Waveguide Fibre Optic Rotary Joint for Antenna Mounted Radar Receivers

SELEX-SI Gematronik

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Motivation

There is a large number of microwave systems operating with high-power transmitters and rotating antennas, in particular radar systems. Such systems typically have the rotating antenna and transmitter and receiver entities in separate locations, primarily due to size considerations. Since receivers are getting more compact due to the application of MMIC's (*Monolithic Microwave Integrated Circuits*) and digital reception technologies, it has become possible to mount the receivers directly at the antenna. Such a configuration, commonly known as antenna-mounted receiver or receiver over-elevation, can reduce losses and increase sensitivity and/or radar range. However the increased performance of integrated digital receivers in terms of range resolution and dynamic range requires the transfer of digital data with very high bandwidth from the antenna over the rotating interface to the post-processing computers, typically located in the radar room. This can only be obtained by applying network standards which support Gigabit Ethernet data rates of 1000MBit/s. It was first attempted to implement this configuration using commercially available 1000Base-T slip rings. Our investigation quickly showed that none of the few products claiming to support this bandwidth was able to reliably deliver Gigabit data rates.. Since we urgently needed such a component to realize a receiver over elevation radar architecture, we decided to develop an integrated WG/FORJ (see Fig.1).

The fibre optic interface is compliant with optical transmission standards and is able to generate eight separate Gigabit Ethernet channels over one optical fibre. This capacity allows the independent setup of e.g. data and control communication channels.

Design of the Waveguide Fibre Optic Rotary Joint

The WG/FORJ is developed and manufactured by Selex-SI. The optical rotary joint is a high precision mechanical part where two single mode fibres are positioned face to face on a specified pitch. The maximum rotating speed is specified with 2000 rpm for temperatures from -40°C to +85°C. The lifetime of the optical rotary joint averages more than 10^8 rotations. In a radar environment this yields a lifetime of about 12 years.

The optical rotary joint has two parts- a rotating (Rotor) and fixed part (Stator). The optical Rotor is connected with a tappet to the rotating part of the waveguide rotary joint (WGRJ). The optical Stator is connected to the fixed part of the WGRJ. The WGRJ can be adapted to the radar system configuration. It is possible to use either single channel or dual channel waveguide rotary joints for the WG/FORJ configuration. Single and dual channel rotary joints use coaxial transitions to transfer the microwave power over the rotating axis. The single mode fibre runs through the coaxial wire to establish the optical connection from Stator to Rotor. In addition the RF and optical part of the WG/FORJ is separately maintainable.

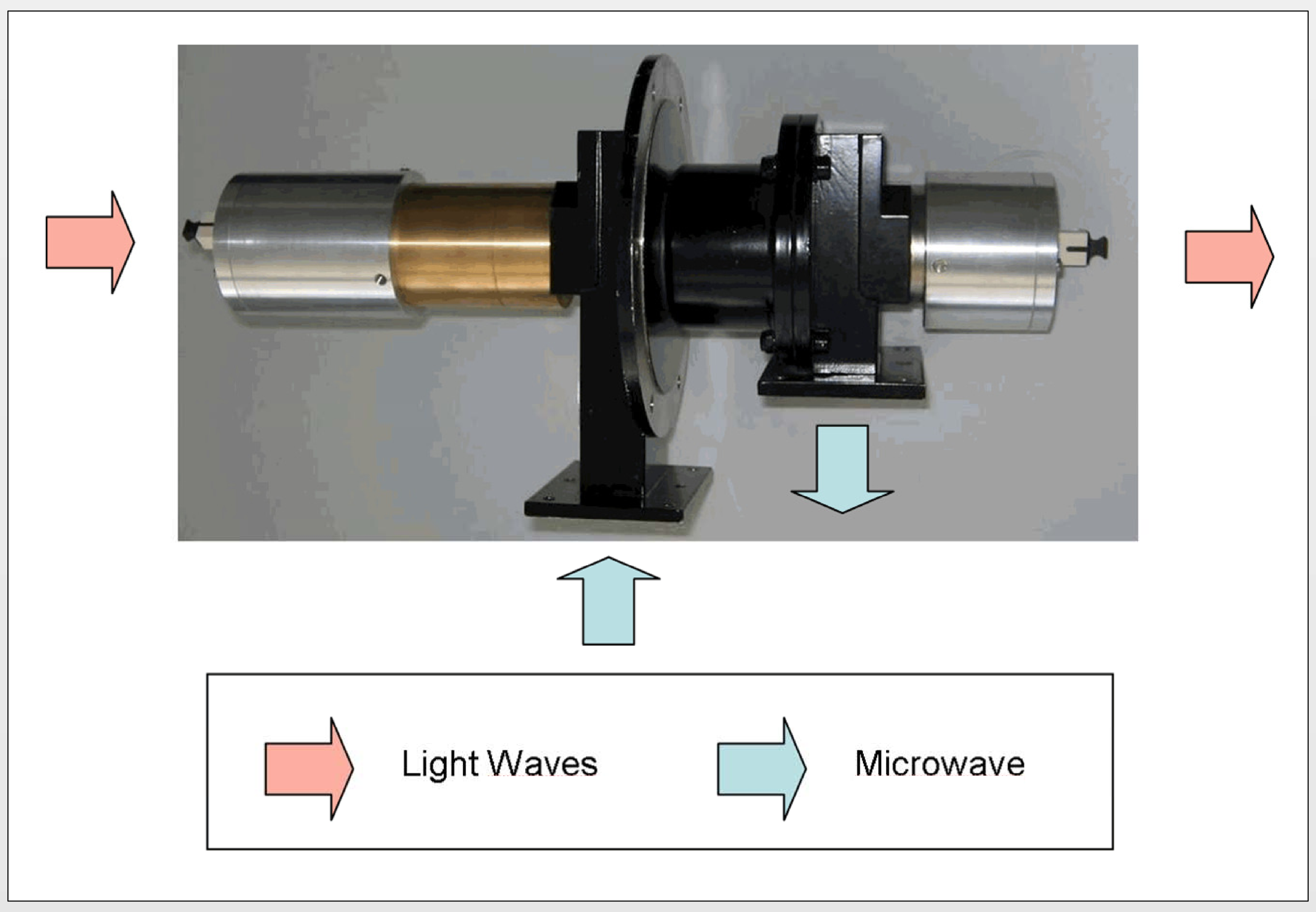

Figure 1: Design example of a single channel WG/FORJ with optical path in red and microwave path in light blue

The optical Gigabit Ethernet network

By using wavelength multiplexing and a proven design integrated fibre optic rotary joint inside a waveguide rotary joint, we are able to generate multiple gigabit Ethernet channels over one fibre optic cable. Also, both 100 Base T and 10 Base T connections are possible. Special configurations, like real time angle data transmission from the encoder can also be considered. Figure 2 shows an example of 4 gigabit Ethernet channels. The number of channels depends on the bandwidth each wavelength channel uses. The present design is capable of establishing eight gigabit Ethernet channels by using 16 wavelengths over one single mode fibre optic cable.

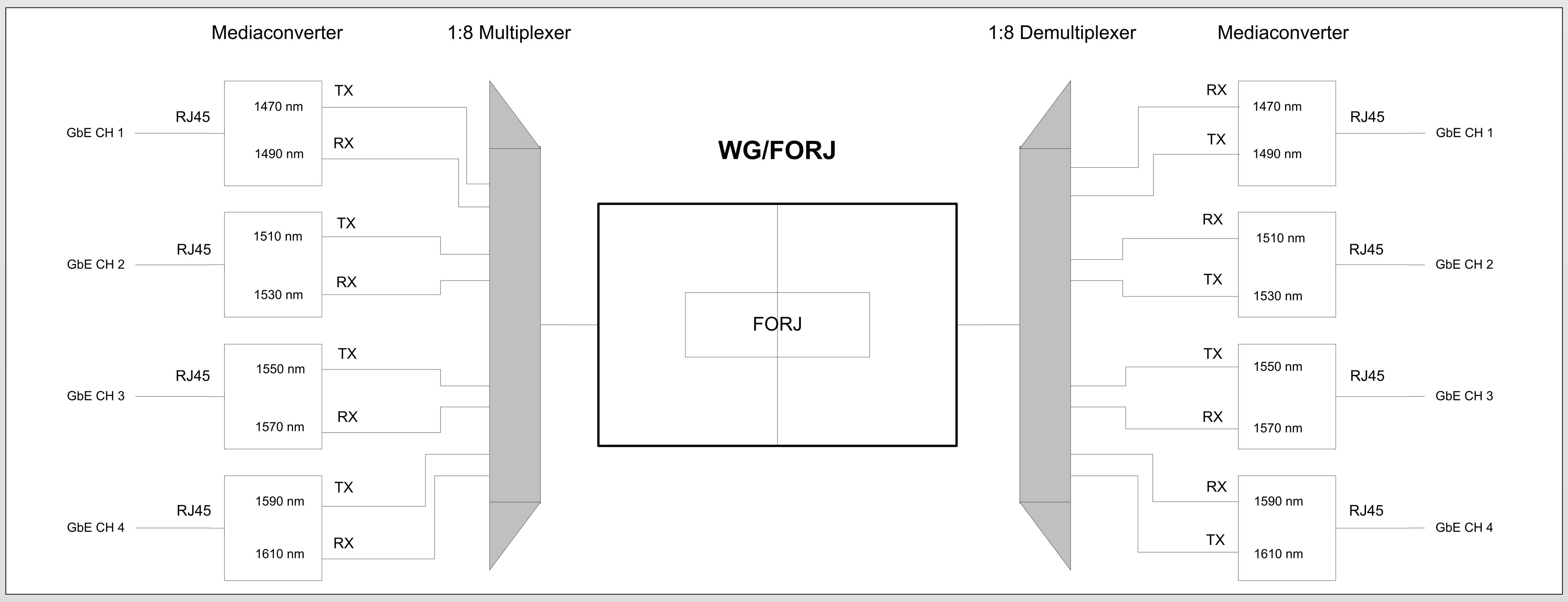

Figure 2: Optical Network example with 4 GbE channels by using media converters, optical multiplexers, optical demultiplexers and the WG/FORJ.

Application of the WG/FORJ with an antenna-mounted radar receiver

In Fig. 3 the application of the WG/FORJ is shown. The WG/FORJ is used in a radar architecture based on an antenna-mounted receiver (AMR, also called Receiver-Over-Elevation, RoEl). The WG/FORJ is responsible for transfer of radar I/Q data via a Gigabit Ethernet protocol from the digital receiver mounted at the antenna to the signal processor.

The processing of the radar signal is designed in a cascaded manner. The digital receiver digitizes IF signals and converts them to baseband. It also provides all signals for the synchronization of the radar. The signal processor performs clutter filtering, signal thresholding and moment estimation.

On the right antenna counterweight the cooled receiver box is mounted containing both analogue and digital receiver parts. Above the receiver box, the dual polarisation waveguide network with TR- limiters is located near the analogue receiver interface. This new radar architecture provides low receiver waveguide losses and therefore high receiver sensitivity. The optical data transmission from the antenna to the signal processor ensures electromagnetic compatibility in the presence of high-power RF signals (radar transmitter), emissions caused by digital servo drives and lighting. In standard radar systems just a single slipring for both data and high power transmission is used. This simultaneous transmission of data and high power has been shown to cause EMC related problems. Naturally, all radar systems need secure data transmission to and from the antenna elevation platform. These data can include BiTE (Build in Test Equipment) messages transfer, digital I/O transfer, angle data and high voltage power for the Engines over sliprings. The WG/FORJ is an answer to all these problems.

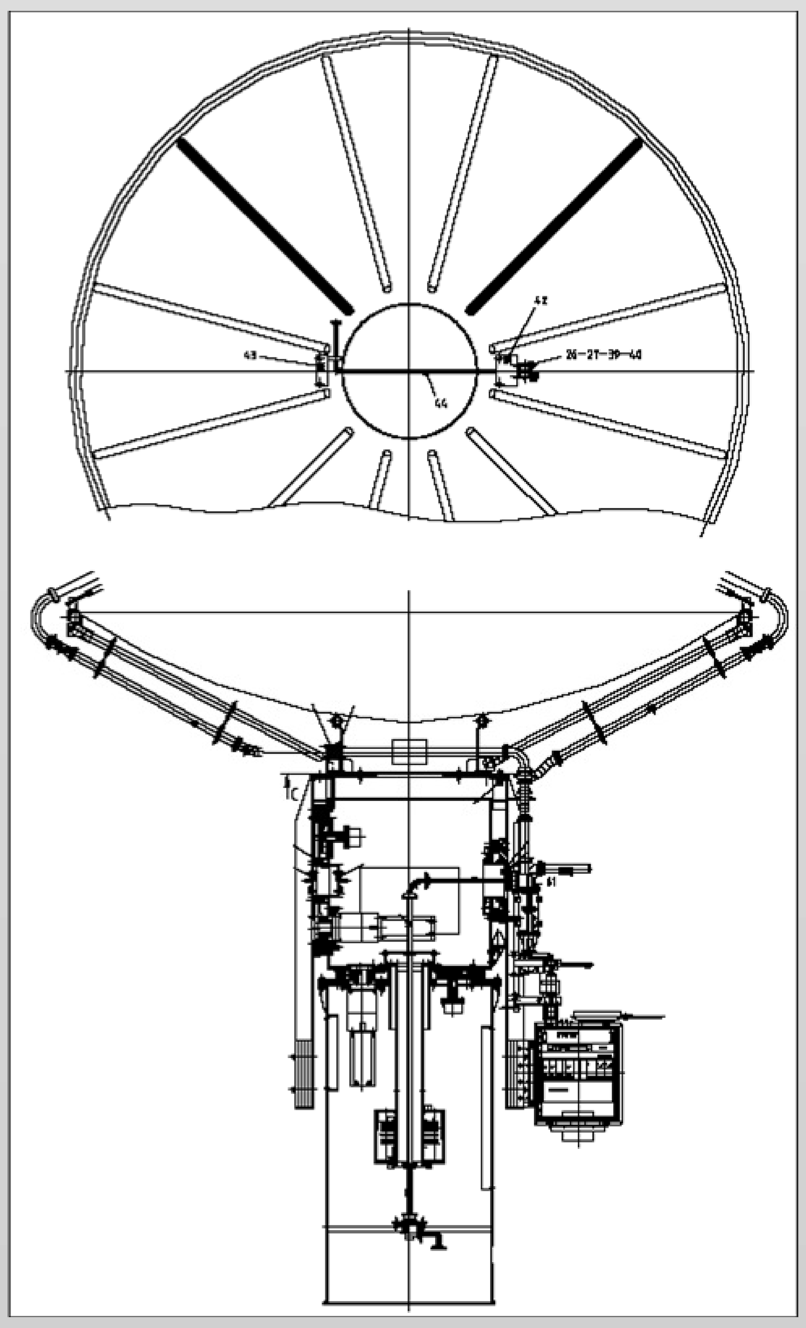

Figure 3: Selex-SI Receiver over Elevation Radar System. Analogue and digital receiver mounted at the right antenna weight.

Conclusions

A solution was presented for the simultaneous transfer of high power microwave and high bandwidth digital data between a stationary and a rotating platform. The WG/FORJ allows the mounting of digital receivers close to the radar antenna without signal processor. This improves the radar data quality significantly and allows the real time raw data analysis for research purposes. In addition the optical transfer of the data substantially enhances the electromagnetic compatibility.

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