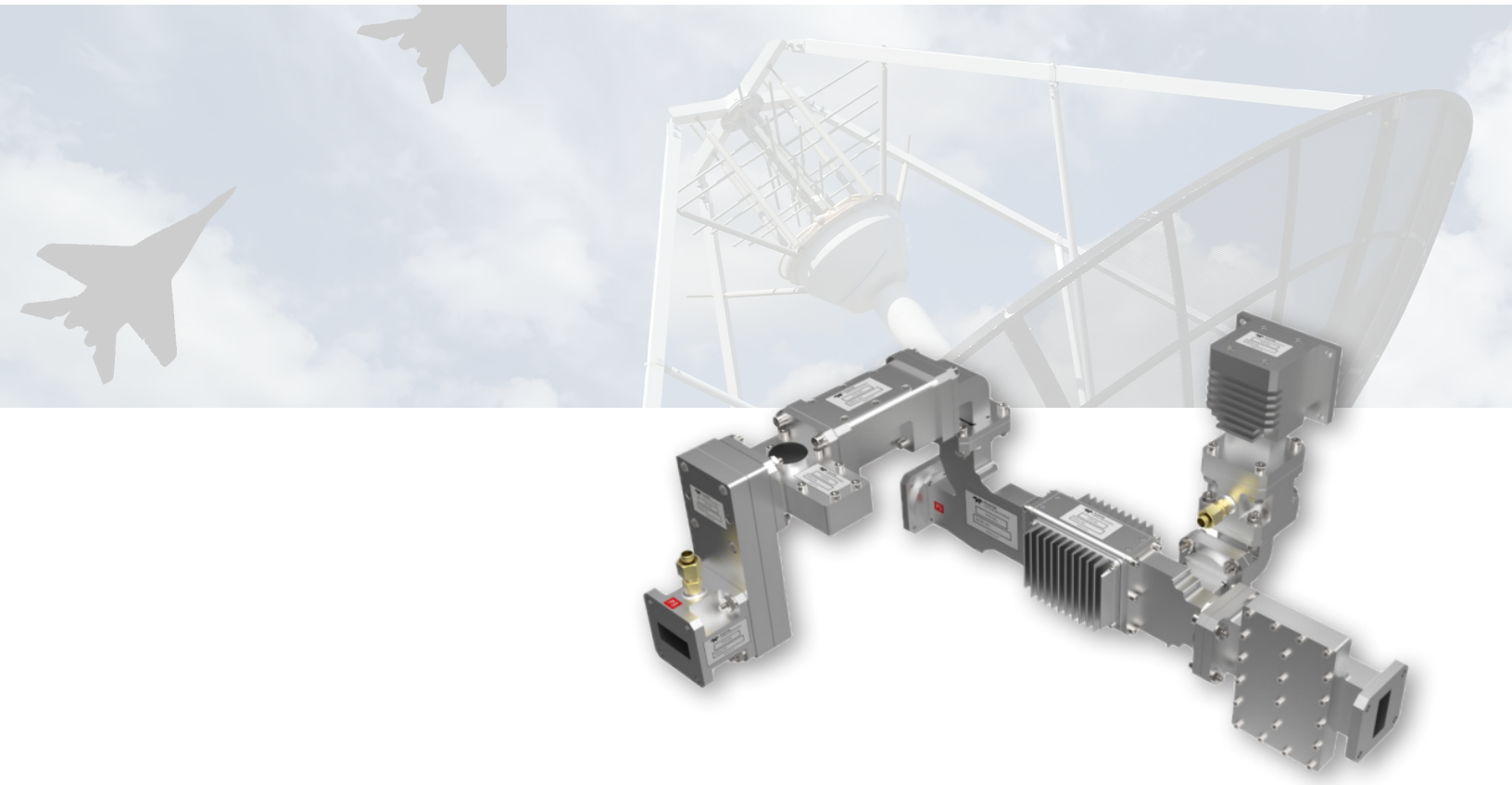
X-Band Surveillance Radar

Taking a Holistic Systems Approach



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Overview

Teledyne Lincoln Microwave has seen a growing demand from customers to supply integrated assemblies which provide the functionality normally delivered by multiple discreet components with the benefit of higher system performance overall. A recent example was an X-Band radar receiver sub-system assembly for use in a ground-based surveillance radar.

Teledyne Lincoln Microwave was approached by a customer to design a waveguide limiter component for a radar application. The **performance specified for the limiter was unusually demanding** and therefore costly for an application of this kind.

Working in conjunction with the customer's engineering group, Teledyne Lincoln Microwave's low noise amplifier, circulator/ Isolator and coupler designers were brought together with systems engineering expertise in a **joint technical team**. By re-balancing the contribution made by each component to the sub-system noise figure, the team was able to create the headroom necessary to **introduce additional functionality and improve the sub-system's overall performance**.

Background

Our customer had been awarded a contract to upgrade an outmoded surveillance radar installation. The **existing radar**'s transmitter and receiver were located in an air conditioned cabin **remote from the antenna**. The noise and attenuation losses introduced by the transmission lines between the cabin and antenna meant that the overall level of **performance targeted for the new radar could not be achieved**.

Teledyne's new design **relocated the radar's receiver sub-assembly from the air-conditioned cabin to the antenna**. Enabling the receiver to be positioned on the antenna demanded that the sub-assembly meet a constrained and **complex space envelope as well as a challenging weight budget**.

Reliability was recognized as a critical issue to address. When operational, the radar installation would be unmanned with planned maintenance activity minimized. Any unplanned maintenance would be costly, with an **unacceptable impact on system availability**.

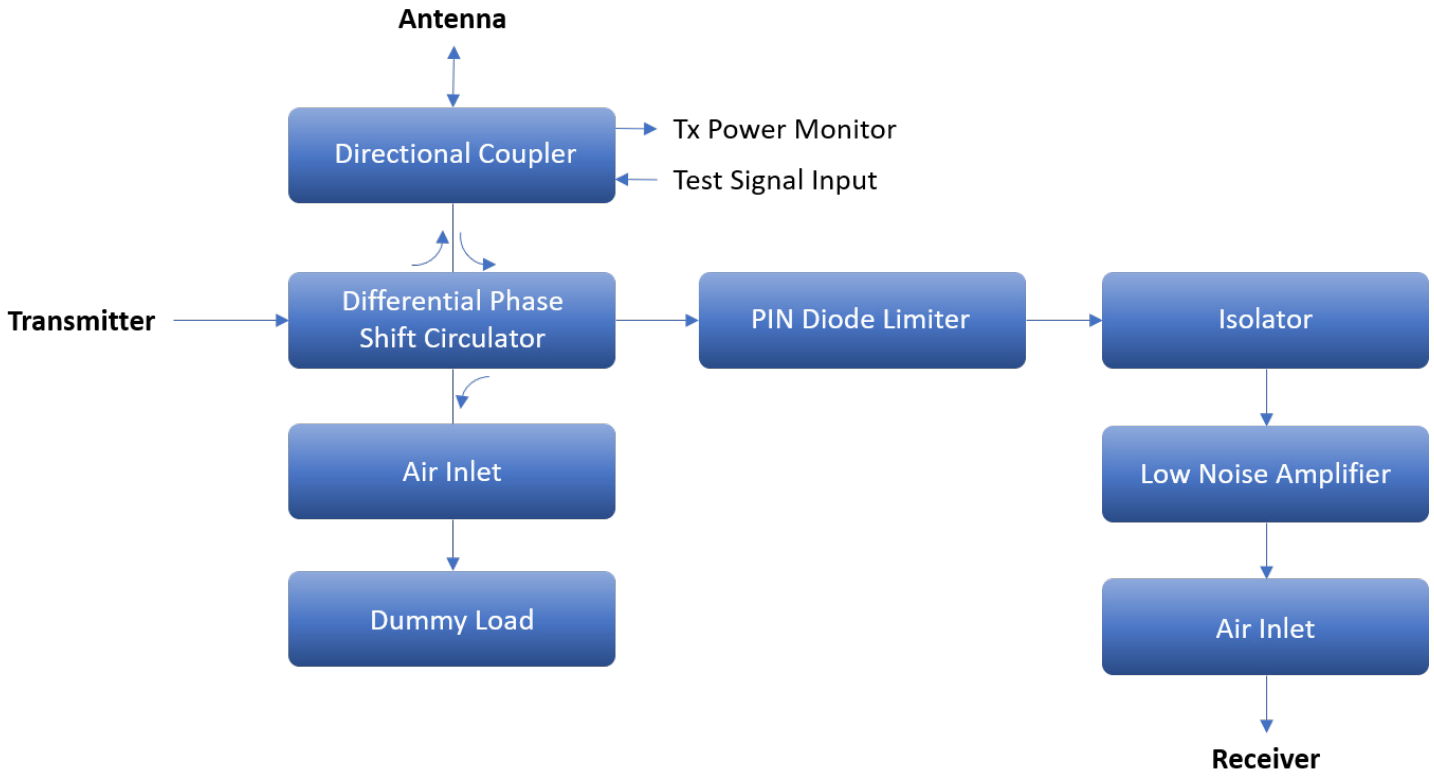
Other design considerations included:

- The control of heat dissipation
- Environmental durability
- Waveguide pressurization
- Minimisation of loss attributable to cable interconnects and waveguide interfaces.

Approach

Our customer initially approached Teledyne Lincoln Microwave with a requirement for a limiter function. The requested level of performance for the limiter was **on the edge of viability** and unusually demanding for an application of this type.

Working in conjunction with the customer's engineering group, Teledyne Lincoln Microwave's team performed a review of the receiver sub-system component line-up (**cascaded noise figure analysis**) which identified a number of opportunities to optimise component selections. These design modifications promised an **overall higher performing sub-system**.



Sub-system functional block diagram

The Solution

The improved performance was made possible by first **identifying a number of small reductions** in the sub-system's insertion losses. A significant contribution to this was made by exchanging an off-the-shelf, connectorized LNA for a **Teledyne Lincoln Microwave LNA with waveguide input**. This eliminated the requirement for a waveguide to coaxial adapter. The LNA waveguide interface was later customized to enable the component to be located in the available space envelope.

This afforded the design margin necessary to **enable the inclusion of an isolator** at the output of the limiter; the isolator stabilised the low noise amplifier performance and thereby **made it possible for the specification of the limiter to be eased**.

Once the cascaded noise figure analysis was complete and the line-up defined, **other sub-system issues were addressed**. Foremost amongst these was the design of a mechanical layout to meet the dual constraints of a complex space envelope and a challenging weight budget.

The solution was found in adding **customized interfaces to our standard components, including the LN**A. This resulted in the **unique structure** seen in the image which remained within the available weight budget.

Other mechanical considerations included locating the limiter's **field replaceable gas switch** in an accessible position, thereby facilitating in-service, in-situ maintenance to **maximise system availability**.

During acceptance testing the resultant sub-system solution **outperformed the target specification**, validating the customer's decision to enhance its system engineering capability by utilizing the specialized component expertise of the Teledyne Lincoln Microwave team.

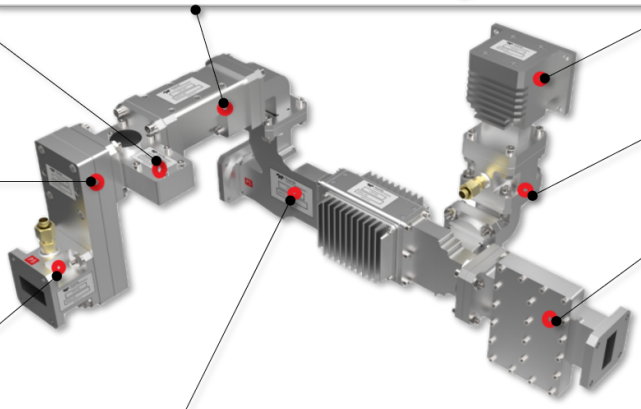
Isolator
Insertion Loss: Typically 0.2dB
Frequency: 9.5GHz – 9.6GHz
Peak Power: 10W

Receiver Protector / Limiter
Insertion Loss: 0.6dB
Frequency: 9.5GHz – 9.6GHz
Peak Power: 60kW

Load
Full fault, Mean Power: 1MW max.
Full Fault power duration: 1 sec. max

Low Noise Amplifier
Frequency Range: 9.5 – 9.6GHz
Input power level: +20 dBm CW max.
Gain Window: 20-25 dB
Noise Figure: 1.5 dB max.

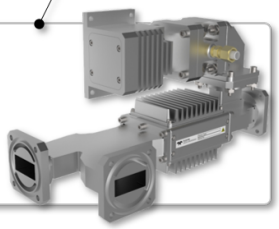
Air Inlet
Leak rate:
.001 Pa x m^3/sec max



Air Inlet
Leak rate:
.001 Pa x m^3/sec max

Directional Coupler
Application: The coupler operation is to transmit the main power through the unit towards the antenna. A sample of power is coupled into the secondary guides, at a level 30dB below the main power.

Differential Phase Shift Circulator
Frequency range: 9.50 – 9.60GHz
Peak operating power: 60kW max.
Isolation: >20dB
Insertion Loss: <0.3dB
Bandwidth: Typically >10%



Subsystem solution successfully employed in surveillance radar application

Summary

Through **intimate knowledge of each component**, combined with a rigorous system engineering approach, Teledyne Lincoln Microwave was able to **improve the size, weight and RF performance** of the microwave subsystem. This allowed relocation of the X-band surveillance radar front end to the antenna, while improving maintainability and closing the overall system link budget.

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