RM3000+ Test Unit Instructions
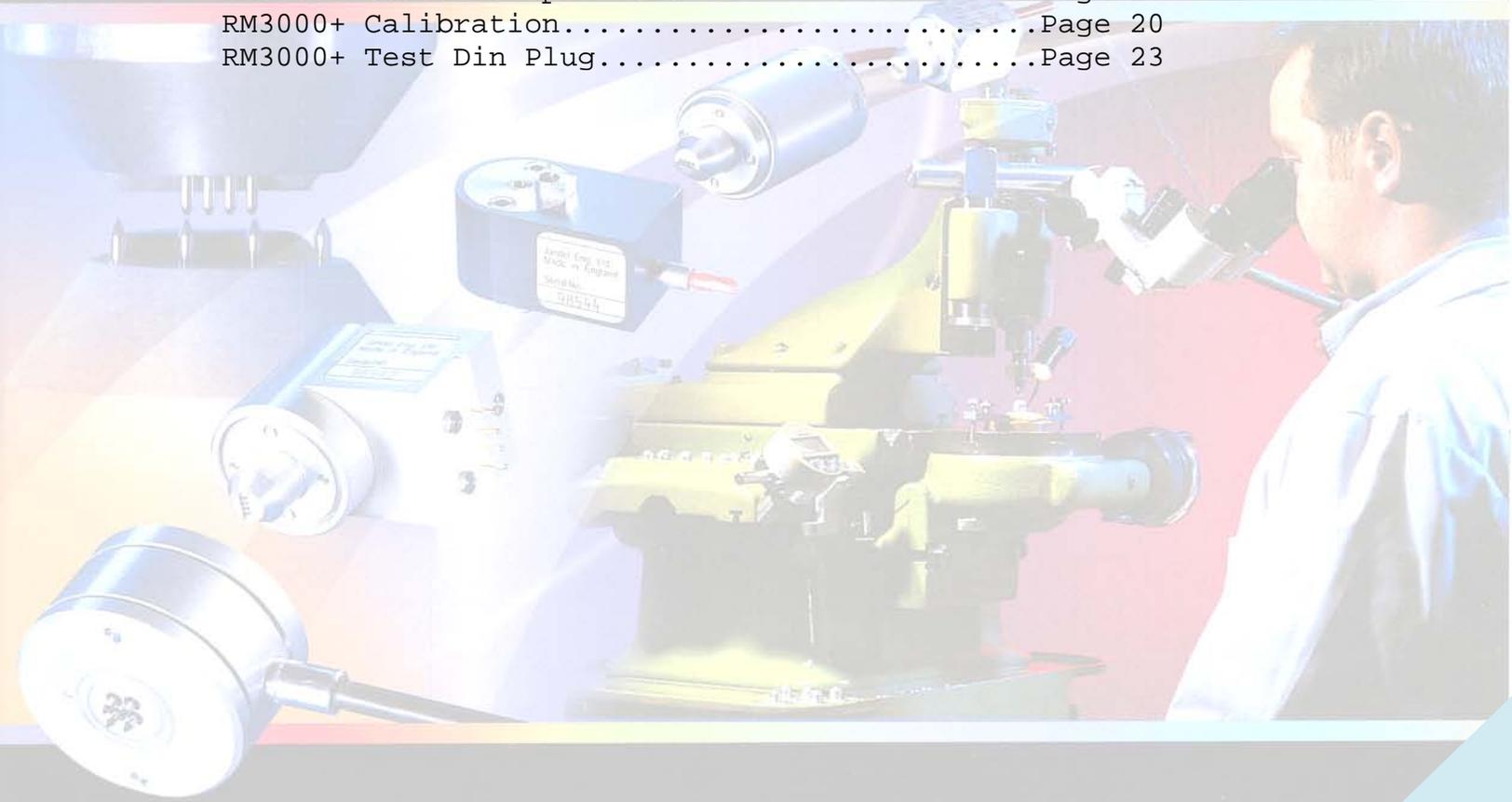
RM3000+ Test Unit Instructions

The RM3000+ is a combined constant current source and digital voltmeter. It has been designed for use in making resistivity measurements in combination with four point probe equipment. The unit supplies a constant current and can display the resultant voltage, sheet resistance or volume resistivity depending which function has been chosen. For calculation of volume resistivity (for wafers or bulk samples) it is possible to input wafer thickness or probe spacing as required.

Unpacking

When you unpack the RM3000+ you should find:

1) A Jandel RM3000+ Test Unit
2) A power lead
3) A green case key which can be used to open the RM3000+ cabinet (not recommended)
4) A USB stick containing a copy of the manual and the RM3000+ software for computer control and exporting of results
5) A USB lead

Getting to know the RM3000+

On the RM3000+ you will find the display area:
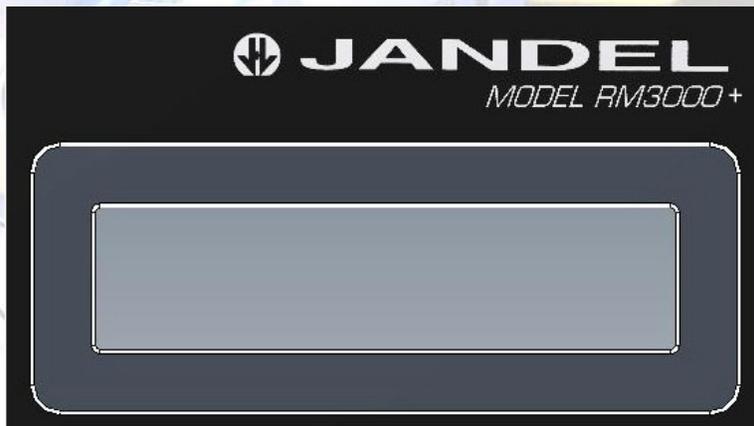
This is where the current being used is displayed, the direction of the current and the output in mV, ohms/square and ohm.cm.

There are also a number of buttons, the names used throughout this manual are listed here:

To the left on the front of the unit you will find:

 Numeric Keypad

 Current level buttons

 Ohm button

To the right of these there are four more buttons:

 Forward button

 Standby / Auto button

 Reverse button

 Zero button

There are four 'preset buttons' marked A-D.

Four buttons remain as follows:

↑ Up Arrow   **↓** Down Arrow
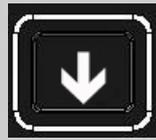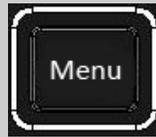
Enter Enter button   **Menu** Menu Button

Operation of the RM3000+

Selecting a current
The keypad is used to input the desired current. It is used in combination with the current level buttons.

The current level buttons are **nA** (nanoamps), **uA** (microamps) and **mA** (milliamps). Values between 10nA and 100mA can be entered. Whole values only are allowed (i.e. 10nA, 57mA, 88uA, not X.XX). If a value is entered which is not between 10nA and 100mA the unit will display "illegal current".

Storing Currents using the Preset Buttons
Commonly used currents can be stored in positions A to D. When the required current has been dialled in, pressing and holding one of the buttons will store the current in that location. Successful storing is demonstrated by the unit beeping. Retrieving the currents is done by simply pressing the relevant letter.

Displaying ohms/square , ohm.cm or mV values
Pressing the ohms button toggles the display between giving measurement results in mV and one of ohms/square, ohm.cm (wafers) or ohm.cm (volume). The default setting toggles between mV and ohms/square. While the display shows the ohms/square value you can use the up arrow or down arrow to switch between the different display values. To get the correct results for wafers or volume resistivity information on probe spacing or wafer thickness may be required from the user which is discussed later in the

manual. If the unit is switched off then next time it is switched on it will be on the default setting of toggling between mV and ohms/square.

If the setting is ohm.cm for wafers a 'W' will also appear when displaying ohm.cm values to indicate that this is the measurement mode

Starting or stopping current flow through the sample

Pressing the forward button will pass the selected current through the probe head in a forward direction, and should yield a positive voltage reading.

Pressing the standby button when current is flowing in the forward or reverse direction will put the unit in standby so that no current is flowing. Pressing the standby button while the unit is already in standby will begin the autorange feature which is discussed later in this manual.

Pressing the reverse button will pass the selected current through the probe head in a reverse direction, and should yield a negative voltage reading of equal or similar magnitude to the forward reading

Storing Readings

When a reading is made the result can be stored on the RM3000+ for later download. To do this press "enter" while the measurement is being displayed. The display will indicate that the value has been stored and show the position of the reading (1/99 through to 99/99). Maximum 99 readings can be stored on the unit. Download of the readings is discussed in the software section of the manual. Readings can be deleted by pressing and holding the "Enter" button – NOTE deleting the readings takes approximately 20 seconds. The displayed value is stored to on board non volatile memory. Readings are time-stamped using an on-board clock.

Mode

The "menu" button allows user adjustable settings to be changed. Pressing the Menu button enters the adjustment menu where the following items can be changed (access each one using the up arrow or down arrow. Exit by pressing "menu" again):

1. Set voltage factor. Access by pressing "enter". This multiplies the measured voltage by the correction factor entered here, for instance if readings need to be corrected for sample size. The correction can be entered by using the keypad and then stored by pressing 'Enter'. Displayed voltages

will be shown having been multiplied by the correction factor. The correction can be removed by setting the correction to 1.00, by setting the unit to its default settings or by switching the unit off and on.

2. Wafer thickness (access by pressing enter). Here the thickness of wafers being measured can be entered (in cm). This enables the unit to display the value of such items in ohm.cm. The default setting is 650 microns (0.065cm). This setting is held in non-volatile memory and so will not change when the unit is switched off. It can be returned to the default value manually or by resetting the RM3000+ to its default settings.

3. Probe spacing (access by pressing enter). The probe spacing (in cm) can be entered here. This enables the unit to display the volume resistivity of bulk samples in ohm.cm. The default setting is 0.1000 (1mm spacing). This setting is held in non-volatile memory and so will not change when the unit is switched off. It can be returned to the default value manually or by resetting the RM3000+ to its default settings.

4. Hold sample mode (access by pressing enter). After a set number of seconds the display will hold the displayed value at that time. Can be switched off by entering a value of 0 seconds

5. Here the correct time can be entered for time stamping readings taken by the RM3000+. The time is set by entering the correct time using the keypad by entering hours, minutes and seconds and then pressing 'store'.

6. Date. Here the correct date can be entered for date stamping readings taken by the RM3000+. The date is set by entering the correct date using the keypad by entering the day, month and year in the format DD.MM.YY (if the unit is in UK format) or MM.DD.YY (if the unit is in US format).

7. Date format. Here the user can press '1' for UK date format (DD.MM.YY) or '2' for US date format (MM.DD.YY).

8. Set defaults. This it to reset the unit to its default modes.

Default modes are as follows:

V Correction: 1.00 (resets to this when unit is switched off)
Wafer thickness: 0.0650cm (non-volatile)
Probe spacing: 0.100cm (non-volatile)
Hold sample mode: Off
Set time: current set time (non-volatile)
Set date: current set date (non-volatile)
Date format: UK (non-volatile)

<u>Getting Started – First use of the RM3000+</u>

Switch the unit on. The RM3000+ will self calibrate and then zero before putting itself in Standby. The unit is now ready to use.

The range of measurement is 0-1000mV.

Attempting to make a reading without having the probe in contact with a sample or where the sample cannot have a current drive through it will result in an error and the message "Contact Limit" will be displayed. If the probe is contact with the sample this could be because the sample is too insulating, because the current needles are not in proper contact with the sample, or simply that a lead is disconnected! Using a lower current will sometimes prevent a 'Contact Limit' error – this could be a situation where the sample has become damaged due to excessive current, or where the contact resistance of the material is high.

<u>Autorange</u>
Queries for poor results are often raised where the cause is simply that an inappropriate current has been selected.

When making measurements and the RM3000+ is in standby, pressing the Standby button will initiate the Autorange feature. It will begin at 10nA and increase the current by a factor of 10 until a suitable level of voltage measurement is made. At this time it will stop and display the voltage. It is not necessary to use only the current given for the measurements, but it indicates the level around which optimum results can be achieved.

Where a sample has very low resistivity the current will autorange up to its maximum current and stop (100mA). This does not mean that the reading obtained is invalid, but the measured voltage may be below what we consider to be ideal (between 10mV and 100mV). Where the maximum current is required and the reading is below 10mV it is more likely that the unit will need to be zeroed (while the probe is in contact with the measured material and the current is flowing) in order to get good forward and reverse readings.

Error Messages

During attempting a reading several error messages are possible instead of a reading.
"Out of Range" indicates that the reading exceeds the maximum display of the in-built DVM. Reduce the current.
"Contact Limit" indicates that the automatic compliance voltage has been reached due to contact resistance or too much current, try reducing the current
"Illegal Current" indicates that the set current is outside the normal 10nA to 100mA range. Set a new current.
"Calibration Error" indicates an error in the factory calibration

Calibration / Self Calibration

The overall calibration of the current source is carried out by potentiometer adjustment. The internal DVM has no calibration potentiometers; its calibration is carried out in the factory. This can be recalibrated if required. If the calibration factor is outside certain limits or has become corrupted 'Calibration Error' is displayed.
A separate internal DVM calibration occurs at power up. Zeroing also occurs at this time.

Compliance Voltage
The compliance voltage is automatic, and is used to limit the power dissipated in the sample under test.

Useful Equations

Sheet resistance = 4.5324 × V/I   (units ohms/square)
Bulk Resistivity for a wafer = sheet resistance × wafer thickness *in cm* (units ohm.cm)
Bulk Resistivity = 2 × π × s × V/I where s is the probe spacing *in cm* (units ohm.cm)

Correction Factors
Probing close to the edge of a sample or on unusual / intermediate shapes and sizes of sample can mean that correction factors are required.

A broad range of correction factors have been determined by Haldor Topsoe. At http://four-point-probes.com/haldor-topsoe-geometric-factors-in-four-point-resistivity-measurement/ you can find all of the pages from the 1966 (revised 1968) Haldor Topsoe book, "Geometric Factors in Four Point Resistivity Measurement", with each page available as an individual PDF file.

Software
The next section of the manual deals with the use of the software supplied with the RM3000+.
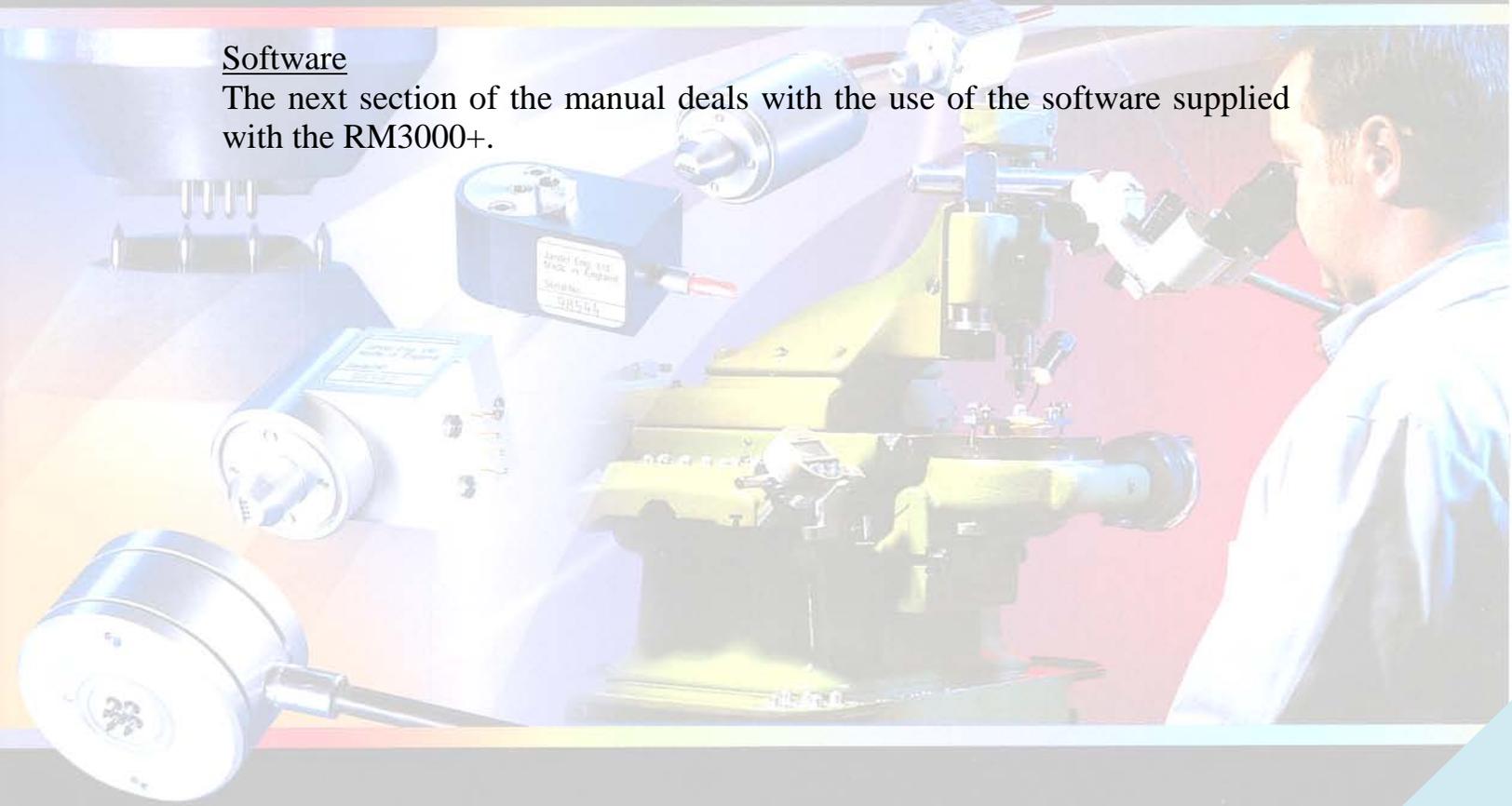
RM3000+ Software Interface for Windows

Section 1 – Contents of Installation Media

The installation media contains a Setup.exe file which will install the RM3000+ Software Interface for Windows to the hard disk of the PC.

Check the readme.txt file for information on installation and uninstallation and the system requirements.

Section 2 – Connection

The RM3000+ can be connected to a PC via USB or RS232. The Connection Status window show the current connection information. Note that when using USB, the software can automatically detect the correct port*. However, if for any reason it will not connect, a manual option is available in the Settings Menu -> Communication Settings.

* The Port must be between COM1 and COM16. The USB port of the instrument can be changed in Windows Device Manager.

Once the settings are established, click on the Hardware Menu and select Connect to RM3000+. The status window will indicate a successful connection.
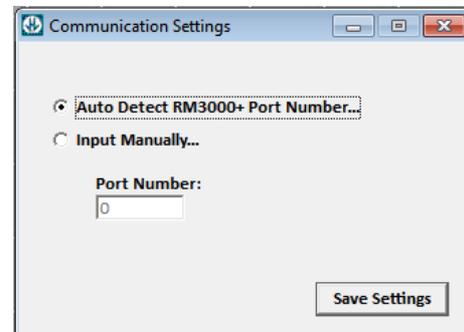
Tip: Use the Hardware Info option to confirm the connection. It will display the current firmware information from the RM3000+

Section 3 – Data Tables

Samples obtained from the RM3000+ via downloading or via data logging are stored in Data Tables. From the Menu, the user can create an empty data table or load a previously saved table from a file. The table stores resistivity information obtained from the RM3000+ and gives the user options to manipulate the data.

Each sample can be double clicked on to input extra information.

The toolbar across the top of the window gives the user table options.

Each line can have a descriptive note added as well as change the result from sheet resistivity to volume resistivity by double clicking and manipulating the settings.
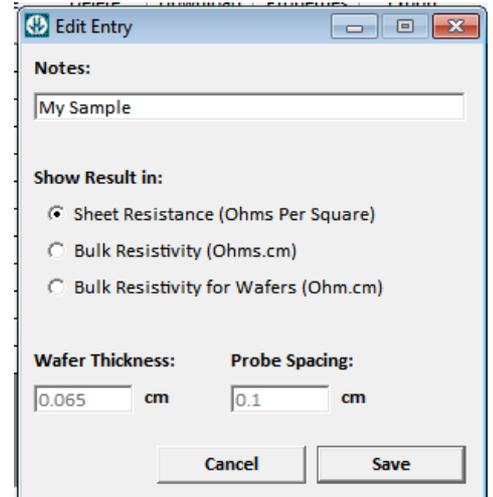
Table options: 💾 Save the table to a file ✖ Delete the table

📟 Download samples stored in the RM3000+ internal memory

📄 Shows extra properties for the table where a title and description can be entered

▦ Export the table to CSV format for opening on a Spread Sheet Program

Exporting: The columns required for exporting to CSV are selectable from the export options.
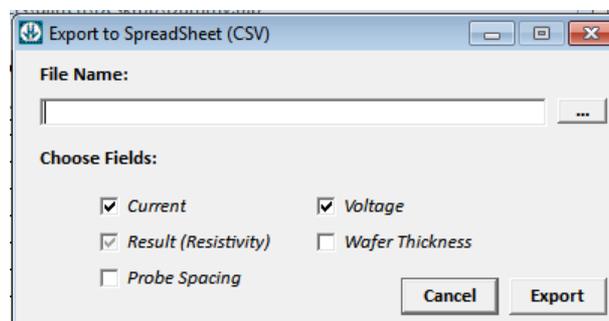
Section 4 – Meter Control

The Meter Control tools included are to control the Current Source and to display the DVM of the RM3000+ resistivity meter.
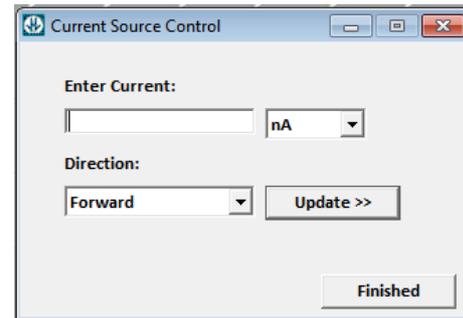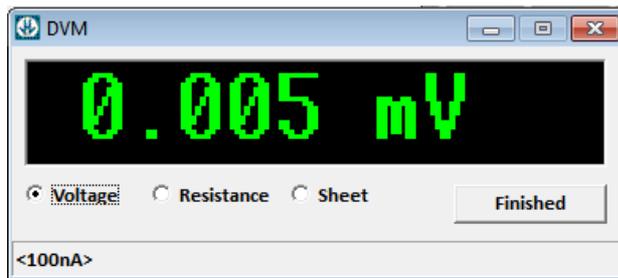
Section 5 – Data Logging

The RM3000+ Interface includes a tool for logging sample data with the option to control the Standby feature upon each sample. Using Standby ensure so current is flowing upon contacting the probe. This is useful when used in conjunction with the Jandel AFPP motorised Z arm.

The user can select an existing table to log the data to. A max of 300 samples can be stored to a data table.
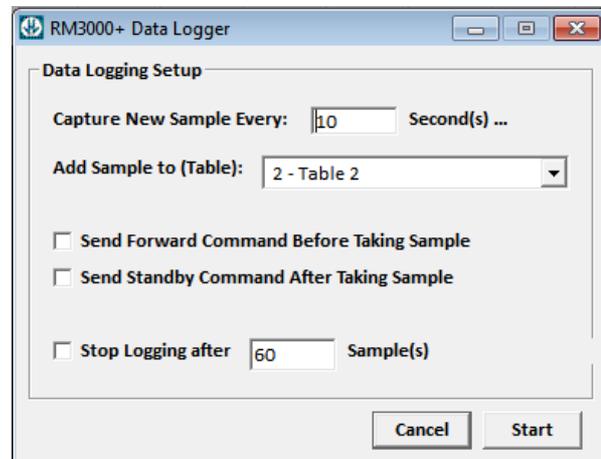
Section 6 – Tools

The RM3000+ interface includes some general tools.

Material Thickness Calculator: Select a known volume resistivity (or enter your own), enter the sheet resistance to return a result of material thickness.

Equations: Shows a window of common Resistivity equations.