



## APPLICATION OF THE CONTINUOUS TRANSVERSE STUB (CTS) ARRAY IN POINT-TO-POINT (PTP) COMMUNICATION SYSTEMS

The Continuous Transverse Stub (CTS) array represents a new class of array antenna that exploits the low-loss, low-dispersion, dimensional robustness, and design flexibility of an open parallel-plate structure as both its transmission-line and radiator basis. Since its invention in 1991, this antenna technology has been successfully demonstrated in over 30 different applications, including electronically-scanned and dual-polarized implementations. Relative advantages of this array type include unusually high aperture efficiencies and precision sidelobe control (through 94 GHz); benign active impedance dependence to frequency and scan angles; and enhanced design robustness, simplicity, and low-cost. The patented CTS antenna is now available as a commercial product for Point-to-Point (PTP) communication systems, most recently as a low-profile, high-efficiency, low-sidelobe antenna for PTP applications in the 23, 26, and 38 GHz frequency bands. This paper will briefly describe the relative advantages and benefits of the CTS array technology specific to the Point-to-Point (PTP) and Point-to-Multipoint (PTMP) communication marketplaces.

The CTS array antenna exploits a unique stub element as its radiator basis. Unlike a typical resonant high-Q radiator such as a dipole, slot, or patch, the CTS stub exhibits a very low-Q impedance characteristic. This results in a significant frequency bandwidth improvement and a unique dimensional insensitivity which in turn translates into significant producibility and reliability advantages. The continuous geometry of the stub radiator allows for a dramatic reduction in part count:  $N$  by  $N$  discrete radiators are replaced by  $N$  continuous stubs. In addition, the stub radiator's high physical aspect ratio (length-to-width) minimizes fringing effects to realize superior polarization purity over that of competing planar array and reflector implementations.

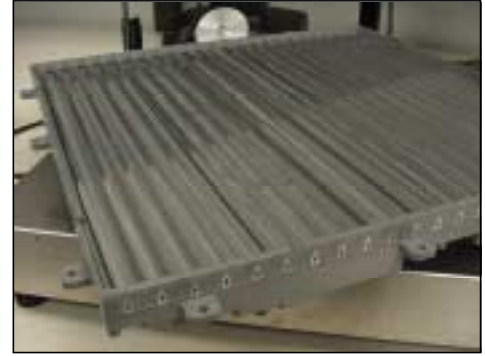
The CTS array uniquely utilizes a continuous (joint-free) air-filled parallel-plate structure as its transmission-line media basis. It exhibits extremely low dissipative losses (less than 0.20 dB/foot at 40 GHz) relative to the microstrip, stripline, and/or bonded waveguide media used in competing planar array approaches.



Molded 23/26 GHz CTS PTP Array



38 GHz CTS PTP Array/Radio



Molded 23/26 GHz CTS PTP Aperture

As a planar array antenna, the True Time-Delay (TTD) CTS array exhibits superior backlobe and sidelobe performance to that of reflector antennas due to the absence of spill-over and/or feed scattering and blockage contributions. As an added benefit, the CTS array utilizes a highly-separable ( $\phi$ -dependent) sidelobe structure that allows for increased sidelobe depression over large angular regions in  $\phi$  (roll). The diamond orientation of the mounted antenna provides for superior sidelobe performance (within  $\pm 35$  degrees of the horizontal and vertical planes) over that of typical ( $\phi$ -symmetric) reflector and planar array antennas. In addition, the diamond orientation and smooth perimeter shaping of the CTS antenna facilitates the efficient shedding of rain and condensation as well as serving to discourage the presence of birds on or near the radiating aperture surface.

The antenna's thin profile and light weight (2 inches and under 8 pounds, typically) enhance the flexibility and ease of its installation. The aesthetic benefits of the antenna's compact form uniquely enable concealed installations, a particularly important attribute in areas for which stringent architectural and/or zoning restrictions apply. The simplicity of a lightweight, compact, integrated radio/antenna unit has dramatic impact on the relative ease and cost of installation. The reduced footprint of the compact antenna minimizes the weight and performance impact of ice accumulation and wind loading, and thereby allows the use of smaller, lighter weight installation hardware and mounting platforms.



The 23, 26, and 38 GHz CTS antenna products have a single common design that exceeds all international high performance requirements, including all applicable MPT, BAPT, and FCC "A" specifications, over their entire respective contiguous operating frequency bandwidths. For example the co-polarized (VV and HH) Radiation Pattern Envelope (RPE) for the 38 GHz CTS array maintains an 8 and 12 dB average margin below the MPT1414 and FCC "A" specifications, respectively down to a relative sidelobe level of -50 dB. Cross-polarized energy is likewise dramatically suppressed, falling below a -50 dB level for all angles outside 2° of the mainbeam. Typical front-to-back ratios exceed -60 dB. Figure 1 illustrates a typical measured radiation pattern for the 38 GHz CTS array with MPT1414 and FCC "A" specifications overlaid for comparison. Figure 2 illustrates measured +2.3 sigma (95 percentile) RPE for both co-polarized and cross-polarized components.

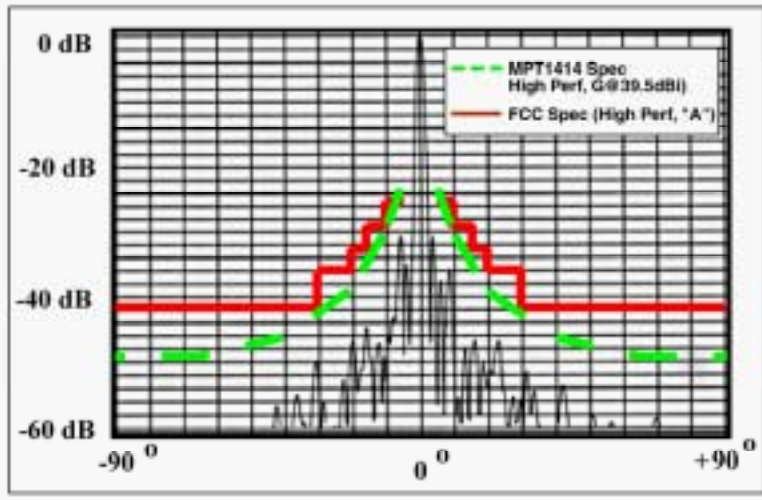


Figure 1. Measured 38 GHz CTS PTP Antenna Radiation Pattern

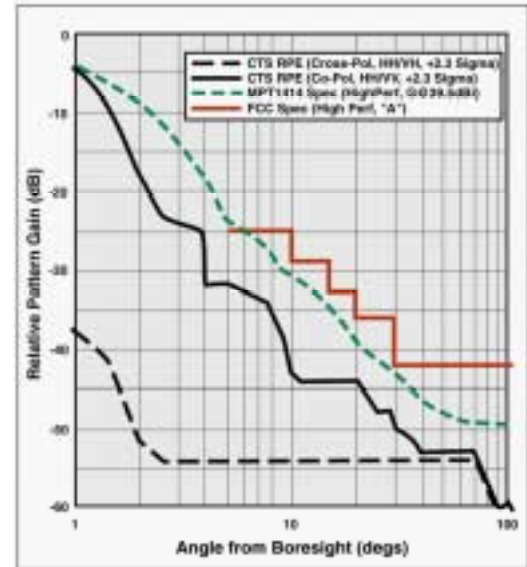


Figure 2. Statistical RPE for 38 GHz CTS PTP

An additional feature of the CTS antenna is its identical vertical (VV, VH) and horizontal (HH, HV) RPEs for both co-polarized and cross-polarized responses. This design feature contrasts with most reflector-based solutions which typically exhibit polarization-dependent RPEs due to their inherently asymmetric feed horn illuminations, with commensurately poorer RPEs for horizontal polarization than for vertical. The favorable polarization equivalence of the CTS array, with its suppressed co-polarized and cross-polarized RPEs, enables increased flexibility and interoperability performance, particularly in high density sites and installations.

As previously discussed, the CTS array uses an air-filled parallel-plate structure as its transmission-line basis and, therefore, exhibits unusually low ohmic losses compared to competing planar array implementations. For example, typical ohmic losses for the 12-inch by 12-inch (10.7-inch by 10.8-inch active aperture area) 38 GHz antenna are 1.1 dB, including radome effects. Combined with low taper (illumination) losses, and low input VSWR, a total aperture efficiency of 60% (78% ohmic efficiency) is achieved. This equates to an average gain of 39.7 dB over the 37 to 40 GHz operating bandwidth as illustrated in Figure 3.

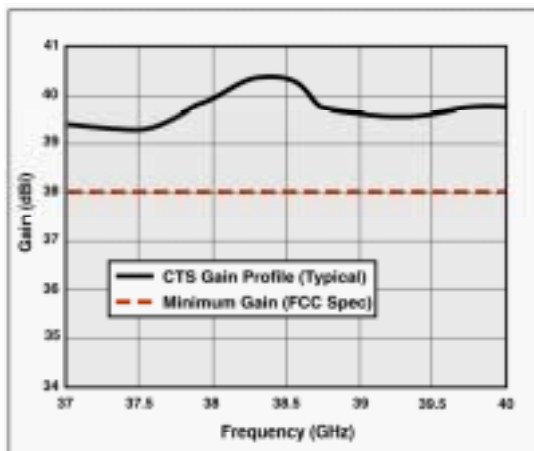


Figure 3. Measured Gain for 38 GHz CTS PTP Antenna

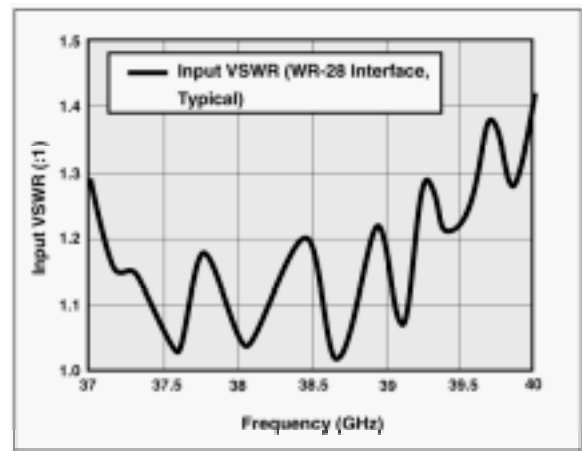


Figure 4. Measured VSWR for 38 GHz CTS PTP Antenna

Though not explicitly mandated by regulatory requirements, a well-matched antenna aperture exhibiting low Voltage Standing Wave Ratio (VSWR) across the frequency band of operation is critical for stable, reliable radio operation. Exploiting the low-Q nature of its constituent components, the CTS array exhibits an unusually low VSWR compared to conventional planar array implementations. Figure 4 illustrates the measured VSWR frequency response for the 38 GHz CTS antenna.

Protected by 10 issued US Patents as well as numerous pending and issued US and foreign patents, the CTS flat-plate antenna exhibits unique efficiency, performance, producibility, and flexibility advantages for a broad range of applications in the PTP and PTMP communication marketplaces for frequency bands extending through 94 GHz. Currently in full-scale production in support of Harris Corporation's 23, 26, and 38 GHz Point-to-Point (PTP) *Microstar Plus*® Radios, the CTS array enjoys high degrees of design and component reuse for all three bands. The dimensional insensitivity, low-cost fabrication processes, non-critical assembly, and built-in design margin of the CTS array renders a design that is completely compatible with high-yield Six-Sigma manufacturing and obviates the need for individual tuning or adjusting. In addition to its enhanced producibility, the CTS array architecture is suitable for a broad range of frequency applications and has been successfully demonstrated in various implementations ranging from 5 through 94 GHz. Frequency bandwidths as high as 4:1 have been successfully implemented with the CTS array and architecture. Directly scaleable in frequency, size, shape, and gain, the CTS array is highly flexible and adaptable in optimally meeting restrictive installation and performance requirements. In addition, both dual-polarized and shaped beam implementations are available for polarization diverse and/or Point-to-Multi-Point (PTMP) applications with similar cost and performance benefits as compared to competing reflector-based solutions.

As an example of the CTS array's simple low-cost construction, the 38 GHz CTS antenna implementation utilizes a radiating aperture comprised of 48 identical stub radiating elements fed by two identical 24-way parallel-plate corporate feed networks. A pair of 48-way waveguide corporate feed networks, integrated in a unified structure and optimized for high-producibility, feed each of the two identical array halves. Unique RF design features allow all antenna components to be assembled without bonding or brazing, and using a minimal number of mechanical fasteners without concern of RF leakage, loss, and/or degradation as is the case with many alternative array implementations. A half-wave solid-wall radome, selectively curved to realize optimal reflective, mechanical, and hydro-phobic properties is precisely realized as an injection-molded structure, providing environmental protection/isolation of the antenna. Total assembly time including all piece parts and mechanical fasteners is 10 minutes.

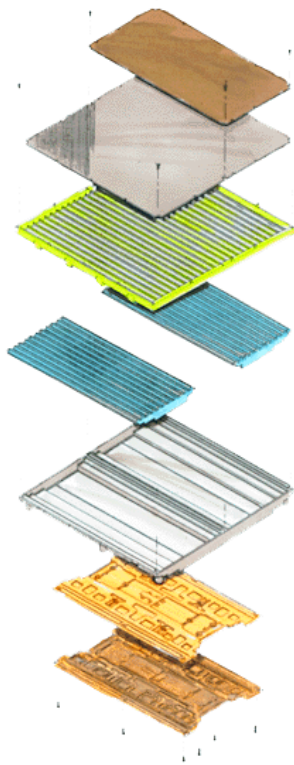


Figure 5. CTS PTP Antenna - Exploded Diagram

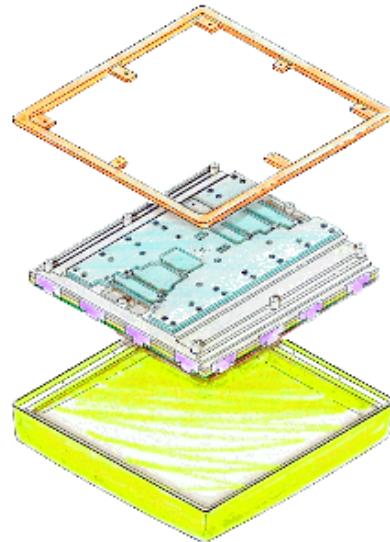


Figure 6. CTS PTP Antenna - Final Radome Assembly

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