TRIAD RF
A COMROD COMPANY

TECH BRIEF

Build or Buy: Comparing Assembled and Integrated ISR Link Solutions

Operators of unmanned systems and vehicles rely on a wide range of intelligence, surveillance, and reconnaissance (ISR) technology to complete critical aspects of their missions. Unmanned systems, including unmanned aerial systems (UAS), unmanned ground vehicles (UGVs), and unmanned surface vehicles (USVs), that use sensors, cameras, signal intelligence (SIGINT) modules, radar, and other technologies generate a vast amount of data. High throughput and long-range radio links are essential for these systems to communicate. These systems also require ultra-reliable command and control connectivity over long distances regardless of the weather. In adverse shock, vibration, or thermal conditions, turnkey ISR link solutions can offer more reliable and effective performance compared to "bolt-on" amplification systems.

INTRODUCTION

There is a wide selection of highly reliable and high throughput radio systems capable of operating in the most adverse spectral conditions. Companies such as Silvus Technologies, Persistent Systems, Domo Tactical Communications, and Doodle Labs are among the radio manufacturers of choice for UAS when a high data-rate, long distance link is needed. All of these radios are capable of UDP throughputs in excess of 50 Mbps, which can easily support data-intensive tasks such as multiple HD video feeds.

Creating a dependable, long-distance ISR link requires optimization of RF margins.

A common way to increase an ISR link's range is to connect a bi-directional amplifier (BDA) in line with the radio's RF port and the antenna. For many modern multiple-input-multiple-output (MIMO) radios, up to four individual BDAs may be required to accomplish this.

Creating a dependable, long-distance ISR link requires optimization of RF margins. It is essential to ensure there is adequate margin to:

- Overcome free space path loss over distance
- Ensure the signal arrives at the receiver (RX) with sufficient signal-to-noise (SNR) to meet the minimum signal quality required for successful reception and demodulation
- Present a signal level that rises above electromagnetic interference (EMI), that may originate from either co-located systems in the vehicle, or from man-made RF noise present in the area of operations.

Achieving acceptable throughput over shorter (<10 km) hops is easily accomplished with the default 1-3W output power per channel the aforementioned radios are capable of. However, when a longer link needs to be closed, or the radios are not operating at their maximum throughput over a target distance, increasing the link's RF power is one of several quick and viable methods for addressing this problem. A common way of increasing an ISR link's RF power is to add a bi-directional amplifier (BDA) connected to a multi-input-multi-output (MIMO) radio inline with the RF path to the antenna. This approach may pose challenges to the unmanned system operator that high performance, turnkey ISR Link solutions won't.

This technical brief endeavors to describe to readers the potential issues associated with deploying "bolt-on" ISR link signal boosting systems, and several ways that turnkey ISR Link solutions result in superior performance and more reliable systems.

Hazards of "Bolt-on" ISR Link Solutions

At first glance, the setup in *Figure 1* seems straightforward and may appear to be functional once assembled. The setup will likely allow for the BDA to perform amplification and boost the signal in both directions, which should result in an improved link. Unfortunately, integrations like these consistently under-perform, sometimes to the point where adding a BDA or amplifier actually results in ***degraded link performance*** that is worse than without the BDA assembly. These bolt-ons may also present several additional challenges to troubleshoot if errors or anomalous events occur.

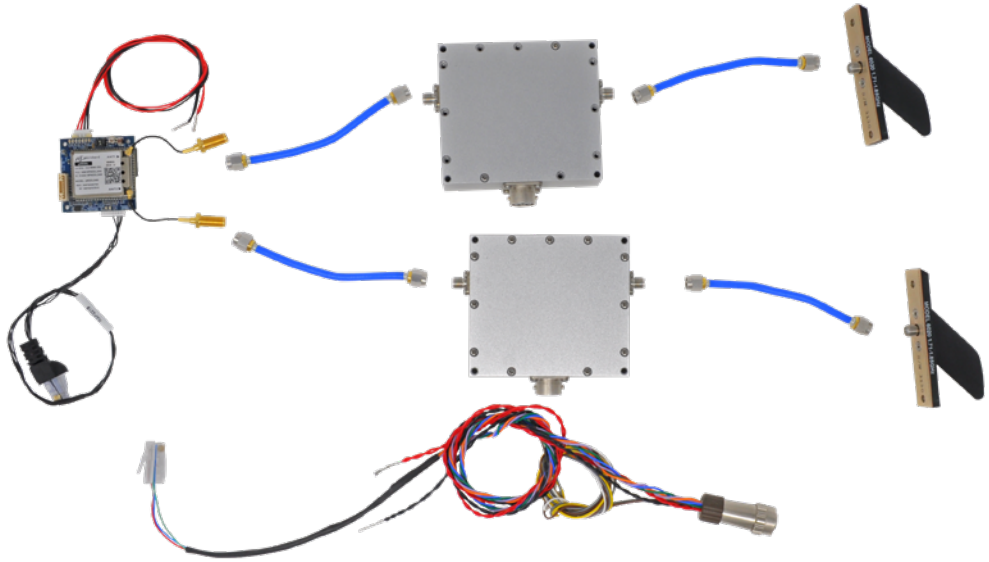


Figure 1

A "bolt-on" bi-directional amplifier (BDA) ISR link radio assembly often results in a cluttered installation that may suffer from several performance degrading factors.

Unstable and Inaccurate Power Output Degrades Link Reliability and Performance

Active components within both the radio and BDA modules have varied flatness over frequency, and also drift in power output over temperature. A 1 dB variation in power isn't much of a concern when operating around 1 W, as it amounts to approximately 450 mW in total power drift. However, when operating at 20 W, this compounded variation results in over 9 W of power drift. If this drift is considered at both ends of the link, the ±1 dB variation adds up to nearly an 18 W range of output power difference from the link's target power.

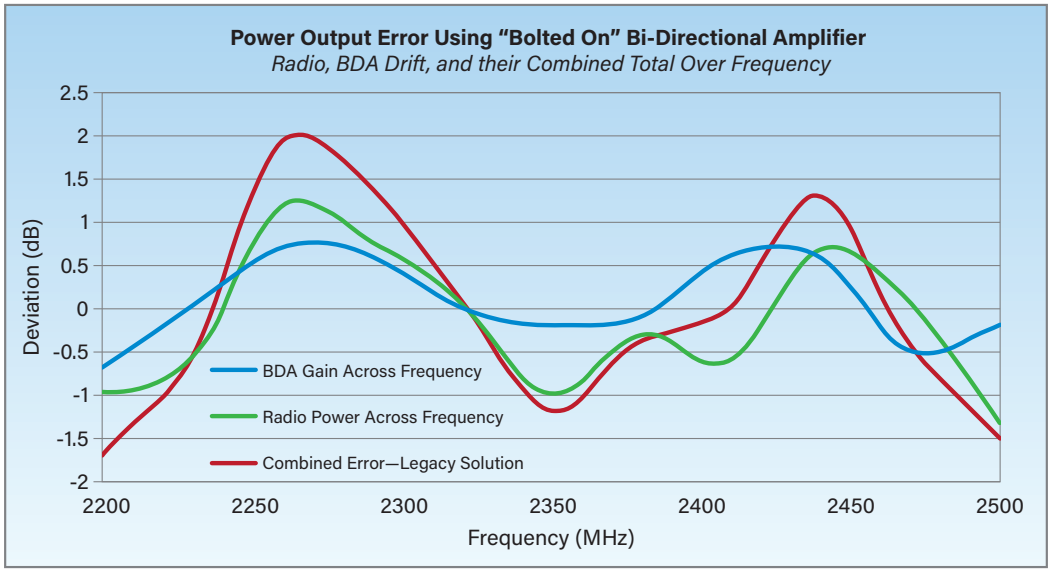


Figure 2

The combined error of the system power drift with bolt-on BDA integration can result in tens of percent of link distance reduction in real-world conditions.

When various subsystems components are connected together, their errors are "stacked" and the differences in output power for the overall link can be significant. The red line in *Figure 2* shows a 3.5 dB total inconsistency in power output across frequency. These inconsistencies can affect the radio link's range by ***over 30%*** over the course of a single flight test. RF output power that drifts too low or high during operation can cause unexpected link failures, especially when a specific targeted data rate needs to be achieved.

Bolt-on BDA Integration Adds Size, Weight, and Reduces Power Efficiency

When performing a bolt-on BDA integration to boost a radio's output power, several additional components are typically required. Each component added between the BDA and antenna adds weight and size to the system, and also imparts an increase in Rx noise figure, further degrading overall performance.

The traditional bolt-on BDA integration typically requires the following additional components:

- DC-DC converter for the BDA
- Radio-to-BDA RF Cable
- Radio Data Cable
- Radio-to-BDA UART Cable
- BDA Power Supply Cable
- BDA cooling system (Heatsinking, Fans, or Coldplate)

By far, the largest consumer of size and weight in any high power RF radio implementation is the cooling system. BDAs and Power amplifiers (PAs) contain many high power density RF integrated circuits (RFICs) that produce heat, and bolting on a heatsink not tailored to the application adds a significant amount of unnecessary weight. Therefore, optimizing the performance of a bolt-on BDA integration can become a significant design challenge with negative real-world consequences when maintaining signal integrity and controlling power consumption is essential.

Troubleshooting Nightmares Born From Bolt-on BDA Integrations

Optimizing the performance of a bolt-on BDA integration can become a significant design challenge with negative real-world consequences.

Most mainstream radio systems include a link testing utility built into their user interface. This is an excellent tool for troubleshooting the link. For instance, if a gimbal's video is dropping out or the C2 link is getting interrupted, the fundamental question of: "am I successfully passing enough Mbps over the air?" is easily answered by running a quick data throughput test. When using stand-alone radios, it is relatively straightforward to identify if antennas, radios, interconnects, or link budgeting is the root cause of the issue.

However, if a system is not obtaining the desired data rate from a "bolt-on" BDA integration, troubleshooting may become much more difficult. When a problem arises, the operator of the link is now faced with the following questions:

- Is the BDA being over-driven, causing the radio to switch to a lower modulation?
- Is the radio power output varying over temperature/frequency?
- Is the radio actually outputting the output power that it has been set to?
- Is the BDA's power output drifting over frequency/temperature?
- How can both Radio and BDA output powers be verified in-system?
- Is the BDA's RX characteristic degrading the radio's internal noise floor (NF)/ SNR calculations?

Having to troubleshoot the above issues after integration, or, even worse, during flight testing, can result in failed demonstrations, and customer loss of confidence in your UAS product, due to a weak radio link.

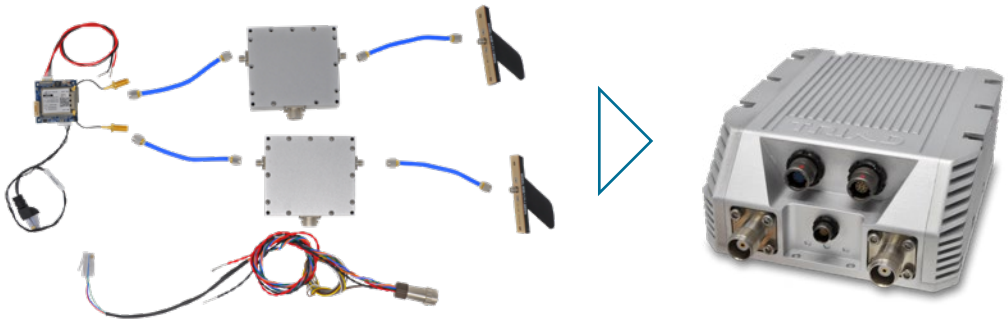
Integrated High Power Radio Module Advantages

Triad has developed and designed the Triad High Power Radio product line (THPR) to provide unmanned systems manufacturers with radio links that deliver unparalleled performance and the most reliable link possible. A THPR is comprised of all of the critical components of a radio link including the radio, BDAs, DCDC converters, control systems, and encoders. The result is a complete ISR Link solution built into a single, highly rugged package that takes up much less

space than a traditional bolt-on BDA integration. Triad's turnkey Amplified Radio Systems, the THPR series, can be a much more compact and weight saving solution compared to a typical bolt-on BDA integration as depicted in *Figure 3*. Along with space and weight savings, a turnkey ISR Link solution can provide several other key performance advantages over less sophisticated solutions.

Figure 3

A THPR system is a complete integration of a ultra-long distance radio link at a size, weight, and DC power that cannot be matched by combining discrete components.



Active Power Control Combats Subsystem Drift

A turnkey ISR link solution can employ active power control to ensure that both the RF Output Power and SNR delivered to the antennas remains ultra-stable in the presence of drift. This results in both greater reliability and ease of use of the equipment. For instance, Triad's THPR series amplified radios yield links that are easier to integrate, deploy, and maintain than other solutions in the industry.

Figure 4

A turnkey ISR link solution can outperform a bolt-on BDA integration by nearly a factor of ten in power accuracy.

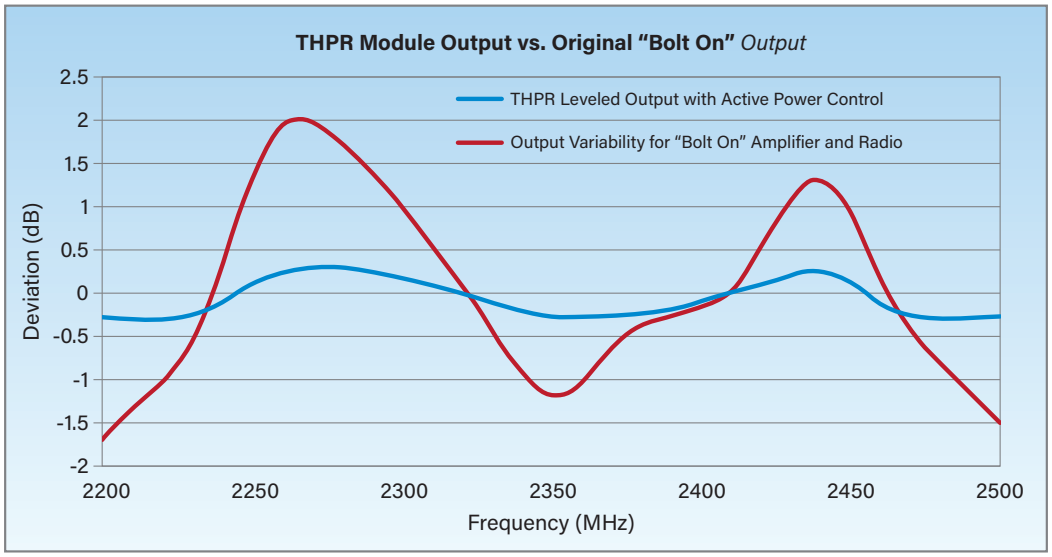


Figure 4 shows the THPR's output across frequency, which is accurate to approx 0.3 dB. The drift of all the components in the system is managed by the THPR's active power control and yields a very predictable, robust, and long-range link. In short, achieving the power setting necessary to meet a desired link margin is best achieved with a turnkey ISR link solution, as all previously uncontrollable radio/amplifier variability is compensated for internally.

Size, Weight, and Power (SWaP) Benefits

Triad's THPR modules have been designed using sophisticated thermal modeling techniques to manage heat without adding excessive weight or cost. This enables their use in extreme ambient temperatures without compromising RF performance or reliability. In addition, the power supply modules are tailored to fit both the radio and internal BDA modules. This removes the need for larger "brick" type DC-DC converters that are typically needed to match up the BDA, Radio, and system supply voltages.

All of the major components of a high power, long distance MIMO radio link are integrated in a single, turnkey ISR link solution.

Triad's THPR modules are designed to operate in extreme ambient temperatures, and achieve high performance without adding further weight to achieve thermal management. This results in reduced power requirements, system weight and cost, without compromising performance or reliability.

THPRs being qualified in Triad's custom-engineered MIMO test stands to ensure they deliver the promised data rate and power during distance testing.

Overcoming Troubleshooting Challenges With Pre-test, Pre-qual, and Built-in-test Features

THPR units are tested and verified to eliminate nearly all the excessive troubleshooting bolt-on BDA integrations inevitably require before fielding. The THPR module can measure actual RF power output levels at the antenna ports with an accuracy of 0.25 dB at any modulation. The output power can also be adjusted on the fly via USB connection, all without having to use the radio UI and waiting for reboots or updated radio settings to be saved. Each THPR comes from the factory with Data Rate, MCS, and Power Output tables included in their standard test data package, which helps to eliminate guesswork during system setup and troubleshooting.

CONCLUSION

Triad's THPR series Amplified Radio Solutions are a more robust and higher performing method of achieving success with a high power radio link in an unmanned system. The consolidation of many traditionally disparate parts into one turnkey assembly eliminates costly, time-consuming integration. Weeks of troubleshooting, rebuilding, and retesting can also be lost when self-assembled in-house solutions reach their failure point. Using Triad's THPR modules also provides a single point of contact when support is required. Triad's highly capable applications engineering and support team provide expert troubleshooting for any data link issue, be it DC/AC power, antennas, EMI, or anything else that may stand in the way of an ISR link's optional operation.

NEXT STEPS

The Triad Advantage

Seamlessly achieve optimized ISR radio links with a Triad Amplified Radio System. Learn more at **www.triadrf.com/radio-systems**

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