Massive Light

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Experiment Description & Measures to Avoid Interference at the A&M RELLIS BCDC IPG

Bottom Line Up Front

Massive Light would like to test the Shockwave™ wireless system's covert communications performance over a 2.5 km distance at the A&M RELLIS Campus for three days during Nov. 17-19, Dec. 8-10, or Dec. 15-17 of 2021. Specifically, Massive Light is requesting permission to transmit wireless signals at the RELLIS campus with the following test parameters:

- **Effective Isotropic Radiated Power (EIRP)**: 1 Watt (30 dBm)
- **Distance**: 2.5 km (line of sight outside)
- **Frequencies**: 5.5-6.3 GHz
- **Duration**: 3 days (Nov. 17-19, Dec. 8-10, or Dec. 15-17)

Problem

In the presence of sophisticated adversaries, there are currently no cost-effective electromagnetic solutions with the flexibility and the bandwidth to accomplish communications tasks without risk of detection and jamming. There are also no electromagnetic solutions that can re-enable assets that have been incapacitated by jammers.

Solution

Massive Light is developing the Shockwave™ wireless system and its anti-jam and covert communications application to give the US mid-band electromagnetic spectrum dominance against near-peer adversaries in semi-permissive and non-permissive environments. The Shockwave™ wireless system is frequency agile and waveform portable within the 2.4-9 GHz range. It unlocks large instantaneous bandwidth (up to 6000 MHz) for next generation wireless, expands horizons for spectrum collaboration, and eliminates hardware bottlenecks for software defined radio. The Shockwave™ wireless system can enable and improve many key interest areas including the following:

- Anti-jam and covert communications (low probability of intercept and detect)
- Frequency agile and waveform portable broadband software defined radio
- Detection and location capability for frequency agile radio transmitters
- Signal processing at the tactical edge for SIGINT
- Force collaboration and footprint reduction
- Satellite communications
- Electronic warfare

TRL Levels

The critical sub-components for the Shockwave™ wireless system have different TRL levels. As they are tested together, the TRL level of the entire Shockwave™ system can advance. The current TRL levels of the critical sub-components of Shockwave™ are shown in Table 1.

Shockwave Sub-Component	TRL Level
Omni-directional low-distortion broadband coaxial horn antenna	7
Front-end for radio frequency up and down-conversion	6
Covert and anti-jam communications application	4

Table 1: TRL levels of Shockwave™ wireless system sub-components.

Technology Description

By combining expertise in 3D printing and electromagnetics, Massive Light invented a patent-pending horizontally omni-directional coaxial horn antenna for Shockwave™ to remove distortion so that signal transmission and reception covering 6000 MHz instantaneously between 2-12 GHz has become possible in a single channel. This large instantaneous bandwidth enables covert communications below the noise floor that are impossible with legacy narrowband communications systems. This 1” x 1” x 1.5” antenna is shown in Figure 1. The unique curvatures of the patent-pending coaxial horn antenna were optimized to reduce distortion across its simulated 2:1 VSWR bandwidth of 2-12 GHz to enable anti-jam and covert communications across large instantaneous bandwidths.

Using commercial off-the-shelf radio frequency and FPGA hardware, Massive Light has invented a patent-pending RF front-end covering 2.4-9 GHz for Shockwave™ and has tested it successfully with a 4000 MHz wide chirp in a single wireless channel. Massive Light has also tested this RF front-end successfully with an 800 MHz wide waveform that represents voice and data comms. This RF front-end bandwidth could be extended to cover the antenna’s 2-12 GHz range with increased cost. The RF front-end is currently being miniaturized for a smaller board layout, as shown in Figure 2.

Figure 1: Patent-pending 3D printed low-distortion broadband coaxial horn antenna.

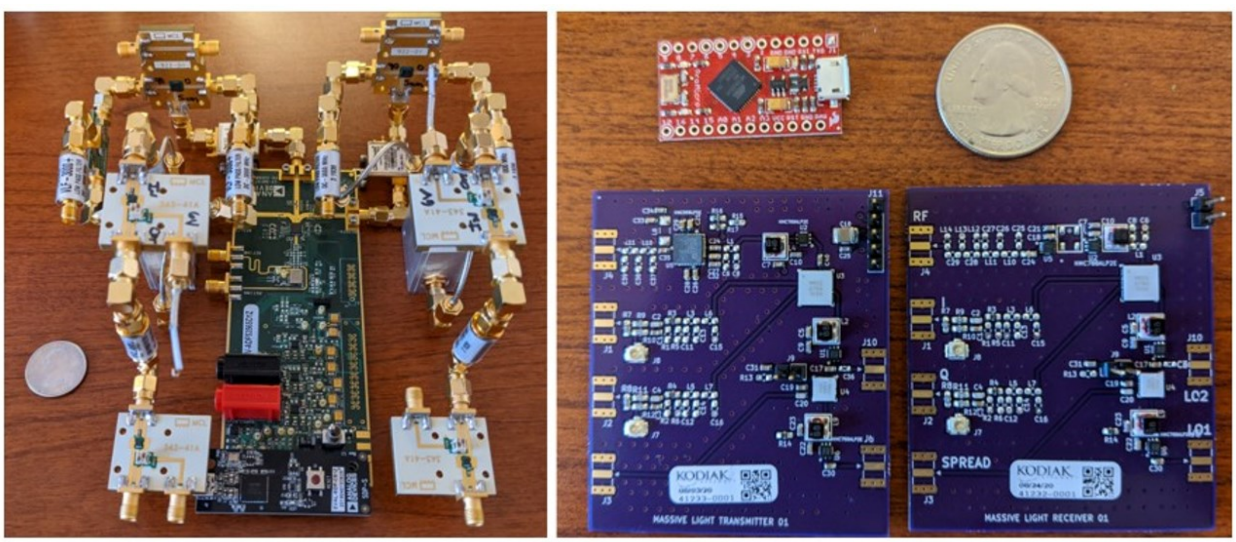

Figure 2: COTS RF front-end development and miniaturization for smaller board layout.

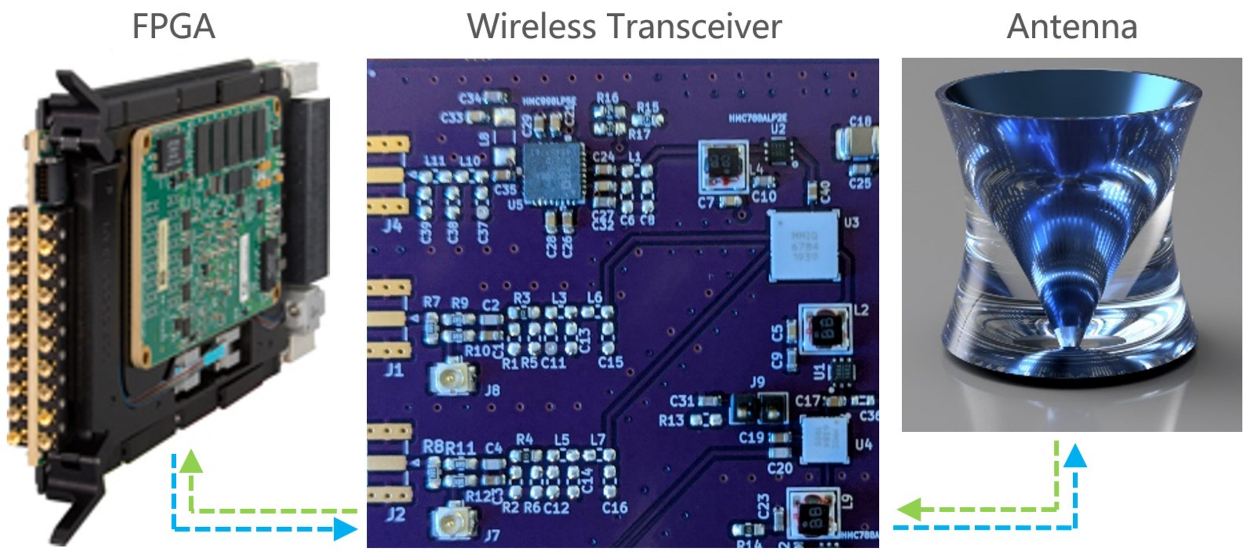

Figure 3: Shockwave™ wireless system hardware components.

Massive Light's anti-jam and covert comms application for Shockwave™ is being developed using a direct-sequence spread spectrum (DSSS) bi-phase shift keying (BPSK) waveform that hides data below the noise floor and retrieves that data from below the noise floor through the encoding gain of the pseudo-noise spreading sequence. The same de-spreading sequence that retrieves the signals from below the noise floor also spreads noise and jammer signals in the receiver to reduce their power level while elevating the intended signal's power level. Massive Light is also developing a featureless waveform to avoid cyclo-stationary sub-noise detection methods.

The Shockwave™ wireless system hardware includes an FPGA, a patent-pending wireless transceiver, and a patent-pending antenna, as shown in Figure 3. The Open-Standard System Architecture (OSSA) of Shockwave™ supports flexible adaptations to both mounted and dismounted terrestrial comms for scalable networks at extended ranges in various applications. Massive Light is developing the anti-jam and covert comms application for Shockwave™ to meet the need for warfighters to be able to communicate effectively without being detected, tracked, or jammed by an adversary in semi-permissive and non-permissive environments. This application could also be used to send machine control signals and position, navigation, and timing information to unmanned airborne and ground vehicles (UAV/UGVs). This communications application has been built and tested in a software environment at TRL 4, and is currently being built into firmware to test it on a communications range to advance it to TRL 5.

Measures to Avoid Interference

To avoid interference with existing systems in the 5.5-6.3 GHz range during the test at the RELLIS BCDC IPG, Massive Light will limit the RF output power to 1 Watt EIRP, which will be spread out across the 5.5-6.3 GHz range instantaneously. The power spreading across this bandwidth will reduce the power spectral density entering the transmit antenna to -59 dBm/Hz (30 dBm – 89 dB Hz), which will then be further reduced by the free space path loss as the energy spreads out across the test range. At a distance of 2.5 km, the power spectral density of the 800 MHz wide signal received with a 3 dB gain antenna is expected to be only -174.82 dBm/Hz, which is low enough that it should not interfere with any of the other local signals within the 5.5-6.3 GHz range.