NON-TRADITIONAL IMPLEMENTATION OF A TRADITIONAL SAFETY SYSTEM

Paul Cook
Aerospace Instrumentation
Curtiss-Wright
Newtown, PA 18940, USA
PCook@curtisswright.com

ABSTRACT

Safety system implementation for Flight Termination involves the interconnection of specific signals from one (no redundancy) or both (redundancy) Flight Termination Receivers (FTR) to be telemetered to the ground for monitoring by the Range Safety Officer (RSO). The number of specific signals per FTR can be as high as 12 independent signals resulting in a large wire harness.

The addition of an RS-232 programming interface on the radar transponder and telemetry transmitters adds weight and cost, takes up space and creates installation and maintenance issues. This paper discusses how switching to a serial wiring approach, such as a multidrop bus, will reduce wiring and allow for other features including more in-depth status information and quick system configuration reprogramming.

INTRODUCTION

Safety system implementation for flight termination involves the interconnection of specific signals from one (no redundancy) or both (redundancy) flight termination receivers (FTR) to a PCM encoder for telemetering to the ground for monitoring by the range safety officer. The number of specific signals per FTR can be as high as 12 independent signals, resulting in a large wiring harness. The addition of an RS-232 programming interface on the radar transponder and telemetry transmitters adds weight and cost, takes up space and creates installation and maintenance issues. Moving to more modern DSP based RF products mitigates the need for the independent signals and wiring, eliminating the need for large wiring harnesses.

FLIGHT TERMINATION SYSTEM

Unmanned military systems, such as UAVs, missiles and targets, are typically fitted with an FTS. The purpose of such a system is to allow an individual, such as a range safety officer, to terminate the flight of a vehicle if it presents a risk to people or property. An FTS generally consists of a command console or other triggering device, a flight termination command encoder/modulator, an amplifier/ transmitter, a redundant flight termination receiver and a termination device. A system diagram of such is shown in figure 1.

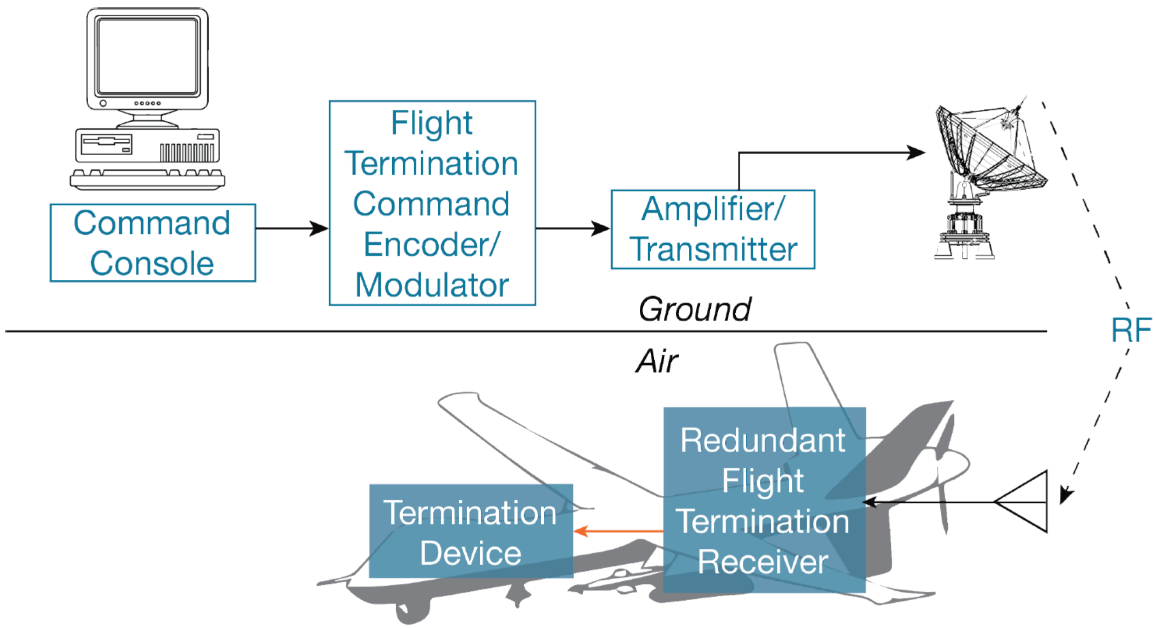

Figure 1: An example of a flight termination system

Figure 2 outlines the elements in a typical FTS. The RF section accepts an RF signal from an antenna input which is then demodulated. The dual redundant flight termination receivers are the elements that decode the tones and issue arm and terminate commands to the safe and arm device. The FTRs are also capable of outputting status information, such as power levels, temperature and receiver signal strength.

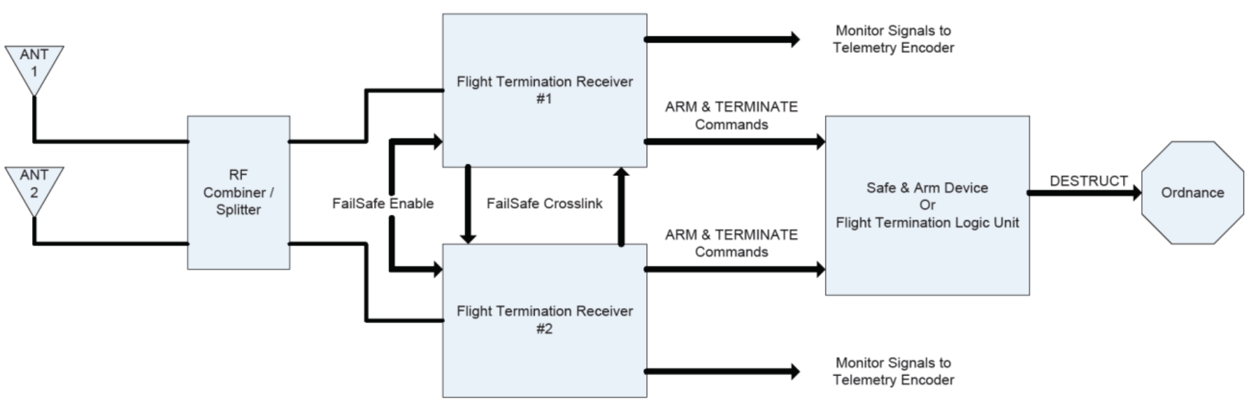

Figure 2: An overview of the elements of a typical FTS

A key requirement of an FTS is reliability. Any failure could lead to serious consequences and thus range safety officers are keen to ensure an FTS is working correctly. The first stage of this process is to ensure the system components are designed and manufactured to applicable standards and all relevant testing and quality controls have been successfully conducted. Preflight checks can be performed to try and catch any failures, as can monitoring the status of the system during flight.

In an ideal world, a range safety officer would have constant access to real-time built-in test (BIT) information from each element of the FTS. In reality, this is not typically the case however. First, it requires that one or more of the system elements provide BIT information. Second, this information must be packaged, along with any other information, encoded and sent to ground. In a traditional safety system this typically means extra wiring is required for each parameter (figure 3). This wiring is heavy, costly and creates a system that is more difficult to install and maintain.

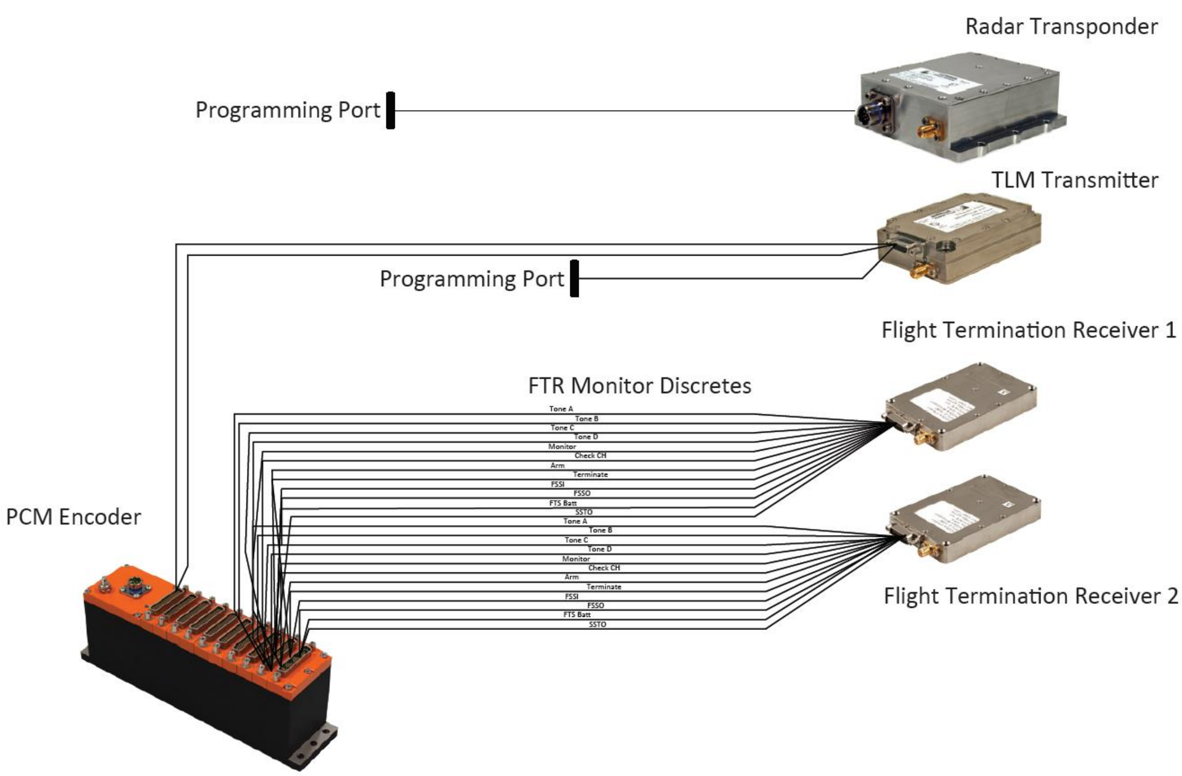

Figure 3: Traditional safety system monitoring

GOING SERIAL

One way to address the problem of extra wiring is to move from a parallel wiring system to a serial one. One method of implementing this is to use a multidrop bus, i.e. a bus where all hardware is connected to a single electrical circuit. A multi-drop configuration allows each piece of hardware to be assigned a unique address (“A1” as an example), addressed independently through a two wire, RS-485 communication bus. This eliminates the need for a large harness with the associated size, weight and cost savings.

In Figure 4, the devices on the bus are in a master-slave configuration with the PCM encoder as the master and the other devices as slaves. Except for the encoder, all devices default to be listeners on the bus. The PCM encoder sends out the preprogramming unit identification address (e.g. A1) to where the unit programmed with this address is now enabled to respond to commands from the encoder. The other devices on the bus remain as listeners. The encoder sends commands to the device of interest that responds with the information requested by the encoder.

The encoder then places this data into the PCM stream for transmission by the telemetry transmitter. Once the encoder accepts the response from the device, it terminates that session to place the device to listen mode only and starts a message string with the next device.

Command response in this system provides data that was generally not available in the past. For example, a C-band transponder that provides a receiver signal strength measurement can be used to place such data into the PCM stream for monitoring. This is also true for the status from the flight termination receivers.

One additional feature of the RS-485 multi-drop bus is having the ability to program the center frequency of the transmitter, transponder, and the FTRs at the telepack level by adding access to the 2 wire, RS-485 bus to the section through an external connector. This access provides the user with the capability of a fast change of frequencies at the last minute through a simple COM port arrangement mitigating the need to disassemble the section to change the frequencies.

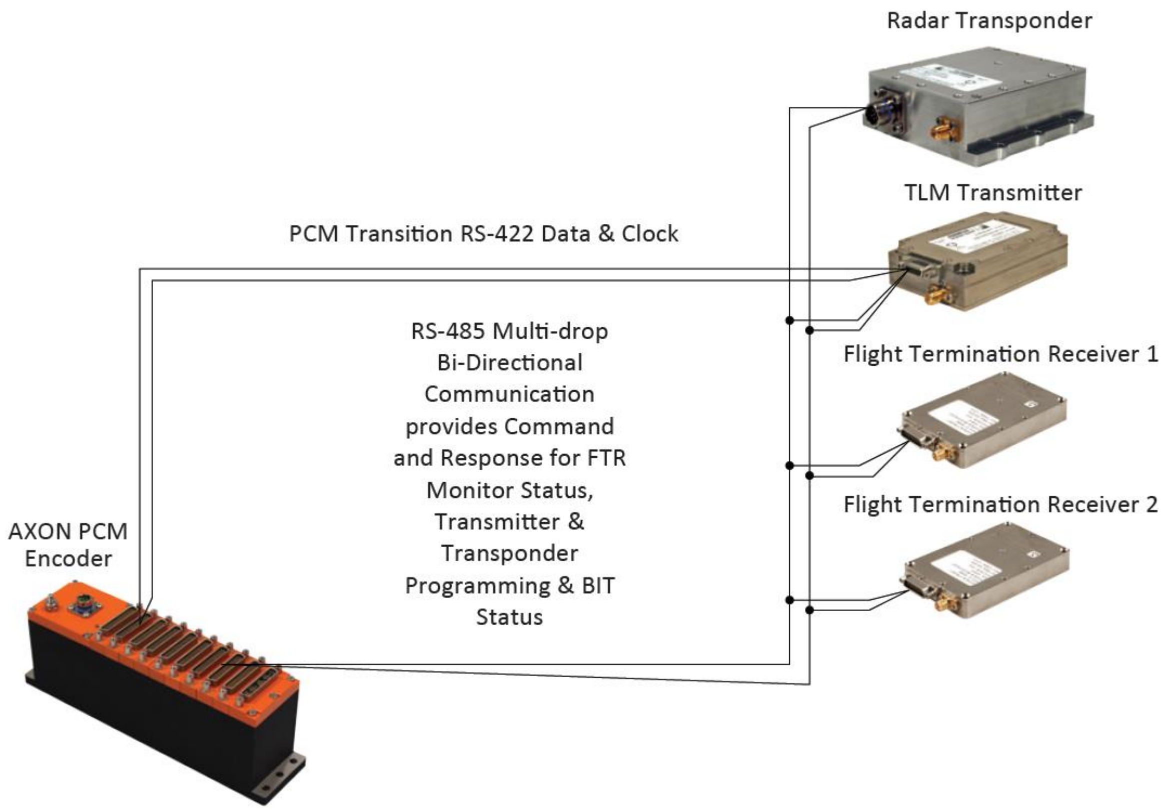

Figure 4: RS-485 Multi-Drop Configuration

A GOOD APPROACH

One should approach the design of its FTS systems to facilitate the wants and needs of range safety officers and telemetry engineers. To this end, all RF products should be DSP based designs that offer a microcontroller interface for programming and configuration. These should also provide status information such as tone, ARM, termination and SSTO status (through a COM port, as an example) from a command response similar to the IRIG-106-17, Appendix 2-C. Other RF products, such as radar enhancing transponders and telemetry airborne receivers, follow a similar command and response status messages through their COM port interfaces.

The basic design of a good FTR should include

- A single conversion super heterodyne RF digital receiver with superior performance
- An FPGA with DSP capability used to implement the digital receiver and tone decoder functions
- A microcontroller with non-volatile memory used for communications and other system functions
- On-board FLASH memory for storage of FPGA configuration and user data
- RS-232C compatible (TTL level signals)
- User interface for configuration and status reads
- Command output control and conditioning
- Telemetry output control
- Fail-safe configuration and control
- Wide range input power supply
- Programmable center frequency
- Programmable tone sets

The design around a multidrop bus means a system can be more easily installed and maintained while lowering cost, weight and space requirements while also facilitating the provision of detailed status information through telemetry.

CONCLUSIONS

Traditional FTSs often require heavy and bulky wiring harnesses to accommodate all the wires necessary to connect the hardware elements together. This is compounded if a range safety officer wants more status information available before, and during, flight as more wires are then required for parameter of interest.

Switching to a serial wiring approach, such as a multidrop bus, will reduce wiring and allow for other features, such as more in-depth status information and quick system configuration reprogramming.