

Individual Component Analysis

The temperature sensor is vital for the Rugged 3D printer as it signals if the printing chamber is within the required range and can be implemented as part of a feedback system to adjust otherwise. The industry mainly utilizes three types of temperature sensors, so before any prototyping, it is important to understand the advantages and disadvantages of each one and select the most suitable type.

Correspondence with Eric Schnell, the sponsor of the Rugged 3D printer allowed for better understanding of the requirements and constraints of the project. He also indicated that the project had temporarily been using the Adafruit BME680. The requirements for the sensor were:

- Temperature sense range from -15 °C to 70 °C
 - Accuracy within 1 °C
 - Durable/rugged (able to withstand shocks and vibrations)
 - Small and compact (fit within the printing chamber without interfering with other components)

Some secondary considerations were:

- Maneuverable within the printer space (able to measure temperature anywhere within the chamber)
- Reach a maximum temperature range of 150 °C
- Not have a breakout board

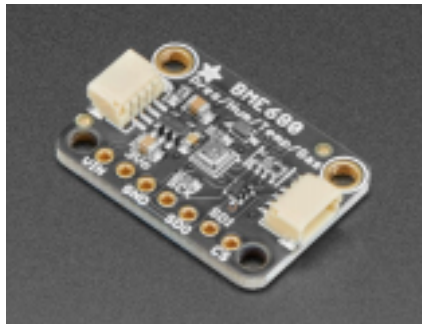
Initial searches and discussion with Audrey from Mouser compiled information in the following table. Audrey was able to clear doubts on the durability of thermistors. Though thermistors are brittle, they are able to withstand the shocks and vibrations to be expected of the Rugged 3D printer. Furthermore, the sensor range must encompass and be larger than the required range to prevent wearing out the sensor.

	Thermistor	RTD	Thermocouple
Temperature range (°C)	-100 to 180	-200 to 650	200 to 1750
Accuracy (°C)	0.05 to 1.5	0.1 to 1	0.5 to 5
Stability @ 100°C	0.2°C/year	0.05°C/year	depends
Linearity	exponential	fairly linear	non-linear
Power required	constant V	constant V	self-powered
Response time	0.12 to 10s	1 to 50s	0.1 to 10s
Susceptibility to electric noise	rarely/susceptible to high resistance	rarely	susceptible/cold junction compensation
Cost	low - mod	high	low
Rugged (?)	yes	no	yes

From this, thermistors are the most suitable, going forward.

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Several thermistor types are noted from Mouser Electronics before selecting the best out of them all. The most suitable thermistor from E3D-Online (a 3D printer parts retailer) is also chosen for comparison, following Audrey's advice to check 3D printer specific sensors. The specifications for these two and the previously used Adafruit were compared. The following sensors all meet the requirement to be accurate within 1°C. The power ratings were not noted, as they were in mWatts whereas the entire system of the Rugged 3D printer operates in hundreds of Watts (therefore the power draw was insignificant).



Name	Sensor type	Range (°C)	Size	Unit Cost
Adafruit BME680	PCB	-40 to 85	16x11 mm	18.95

It is worth noting that the Adafruit BME680 also measures humidity, pressure, and gases. Information for this sensor was obtained from its specification sheet.



Name	Sensor type	Range (°C)	Size	Unit Cost
Vishay / BC Components NTCALUG01A104FA	wire lead	-40 to 150	7.2mm 15.7 mm	2.79

Information gathered from the vendor's website, Mouser Electronics.



Name	Sensor type	Range (°C)	Size	Unit Cost
E3D cartridge type Semitec 104Gt	wire lead	-50 to 280	15mm 50 mm length	6.44

It is worth noting that this thermistor is the same as the one used by the 3D printer. Information for this sensor was obtained from the distributor's website, E3D-Online and Keith, a technical support correspondent.

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The pros and cons of each thermistor is summarized in this table:

Thermistor	Pros	Cons
Adafruit BME680	Measures humidity (can affect print quality), easily mountable	Can only be attached to flat surfaces, does not measure reach max temperature, many unneeded features, expensive
Vishay / BC Components NTCALUG01A104FA	Cheapest, maneuverable and flexible, smallest size	Does not comfortably encompass max temperature range
E3D cartridge type Semitec 104Gt	Moderately priced, maneuverable and flexible, same type as used in 3D printer (reduces complexity of feedback system), comfortably encompasses max temperature range	More than twice the price of Vishay

The conclusion then, is that the E3D cartridge type Semitec 104Gt is the most suitable temperature sensor for the Rugged 3D printer. It has the advantage of reducing feedback system complexity while being moderately priced (the cost is within an acceptable margin), and meets the temperature range requirements.

References:

Keywords – temperature sensors, thermistors, compact, maneuverable, durable,
accurate Phone calls – Audrey, Mouser Electronics, (800) 346-6873

Chat – Keith, <https://e3d-online.com> support chat