NTC type thermistor sensors

The main aim of this project is measuring Urine volume of a patient. Also this project is based on Thermistor sensor. So choosing the best thermistor type is very important fact.

Mainly, there are two types of thermistors.

1. PTC (Positive temperature coefficient) thermistors
2. NTC (Negative temperature coefficient) thermistors

NTC Thermistors

Negative temperature coefficient of resistance thermistors, or *NTC thermistors* for short, reduce or decrease their resistive value as the operating temperature around them increases. Generally, NTC thermistors are the most commonly used type of temperature sensors as they can be used in virtually any type of equipment where temperature plays a role.

NTC temperature thermistors have a negative electrical resistance versus temperature (R/T) relationship. The relatively large negative response of an NTC thermistor means that even small changes in temperature can cause significant changes in their electrical resistance. This makes them ideal for accurate temperature measurement and control.

An NTC thermistors reduces its resistance with an increase in temperature and are available in a variety of base resistances and temperature curves. NTC thermistors are usually characterized by their base resistance at room temperature, that is 25^{o}C, (77^{o}F) as this provides a convenient reference point. So for example, 2k2Ω at 25^{o}C, 10kΩ at 25^{o}C or 47kΩ at 25^{o}C, etc.

According to these characteristics, NTC Thermistors can be used as temperature sensor.

PTC Thermistors

PTC Thermistors are an electronic component where the resistance remains almost constant near room temperatures. However, when the temperature exceeds a constant temperature, the resistance suddenly increases. In PTC thermistors when temperature goes up, the resistance of the thermistors will increase. Hence PTC type thermistors are act as a some kind of fuse.

But in this project, we want a temperature sensor. Therefore NTC type thermistor is the best for this project.

DIFFERENT TYPES OF NTC THERMISTORS

By mixing various metal oxides (usually two or more) with a suitable binder you are able to create an NTC thermistor. Common oxides used in creating NTC thermistors are cobalt, titanium, copper, and even manganese. By combining different oxides, thermistors can have different sintering temperatures and a wide resistivity. There are many types of NTC Thermistors. Below we will be going over some of the major differences between thermistors.

First, when referring to commercial thermistors, there are two main classification groups. The difference is between which electrodes attach to ceramic bodies. Within those two groups, there are more categorizations. For instance, there are bead type thermistors. You can get bare beads, glass coated beads, or ruggedized beads, which are all subdivisions of bead type thermistors.

Miniature glass bead thermistors are used mostly in scientific high temperature applications. Less expensive chip thermistors are suitable for commercial use. Surface Mount Thermistors (SMD) have metal contacts, they are used in automotive industry and other industrial applications.
In this project, They used a catheter as a urine flow rate controller. Also only a small urine drop is touched the thermistor. when considering the arrangement of the catheter and behavior of the sensor , the most useful thermistor type is epoxy NTC thermistor. It is the reason why surface mounted NTC thermistor didn't use in this project.

Temperature behavior of the urine sample

Urine is typically the same as a person's body temperature. On average, this is 37 celsius. Some people have normal temperature variations that may be sightly hotter or sightly cooler than this. Urine will usually maintain its temperature outside the body for about four minutes.

Therefore, the thermistor steady temperature must be higher than the urine sample. But temperature of the urine sample can be fluctuated between 32 celsius and 47 celcius degree. Hence thermistor temperature must be higher than about 47 celsius degree.

Thermistor parameters

- **B value of a thermistor**

The B value is a material constant which is determined by the ceramic material from which it is made. it describes the gradient of the resistive (R/T) curve over a particular temperature range between two temperature points. Each thermistor material will have a different material constant and therefore a different resistance versus temperature curve. The B constant expresses a degree of thermistor sensitivity (change rate of its resistance) to temperature changes. The change rate can also be expressed by the gradient of a line. The larger the gradient, the higher the sensitivity.

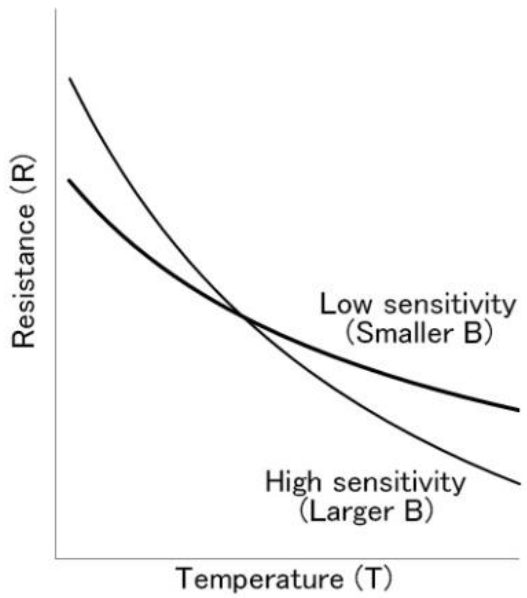
- **Temperature coefficient**

The temperature coefficient of a thermistor denotes the rate of change of thermistor resistance per 1℃ and is commonly expressed in %/℃. The negative sign of the coefficient α indicates that the thermistor resistance decreases with increasing temperature.

- **Thermal time constant**

The Thermal Time Constant is a measurement of the time required for the thermistor to respond to a change in the ambient temperature. The technical definition of Thermal Time Constant is, "The time required for a thermistor to change 63.2% of the total difference between its initial and final body temperature when subjected to a step function change in temperature, under zero power conditions".

The thermal time constant is affected by the medium in which the test is performed. For example, the thermal time constant will be shorter in moving air than in still air and shorter in moving water than in still water.



NTC SC type epoxy thermistor was chosen as temperature sensor.

Thermometrics Epoxy Type SC NTC Interchangeable Thermistors are sleeved interchangeable chip thermistors with heavy isomid insulated nickel lead wires. They provide accurate temperature measurement, control and compensation with use over a range of -40°C to 105°C (-40°F to 221°F) and high sensitivity greater than -4%/°C at 25°C (77°F), making them ideal for medical applications.

There are two types of SC NTC thermistor.

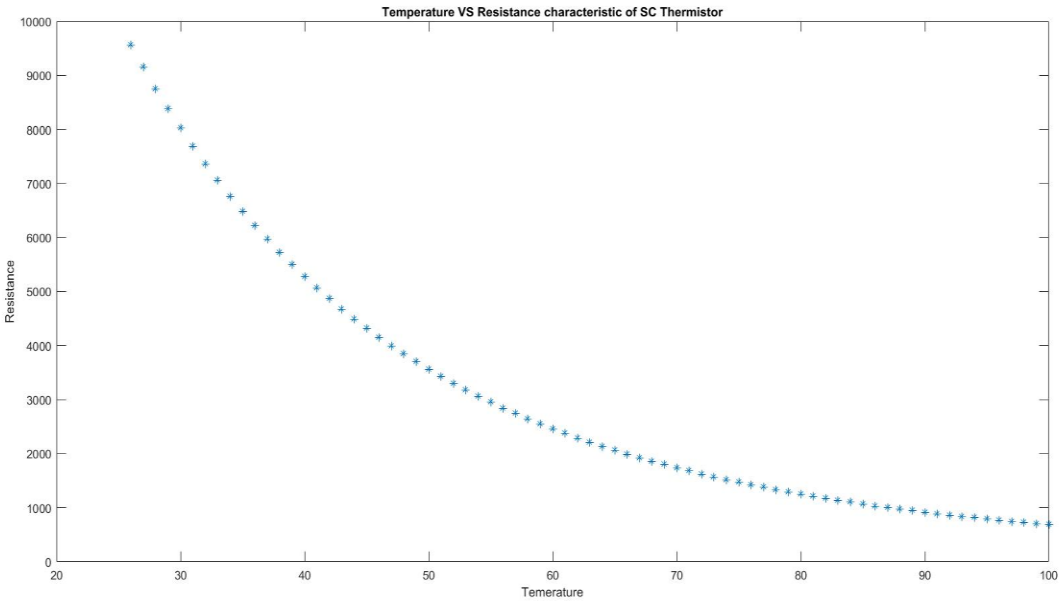
1. SC30 type
2. SC50 type

SC30 type has low thermal time constant than SC50 type and also SC30 has low power dissipation constant.

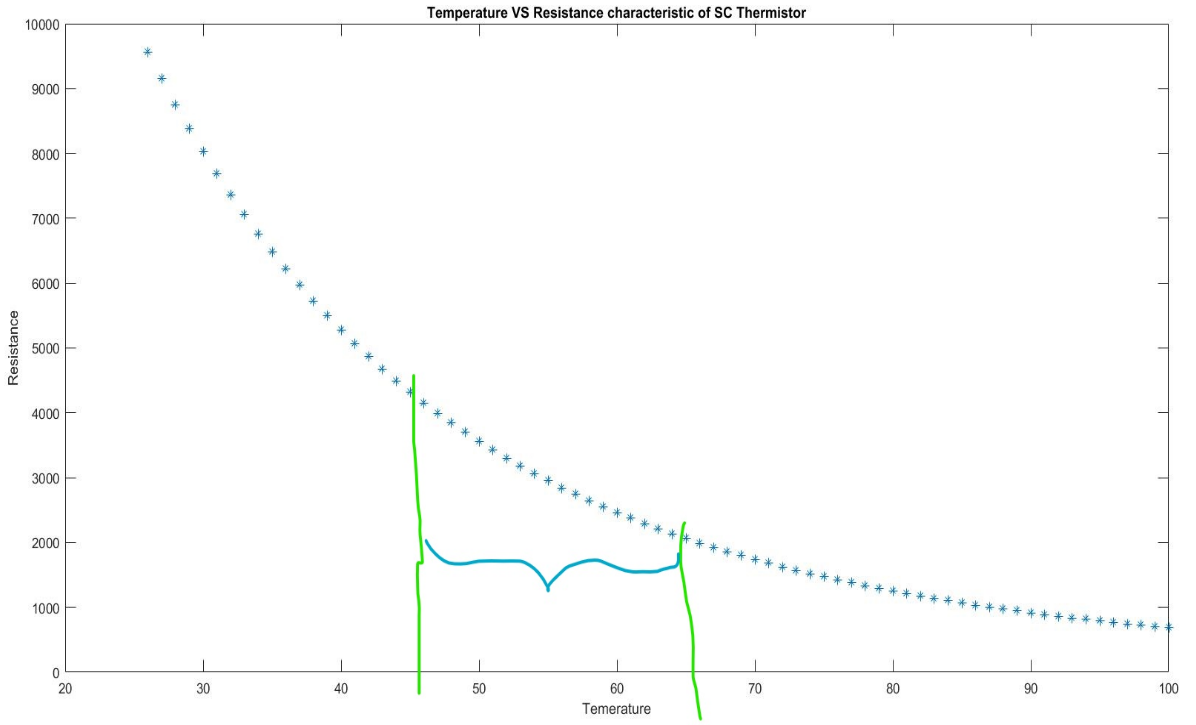
Therefore SC30 type is the best thermistor for this medical device project.

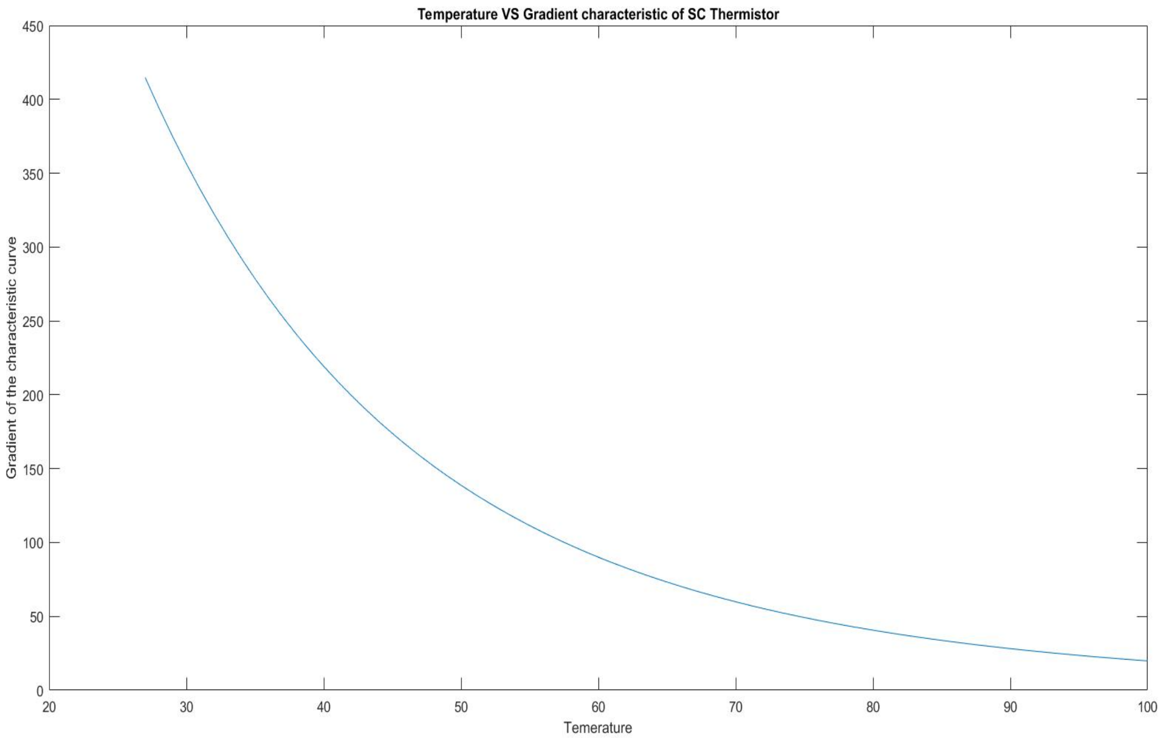
Temperature VS Resistance characteristic of the thermistor

- SC30 NTC thermistor temperature VS Resistance of the thermistor

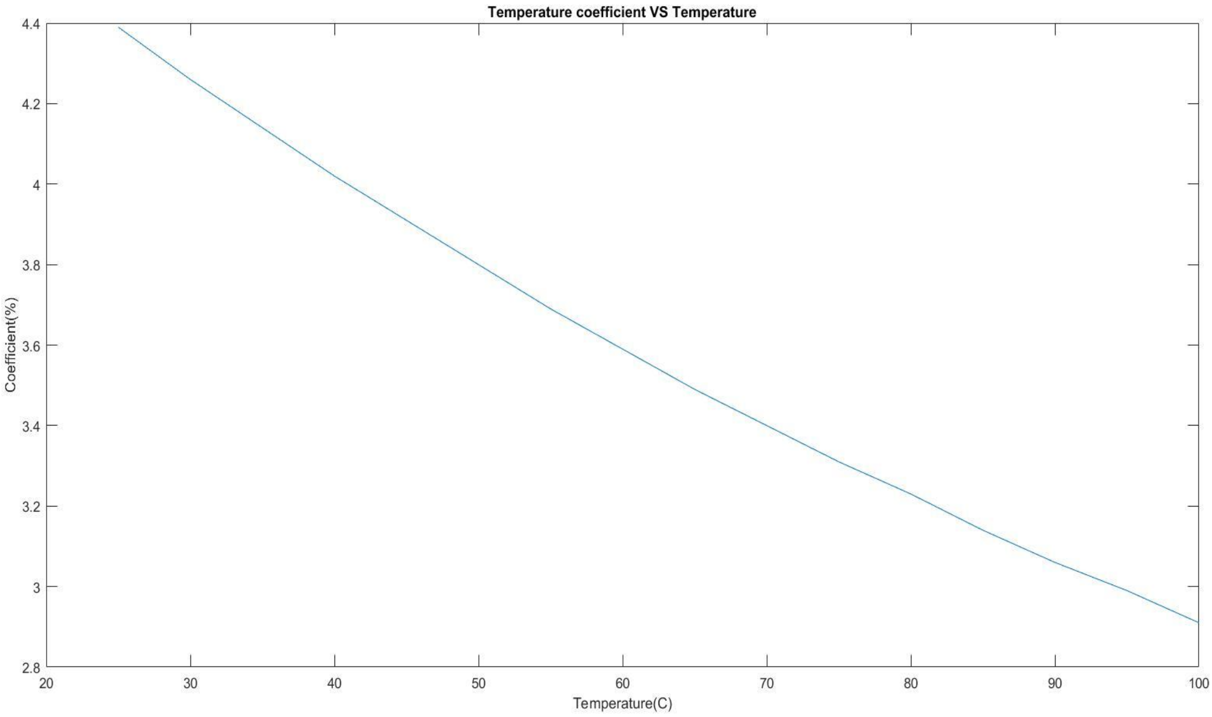


Existing higher voltage drop across the thermistor is good condition for task of the project. When thermistor has higher voltage drop, detecting urine drop count is more easier. Also higher resistance drop across the thermistor is caused to higher voltage drop across the thermistor. But at the end of the temperature axis in above thermistor characteristic (in higher temperature values) has low temperature coefficient. But practically we can't choose low temperature value range, because steady constant temperature level of the thermistor of this project must be above 32 celsius - 45 celsius range(this is disused in week 3). Therefore I think the constant temperature level of the thermistor may be in below range is good.





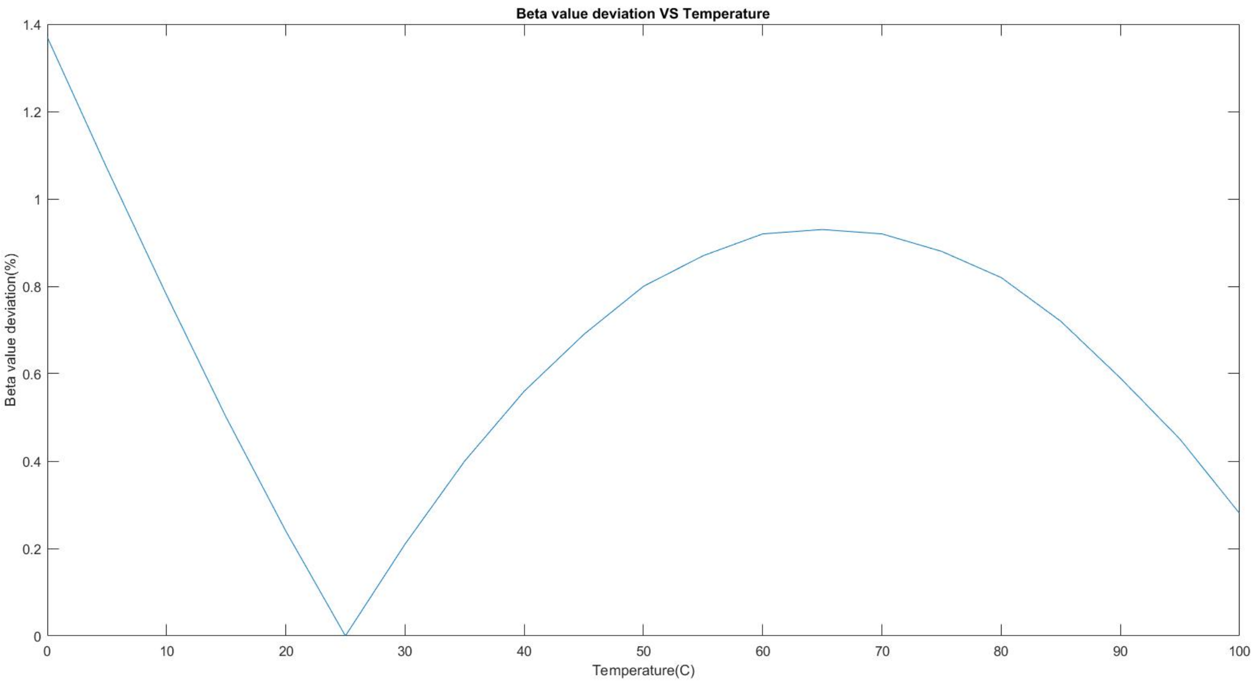
Gradient of the thermistor characteristic

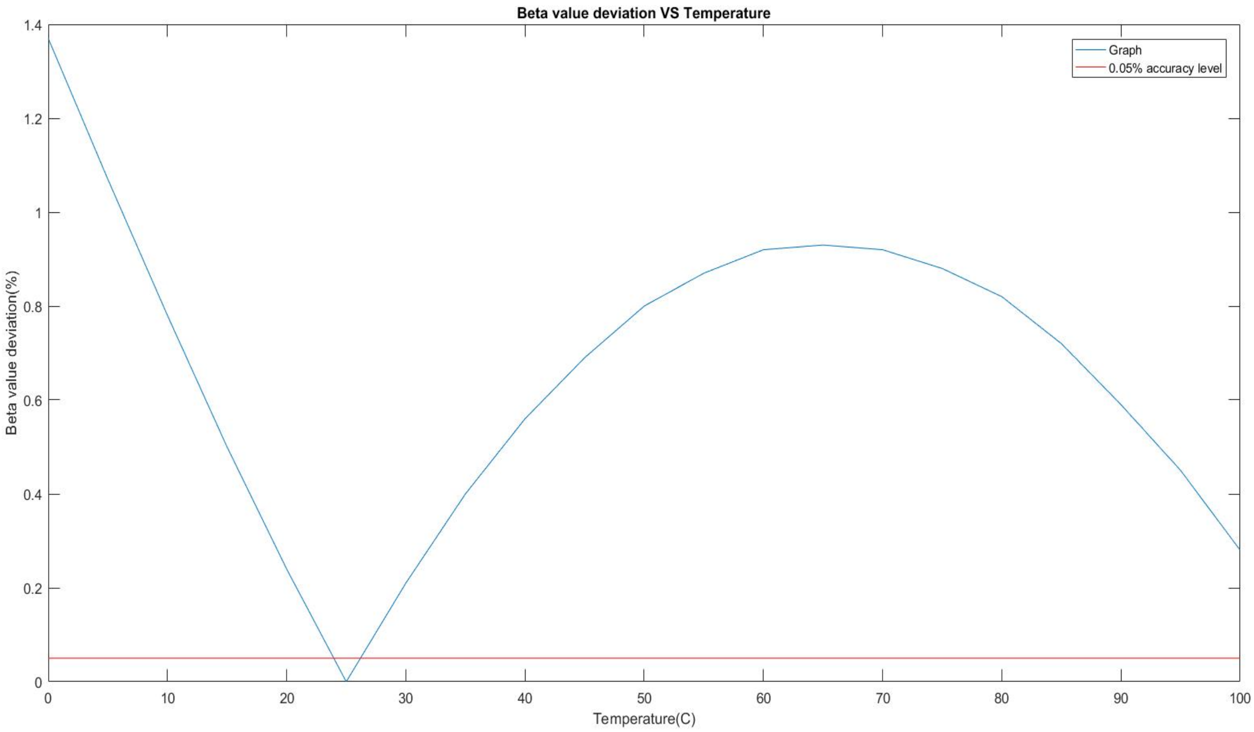


Temperature VS Temperature coefficient of the thermistor

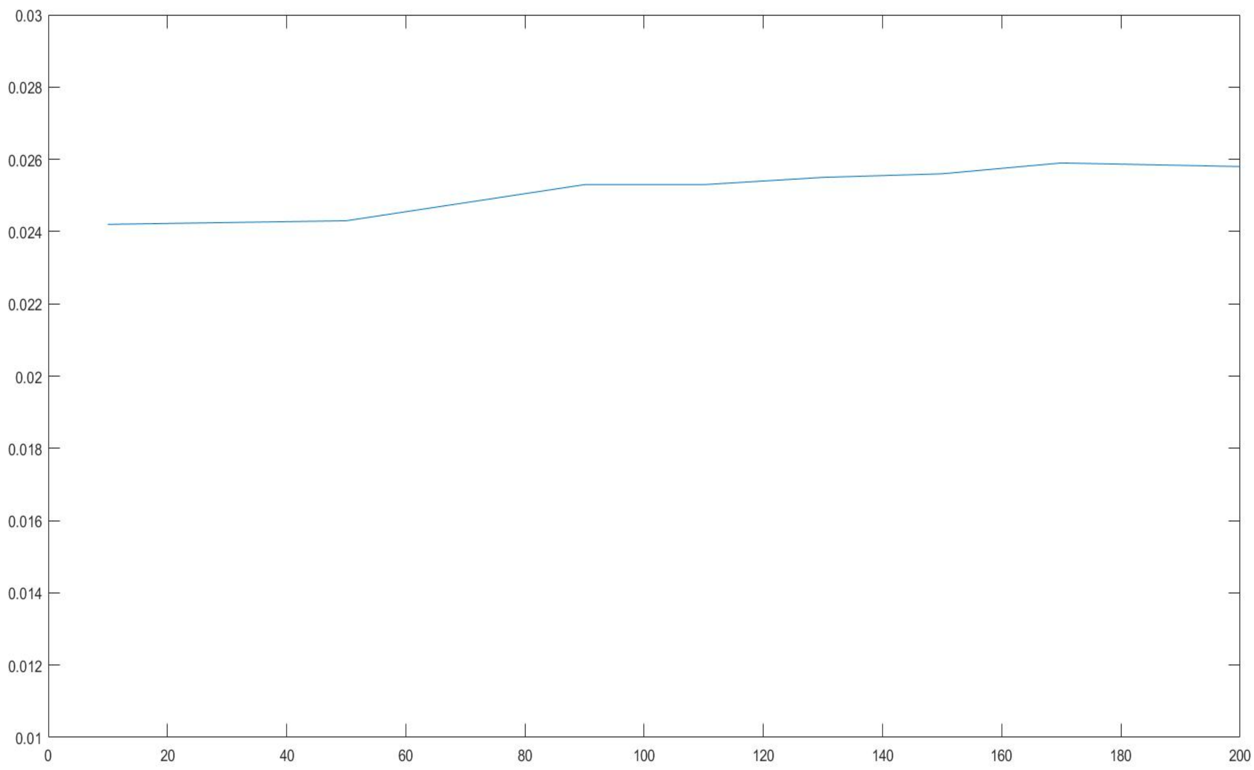
B (beta) value deviation of the SC30 thermistor

The deviation of the B value of the thermistor is zero in 25 celsius. Temperature range for within 1% B value deviation is shown in below.





Affecting of drop volume with flow rate



Fluctuating of total calculated volume with urine flow rate

Variation of drop volume with the flow rate

~~total~~
actual value of total volume infuse = 5ml.

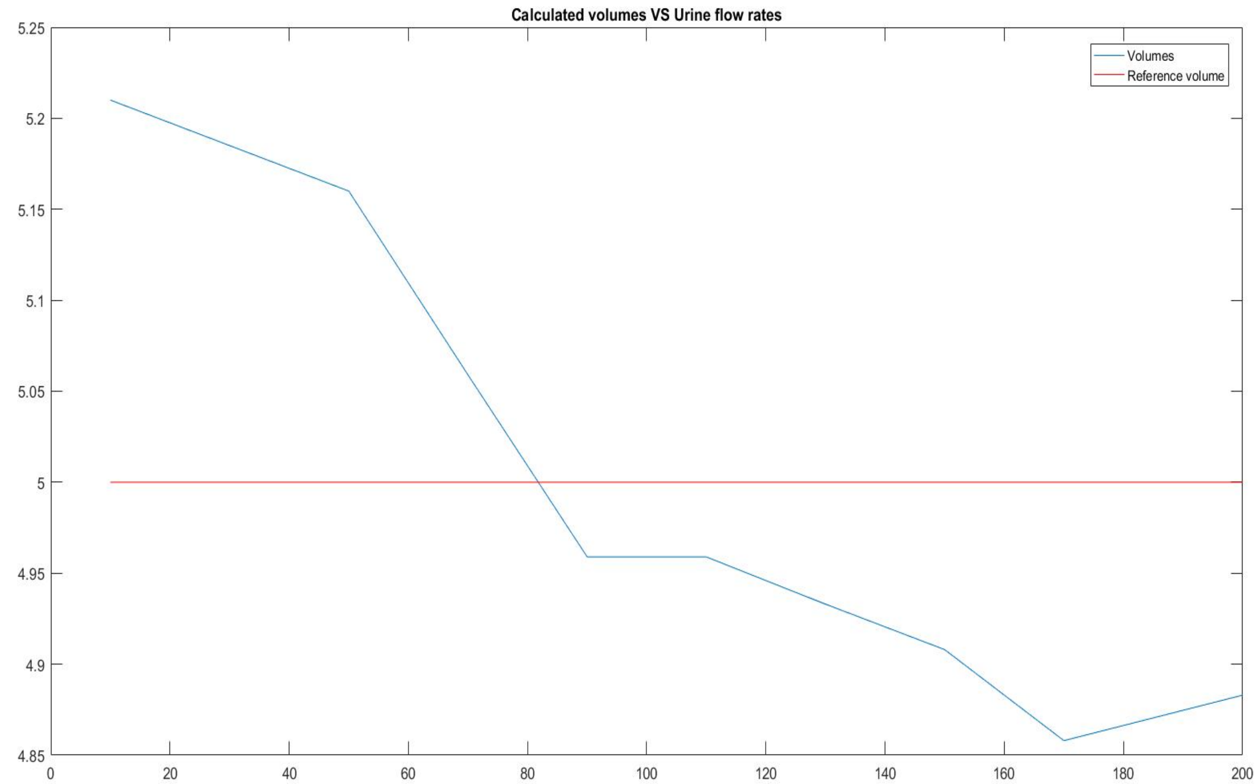
Suppose calculated volume accuracy for → 1%

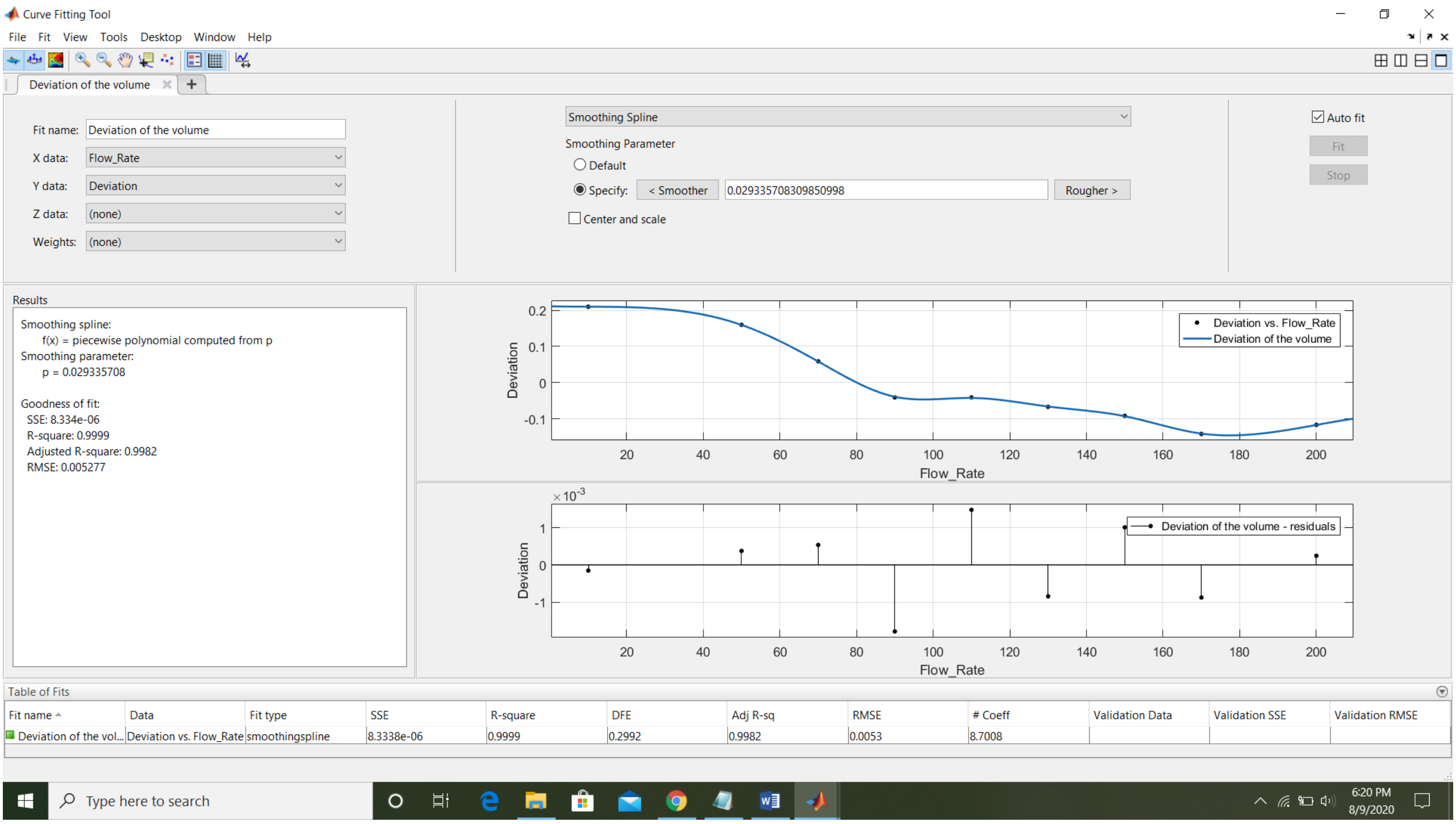
flow rate (ml/s)	total calculated vol:	deviation of volume
10	5.210	+ 0.21
50	5.160	+ 0.16
70	5.059	+ 0.059
90	4.959	− 0.041
110	4.959	− 0.041
130	4.933	− 0.067
150	4.908	− 0.092
170	4.858	− 0.142
200	4.883	− 0.117

devation of volume for assumed accuracy, (x)

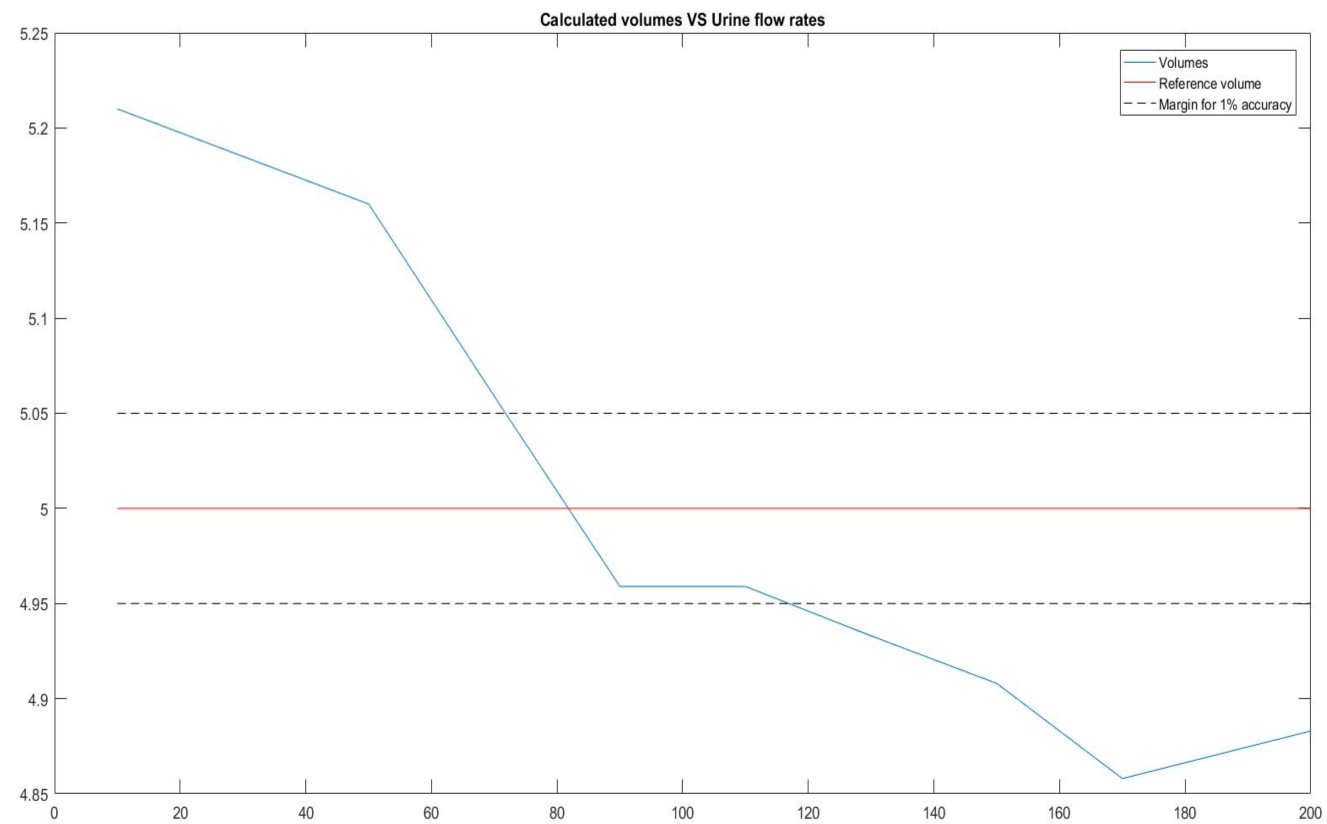
$$x = \frac{1}{100} \times 5$$
$$= 0.05$$

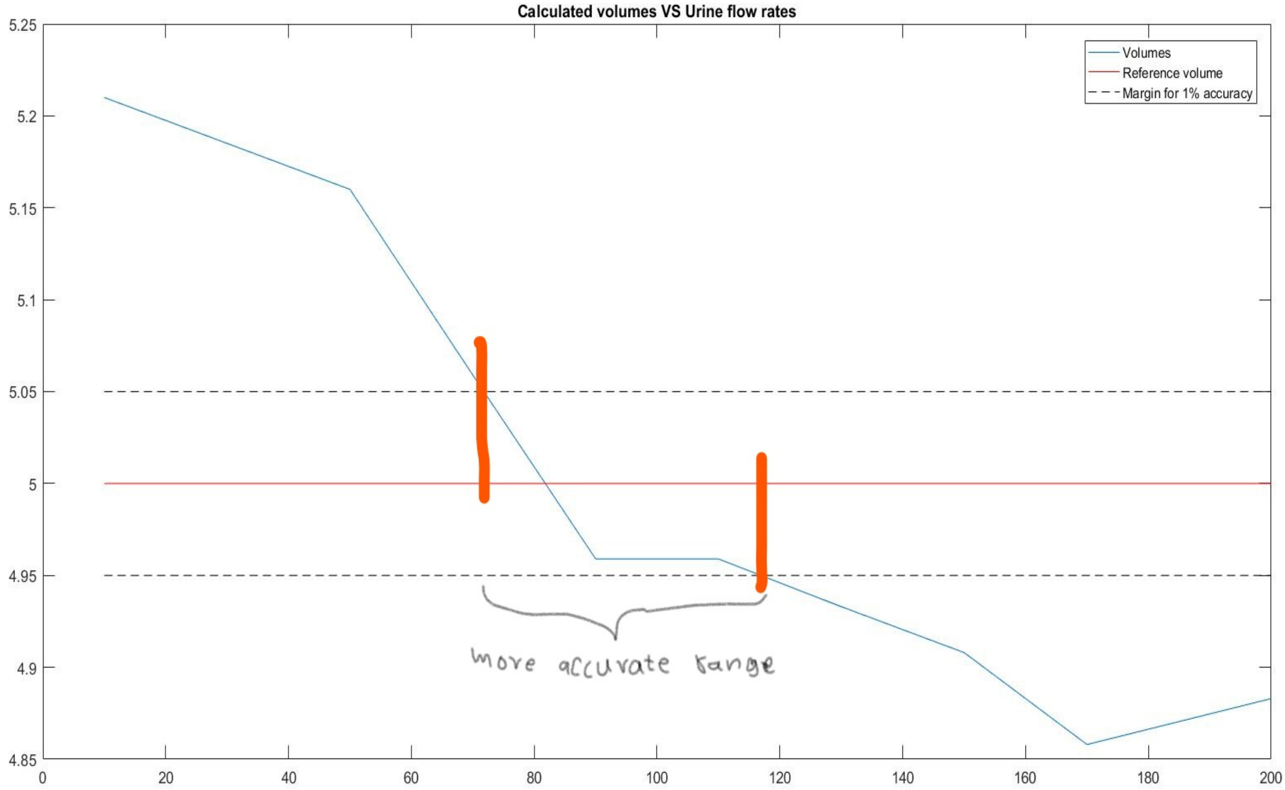
deviation range = $-0.05 \longleftrightarrow +0.05$





According to above graph, the calculated volume has a small deviation from actual urine volume when changing urine flow rate. But we can choose best urine flow rate range for 1% error deviation from actual. Hence it is middle range of the tested flow rate range.




Calculated volumes VS Urine flow rates
Volumes
Reference volume
Margin for 1% accuracy
5.25
5.2
5.15
5.1
5.05
5
4.95
4.9
4.85
0
20
40
60
80
100
120
140
160
180
200
more accurate range