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An EMI-shielded Module for the Parkes Cryo-PAF RFSoC Digitizers

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Requirements for high dynamic range and increased field-of-view in modern radio astronomy receivers have driven a desire for high-performance digitizers to be integrated into the receiver package. This approach is particularly attractive for phased array feeds (PAFs), which can have hundreds of channels. Digitizing close to the focus allows fiber optics to replace long, bulky coaxial cables. RF over Fiber is the traditional replacement for coax but doesn't offer enough dynamic range to handle external electromagnetic interference (EMI).

High-performance digitizers like the Xilinx RF System-on-Chip (RFSoC) produce their own broadband EMI which has the potential to strongly interfere with radio astronomy observations. Careful filtering, shielding and printed circuit design are necessary in order to maintain receiver sensitivity while taking advantage of the capabilities of the RFSoC.

Building on development from the ASKAP PAFs and Parkes Ultra-Wideband receiver, a tightly integrated, shielded "Warm Electronics Module" has been developed for the Parkes Cryogenic L-Band PAF (Cryo-PAF). This module contains the 'Jimble', an RFSoC digitizer board, along with RF amplifiers and filters for 8 high-bandwidth channels and power for the cryogenic LNAs. The Jimble is housed in a shielded compartment, isolated from the analogue circuitry, which is then shielded again. Reference signals, 3 × 100 Gb/s ethernet data streams, and ethernet communications for monitoring and control are all transported into the module on a single 12-fiber ribbon. The module is powered from an external isolated 48 V DC supply. Internal power rails are generated by a shielded switched-mode power supply. All external and internal power rails are filtered with high-performance 10 GHz feedthrough filters. An external fan provides cooling for over 130 W of internal power dissipation.

This design is capable of digitizing 8 × 12-bit 4 GS/s channels simultaneously, including a digital polyphase filter bank. The machined aluminium enclosure minimizes weight to fit within a limited overall mass budget while maintaining thermal performance and shielding effectiveness; the module is 154 × 408 × 82 mm and weighs only 4.3 kg when fully populated. Initial testing of the radiated EMI has shown that the enclosure effectively shields the Jimble digitizer and other electronics. With only the internal shielding in place (Figure 1 inset), all self-generated EMI fell below the noise floor of the EMI test system, which is more than 20 dB below pre-compliance MIL-461F RE102 at 100 kHz resolution bandwidth.

This design demonstrates a receiver module incorporating a tightly integrated digitizer which can be re-used for other radio astronomy receivers with multiple channels, particularly those with tight weight and space constraints.

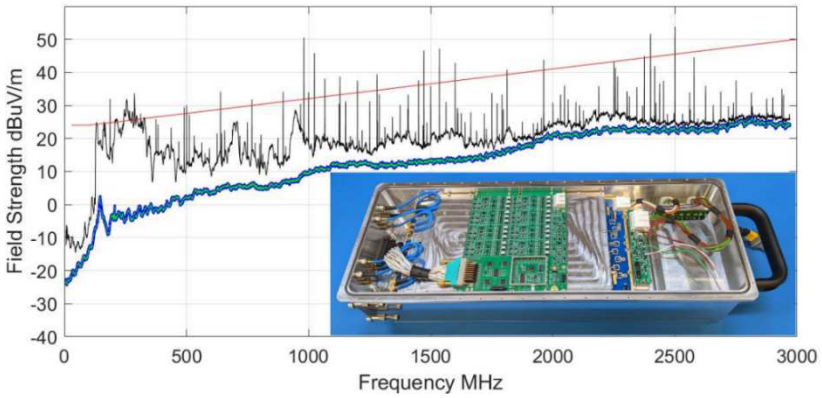

Figure 1. Radiated EMI measurement (100 kHz resolution bandwidth), showing the MIL-461F RE102 limit (red), without shielding (black), with shielding (green), and a baseline 'empty room' measurement (blue). Inset: Cryo-PAF Warm Electronics Module test unit.