# Highly reliable control and power systems for remote operation, featuring $LiFePO_4$ batteries

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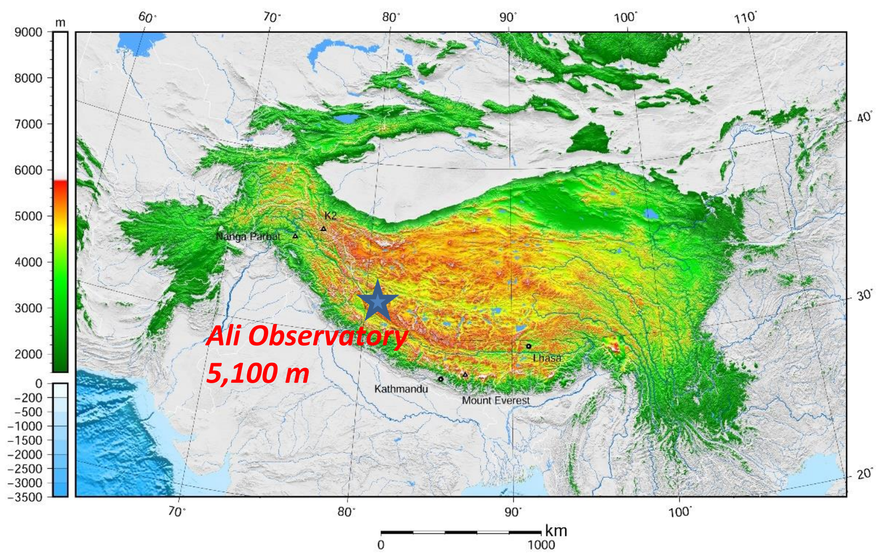
## THE HIGH PLATEAUS OF ANTARCTICA AND TIBET

Since 2007 UNSW has been collaborating with Chinese institutions to provide highly reliable power, communications, and instrument control for astronomical telescopes at China's Kunlun Station on the high Antarctic plateau. In 2018 we installed equipment at China's Ali Observatory in Tibet, at an altitude of 5,100 metres.


With no human presence on-site at Kunlun Station for 49 weeks of each year, and a very challenging physical environment, we require highly reliable control systems and computers. Satellite communications is provided by the Iridium network. CubeSat systems are being explored as possible alternatives.

Our approach to reliable autonomous control includes using the Controller Area Network (CAN) for communications, redundant power systems, reconfigurability to route around failures, and highly-reliable mil-spec Debian Linux computer systems using read-only filesystems and power watchdogs. All our systems can survive cold-soaking to −80°C and can boot-up from this temperature. We have now accumulated over 30 years of continuous uptime on several of these systems at three locations on the Antarctic plateau.

Two novel electronic systems that we have developed for our project are the *CAN Inspector* – a CAN node that allows us to remotely digitise the CAN+ and CAN− data lines to diagnose electrical issues, and a $LiFePO_4$ battery management system using infrared communications to eliminate wiring and connectors. These are described in more detail below.

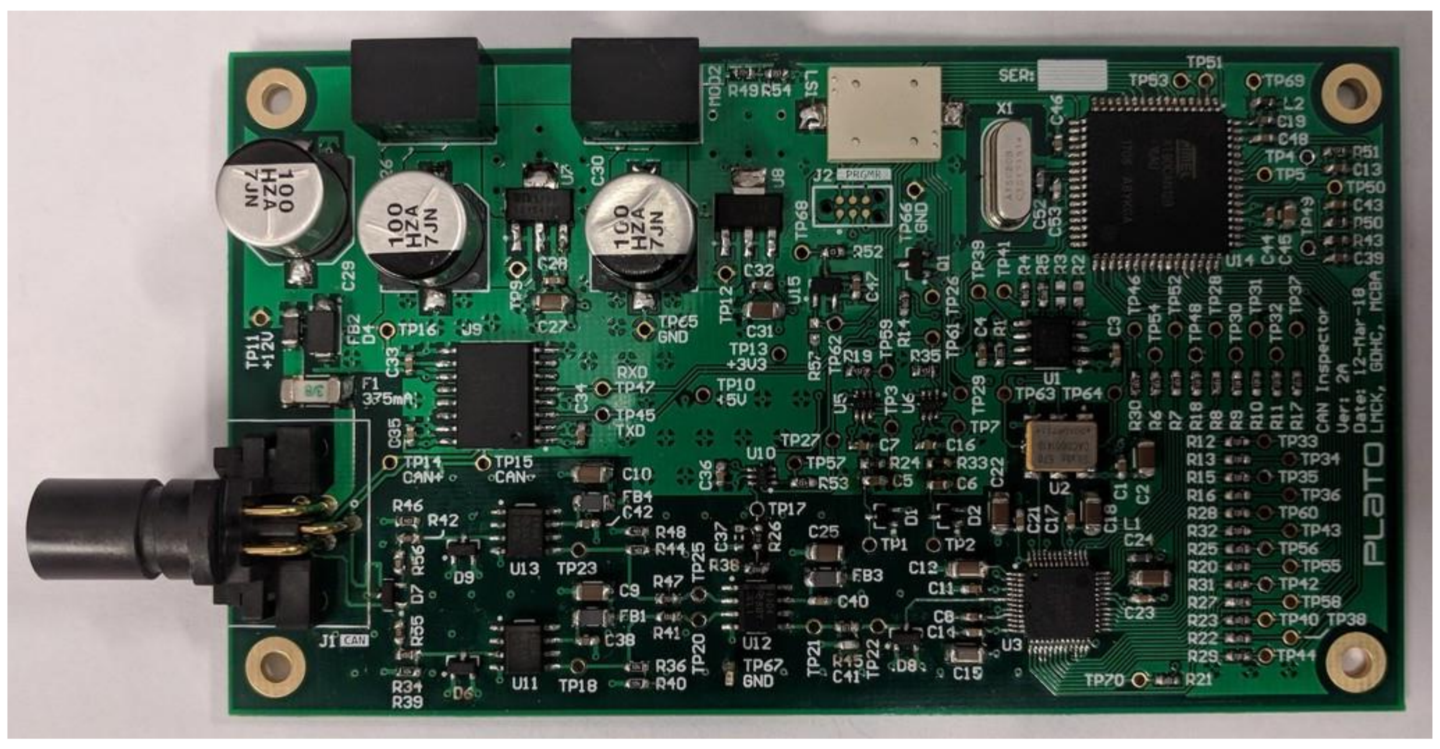

Two 0.5 metre optical telescopes at China's Kunlun Station in Antarctica, supported by the UNSW PLATO-A Instrument Module containing control systems, computers, and satellite communications. Power is provided by the UNSW PLATO-A Engine Module containing five 1kW diesel engines, supplemented with 4 kW of solar panels during summer.

Colin Bonner (3rd from left) and Michael Ashley (5th from left) with Chinese colleagues at the Ali Observatory in Tibet in April 2018, following installation of one of two sonic radars (at left) for monitoring the atmospheric turbulence. The sonic radar is controlled by a PC/104 Linux computer. The data are transmitted to Fulcrum3D offices in Sydney for processing.

## CAN Inspector

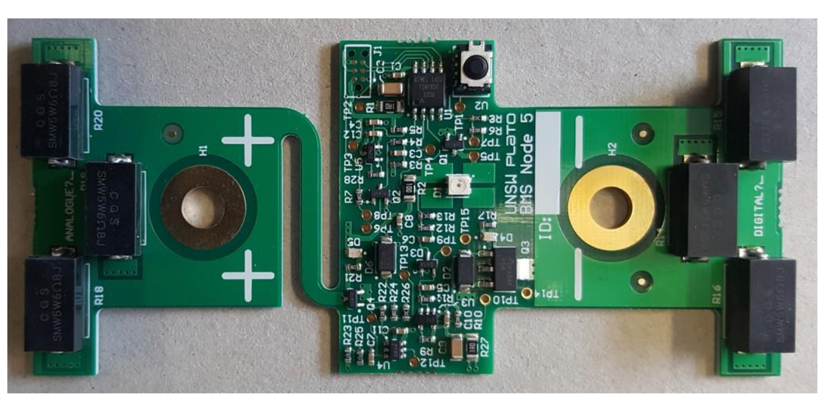
The *CAN Inspector* (see photo below) is a Controller Area Network node that attaches to a CAN bus to allow remote analysis of bus faults such as shorted or missing CAN+ and CAN- data lines and termination issues. The *CAN Inspector* contains a 300 MHz ADC that can sample 1024 points over the leading edges of CAN packets, thereby diagnosing poor or missing termination, baud-rate mismatches, and malfunctioning nodes. The CAN+ and CAN- active and recessive voltage levels can also be measured.

While such measurements could be made using a digital oscilloscope, the advantage of the *CAN Inspector* is that it can be easily added to an existing network by untrained people, and the diagnosis of faults can be conducted remotely via satellite.

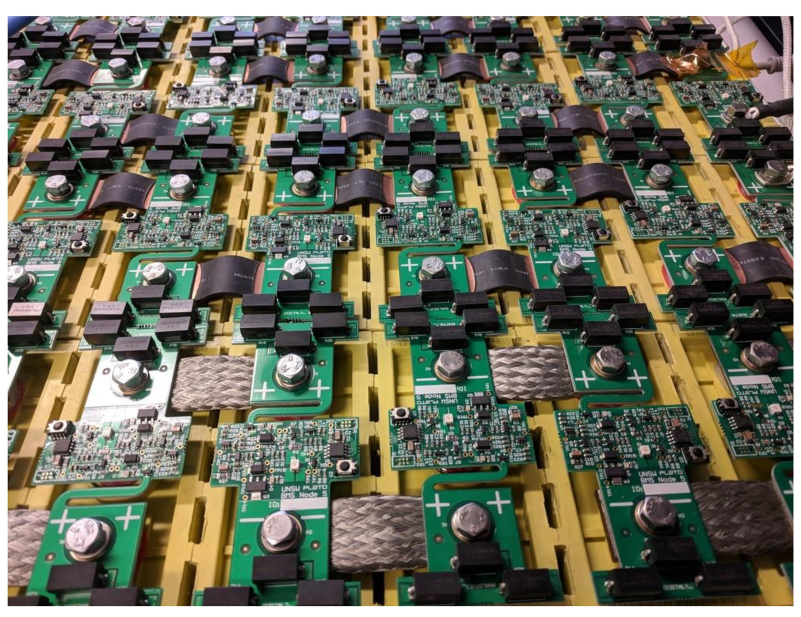



## Battery Management System with infrared comms

Our equipment in Antarctica uses a 20 kWhr $LiFePO_4$ battery pack containing three strings of 38 60Ahr cells. To simplify the in-field servicing of the pack and to eliminate reliability issues from wiring and connectors, we designed and deployed a battery management system (BMS) using infrared communication. Each cell has its own BMS node based on an ATtiny85 microcontroller, with a completely separate analogue system for backup. The nodes communicate using infrared at 2000 baud with a master controller. The voltages of all 108 cells can be read in 3 seconds. Discharge thresholds can be set by the master either globally or on a per-cell basis. The firmware of the nodes can be updated over infrared, and any node can program any other node. The nodes can operate down to −80°C, although the cells themselves should be kept warmer than about −10°C.



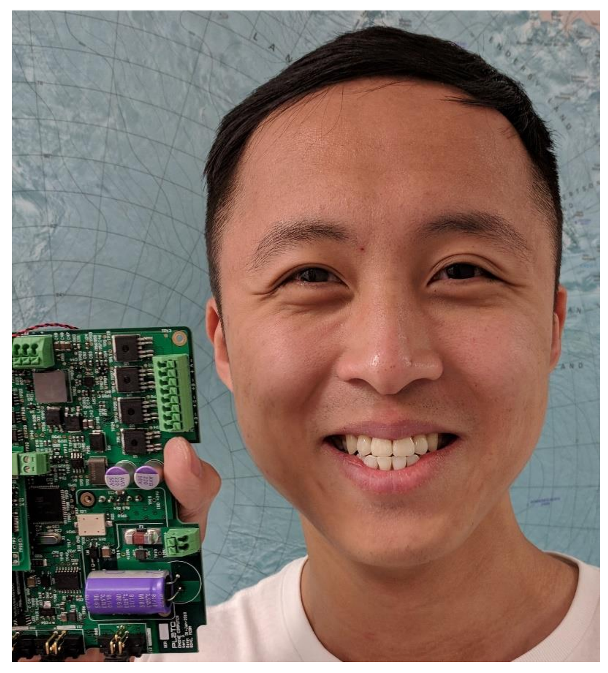
A single BMS node. Resistors are used for charge balancing. There are two entirely separate BMS systems on this board: one using an ATtiny85 microcontroller, and a purely analogue backup system.



Part of a battery pack containing multiple nodes.

## OUR EXPERTS

Prof. Michael Ashley
Electronics, mechanical, optical design, and software.



Geoffrey Chen
Electronics & PCB design.

Dr Colin Bonner at Ali Observatory in Tibet. Colin is an expert in electronics, mechanical design, and software. He is the Technical Director of Fulcrum 3D.

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