Temperature Measurement with BQ76952

Additional Options for Thermistor Biasing

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- The BQ76952 is designed for use with external thermistors, which are biased and measured periodically, then used to calculate temperature.
- The device includes two internal pullup resistors (nominally 18-kΩ and 180-kΩ) which can be selected for use to bias a thermistor.
- The pullup resistors are only powered periodically when the thermistor is being measured, in order to reduce power dissipation in the pack. The pullup resistors connect to the device's REG18 LDO voltage.
- During thermistor measurement, when the pullup resistor is enabled, the ADC converts the voltage at the selected pin using the REG18 voltage as the reference for the ADC. This implements a ratiometric measurement, such that the absolute value of the REG18 voltage does not impact the accuracy of the measurement.

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- The internal pullup resistors in the BQ76952 are not trimmed in the factory, and so will vary in value from device to device. However, these resistors (and the series pad resistances) are measured during TI factory test and their values stored within each device.
- When the device computes the temperature using the digitized thermistor voltage data, these stored values are used to correct for the variation in the resistance from device to device. It is during this computation that the device uses the polynomial coefficients stored in ***Calibration:18K Temperature Model***, ***Calibration:180K Temperature Model***, or ***Calibration:Custom Temperature Model***.
- If a customer does not want to use the internal temperature polynomial within the BQ76952 (which is reported using the *TS1 Temperature(),* and similar commands for other pins), they can access the raw ADC digitized data, which is available in the *DASTATUS6()* and *DASTATUS7()* subcommands as *TS1 Counts*, etc.
- However, because this raw ADC data is not corrected based on the stored measurement of the pullup and pad resistances, it will generally include additional error due to the variation in these resistances from device to device.

Workaround Approach
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- A workaround for this approach is to load a “dummy” polynomial into the calibration coefficients, such that the device will still perform corrections associated with the pullup and pad resistances, but otherwise will provide the ADC code corresponding to the measured thermistor voltage.
- The resulting data is still reported using the *TS1 Temperature()* and similar commands, but the data will need to be further processed by the host to determine the temperature of the thermistor.
- The “dummy” polynomial to use in this case is:
  - A1 = 0 B1 = 0
  - A2 = 0 B2 = 0
  - A3 = 0 B3 = 32767
  - A4 = 0 B4 = 0
  - A5 = 16384
  - Adc0 = 11703 (if the 18-kΩ pullup is selected).

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- In this case, if the thermistor = 10-kΩ, pullup resistor = 18-kΩ, and pad resistance = 526-Ω, the raw ADC code (24-bit version) which can be read from *TS1 Counts* in *DASTATUS6()* will be approximately

  TS1 Counts = (10000 + 526) / (10000 + 526 + 18000) * 3 / 5 * 8388608 = 1857221

- The value reported in the *TS1 Temperature()* command using the "dummy" polynomial will be approximately

  TS1 Temperature() = (10000 + 526) / (10000 + 526 + 18000) * 32767 = 12091

- Note, though, that the value reported by *TS1 Temperature()* will be corrected based on the measured pullup and pad resistance values stored in the device, so will be more accurate than relying only on the raw ADC code.

Using an External Pullup Resistor

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- If a customer prefers to use an external pullup resistor for thermistor measurement, while still using the ADC in the BQ76952, then the accuracy of the voltage source used to bias the pullup resistance becomes important, unless special steps are taken to implement a ratiometric measurement.
- It is important to bias the thermistor so that the voltage applied to the ADC input pin does not exceed approximately 2.0V.
- If an external pullup resistor is biased to a fixed voltage rail, such as the REG1 output of the BQ76952, then this circuit will draw power continuously, which is generally not acceptable.
- An alternative approach which avoids this is shown next.

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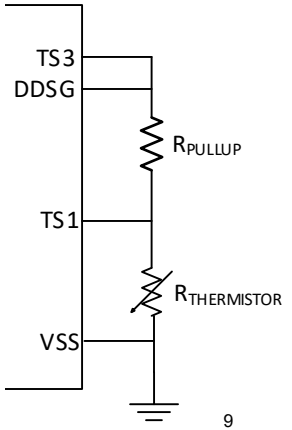
To implement an alternative approach which will provide a ratiometric measurement:

- Enable the REG1 LDO in the BQ76952 and program it to output a level of 1.8V.
- Select an unused pin on the BQ76952 for the thermistor measurement, such as TS1. This pin will be configured in ADCIN mode, thus will use the internal VREF1 for the ADC reference.
- Select another unused pin with ADCIN functionality, such as the TS3 pin. This pin will also be configured in ADCIN mode.
- Select an unused pin with GPO functionality, such as DDSG. This pin will be configured as a GPO to drive its output based on the REG1 voltage rail.
- Connect the pullup resistor between the GPO pin (DDSG) and the first ADCIN pin (TS1).
- Connect the GPO pin (DDSG) directly to the second ADCIN pin (TS3).
- Connect the thermistor from the first ADCIN pin (TS1) to VSS.



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- When a temperature measurement is desired:
  - Program the GPO pin (DDSG) to drive a high output, which will bias the pin at the 1.8V REG1 voltage level
  - Wait sufficient time for the transients to settle.
  - Read the measured result for the TS1 pin from the *TS1 Counts* in *DASTATUS6()*. Ensure a new measurement has been taken by waiting for the *[FULLSCAN]* bit in *Alarm Status()* to be set, then cleared, then set again. Refer to this result as TS1_code.
  - Read the measured result for the TS3 pin from the TS3 Counts in DASTATUS6(). Ensure a new measurement has been taken by waiting for the *[FULLSCAN]* bit in *Alarm Status()* to be set, then cleared, then set again. Refer to this result as TS3_code.
  - Program the GPO pin (DDSG) to drive a low output, which will bias the pin at 0V, to avoid power dissipation in the thermistor circuit when a temperature measurement is not needed.
  - The ratiometric result of the circuit is obtained by taking TS1_code / TS3_code. By measuring the bias voltage with TS3 and dividing this from the TS1 measurement, the accuracy of the bias voltage (the voltage driven at DDSG) is no longer a limitation.
  - Repeat this procedure whenever a new temperature measurement is desired.
  - Note that a capacitor can be added into the circuit to provide addition filtering. Be aware the time needed for transients to settle will vary depending on the value of capacitance.