

# PROBE COEFFICIENT CALCULATOR & CONVERTER

## Software Instruction Manual

### 1. Introduction

The THL - ITS90 Calculator software provides calculation of probe coefficients for resistance thermometer or thermocouple sensors over the range calibrated using “data pairs” (absolute reference temperature in deg.C. from a reference probe or Fixed Point cells at their relevant FP temp. and the data from the probe being calibrated in ohms for PRT’s and voltage for thermocouples)

NOTE : Using the automatic comparison calibration software (TTI7 EC) and its CALIBRATION section programme in conjunction with the Report Writer software. The final average reading of each temperature calibration point “Data Pairs” in the TTI7 calibration programme are generated and listed in the report writer programme for conversion using this software.

The generated coefficients can be stored under a “Constants” file against the probe serial number and user to provide a complete record of all probes calibrated with their coefficients.

An additional temperature converter is included for a set of probe coefficients entered to convert any probe resistance (or emf for thermocouples) to temperature.

There are 3 types of coefficient calculations which can be selected :-

**CvD** – Callendar van Dusen quadratic equation for resistance thermometers (25 or 100 ohm) which remains in use today by some users and operated within some instruments, converting the measured ohms to absolute temperature.

**ITS90** – The International Temperature Scale of 1990. This is now in general use for resistance thermometers where the relationship between the resistance ratio ( $W$ ) and temperature is determined by the deviation from the PRT relationship (formulae) of 2 thermometers. One thermometer covers the range 13.8033 K. (-259.3467 deg.C.) and a second thermometer covers 0.01 to 961.78 deg.C.

The PRT relationships are defined by 2 reference functions.

The deviation of any calibrated PRT to these reference functions is defined by deviation functions over the 2 ranges with a number of sub ranges where the PRT has a smaller range of use.

e.g. sub range -259.3467 to 0.01 deg.C.

sub range -38.8344 to 29.7646 deg.C

sub range 0.01 to 231.928 deg.C.

sub range 0.01 to 961.78 deg.C.

**TC's** (thermocouples) The TC is calibrated against a reference (calibrated thermocouple or PRT) and the difference plotted against the standard e.m.f. to temperature norms / tables. A set of polynomial coefficients is generated to enable any emf measured on the calibrated TC to be converted to an accurate temperature.

## 2. Software Supply and Installation.

The Probe Coefficient Calculator and Converter software is supplied either on a CD with supporting files or it can be downloaded from the web site of THLsystems.com using your customer registration number and password. It must be loaded into the PC hard drive, root directory C:\(data file).

On the CD the software is in an uncompressed file. Go to the set up.exe installation folder and download.

From the web site, DOWNLOAD ITS90 calculator file.

File Download – File is compressed (zipped) Select SAVE.

Save As – Save in : select (say desktop) Select SAVE.

Exit website and select ITS90 calculator (desktop)

Select ITS90 calculator Dinstaller.

Select ITS90 calculator, setup.exe. and RUN.

Browse to select install drive (C drive) , OK then select Install.

## 3. Programme Start.

Go to My Computer and Local Disc C.

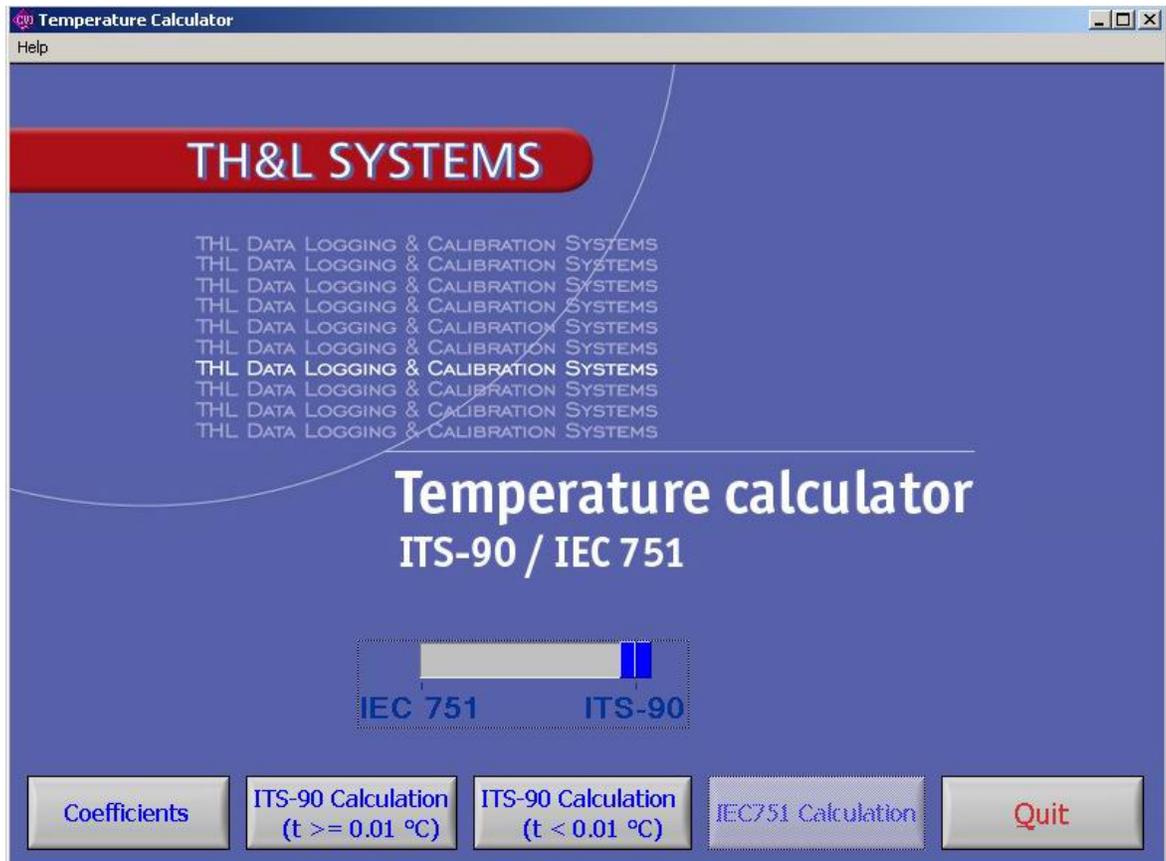
Select ITS90 Calculator and main screen appears (diagram 1.)

Select the required coefficient calculator section (IEC 751 ; ITS90 ; TC) and proceed as listed under the relevant section below:-

**(A) ITS 90 coefficients for Resistance Thermometers**

The lower left 3 selection boxes will be illuminated (Coefficients, ITS90 calculation above 0 deg.C. and ITS90 calculation below 0 deg.C.) In the example now illustrated we will generate coefficients for a probe calibrated over -38.834 to 660.323 deg.C. Under ITS90 this will mean calibrating over 2 ranges. Range 7 (0.01 to 660.323) with data at the Tin fixed point (231.928 deg.C.) ; Zinc fixed point (419.527 deg.C.) and the Aluminium fixed point (660.323 deg.C.) and the range 5 (-38.834 to 29.7646 deg.C.) with data at the Triple point of water (0.01 deg.C.) ; Mercury triple point (-38.834 deg.C.) and the Gallium melting point (29.7646 deg.C.) If calibration by comparison procedures are made then the fixed point cells and their temperature values will be replaced by the measured temperature value of the reference PRT at a similar set of values OR values close to customers required points e.g. 660 deg.C. may be taken at 500 deg.C. if the upper limit of probe is 550 deg.C. and it will be used to a maximum of 500 deg.C. In this illustration we will need to use both the calculator sections of ITS90 above and below 0 deg.C.

Diagram 1



Select **ITS90 Calculation above 0.01C**. and select the range required (see diagram 2) from 7 to 11 for the probe calibrated.

- e.g. Range 7 0.01 to 660.323 deg.C.
- Range 8 0.01 to 419.527 deg.C.
- Range 9 0.01 to 231.928 deg.C.
- Range10 0.01 to 156.5985 deg.C.
- Range11 0.01 to 29.7646 deg.C.

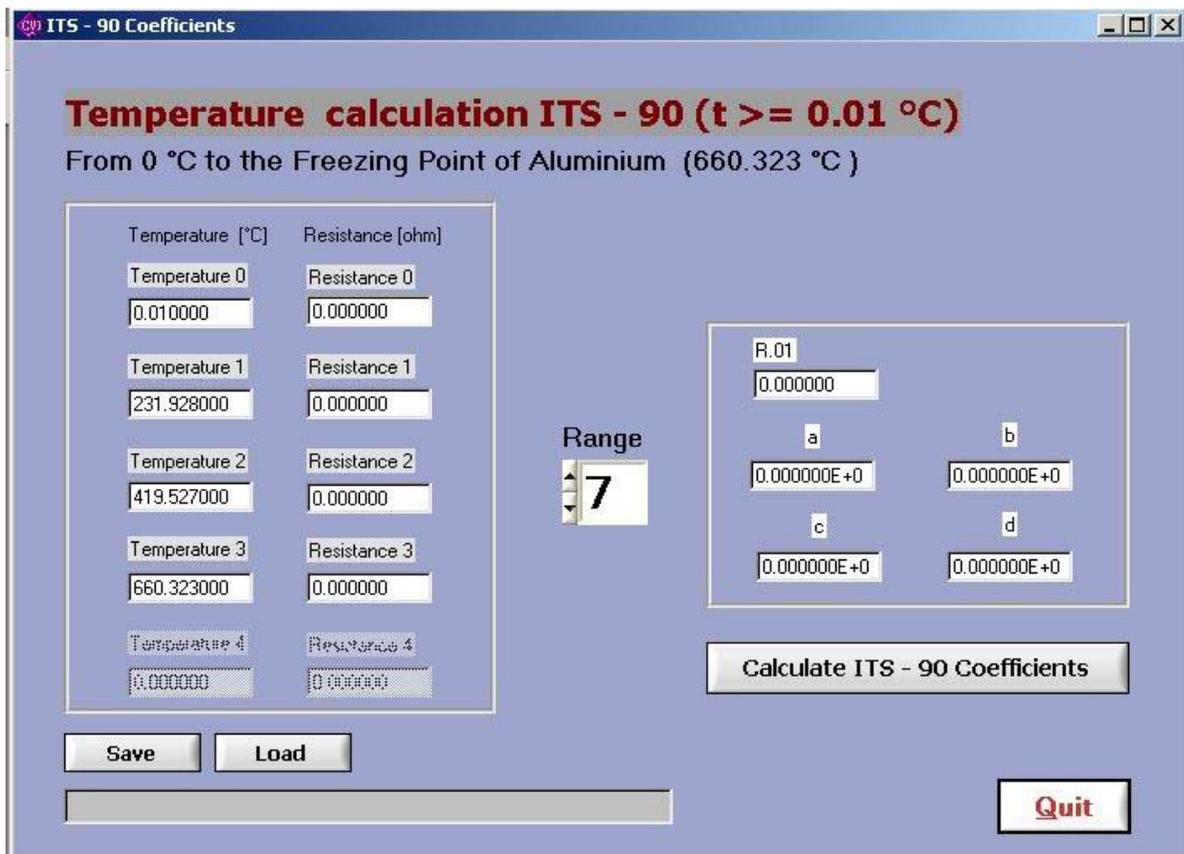
Enter the values of resistance measured on the bridge (F700 or TTI7 etc.) for each temperature listed (fixed points) or alternatively for other temperatures such as comparison values change the temperatures to the average reference thermometer values measured in the comparison calibration or obtained from the report writer.

For this fixed point cell example select Range 7 and enter :-

- Temperature 0 (0.01) 100.0562
- Temperature 1 (231.928 Tin) 189.3305
- Temperature 2 (419.527 Zinc) 256.9303
- Temperature 3 (660.327 Al.) 337.6216

(Temperature 4 is not illuminated / used as this is for ITS90 to 960 C.

Diagram 2



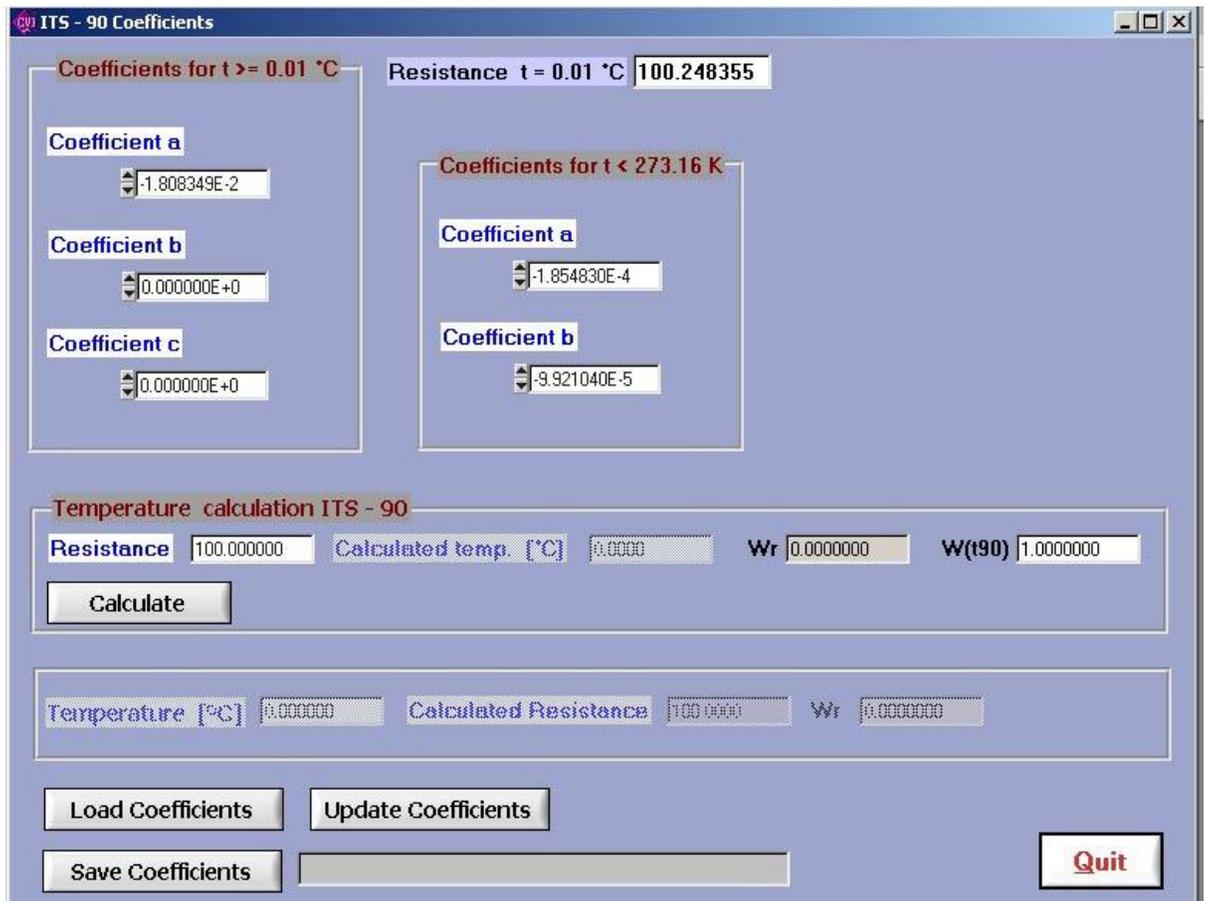
Select **Calculate ITS90 Coefficients** and the following values are obtained.

- Ro.o1 100.0562
- a (A7) -5.27438 e-4
- b (B7) -1.254611 e-4
- c (C7) 2.021773e-5

If only coefficients above 0 deg.C. were generated for a probe then these would be saved under a file name (probe serial number / user) on this screen under **Save**. As coefficients above and below 0 need to be saved in one file, select **Quit** to main screen (diagram 1) and select **Coefficients** screen (diagram 3)

Select **Update Coefficients** on this screen when the coefficients above 0 deg. are entered as above from the previous screen under a, b, c.

Diagram 3



Select **Quit** to main screen.

Select **ITS90 Calculation below 0.01** screen (diagram 4) and select the range required (4 or 5) for the probe calibrated.

e.g. Range 4 0.01 to -189.344 deg.C.

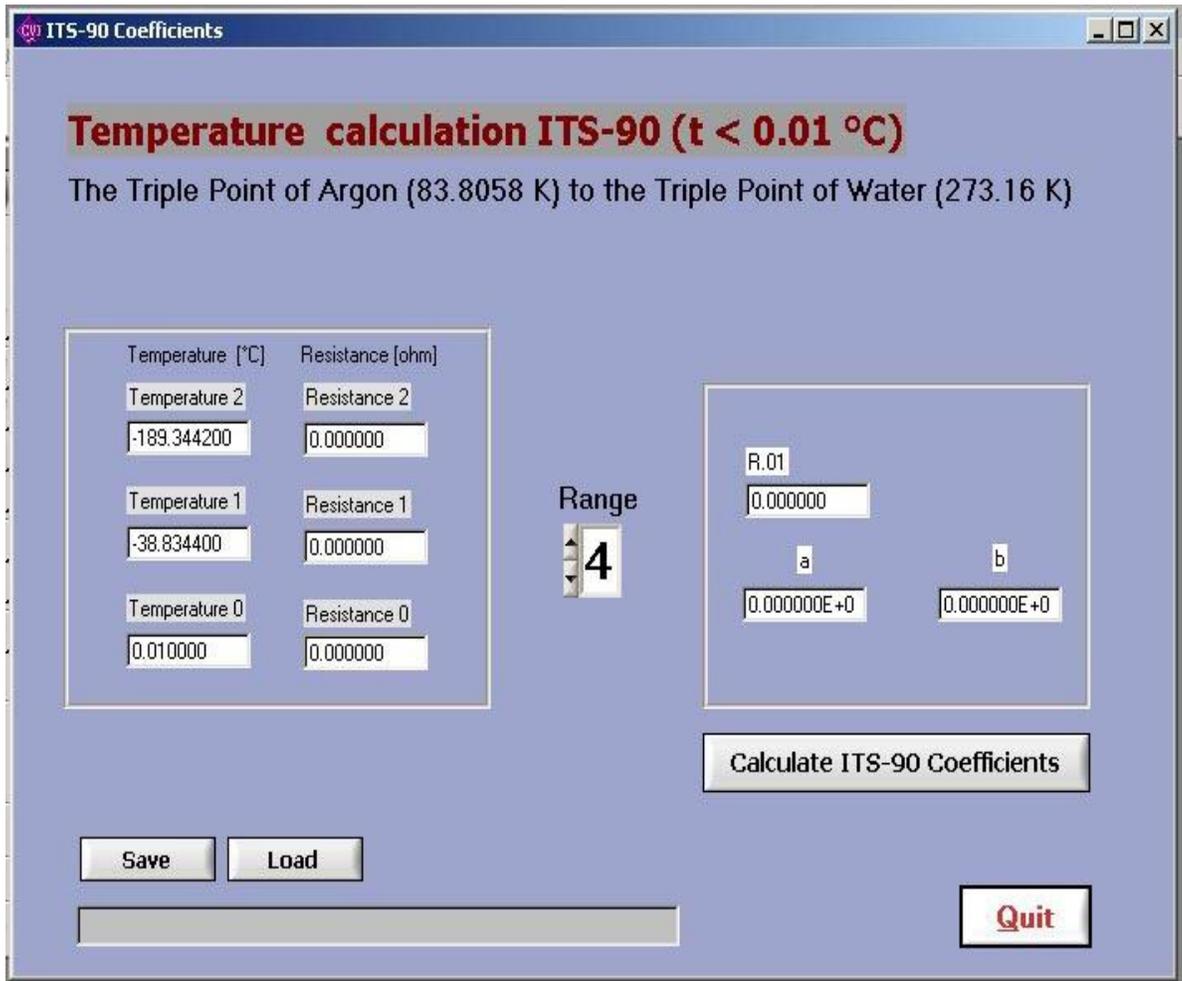
Range 5 -38.834 to 29.7646 deg.C.

Enter the values of resistance measured on the bridge (F700 or TTI7 etc.) for each temperature listed (fixed points) or alternatively for other temperatures such as comparison values, change the temperatures to the average reference thermometer values measured in the comparison calibration. For liquid nitrogen comparison temperature use range 4.

For this fixed point cell thermometer calibration example select Range 5 and enter :-

Temperature 0 (0.01)	100.0562
Temperature 1 (-38.834 Hg.)	84.4698
Temperature 2 ( 29.7646 Ga.)	111.8703

Diagram 4



Select **Calculate ITS90 Coefficients** and the following values are obtained.

Ro.o1	100.0562
a	-5.358222e-4
b	-7.054034e-5

If only coefficients below 0 deg.C. were generated for a probe then these would be saved under a file name (probe serial number / user) on this screen under **Save**. As coefficients above and below 0 need to be saved in one file, select **Quit** to main screen (diagram 1, page 3) and select **Coefficients** screen (diagram 3, page 5)

Select **Update Coefficients** on this screen when the coefficients below 0 deg. are entered as above from the previous screen under a, b. This coefficient screen now has all the coefficients for this probe above and below 0 deg.

A check can be made on the accuracy by entering a resistance in the **Temperature Calculation ITS90** box. Eg. 84.4698 ohms for the mercury point gives the correct calculated temperature of 29.7646 deg.C. Select **Save Coefficients** on this screen and file under the probe serial number and user / customer name

NOTE : When using the Report Writer, the generated coefficient file in this programme can be downloaded into the relevant probe report file and printed on the final certificate.

**(B) IEC 751 Coefficients for Resistance Thermometers.**

Select **IEC 751** coefficient calculator section on main screen (diagram 1) The IEC 751 lower selection box will now be illuminated.

Select **IEC751 Calculation** and on the IEC751 data screen (see diagram 5) enter the 5 reference temperatures used in the calibration and the corresponding resistance values of the thermometer being calibrated.

NOTE : For correct IEC751 calculation it is necessary to have one negative temperature point close to the probes lowest temperature being used below 0 deg. A negative point is not required for probes being used only above 0 deg. It is necessary to have 2 positive points, one near to 100 deg. and the second close to the probes highest temperature. Two close to zero degree values are used taken at the beginning and end of the calibration.

Diagram 5

The screenshot shows the 'IEC 751 Coefficients' software window. The title bar reads 'IEC 751 Coefficients'. The main content area has a heading 'Temperature calculation IEC 751'. Below this, there are two columns of input fields. The left column is labeled 'Temperature [°C]' and the right column is labeled 'Resistance [ohm]'. There are five rows of input fields, each with a label to its left: 'Nearest 0°C (1st)', 'Negative Temp.', 'Nearest 100°C', 'Other Positive Temp.', and 'Nearest 0°C (2nd)'. To the right of these input fields, there is a separate box containing four input fields labeled 'R0', 'A', 'B', and 'C'. At the bottom of the window, there are four buttons: 'Load', 'Save', 'Calculate IEC 751 Coefficients.', and 'Quit'. A status bar is visible at the very bottom.

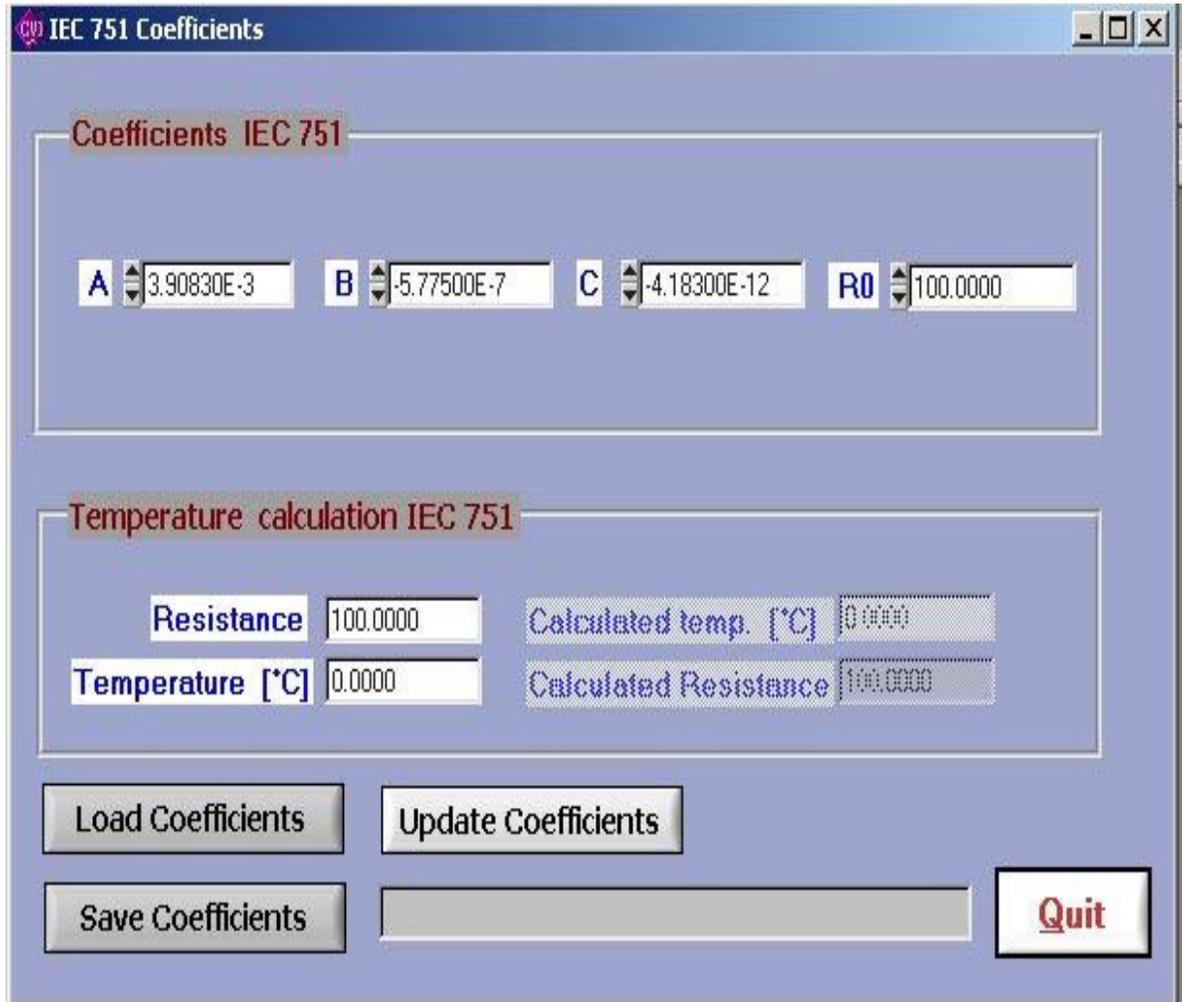
Select **Calculate IEC 751 Coefficients** and the values will be entered into the table (Ro, A, B, C) The coefficients may be saved under a file name in this calculation screen (diagram 5) or downloaded into the IEC coefficient file and converter.

Select **Quit** to main screen and select **Coefficients** screen.

Select **Update Coefficients** to obtain the A, B, C and Ro. These can then be saved on this screen and filed under the probe serial number and user / customer name.

A resistance to temperature converter can be used for a particular probe and its entered set of IEC751 coefficients.

Diagram 6



(C) TC Coefficients for Thermocouples.