NEW PERFORMANCE STANDARDS IN SUBSEA CONNECTIVITY

By Amy Brown,
CMO, BIRNS, Inc.

» *BIRNS Millennium 3M-16, capable of 9+/G/s. (Photo credit: BIRNS)*

The subsea equipment market has seen some exciting new advancements recently, and as a result, industry interconnect manufacturers have been required to establish and meet challenging new performance standards due to demanding technical requirements of subsea products. Today's array of connectivity capabilities has grown as well, ranging from extreme depth and extreme cold to high performance optical and gigabit Ethernet data speeds. The result is a new set of standards for connectors and cable assemblies.

BIRNS has had a range of breakthroughs in subsea connectivity technology with new capabilities in coax, gigabit Ethernet data rates and optical fiber with the BIRNS Millennium™ series. This high performance, dry-mate range is designed for deep submergence applications to 6 km depth. The new connectivity technology is reducing many of the historical tradeoffs in function that had formerly been encountered in many marine connectors, like sacrificing open face pressure resistance when using coax, or Ethernet data rates topping out at only approximately 2 gigabits per second.

GIGABIT ETHERNET

Highly advanced subsea systems have become even more sophisticated, and there is now a need for data transfer capabilities to match. New defense, oil and gas, and research applications require unmanned vehicles capable of extended operations, and to transfer huge amounts of real-time data from the seafloor, whether for minesweeping, ISR (Intelligence, Surveillance and Reconnaissance) or survey and inspection. In 2020, BIRNS introduced groundbreaking new advancements with 6 km-rated cable assemblies that produced, at pressure, consistent data transfer rates of a remarkable 9.4± 0.1G/s. It's likely that the speed is actually far higher, as testing is simply limited by the current computer technology that is commercially available. Extensive performance testing proved that data consistently transmitted at this rate over the entire range of pressures from 0 to 8700 PSI/600 bar (6,000-m equivalent depth). These results were still maintained even when daisy-chaining five cables together.

This was developed originally for a customer requesting a solution that would come close to 10 G/sec for an extreme depth AUV system. Until recently, data transfer rates for commercially available underwater connectors had been limited to "Ethernet" speeds—that is, only around 1 G/s. It is unclear if testing of such connectors had actually been done, as objective quality evidence in the form of test data was not found. The new performance characteristics required would represent a full order of magnitude improvement over all existing connector products. The team developed an exclusive 52A-278 cable constructed for Cat 8.2 use. The BIRNS team also developed exclusive new proprietary termination protocols to further reduce loss and increase bandwidth for this unique cabling.

RADIO FREQUENCY (RF)

In applications from oceanographic, defense, and antennas to towed systems as well as manned and unmanned and autonomous vehicles of all types, coax connectors are widely used for GPS-frequency systems, large data and HD video and telemetry signal applications.

Tradeoffs had traditionally been found in the development and use of marine industry coax connector technology, requiring the sacrifice of open face pressure rating and often, speed and throughput. But BIRNS's new breakthroughs have provided the advantages of coax, without the drawbacks or limitations formerly associated with it; in other words, extraordinarily low insertion loss, incredibly high frequency capability, and even open face pressure resistance.

Designers of subsea RF connectors had been challenged with preventing the dielectric and or center conductor from being extruded from the outer conductor or creating a leak path under pressure. The result was the general industry acceptance that coax subsea connectors simply could not withstand open face pressure at all based on design issues with controlling electrical impedance and the overall challenges of performance in requisite dielectric materials.

However, in 2015 the BIRNS team developed completely new proprietary 50 ohm RF coax contacts that overcame these issues, and delivered advanced performance attributes, even including open face hydrostatic pressure to depths of 1,433 m. To achieve this, its engineers optimized transitions to prevent extrusion and minimize impedance discontinuities, and also incorporated seals made of low dielectric constant materials to prevent leakage under pressure.

These new coax connectors and cable assemblies also offer very low data transmission loss even at GPS frequencies. For example, the company has performed extensive testing, resulting in test data proving that at signal frequencies of 3GHz, BIRNS Millennium 1C cable assemblies provide ≤0.7 dB UHF insertion loss and ≤1.7:1 VSWR (voltage standing wave ratio). (VSWR measures how efficiently RF power is transmitted.) At 1.5GHz, the BIRNS 1C has only .32dB loss and 1.17 VSWR, compared to data loss at 1.5GHz of two other commercially available RF connector brands reported at ~2.5dB and ~3.5dB, respectively.

In 2021, BIRNS launched yet another RF solution in the BIRNS 1V series, featuring a compact coax contact that offered 75Ω impedance in the same footprint of a 50Ω contact. With its extremely compact size, it fit into any of the many BIRNS coax pin configurations, offering a range of flexible, powerful new options in a small space. BIRNS has also developed 1B pressure-rated low-loss RF connectors, exclusively for the US Military, for use to SHF band Ku (18GHz). 1B connectors have previously been qualified for US Navy applications and have successfully completed US Navy qualification including transmission and open-face in saltwater under conditions of cold (27°F/3°C) and hot (100°F/38°C) hydrostatic pressure.

OPTICAL FIBERS

Optical fibers are often used in systems that require greater bandwidth over longer distances, with a smaller footprint—smaller hull penetrations—for applications such as offshore oil and gas, towed arrays, side scan sonar systems, oceanographic instrumentation, and subsea scientific programs.

BIRNS Millennium new optical and electro-optical cable assemblies deliver high-performance data transmission, with designs qualified in cold-water high pressure testing and proven in service. Challenges can arise in manufacturing these assemblies such that can create discontinuity or if bend radii is too high, which can cause breakage or reflection in delicate fibers. Accurately aligning two fibers with diameters of only 8.7µm presents challenges, and failure to do so with precision can greatly affect optical loss. BIRNS developed optical fiber engineering protocols and termination methods that result in speeds of gigabits of data per second. Optical cable assemblies in the BIRNS Millennium series have low insertion loss (per ANSI/TIA/EIA-455) in single-mode of 0.5 dB max (0.10 dB typical) and multi-mode of 1.0 dB max (0.25 dB typical) These assemblies have been tested to demonstrate return loss of 35dB per minute.

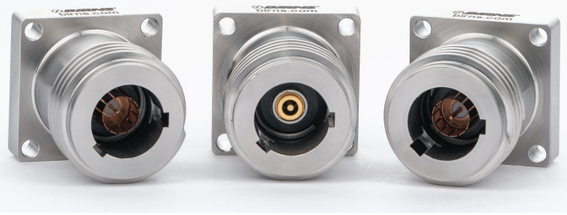
In 2019, BIRNS was called upon to provide electro-optical cable assemblies capable of operating in extreme cold at 6 km. The team developed a new precision testing capability, an extreme low temperature, extreme depth testing system, allowing 48 hour+ continuous testing of connectors and cable assemblies at 6 km in a controlled 2°C (±1°C) environment.

» *A BIRNS 3O-1F3 cable assembly during unique extreme cold, extreme depth testing at 6 km in a controlled 2°C (±1°C) environment. (Photo credit: BIRNS)*

LOOKING AHEAD

The subsea industry will continue to demand smaller, more efficient connectivity solutions that can do far more with less. Packing more capabilities into smaller and far more powerful connectors will continue to support systems that require extremely high-performance assemblies with 10 G/sec data rates, extremely low insertion losses, and maximum efficiency in transmissions and VSWR. Connector companies will continue to innovate and test these connectivity systems to meet the design demands of increasingly complex next generation subsea applications.

For more information, visit: *www.birns.com*.



» *6 km-rated connector with a BIRNS 1C 50 Ω contact (left), with a BIRNS 1B contact for SHF band Ku (middle), a BIRNS 1V 75 Ω contact. (Photo credit: BIRNS)*