Changes

220715-15:00 – released describing knh002r8 schematicRs485_220715review.pdf

Description

This is a design description. As of 2022July15 circuit is still in design.

The Modbus wingboard has a fanout of 6 RS485 wires, and two SDI-12 at 12V. The board's primary design is to provide an "easy" connection to Modbus instruments from the Mayfly board through either individual wire to screw-posts, or through pre-assembled Grove connectors.

When operating the Modbus wingboard, Mayfly RS485 transmissions show as a short RED LED flash, and Modbus instrument responses as a GREEN LED flash. The sequence of flashes is defined by the software used.

The Modbus wingboard has two bolt holes to securely clamp wingboard to a Mayfly backing plate. This supports mechanical configuration and long-term mechanical integrity

The board supplies an accurate switched 12V +/-5%, 0.5A current (or 6W) using a Pololu booster. Each connected Modbus wire has an e-fuse to protect other equipment on the power line. The theoretical limit of powering from the LiIon Battery's is what the connectors are rated for ~2A. At 3.8V this is 7.6W of power can be supplied.

When 12V is turned OFF, all power is removed from the Modbus power lines, and the Modbus Tx and Rx to the Mayfly uses no power with the Ioff buffer SN74LVC2G34

The RS485 circuit translates the short distance 3.3V logic levels from the Mayfly board to half duplex RS485 level signals through MAX13487 that can transmit up to 4000' depending on Modbus configurations.

The power up sequence of the board is typically, activate the Mayfly +5VSw which turns on the RS485chip. Activate the 12V boost power with "12VswAEn". This also enables the boost and power switch, and rate limits the charge on the 330uF to 0.5A on power up. Then application software controls individual instruments (power consumption) with the Modbus protocol

The 12V boost power, turns on the +12V. When turned off, the U3V40F12 device doesn't disconnect from the battery. It still has an electrical path through a diode/inductor to the output, and will conduct the 3.8V battery from input to output. A "12V Power Sw" is required to truly electrically disconnect from the battery. There are two possibilities under considered – a SIL2308 with PMOSFET 5A – available in large qty, and more recent IC MP5036 – "12V, 0.4A to 5A, Current Limit Switch" with soft start and thermal shutdown, unfortunately with limited availability. The MP5036 with current limit set to ~ 0.65A, is a better choice if available when going to production. The SIL2308 can do most of what is necessary and more detail described under "failure mode"

Fuses

As with all power delivery, there is a tradeoff of powering the Modbus sensors and detecting real world short circuits. The e-fuses protect against sensor power line shorts by becoming high resistance and reducing current draw. The specific instruments on that sensor line stop responding, but all the other lines still operate.

A number of Modbus and SDI-12 instruments may be connected, and the equipment configurator needs to create a budget for all instruments to see that it doesn't exceed 500mA. The circuit supports more than 500mA at fully charged battery, however batteries run down, and at some low battery voltage it will not support more than 500mAs, and is likely to cause a system reset.

A range of Modbus equipment, Yosemitech, has been characterized for having a brush running current draw of 52mA, and a periodic surge up to 290mA for 10mS.
(https://github.com/EnviroDIY/YosemitechModbus#power-supply)

An example configuration may for instance be 6 instruments at 52mA for a total of 312m, and periodic wiper surges.

The e-fuse is a thermal device, that is ambient temperature dependent. It is rated for a "holding current" and a "trip current". The holding current is what is guaranteed to always be passed. The trip current is what causes the device to trip – go high circuit within a short period of time. In between is a current range that can be exceeded for a period of time. The device selected is PRG18BC3R3MM1RB 3.3Ohm 120mA/60C 480mA/-10C

Failure Mode

Normal failure theory assumes only one failure at a time – eg a sensor Modbus power line short. However, it's possible with a human installation error could result with a number (2 to 8) of sensor power lines shorted. The electronic fuses operate on a high current, and when cold the current threshold is higher. The U3V40F12 12Vbst when shorted, contribute as much current as it can through its internal diode. The data sheet states "and exposure to short circuits or other excessive loads will damage the regulator".

Opting for the IC MP5036GJ can safely limit the current to 0.65A, hopefully this IC is available in build timeframe.

The other alternative PMOSFET Q1B of SIL2308 is a switch, controlled by the same bit as the U3V40F12 turns On the power, and also by definition turns OFF the power. Q1B is controlled by NMOSFET Q1A. What is needed is an Under Voltage Lock Out (UVLO) to turn off the Q1B when under 4.2V, and thereby limit damaging currents, even when it is turned ON by the NMOSFET Q1A. When there is short circuit on a number of output pins, all the fuse resistances are in series, and the U3V40F12 is attempting to boost the voltage by greater than 4V. If too much current is taken (from a short circuit) it fails to boost and conducts through its internal diode/inductor.

Detail Design Description of SIL2308 UVLO function. The PMOSFET Q1B of SIL2308 turn on is at a Vgs=-2.5V. It is considered off Vth at about -0.7V (though could be as low as -0.3V), and between -0.7V and -2.5V is a linear analog region. To turn ON Q1B when the 12Vbst output is greater than 10V, with Vgs=2.5V The Resistor divider between the Q1B-S-pin2 and Gate and Q1-G-pin3 and Q1A-D-pin6 can be used to do this by assigning values of 68K to 200K. Then if 12Vbst is not boosting, shorted at the sensors line, and conducting the batteries 4.2V through the Diode, the current drain will pull the 12VBst to ~ 3.6V, which will have Vgs=-0.9V and should turn off Q1B, which then allows 12VBst to recover, which will turn ON Q1B, so it will oscillate. However, this does mean the Q1B will be dissipating heat and a good heating dissipation is needed. As Q1B gets hotter its Vth increases slightly, which is good for negative feedback.

Alternatively, 12Vbst input is likely limited by the input impedance of the battery, as more current is taken the voltage drops lower. At 3.3V the current is likely to be about 4.3A, which is likely this will cause the processor to reset, but not cause any lasting damage.

Conclusion: with a large number of line shorts, it is designed to minimize electronic damage, however it is likely to start resetting.