Qnnect with Cristek

Twist Capsule Assemblies

Reliable Power & Signal Transmission
Across a Defined Angle Rotation Interface.

Military and civilian aerospace industries rely heavily on advanced electronic systems for the transmission of power and signals. The engineering challenge is complex due to the involvement of components requiring relative movement. Here are some examples of this challenge, ranging from common to high-tech:

- Power and signal transmission between stator and rotor electro-optic sensors in weapon systems.
- Operation of pan-tilt mechanisms for video cameras or other sensors.
- Reliable power and data transmission for antenna pointing mechanisms, elevation and azimuth gimbals, and other sensitive equipment in harsh space environments.

Gimbals must rotate in multiple axes, requiring system and subsystem engineers to ensure the dependable transmission of power and signals across moving interfaces. Additionally, military and aerospace applications must operate reliably under extreme conditions like high temperatures, severe vibrations, noxious fumes, and the vacuum of space.

> **"For high-end aerospace applications, the right supplier makes the difference between a successful end-product and a commercial dead-end"**

Various technical solutions are available to ensure dependable power and signal transmission across rotating interfaces. For example:

- A slip ring is vital for the continuously rotating azimuth axis of an electro-optic gimbal.
- Different options are viable when a defined maximum angle rotation is needed.
- Limited angle rotation scenarios, like the elevation, pitch, or yaw axes of a missile's infrared sensor, can benefit from cable wraps and twist capsules.

An engineer's component selection is crucial for reliability, as failure can lead to system breakdown. The project engineer must trust the supplier to deliver promptly and comprehensively understand the intended application. With a holistic systems engineering approach, the supplier should provide a complete solution considering various factors like application parameters, manufacturability, testing, and continuous improvement.

Choosing the right supplier is paramount for complex aerospace applications, as it can determine the success or cause a standstill. This article explores engineers' challenges in designing signal transmission across rotation interfaces and emphasizes the importance of selecting the appropriate technology and partnering with the right supplier.

Rotating Joint Interface Solutions

When selecting technology for a rotating joint interface, various technical factors play a role, but the main decision hinges on the required degree of rotation. For instance, the continuous rotation of an electro-optic gimbal's azimuth axis necessitates a different mechanical approach compared to the limited-rotation axes of a missile's IR sensor like elevation, pitch, or yaw.

For continuous rotation, the go-to solution is the slip ring, which consists of noble metal rings and sliding wipers (or brushes) per channel, separated by insulators to transmit power and signals from moving rings to stationary conductors. While effective, slip rings struggle with gigahertz (GHz) signals due to their non-permanent connections, leading to issues like signal integrity loss, large size (especially with multiple channels), complexity, failure modes, lifespan constraints, and cost concerns.

For restricted angle rotation (typically between 365° and 720°), two reliable options are cable wraps and twist capsules. These fixed mechanical connectors ensure high-integrity, high-frequency power and signal transfer with minimal losses and interference. Although cable wraps and twist capsules may appear similar externally, the former employs cable bundles for data and power transmission, while the latter uses flexible printed circuit tape (flex cable).

In a cable wrap setup, the design should allow enough cable length for the device to rotate freely within the required angle range before returning to the starting position. Cable wraps offer advantages like supporting composite conductors, being cost-effective with short supply lead times. However, they come with downsides such as high and inconsistent drive torque requirements, poor torque repeatability, and limited cycle lifespan due to cable bending.

On the other hand, twist capsules replace cable bundles with flex cables for data and power transmission. While variations like rolling twist capsules exist, a typical design involves wrapping the flex cable around the rotational axis in a clock spring shape. This mechanism winds and unwinds the flex cable around the central shaft, usually supported by ball bearings (though bearing-free options are available).

In contrast to cable wraps, employing flex cables in a twist capsule for the rotating interface offers numerous benefits, such as:

- Compact design and lightweight structure.
- Enhanced flexibility and reduced torsional counterforces.
- Specific stiffness tailored for movement requirements.
- Unique conductor layout for impedance regulation, radiofrequency integrity and current capacity.
- Reliable performance and stable contacts, even under operational temps reaching up to 150°C.

Rotating the axis in relation to the outer housing of the twist capsule enables the end-product to rotate while winding up the clock spring. The clock spring's minimum bend radius is designed to minimize material stresses from repetitive bending. As the interface rotates, the flex cable clock spring generates a slight counter torque that increases proportionally with rotation. In a well-designed twist capsule, this torque remains consistently low, posing no challenges at the system level. Most designs feature symmetrical circuit tapes with equal torque values for both clockwise and counterclockwise rotations.

The consistent and dependable torque properties of the twist capsule enhance servo control on the driven axis, crucial for precision pointing applications. During twist capsule production, the flex cable lengths are carefully adjusted to prevent binding at the travel ends and to account for cable length contraction due to temperature decreases. Together with the flex cable's material characteristics, specified bend radius, and low torque operation, these measures ensure system longevity and maintain the twist capsule's performance over its lifetime as required by the system, without degradation.

Table summarizes the characteristics of slip rings, twist capsules and cable wraps.

Parameter	Slip Ring	Cable Wrap	Twist Capsule
Rotation angle	Unlimited	<720 degrees	<720 degrees
Low consistent torque	Yes	No	Yes
Low electrical resistance variability	No	Yes	Yes
Good signal integrity up to 5GHz	No	Yes	Yes
Good EMI shielding	No	Yes	Yes
Lifetime cost	$$$	$	$$
Reliability	Very good	Good	Excellent
Size	Large	Small	Small
Number of cycles	High	Medium	Very high

CHOOSING THE RIGHT SOLUTION AND SUPPLIER

Although cable wraps may suffice for certain low-cost limited-angle rotation interfaces, twist capsules are the ideal choice for high-reliability, long-lasting applications. By incorporating flex cables within the twist capsules, this solution provides a compact size, precise control over electrical properties, high-temperature and high-frequency capabilities, and consistent low torque characteristics.

Once the project engineer determines that a twist capsule is the optimal component for their limited angle rotation interface application, there are several other considerations when selecting a specific solution from a particular supplier. These factors include:

- The amount of current and voltage that needs to be transferred across the interface.
- The type of signals that need to be transmitted (e.g., analog/digital, electrical/optical).
- The maximum transfer frequency.
- The level of signal integrity required by the application.
- The space available in the system for the twist capsule.
- The project budget.
- The torque profile of the application (e.g., maximum torque, need for constant torque, maximum hysteresis torque).
- The expected lifecycle of the solution.
- The specifications and standards to which the solution is qualified.

While meeting all engineering specifications is crucial for the chosen solution, there is an additional key factor to consider. Despite twist capsules constituting a small portion of the system's overall cost, they play a significant role. For instance, in a scenario where an electro-optic gimbal sub-system for an aircraft costs hundreds of thousands of dollars, the twist capsule, though a minor expense, is essential. Its failure could render the entire multi-million dollar system inoperable.

However, ensuring the product's reliability depends on collaborating with the correct partner. This partner should have extensive experience in the field, utilize top-notch components – particularly the flex cables and connectors crucial to the twist capsule – tailor the solution to fit the system flawlessly, conduct thorough product prequalification, and perform rigorous testing. Cristek is the partner that meets these criteria.

A RESPECTED TWIST CAPSULE MANUFACTURER

Since 2008, Cristek has specialized in the design and production of twist capsules. Our product line includes a variety of commercial-grade twist capsules with modular designs, offering a broad range of options at a lower cost, with shorter lead times. These twist capsule designs incorporate the company's own military specification connectors and flex circuits, many of which are qualified for use in space programs and have passed essential qualification tests. By pre-qualifying their twist capsules, Cristek spares customers the expense and time of extensive testing.

MISSION ACCOMPLISHED

Cristek goes above and beyond simply delivering a dependable product by assigning a specialized engineering team to every customer project. This dedicated team guarantees not only the optimal solution but also smooth integration into the sub-system and system without any concessions. Moreover, they provide tailored solution designs and system adjustments to ensure ideal compatibility with the twist capsule.

The company's dedication to customer satisfaction shines through various areas:

- Providing in-house precision cleaning and shipping fixture supply, simplifying the integration process for clients.
- Enhancing customer service by transitioning from soldered joints to mechanical ones, increasing convenience and cost-effectiveness for future rework on the twist capsule.
- Prioritizing solution reliability through a meticulous in-house testing procedure, consisting of development, qualification, and final testing stages to ensure top-notch product quality, resulting in zero twist capsule field failures.
- Emphasizing punctual and precise delivery of twist capsules, never causing disruptions in customer production lines and consistently boosting customer efficiency by delivering on schedule.

A History of Cristek in Space

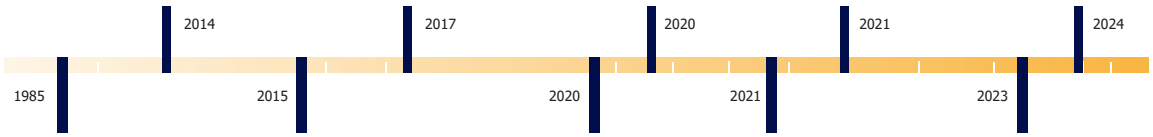
Orion Spacecraft

Viasat-3 Hydra

Dream Chaser RF

SDA LEO Constellations Tranche 0

Proliferated Warfighter Space Architecture's (PWSA) Fire Control

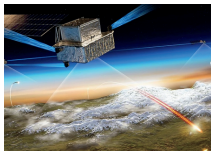


Cristek founded in Anaheim, CA

Cleanroom ISO7
X-ray capabilities added

Hypersonic and Ballistic Tracking Space Sensor Satellites

Thales Space



SDA LEO Constellations Tranche 1

ABOUT CRISTEK

Established in 1985, Cristek provides a unique combination of proven interconnect design, expertise in flex cables, extensive manufacturing knowledge, and exceptional customer service. The company excels in engineering support, quick responses to customer needs, connector proficiency, and qualifications for space applications.

Utilizing vertical integration and engineering expertise, Cristek distinguishes itself as a premier manufacturer of cables, harnesses, and complex electromechanical assemblies. Among interconnect suppliers, Cristek is renowned for its specialization in DC through 67 GHz RF frequency connectors, cables, and electromechanical design and assembly. Moreover, Cristek is recognized for its skill in nano-miniature and microminiature connector technology, offering standard applications and customized solutions for high-density, high-reliability interconnects in both rectangular and circular formats.

Following its acquisition by Qnnect in November 2022, Cristek's reputation as a top-notch manufacturer of specialty interconnect products and assemblies has been further reinforced. Qnnect, a global leader in advanced electronic interconnect solutions for high-density and high-speed applications, boasts over a century of combined experience in catering to original equipment manufacturers in Defense & Aerospace, Hi-Rel, Semiconductor, Test & Measurement, and Consumer Electronics sectors.

At Cristek, our approach involves designing the complete solution by seamlessly integrating electrical performance parameters, mechanical packaging limitations, environmental conditions of end applications, and safety agency requirements.

Cristek is certified and adheres to the following standards:

- AS9100/ISO9001
- ITAR Registered
- IPC J-STD-001S
- IPC-A-610S
- IPC/WHMA-A-620S
- MIL-PRF-27G
- MIL-STD-981C
- MIL-STD-202
- MIL-C-15305
- MIL-PRF-21038
- NADCAP - AC7121

MANAGEMENT SYSTEM CERTIFICATION DNV ISO 9001 = AS9100

ISO 13485:2016

IPC Certified IPC-A-610

IPC J-STD-001

IPC Certified IPC/WHMA-A-620

Accredited Nadcap™ AC7121 Electronics