1 CAN Overview

Currawong has developed its own system of networking all of the electronic systems within the aircraft including the servos, engine control unit, power supply, autopilot and the payload. This networking system is based on the Controller Area Network (CAN) standard, where point to point wiring is replaced by one serial bus connecting all electronic systems. CAN was first developed by Robert Bosch in the 1980s for use in the automotive industry. It is a very reliable and robust technology and offers many benefits for UAVs.

The CAN standard includes differential signalling which greatly improves noise immunity of the nodes. CAN communications are also largely immune to ground potential differences between nodes and provides for better isolation between interconnected systems.

Utilising CAN in a UAV provides a versatile communications system which allows multiple avionics subsystems to communicate simultaneously between each other, and with various sensors and actuators. A properly considered CAN setup can include redundant sensors or actuators which communicate with each other and resolve contention issues transparently without any input from the autopilot. This can all be achieved while at the same time reducing the I/O burden on avionics systems because all CAN devices are connected to a multi-drop bus topology.

CAN communication features hardware bus arbitration, device addressing, message checksums, and automatic retransmission of corrupted messages. Designed for the automotive industry, where reliability under all situations is vital, CAN is a robust communication standard which is very suitable for UAV applications.

1.1 What are nodes?

Within the CAN specification, a node is a singular end-point device (such as a sensor or actuator, or a more complex self-contained system such as an engine control unit or Autopilot). These are the individual devices which communicate on the CAN. The CAN must have two or more active nodes to function correctly.

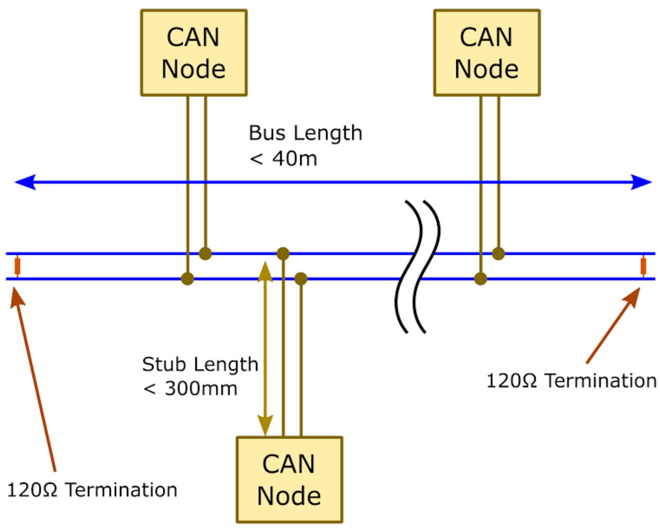

Figure 1 - CAN nodes and specifications

All CAN nodes are connected directly to the CAN via the two differential signal wires. The CAN 2.0 standard defines hardware specifications for bus wire length, depending on the CAN transmission speed (bit rate).

The CAN specifications require that some important conditions be met for reliable network communication. This is especially important for transmission at high bit-rates.

1.2 Bus Termination

The CAN bus must be terminated at each end with a 120Ω resistor (one resistor at each end) which prevent signal reflections on the bus.

1.3 Bus Length

The CAN standard defines maximum cable length for the bus. For 1Mbit/s transmission, the maximum cable length is 40 metres.

1.4 Stub Length

As the CAN stubs are essentially unterminated, care must be taken to ensure that the length of the stubs does not exceed a given length and induce signal reflections onto the bus. The CAN standard recommends a maximum stub length of 0.3m for 1Mbit/s signaling.

Currawong simplifies the implementation of a CAN system in your aircraft by taking care of the bus termination and node connection. The CE949 Avionics Hub provides a simple yet flexible CAN connection architecture which includes integrated bus termination and simplifies the network topology considerations.
Currawong also provides node connections for integrating endpoint devices into the bus without having to splice each node into the CAN cabling.

1.5 Message priority

As part of the hardware message arbitration, CAN provides message priority functionality based on the message ID which is transmitted first, before the message data. Messages with a lower ID are given a higher priority and will be transmitted first if multiple nodes attempt to transmit at the same time. The concept of message priority is very important when considering a UAV application where multiple devices can be transmitting on the same bus. High priority messages such as actuators and sensors which form a high-speed feedback loop require low latency and thus timely transmission must be guaranteed. CAN allows for this simply by allocating lower message ID values for messages which are more important.

1.6 How is CAN superior to Serial?

CAN provides a number of significant improvements over a traditional serial link such as RS232. Firstly, differential signalling improves signal integrity and reduces the effects of electromagnetic interference. This is especially important in a UAV system where there are many electronic devices switching heavy loads at high frequency.

CAN also improves immunity to ground potential differences between nodes, which is important when devices are at different potentials due to high current draw through long conductors (for example power wires running the length of a fuselage in a UAV).

CAN is also a multi-drop protocol which means that multiple devices can be connected together using the same wires. This is of great benefit to a UAV system engineer for three major reasons:

- reduces length of wires and number of connectors needed inside airframe which reduces weight;
- reduces I/O requirements on autopilot/avionics which means smaller autopilots can be used, or I/O used for dedicated connections to various subsystems can be repurposed for other uses; and
- multiple avionics systems can communicate with all CAN nodes which can simplify the communications structure and provide greater system flexibility.

Further, CAN introduces hardware error checking, automatic retransmission of messages, and complex message addressing and arbitration that otherwise requires significant software overhead when using a serial interface such as RS485.

2 Currawong Avionics Architecture

Currawong has developed an avionics architecture that simplifies the implementation of avionics communication in your aircraft. Figure 2 illustrates an example communications configuration using the Avionics Hub as the nexus. Many and varied configurations are supported by the Hub.

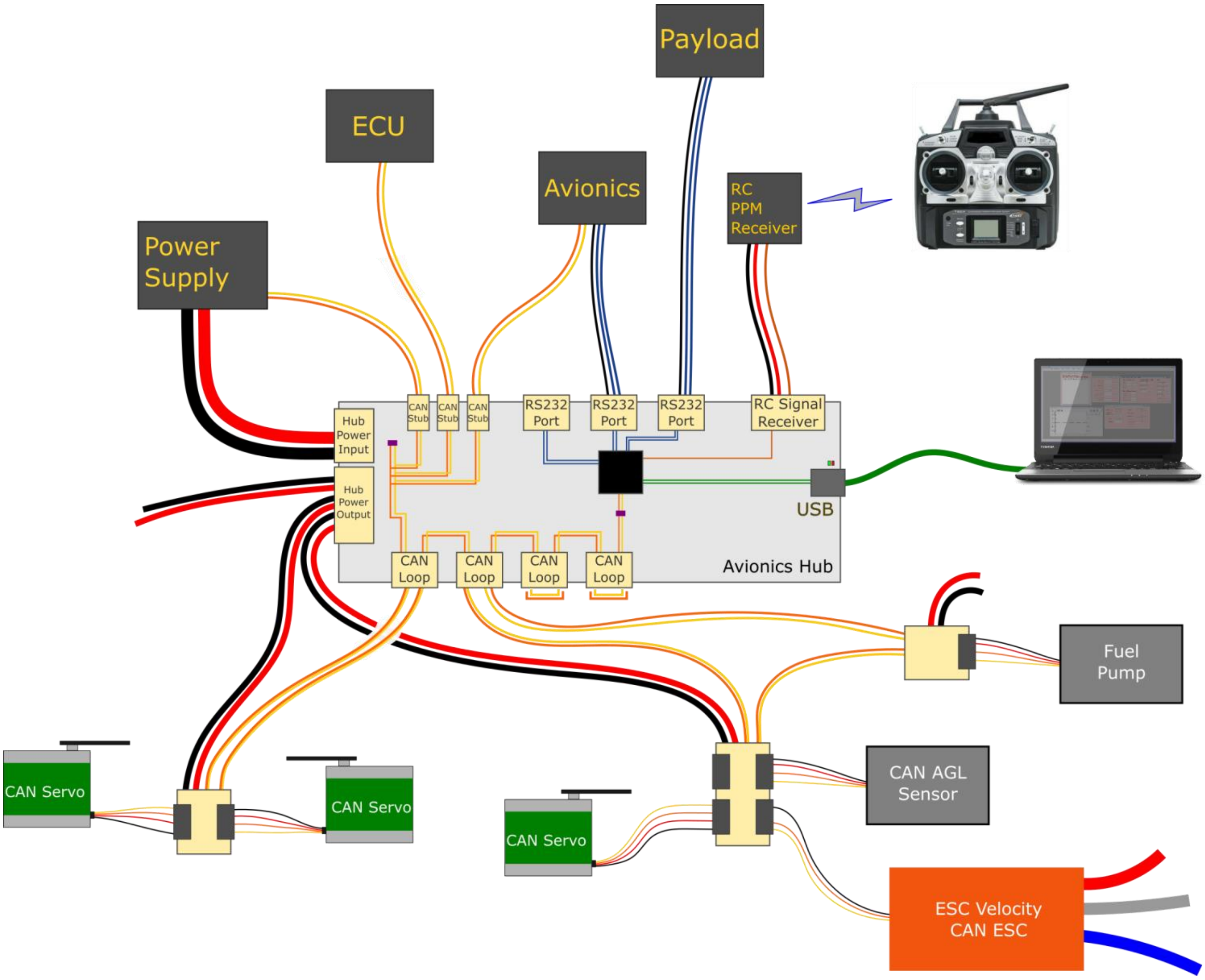

Figure 2 - Example Avionics Configuration

With reference to Figure 2 above, read on for further information on each of the systems in the example case.

2.1 Avionics Hub (CE949)

The Avionics Hub is the central point for CAN communication in the aircraft. In accordance with the CAN specification, CAN devices must be connected in a single loop arrangement, terminated at each end. The Avionics Hub provides flexibility in connecting the various CAN devices.

In addition to providing CAN communications management, the Hub also provides three (3) RS232 ports and acts as a single external connection point to the ECU (via a USB connector). Simply connect a USB cable to the Hub to provide full access to the CAN bus and each RS232 port, without the need for any external USB adapters.

This allows for simplified (and simultaneous) configuration of and communication with various aircraft subsystems such as the Avionics controller or ECU. The Avionics Hub is shown below in Figure 3.

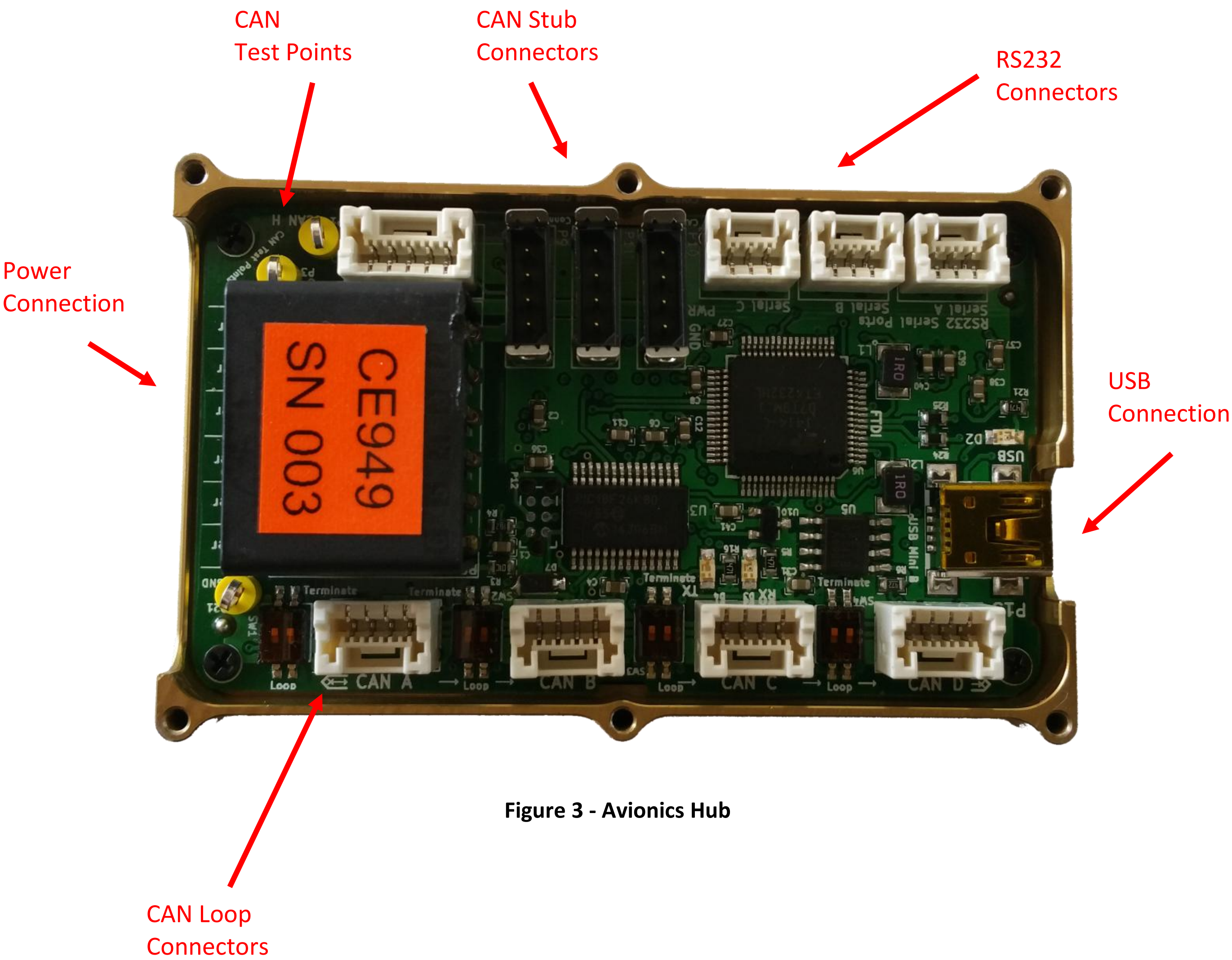

Figure 3 - Avionics Hub

2.1.1 CAN Stub Connections

CAN devices can be directly connected to the Avionics Hub via the *CAN Stub* connectors. These are useful for connecting devices installed close to the Avionics Hub, or for the temporary connection of CAN nodes without disturbing the loop network.

2.1.2 CAN Loop Connections

The majority of CAN nodes will be installed via the *CAN Loop* connectors. These provide a flexible way to connect devices arbitrarily while still observing the strict CAN termination requirements.

CAN nodes are inserted into the CAN bus via CAN Stars (see Figure 4) and can be connected in a variety of arrangements – as long as the differential CAN wires provide a return path to the Avionics Hub.

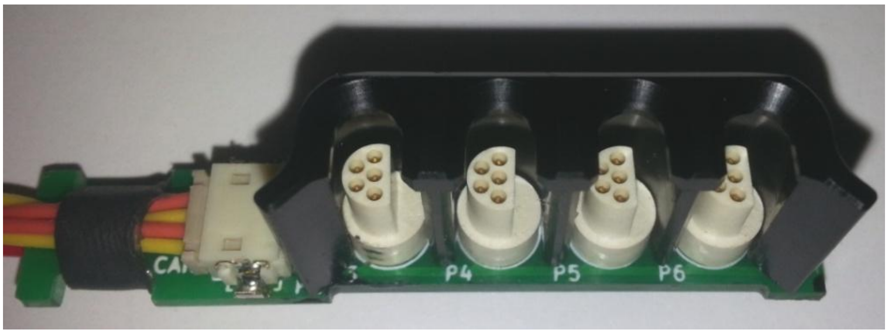

Figure 4 - CAN Star (CE1202)

Any unused *CAN Loop* connectors can be bypassed using switches on the Hub to complete the loop.

2.1.3 RS232 Connections

The Avionics Hub provides multiple ports for serial connection to devices that require configuration over RS232 (such as aircraft payloads). Using the integrated USB connector, the user can quickly connect to any device connected to the Hub via serial, just as they can communicate with any device on the CAN bus.

2.2 CAN Nodes

Nodes (such as CAN actuators, sensors, avionics devices, etc) connect to the Hub directly via the *CAN Stub* connectors, or to the *CAN Loop* connectors using CAN Stars (CE1202).

2.3 CAN Servo (CE9855)

Closed loop control of flight surfaces and other actuated airframe components can be achieved in an elegant manner with the CBS range of CAN Servos developed by Currawong (CE985). These servos provide real-time feedback of various operational data such as position, current and temperature. In addition, with integrated accelerometers a network of servos around the airframe provides a distributed vibration monitoring system for the aircraft.

2.4 Electronic speed controller (CE1101)

Currawong has developed an innovative aerospace grade electronic speed controller which provides high power, high reliability brushless motor control for UAV power systems, with a high-speed CAN interface. The first offering in the ESC Velocity series is the 80V unit with two further options currently being developed.

2.5 Power supply (CE1000)

Currawong's 250W Power Supply (CE1000) provides power to all aircraft systems, with battery backup. Servos are powered from the *Servo* power rail, and the Avionics Hub acts as a distribution point for the servo power rail, as shown in **Error! Reference source not found.**2.

The power supply also provides avionics power to critical systems such as the avionics controller and the ECU on a higher voltage rail.

2.6 Engine control unit (CE367)

Currawong provides a highly-proven engine control unit (ECU) which is fully integrated with Piccolo Autopilots. This ECU is a critical part of the Corvid series of UAV engine powertrain systems.

2.7 Avionics controller

Avionics controllers / flight management systems and other systems that may require an RS232 interface can also be connected here. Care should be taken to supply power to these systems in the appropriate manner.

2.8 Payload

The payload has its own power rail provided by the power supply. If required, the payload can be connected to the Avionics Hub for configuration via PC.

2.9 RC Receiver

Using CAN actuators allows for multiple control inputs to the various aircraft actuators. If desired, the Avionics Hub can be used to receive manual control inputs and route them to CAN actuators in a highly configurable manner. Using an RC receiver with PPM output allows the Avionics Hub to act as the control source for some or all of the aircraft actuators.

2.10 USB Interface

The Avionics Hub provides a single USB interface to the aircraft which drastically simplifies the process of communication with and calibration of the various aircraft systems. All USB signal processing is performed on the Hub, and there are no external USB adapters required for connection to the aircraft. Simply connect a USB cable from the Hub to the computer for full access to the CAN and the three (3) RS232 ports on the Hub.

2.11 Configuration via PC

In addition to full communication access to the CAN and RS232 ports, the functions of the Hub can be configured via the cEQUIP software. This software was developed in house and is provided free of charge to Currawong customers.