CIRCUIT DESCRIPTION - SCHEMATICS TGRF-3XXX-C Sheet 1 & 2

The Sheet 1 schematic covers the core of the logger; power supply, microcontroller, communications & radio transceiver.
The Sheet 2 schematic covers the input signal processing.

Sheet 1 SCHEMATIC:

U1 is the MSP430F168 microcontroller, which controls the logger. The controlling firmware is programmed into its internal flash memory.
The MSP430 also incorporates an 8-channel, 12 bit ADC, which is used for measuring the various inputs.

The microcontroller is clocked by an internal 4MHz DCO. The firmware uses the external 32KHz clock (XTAL1) as a reference to keep the DCO on frequency.

U3 is a 8KB FRAM memory, used as a buffer for logged data.
U2 is a 512KB Flash memory used for storage of logged data.
Q5 removes power from U2 when not required (to save battery power).

The logger can be supplied with either a single 3.6v lithium cell or 2x 1.5v alkaline cells.

There is a 4-way interconnect cable between the battery board & Conn6 on the logger board.

If the alkaline option is fitted, the battery is connected between pins 1 & 3 of Conn6.
Q10 connects pin 3 to ground if the polarity is correct (negative on pin 3), otherwise it remains off.
Positive on pin 1 connects via Q9 to U7, a charge-pump power supply with 3.3v output.
U10 is a voltage supervisor. If the input voltage rises above 3.4v its output goes high and switches off Q9, protecting U7 from excessive voltage.
This is required in the event that a user fits lithium cells instead of alkaline.

Q12 & R23, R24 are used by the microcontroller to apply a load to the alkaline battery when measuring the battery voltage via the ADC0 input.

The regulated output of the charge pump is filtered by L6, C38 & connected via a link (pins 2 & 4) in the battery board cable to Q14 & Q7, which form the battery switch. The microcontroller can put U7 into "snooze mode" via R25, to reduce drain on the battery when current demand is low.

If the lithium option is fitted, the cell is connected to pins 4 & 3 of Conn6. This connects the negative terminal to the polarity protection & the positive terminal to Q14, Q7.

Q14, Q7 are controlled by the voltage at the junction of R5 & R6. If there is no external supply connected to the DC input socket then Q14 & Q7 will be on & Q6 will be off, connecting the battery supply through to Q8, the on/off switch, & disconnecting Q6, the external DC source.

If a DC supply is connected to Conn5 or a PC is connected in the case of a logger configured as a receiver, then there will be a voltage (limited to 7v by zener D3) on the gates of Q6, Q7 & Q14. This will turn on Q6 & turn off the battery supply.

U4 is an LDO regulator with 3.3v output.

Q8 is used by the microcontroller, via Q11, to turn the logger on & off. R11 & C14 serve to temporarily turn on the power (& therefore boot the microcontroller) in the event of the power being lost & then restored again.
The ON/OFF pushbutton signals the microcontroller that the user wishes to turn the logger on (or off).

The microcontroller then actions the request via Q11.

Q1 & Q2 are the RS-232 driver transistors, for communication with the PC (or another logger). Q3 & Q15 are the RS-232 receiver.

Q13 is a pulse-counting input circuit, available to channel A via LK18.

U9 is a magnetic sensor. It is monitored by the microcontroller during power-on boot-up. If the user swipes a magnet past the sensor position (adjacent to the LEDs) 8 times immediately after power-on then the factory default settings are reloaded (from program memory) & the data storage pointers are reset, effectively deleting all logged data.

U6 is the integrated radio transceiver, a Chipcon (TI) CC1000.
Its reference oscillator is driven by a 14.7456MHz crystal (XTAL2). Its operating frequency is generated by a phase-locked VCO. L1 is the VCO inductor.
RF output from pin 4 is coupled to the 1/4 wave antenna via a low-pass pi-filter, L4, C18 & C19.
Q4 allows the microcontroller to remove power from the transceiver when shutting down, which prevents any uncontrolled transmission.
Pins 23 - 27 of U6 are the SPI bus connections to the microcontroller. These are used to both control the transceiver and to pass data.
Pin 28 is the RSSI signal, monitored by ADC1 in the MSP430 to confirm that the frequency is clear prior to transmitting.

The dual-colour LED (LED1) is for user-feedback. It flashes green once every 4s during normal operation & red if there is a problem, such as low-battery, not meshed with the network or an alarm threshold has been exceeded.

Sheet 2 SCHEMATIC:

The logger board has 4 5-pin I/O sockets, Conn1 - Conn4 for channels D to A. These are connected to the 5-pin connectors on the logger enclosure & used for all interconnection with external probes, signal inputs or PC communication. Solder-blob links are used on the board to connect various parts of the circuitry to these connectors, dependent on the required configuration.

I/O pin connections:

1 - Ground
2 - Temperature probe (thermistor or RTD) on all channels, & Transmit RS-232 Data on channel A (via link LK10).
3 - Voltage input on all channels, & Clock output for external Humidity Probes on channels A & B (via links LK8 & LK17).
4 - Data from Humidity Probe on channels A & B (via links LK6 & LK15), Receive RS-232 Data on channel A (via link LK11). Unused on channels C & D.
5 - Power output for Humidity Probe on channels A & B (via links LK7 & LK16), DC power input (from RS-232 cable) on channel A (via link LK12). Unused on channels C & D.

Links LK5, LK14, LK9 & LK13 connect shunt 59R resistors across the voltage inputs of the 4 channels, so that they can measure current instead.

To conserve power, the supply voltage feeding the dividers for temperature measurements is only turned on only during the measurement cycle (Sensor_Pwr).

TEMPERATURE

The temperature sensor elements in the external probes form part of a resistive divider. If Pt1000 RTDs are to be used then the divider ratio is modified via links LK1 - LK4. The resultant voltages are connected to 4 ADC inputs on the microcontroller. These provide 12-bit resolution measurements.

Additionally, the 4 inputs connect to U11, an analogue multiplexer. The output from the multiplexer is fed to an op-amp buffer which adds a small dither signal to the divider DC level. The dither signal is derived from a 16KHz clock signal within the microcontroller. It is processed by R61, C48, C46 & R47 to produce a triangular waveform. The output of the buffer is oversampled via ADC3 and a 16-bit measurement produced.

U15 - U18 are ESD protection diode arrays.

VOLTAGE & CURRENT

The voltage channels accept bipolar signals by connecting each input to a divider circuit that provides a voltage offset, such that a 0v input results in a half-range signal being fed to the ADC.

The offset divider is connected between ground & a 2.5v reference & is made up of R52, R53 & R57 for channel A. Links LK19 - LK22 are connected for voltage inputs but left open for current inputs. A 2.5v reference generated within the microcontroller is buffered by op-amp U13 to feed the dividers.

The output from the 4 dividers connects via multiplexer U11 to op-amp buffer U12. Here, a dither signal can be added via C47, R49 for over-sampling if better than 12-bit resolution is required.

U14, C41 & C43 are not normally fitted. They provide optional decoupling for reference supplies, with disconnect switches (U14) to conserve power.

HUMIDITY

Humidity is measured with a Sensirion SHT75 sensor housed in an external plug-in probe. This has a serial digital connection to the logger.

Power, clock & data connections are made via links LK6-LK8 for Channel A & LK15-LK17 for Channel B.