PUTSI™ WiFi Application Notes

AN001: Measuring Temperature

Written by:
Martin Alcock, M. Sc, VE6VH

For Software Revision: 0.2a

Alberta Digital Radio Communications Society,
43 Citadel Bay NW,
Calgary, AB T3G 3Y4
www.adrcs.org

Table of Contents

List of Figures iii
List of Tables iii
Document Revision History iv
Reference Documents v
Glossary of Terms vi
Intellectual Property Notice vii
Disclaimer vii
Introduction 1
Using a Thermistor 2
Configuring the Input 3
Measurement 3
Configuring Allstar 4
USRP Telemetry 4
Calibration 6
Using an Active Device 7
Configuring the Input 7
Measurement 8
Configuring Allstar 9
USRP Telemetry 10
Calibration 11

List of Figures

Figure 1 TMP6131LPGM Leaded Thermistor Device 2
Figure 2 Configurable analog Input 3
Figure 3 Analog Devices TMP36 in a TO-92 package 7
Figure 4 Analog Input Circuit 8

List of Tables

Table 1 Revision History iv
Table 2 Probe types 1
Table 3 A/D Voltage inputs and reading for TMP61 3
Table 4 Allstar Readings in Degrees C 4
Table 5 Allstar Readings in Degrees F 4
Table 6 USRP Readings in Degrees C 5
Table 7 USRP Readings in Degrees F 5
Table 8 A/D Voltage inputs and reading for TMP36 8
Table 9 Measuring Temperature in deg C using TMP36 9
Table 10 Measuring Temperature in deg F using TMP36 9
Table 11 USRP Readings in Degrees C 10
Table 12 USRP Readings in Degrees F 10

Document Revision History

Date	Rev	Description
Sept, 2023	0.2a	Initial draft, companion to rev 0.2a manual

Table 1 Revision History

Reference Documents

[1] gnu.org, "General Public Licence," [Online]. Available: https://www.gnu.org/licenses/gpl-3.0.en.html. [Accessed 25th February 2018].

[2] Analog Devices Inc, "Low Voltage Temperature Sensors," [Online]. Available: https://www.analog.com/media/en/technical-documentation/data-sheets/TMP35_36_37.pdf. [Accessed 20 09 2023].

[3] Texas Instruments, "TMP61," [Online]. Available: https://www.ti.com/product/TMP61. [Accessed 20 09 2023].

Glossary of Terms

PBX	Private Branch Exchange. A node in a telephone network that provides connectivity for a series of local extensions to a set of trunks.
VOIP	Voice over Internet Protocol. A system where telephone calls are placed, and audio is exchanged using the Internet Protocol.
PUTSI	PIC USB Telemetry System Interface
Wi-Fi	Wireless Fidelity implementing the IEEE 802.11x standards.

Intellectual Property Notice

The hardware components and all intellectual property described herein is the exclusive property of the Alberta Digital Radio Communications Society and others ("the owner"), all rights are reserved.

The owner grants licence to any Amateur for personal or club use, on an as is and where is basis under the condition that its use is for non-commercial activities only, all other usages are strictly prohibited. Terms and conditions are governed by the GNU public licence [1].

No warranty, either express or implied or transfer of rights is granted in this licence and the owner is not liable for any outcome whatsoever arising from such usage.

Disclaimer

This document is a preliminary release for a product still in development and may be subject to change in future revisions. The software may be subject to unpredictable behaviour without notice. You are advised to keep a can of RAID™ Ant, Roach and Program Bug killer handy. Spray liberally on the affected area when needed.

Introduction

Measuring temperature is an important part of determining the health of a repeater system. Critical temperatures such as the heat sink on the power amplifier, shack internal temperatures can easily be measured with the PUTSI device using one of two types of devices, a thermistor or active temperature probe.

A thermistor type temperature probe is a passive device that acts as a resistor which varies over temperature. These devices can be connected directly to PUTSI using one of the three configurable inputs, without any external components.

An active temperature probe is a solid state device that has an internal reference and provides a voltage output based on external temperature. These devices require a power supply and can be connected to any one of the analog inputs, including the configurable inputs.

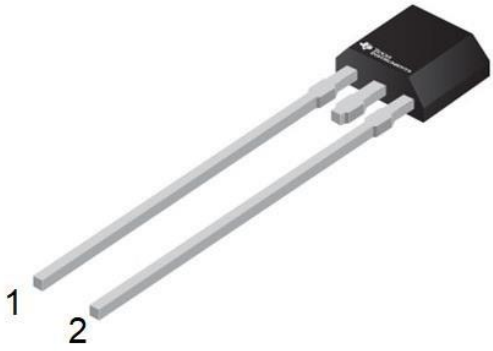
Table 2 illustrates the types and number that can be utilized:

Device Type	Connection	Max per System
Thermistor	Configurable inputs only	3
Active probe	Any analog input	7

Table 2 Probe types

Using a Thermistor

The recommended device is a TMP61 from Texas Instruments [2], which retails for around $1. Connect pin 2 to the regulated supply voltage of 3.3v (available at J301-4), and pin 1 to one of the configurable inputs on J401 or J402.



Pin Functions

PIN		TYPE	DESCRIPTION
NAME	NO.		
–	1	—	Thermistor (–) and (+) terminals. For proper operation, ensure a positive bias where the + terminal is at a higher voltage potential than the – terminal.
+	2		

Figure 1 TMP6131LPGM Leaded Thermistor Device

To measure power amplifier temperature the device can be mounted on a heat sink to measure or placed anywhere in the shack to measure the ambient temperature. The leads should be made of 24AWG wire, the length is not a factor as the resistance is minimal, however a length of under 10’ (3m) is recommended.

Configuring the Input

For a thermistor application, the jumper is connected to VCC (pins 2-3), the series resistor is jumpered, and pin is connected between an input and ground. RG is set to 10KΩ. A 1% tolerance resistor is recommended for better temperature accuracy, and to match the accuracy of the device. A maximum of three (3) devices can be supported.

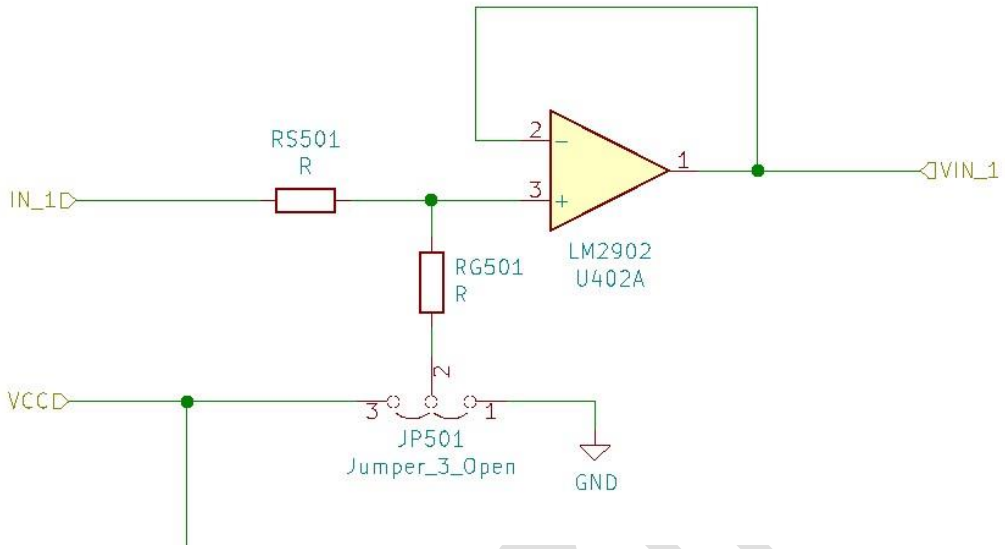


Figure 2 Configurable analog Input

Measurement

Table 3 illustrates the voltage inputs and A/D readings for the TMP61.

Temp (°C)	Temp (°F)	Res (Ω)	A/D Input	USRP Value	Allstar Value
-40	-40	6587	1.31	406	101
-25	-13	7265	1.39	430	107
-15	5	7750	1.44	447	111
0	32	8527	1.52	471	117
15	59	9368	1.60	495	123
25	77	9966	1.65	511	127
40	104	10920	1.72	534	133
65	149	12676	1.84	572	143
80	176	13832	1.92	594	148
100	212	15502	2.01	622	155

Table 3 A/D Voltage inputs and reading for TMP61

Configuring Allstar

Operating with Allstar requires that an entry is added to the meter faces stanza in the configuration file, and a function entry. For more information, consult the PUTSI manual document. The examples below illustrate entries for degrees Centigrade and Fahrenheit.

```
[meter-faces]
tempdegC = scale(-101,0.4,-40),rpt/thetemperatureis,?
tempdegF = scale(-117,0.222,32),rpt/thetemperatureis,?
```

Table 4 illustrates the expected readings from Allstar in degrees C based on the abbreviated word size and scaling factors shown above. Note that it is reasonably accurate from -40 to +65, but at higher temperatures it becomes non-linear.

Temp (°C)	Reading	Prescaler	Scalar	Postscaler	Temperature
-40	101	-101	0.4	-40	-40
-25	107				-25
-15	111				-15
0	117				0
15	123				15
25	127				25
40	133				40
65	143				65
80	148				78
100	155				95

Table 4 Allstar Readings in Degrees C

Table 5 illustrates the expected readings from Allstar in degrees Fahrenheit. The same non-linearity can be noticed above 150 degrees.

Temp (°F)	Reading	Prescaler	Scalar	Postscaler	Temperature
-40	101	-117	0.2222	32	-40
-13	107				-13
5	111				5
32	117				32
59	123				59
77	127				77
104	133				104
149	143				149
176	148				172
212	155				203

Table 5 Allstar Readings in Degrees F

USRP Telemetry

In the USRP (WIFI) mode, the readings are four times those in Allstar, as the full word size is utilized. The scaling factors are changed, as illustrated in Table 6 and Table 7. The non-linearities become more apparent earlier due to the wider word size.

Temp (°C)	Reading	Prescaler	Scalar	PostScalar	Temperature
-40	406	-406	1.625	-40	-40
-25	430				-25
-15	447				-15
0	471				0
15	495				15
25	511				25
40	534				39
65	572				62
80	594				76
100	622				93

Table 6 USRP Readings in Degrees C

Temp (°C)	Reading	Prescaler	Scalar	PostScalar	Temperature
-40	406	-471	0.902777	32	-40
-13	430				-13
5	447				5
32	471				32
59	495				59
77	511				76
104	534				102
149	572				144
176	594				168
212	622				199

Table 7 USRP Readings in Degrees F

Calibration

The scalar has been calculated based on the device resistance as specified by the manufacturer so it will not need to be adjusted. The prescaler value is the expected reading at the temperature specified in the postscaler, which is -40 in degrees C and 32 in degrees Fahrenheit.

The simplest adjustment can be made by altering the postscalar value until it reads accurately. Adjusting by ±1 will adjust the calculated temperature according, in the relevant scale. The accuracy is within ±1 degree in the linear range.

Using an Active Device

The recommended active device for temperature measurement is the TMP36 [3] from Analog Devices, which retails for about $3. Connect pin 1 to the regulated supply voltage of 3.3v (available at J301-4), pin 2 to a configurable input and pin 3 to ground.

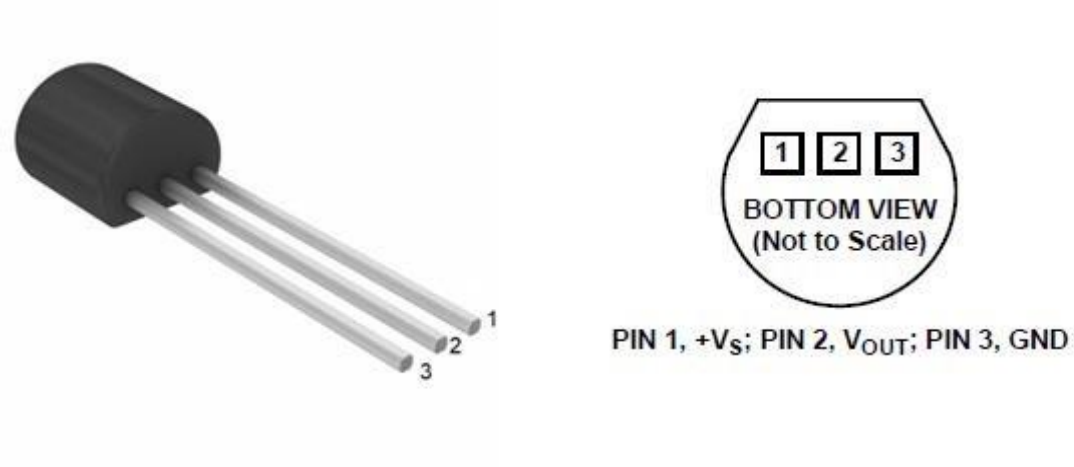


Figure 3 Analog Devices TMP36 in a TO-92 package

As the device sources a voltage, any length of wire can be used, however it is recommended to keep it to less than 25’ in order to maintain the correct power supply voltage for 24AWG. However, for longer lengths a larger wire gauge is recommended.

Configuring the Input

Figure 4 illustrates one if the 4 non-configurable analog inputs. Two resistors are used to implement a voltage divider, Rs and Rg. A configurable input by inserting the jumper to ground (pins 1-2), in which case it has the identical circuit. Any one of the 7 inputs can be used.

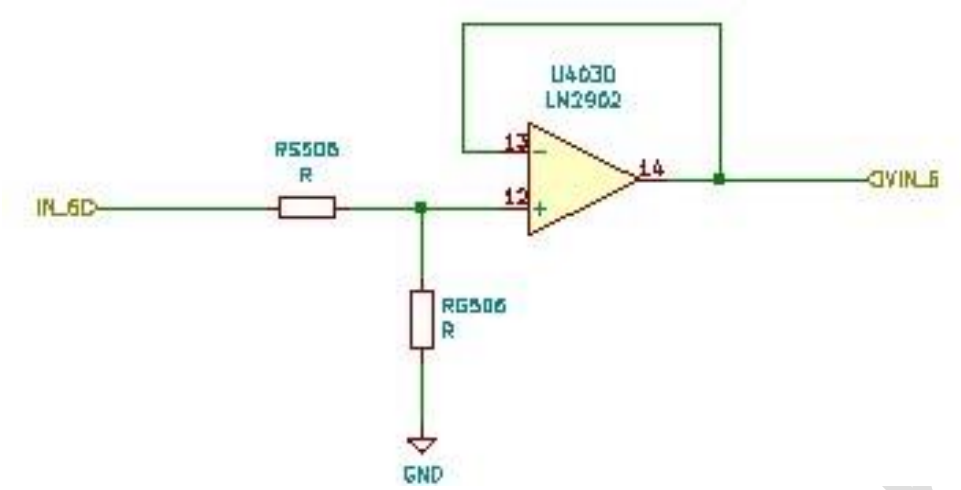


Figure 4 Analog Input Circuit

For both degrees Centigrade and Fahrenheit, the output voltage is within the A/D input limits, so Rs can be jumpered with a wire, and Rg omitted.

Measurement

Table 8 illustrates the voltage inputs and A/D readings for the TMP36.

Temp (°C)	Temp (°F)	A/D Input	USRP	Allstar
-40	-40	0.1	31	7
-25	-13	0.25	77	19
-15	5	0.35	108	27
0	32	0.5	155	38
15	59	0.35	108	27
25	77	0.75	232	58
40	104	0.9	279	69
65	149	1.15	356	89
80	176	1.3	403	100
100	212	1.5	465	116

Table 8 A/D Voltage inputs and reading for TMP36

Configuring Allstar

Operating with Allstar requires that an entry is added to the meter faces stanza in the configuration file, and a function entry. For more information, consult the PUTSI manual document. The examples below illustrate entries for degrees Centigrade and Fahrenheit.

```
[meter-faces]
tempdegC = scale(-7,0.8,-40),rpt/thetemperatureis,?
tempdegF = scale(-8,0.4444,30),rpt/thetemperatureis,?
```

Table 9 illustrates the expected readings from Allstar in degrees C based on the abbreviated word size and scaling factors shown above.

Temperature	Voltage	A/D Count	Prescaler	Scalar	PostScaler	Scaled
-40	0.1	7	-7	0.8	-40	-40
-25	0.25	19				-26
-15	0.35	27				-16
0	0.5	38				-2
15	0.65	27				13
25	0.75	58				23
40	0.9	69				37
65	1.15	89				62
80	1.3	100				76
100	1.5	116				96

Table 9 Measuring Temperature in deg C using TMP36

Table 10 illustrates the expected readings from Allstar in degrees F.

Temperature	Voltage	A/D Count	Prescaler	Scalar	PostScaler	Scaled
-40	0.1	7	-38	0.4444	30	-40
-13	0.25	19				-13
5	0.35	27				5
32	0.5	38				30
59	0.65	27				57
77	0.75	58				75
104	0.9	69				99
149	1.15	89				144
176	1.3	100				169
212	1.5	116				205

Table 10 Measuring Temperature in deg F using TMP36

USRP Telemetry

In the USRP (WIFI) mode, the readings are four times those in Allstar, as the full word size is utilized. The scaling factors are changed, as illustrated in Table 11 and Table 12. The non-linearities become more apparent earlier due to the wider word size.

Temp (°C)	Reading	Prescaler	Scalar	PostScalar	Temperature
-40	31	-31	3.2	-40	-40
-25	77				-26
-15	108				-16
0	155				-1
15	201				13
25	232				23
40	279				38
65	356				62
80	403				76
100	465				96

Table 11 USRP Readings in Degrees C

Temp (°C)	Reading	Prescaler	Scalar	PostScalar	Temperature
-40	31	-31	1.7	-40	-40
-13	77				-13
5	108				5
32	155				32
59	201				59
77	232				76
104	279				102
149	356				144
176	403				168
212	465				199

Table 12 USRP Readings in Degrees F

Calibration

The scalar has been calculated based on the device resistance as specified by the manufacturer so it will not need to be adjusted. The prescaler value is the expected reading at the temperature specified in the postscaler, which is -40 in both scales.

The simplest adjustment can be made by altering the postscalar value until it reads accurately. Adjusting by ±1 will adjust the calculated temperature according, in the relevant scale. The accuracy in the linear range is with ±2 degrees.