

# Rotary Joints Deliver High Power to 170 GHz

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**A**ntennas with rotary joints are widely used in radar systems to scan targets, in ground stations to track satellites and in radio telescopes to scan the sky. For optimum system performance, the rotary joints should minimize amplitude and phase variations when rotated. Eravant has developed an updated series of rotary joints operating over full waveguide bands from 50 to 170 GHz. An example of one of these rotary joints is shown in **Figure 1**. With over 360 degrees of rotation, members of the SAN series of rotary joints limit variations to as little as 0.2 dB in amplitude and 2.0 degrees in phase, as shown in **Table 1**.

A variety of rotary joints have been developed over the years, with a relatively small set of design strategies prevailing due to their consistently favorable results. One such design approach uses the TE-01 propagation mode to pass signals through circular waveguides positioned along the axis of the rotary joint. The

TE-01 mode concentrates electromagnetic energy away from the waveguide wall. It also supports higher power levels than other waveguide modes without generating longitudinal currents on waveguide surfaces. By avoiding longitudinal currents, TE-01-based rotary joints do not require electrical continuity between the rotating and stationary waveguides. The non-contacting electrical interfaces provide low insertion loss, good impedance matching and excellent amplitude and phase stability.

The SAN series of rotary joints incorporates the TE-01 design approach and combines it with an improved mode converter design. The mode converter employs an eight-way signal divider/combiner network that feeds a circular array of rectangular waveguide ports surrounding a circular waveguide section, as shown in **Figure 2**. The symmetry of the mode converter suppresses unwanted propagation modes and limits the distortion of electromagnetic fields within the circular waveguide, enabling good impedance matching and avoiding spurious resonances.

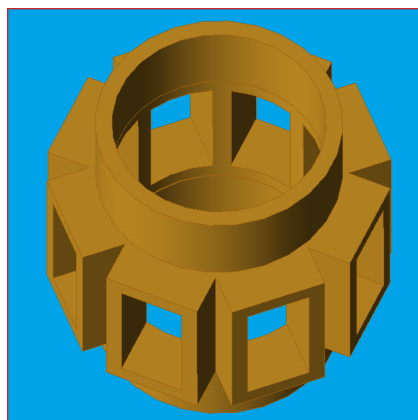
The signal divider/combiner in the mode converter is similar to discrete waveguide



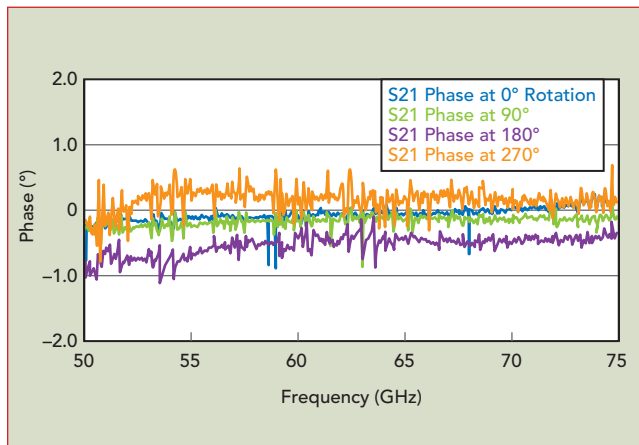
▲ Fig. 1 Rotary joint.

**TABLE 1**  
SAN SERIES HIGH-POWER ROTARY JOINTS

Model	Frequency Range (GHz)	Configuration	Insertion Loss (dB)	Loss Variation (dB)	Phase Variation (°)
SAN-06I06I-S1	110 to 170	In-Line	2.5	0.4	4.0
SAN-06I06R-S1	110 to 170	L-Style	2.3	0.4	3.5
SAN-06R06I-S1	110 to 170	L-Reverse	2.3	0.4	3.5
SAN-06R06R-S1	110 to 170	U-Style	2.3	0.4	3.5
SAN-10I10I-S1	75 to 110	In-Line	2.0	0.2	3.0
SAN-10I10R-S1	75 to 110	L-Style	1.7	0.2	2.5
SAN-10R10I-S1	75 to 110	L-Reverse	1.7	0.2	2.5
SAN-10R10R-S1	75 to 110	U-Style	1.7	0.2	2.5
SAN-12I12I-S1	60 to 90	In-Line	1.7	0.2	3.0
SAN-12I12R-S1	60 to 90	L-Style	1.5	0.2	2.5
SAN-12R12I-S1	60 to 90	L-Reverse	1.5	0.2	2.5
SAN-12R12R-S1	60 to 90	U-Style	1.5	0.2	2.5
SAN-15I15I-S1	50 to 75	In-Line	1.5	0.2	2.5
SAN-15I15R-S1	50 to 75	L-Style	1.2	0.2	2.0
SAN-15R15I-S1	50 to 75	L-Reverse	1.2	0.2	2.0
SAN-15R15R-S1	50 to 75	U-Style	1.2	0.2	2.0



▲ Fig. 2 Eight-way signal divider/combiner network.



▲ Fig. 3 V-Band phase performance.

feed networks that are often used at lower frequencies. The improved waveguide network is machined into a solid block of metal that surrounds the circular waveguide, avoiding the cost and the difficulty of connecting multiple waveguide sections. Additionally, the solid-block network is easily adapted to different waveguide bands by mechanically scaling the structure.

Configuration options for the rotary joints include an in-line arrangement for both ports (I/I). Other configurations include the L-style (I/R), the reversed L-style (R/I) and the U-style (R/R). L-style rotary joints have one right-angle waveguide port mounted on the rotating end of the assembly. Reversed L-style models have one right-angle port mounted on the stationary end. U-style rotary joints have right-angle ports on both ends. The right-angle waveguide ports are oriented

with their E-plane perpendicular to the axis of rotation.

All the rotary joints can handle up to 250 W of RF power while rotating at 60 RPM or more. They are constructed from stainless steel and gold-plated aluminum with UG-385/U or UG-387/U anti-cocking flanges on the waveguide ports. Typical mid-band insertion loss ranges from 1.2 dB for V-Band models up to 2.5 dB for W-Band versions. For V-Band models, the minimum return loss is 12 dB and the maximum insertion loss is 3.0 dB from 50 to 75 GHz. Phase variation over 360 degrees of rotation is typically within  $\pm 1.0$  degree for V-Band models, as shown in **Figure 3**. This level of phase control is roughly equivalent to maintaining 0.001 in. of end-to-end stability, indicating the level of mechanical precision built into the rotary joints.

For WR06 versions of the rotary joints, the circular mounting flange on the stationary side measures 2.5 in. in diameter while the rotating side of the assembly is 2.0 in. in diameter. For the WR10, WR12 and WR15 models, the mounting flange on the stationary side is 3.25 in. in diameter while the rotating side of the assembly is 2.75 in. in diameter. The temperature range of the rotary joints is  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  with an environmental rating of IP40 to reject foreign objects larger than 1 mm.

The rotary joints complement a wide selection of antennas and accessories offered by Eravant, including reflector antennas and lens-correct horn antennas that are often found in scanning radar systems, satellite-tracking communication links and mobile communication systems. In a common radar application, a rotary joint is combined with a high-sensitivity Doppler radar sensor, a rotating servo mechanism and a suitable antenna to scan the terrain and detect moving objects such as personnel, drones and low-flying aircraft. For additional information see [eravant.com/products/antenna-feeds/waveguide-rotary-joints](http://eravant.com/products/antenna-feeds/waveguide-rotary-joints).

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