Introduction

Congratulations on purchasing a Millswood Engineering Failsafe. The Failsafe and Failsafe PTZ provide reliable control surface and engine management in the event of autopilot, communications or power system failure. The PTZ version sacrifices 4 failsafe channels to provide 4 channels of payload control – nominally pan, tilt, zoom and trigger.

Failsafe operation is similar to a deadman switch: a heartbeat must be detected on a regular basis or the failsafe will activate. When activated the failsafe takes control of all servos and drives them to predetermined failsafe positions. The failsafe positions are fully programmable, and do not have to result in flight termination.

Activation of the Failsafe is highly configurable: it can be enabled, disabled, triggered manually or automatically, there are multiple heartbeat sources that may be used separately or in combination, the timing is programmable as is the heartbeat string, and failsafe activation can be reported on the downlink with yet another programmable string.
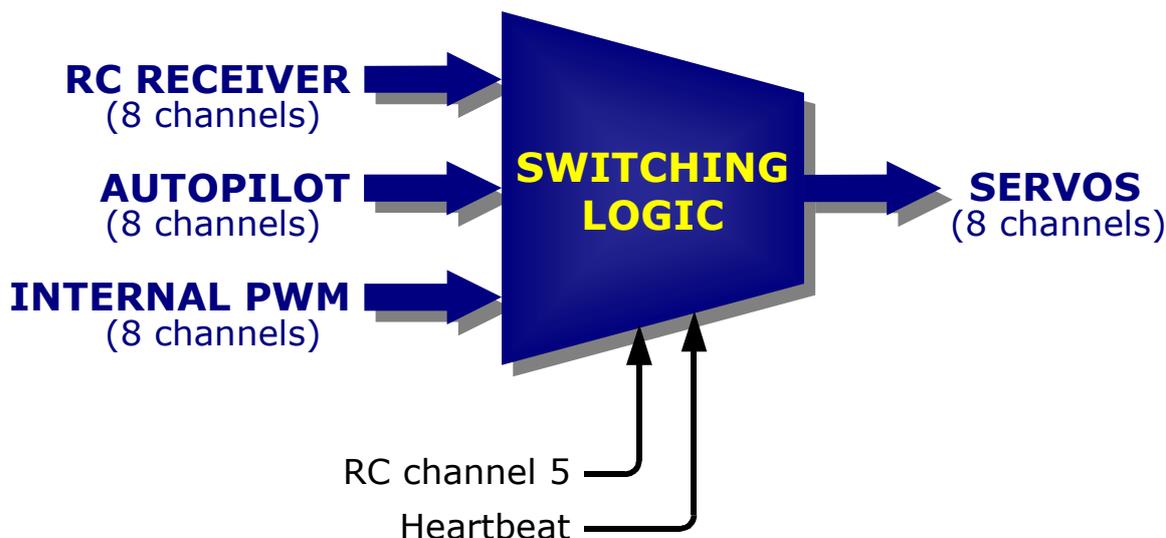

RC RECEIVER
(8 channels)

AUTOPILOT
(8 channels)

INTERNAL PWM
(8 channels)

SWITCHING LOGIC

SERVOS
(8 channels)

RC channel 5

Heartbeat

Fig. 1: Basic failsafe operation – selecting one group of 8 channels from 3 possible sources

Radio control may be resumed any time a valid RC signal is present, even after the Failsafe has activated and taken control of the aircraft. The 4 payload channels of the PTZ also have failsafe positions, but telemetry control resumes immediately after activation and continues for as long as the uplink remains viable.

The Failsafe includes a switching power supply that is capable of sourcing 2 Amps from an 8 to 22 Volt DC supply. A redundant power system can be constructed from a Failsafe and a ServoStation, ensuring control surface authority even after primary electrical power failure.

Two full-duplex RS232 / TTL converters are included to allow easy connection of a computer to the telemetry radio and the autopilot. These RS232 ports are used for configuring the radio and autopilot on the ground, and are usually linked out during flight.

Installing the telemetry radio

Fitting a Digi XTend radio modem is simple: install the 4 aluminium posts with the M3 socket-head screws provided, plug the radio into the radio connector, and secure with the remaining socket-head screws.
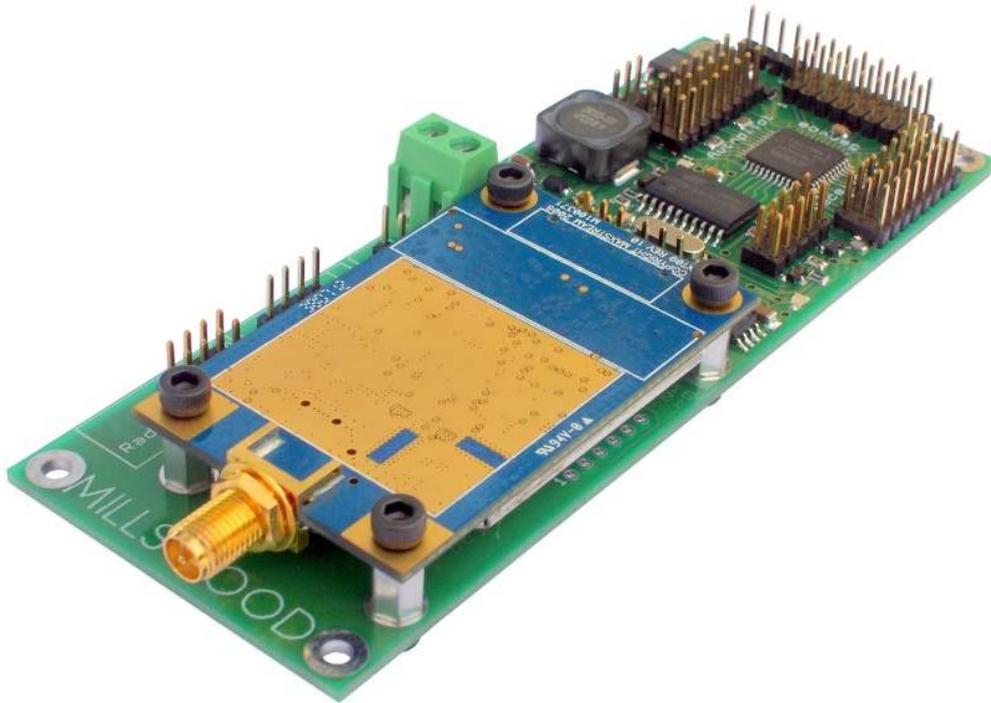
Fig. 2: A Failsafe fitted with a Digi XTend radio modem

As well as providing a way to connect different telemetry radios, the generic telemetry radio connector may also be used to control the Digi XTend radio, as shown in the table below:

Pin	Name	Description
1	GND	Ground
2	+5VDC	Source of 5V power with a 3 second delay on power up. Can be switched on and off using the radio silence jumper.
3	DI	TTL serial data input to telemetry radio / output from RS232 converter.
4	DO	TTL serial data output from telemetry radio / input to RS232 converter.
5	/SHDN	A low signal (such as an active open collector output) will shutdown the Digi XTend radio. A 10kΩ pull-up resistor is fitted internally.
6	RSSI	Connects to the RSSI output of the Digi XTend radio.

As noted above, fitting radios other than the Digi XTend is possible using the generic telemetry radio connector. Please note that DI has TTL input thresholds, and DO is a 5V logic level output.

Programming the XTend

Because RS232 / TTL conversion is built-in, connecting your XTend to a computer for programming requires nothing more than a suitable cable.

Just connect your computer's serial port to the Radio pins in the RS232 interface. Only 3 of the 4 pins need to be connected (a ground is provided at both ends so that different connector pin-outs can be used). Don't worry about plugging the cable in backwards; we do it all the time. The photo doesn't show a radio – obviously you need to have one of these installed!

Note that you can use a Digi XTend / Failsafe combo instead of a packaged XTend for your ground station telemetry radio. Buying a Failsafe and an OEM (naked) XTend is actually cheaper than buying a packaged XTend.
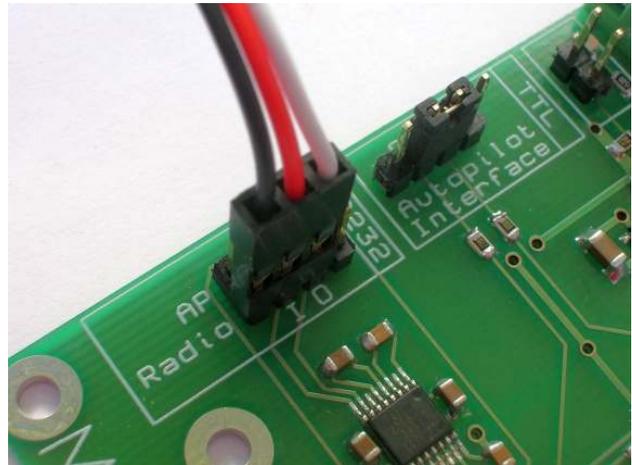

Fig. 3: Showing where to connect the programming cable to configure the Digi XTend

Programming the Failsafe

Plug the programming cable into the failsafe board as shown.

For the programming software to work correctly you must have the "I" and "O" pins of the TTL Autopilot Interface linked together, either directly with a jumper or indirectly with a telemetry-transparent autopilot. You must also ensure that the status reporting jumper is fitted in the "E" position.

Download the programming software from the Millswood Engineering website (www.millswoodeng.com.au/downloads.html) and configure your Failsafe.
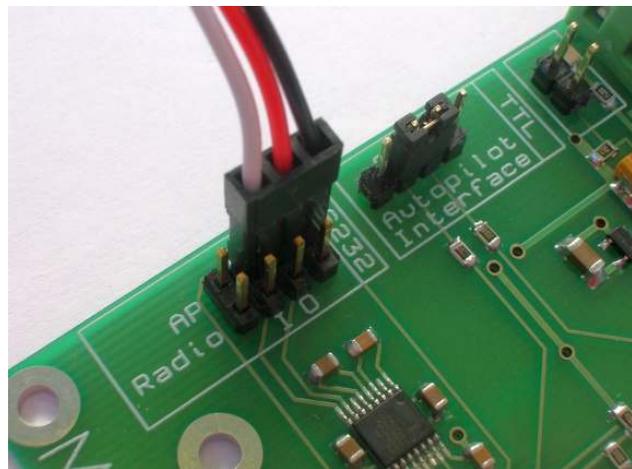

Fig. 4: Showing where to connect the programming cable to configure the Failsafe

Connecting telemetry to your autopilot

There are two ways to connect up telemetry – if your autopilot is "telemetry transparent" you can just connect directly to the TTL Autopilot Interface connector. By "telemetry-transparent" we mean that all data that goes into the autopilot's telemetry input comes out from its telemetry output. In other words, as far as telemetry data is concerned, the autopilot behaves like a piece of wire.

This is important is because, generally speaking, you will want telemetry data to be able to reach the Failsafe. This allows in-flight control of pan, tilt, zoom, trigger, the ability to terminate flight remotely, the ability to reconfigure the Failsafe after installation, and so on. As can be seen in figure 5, when the autopilot is transparent all telemetry data will eventually reach (and pass through) the Failsafe. (The Failsafe itself is completely transparent to all telemetry data.)
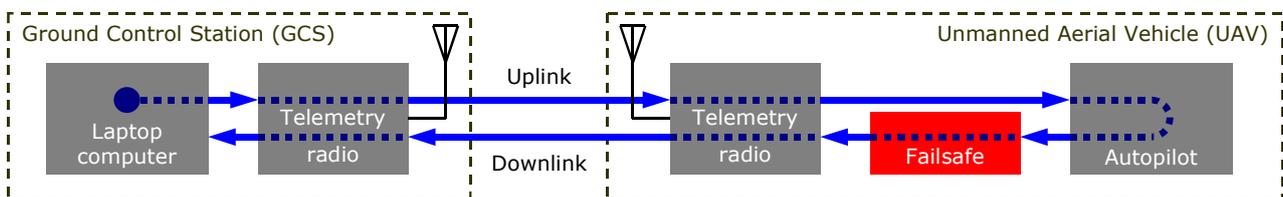

Fig. 5: Data flow with telemetry-transparent autopilots

Attopilots are telemetry transparent and may be plugged directly into the TTL Autopilot Interface connector, as shown in figure 6 below:
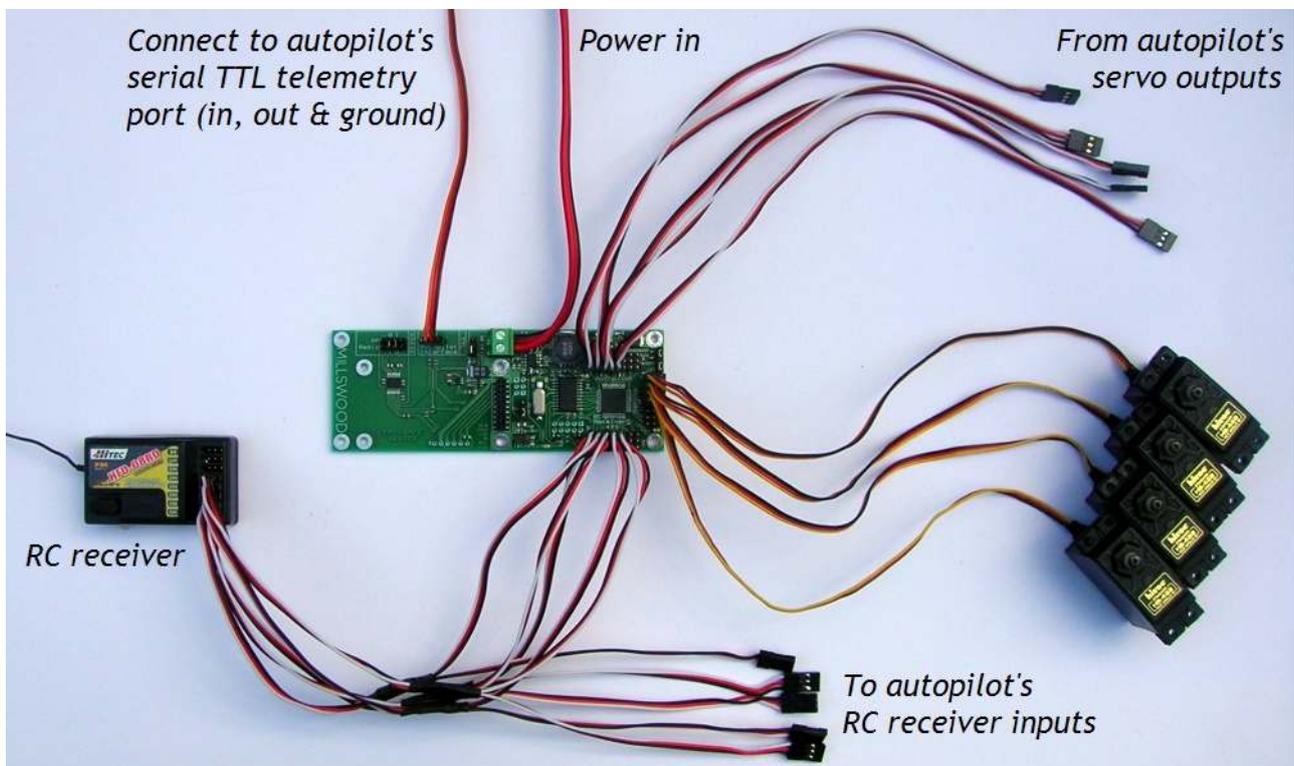

Fig. 6: A typical Attopilot installation

But before you wire up your UAV like this, you should be aware that there is another way, and it offers significant performance advantages.

Connecting telemetry to your autopilot, take 2

Many autopilots are not transparent to telemetry data. This is not a big problem, the solution is simply to swap the relative positions of the Failsafe and autopilot, as shown in figure 7 below:
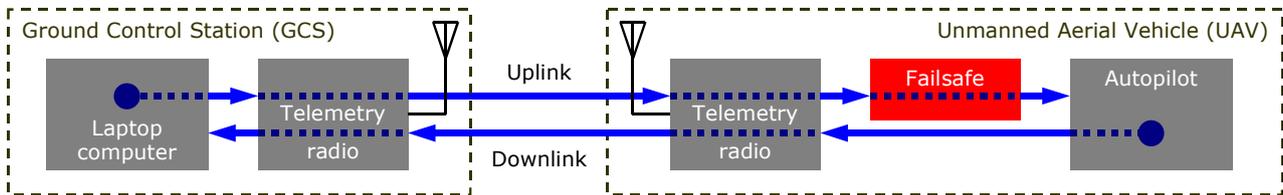

Fig. 7: Telemetry data flow with non-transparent autopilots

This arrangement is universal in the sense that it will work with any autopilot. Naturally there are pros and cons:

Advantages	Disadvantages
A crashed autopilot cannot interfere with GCS to Failsafe communications.	Cannot detect autopilot failure, only loss of uplink.
Faster, smoother pan, tilt, zoom & trigger servo movement.	No status reporting.
Less data on the downlink, reducing UAV power consumption.	

The procedure is as follows:

1. Remove the status reporting jumper and place it across the "I" and "O" pins of the TTL Autopilot Interface.
2. Connect "Telemetry data out" from your autopilot to the centre pin of the status reporting header.
3. Connect "Telemetry data in" from your autopilot to the "D" pin of the status reporting header. The "E" pin should be left unconnected.

If you are connecting your Attopilot this way, then just pull the earth wire out of the telemetry cable and plug the modified telemetry cable into the status reporting header as shown in figure 8. (You still need to put a jumper across the TTL Autopilot Interface "I" and "O" pins.)
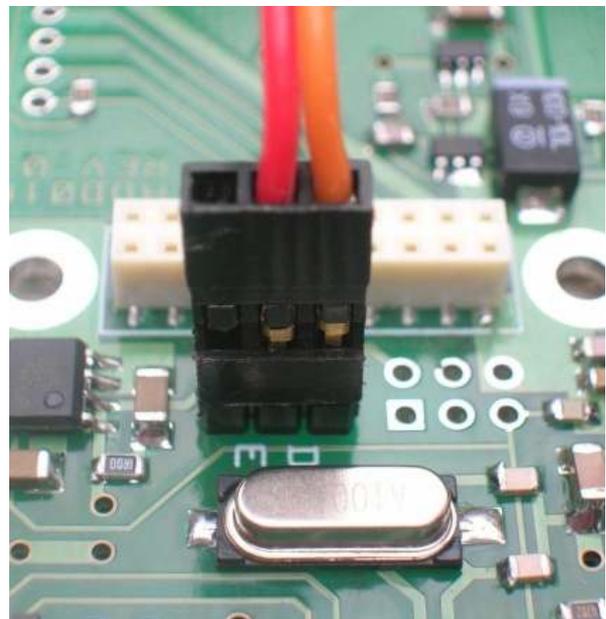

Fig. 8: Connecting autopilot telemetry for better pan and tilt performance

Electrically powered vehicles

In electrically powered vehicles one of the autopilot's output channels – usually channel 3 – controls the vehicle's throttle. This channel ultimately connects to an Electronic Speed Controller (ESC), which then drives the motor. Most ESCs have an on-board Battery Eliminator Circuit (BEC) that provides 5 volts for powering vehicle electronics. If the BEC is capable of delivering at least 1 Amp continuously, then it may be used to power the Failsafe (and thus autopilot, RC receiver, servos and radio modem). A second battery may be connected directly to the Failsafe to provide power supply redundancy.

Note: If the BEC is rated at less than 1 Amp, then this is insufficient to power the Failsafe reliably. The BEC must be disconnected or at least disabled, preferably both (see the next section for instructions on how to do this). The failsafe power jumpers must be set to "stand-alone" operation and a power source connected to the Failsafe's main power input.

Note: If you are using a ServoStation then the BEC must be disconnected or at least disabled, preferably both. See the next section for instructions on how to do this.

To power the Failsafe from your ESC's BEC:
1. Configure the Failsafe's power jumpers for redundant operation (link the middle two pins together). You must do this regardless of whether you connect a battery to the Failsafe or not.
2. Plug the ESC's receiver connector into the throttle servo connector on the Failsafe (usually channel 3). This connection delivers the BEC's power to the Failsafe.

A secondary power source may be connected to the Failsafe's main power input. ***We strongly recommend that you do this.*** Under normal circumstances the Failsafe will draw power from the ESC's BEC in preference to its own battery. When the ESC's battery is depleted and the BEC output fails, the motor will stop running but the Failsafe will use the secondary battery to continue to deliver power to the autopilot, RC receiver, radio modem and servos.

There are a few things to be aware of when using this arrangement:
- BECs are usually linear regulators and will get hot. If a BEC gets too hot it will go into thermal shutdown. If this happens and there is no secondary power source available to take over, all electronics will fail and your vehicle will crash. Avoiding this problem is simple: connect a secondary power source to the Failsafe's main power input.
- A Digi XTend can consume up to 1 Amp if configured for maximum power output. Make sure that the BEC can provide enough current to supply the Digi XTend as well as all of the servos. (The autopilot, RC receiver and Failsafe draw negligible current compared with the Digi XTend and servos.)
- When operating from secondary power (following BEC or main battery failure), the Failsafe will only maintain the 5 volt rail at approximately 4.8 volts.
- If the power wire in the servo cable connecting BEC to Failsafe fails, power for the Failsafe will be drawn from the secondary battery (if fitted). If this secondary battery becomes depleted before the primary battery (now just supplying the motor), all electronics will fail and your vehicle will crash.

Redundancy implemented with a ServoStation has none of these limitations.

Disconnecting a BEC

If your system includes a ServoStation, or your ESC's BEC is not up to the job of supplying the Digi XTend and all your servos, then it must be disconnected or at least disabled. This section shows you how.

If the ESC is configurable, configure its BEC to be off.

Now we're going to disconnect the ESC's BEC, preventing it from conflicting with the Failsafe or ServoStation. Of course you *can* just cut the middle wire, but a nicer (and completely reversible) way to do it is to pull the middle pin out of the ESC's receiver connector, like this:
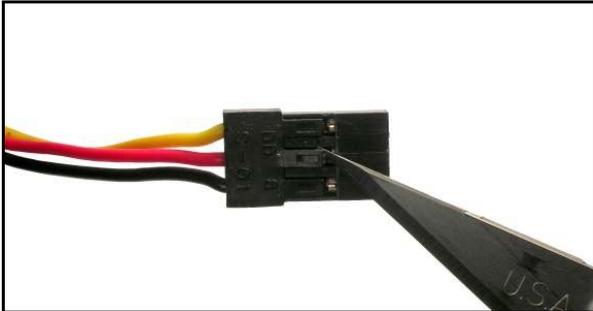
Step 1: Insert a scalpel blade behind the middle plastic tongue of the ESC's receiver connector.
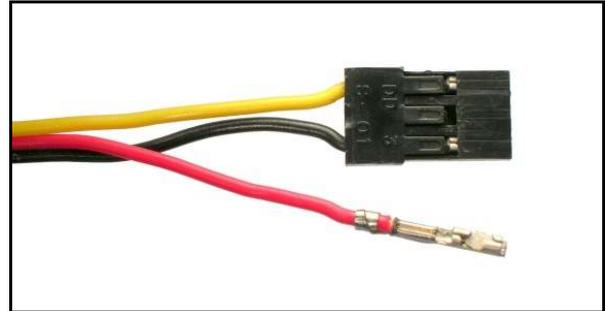
Step 3: The middle pin is now out.
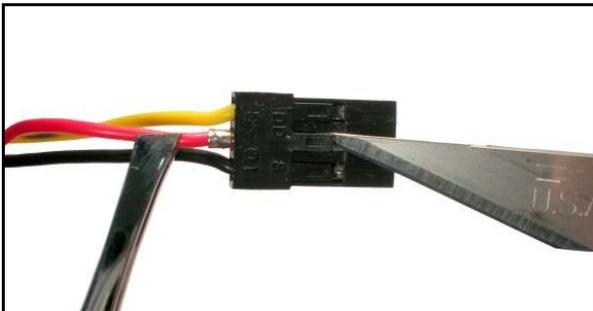
Step 2: Lift up the plastic tongue and pull out the middle wire with its pin. Tweezers and a third hand are useful.
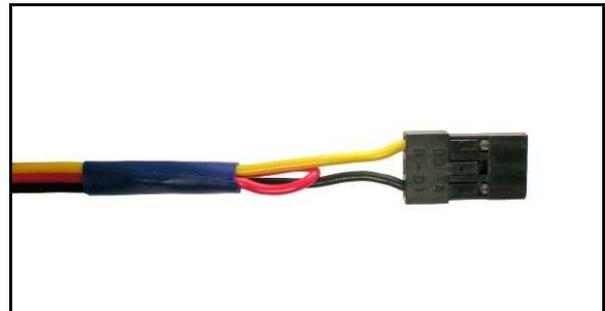
Step 4: Secure the wire and pin with some insulating tape or heatshrink tubing.

Now you can plug the ESC's modified receiver connector directly into the throttle servo connector on the Failsafe or ServoStation.

Implementing a redundant power system with a ServoStation

In combination with a ServoStation, a Failsafe can be configured to provide redundant power supply operation. This means that when two power sources are connected, removal of either one will not affect operation of the failsafe system.

Servos do not twitch during the changeover and the system tolerates either battery becoming a dead short to ground.

Redundant power is delivered to the servos, autopilot, RC receiver and radio modem.

When two power sources are connected, power is drawn preferentially from the battery supplying the ServoStation. The switching power supply inside the Failsafe is running, but not actually powering anything. If the ServoStation's main 6 volt rail begins to fail, the Failsafe takes over.

Fig. 9: Showing the power jumpers set for redundant operation and the external power cable

To configure the Failsafe for redundant power supply operation:

1. Connect a primary power source to the ServoStation.
2. Connect a secondary power source to the Failsafe (can be identical to the primary power source).
3. Set the power jumpers on the Failsafe board as shown in figure 9 (link the middle two pins together).
4. Connect a female-female servo cable between the Failsafe and the ServoStation. This cable plugs in to the external power header on the Failsafe (seen on the right in figure 8), and into any one of the servo outputs on the ServoStation. If all 8 servo outputs are already in use, the cable may be "Y" connected into one of them.
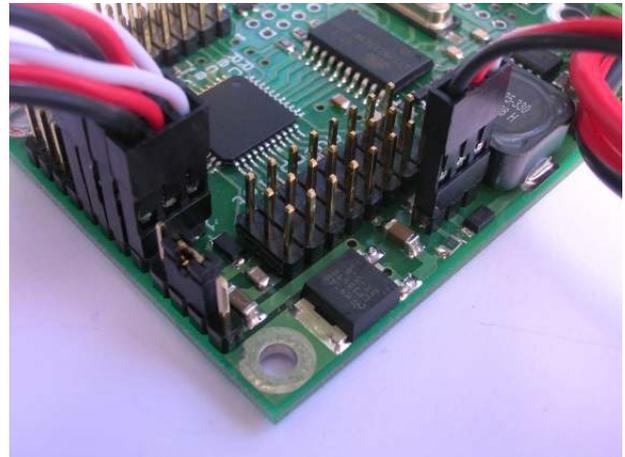
Reference data

1. RS232 INTERFACES
Autopilot: GND – TXO – RXI – GND
Telemetry radio: GND – RXI – TXO – GND

2. AUTOPILOT TTL INTERFACE
Pinout: GND – TXO – RXI – GND

3. RADIO SILENCE JUMPER
Radio silence: Short
Normal operation: Open

4. POWER INPUT
+8 to +22 VDC

5. EXTERNAL SERVO POWER OUTPUT
Pinout: NC – +6V – GND

6. AUTOPILOT PWM INPUTS

7. POWER SOURCE JUMPERS
Stand-alone: Short 1-2 and 3-4
Redundant: Short 2-3

8. SERVO PWM OUTPUTS

9. RC RECEIVER PWM INPUTS

10. PROGRAMMING CONNECTOR
Pinout: MISO – VCC – SCK – MOSI – RST – GND

11. STATUS REPORTING JUMPER
Status reporting: E(nable)
No status reporting: D(isable)

12. DIGI XTEND CONNECTOR

13. GENERIC TELEMETRY RADIO CONNECTOR
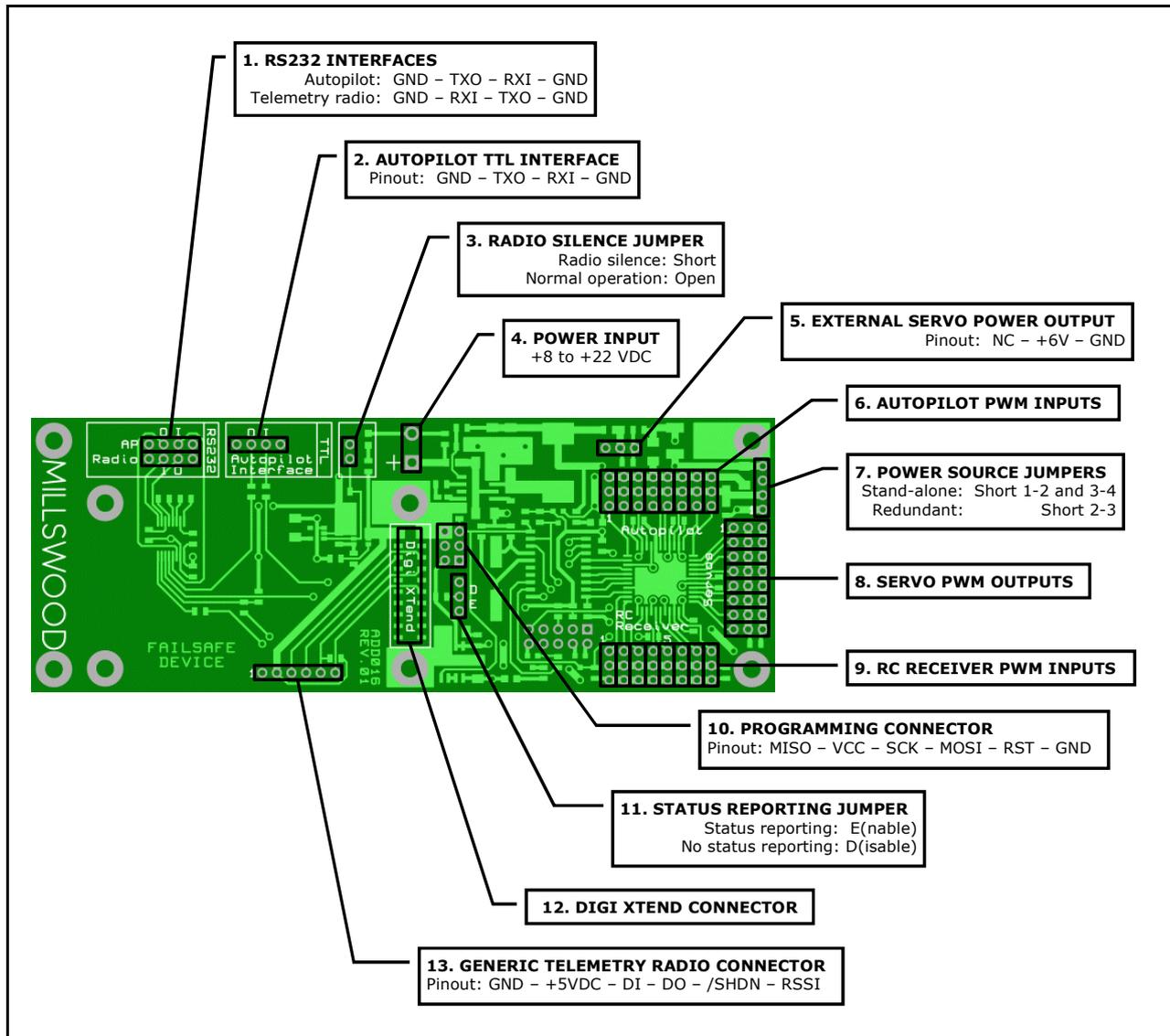Pinout: GND – +5VDC – DI – DO – /SHDN – RSSI

Fig. 10: Locations of connectors and jumpers

Further Information

Visit us on the web at www.millswoodeng.com.au

Didn't find what you wanted? Send us an email or give us a call – contact details are on our website.

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