

Pseudo-random Polarization Hopping (PPH) – Technology Brief

1. PPH AT A GLANCE

Unique features:

- Signal hops in polarization domain ,occupying a narrow spectrum
- Employs multiple constellations in polarization domain to enhance the low probability of exploitation (LPE)
- Employs adaptive polarization nulling to offer high level of anti jamming
- FPGA base-band, Polarization agile antenna and MIMO processing at receiver to offer a state of the art implementation with high QoS

Threat mitigation:

Eavesdropping

As the signal polarization hops pseudo-randomly , received signal at the antenna of the eavesdropper swings pseudo randomly in amplitude, making the signal detection and exploitation impossible. This feature again enhanced by multiple levels of randomness in data transmission.

Denial of service

Jamming

Jamming power reduced due to polarization mismatch. Anti jamming enhanced by an adaptive polarization nulling algorithm at the receiver.

Present technology:

- Frequency Hopping and Direct Sequence Spread Spectrum.
- Requires very wide spectrum for operation
- Unsuitable for high data rate (broadband) links due to the enormous spectral requirement

Value proposition:

- Occupies less than 1 % of the spectrum compared to spread spectrum
- Data rate more than 100 times compared to spread spectrum
- Ideal for security critical broadband applications
- Offers huge cost savings for both tactical and commercial links

2. BACK GROUND

Present Art:
Spread spectrum

Low Probability of Exploitation (LPE) and Anti Jamming (AJ) are the two important features of any secure and survivable communication system. Presently, LPE and AJ communication systems are designed based on modulations which employ spreading or hopping in time, frequency or phase domains and are inherently wideband. Both Direct Sequence Spread Spectrum (DSSS) and Frequency Hopping Spread Spectrum (FHSS) offer LPE and AJ properties at the cost of bandwidth (spectrum) redundancy.

Spread spectrum :
Vulnerable to signal
advanced processing

With the advent of high speed signal processors and signal processing algorithms offering high computational efficiency, the existing methods are becoming increasingly vulnerable to signal intelligence and jamming. Moreover, with the electromagnetic spectrum getting ever more congested, wide band (wide spectrum) LPE and AJ solutions need to be replaced with narrowband techniques for conserving spectrum For example, a data link of 10 Mbps transmission rate will occupy a spectrum of more than 500 MHz width to offer an acceptable AJ feature if DSSS or FHSS are used. This shows that the DSSS and FHSS are not suitable for high data rate wireless communication networks. What is needed is a modulation which is narrowband in nature, yet offers excellent LPE and AJ features.

Spread spectrum :
Not suitable for
broadband

3. TECHNOLOGY

PPH :
Spectrum efficiency,
LPE, AJ

PPH is an LPE and AJ communication system which employs a novel modulation offering high spectral efficiency. Unlike the prior art , this novel modulation does not need bandwidth redundancy to provide LPE and AJ features to a wireless communication link. This is achieved by hopping in polarization domain and by employing a novel adaptive polarization nulling algorithm to detect and eliminate jamming signal

New Modulation:

Pseudorandom
Polarization Shift
Keying
(PPOLSK)

PPH is based on an innovative modulation called Pseudorandom Polarization Shift Keying (PPOLSK) which can generate polarization hopping using pseudo random assignment of digital information to states of polarization (SOP) of an electromagnetic signal selected from a multitude of constellation arrangements. The presented modulation uses pseudorandom code at the transmitter and maps the digital information onto the SOPs.

SDR based design:

Polarization agile
antenna

To generate these SOPs, a dual polarization array antenna is fed with suitable amplitude and phase signals to its ports. By designing a suitable amplitude and phase selection circuits feeding a Right Handed Circular Polarization (RHCP) and a left Handed Circular Polarization (LHCP) antenna , or a Linear Horizontal Polarization (LHP) and a linear vertical polarization (LVP), the State of Polarization (SOP) of the transmitting signal can be made to hop pseudo randomly between a set of predetermined SOPs.

**Optimum
Receiver:**

Stokes space receiver

At the receiver, the SOP of the incoming electromagnetic wave is determined by sensing the amplitude and phase of the received signals at a high isolation dual polarized array. The amplitude and phase relation ship between the two received signals are further processed in the Stokes space to determine the received state of polarization. Alternatively, a novel algorithm called Maximum Likely Cross Polarization Interference Cancellation (ML-XPIC) algorithm is used to determine the received SOP . The presence of the jamming signal is identified during the training / pilot phase of the operation of the receiver and an estimate of the jamming signal is then cancelled out using an innovative Adaptive Polarization Nulling (APN) algorithm

XPIC:
based on MIMO
processing

4. THREAT MITIGATION

LPE:
multiple levels of
randomness

Without the knowledge of the spreading code , an eavesdropper is always at polarization mismatch and the received signal on their fixed polarization antenna assumes pseudo-random noise like properties, thus ensuring a high level of LPE performance. As the state of polarization of the transmitted signal changes pseudo-randomly, the signal received on a fixed polarization antenna used by the eavesdropper records an amplitude which changes pseudo randomly within a very high value (when there is a polarization match) and zero (when the polarization of the eves dropper antenna is orthogonal to the transmitted SOP). No conventional receiver can demodulate and detect such a noise like received signal thus rendering the system invulnerable to eavesdropping .

ANTI JAMMING:
Adaptive polarization
nulling algorithm

As the signal between intended parties assume various polarizations for communicating the data, the jamming signal power is greatly reduced by polarization mismatch. This feature is further enhanced by the adaptive polarization nulling algorithm at the receiver. During the training / pilot phase of transmission, a series of custom designed symbols are inserted into the pilot transmission. During this transmission, the presence of the jamming signal is detected first and then the jamming power and the polarization of the jamming signal are determined . This estimate is then subtracted from the received signal.

5. PRODUCTS

Tactical WLAN:
(TacLAN)

Tactical WLAN is a proprietary WLAN technology providing tactical / high security communications with unmatched security features, high throughput, wide range and most uniquely the desired quality of Anti- Jamming capability. Based on an 802.11 compliant MAC, this technology offers an adaptive throughput of 16 Mbps, 32 Mbps or 54 Mbps with a range of up to 100 m and employs a Physical layer (PHY) based on Pseudorandom Polarization Hopping. Equipped with security

features compliant to 802.1x at the MAC layer together with a cryptic and anti jamming modulation at the PHY makes the most secure and invulnerable wireless LAN technology presently available and is the ideal solution for strategic WLAN installations.

**Tactical BWA:
(TWIN)**

Tactical Wireless Information Network (TWIN) is a secure broadband wireless network providing country / region wide survivable multimedia communications to support strategic and tactical forces during all levels of conflict. It offers an invulnerable and anti jam air interface with a light weight, multi band, multi mission, mobile terminal to support voice/imagery/signaling applications. These terminals provide remote personnel with constant and effective communication capability and provide communications links to distant forces enabling an efficient implementation of battlefield Command Control Communications and Information (C³I) systems.

6. CONCLUSION

PPH is a unique technology with enormous commercialization possibilities. It offers an innovative solution to secure the broadband wireless links by providing stealth property and anti jamming . PPH can support huge data rates typical of today's networks. PPH offers the much needed information security for mission critical data .

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