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Application Note AN0301

ETTR Serial Communications Protocol

Associated Product: ETTR

Summary

The ETTR device may be programmed via a PC interface. The interface is responsible for setting the device modes as well as the temperature characteristics of the relay. The interface program may also be used to collect temperature information for display, logging or control purposes. By implementing a PID algorithm on a control PC, it is possible to add functionality to the simple relay.

The ETTR device collects temperature data and acts according to the settings stored in its memory. Memory settings and data may be collected from the device using RS-232 serial communications.

Temperature Representations:

The thermistor resistance changes in relation to its temperature. The ETTR reads the voltage drop across the thermistor in terms of its 10-bit A/D converter. This data is relayed via the serial line as two bytes. The high byte is sent first, followed by the low byte. To determine the 16-bit equivalent, the following formula may be used:

*ADC Reading = (High Byte * 256) + Low Byte;*
(1)

Given the ADC reading, it is possible to determine the thermistor resistance:

$$R = 10{,}000 * \left(\frac{1{,}024}{ADC}\right) - 10{,}000 \qquad \textbf{(2)}$$

Given the resistance, the temperature may be calculated using the Steinhart-Hart equation below:

$$\frac{1}{T_K} = A + B * \ln(R) + C * (\ln(R))^3 \qquad \textbf{(3)}$$

Where:

- A, B, and C are constants, specific to the thermistor,
- R is the thermistor's resistance in Ohms,
- T_K is the temperature in Kelvin.

The equation may be re-written in terms of °C:

$$T_{\circ C}(R) = \frac{1}{A + B * \ln(R) + C * (\ln(R))^3} - 273.15$$
(4)

where:

A = 0.0011736669200757
B = 0.000226810153789725
C = 1.16919057888479E-07

By substituting the resistance found in (2) into the equation in (4) the corresponding temperature value may be calculated.

The temperature/ADC value may also be determined using the look-up table provided (table 1.1). A 'C' structure containing the values is also provided.

Timer Representations:

The timer in the ETTR is used to determine the minimum cycle time. The device uses a signed integer (16-bit) whole number, in 100ms

increments. Therefore, 10 seconds is represented as 100, and 0.5 seconds is represented as 5.

The ETTR device will start counting down its internal timer every time a change of state occurs. Thus, if the timer is set to 50 (5 seconds), when the relay switches, the timer will start to count down. The relay will not be permitted to switch state until the timer elapses to zero. The timer will only count down when its value is greater than zero. Thus, to enable the "lockout" feature, set the timer to a negative number (-1 for example). This will cause the timer to stop from counting down, and after a relay switchover, will cause the relay to stay in that state until the device is reset (by cycling power to the unit). To disable the short-cycle time feature, set the timer to 0.

Mode Representations:

There are four modes of operation:

0 – "Range" Mode:
The relay will be ON between the low and high temperatures, and OFF at all other times

1 – "Setpoint (Heating)" Mode.
The relay will turn ON below the low temperature, and OFF above the high temperature. Between the two temperatures, the relay will not change from its previous setting. By adjusting the difference between the high/low temperatures, it is possible to adjust for the hysteresis of the device

2 – "Setpoint (Cooling)" Mode.
The relay will turn OFF below the low temperature, and ON above the high temperature. Between the two temperatures, the relay will not change from its previous setting. By adjusting the difference between the high/low temperatures, it is possible to adjust for the hysteresis of the device

3 – "Manual" Mode.
The relay will only turn ON/OFF when directed by the software application (using the "o" command)

Checksum:

Checksums are calculated as the 8-bit sums of all the bytes in the transmitted data. The sum is to "roll-over" upon overflow. For example, for a data string of 0x01, 0x02, 0x03, 0x04, the checksum would be 0x0A.

Port settings:

Data Bits:	8
Stop Bits:	1
Parity:	N
Baud:	9600

All communications to the ETTR (transmit operations) must start with a colon ":".

All communications from the ETTR (receive operations) must end with a semi-colon ";"

All commands are **case sensitive**

Commands:

w – Write settings to device EEPROM
d – Read device EEPROM settings
a – Read ADC (temperature) and relay status
o – Toggle output relay

Command formats:

Write to EEPROM:

Query:

:	w	Low Temp MSB	Low Temp LSB	High Temp MSB	High Temp LSB	Min. Cycle Timer MSB	Min. Cycle Timer LSB	Mode

Response: None

Read from EEPROM:

Query:

:	d

Response:

Low Temp MSB	Low Temp LSB	High Temp MSB	High Temp LSB	Min. Cycle Timer MSB	Min. Cycle Timer LSB	Mode	Checksum	;

Read ADC (temperature) and relay status:

Query:

:	a

Response:

ADC Reading MSB	ADC Reading LSB	Relay Status 1=ON; 0=OFF	Checksum	;

Note: within the Relay Status byte also exists the firmware revision code. To read the relay status, read the low nibble of the byte. To read the firmware revision, read the high nibble of the byte:

Example: Relay status comes back as 0x11:

Relay status=0x11 AND 0x01=1=ON
Firmware=(0x11 AND 0x10)>>4=1=version 1

Toggle Output Relay Status:

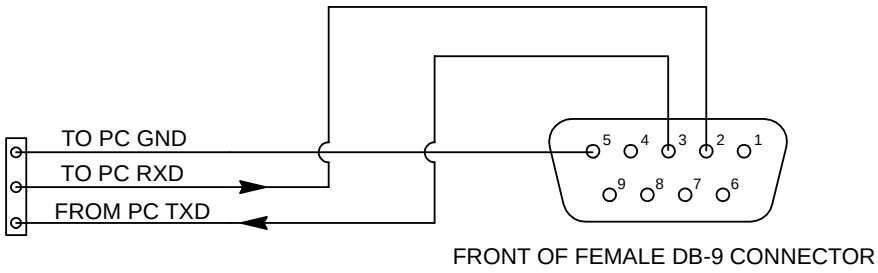
Query:

:	o

Response: None (relay is toggled).

NOTES:

1. The ETTR device does not check the Low/High temperatures. It is up to the programmer to make sure the values are within the specified range
2. The ETTR device does not check the minimum cycle time. Any value between –32768 and 32767 (-3,276.8 -> 3,276.7 seconds) will be accepted. See section “Timer Representations” for more information.
3. The relay may be toggled in any mode of operation, but the ETTR device will override the relay based on the state that it determines the relay should be in. Relay toggle should only be used in “Manual” mode.
4. Values below -25°C and above 100°C (ADC Readings of below 72, and above 961) are extreme readings and may contain larger errors. It is recommended to treat values outside this range as under/over range values, and/or wiring errors.
5. An ADC Reading value of below 5 is considered a “Wiring Error”. ETTR will flash the green light upon detection of such a state. The relay will always toggle “OFF” in case of a wiring error. To operate in manual mode without a relay, short the thermistor inputs.



FRONT OF FEMALE DB-9 CONNECTOR

ADC Reading	Temperature (°C)	ADC Reading	Temperature (°C)	ADC Reading	Temperature (°C)
70	-26.1	370	12.5	670	40.2
80	-23.7	380	13.4	680	41.3
90	-21.5	390	14.3	690	42.4
100	-19.4	400	15.2	700	43.6
110	-17.6	410	16.1	710	44.7
120	-15.8	420	16.9	720	45.9
130	-14.2	430	17.8	730	47.1
140	-12.6	440	18.7	740	48.4
150	-11.1	450	19.6	750	49.6
160	-9.7	460	20.5	760	51
170	-8.4	470	21.3	770	52.3
180	-7.1	480	22.2	780	53.8
190	-5.8	490	23.1	790	55.2
200	-4.6	500	24	800	56.7
210	-3.4	510	24.9	810	58.3
220	-2.3	520	25.8	820	60
230	-1.2	530	26.7	830	61.7
240	-0.1	540	27.6	840	63.5
250	1.0	550	28.5	850	65.5
260	2.0	560	29.4	860	67.5
270	3.0	570	30.3	870	69.6
280	4.0	580	31.3	880	71.9
290	5.0	590	32.2	890	74.4
300	6.0	600	33.2	900	77.1
310	7.0	610	34.1	910	80
320	7.9	620	35.1	920	83.2
330	8.8	630	36.1	930	86.7
340	9.8	640	37.1	940	90.7
350	10.7	650	38.1	950	95.2
360	11.6	660	39.2	960	100.4

Table 1.1: ADC Values and the corresponding temperatures.

NOTE: Use linear interpolation to determine values between those printed above.

Below, a C style array definition is provided. The temperatures are provided for every ADC value in the range of 72 (~-25.6°C) to 961 (~100.5°C).

Note that the first element in the below array corresponds to an ADC value of “72”, and the last element corresponds to an ADC value of “961”.

float temperatures[] = {-25.6, -25.4, -25.1, -24.9, -24.6, -24.4, -24.2, -23.9, -23.7, -23.5, -23.2, -23, -22.8, -22.6, -22.3, -22.1, -21.9, -21.7, -21.5, -21.3, -21.1, -20.9, -20.7, -20.4, -20.2, -20, -19.8, -19.7, -19.5, -19.3, -19.1, -18.9, -18.7, -18.5, -18.3, -18.1, -17.9, -17.8, -17.6, -17.4, -17.2, -17, -16.9, -16.7, -16.5, -16.3, -16.2, -16, -15.8, -15.7, -15.5, -15.3, -15.2, -15, -14.8, -14.7, -14.5, -14.3, -14.2, -14, -13.9, -13.7, -13.6, -13.4, -13.2, -13.1, -12.9, -12.8, -12.6, -12.5, -12.3, -12.2, -12, -11.9, -11.7, -11.6, -11.4, -11.3, -11.2, -11, -10.9, -10.7, -10.6, -10.4, -10.3, -10.2, -10, -9.9, -9.7, -9.6, -9.5, -9.3, -9.2, -9.1, -8.9, -8.8, -8.7, -8.5, -8.4, -8.3, -8.1, -8, -7.9, -7.7, -7.6, -7.5, -7.3, -7.2, -7.1, -7, -6.8, -6.7, -6.6, -6.5, -6.3, -6.2, -6.1, -6, -5.8, -5.7, -5.6, -5.5, -5.4, -5.2, -5.1, -5, -4.9, -4.7, -4.6, -4.5, -4.4, -4.3, -4.2, -4, -3.9, -3.8, -3.7, -3.6, -3.5, -3.3, -3.2, -3.1, -3, -2.9, -2.8,
-2.6, -2.5, -2.4, -2.3, -2.2, -2.1, -2, -1.9, -1.7, -1.6, -1.5, -1.4, -1.3, -1.2, -1.1, -1, -0.9, -0.8, -0.6, -0.5, -0.4, -0.3, -0.2, -0.1, 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 4, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 6, 6.1, 6.2, 6.3, 6.4, 6.5, 6.5, 6.6, 6.7, 6.8, 6.9, 7, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 8, 8.1, 8.2, 8.3, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.6, 9.7, 9.8, 9.9, 10, 10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7, 10.7, 10.8, 10.9, 11, 11.1, 11.2, 11.3, 11.4, 11.5, 11.6, 11.7, 11.7, 11.8, 11.9, 12, 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 12.6, 12.7, 12.8, 12.9, 13, 13.1, 13.2, 13.3, 13.4, 13.4, 13.5, 13.6, 13.7, 13.8, 13.9, 14, 14.1, 14.2, 14.3, 14.3, 14.4, 14.5,14.6, 14.7, 14.8, 14.9, 15, 15, 15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8, 15.8, 15.9, 16, 16.1, 16.2, 16.3, 16.4, 16.5, 16.5, 16.6, 16.7, 16.8, 16.9, 17, 17.1, 17.2, 17.3, 17.3, 17.4, 17.5, 17.6, 17.7, 17.8, 17.9, 18, 18, 18.1, 18.2, 18.3, 18.4, 18.5, 18.6, 18.7, 18.7, 18.8, 18.9, 19, 19.1, 19.2, 19.3, 19.4, 19.4, 19.5, 19.6, 19.7, 19.8, 19.9, 20, 20.1, 20.1, 20.2, 20.3, 20.4, 20.5, 20.6, 20.7, 20.8, 20.8, 20.9, 21, 21.1, 21.2, 21.3, 21.4, 21.5, 21.6, 21.6, 21.7, 21.8, 21.9, 22, 22.1, 22.2, 22.3, 22.3, 22.4, 22.5, 22.6, 22.7, 22.8, 22.9, 23, 23, 23.1, 23.2, 23.3, 23.4, 23.5, 23.6, 23.7, 23.8, 23.8, 23.9, 24, 24.1, 24.2, 24.3, 24.4, 24.5, 24.6, 24.6, 24.7, 24.8, 24.9, 25, 25.1, 25.2, 25.3, 25.4, 25.4, 25.5, 25.6, 25.7, 25.8, 25.9, 26, 26.1, 26.2, 26.3, 26.3, 26.4, 26.5, 26.6, 26.7, 26.8, 26.9, 27, 27.1, 27.2, 27.2, 27.3, 27.4, 27.5, 27.6, 27.7, 27.8, 27.9, 28, 28.1, 28.2, 28.2, 28.3, 28.4, 28.5, 28.6, 28.7,28.8, 28.9, 29, 29.1, 29.2, 29.2, 29.3, 29.4, 29.5, 29.6, 29.7, 29.8, 29.9, 30, 30.1, 30.2, 30.3, 30.4, 30.5, 30.5, 30.6, 30.7, 30.8, 30.9, 31, 31.1, 31.2, 31.3, 31.4, 31.5, 31.6, 31.7, 31.8, 31.9, 32, 32, 32.1, 32.2, 32.3, 32.4, 32.5, 32.6, 32.7, 32.8, 32.9, 33, 33.1, 33.2, 33.3, 33.4, 33.5, 33.6, 33.7, 33.8, 33.9, 34, 34.1, 34.2, 34.3, 34.4, 34.5, 34.6, 34.7, 34.7, 34.8, 34.9, 35, 35.1, 35.2, 35.3, 35.4, 35.5, 35.6, 35.7, 35.8, 35.9, 36, 36.1, 36.2, 36.3, 36.4, 36.5, 36.6, 36.7, 36.8, 36.9, 37, 37.1, 37.2, 37.3, 37.5, 37.6, 37.7, 37.8, 37.9, 38, 38.1, 38.2, 38.3, 38.4, 38.5, 38.6, 38.7, 38.8, 38.9, 39, 39.1, 39.2, 39.3, 39.4, 39.5, 39.6, 39.7, 39.9, 40, 40.1, 40.2, 40.3, 40.4, 40.5, 40.6, 40.7, 40.8, 40.9, 41, 41.1, 41.3, 41.4, 41.5, 41.6, 41.7, 41.8, 41.9, 42, 42.1, 42.2, 42.4, 42.5, 42.6, 42.7, 42.8, 42.9, 43, 43.1, 43.3, 43.4, 43.5, 43.6, 43.7, 43.8, 43.9, 44.1, 44.2, 44.3, 44.4, 44.5, 44.6, 44.8, 44.9, 45,45.1, 45.2, 45.3, 45.5, 45.6, 45.7, 45.8, 45.9, 46.1, 46.2, 46.3, 46.4, 46.5, 46.7, 46.8, 46.9, 47, 47.2, 47.3, 47.4, 47.5, 47.6, 47.8, 47.9, 48, 48.1, 48.3, 48.4, 48.5, 48.7, 48.8, 48.9, 49, 49.2, 49.3, 49.4, 49.6, 49.7, 49.8, 49.9, 50.1, 50.2, 50.3, 50.5, 50.6, 50.7, 50.9, 51, 51.1, 51.3, 51.4, 51.5, 51.7, 51.8, 52, 52.1, 52.2, 52.4, 52.5, 52.7, 52.8, 52.9, 53.1, 53.2, 53.4, 53.5, 53.6, 53.8, 53.9, 54.1, 54.2, 54.4, 54.5, 54.7, 54.8, 55, 55.1, 55.3, 55.4, 55.6, 55.7, 55.9, 56, 56.2, 56.3, 56.5, 56.6, 56.8, 56.9, 57.1, 57.2, 57.4, 57.6, 57.7, 57.9, 58, 58.2, 58.4, 58.5, 58.7, 58.9, 59, 59.2, 59.3, 59.5, 59.7, 59.8, 60, 60.2, 60.4, 60.5, 60.7, 60.9, 61, 61.2, 61.4, 61.6, 61.7, 61.9, 62.1, 62.3, 62.5, 62.6, 62.8, 63, 63.2, 63.4, 63.6, 63.8, 63.9, 64.1, 64.3, 64.5, 64.7, 64.9, 65.1, 65.3, 65.5, 65.7, 65.9, 66.1, 66.3, 66.5, 66.7, 66.9, 67.1, 67.3, 67.5, 67.7, 67.9, 68.2, 68.4, 68.6, 68.8, 69, 69.2, 69.5, 69.7, 69.9,70.1, 70.3, 70.6, 70.8, 71, 71.3, 71.5, 71.7, 72, 72.2, 72.5, 72.7, 72.9, 73.2, 73.4, 73.7, 73.9, 74.2, 74.4, 74.7, 75, 75.2, 75.5, 75.8, 76, 76.3, 76.6, 76.8, 77.1, 77.4, 77.7, 78, 78.2, 78.5, 78.8, 79.1, 79.4, 79.7, 80, 80.3, 80.6, 80.9, 81.3, 81.6, 81.9, 82.2, 82.5, 82.9, 83.2, 83.5, 83.9, 84.2, 84.6, 84.9, 85.3, 85.6, 86, 86.4, 86.7, 87.1, 87.5, 87.9, 88.3, 88.7, 89.1, 89.5, 89.9, 90.3, 90.7, 91.1, 91.5, 92, 92.4, 92.9, 93.3, 93.8, 94.3, 94.7, 95.2, 95.7, 96.2, 96.7, 97.2, 97.7, 98.3, 98.8, 99.3, 99.9, 100.5};