameters are to be dynamically selected in accordance with the blue force radio receive channel frequencies and bandwidths that the CNF notch is intended to protect, with notch width no wider than needed to afford that RFI protection while minimizing the impact to jamming effectiveness.

Conventional transmitter PA notch filtering, if done at a low power point preceding the PA, loses effectiveness because the nonlinear behavior in a power-efficient PA causes the transfer of power from other PA frequencies into the notched frequencies, thereby filling in each notch to some degree. If done at the PA output with conventional filtering, there are many obstacles which make that approach woefully inadequate. These obstacles include: the risk of damaging the PA by high power from the PA flowing into the high VSWR of a notch stopband; excessively wide notch bandwidth that suppresses much more of the

jammer spectrum than desired; limited notch depth due to lossy resonator components; excessive physical size; difficulty in achieving tuning agility commensurate with receiver frequency-hopping rates; excessive passband loss and ripple; and limitation in RF power handling. These obstacles are compounded when multiple simultaneous notches are needed to protect multiple frequency-agile receivers. The proposed CNF is a novel approach to jammer transmitter notch filtering that overcomes ALL of these obstacles. The CNF uses electronically-tuned active filters in a network via directional couplers around the jammer PA.

CNF Feature	Advantage	Benefit
CNF notches jammer components at Rx frequency (f_R) prior to Tx antenna	Jammer spectral components at f_R are not radiated	Cosited comms Rx and many nearby blue force Rxs tuned to f_R are protected from jammer RFI, thereby greatly extending the range of these comm radios
CNF notch formed at PA output	PA nonlinearities don't fill in notch as they would with notch at PA input	Deeper notch formed reduces RFI power in blue force radio channels, thereby extending reception range of many nearby receivers
When jammer spectrum is concentrated near f_R most RFI is notch out at the Tx	Cosited Rx is no longer driven into saturation	Reception to most frequencies is restored as in the effective range and AJ capability of frequency hopping (FH) radios
CNF notch at jammer Tx complements RFI mitigation from an Interference Canceller (AIC) at the Rx	Prevents cosite Rx front end overload	Restores normal function and comms range of FH receivers
CNF NWs are adjustable	Prevents RFI to blue force Rxs with minimal impact to jammer spectrum	Allows blue force compatibility without significant impact on EW function of jammers
CNF requires only a directional coupler to be added at the PA output	Insertion loss to PA output power is < 0.5 dB for up to four notches	More PA power reaches Tx antennas for greater jammer effective range
Present conventional notch filters are placed at PA output, CNF only needs directional coupler at output	Avoids placing high VSWR notch filter at high power PA output	Removes risk of damage to jammer PA from PA high power flowing into reflecting stop band of conventional notch filter
Frequency agile multiple notch CNF tuned by synthesizers, not resonators	Tuning agility commensurate with SINCGARS and HAVE QUICK FH rates without excessive size of high power resonator filters	Low SWAP for aircraft application
CNF augments TX-RX antenna isolation and RX interference canceller performance	Combining use of CNF interference reduction with a receiver Interference canceller may reduce cosite interference by as much as 100 dB	Restores usable radio range in the presence of cosite interference
Prototype CNF operates automatically but permits NW and f_C to be manually changed in flight	CNF parameters can be updated if blue force comms frequencies are changed during mission	Automatic mode reduces crew work load. Manual changes allow updating f_C and NW to reduce RFI to blue force radios when crew work load permits changes

CURRENT STATE OF DEVELOPMENT

Accomplishments to Date: TRL 4

- Initial Breadboard CNF achieved a 30 dB deep notch at a notch width (NW) of 25 kHz
- Initial Breadboard CNF tunable over 225-400 MHz using external oscillator
- Improved CNF achieved a 45 dB deep notch over 25 kHz NW; with narrower -3 dB NW and 20 µsec. notch center frequency tunability
- Initial Breadboard CNF and Improved CNF demonstrated dual notch capability over 225-400 MHz UHF band
- Successfully interfaced and operated CNF with power amplifier components of airborne jammer and protected ARC-210 receiver from RFI

Remaining Tasks

- Achieve dynamically variable NWs
- Incorporate fast tuning frequency synthesizer into each CNF module to more rapidly tune notch center frequency
- Develop and demonstrate CNF with four simultaneous notches having dynamically tunable NWs and center frequencies
- Test prototype CNF with jammer transmitter system
- A test of the prototype V/UHF CNF subsystem is scheduled for May 2010

ABOUT THE COMPANY: Zeger-Abrams Inc. (ZA)

- Founded in 1977
- Main Business is RFI Cancellation for NAV, COMMS, EW, RADAR
- A Small Business – Located near Philadelphia, PA
- Selected by the Navy in 2005 as SBIR Success Story for ZA's HAIC™ leading to the VCU for USMC's EFV

Dual Band Frequency Hopping Adaptive Interference Canceler (HAIC™)

SINCGARS VHF Cosite Unit (VCU) 30-88 MHz For USMC EFV

Prototype SHF Shipboard Cosite Interference Canceller; Protects SLQ-32 EW Rx from SHF SATCOM RFI

GPS Adaptive AJ LEAN
(Low Elevation Antenna Nuller)
360° Azimuthal Ring Null toward horizon at L1, L2

ZA is a Small Business located in Glenside, PA, a northern suburb of Philadelphia. Founded in 1977, ZA has become a nationally recognized leader in developing and applying advanced signal processing techniques for cancellation of mission threatening RFI. The company has facilities comprising engineering offices, modern R&D laboratory, and model shop, occupying approximately 2,800 square feet. The ZA laboratory is well equipped with company-owned instruments for the development, fabrication, and test of analog and digital electronic circuits and systems at RF, IF, and baseband. ZA also owns modern computer facilities for engineering uses in system study, simulation, and design engineering support.