# ROWTEST ROTOR REFLECTOMETER

# TDR200

# OPERATION IN DIGITAL MODE

## USER GUIDE V3.02

January 2018

ROWTest Ltd.,
64, Courthill House,Water Lane, Wilmslow, Cheshire.  SK9 5AJ. UK
Phone/Fax +44 - (0) - 1625 - 418722
Email: enquiries@Rowtest.com   Website: www.Rowtest.com

## SAFETY WARNING

**The use of the TDR200 equipment on a rotor installed in an operational generator must be carried out with the explicit permission and under the supervision of the local plant operator. All local safety rules and procedures must be complied with.**

**In particular, the equipment must only be connected to the generator rotor after the field supply has been disconnected and isolated in accordance with local safety regulations. Failure to comply with this instruction will damage the equipment and may endanger both the the plant and the operator.**

## AN IMPORTANT NOTE ABOUT YOUR CONTROL PC

Your **TDR200 Control PC** uses the latest Microsoft Operating system (**Windows 10**) and has been set up and optimised to control the **TDR200 Rotor Reflectometer**. It is not intended to be used as a general-purpose PC and should be used only for controlling the **TDR200 unit**.

Experience to-date has shown that **updates** to the **MS Windows 10 operating system** can make major changes to the **PC settings** and also corrupt or disable other software.

Unfortunately, unlike previous Microsoft operating systems, **it is not possible to turn off the automatic update operation in Windows 10**, as these updates are **delivered automatically via any live internet connection.**

Consequently, we strongly advise that this PC is **never connected to the internet**, to prevent any **operating system updates** from corrupting the **control software**. We have therefore **disabled the Wifi on this PC**.

Please use USB memory sticks etc. to transfer files to or from this PC.


**The TDR200 RSO Rotor Reflectometer**

## NOTE ON POWER SUPPLIES

The **TDR200** can be operated from either **mains power** (110 - 240Vac ) or from its **internal batteries**.

For **mains power operation**, connect an IEC mains lead to the mains socket on the rear panel and operate the **Supply ON** switch on the rear panel so that the **neon indicator** on the switch rocker is lit. The **GREEN LED** on the front panel will light to show that the **internal battery** is charging.

To **switch on the unit**, operate the **POWER** switch on the front panel. The RED LED will light to show that the unit is active.

To revert to **battery operatiion only,** switch off the **supply ON** switch on the rear panel and remove the mains lead. The unit should operate continuously for a minimum period of 8 hours following a full charge

The internal batteries will be fully charged after approximately 20 hours of charging and we recommend that the charging should be terminated after 24 hours.

## CONTENTS



**APPENDICES**

## 0. CHANGES FROM PREVIOUS TDRPLOT V1.0 VERSION

The **TDRPlot V3.0 software** is an enhanced version of the previous **version 1.0 and 2.0 software**, with the following additional functionality compared with the V1.0 vesrion:

1. The **TDR200** can now operate in both **on-line** and **off-line** modes.

2. In **on-line mode**, the software controls the **TDR200** unit to display and capture RSO data using a revised new data file format (see 4 below).

3. In **off-line mode**, the software reads and displays data from **files** captured during operation in **on-line** mode. This allows **saved RSO data** to be re-plotted and analysed.

4. The **data file format** has been modified to include the **Control parameters** used to capture the data.

5. The **vertical time cursor** now shows **RSO waveform differences** as a **percentage of their average value.**

6. A new **persistence mode** allows live waveforms to be viewed in an overlaid format.

7. The **Save frame** button saves text as well as bitmap files when in on-line mode (but only bitmap files in off-line mode).

8. A new **Locate** button in the **Control window** calculates the probable fault location from a set of RSO measurements.

9. The frame capture rate remains constant each time the program is run.

### 0.1 Note on File formats.

The format for data files in versions 3.0 and 2.0 differs from that in version 1. **Appendix 2** gives information about converting version 1.0 files to version 2.0 format

# 1. INTRODUCTION

## 1.1 SUMMARY OF HARDWARE AND SOFTWARE DETAILS

This **User Guide** refers to **the operation of the TDR200 Rotor Reflectometer in digital mode, using the TDRPlot** software. **The TDR200** instrument is similar to the original analogue **TDR100** version, but contains an additional **digital interface** which interfaces to a **Laptop PC** via a **USB** connection. The **TDR200** version can operate as a normal **analogue Rotor Reflectometer,** displaying the RSO waveforms on an oscilloscope, but is intended to be operated in a **digital mode**, controlled by a **PC** running the **TDRPlot** software, which displays and stores the input and output end RSO waveforms. This **Operation Guide in Digital Mode** should be used together with the **TDR100 INSTRUCTION MANUAL,** which describes the **principle of operation** of both of these RSO reflectometers in detail.

## 1.1 SUMMARY OF OPERATION IN ANALOGUE MODE

When both the **TDR 100 and 200 RSO reflectometers** operate in **analogue auto** mode, rectangular pulses are applied to each end of the rotor winding alternately via a bridge switching network. The resulting **input** or **output** end waveforms are displayed on single channels of an **analogue oscilloscope** as 2 alternating waveforms. Because the bridge switching operates at a relatively high speed (around 500Hz), these appear as 2 superimposed waveforms on the oscilloscope screen, allowing any differences between these 2 waveforms to be viewed directly.

In **analogue mode**, a single frame of input data consists of the waveform applied to and measured at end 1 of the rotor winding, followed by the waveform applied to and measured at end 2 of the rotor winding. The **pulse repetition rate** is set by the **Frequency** control on the **Reflectometer front panel**. The **width** of the applied pulse is also set by a pair o**f Pulse Width controls** on the **Reflectometer**.

NB For full information about the use of the **TDR100/200 Reflectometers** in **ANALOGUE** mode with an **OSCILLOSCOPE**, please refer to the **TDR100 INSTRUCTION MANUAL**.

## 1.2 OPERATION IN DIGITAL MODE

When the **TDR200 Reflectometer** is connected to a PC running the **TDRPlot software**, it operates in **digital mode** and the **pulse repetition rate** is set by the **Control PC.** In this mode, the **waveforms** are captured, digitised and sent to the PC via a USB interface by the **TDRPlot software, which** allows the waveforms at the **input** or **output** ends of the rotor windings to be viewed and captured as either **bitmap** or **text data files**. The **difference between the waveforms** can also be displayed, and this difference plot should be a straight horizontal line for a fault-free rotor winding. The **horizontal plot width** of the displayed waveforms is calibrated and **cursors** can be used to accurately measure **time delays** at points of trace divergence and a **locate** algorithm used to estimate the position of winding faults.

### 1.3 CONNECTION TO THE CONTROL PC

The connection to the **Control PC** is via a **USB printer cable** to a connector on the rear panel of the **TDR200 unit.** The USB connection simulates a standard PC com port and it is necessary for the User to know the number of the **PC comport** in use. Details of where to find or reset the **com port number** are given in **Appendix 4.**

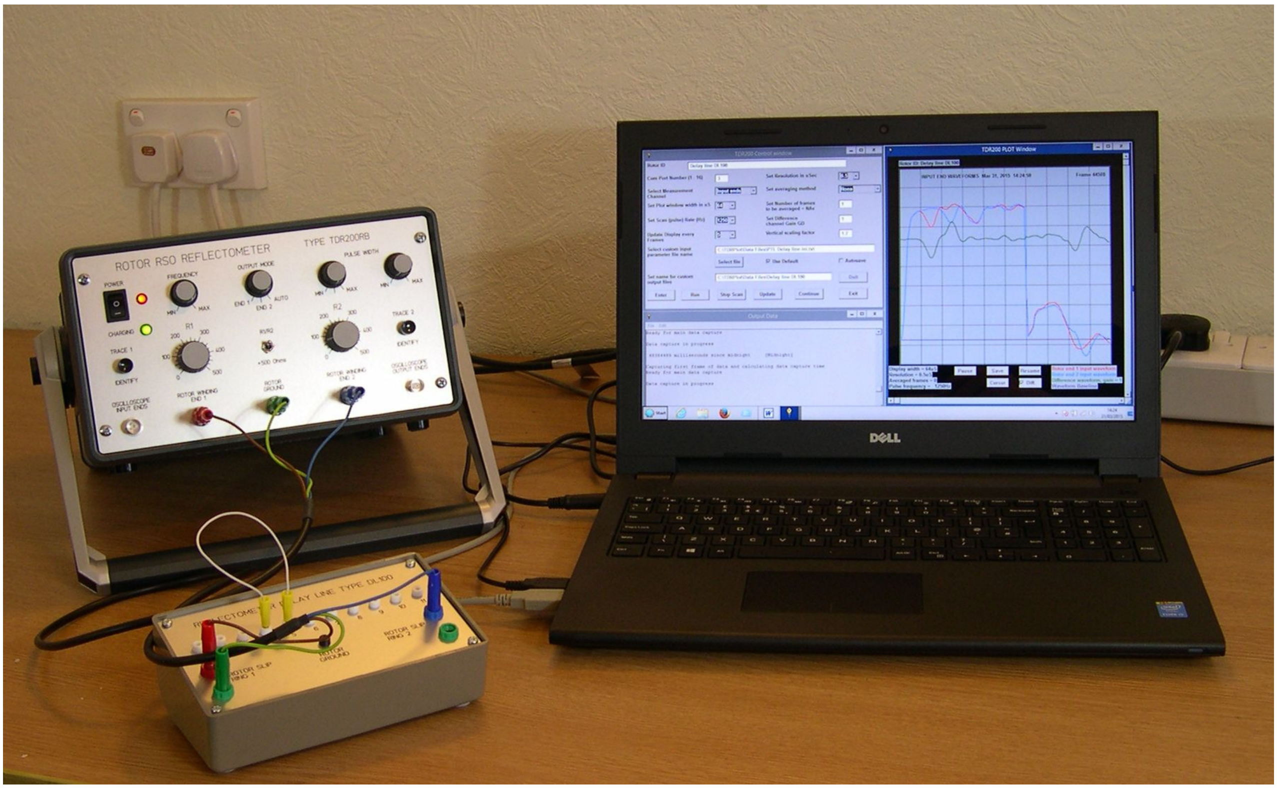



**Figure 1.1 The TDR200 unit connected to the demonstration DL100 delay line**

### 1.4 MANUAL CONTENTS

In this manual, the **Quickstart section 2** decribes how to use **TDR200** unit in digital mode using the supplied **DL100 delay line** to demonstrate the use of the **TDRPlot software**. **Sections 3 to 6** give more detailed information about the **TDRPlot software** and **Section 7** explains how to use the **TDR200** unit in digital mode under PC control for a real rotor winding. **Section 8** describes how to display and analyse captured data files, **section 9** describes fault location methods and **section 10** gives some examples of test results from real rotor windings.

References are made throughout to sections in the **TDR100 Operating Manual** which contains more detailed information about RSO testing in general and also the **operation of the TDR200 unit in analogue mod**e.

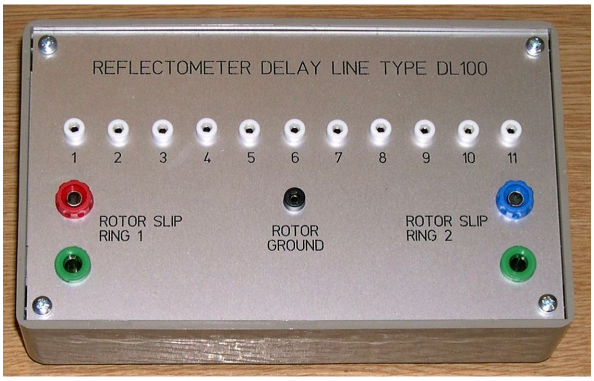
## 2. QUICKSTART INSTRUCTIONS

## USING THE REFLECTOMETER IN DIGITAL MODE

In this section we describe how to set up and use the **TDR200** in digital mode using the **DL100 demonstration delay line**. More detailed operating instructions are given later in section 7 and elsewhere.

### 2.1 THE DEMONSTRATION DELAY LINE

The delay line unit, which simulates and approximates to a real rotor winding, is used to check that the Reflectometer is operating correctly and is also an aid to demonstrating and understanding the RSO test method. It is a 10 section lumped component delay line with a characteristic impedance of 100Ω. The propagation time for a single pass through the unit is approximately 10µS. The junctions between each section of the delay line are connected to a series of white 2mm sockets, enabling external connections to be made to these points using a **patch lead**. The input and output ends of the unit are connected to 4mm sockets as shown in figure 2.1.1 below.



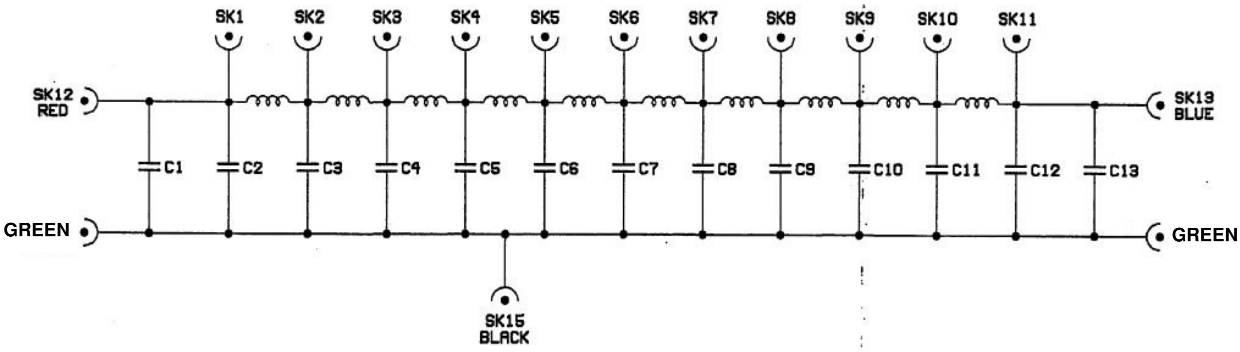




**Figure 2.1.1 Delay line type DL100**

In use, the **Delay line** is connected to the **Reflectometer** using the **1m 3-core test lead** supplied and shown in figure 2.1.2. At the **Delay line** end, the **red banana plug** is connected to the **red input terminal** on the delay line, the **blue banana plug** is connected to the **blue output terminal** and the **green banana plug** is connected to one of the **green common terminals**. The same plug colour convention is used to connect this lead at the reflectometer end, as shown in figure 2.2.1

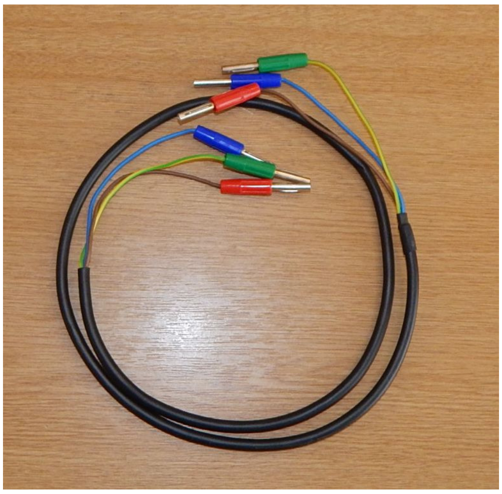


**Figure 2.1.2. 1m delay line connection lead**

## 2.2 SETTING UP THE EQUIPMENT

1. Ensure that the **delay line patch lead** (white lead with yellow plugs) is disconnected from the delay line and connect the **delay line** to the **TDR200** using the short connecting lead shown in figure 2.2.

Connect the **Reflectometer** to the **PC** via the **USB cable**, connect the **mains lead** to the mains supply and the rear panel connector and and switch on using the front and rear panel **supply on** switches. Operation of the **rear panel switch** charges the battery and lights the **green Charging** LED, while **that on the front panel** switches on the unit and lights the **red Power** LED.

Note that the **USB connector** (printer-type) is on the rear panel of the **TDR200 unit.**

The connection arrangements are shown in figures 2.2.1 and 2.2.2.

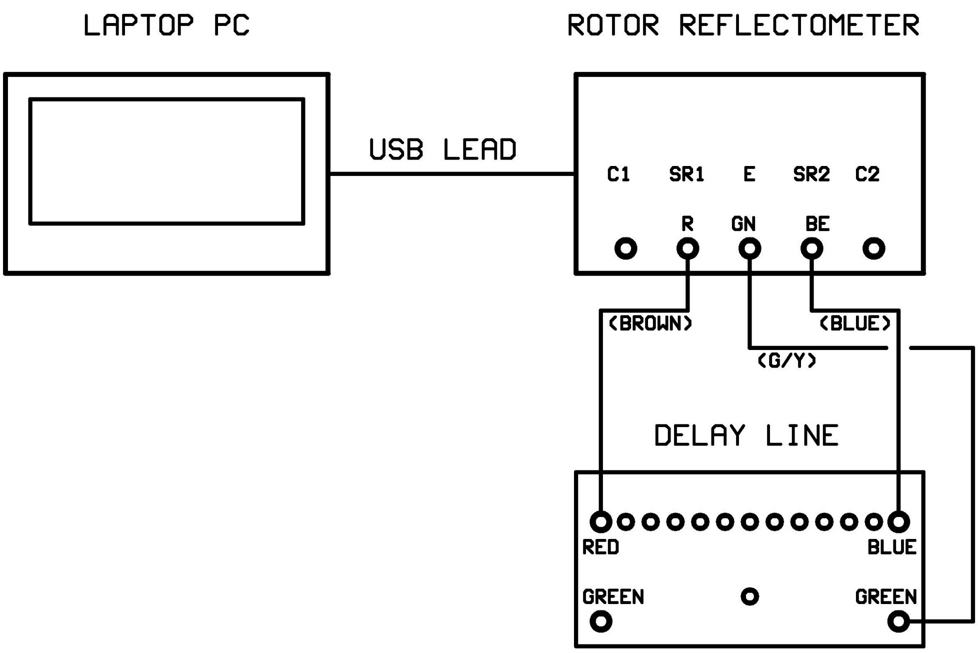



**Figure 2.2.1 Connection diagram using delay line**

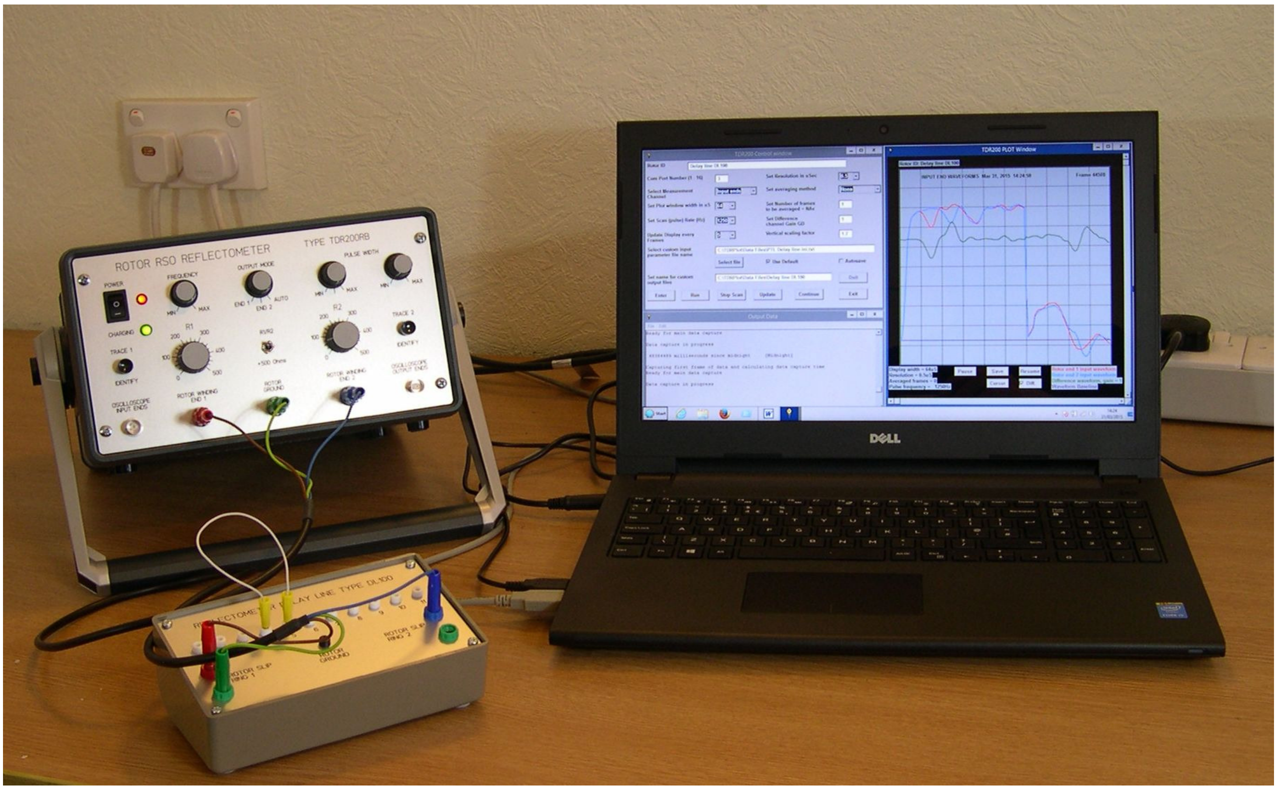



**Figure 2.2.2 TDR200 system with DL100 delay line**

3. Boot up the PC and run the TDRPlot software by clicking on the **TDRPlot Desktop icon** . The program will run and the **TDRPlot screen** will open as shown in figure 2.2.3.

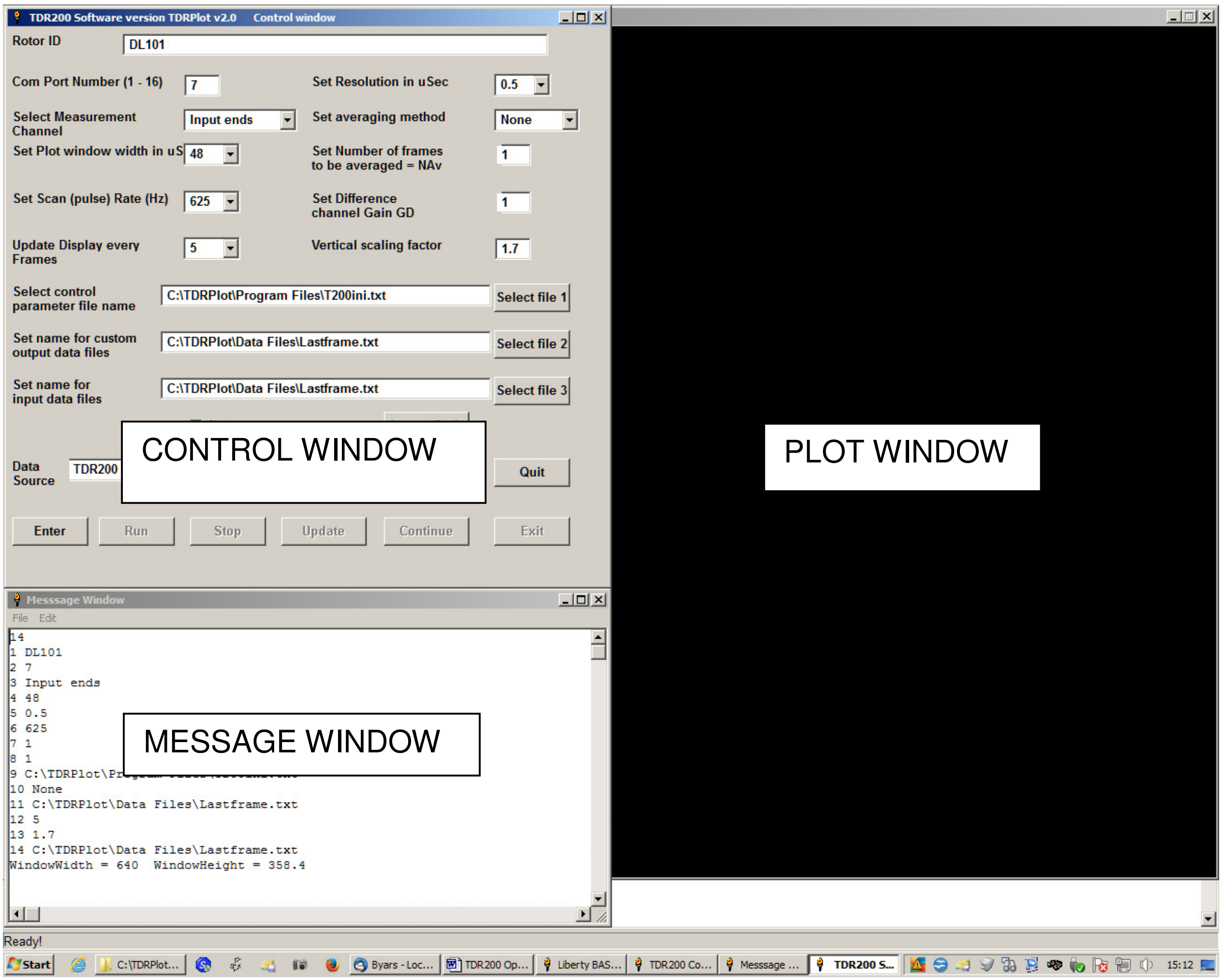



**Figure 2.2.3 Initial TDRPlot screen**

The **TDRPlot screen (**shown in fig. 2.2.3 above**)** contains 3 windows:

1. A **Control Window** (upper left region of screen).
2. An **Output message window** (below the Control Window).
3. A **Plot window** at the Right Hand Side (RHS) of screen, which is blank at start-up.

The **Control window** at start-up should ressemble that shown in figure 2.2.4 below, although some of the parameters at start-up may vary from those shown.

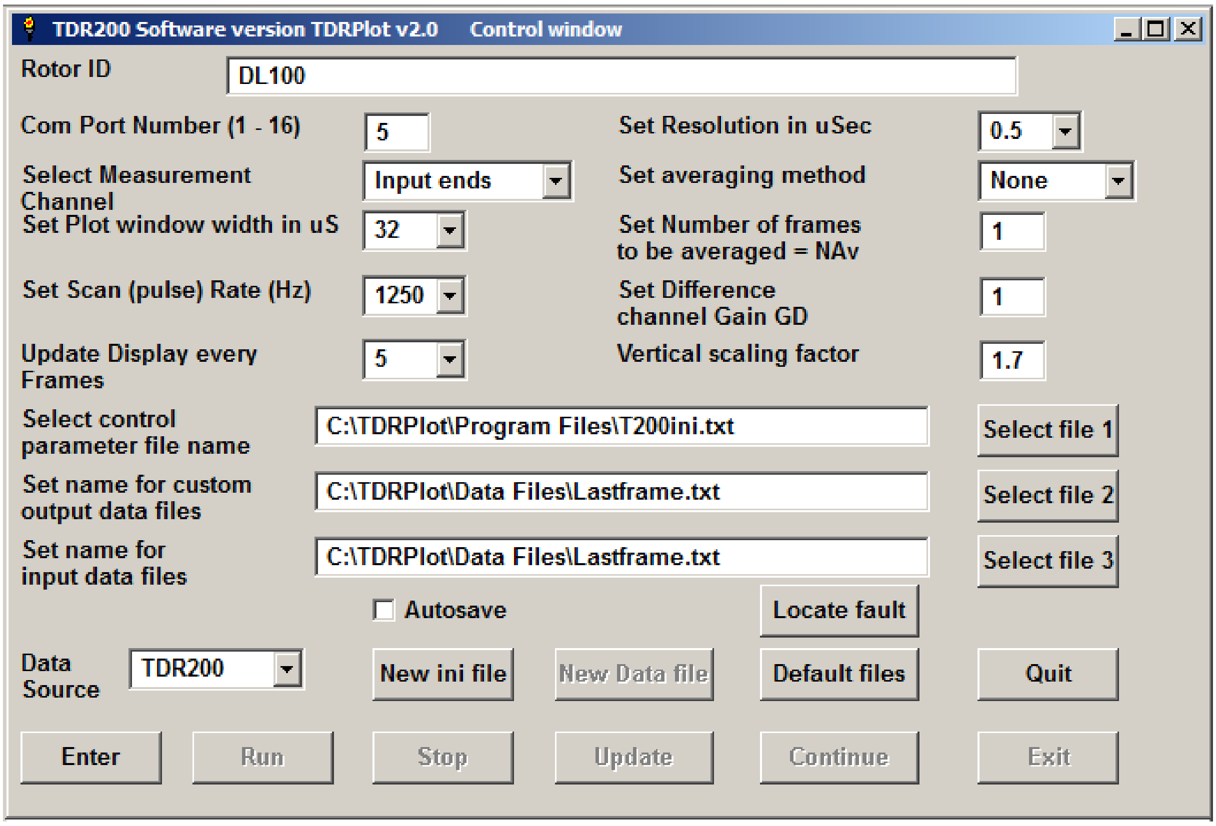



**Figure 2.2.4 Initial Control Window**

## 2.3 SETTING THE TDR200 FRONT PANEL CONTROLS

Adjust the front panel controls on the **TDR200** unit as follows:

**Frequency**: Max clockwise

**R1 and R2 controls**: Set to 100 Ohms

**Pulse width switch**: middle position

**Pulse width control**: Fully counterclockwise (minimum)

**Output mode switch**: Auto

## 2.4 INITIALISING THE PARAMETERS IN THE CONTROL WINDOW

Set the parameters in the **Control Window** as follows:

**Rotor ID**: Enter the text "DL100 Delay Line"

**Com Port Number**: The number of the PC com port in use (see **Appendix 4**).

**Select Measurement Channel**: Input ends

**Set Plot window width:** 48uS

**Set scan Rate Hz** 1250

**Update Display:** 5 frames

**Set resolution :** 0.5uS

**Set averaging method:** None

**Set number of frames to be averaged (Nav)**: 1

**Set difference channel gain (GD)**: 1

**Set Vertical Scaling factor =** 1.6

## 2.5 STARTING DATA CAPTURE

### 2.5.1 Viewing the RSO waveforms at the input ends

Once the correct parameters have been entered in the **Control window**, click on the **ENTER** button. This loads the set parameters into the **TDRPlot** software.

Next click on the **Run** button, which starts the data capture process. The waveforms at the **input ends** of the delay line (which simulates the rotor winding) will be displayed in the **Plot window** as shown in figure 2.5.1.

Note that there are 2 identical but superimposed waveforms plotted in **red** (end 1) and **blue** (end 2), corresponding to the pulses injected at each end of the rotor winding. There is also a **green** plot which shows the difference between the plotted waveforms.

To confirm the presence of the 2 superimposed waveforms, push the **Trace 1 identify** button on the front panel of the **TDR200 unit**. The **red** trace for end 1 will be displaced downwards while the button is kept pressed.

Similarly, if the **Trace 2 identify** button is pressed, the **blue** (end 2) waveform will be displaced downwards.

Adjust the value of both **R1** and **R2** to approximately 100 Ohms. on the **TDR200** unit so that the displayed waveform ressembles that shown in figure 2.5.1.

Click on the **Pause button** in the **Plot window**, which will stop the scanning.

Now click the **mouse pointer** at a point near the centre of the waveforms. This will generate a white vertical time **cursor line** as shown in figure 2.5.1.

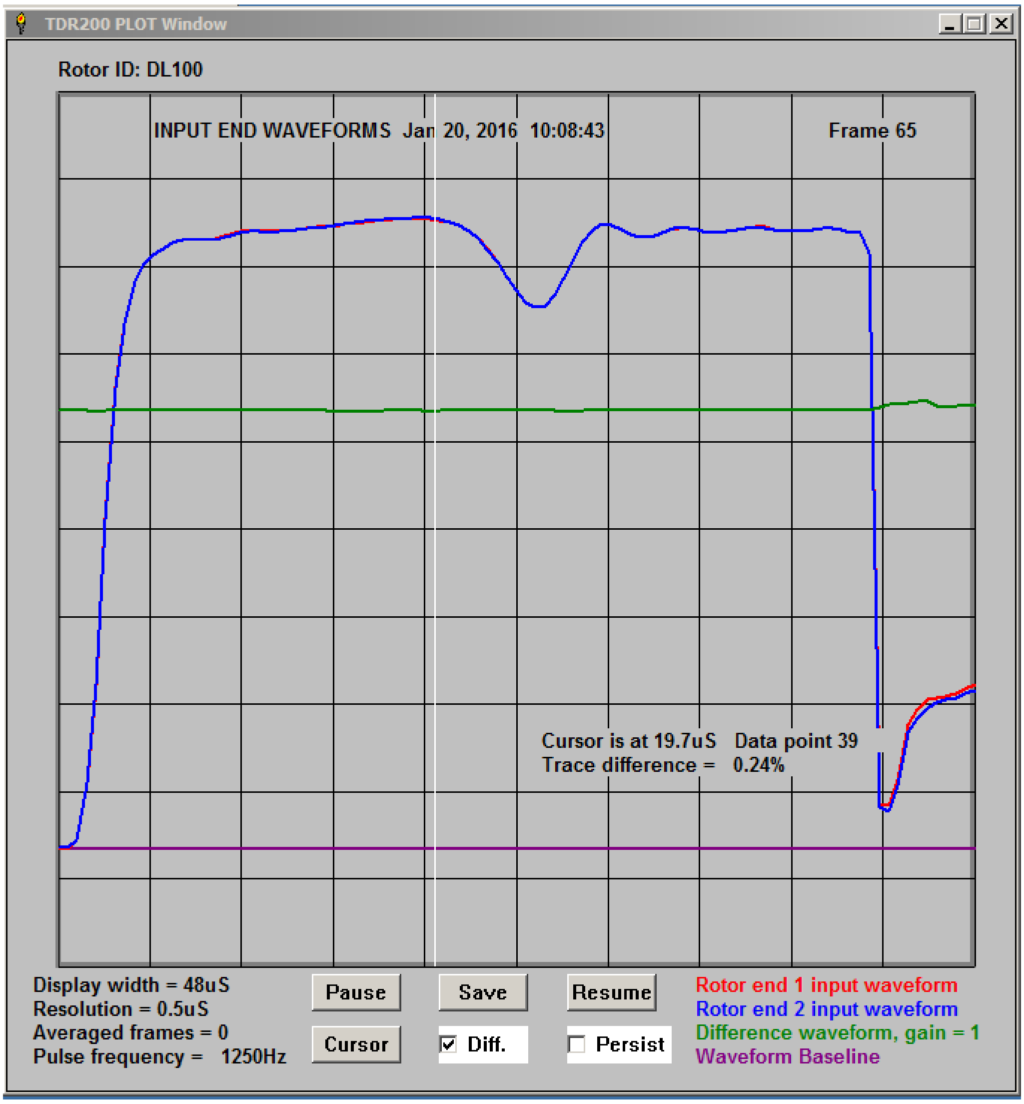



**Figure 2.5.1 Input end waveforms for fault-free delay line**

Click on the **Resume button** to resume scanning.

Note that there is a major change in the waveforms in figure 2.5.1 after about 20uS. This is caused by an intrinsic change in the characteristic impedance at each end of the demonstration delay line. This effect will not normally be seen when testing an actual rotor winding.

### 2.5.2 Viewing the RSO waveforms at the output ends

Now click again on the **Pause button** and set the **Measurement channel** box in the **Control window** to display the **output end** waveforms.

Set the **Plot window width** to 32uS, then click the **Update** button in the **Control window** and then the **Continue** button to display the **output end** waveforms as shown in figure 2.5.2.

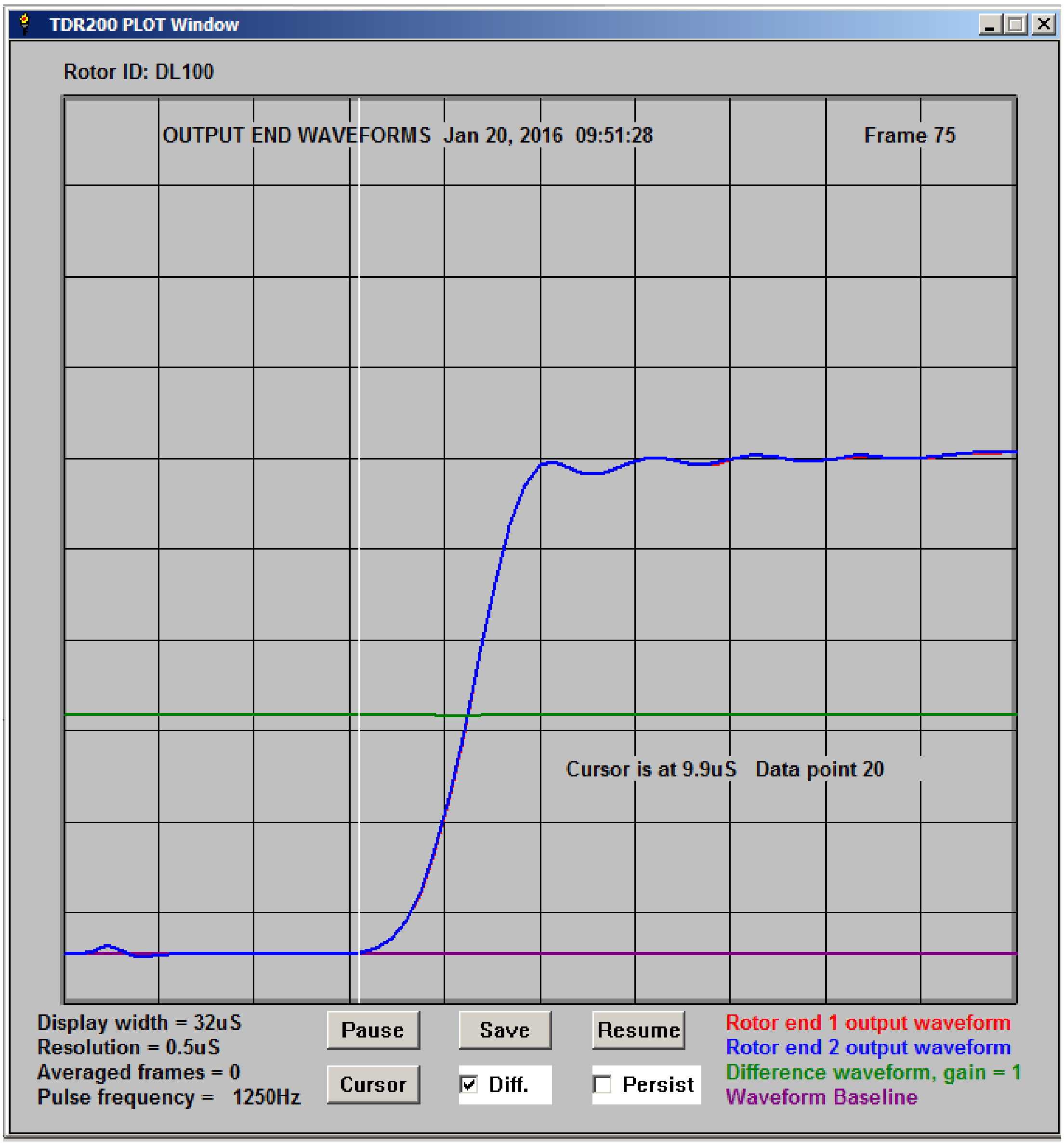



**Figure 2.5.2 Output end waveforms for fault-free delay line**

The **output end** waveforms are zero initially because it takes a finite time, known as the **Single Pass Transit time** (SPT**)** for the leading edge of the applied pulse to reach the end of the simulated rotor winding. This time can be measured using the **Cursor button**.

Click on the **Pause button** in the **Plot window.** Now click the **mouse pointer** at the start of the leading edge of the output pulses as shown in figure 2.5.2, where the transit time (SPT) is measured as 9.9uS.

## 2.6 SETTING THE MATCHING CONTROLS R1 AND R2

The **impedance matching controls R1 and R2** have a major effect on the displayed waveforms. However, the effects are identical for both sets of RSO waveforms and it is impossible to obtain different waveforms for each half-winding of a fault-free rotor winding by incorrect setting of these controls. The correct values of R1 and R2 for use with the delay line are approximately 100 Ohms. However, for a rotor winding, this value will be unknown initially and must be measured as described below.

### 2.6.1. EFFECTS OF THE VALUE OF R1

The visual effect of adjusting R1 is primarily to adjust the amplitudes of the displayed RSO waveforms. In practice, R1 is normally set to the same value as R2, once the correct value for R2 has been found, as described in section 2.6.2.

### 2.6.2 SETTING THE VALUE OF R2

On the front panel of the **TDR200** unit, set the values of **R1** and **R2** = 100 ohms and disconnect the **delay line patch lead**. Click on the **Resume button** in the **Plot window** to restart scanning.

Now set the value of **R2** to 200 Ohms. The displayed waveforms should appear as shown in figure 2.6.1 below. Notice that the amplitude of the pulse waveform increases after approximately 20uS (twice the single-pass transit time) because of the reflection at the mismatched impedance at the end of the delay line.

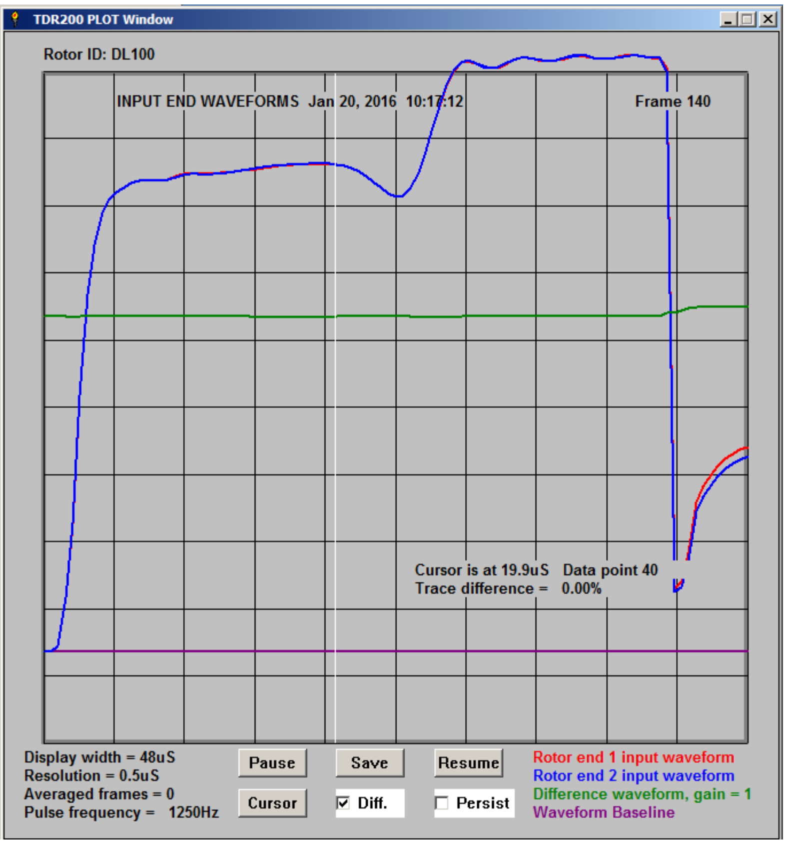



**Figure 2.6.1 Input end waveforms with R1 = 100 Ohms and R2 = 200 Ohms**

Now set the value of **R2** to zero and resume scanning.

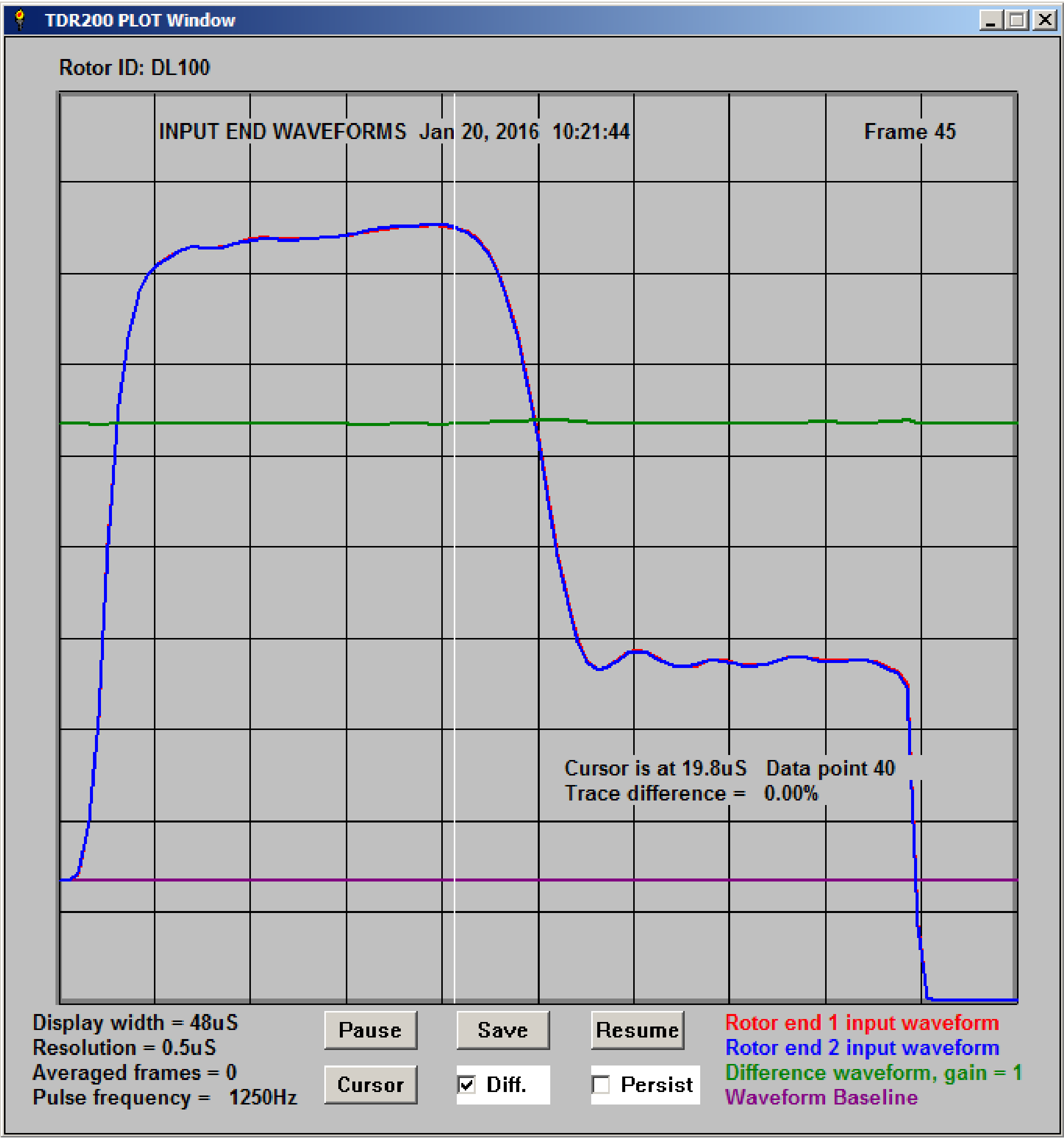



**Figure 2.6.2 Input end waveforms with R1 = 100 Ohms and R2 = 0 Ohms**

Now the reflected pulse becomes negative and causes the amplitude of the RSO waveform to decrease after approximately 20uS.

The time from the start of the injected pulse to the point at which the waveforms change when R2 is varied is known as the **Double-Pass Transit time** (DPT) and is the time taken for the pulse to travel from one end of the winding and back again when the terminating impedance R2 is incorrect.

The correct value for R2 (and hence R1) is the value which causes no net reflection at the output ends of the rotor winding, so that the waveforms are similar to those shown in figure 2.5.1.

## 2.7 DEMONSTRATING WINDING FAULTS WITH THE DL100 DELAY LINE

Revert to monitoring the **input end** waveforms by setting the **Measurement channel** box in the **Control window** to display the **input end** waveforms, then click the **Update** button and then the the **Continue** button to resume scanning.

Some sample waveforms obtained using the **TDRPlot software** for a simulated inter-coil and earth fault are given in the next two figures.

### 2.7.1 Simulated inter-coil fault

Apply a simulated inter-coil fault by connecting the delay line patch lead between terminals 4 and 5 on the delay line. Figure 2.7.1 shows the resulting waveforms.

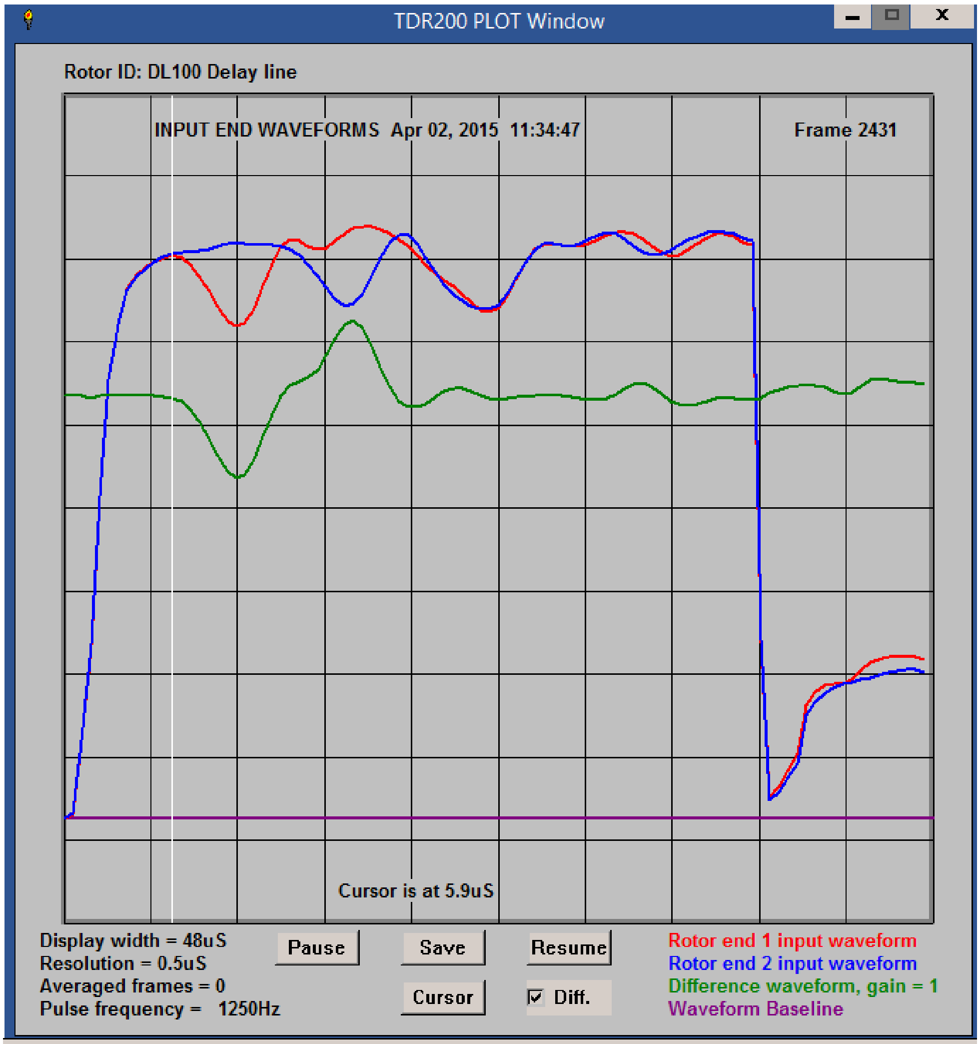



**Figure 2.7.1.**

**Input end and difference waveforms for a short between terminals 4 and 5**

By locating the cursor at the point where the waveforms start to diverge and comparing the cursor time with the single-pass transit time, the approximate fault location can be deduced. Note that the green difference trace is no longer a horizontal line.

### 2.7.2 Simulated earth fault

Apply a simulated earth fault by connecting the **delay line patch lead** between terminal 4 and the **black Rotor Ground terminal** on the **delay line**. Figure 2.7.2 shows the resulting waveforms.

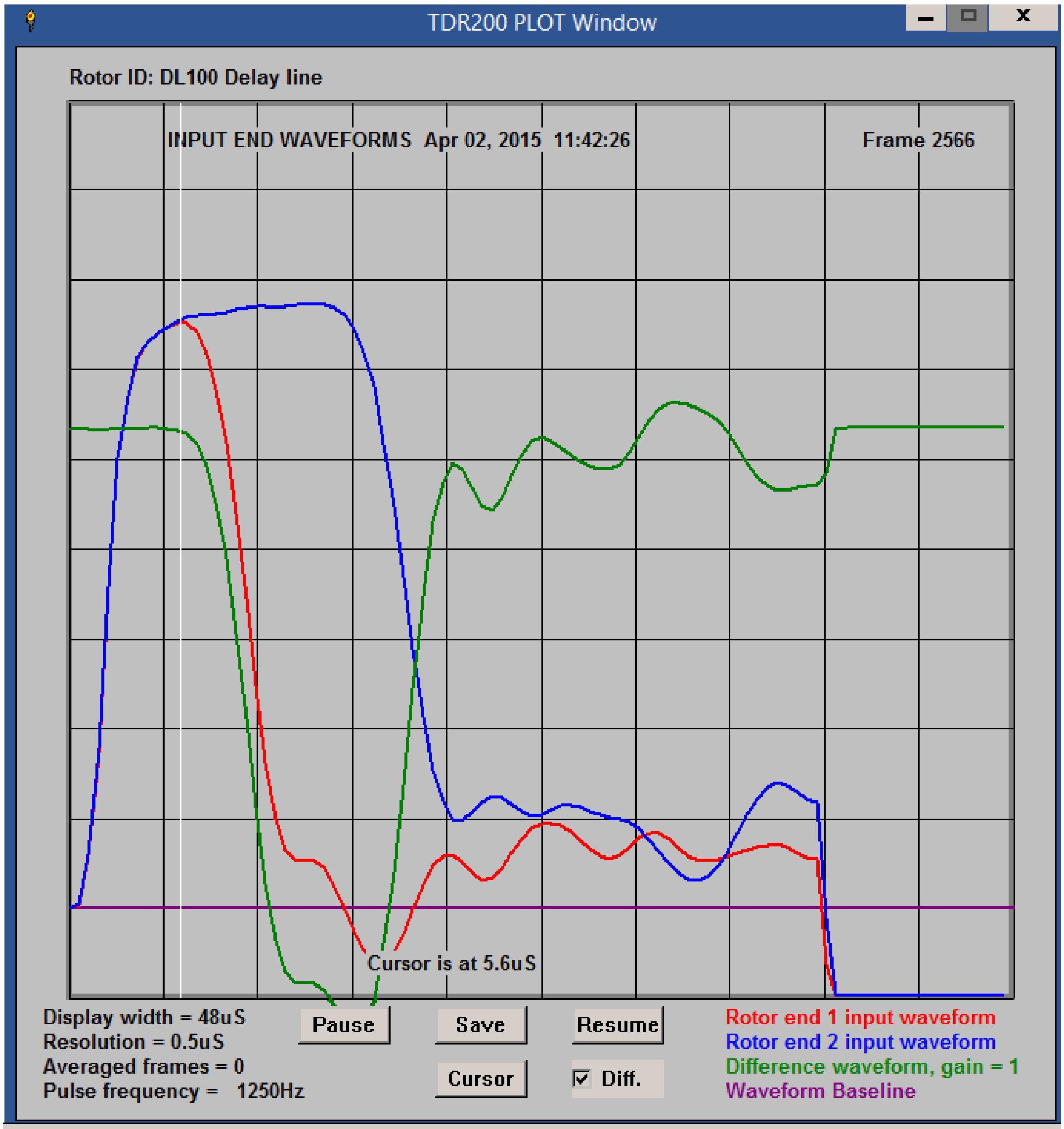



**Figure 2.7.2**

**Input end and difference waveforms for a short between terminal 4 and ground**

**Notes**

1. It is possible to turn the **Difference** waveform on and off by checking or unchecking the **Diff checkbox** after the **Pause** button has been clicked.

2. The **waveforms for a real rotor winding** with winding faults will normally show **much less difference** between the traces for each end under fault conditions.

## 2.8 INTERPRETING THE WAVEFORMS

A **normal fault-free rotor winding** is characterised by **2 identical waveforms** at each end of the rotor winding (red and blue waveforms) with a horizontal straight line (green) difference waveform, as shown in figure 2.5.1.

Detailed information about how to interpret the **RSO waveforms** is given in the **TDR100/200 Instruction Manual.**

## 2.9 EXITING THE SOFTWARE

After scanning has started, press the **EXIT** button in the **Control** window to terminate the program.

This generates a number of files containing the last frame of ADC data and also a copy of the **Plot window** in bitmap format as described in section 3.2. An **Output File Details window** is also generated as shown in figure 2.9.1.

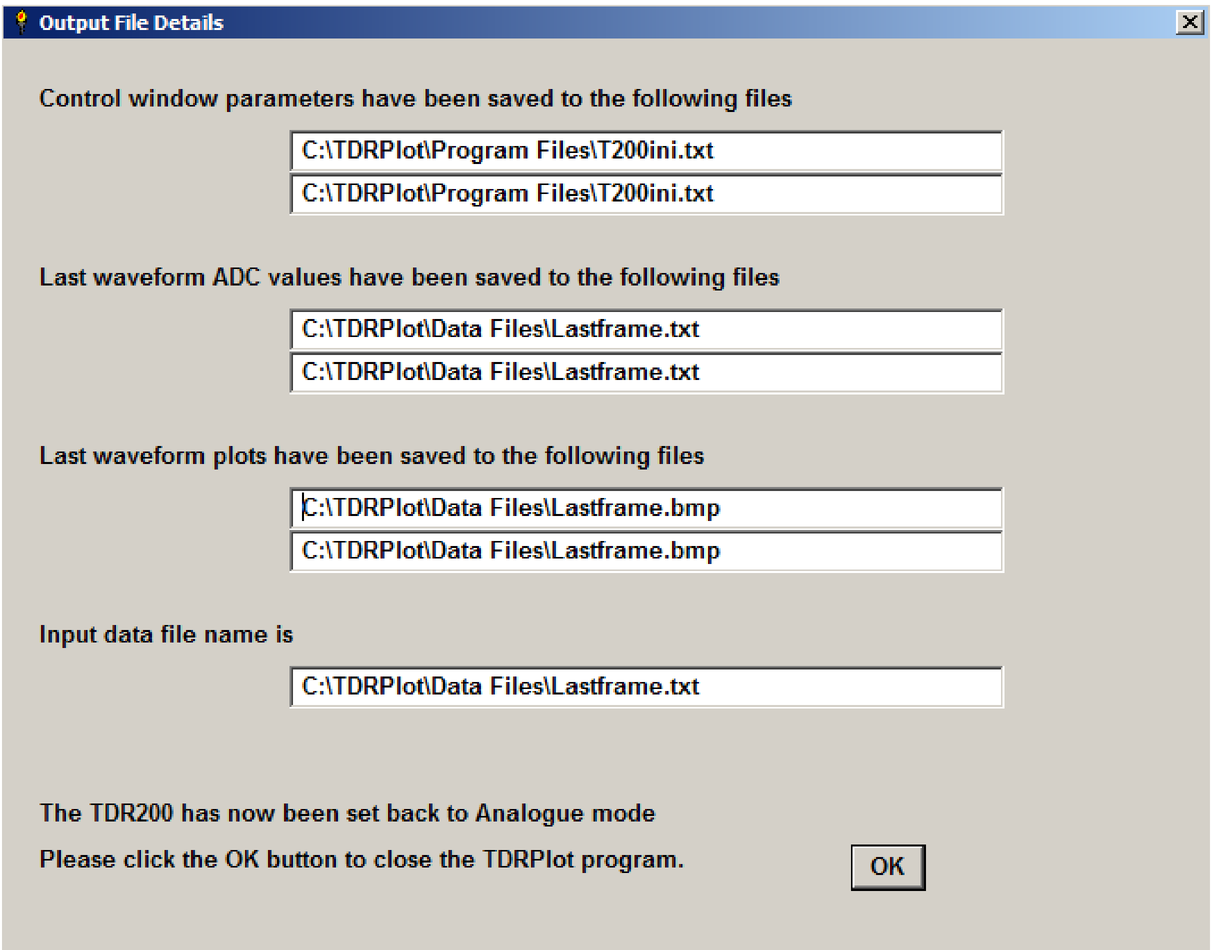



**Figure 2.9.1 Output File Details window**

Note that to exit the software before scanning has started, click on the **QUIT** button in the **Control window**. In this case, no new data files will be generated.

## 2.10 OUTPUT FILE MANAGEMENT

The **output data files** generated by the **TDRPlot** software will be in the **Data Files** subfolder in the **Default** folder (see **Appendix 1** for more information)..

Once a test has been completed, we suggest that **a new folder** should be created with a unique name which identifies the rotor under test.

The files in the **Data Files** subfolder should then be moved to this new folder for safe keeping.

## 2.11 THE NEXT STEPS

This concludes the **Quickstart** section.

Detailed information about the **RSO test** and practical advice on using this test method on real rotor windings can be found in the **TDR100 Rotor Reflectometer Instruction Manual** and also in a number of technical papers included in the supplied **software and documentation CD** or **USB flash memory drive**.

Further information about using the **TDRPlot** software with real rotor windings is given in section 7.

The remaining sections of this manual give additional information about the **TDRPlot** software. These sections contain some repetition of previous sections to help new users acquire experience and confidence in the use of the software.

# 3. OVERVIEW OF THE TDRPlot SOFTWARE

## 3.1 HARDWARE AND SOFTWARE CONFIGURATION

The **Control PC** is connected to the **TDR200** unit using a standard USB printer lead and the control software (**TDRPlot.exe**) is used to display and capture the rotor waveforms.

The **TDRPlot** software can operate in either **On-line** or **Off-line** modes.

In **On-line** mode, the software controls the **TDR200** unit to capture, display **live RSO waveforms** and saves them to both **text** and **bitmap** data files

In **Off-line** mode, the software can be used to display and analyse a **previously-captured** data file.

All of the program and data files are contained within a single folder (the **"Default folde**r") on the **Control PC**. Most of the **data files** generated by the software are saved to a **Data Files subfolder** of the **Default folder**.

When the **TDR200** is operated in **digital mode** using a **Control PC** running the **TDRPlot** software, the **pulse repetition (scan) rate** ("**Frequency**" in analogue mode) is set by the control software instead of the **Frequency** control on the **TDR200** front panel (which is **inoperative** in **digital control mode**).

The **rotor input and output end waveforms** can still be displayed and observed by connecting an oscilloscope to the **TDR200 oscilloscope terminals**, as in analogue mode, but an oscilloscope is no longer necessary, as the primary method of displaying the waveforms is now the screen of the **Control PC.**

A pair of high-resolution 16 bit Analogue to Digital Converters (ADCs) in the **TDR200** digital interface are used to digitise the waveforms at the input and output ends of the rotor winding and to construct frames of data containing the waveforms at the input and output ends. In **digital mode**, the **waveform frames** are built up using a number of sequential measurement scans (pulses), where the number of scans per measurement frame depends on the measurement resolution set by the user.

## 3.2 PROGRAM WINDOWS

The **TDRPlot** software generates 3 windows when it is run as follows:

A **Control Window** which allows the user to set/select the required **control parameters** and **file names** etc.

A **Plot Window** which displays the **measured waveforms**.

A **Message Window** which is primarily used for diagnostic purposes and error-checking etc.

### 3.3 DATA FILES

#### 3.3.1 Input files

**In on-line** mode, the **TDRPlot** software uses an **input data file** to initialise the **control parameters**. This file (**T200ini.txt)** contains the last used values for the control parameters. This file is always loaded by default when the program is run.

A similar **customini.txt** file, which holds set up data for a specific measurement configuration, can also be defined and loaded by the user to update the control parameters to a new measurement configuration.

In **off-line** mode, the **TDRPlot** software can be used to load and display waveforms and data files previously captured during on-line mode operation.

#### 3.3.2 Output files

The software generates a number of **output files** in a **Data Files** sub-folder:

When the **TDRPlot** program is terminated in **On-line** mode using the **Exit button**, the **control window parameters** and the **last frame of data** are saved to 3 **default** data files and also to 3 **custom** data files.

The **default** file names are:

**T200ini.txt** which contains the set of **control window parameters** on exit.
**Lastframe.txt** which contains the set of **ADC readings for the last frame of data**.
**Lastframe.bmp** which contains a **bitmap image of the last plot window**.

The **custom** file names, which contain similar data are:

**RotorID$-ini.txt**
**RotorID$.txt**
**RotorID$.bmp**

where **RotorID**$ is the rotor ID (name) as specified in the top text box of the Control window.

Note that the **T200ini.txt** file is saved to the **Program files** folder **C:\TDRPlot\Program files**, whereas all of the other files are saved to the **Data files** folder **C:\TDRPlot\Data files**.

In addition, data can be saved for any data frame by pausing data capture and using the **Save** button in the **Plot window**.

Detailed information about the data file formats with examples is given in Appendix 2.

## 3.4. THE CONTROL WINDOW.

When the program is run, a **Control window** appears as shown in **Figure 3.4.1** below. This window contains the **control parameters** which must be set before the program is run. The program retains the last-used control parameters by default in the **T200ini.txt** file and also in an optional **custom ini** file if one has been defined by the used..

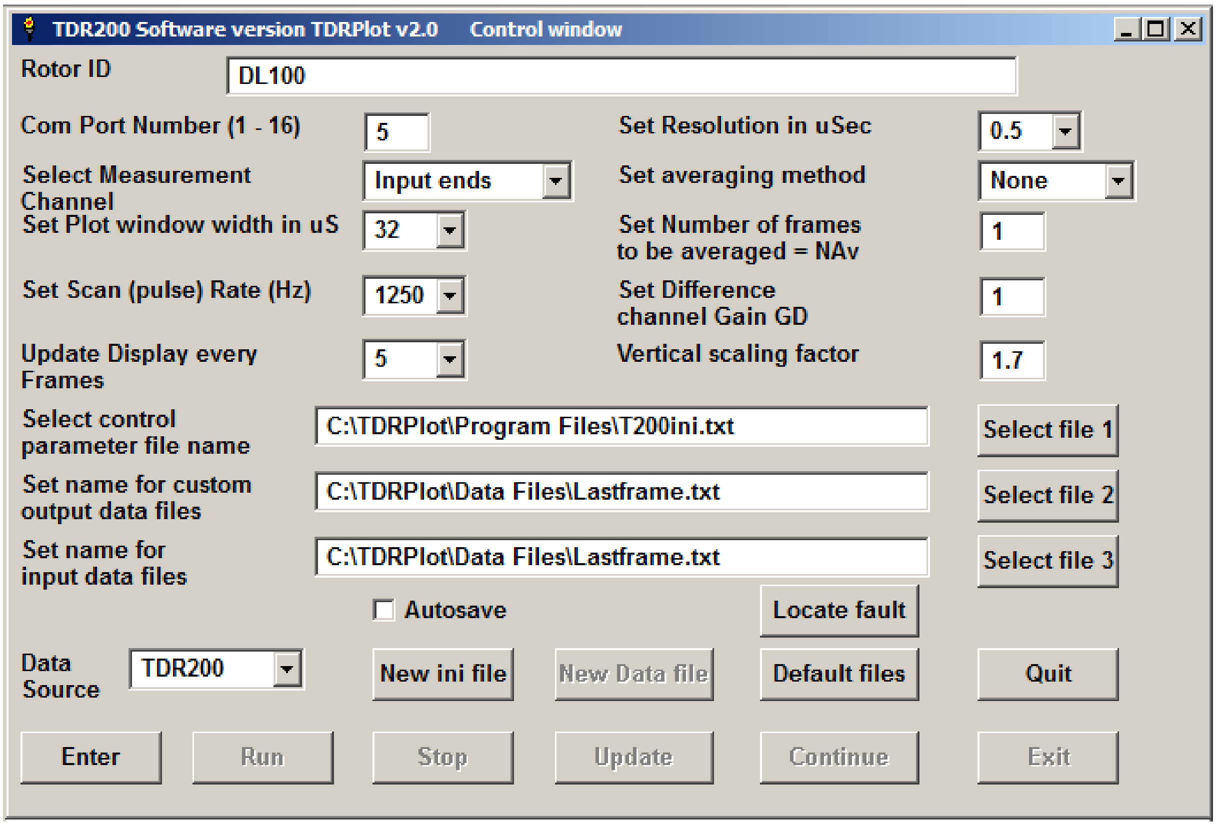



**Figure 3.4.1. Control window**

Full details of the **Control window** parameters are given in section 4.

### 3.4.1 RUNNING THE SOFTWARE USING THE DEFAULT CONTROL PARAMETERS IN ON-LINE MODE

Set the **Data Source box** to the **On-line mode** of operation by selecting the **TDR200** (default) option.

Now run the program by clicking on the **Enter** and **Run** buttons in sequence. The software will run and live RSO data will be displayed in the **Plot window**.

Next terminate the program using the **Stop** and **Exit** buttons in sequence. The **last frame of data** will automatically be saved to files with the names **Lastframe.txt,** which contains the set of **ADC** readings for the last frame of data and **Lastframe.bmp,** which contains a **bitmap image** of **the Plot window** for this data frame. A number of other files may also be generated, as described later.

### 3.4.2 LOADING A NEW SET OF CONTROL PARAMETERS

If the **control parameters** which are loaded on opening the program are not correct for the rotor to be tested, they can either be editted manually or changed by reading the correct data from a custom **control parameter file** (assuming one has been saved on a previous occasion).

A new **control parameter file** for a different rotor can be loaded as follows:

Use the **Select file 1** button to browse for the the required **control parameter file**. This file will be in the **Data files** folder.

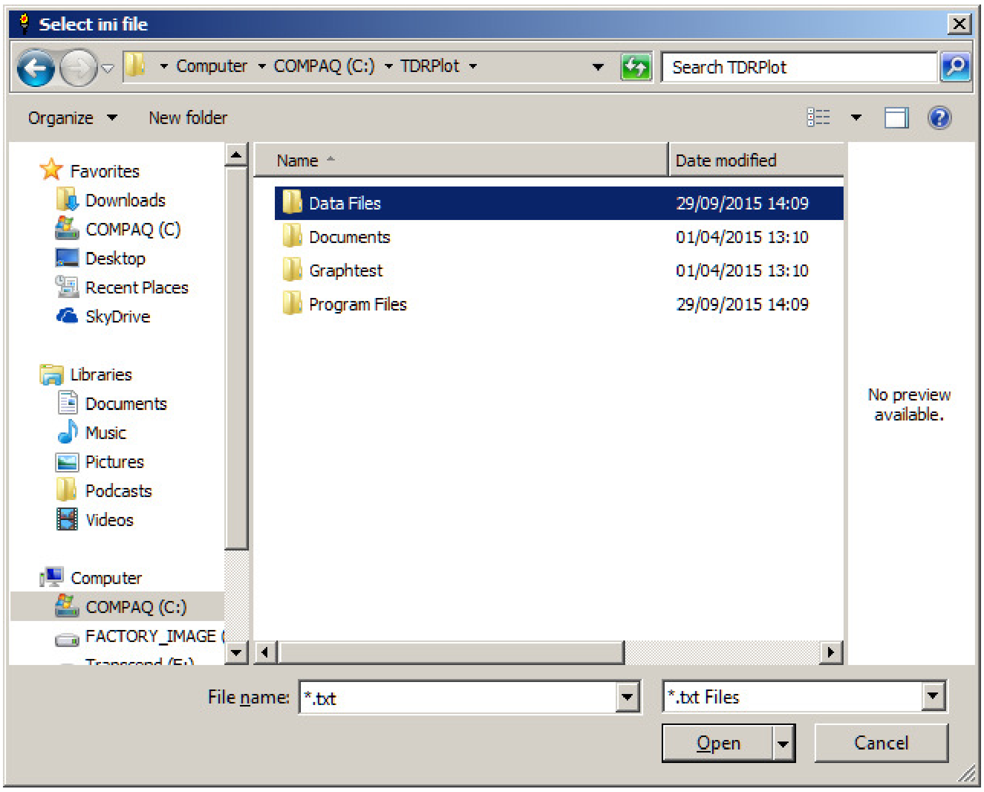



**Figure 3.4.2 The Select file window**

Open the **TDRPlot\Data files** folder and select the required **control parameter file**, which will have the form: **Name-ini.txt**.

Then click on the **New ini file** button. This will read the contents of the selected file to the **text boxes** in the **control window**.

If the output file names do not follow the naming rules, click on the **Default files** button to set the output data files to the default names for this new Rotor.

### 3.4.3 SAVING FILES TO NEW DEFAULT FILE NAMES

If the **Default files** button is clicked, the set of 3 data file names in the **Control window** are set to default names based on the **Rotor name** entered in the Rotor ID box at the top of the Control window, as shown below.

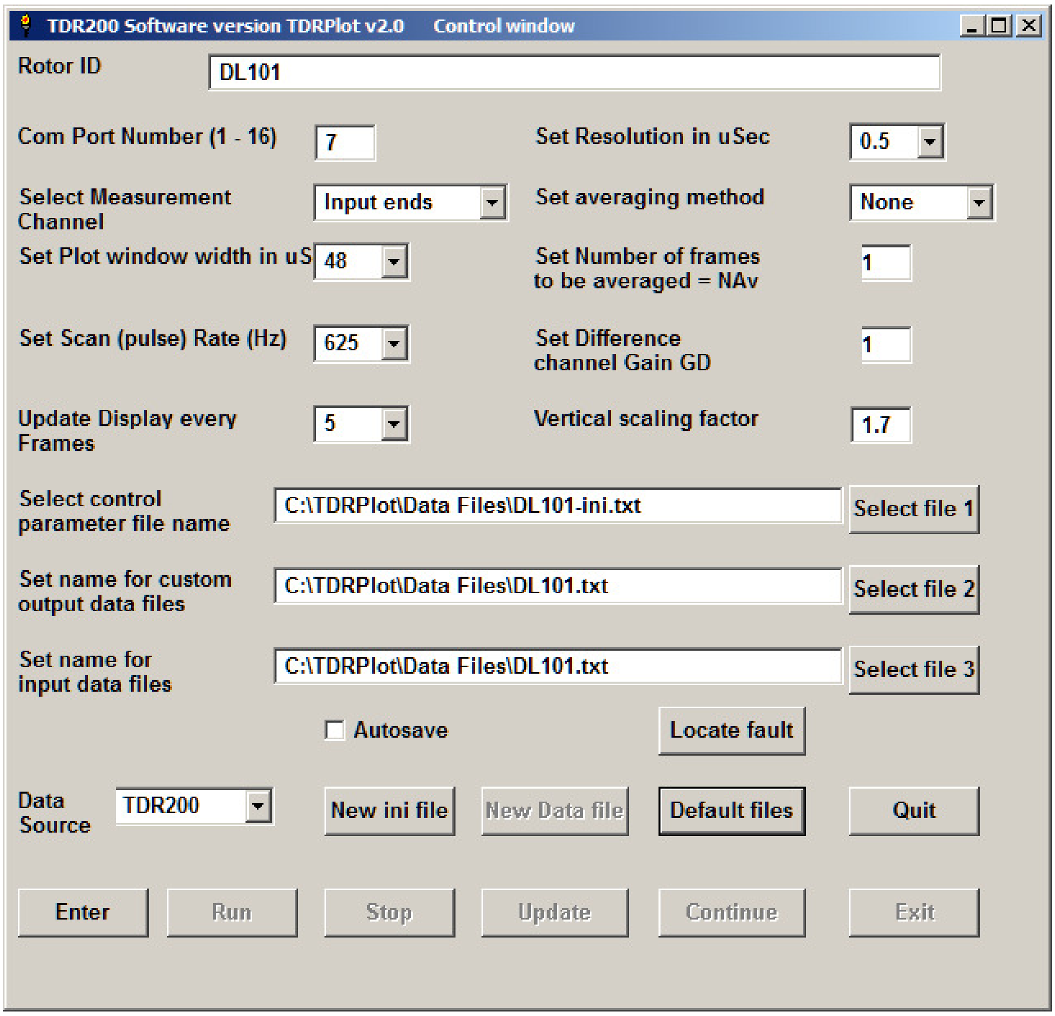



**Figure 3.4.3 Setting new default file names**

This can be a useful feature for setting unique file names for each rotor type or test.

Note that the **output data file** will be **over-written** on program exit in **On-line** (TDR200) mode, so it may be necessary to use unique Rotor ID names for each test if relying on the data saved on program exit.

### 3.5 THE PLOT WINDOW

Once the **control parameters** have been modified or confirmed, the program is run by clicking the **ENTER** button, followed by the **RUN** button. This generates a **Plot window**, shown in simplified form for a **fault-free rotor winding** in figure 3.5.1 below.

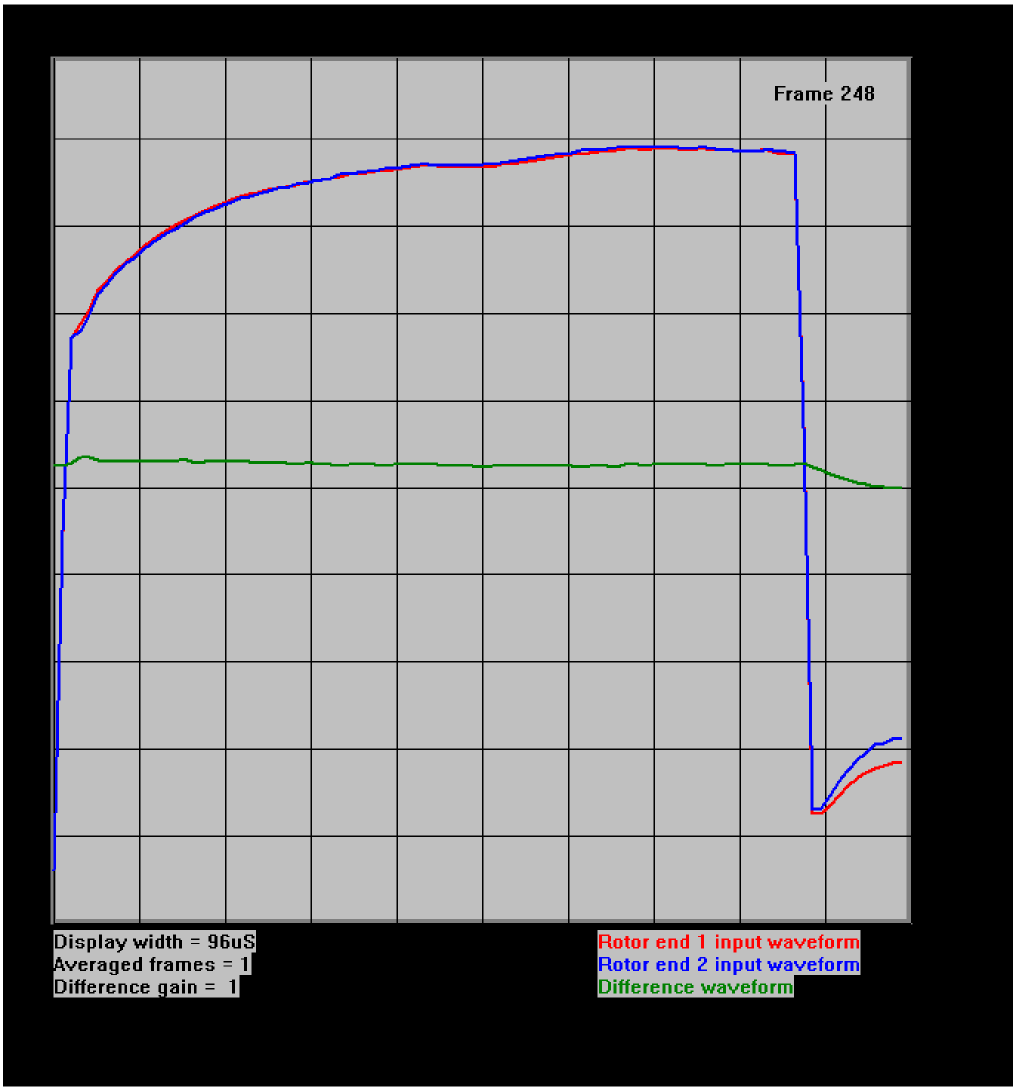



**Figure 3.5.1 Plot window showing input end waveforms for a fault-free rotor winding ***

The **Plot window** shows the rotor waveforms at either the **input, output** or **both ends** of the **rotor winding** depending on the option set in the **Measurement Channel selection box** in the **Control window**.

Figure 3.5.1 shows the waveforms at the **input ends** of the windings for a fault-free rotor. As well as the 2 input waveforms (shown in red and blue), the difference between these 2 waveforms is shown in green. It is also possible to display (white) time cursors as described later.

The **width** of the **Plot window** (**Plot width**) is set in the **Control window**. However, the actual width of the **applied pulse** is still set by the pair of **pulse width controls** on the front panel controls on the **TDR200 Reflectometer**.

Similarly, figure 3.5.2 shows the **Plot window** in simplified form for the **output ends** of the rotor winding

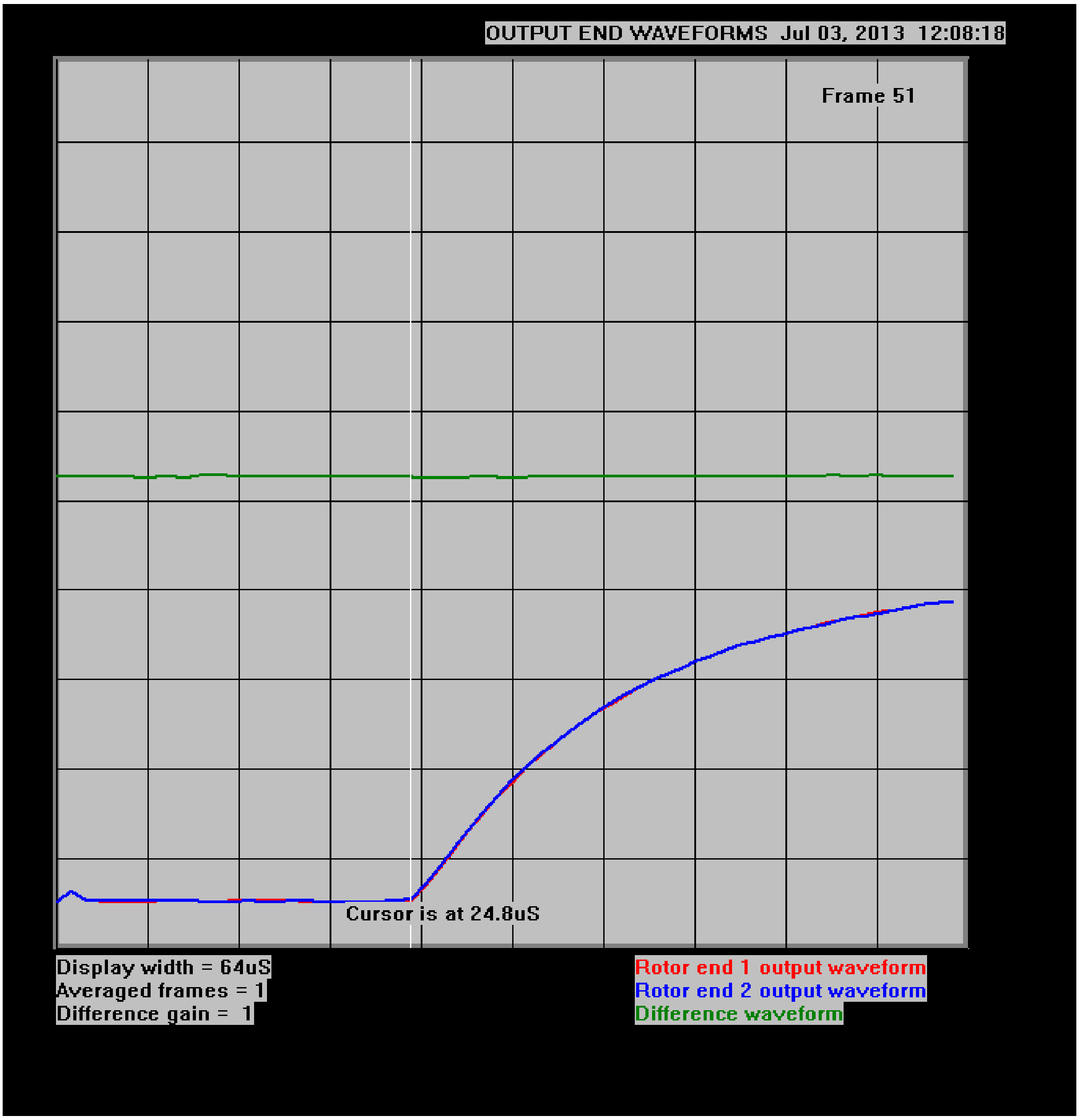



**Figure 3.5.2 Plot window showing output end waveforms for a fault-free rotor winding ***

Full details of the **Plot window** parameters are given in section 5 .

## 4. CONTROL WINDOW DETAILED INFORMATION

When the **TDRPlot** program is opened, the **parameters in the Control window** are loaded from the **default control parameter file T200in.txt** and the values appear in the text boxes. These parameters will have the values set when the program was last run.

A typical start-up window is shown below, where **DL100** is the nominated RotorID.

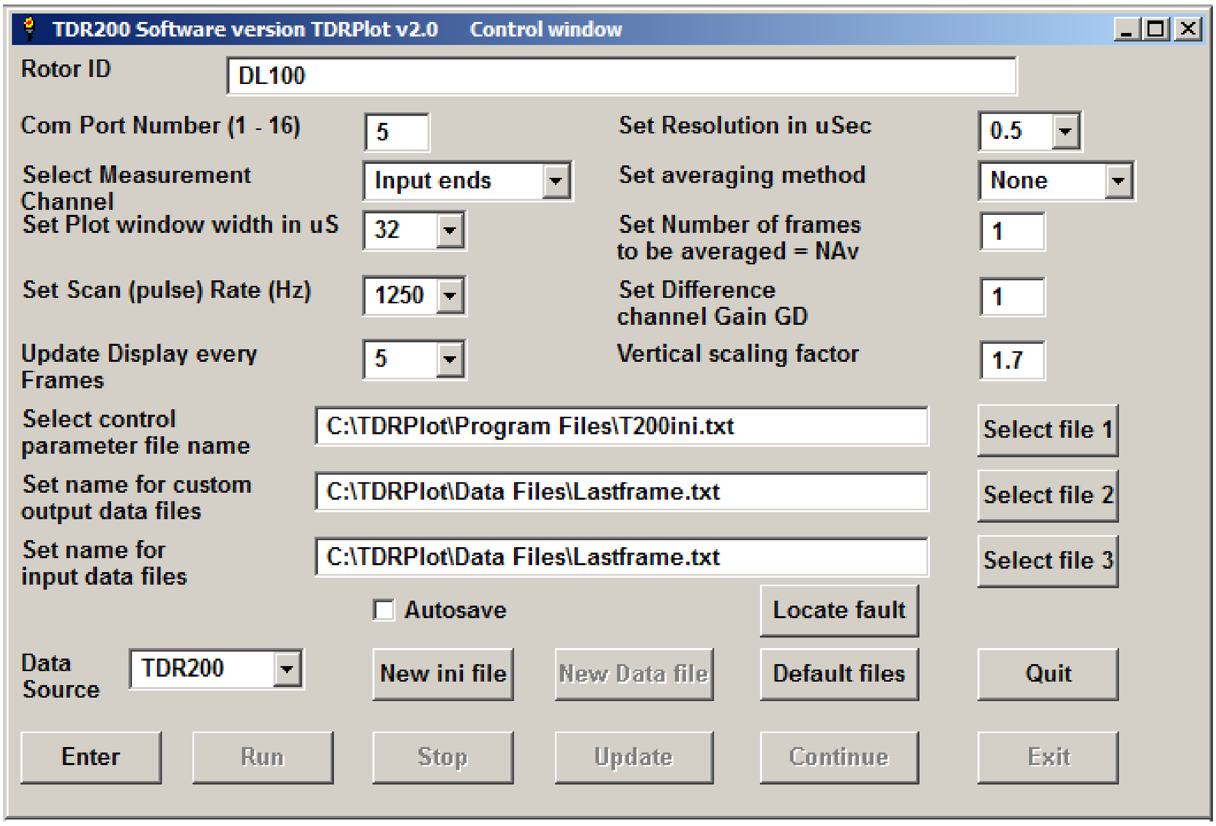



**Figure 4.1 The Control window**

### 4.1 CONTROL WINDOW PARAMETERS

Details of the **Control window** set up parameters are as follows:

#### 1. Rotor ID:

A user-entered Name (character string) which identifies the rotor being tested. (Max 64 characters). As this name is also used to define the names of the stored output data files, it helps to choose a fairly short or abbreviated Rotor ID name.

#### 2. Com Port Number:

The number of the **com port** on the laptop PC connected to the **TDR200 reflectometer.** Details for obtaining or setting this number are given **in Appendix 4**.

**3. Select measurement channel**

To view the waveforms at the input ends of the rotor, select **Input ends**.
To view the waveforms at the output ends of the rotor, select **Output ends**.
To view the waveforms at both ends of the rotor, select **Both ends**.

**4. Set Plot window width**

This parameter sets the width of the waveform plotting window in integer multiples of 16uS. A suitable value for the test delay line is 48uS.

Note that the actual applied pulse width is set by the **front panel controls** of the **TDR200** unit.

**5. Set Scan (pulse) Rate (Hz)**

When the **TDR200 unit** is under **PC contro**l, the **Frequency control** on the front panel of the **TDR200** unit is inoperative.

Instead, the repetition rate of the applied voltage pulse is set by the **Set Scan (pulse) Rate (Hz)** parameter in the **Control Window**.

**6. Update Display every N frames**

The value of **N** selected determines how often the **Plot window** is updated. For example, if N = 5, the plot window is updated after every 5 frames of measured data.

**7. Set Resolution parameter**

This parameter sets the effective sampling rate for the displayed waveforms in multiples of 0.1us.

(A suitable resolution value for the supplied delay line is 0.5uS).

**8. Set averaging method**

This allows data for consecutive frames to be averaged to reduce any noise in the displayed waveforms. The options are **None, Rolling** or **Exponential** with the following meanings:

**None:** No averaging
**Rolling**: Frames are averaged using a true rolling average algorithm
**Exponential:** Simple cumulative averaging using an exponential averaging algorithm.

**9. Set Number of frames to be averaged NAv**

This parameter (**NAv**) sets the number of frames to be averaged

**10. Set difference channel gain**

This parameter (GD) allows the gain applied to the difference channel to be modified as required. The normal (default) value is 1.

**11. Vertical scaling factor:** This parameter allows the vertical span (height) of the displayed waveforms to be adjusted. Valid values for this parameter are in the range between 0.5 and 2.

**12. Set custom input parameter file name:** This output data file is generated as an option by the **TDRPlot** software and contains initialisation parameters for a **specific Rotor or test site**.

**13. Set Default check box:** If this box is checked, the file names in (12) and (14) are set automatically by the name chosen for the Rotor ID (1). The default mode at start-up is ticked.

**14. Autosave check box:** If this box is ticked, A bitmap image of the plot window is saved after every 1000 frames. The default mode at start-up is not ticked.

**15. Data Source select box**: Selects **ON-line** (TDR200) or **OFF-line** (File) mode of operation. **Default mode** is **TDR200** (on-line).

## 4.2 CUSTOM DATA FILE NAMES

The **custom data file names** are specified in the **3 file name** boxes in the **Control window.**

Standard file names derived from the **Rotor ID name** can be generated automatically by clicking on the **Default files** button.

Although it is possible to set different **output file** names by using the **Select file 2** button (for example to identify different tests of the same rotor) it is preferable to edit the rotor file name instead (eg RotorID-1, RotorID-2) to identify the results for different tests conditions.

The file name box details are as follows:
.

**1. Set name for control input parameters**

This box contains the **file name** for the control input parameters to be used.

**2. Set name for custom output data files (on-line mode)**

This box contains the **file name** for the output data files.

**3. Set name for custom input data files (off-line mode)**

This box contains the **file name** for the input data file to be read in off-line mode.

## 4.2 LIMITATIONS ON THE VALUES OF THE CONTROL PARAMETERS

The **maximum horizontal resolution achievable is 0.1 uS**, but the amount of internal memory in the **TDR200** imposes a limit on the **combination** of **resolution** and **plot window width** for the captured waveforms. As the **plot window width** (time) is increased, the maximum resolution achievable decreases.

For example, for displaying data at either the **input** or **output ends** of the rotor winding at the maximum resolution of 0.1uS, the longest possible data capture time corresponds to 48uS. When the **Control window** is set to display data at **both ends** of the winding simultaneously, the maximum window width is 24uS.

It is therefore necessary to **reduce the measurement resolution** accordingly when **longer plot window times** are required. Alternatively set the software to display the waveforms at either the input or output ends only..

Note that as both the **plot window width** and **measurement resolution** are increased, the **time to capture a frame of data also increases**.

There is also a limit on the **pulse scan rate** when long pulse widths are set on the **TDR200** unit, as high pulse repetition rates can result in potentially damaging power dissipation in the internal electronic circuitry. Consequently, when the **TDR200 pulse width switch** is set to the highest pulse width setting, the maximum **pulse scan rate** is restricted to **250 Hz**. If attempts are made to set a higher pulse rate, this is detected by the software and a value of **250Hz** is set automatically in the **Control Window**.

If attempts are made to exceed the permitted combinations of pulse width, measurement resolution and/or pulse rate, a number of **warning windows** are displayed.

## 4.3 CONTROL BUTTON DETAILS

The functions of the various buttons in the **Control window** are as follows:

**Enter**: Used to confirm the data defined in the **Control Window** before running the program.

**Quit**: Used to quit the program before the **Run** button is clicked. The **Quit** button is inoperative once the **Run** button has been selected. Use the **Exit** button to quit the program after it has been run.

**Run:** Used to run the program after the control data has been confirmed by use of the **Enter** button.

Both the **Enter** and **Run** buttons become inoperative after the **Run** button is clicked for the first time. Use the **Update** and **Continue** buttons instead to modify any of the control parameters after stopping or pausing the scanning (see below).

**Stop**: Used to Stop the program to allow the control data to be changed.

**Update**: Used to confirm the modified control data.

**Continue**: Used to restart the program after updating the control data. Note that when the **Stop Scan**/**Continue** buttons are used, the frame count is reset to 1 when the **Continue** button is clicked.

To stop the scanning while retaining the frame count, use the **Pause**/**Resume** buttons in the **Plot window** instead of the **Stop Scan**/**Continue** buttons in the **Control window** (see section 5).

**Exit:** Used to exit the program after the **Stop button** has been clicked.

When the **Exit button** is clicked, a number of files are generated as detailed in section 6 and Appendix 2.

**New ini file:** This is used to load a new control parameter data file and its operation is described in detail in section 4.4.

**New Data file**: Used to select a **new data file** to be viewed in **persistence mode** without erasing the previous data (off-line mode only).

**Default files:** Used to set the file names to default names based on the Rotor ID.

**Select File buttons**: Used to select **control parameter**, **output** or **input** data files for previously saved specific measurement configuration or data. See section 4.4 for more information.

**Locate button**: This runs a macro-program which calculates the fault location from a set of RSO measurements as described in section 10.

## 4.4 LOADING A NEW SET OF CONTROL PARAMETERS

If the **control parameters** which are loaded on opening the program are not correct for the rotor to be tested, they can either be editted manually or changed by reading the correct data from a custom **control parameter file** (assuming one has been saved on a previous occasion).

A new **control parameter file** for a different rotor can be loaded as follows:

Use the **Select file 1** button to browse for the the required **control parameter file**. This file will be in the **Data files** folder.

Open the **TDRPlot\Data files** folder and select the required **control parameter file**, which will have the form: **Name-ini.txt**.

Then click on the **New ini file** button. This will read the contents of the selected file to the **text boxes** in the **control window**.

If the output file names do not follow the file-naming rules, click on the **Default files** button to set the output data files to the default names for this new Rotor.

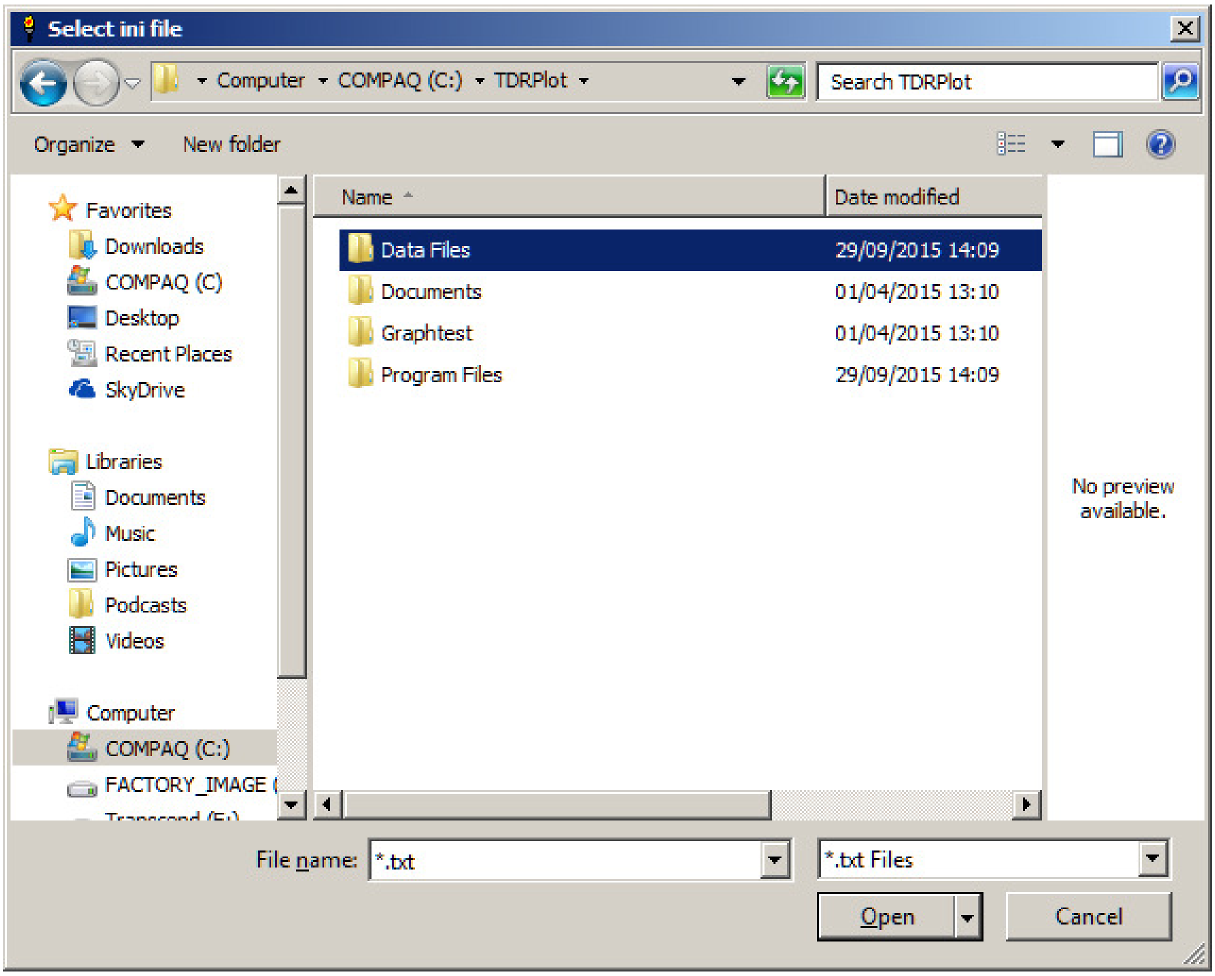



**Figure 4.4.1 Selecting a new control parameter (ini) file**

## 5. THE PLOT WINDOW

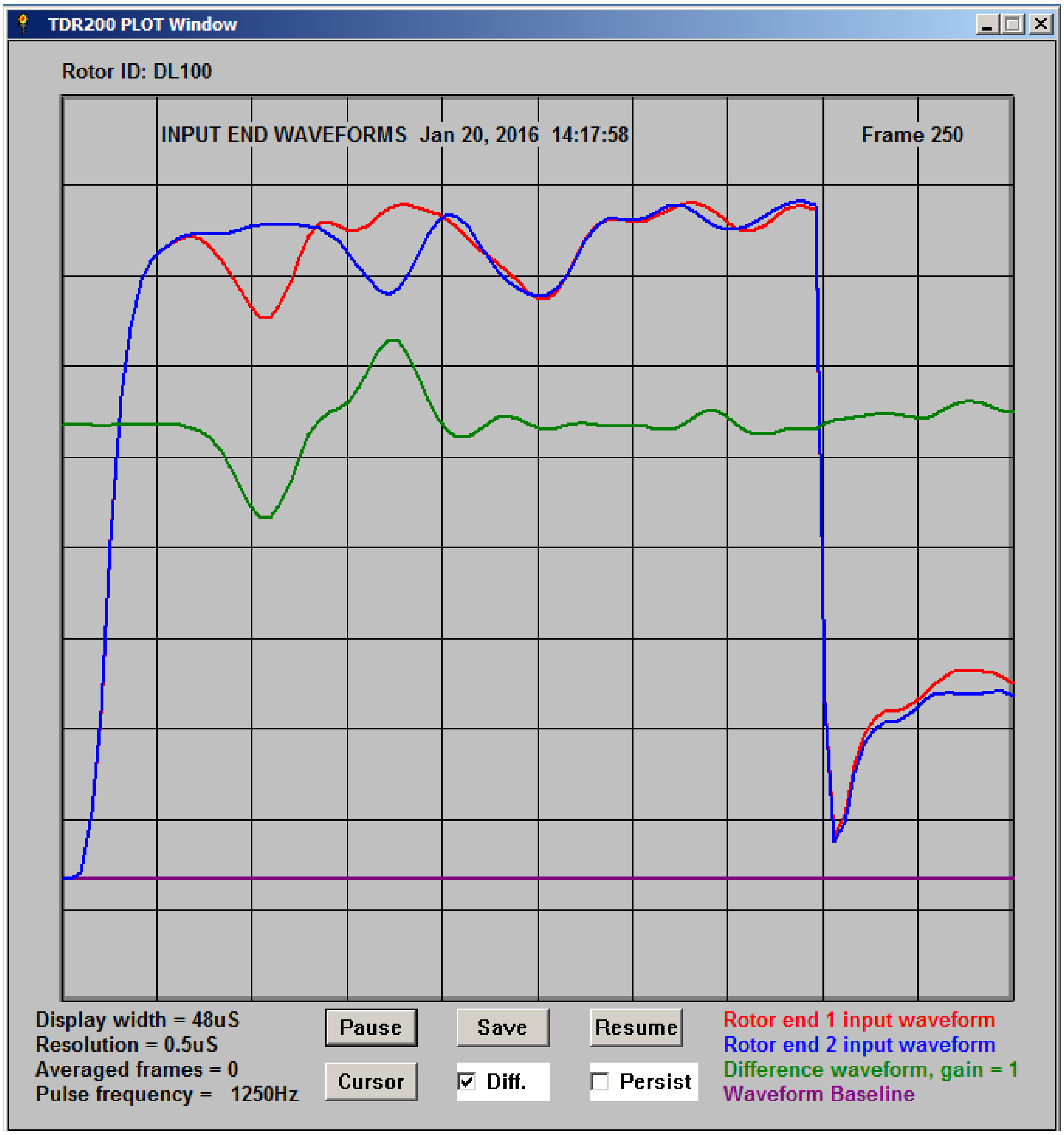



**Figure 5.1 The Plot window for the test delay line with simulated shorted coil**

### 5.1 DISPLAY DETAILS

The **Plot window** displays the **rotor waveforms** at either the **input** or **output** or **both ends** of the **rotor winding** depending on the option set in the **Measurement Channel selection box** in the **Control window**. Figure 5.1 shows the waveforms at the **input ends** of the demonstration **delay line** containing a simulated inter-coil fault. The waveform for end 1 is shown in **Red,** the waveform for end 2 is shown in **Blue**, and the difference between these 2 waveforms is shown in **Green.** The waveform baseline is shown in **Purple**.

The **width** of the **Plot window** (**Plot width**) is set in the **Control window** and is shown at the bottom left hand corner of the window. However, the actual width of the **applied pulse** is still set by the pair of front panel controls on the **TDR200 Reflectometer**. Other parameters displayed in this part of the window are the **horizontal resolution**, **number of frames averaged** and the **pulse frequency**.

## 5.3 CONTROL BUTTONS

The functions of the **Control buttons** in the **Plot window** are as follows:

**Pause button**: Stops the scanning and allows use of the remaining control buttons and the mouse pointer for cursor generation (see below).

**Save button**:

When this button is clicked, the **current waveform image frame** is saved as a bitmap file in the **Data Files** subfolder, with a filename of the form **customout-frame number.bmp.** Any number of frames can be saved to individual file names using the **Save button**. A similar text file of data is also generated.

Note that when the **Save** button is pressed in **on-line** mode, both **bit-map** and **data text files** are generated.

However, in **off-line mode**, only **a bit-map image file** is saved, but with a modified file name to indicate that it has been generated from **file input data**.

**Resume button**:

Clicking on this button erases the current **Plot window** and resumes scanning and plotting the next frame number. (Note that the use of the **Pause**/**Resume** buttons to stop the scanning retains the **frame count,** whereas the use of the **StopScan**/**Continue** buttons in the **Control Window** resets the frame count to zero.)

**Cursor button**:

After this button has been clicked, a **vertical white cursor line** appears at the **horizontal location** of each point on the screen at which the mouse is subsequently clicked and the corresponding **time from the start of the pulse** is displayed in the **waveform plot area**. A new cursor line is displayed for each mouse click, but the time displayed corresponds to the last mouse click only.

When the **input end waveforms only** are displayed, the cursor text also shows the **percentage difference** between the **end 1 (red )** and **end 2 (blue)** waveforms.

Note that the use of the **Cursor** button is optional as clicking on the **Pause** or **Stop** buttons automatically enables the **mouse cursor** function.

**Diff Check box**:

If checked, this displays a trace which plots the difference between the 2 input or output end waveforms. This box is ticked by default at program initialisation.

**Persist check box:**

If checked, the display area is not cleared between successive data frames. This allows successive data frames to be compared. The following plot shows the effect of adjusting the terminating impedance R2 when persistence mode is enabled.

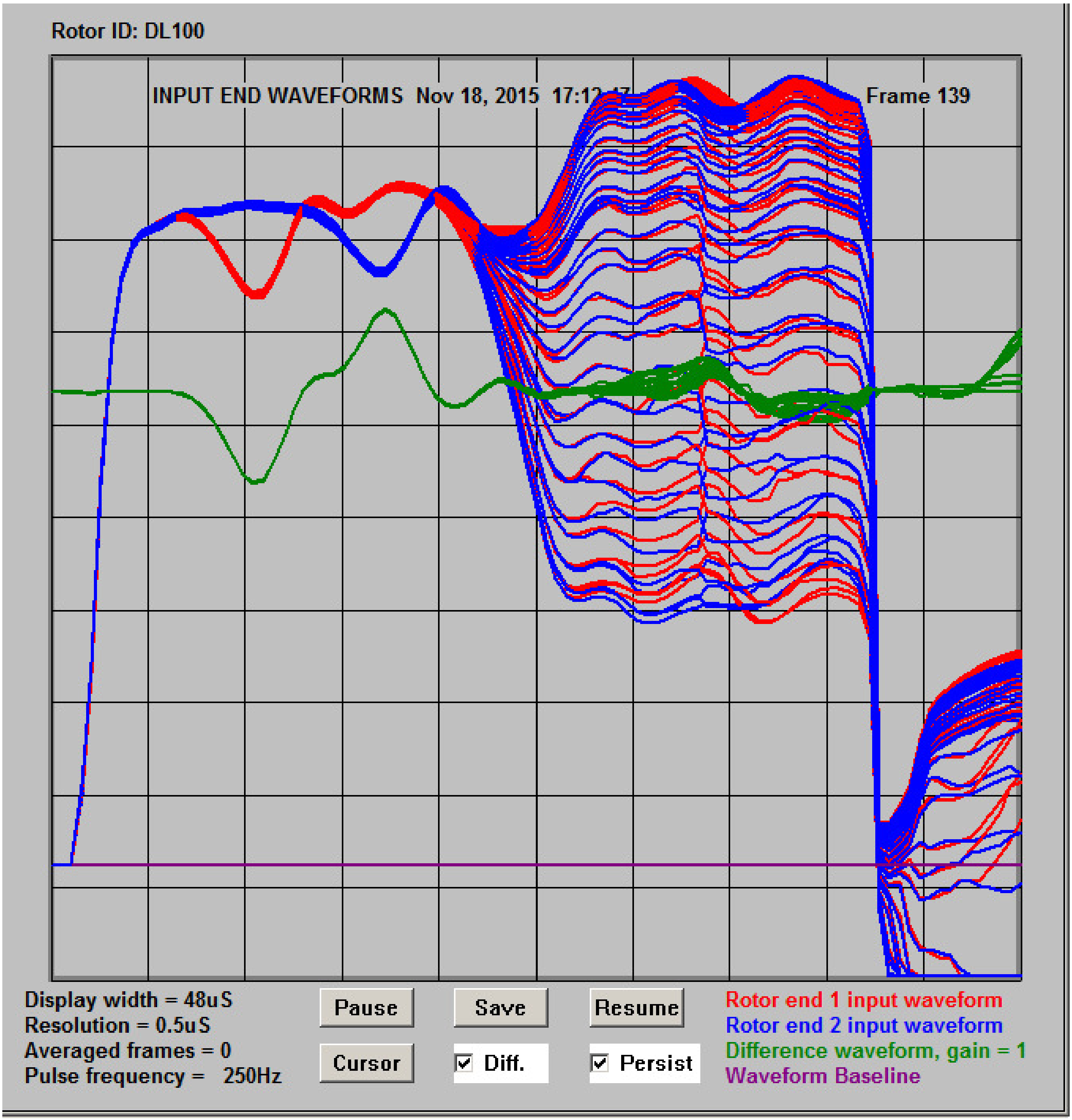



**Figure 5.3.1. Use of persistence mode**

**Persistence mode** can be useful for measuring the **double-pass transit time** of the rotor winding. It can be used in both **on-line** and **off-line** modes and can therefore be used to compare historical date files.

## 6. THE OUTPUT FILE DETAILS WINDOW

### 6.1 FILES GENERATED FOLLOWING USE OF EXIT BUTTON

When the **Exit button** is clicked, a number of files are generated and are summarised in the **Output File Details** window.

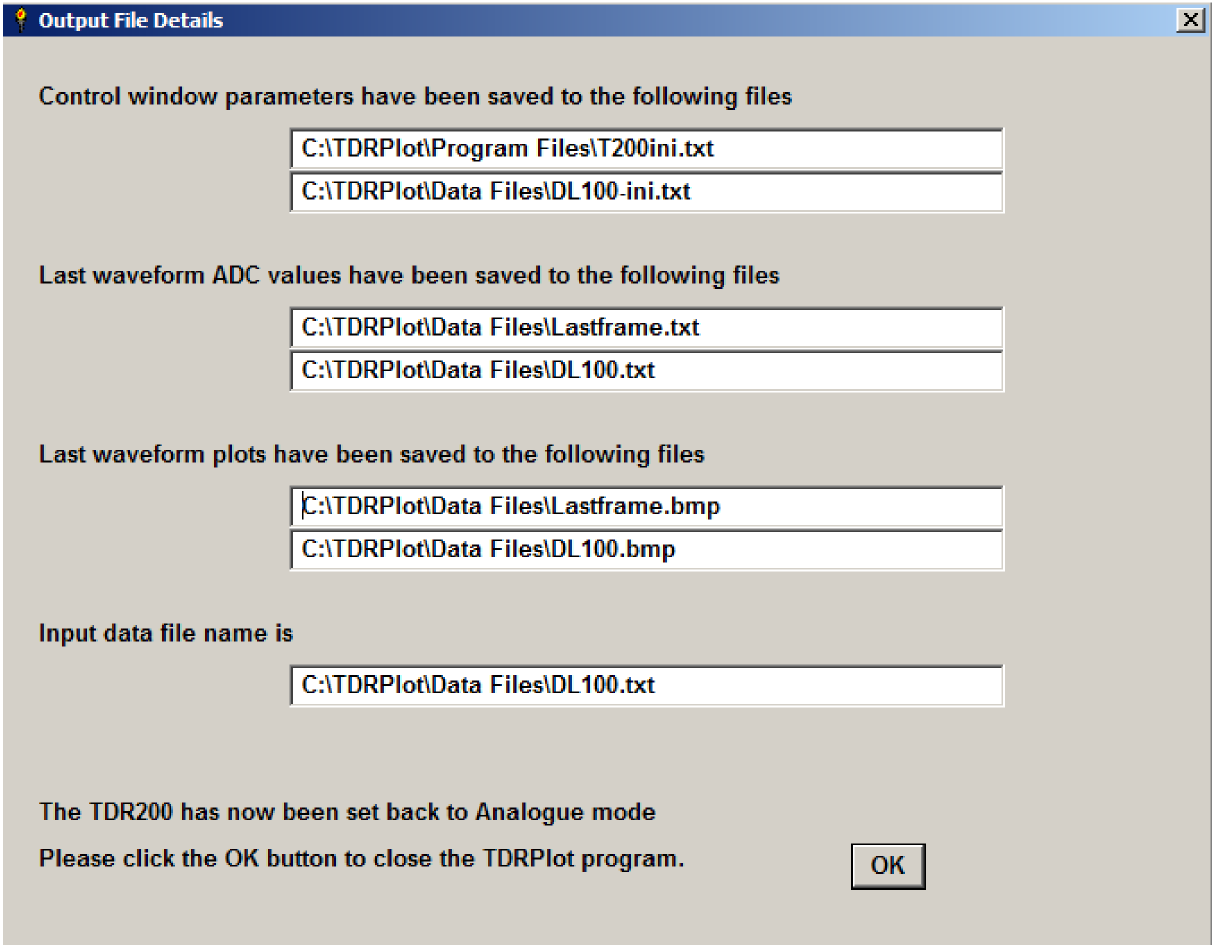



**Figure 6.1 The Output File Details window.**

The **Output File Details window** lists the full names of the files which contain the **last frame of data** before the **Exit button** was clicked.

By default, this data is always saved to the filenames **Lastdata.txt** (as a set of integer ADC readings) and **Lastframe.bmp** (as an image bitmap file).

In addition, the same data is saved to **Custom file names** if these have been defined in the **Control window**.

The **output data files** are saved by default to the the **Data Files subfolder** when the **OK button** is clicked to exit the program. These files should be copied to individual folders elsewhere on the PC immediately after data capture for security and for possible use in other software. Further details are given in sections 6.2 - 5.

## 6.2 FILE NAME DETAILS

When the **TDRPlot** program is terminated in **On-line** mode using the **Exit button**, the **control window parameters** and the **last frame of data** are saved to 3 **default** data files and also to 3 **custom** data files.

The **default** file names are:

**T200ini.txt** which contains the set of **control window parameters** on exit.
**Lastframe.txt** which contains the set of **ADC readings for the last frame of data**.
**Lastframe.bmp** which contains a **bitmap image of the last plot window**.

The **custom** file names, which contain similar data are:

**RotorID$-ini.txt**
**RotorID$.txt**
**RotorID$.bmp**

where **RotorID**$ is the rotor ID (name) as specified in the top text box of the Control window.

Note that the **T200ini.txt** file is saved to the **Program files** folder **C:\TDRPlot\Program files,** whereas all of the other files are saved to the **Data files** folder **C:\TDRPlot\Data files**. Detailed information about data file formats with examples is given in Appendix 1.

## 6.3 SETTING THE CUSTOM FILE NAMES

The **custom data file names** are specified in the **3 file name** boxes in the **Control window**.

Standard file names derived from the **Rotor ID name** can be generated autoatically by clicking on the **Default files** button.

## 6.4 SETTING NON-DEFAULT FILE NAMES

Although it is possible to set different output file names by using the Select file 2 button (for example to identify different tests of the same rotor) it is preferable to edit the rotor file name instead (eg RotorID-1, RotorID-2) to identify the results for different tests conditions.

## 6. 5 FILES GENERATED FOLLOWING USE OF SAVE BUTTON

When data capture is paused and the **Save** button is clicked in the Plot window, the **current waveform image frame** is saved as bitmap and text files in the **Data Files** subfolder, with filenames of the form **customout-frame number.bmp/txt.** Any number of frames can be saved to individual file names using the **Save button.**

Note that in **off-line mode**, only **a bit-map image file** is saved, but with a modified file name to indicate that it has been generated from **file input data**.

## 7. USING THE REFLECTOMETER IN ON-LINE MODE

### 7.1 SETTING UP THE EQUIPMENT

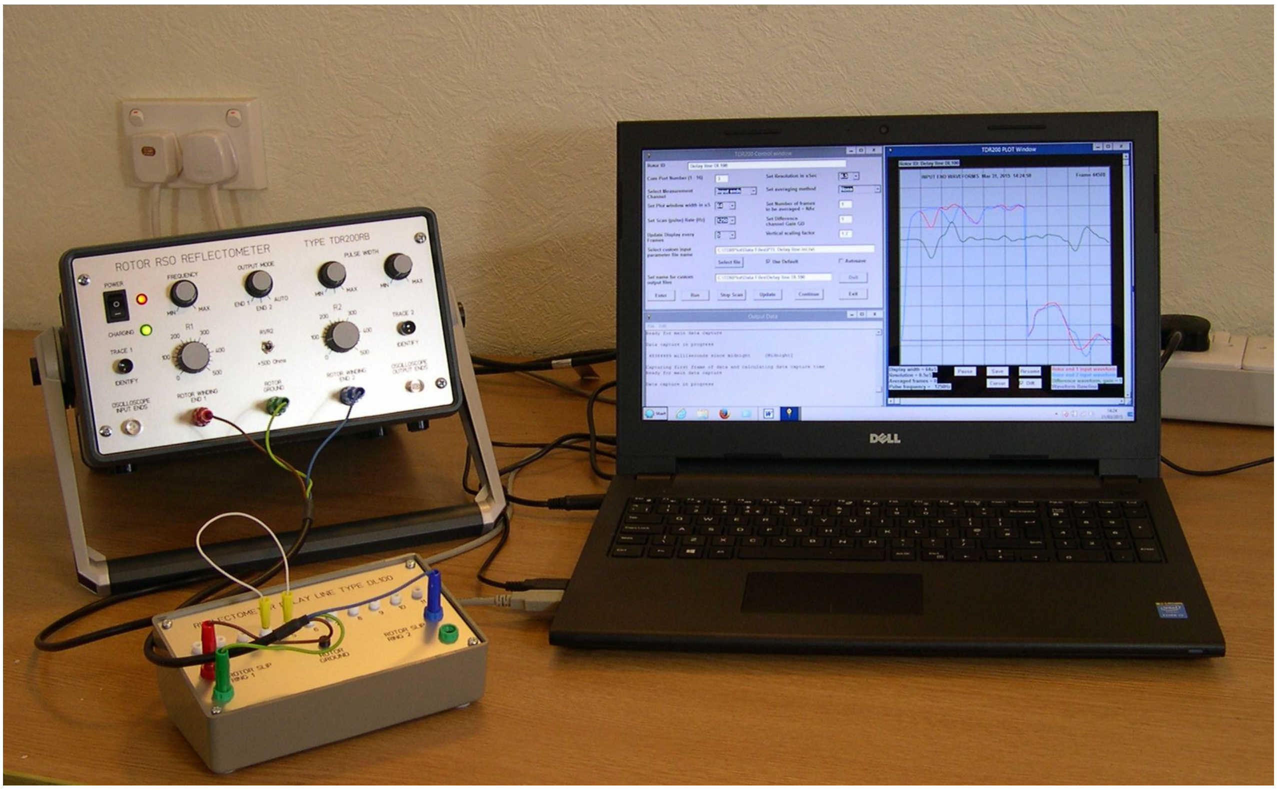



**Figure 7.1.1 TDR200 system with DL100 delay line**

Connect the rotor winding to the **TDR200** unit as described in Section 2 of the **TDR100 Instruction Manual.** Note that an oscilloscope is not required, although if one is available, it can be useful to check the waveforms displayed on the PC.

If this is being done for the first time, we suggest that the supplied **DL100 delay line** is used instead of an actual rotor winding to gain familiarity with the **TDRPlot software,** as shown in figure 7.1.1 above.

In this case, use the **short delay line lead** to connect the delay line to the **TDR200** unit as shown above.

In general, the connection diagram shown in figure 7.1.2 should be used for actual rotor windings. In this case, **the long connection lead and connection module** should be used. Full details are given in the **TDR100 Instruction Manual.**

Connect the **Reflectometer** to the **PC** via the **USB cable** and switch it on. Note that the **USB connector** (printer-type) is on the rear panel of the **TDR200 unit.**

Boot up the PC and run the **TDRPlot** software by clicking on the **TDRPlot Desktop icon**.

The program will run and the **TDRPlot screen** will open as shown in figure 7.1.3.

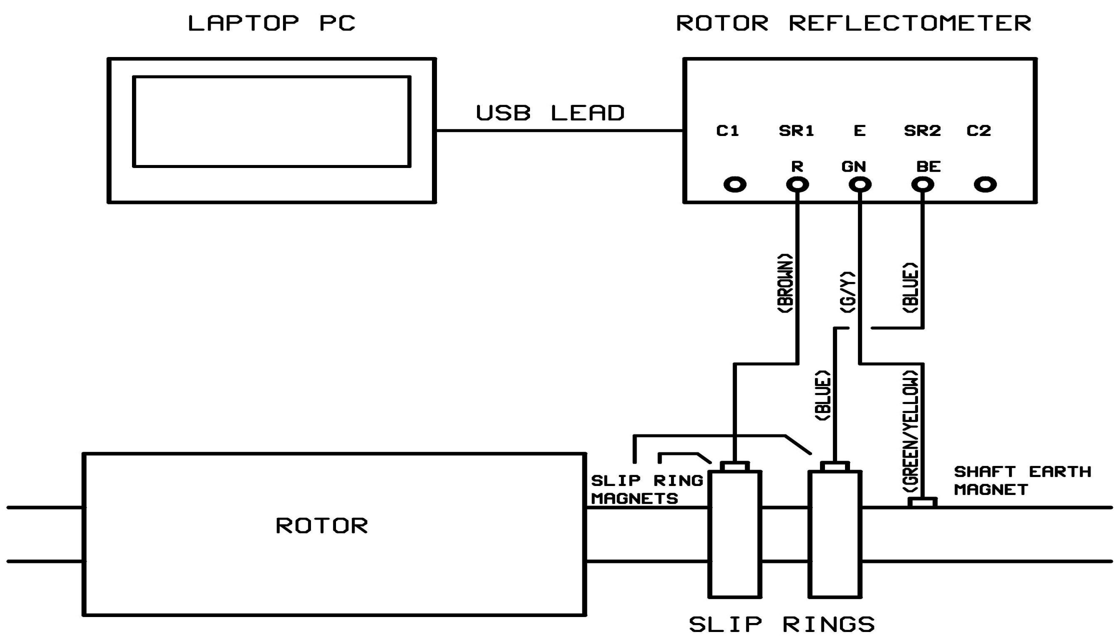



**Figure 7.1.2 Connection diagram for PC control mode**

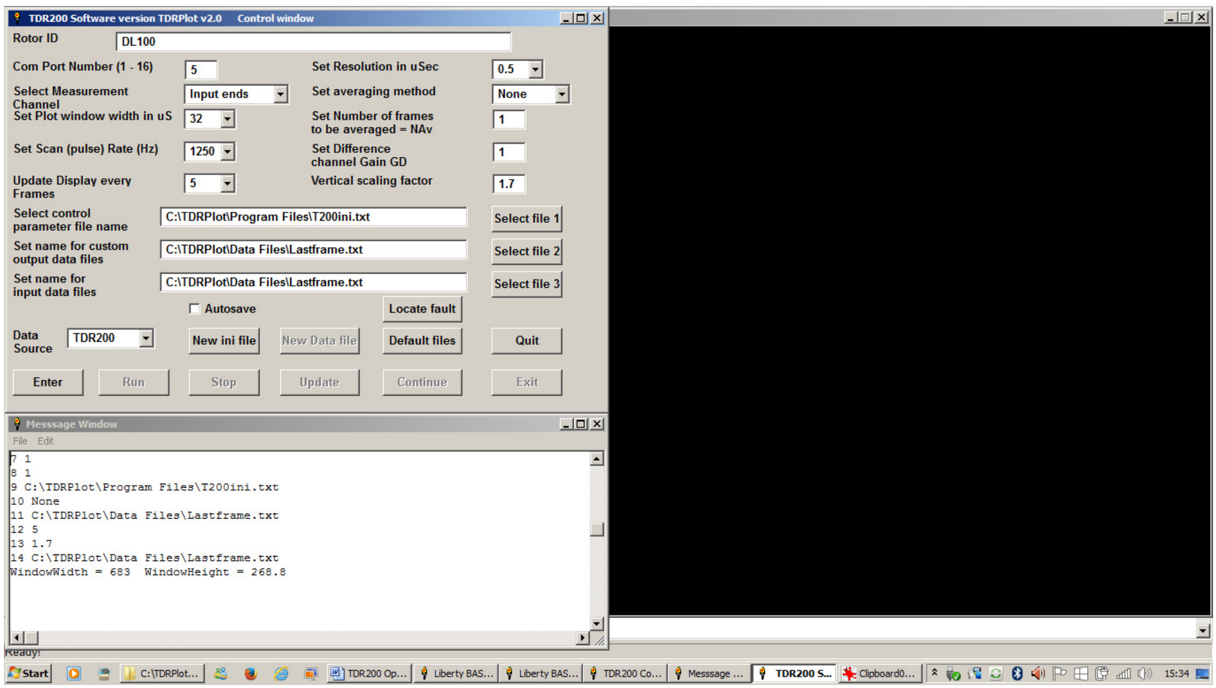



**Figure 7.1.3 Initial TDRPlot screen**

The **TDRPlot screen** contains 3 windows:

1. A **Control Window** (upper left region of screen).
2. An **Output text window** (below the Control Window).
3. A **Plot window** at the Right Hand Side (RHS) of screen, which is blank at start-up.

When the **TDRPlot** program is run, a **Control window** appears as shown in **Figure 3.4.1** below. This window contains the **control parameters** which must be set before the program is run. The program retains the last-used control parameters by default in the **T200ini.txt** file and also in an optional **custom ini** file if one has been defined by the used. The **Control window** at start-up should ressemble that shown below, although some of the parameters may differ from those shown.

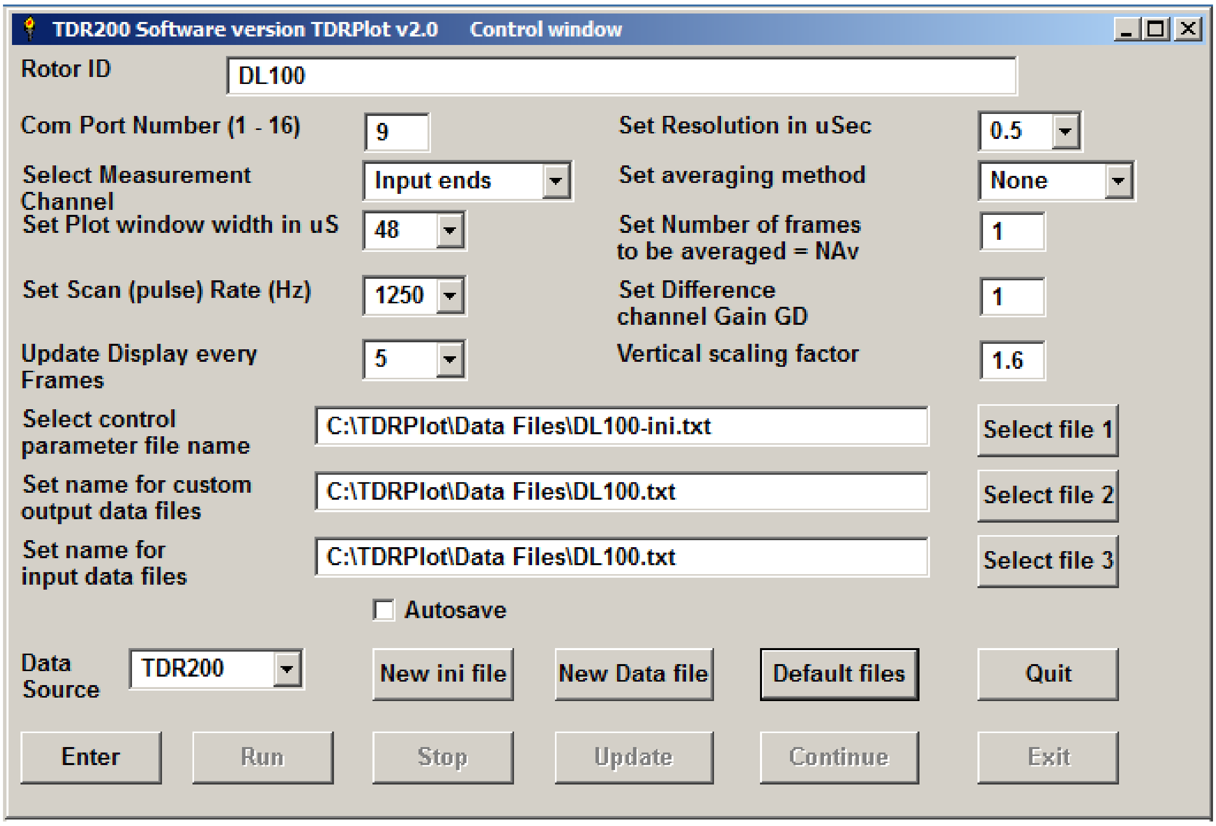



**Figure 7.1.4 Initial Control Window**

## 7.2 MEASURING THE ROTOR SINGLE-PASS TRANSIT TIME

The first task is to measure the approximate time it takes for the input pulse to travel from one end of the rotor winding to the other. This information is needed in order to set up the correct control parameters for the software.

It may help to connect an **analogue oscilloscope** to the Reflectometer if you are using the **TDRPlot** software for the first time.

### 7.2.1 SETTING UP THE TDR200 FRONT PANEL CONTROLS

Adjust the front panel controls on the **TDR200** unit as follows:

**Frequency**: Max clockwise

**R1 and R2 controls**: Set to 100 Ohms

**Pulse width switch**: middle position

**Output mode switch:** Auto

**Pulse width control**: Fully counterclockwise (minimum)

### 7.2.2 INITIALISING THE PARAMETERS IN THE CONTROL WINDOW

Set the parameters in the **TDRPlot Control Window** as follows:

**Rotor ID**: Enter a text description for the rotor under test (Max 64 characters)

**Com Port Number**: The number of the PC com port in use (see **Appendix 4**).

**Select Measurement Channel**: Output ends

**Set Plot window width:** 160uS

**Set scan Rate Hz** 1250

**Update Display:** 5 frames

**Set resolution :** 0.5uS

**Set averaging method:** None

**Set number of frames to be averaged (Nav)**: 1

**Set difference channel gain (GD)**: 1

**Set Vertical Scaling factor =** 1.6 (or adjust to suit window height)

**Data Source: TDR200** (default)

Check that the control parameters have been input correctly in the **Control Window** and then click on the **Enter** button. The control parameters will be updated in the **Control window.**

### 7.3 STARTING DATA CAPTURE

Once the correct parameters have been entered in the **Control window**, click on the **ENTER** button. This loads the set parameters into the **TDRPlot** software.

Next click on the **Run** button, which starts the data capture process. The **waveforms at the output ends of the rotor winding** will be displayed in the **Plot window** as shown in figure 7.3.1, which shows the data for the test delay line supplied with the reflectometer.

All of the following example waveforms were obtained using the **DL100 demonstration delay line** which is supplied with each **TDR200** instrument.

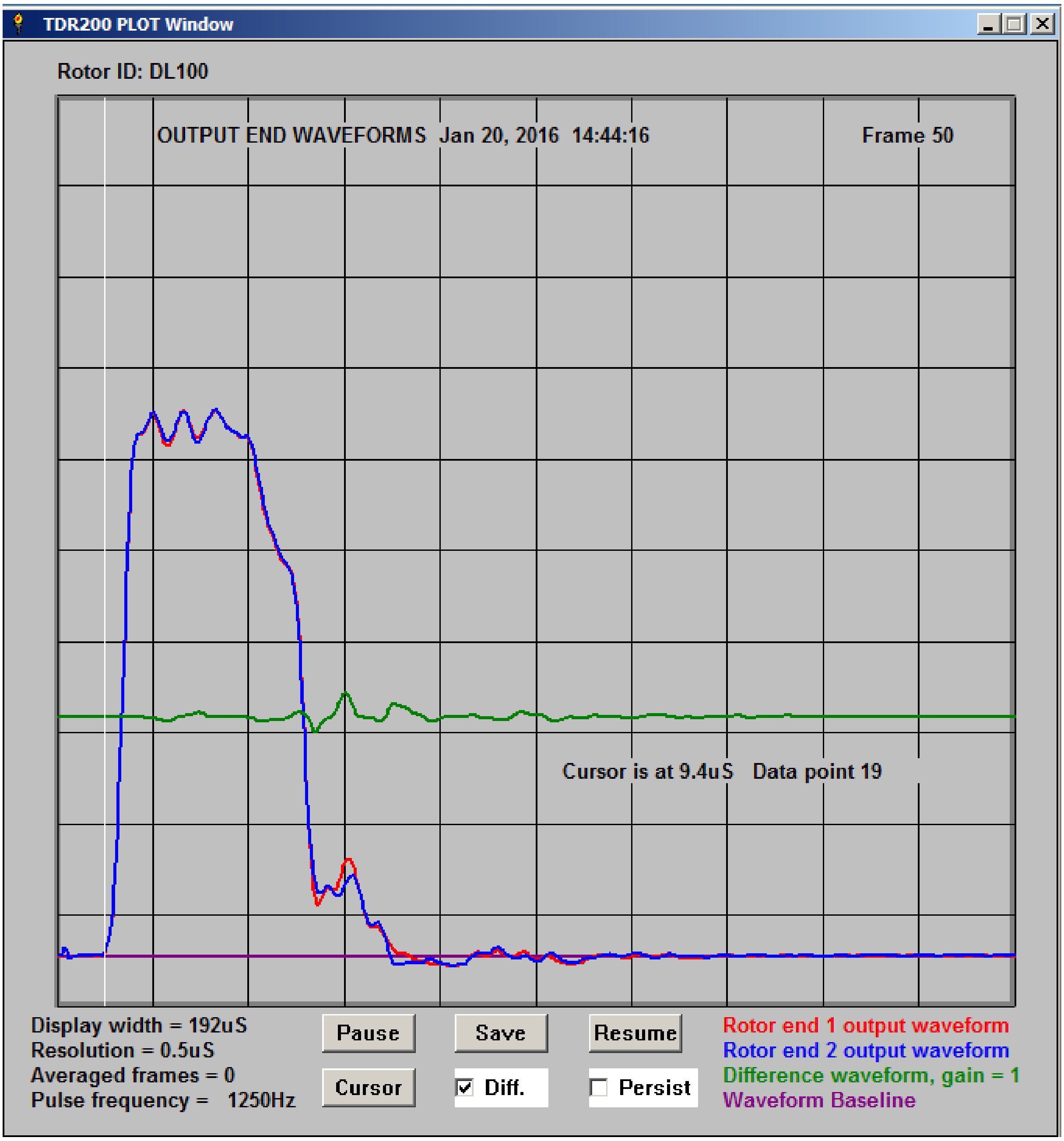



**Figure 7.3.1. Plot window (output ends)**

Adjust the value of **R1** on the **TDR200** unit so that the height of the trace is approximately half the plot window height, then click on the **Pause button** in the **Plot window**, which will stop the scanning. Now click on the **Cursor button** in the **Plot window** and then click the **mouse pointer** at the point near the start of the output waveforms (where the waveform starts to increase). This will generate a white time cursor line as shown in figure 7.3.1.

Note that when the **Cursor** button is pressed following operation of the **Stop** or **Pause** buttons, the **time at the cursor position** is displayed, together with the **percentage difference** between the two rotor waveforms. The percentage difference is calculated relative to the average of the amplitudes of the 2 rotor waveforms.

Note the time displayed for the cursor (9.4uS). This is the time in microseconds for the pulse to pass through the rotor winding from one end to the other. This is known as the **single-pass transit time (t1)**.

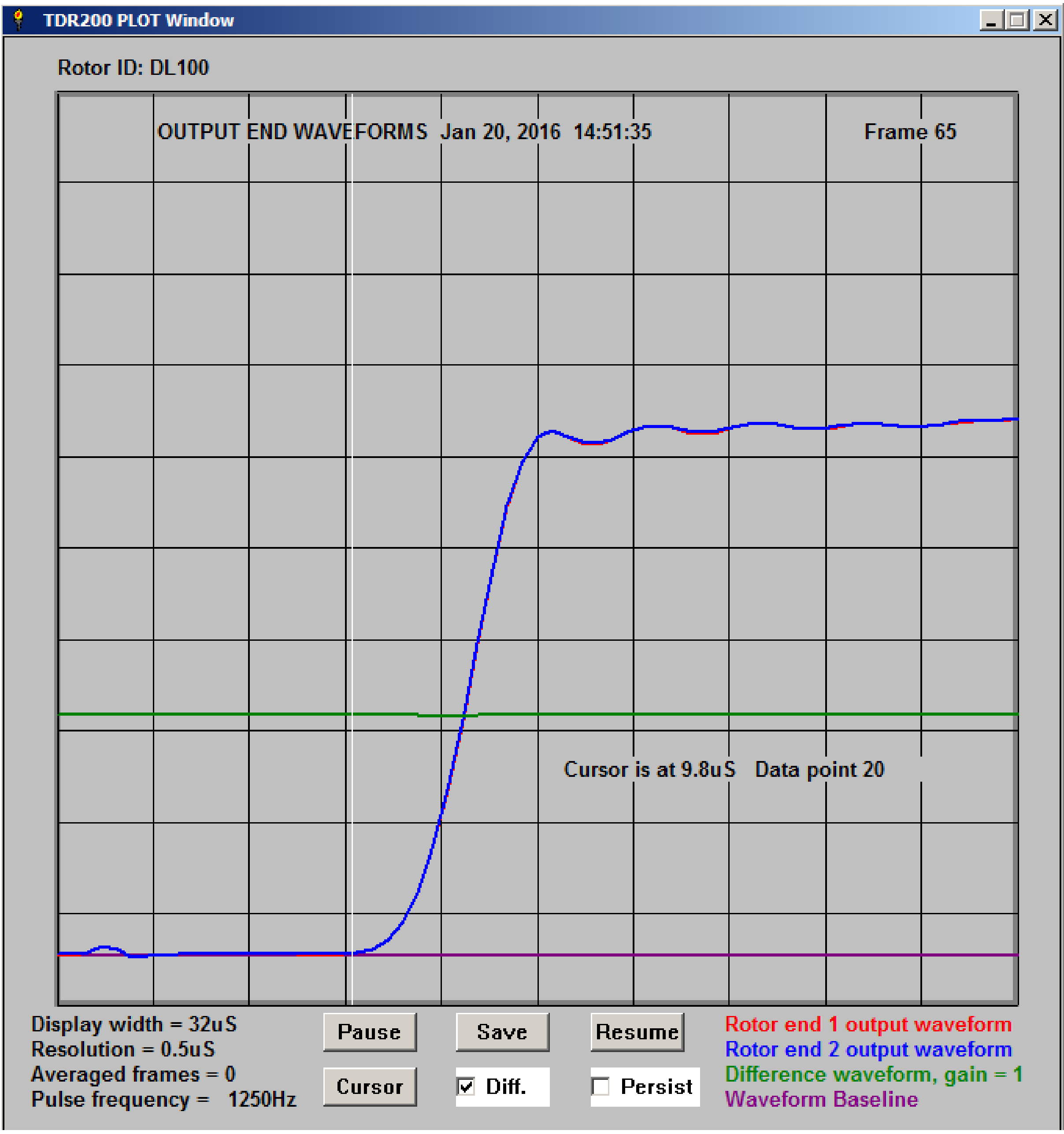
### 7.4 OPTIMISING THE CONTROL PARAMETERS.

Now that the **single-pass transit time t1** is known, the **Control parameters** can be optimised.

The **Plot width** should be adjusted to have a value around **2.5 x t1**. This is done as follows:

Click on the **Pause** button to stop the scanning and modify the **Plot width** parameter in the **Control window** to give a **Plot window width** around **2.5 x t1**. Note that the **Plot window width** is always a **multiple of 16uS**, so choose a value for the **Plot width** parameter closest to the desired value.

Click on the **Update** button to set the new **plot width** value and then click the **Continue** button. An updated plot window for the **output end** waveforms will be displayed as shown in figure 7.4.1 below:




**7.4.1 Optimised Plot window (output ends)**

Click on the **Cursor button** and then use the mouse to obtain a more accurate estimate of **t1 (9.5uS)**.

Now click again on the **Pause button** and set the **Measurement channel** box in the **Control window** to display the **input end** waveforms. It may also be helpful to increase the Plot window width by one or more 16uS increments.

Click the **Update** button in the **Control window** and then the **Continue** button to display the **input end** waveforms as shown in figure 7.4.2.

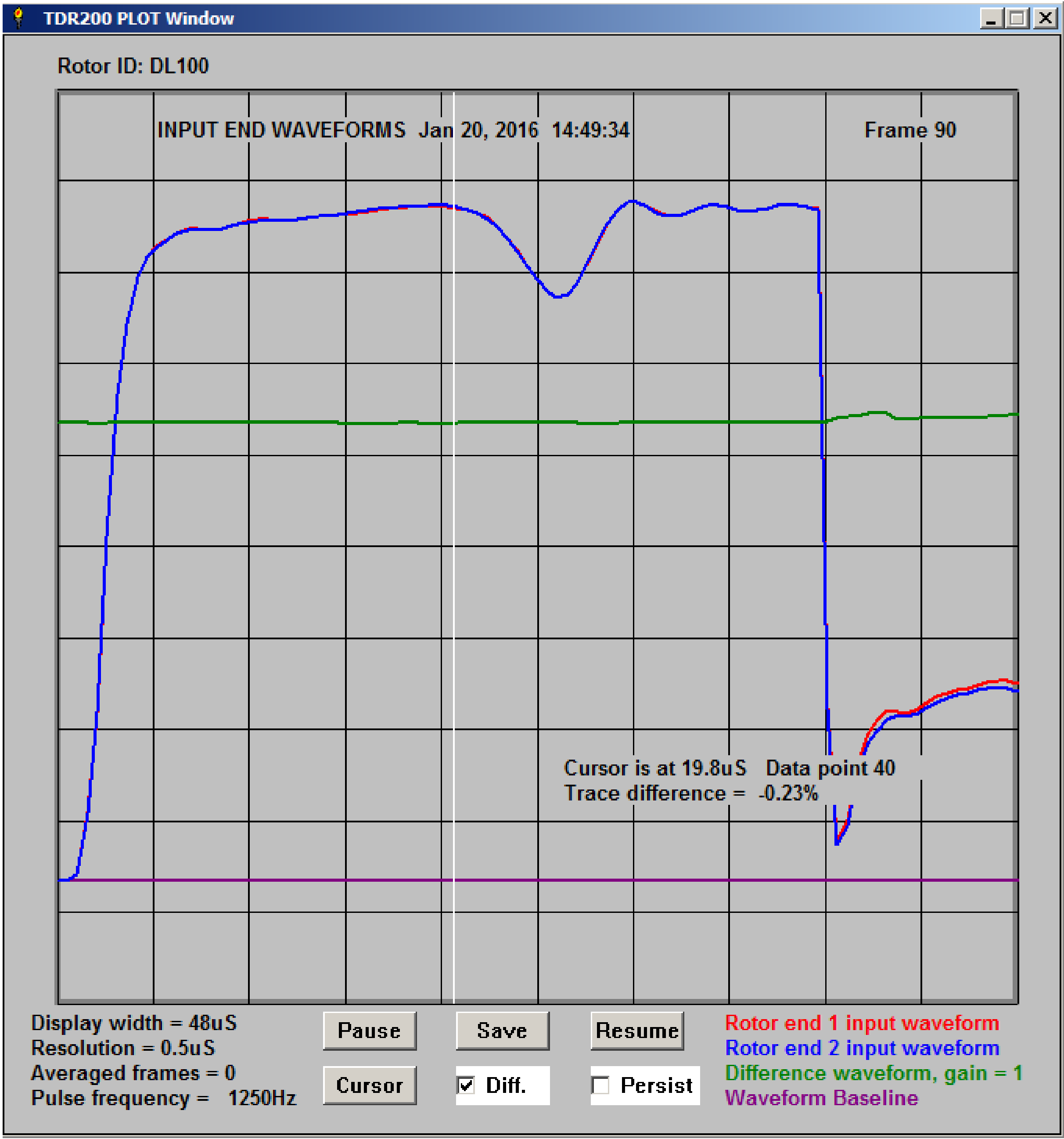



**Figure 7.4.2 Optimised input end waveforms**

Now adjust the value of **R2** on the **TDR200** unit to minimise the reflection from the ends of the rotor windings. The values of **R1** and **R2** set on the **TDR200 unit** should now be approximately equal. (around **100 Ohms** for the **DL100 delay line**).

By deliberately mis-matching the o**utput end terminating impedance control (R2)** on the **TDR200** unit, it is now possible to see where the reflections from the winding ends start and to measure this time using the **Cursor** facility. An example of the use of persistence mode has been given already in figure 5.3.1.

The final step is to check the effects of changes in the the **scan pulse rate,** as setting too high a pulse rate can cause changes to the overall shape of the **RSO waveforms**.

**Reduce** the **scan pulse rate** in stages in the **Control window** and check to see if the waveforms change shape. The **highest scan pulse rate** which does not change the overall shape of the measured waveforms should be used for all subsequent measurements.

## 7.5 DEMONSTRATING WINDING FAULTS WITH THE DL100 DELAY LINE

Full details of using the **DL100** delay line are given in section 4 of the **TDR100 Instruction manual.**

Some sample waveforms obtained using the **TDRPlot software** for a simulated inter-coil and earth fault are given in the **Quickstart** section of this manual (section 2. 7).

## 7.6 INTERPRETING THE WAVEFORMS

Detailed information about how to interpret the **RSO waveforms** is given in the **TDR100/200 Instruction Manual**, including the use of the demonstration delay line to show the effects of simulated winding faults.

A normal fault-free rotor winding is characterised by 2 identical waveforms at each end of the rotor winding (red and blue waveforms) with a horizontal straight line (green) difference waveform, as shown in figure 7.4.2.

## 7.7 TESTING A ROTOR AT SPEED

The RSO test can also be used to check a rotor winding while the rotor is rotating. This requires the use of insulated brushes and full details are given in section 2.4 of the **TDR100/200 Instruction Manual**. The following paragraphs and figures give further information about this when using the **TDR200** unit in **digital mode**.

The main problems which may be experienced with the rotor at speed are caused by **poor brush contact with the slip-rings or rotor shaft.** It is always best to try to ensure that good brush contact is made. However, as the following figures show, it may be possible in some cases to obtain good results even with poor brush contact.

### 7.7.1 Test results obtained with rotor at rest.

Figure 7.7.1 shows a set of test results for a fault-free 500MW rotor at rest.

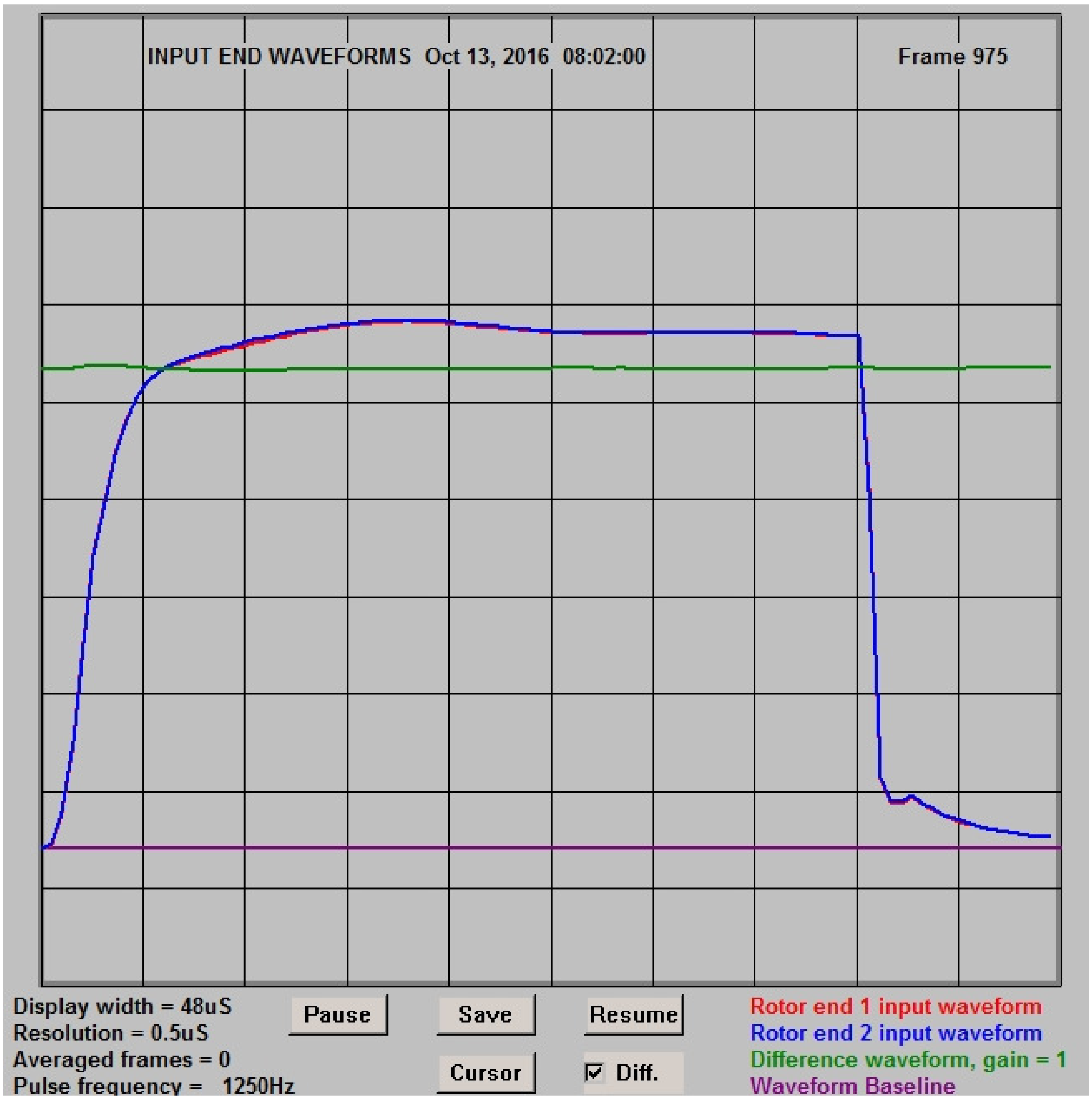



**Figure 7.7.1 fault-free 500MW rotor at rest.**

### 7.7.2 Test results with rotor at 3000 rpm showing effects of poor brush contact

Figure 7.7.2 shows the tests results obtained for the same rotor while rotating at 3000 rpm.

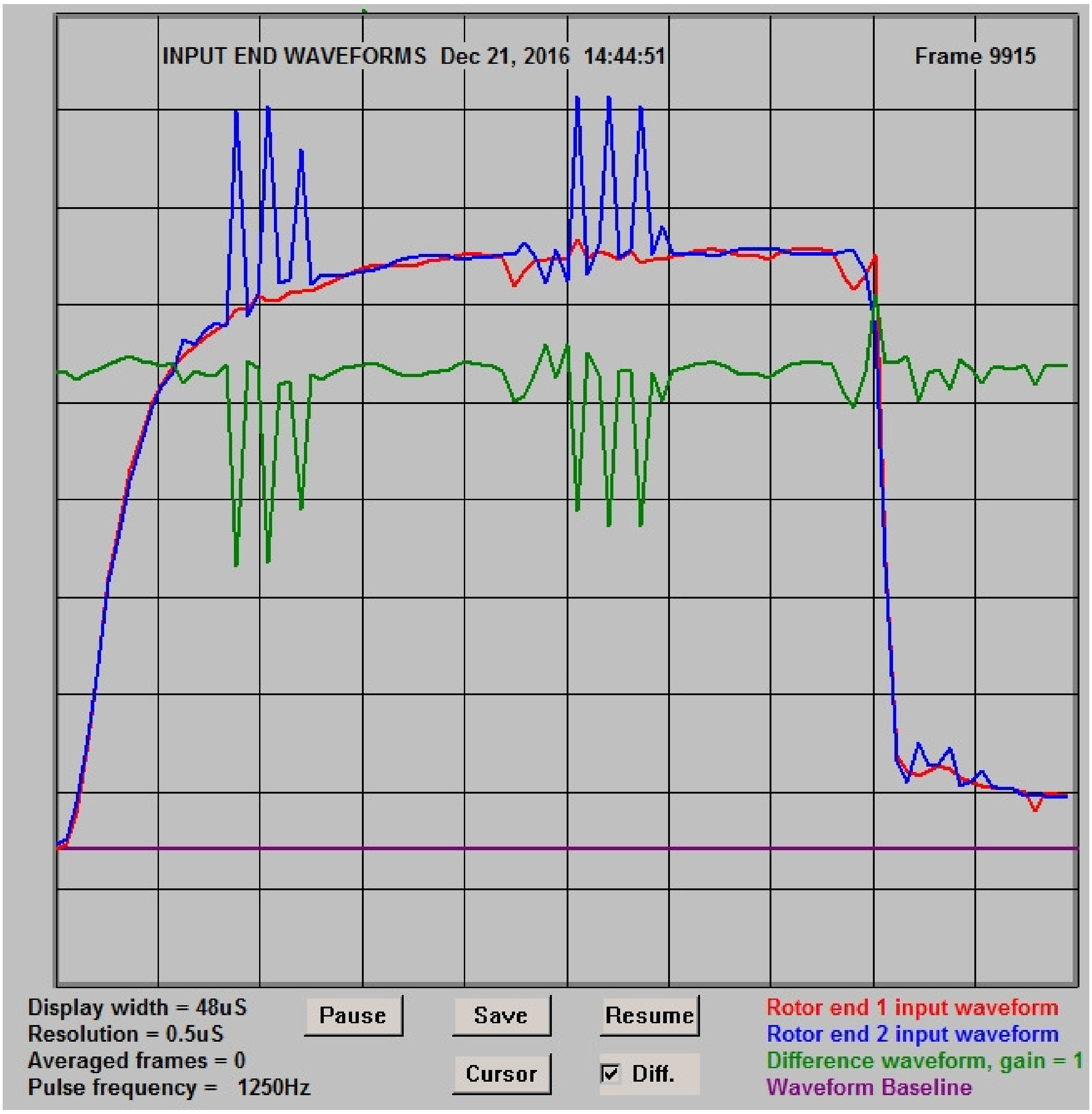



**Figure 7.7.2 Rotor rotating at 3000 rpm.**

While the brush connected to end 1 of the winding (the red trace) is making reasonably good contact with the slip rings, the brush connected to end 2 (the blue trace) is making very poor contact, producing erratic results in the blue and the green (difference) waveforms.

### 7.7.3 Improving the results obtained at 3000 rpm using averaging.

The next figure shows how the test results can be improved by the use of rolling averaging.

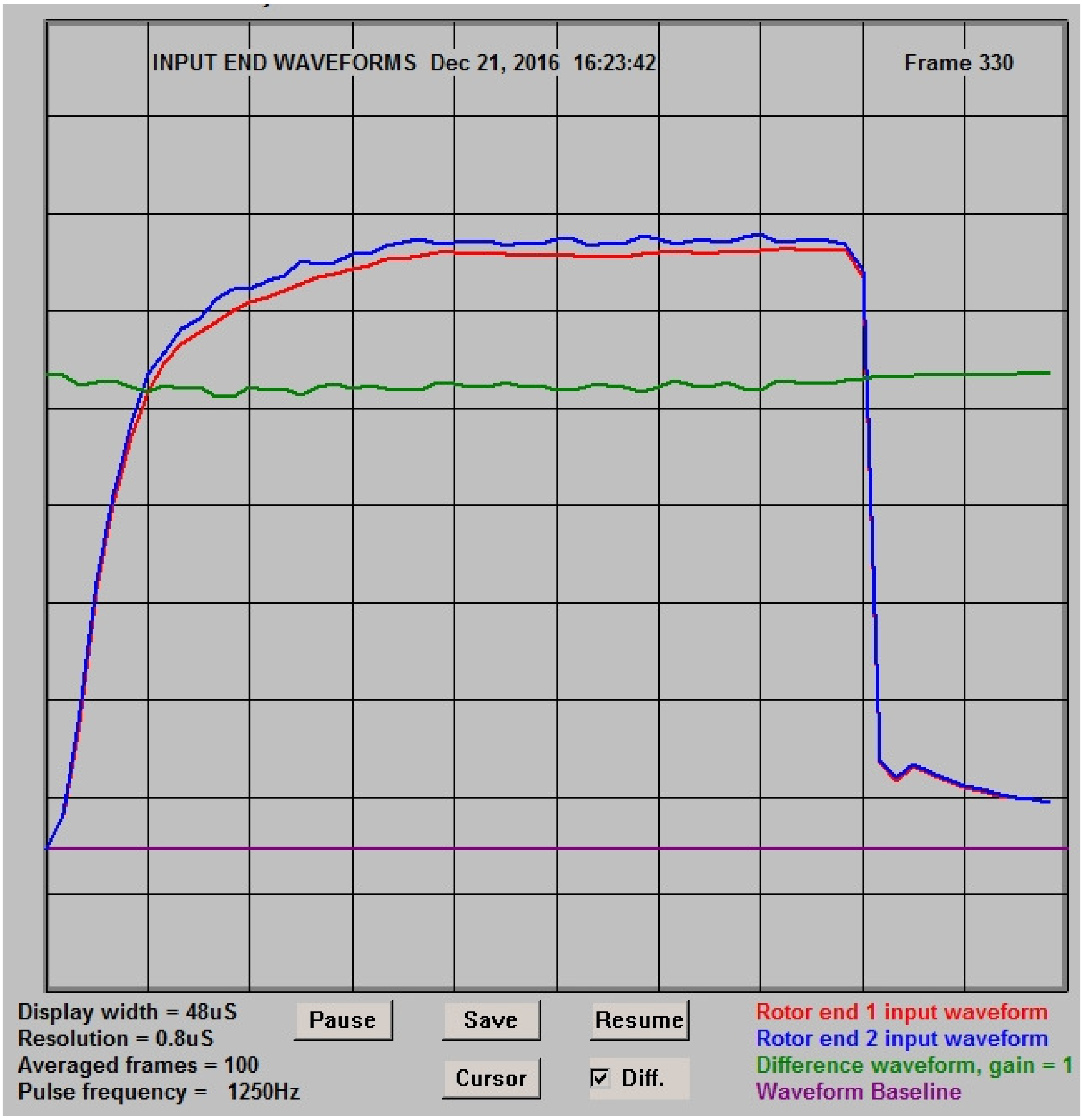



**Figure 7.7.3 Improving the results using averaging.**

Figure 7.7.3 was obtained by setting the **Control window** to average 1**00 frames of data** on a rolling basis. The brush noise on the blue waveform has been almost eliminated and appears instead as a slight vertical displacement of the blue trace, similar to the effects which would be caused by a high-resistance in series with the brush at end 2 of the winding.

### 7.7.4 Results at 3000 rpm obtained with improved brush contact.

Finally, the results shown in figure 7.7.4 show the RSO waveforms at 3000 rpm after new carbon brushes had been fitted to the rotor.

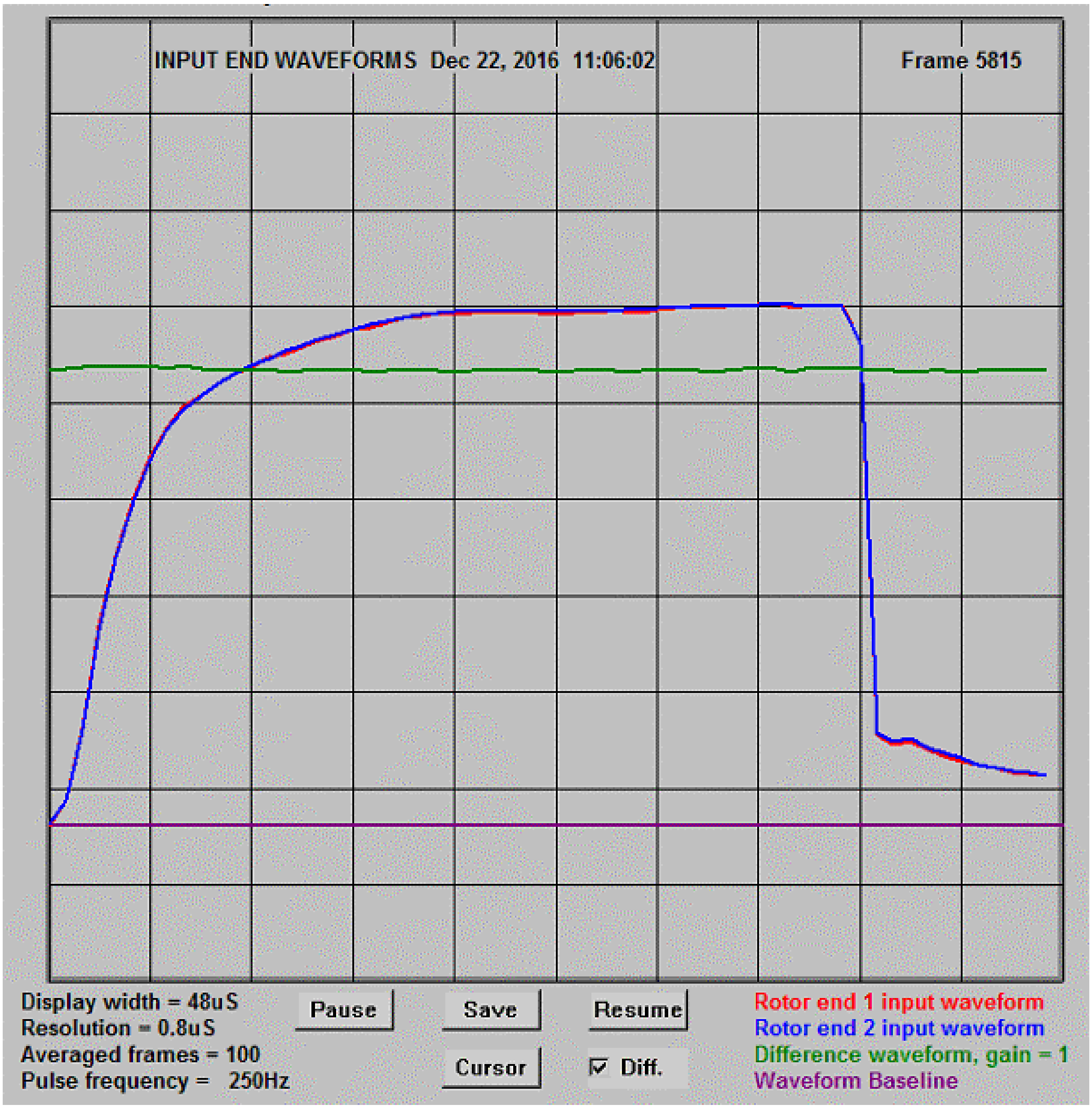



**Figure 7.7.4 Improved brush contact**

These results confirm that good results can be obtained when carrying out the RSO test at speed, as long as good brush contact is maintained with the rotor slip rings.

## 7.8 EXITING THE SOFTWARE

After scanning has started, press the **EXIT** button in the **Control** window to terminate the program.

This operation generates a number of files containing the last frame of ADC data and also a copy of the **Plot window** in bitmap format as described in section 3.5. An **Output File Details window** is also generated as shown in figure 7.6.1.

To exit the software before scanning has started, click on the **QUIT** button in the **Control window**.

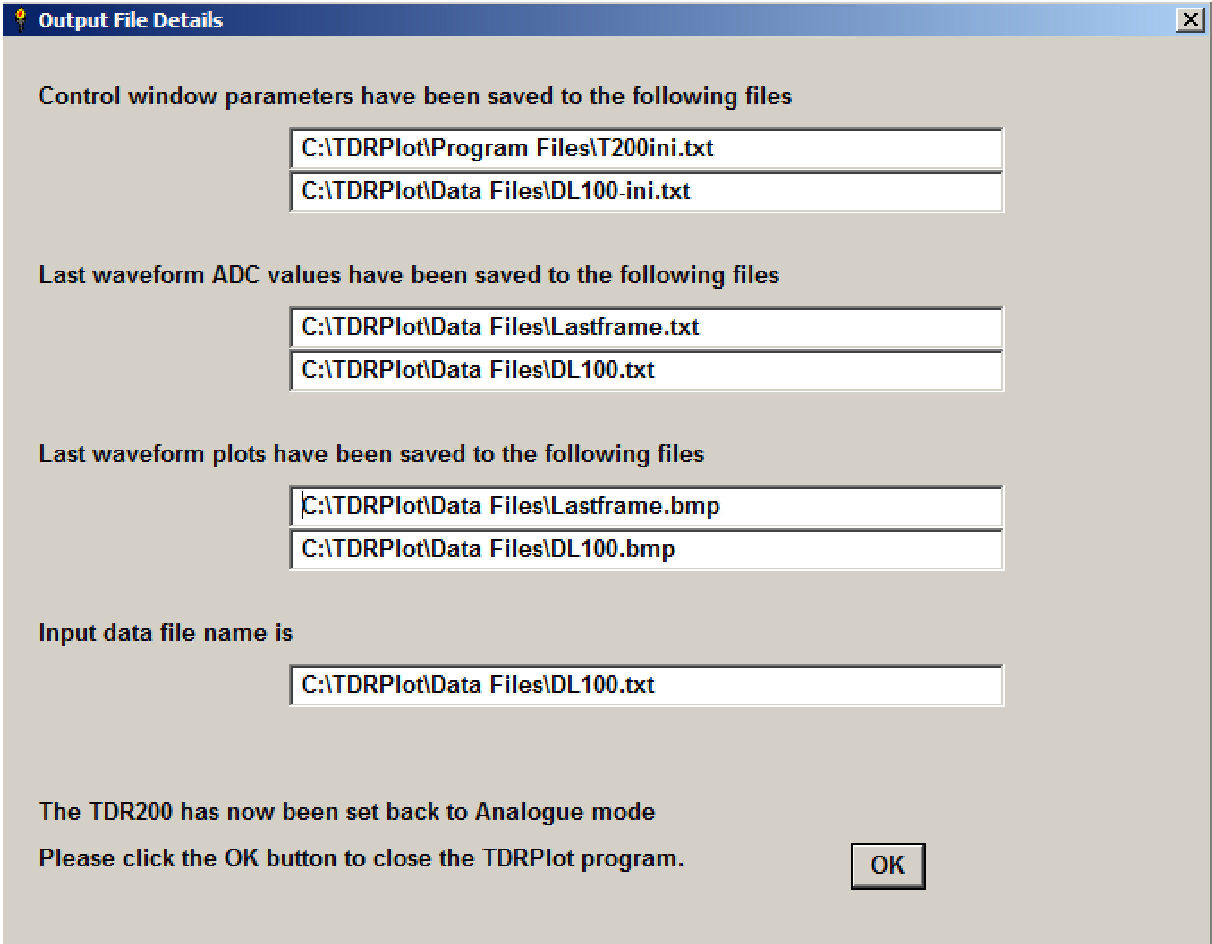



**Figure 7.6.1 Output File Details window**

Note that if the **Both ends** option is selected in the **Control** window on exit, the **waveform (.bmp)** image files will contain the correct image. However the **Data (.txt)** file will contain only the data for the **input end** waveforms.

## 7.9 OUTPUT FILE MANAGEMENT

The **output data files** generated by the **TDRPlot** software will be in the **Data Files** subfolder in the **Default** folder.

Once a test has been completed, we suggest that **a new folder** should be created with a unique name which identifies the rotor under test.

The files in the **Data Files** subfolder should then be moved to this new folder for safe keeping.

## 8. USING THE REFLECTOMETER IN OFF-LINE MODE

In **OFF-LINE** mode, the **TDRPlot** software can be used to display and analyse data from a **previously-captured** data file using the **Select 3** button in the Control window. The data files contain a **header section** containing the control parameters and a **data section** containing the 16 bit ADC values measured for each waveform. The data file formats are explained in detail in Appendix 2.

Off-line mode is selected by setting the **Data sources** box to **File**.

### 8.1 TO LOAD AND VIEW A CAPTURED DATA FILE

Set the **Data source** box to **File**

Select the required **input data file** using the **Select file 3** button.

Click on the **Enter** and then on the **Run** buttons. This will read and update the **Control parameter** data from the file header section and display the saved **RSO waveforms** in the **Plot** window.

### 8.2 TO VIEW DATA FROM ANOTHER DATA FILE:

Select a **new input data file** using the **Select file 3** button.

Click on the **New Data File** button. This will read and update the Control parameter data from the file header section and display the saved **RSO waveforms** in the **Plot** window.

### 8.3 TO VIEW DATA FROM ANOTHER FILE WITHOUT ERASING EXISTING WAVEFORM:

Note that this only makes sense if the 2 data files were captured using the same control parameters. Moreover the displayed text will be that for the first file loaded only.

Tick **Persistence mode** box

Select the new input data file using the **Select 3** button.

Click on **New Data file** button**.**

**This will** select a **new data file** to be viewed alongside the previous data.

An example of viewing 2 data files simultaneously is shown in figure 8.3.1.

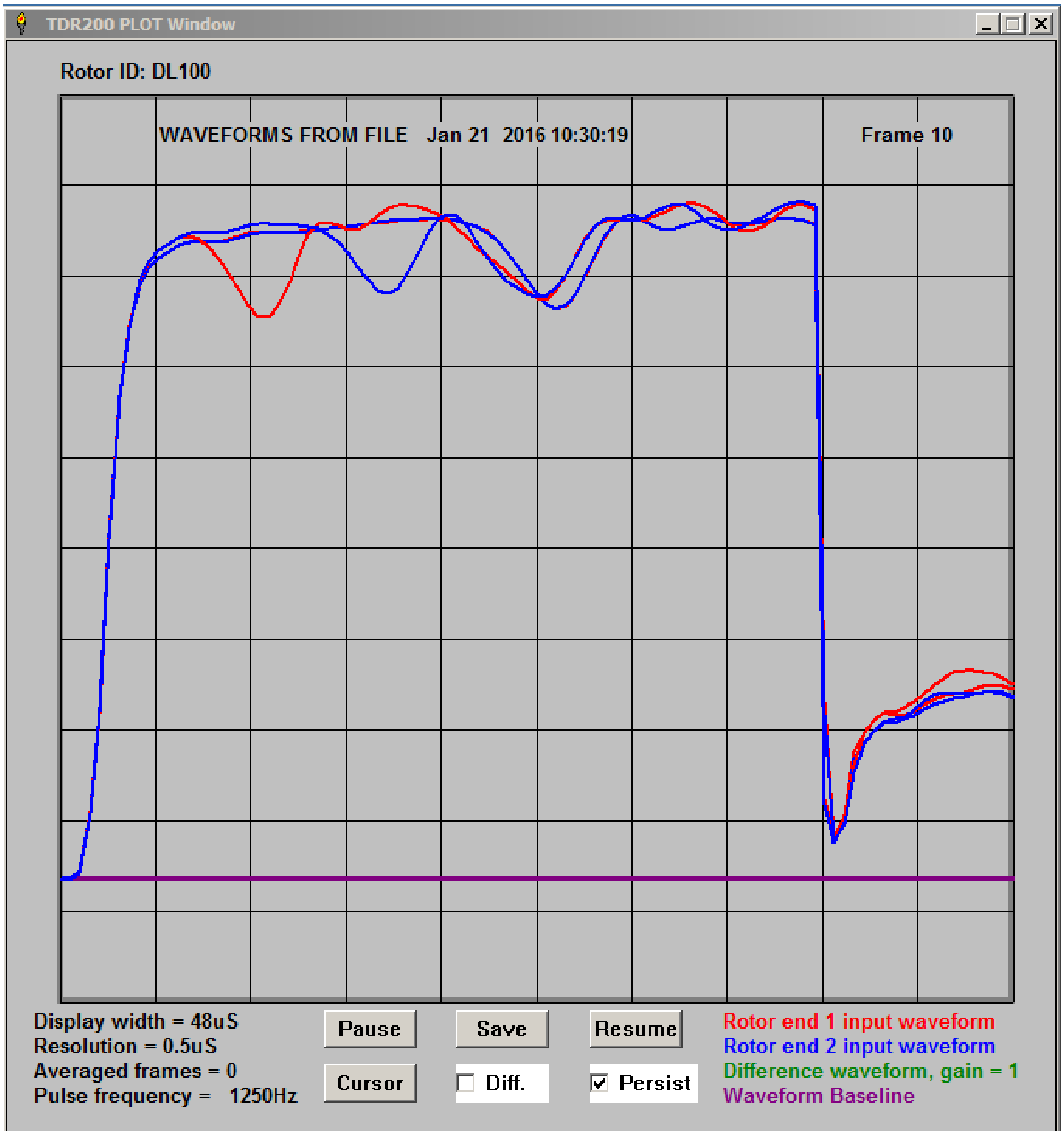



**Figure 8.3.1 Viewing 2 data files simulaneously in persistence mode**

## 8.4 TO VIEW ONLY THE MOST RECENT FILE

Click the **Persist box** to disable **persistence mode.**

Click the **Continue** button.

## 8.5 TO EXIT THE PROGRAM OR REVERT TO ON-LINE MODE

Click on the **Exit** button. In off**-line mode**, the output window is not shown as no output data files are saved or modified on program exit.

It is not possible to switch back to **on-line mode** directly from file mode. Instead, the program must be restarted following use of the **Exit** button.

## 9. LOCATING FAULTS USING TIME SCALING

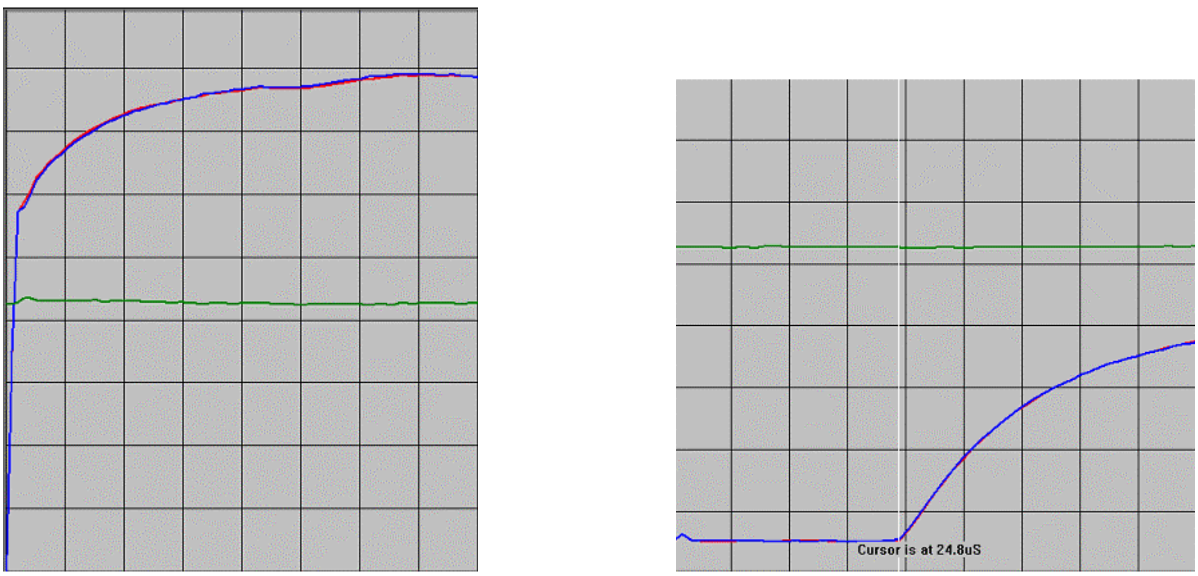
### 9.1 OVERVIEW

In principle, the location of any **winding fault** can be found by measuring the time to the point of **waveform divergence** and comparing this with the **single-pass transit time** (SPT). This is the time taken for the pulse injected at one end of the rotor winding to travel through the winding to the other end. It is measured easily by viewing the output end waveforms as described in section 2.5.2.

In practice, this only give approximate results for the following reasons:

The rotor winding is an imperfect transmission line, consisting of multiple sections, each having differing characteristic impedances. In particular the impedance in the slot regions is very different from that in the end ring regions. The winding is therefore a periodic structure and the effect on the applied pulse waveform is similar to that of passing it through a low-pass filter.

In addition other (non-transmission line) modes of propagation exist which travel at different speeds from the main mode and these further distort the output pulses. A further problem is that at the fault location, it can be unclear where to measure the point at which the waveforms diverge.




**(a) Input end waveforms** **(b) Output end waveforms**

**Figure 9.1 Pulse distortion.**

The pulse applied by the TDR200 via R1 is a true square pulse. However, at the output of the input-matching resistor R1, it has become distorted by the rotor input impedance, as shown in figure 9.1(a) above. By the time it has travelled to the far end of the winding, it has become a pulse with an exponentially increasing leading edge, as shown in figure 9.1(b).

Because of the progressive distortion of the pulse as it travels along the rotor winding, the effective pulse transit time through the rotor winding is non-linear. This can be confirmed by measuring and comparing both the single-pass (SPT) and the double-pass (DPT) transit times. The DPT is the time taken for the pulse to travel through the winding and back again to the input end. It is measured by monitoring the input end waveforms and adjusting the value of the output end matching resistor to cause a deliberate impedance mismatch, as described in section 2.6.2. The Double - pass transit time is normally longer than 2 x the Single - pass transit time, indicating that the effective pulse speed of propagation slows down as the pulse travels further along the rotor winding.

The effect of this is that the pulse appears to travel further per unit time near the start of the winding and less far as it reaches the far ends of the winding.

## 9.2 TRANSIT TIME CALCULATION

One method for dealing with the non-linear transit time problem was proposed by G.A. Elsworth of the UK Central Electricity Generating Board (CEGB). The basis of the method is to approximate the relationship between the transit time **t** and the distance travelled through the winding **d** as a second-order polynomial of the form:

$$\mathbf{t = A.d + B.d^2} \qquad \mathbf{(1)}$$

where **A** and **B** are constants for a specific rotor winding.

The values of t and d can be measured for 2 specific conditions (the single and dual-pass transit times SPT and DPT), giving 2 simultaneous equations which can be solved to obtain the vaules of A and B as follows:

$$\mathbf{SPT = A.d1 + B.d1^2} \qquad \mathbf{(2)}$$

$$\mathbf{DPT = A.d2 + B.d2^2} \qquad \mathbf{(3)}$$

where d1 is the length of the rotor winding (d) and d2 = 2.d1 = 2.d

So the equations become:

$$\mathbf{SPT = A.d + B.d^2} \qquad \mathbf{(4)}$$

$$\mathbf{DPT = 2.Ad + 4.B.d^2} \qquad \mathbf{(5)}$$

Solving for A and B we obtain:

$$\mathbf{A = (4.SPT - DPT) / (2.d)} \qquad \mathbf{(6)}$$

$$\mathbf{B = (DPT - 2.SPT) / (2.d^2)} \qquad \mathbf{(7)}$$

Re-arranging equation (1 )

$$\mathbf{B.d^2 + A.d - t = 0} \qquad \mathbf{(8)}$$

which is a quadratic equation with solution:

$$\mathbf{df = - A \ +/- \ SQRT( A^2 \ - \ 4.B.tf ) / (2.B)} \qquad \mathbf{(9)}$$

So for any measured time to the fault **tf**, we can use equations 6, 7 and 9 to obtain the distance **df** of the fault from one end of the winding. In practice, the positive solution of equation 9 gives the correct value of df.

**9.3 SOFTWARE IMPLEMENTATION**

The equations derived in section 9.2 have been incorporated into the **TDRPlot** software and are implemented using the **Locate** button in the **Control** window.

Before the **Locate** button can be used, the following measurements must be carried out and the results noted:

1. Delay period before start of input pulse

2. Rotor single-pass transit time (measured using output ends plot window).

3. Rotor double-pass transit time (measured using input ends plot window).

4. Time to fault (trace divergence) (measured using input ends plot window)

5. Number of winding end nearest fault.

6. No of rotor coils per half-pole winding.

The methods used to measure these quantities are described in the next section.

## 9. 4 MEASUREMENT OF INPUT PARAMETERS FOR THE LOCATE PROGRAM

### 9.4.1. Delay period before start of input pulse

This parameter is obtained from the **input ends** plot window.

There is a short **time delay** in the electronic switching circuitry before the **start of the input pulse** appears in the **plot window**. This time (the **input pulse start delay time**) can be measured using the **input ends** plot window as shown below.

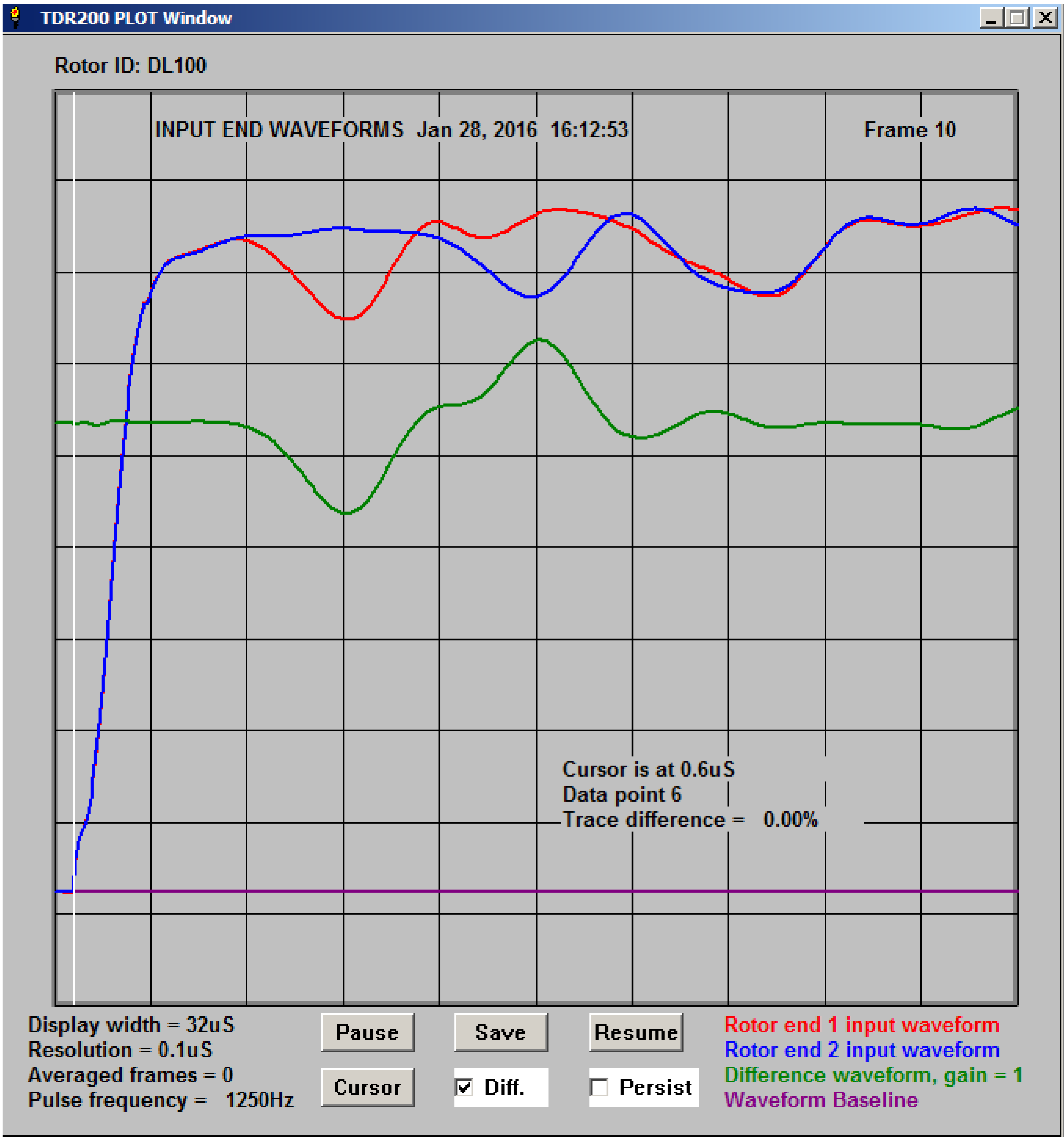



**Figure 9.4.1 Measurement of input pulse start delay (0.6uS)**

Locate the cursor at the point at which the input pulse waveform starts to increase from zero, as shown above and note this time, which is the **input pulse start delay time** (**0.6 uS** in this case).

### 9.4.2. Rotor single-pass transit time

This parameter is measured using the **output ends** plot window as shown in figure 9.4.2 below.

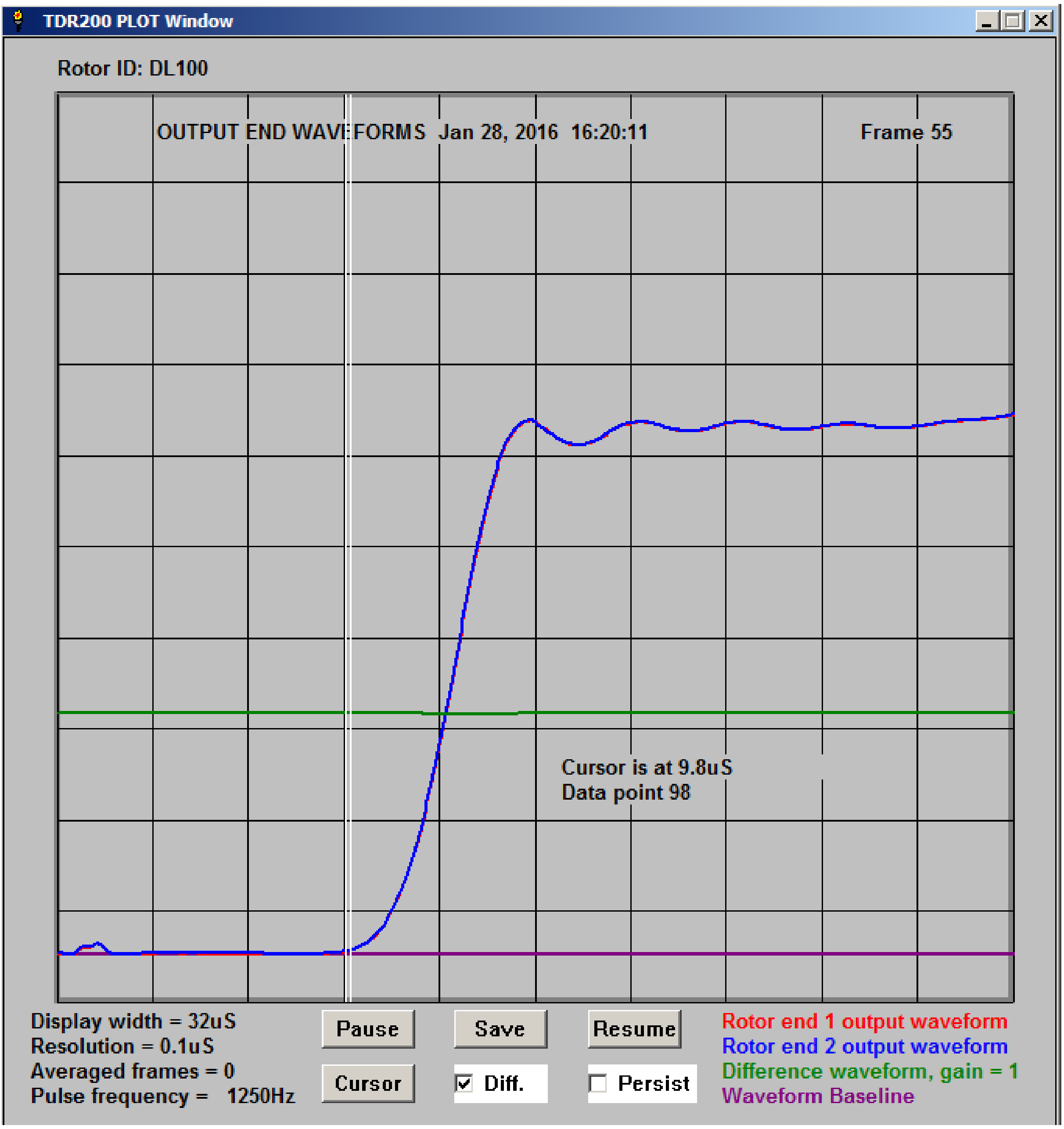



**Figure 9.4.2 Measurement of single-pass transit time (9.8uS)**

Simply locate the cursor at the point where the output waveform starts to increase from zero and record the **single-pass transit time** (**9.8uS** in this case)**.**

### 9.4.3 Rotor double-pass transit time

This parameter is measured using the **input ends** plot window by deliberately setting the value of the impedance matching resistor R2 to zero. This cause a negative-going reflection as shown below.

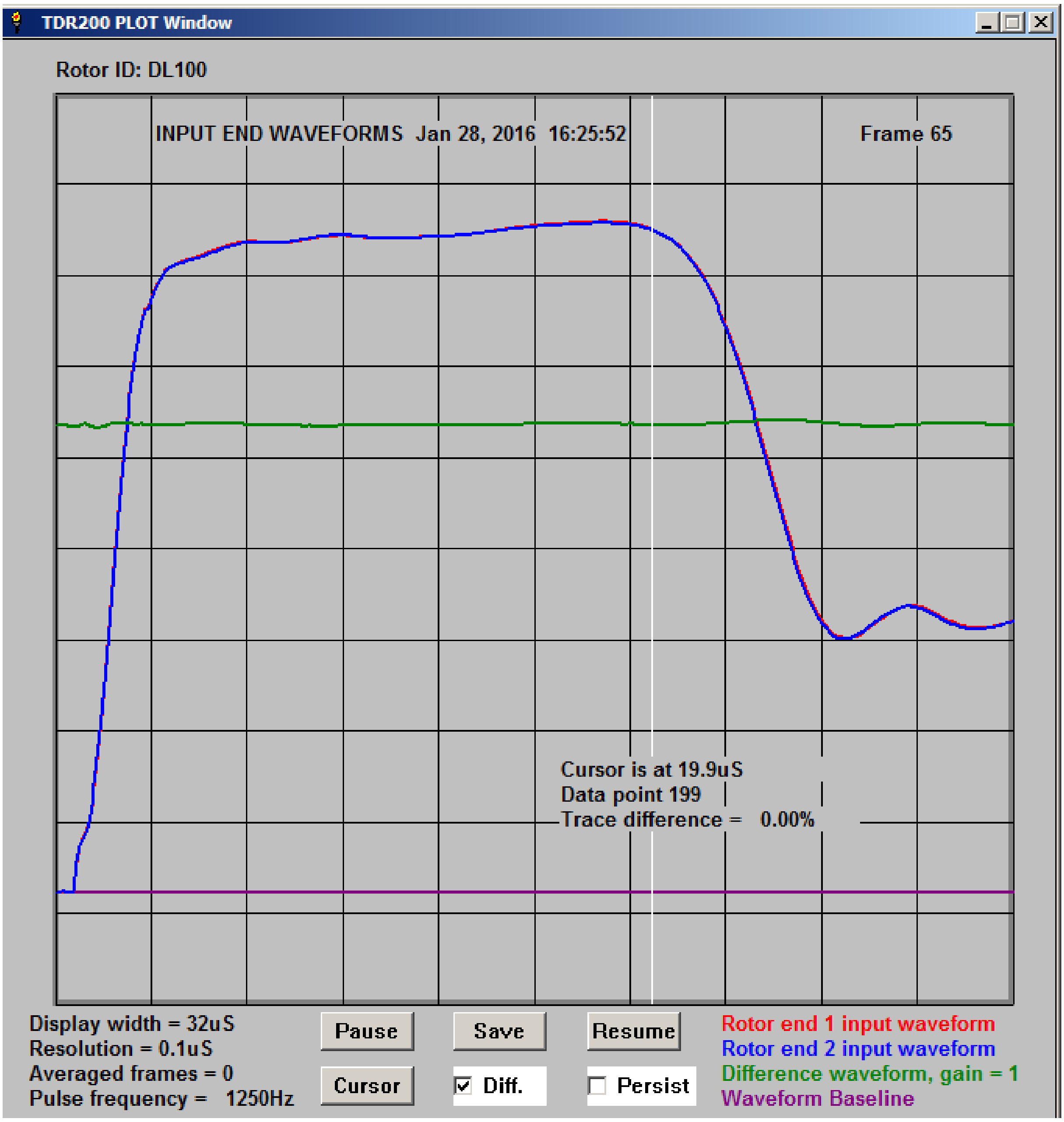



**Figure 9.4.3 Measurement of double-pass transit time (19.9uS)**

This is the most difficult parameter to measure accurately because of the nature of the waveforms reflected from the far ends of the rotor winding. It should be measured at the point where the waveforms have just started to decrease as shown above **(19.9uS** in this case)..

### 9.4.4 Time to fault (trace divergence)

This parameter is obtained from the **input ends** plot window.

Figure 9.4.4 below shows the waveforms obtained using the demonstration delay line with a short circuit applied between coil (4-5).

(DPT)

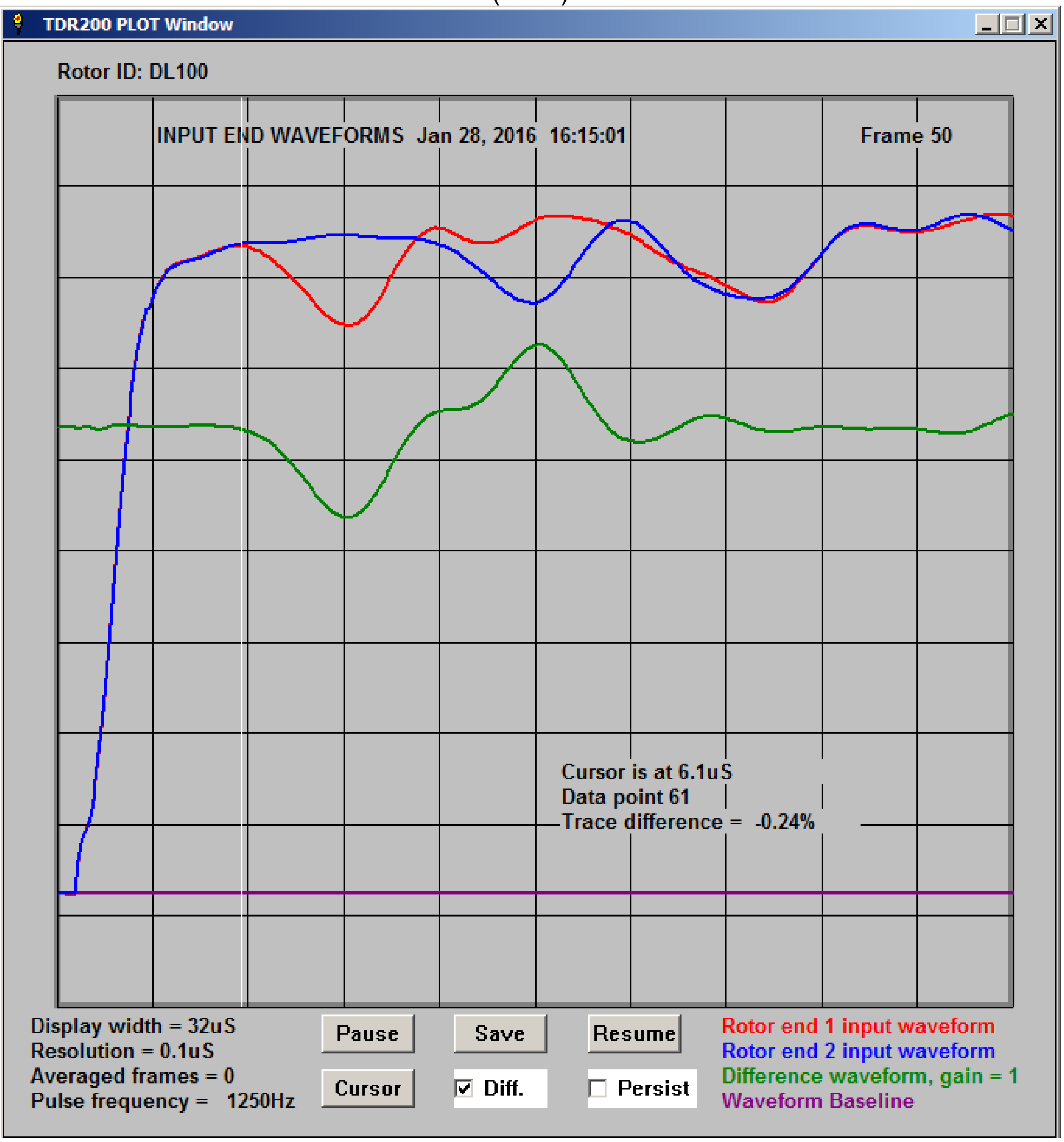



**Figure 9.4.4 Measurement of time to fault (6.1uS)**

The time to the fault is measured by locating the cursor at the point at which the red and blue waveforms start to diverge, as shown above (**6.1uS** in this case).

**This concludes the set of measurements required to locate the winding fault.**

However, it is also necessary to note which winding end is closest to the fault and to note the number of coil slot-pairs in each half-winding.

## 9.5 CALCULATING THE FAULT LOCATION.

Once the measurements have been completed, the **Locate** button in the **Control window** can be used to calculate the approximate fault location as follows:

Click on the **Locate button** in the **Control window**. A series of **prompt windows** will appear and text messages will be generated in the message window.

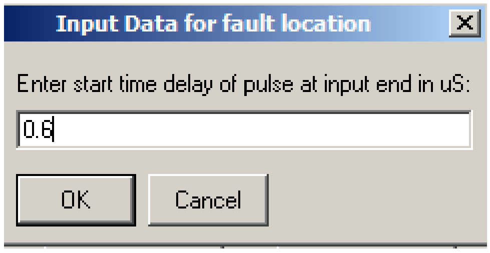



**Figure 9.5.1 Prompt window for Start delay time**

Input the data requested for each prompt window and then press **Return** to move onto the next window. If using a mouse, try to keep its position still, as this affects the location of the **prompt windows** on the PC screen.

Note that default values appear in some of the windows. Simply over-write these values with thcorrect ones.

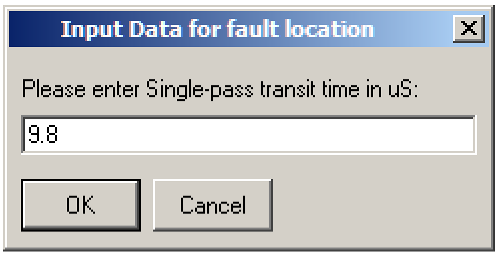



**Figure 9.5.2 Prompt window for single-pass transit time**

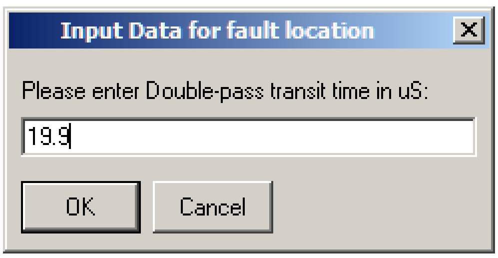



**Figure 9.5.3 Prompt window for double-pass transit time**

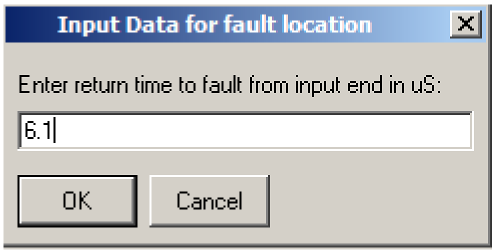



**Figure 9.5.4 Prompt window for time to winding fault**

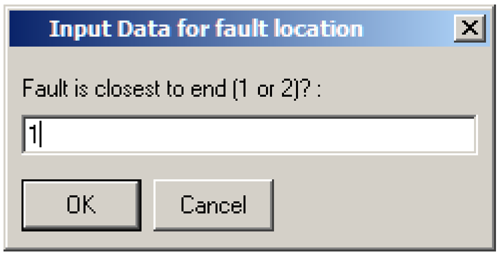



**Figure 9.5.5 Prompt window for input end number**

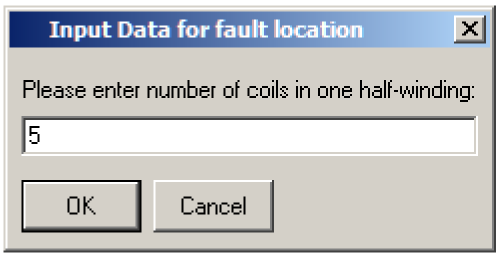



**Figure 9.5.6 Prompt window for number of coils in each half-winding**

This complete the input data and the location results are printed in the message window. A typical output example follows

****************************************************************************

**Number of rotor coils in each half-pole winding is 8**
**Corrected single-pass transit time is 9uS**
**Corrected double-pass transit time is 21uS**
**Corrected double-pass time to fault is 7uS**
**Corrected single-pass time to fault from End 1 is 3.5uS**

**Distance to fault from End 1 is approximately 43% of winding length**
**Fault is probably in coil 7 from RED end 1**

****************************************************************************

**Figure 9.5.6. Example of output in Message window**

## 9.6 FAULT LOCATION BY APPLYING MIRROR FAULTS.

The time scaling method can only give the approximate fault location. The fault can be located more accurately once the rotor has been removed from the generator by applying an identical temporary fault to the fault-free half winding. By adjusting the position of this fault until the waveforms for the 2 winding ends are identical or nearly so, the faulty turn can usually be identified.

If the rotor has radial cooling holes, it may be possible to access the winding turns using a special shorting probe. Otherwise, similar techniques can be used once an end ring has been removed.

The methods available for doing this are described in detail in section 2.5 of the **TDR100 user manual**.

## 9.7 ESTIMATING THE SINGLE-PASS TRANSIT TIME FROM RSO WAVEFORMS FOR A ROTOR WINDING CONTAINING AN EARTH FAULT

If a rotor winding contains an **earth fault**, it is not possible to measure the **single-pass transit time** directly, as the waveforms viewed at the **output ends** of the winding will be zero traces. It is, however possible to estimate this time by analysing the waveforms reflected from the earth fault at the input ends of the winding to obtain the **double-pass transit time**.

An **earth fault** will cause the amplitude of the pulse monitored at the **input ends** of the winding to start to decrease in amplitude, after the time taken for the pulse to reach the earth fault and be reflected back to the input ends of the winding.

The waveforms shown in figures 1 and 2 were obtained using the **DL100 demonstration delay line** with a deliberate earth fault applied between terminal 4 and ground. The difference waveforms have been turned off in figures 1 and 2 for clarity. The figures display the input end waveforms reflected from the earth fault. and it is clear that the fault is nearest to the **Red** end (1) of the winding.

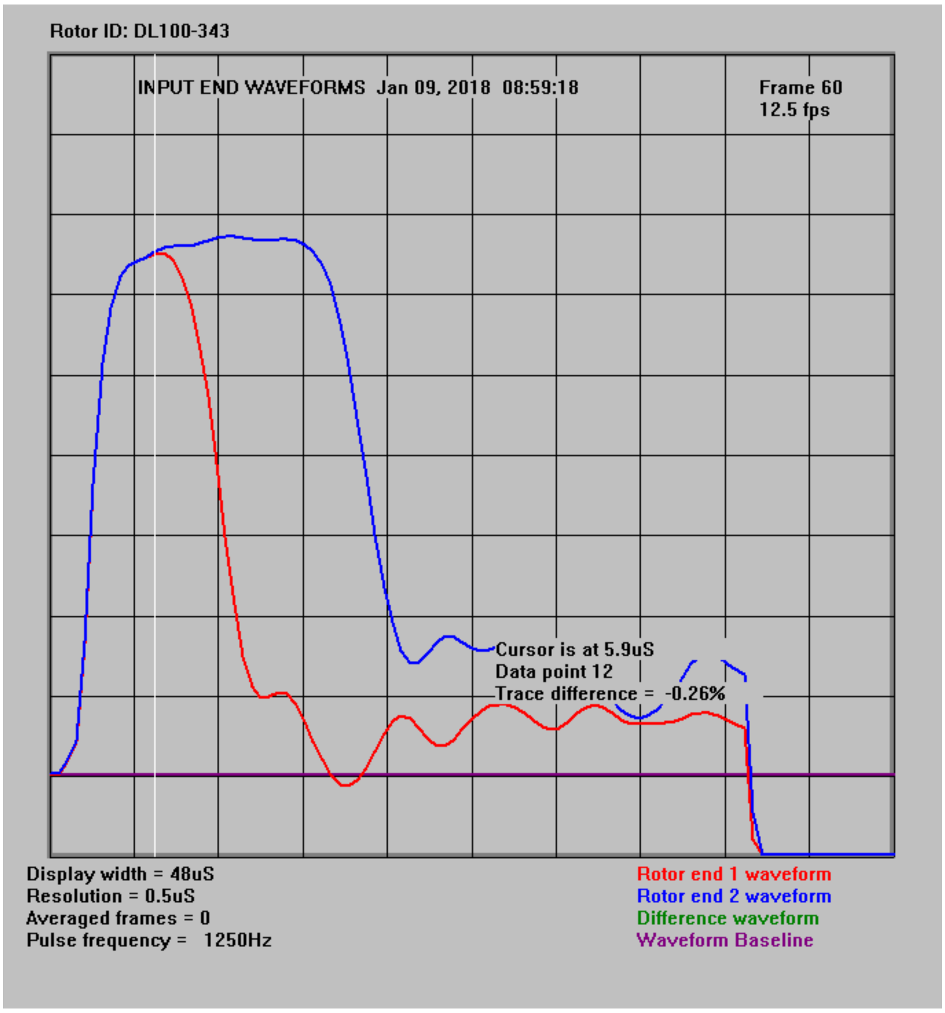



**Figure 9.7.1. Delay line waveforms with Earth fault applied between terminal 4 and ground**

In figure 9.7.1, the cursor has been located at the point of divergence between the **Red** and **Blue** waveforms and this shows that for the **Red** waveform, the reflected signal from the fault occurs **5.9uS** after the start of the RSO pulse injected at end 1.

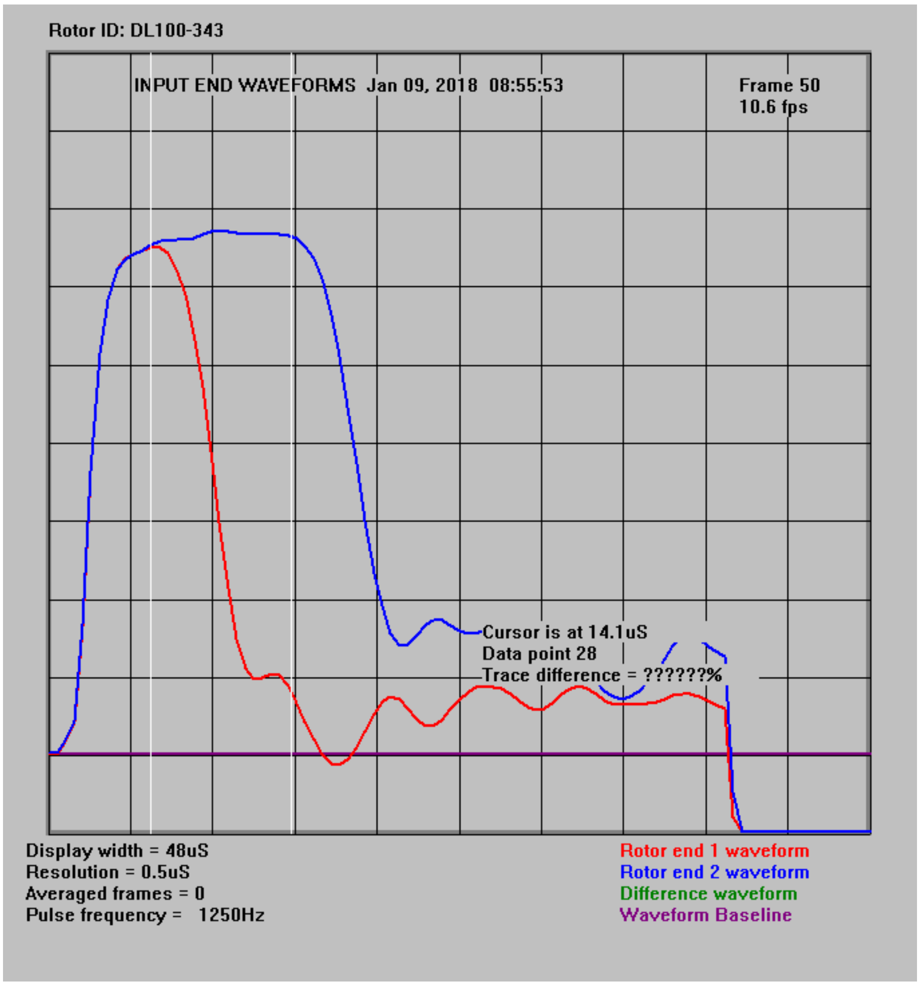



**Figure 9.7.2. Delay line waveforms with Earth fault applied between terminal 4 and ground**

In figure 9.7.2, the cursor has been moved to the point at which the **Blue** waveform starts to decrease in amplitude. This occurs **14.1uS** after the start of the RSO pulse injected at the **Blue** end (2) of the winding .

By summing these 2 values, the **double-pass transit time** will be 5.9 + 14.1 = 20uS. The **single-pass transit time** will therefore be approximately half this value, ie **10uS**.

## 10. SAMPLE TEST RESULTS FROM A 660 MW 2-POLE ROTOR

### 10.1 RESULTS FOR A FAULT-FREE ROTOR WINDING

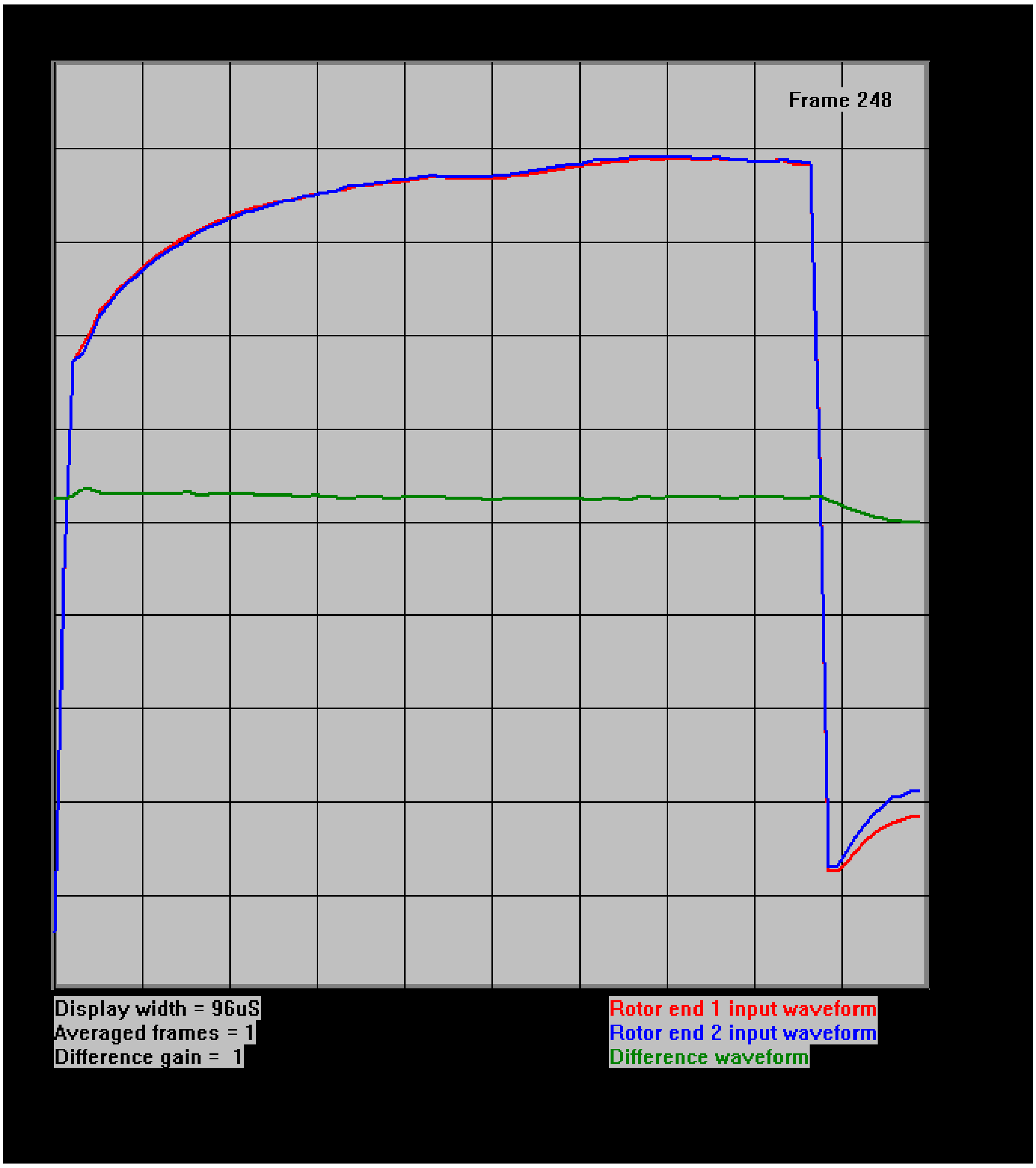



**FIGURE 10.1.1 FAULT-FREE 660 MW ROTOR INPUT END WAVEFORMS**

**FAULT-FREE**

**Comments:**

Note the two identical end1 (red) and end 2 (blue) waveforms and the horizontal (green) difference waveform. These are the results which should be obtained for a healthy rotor winding.

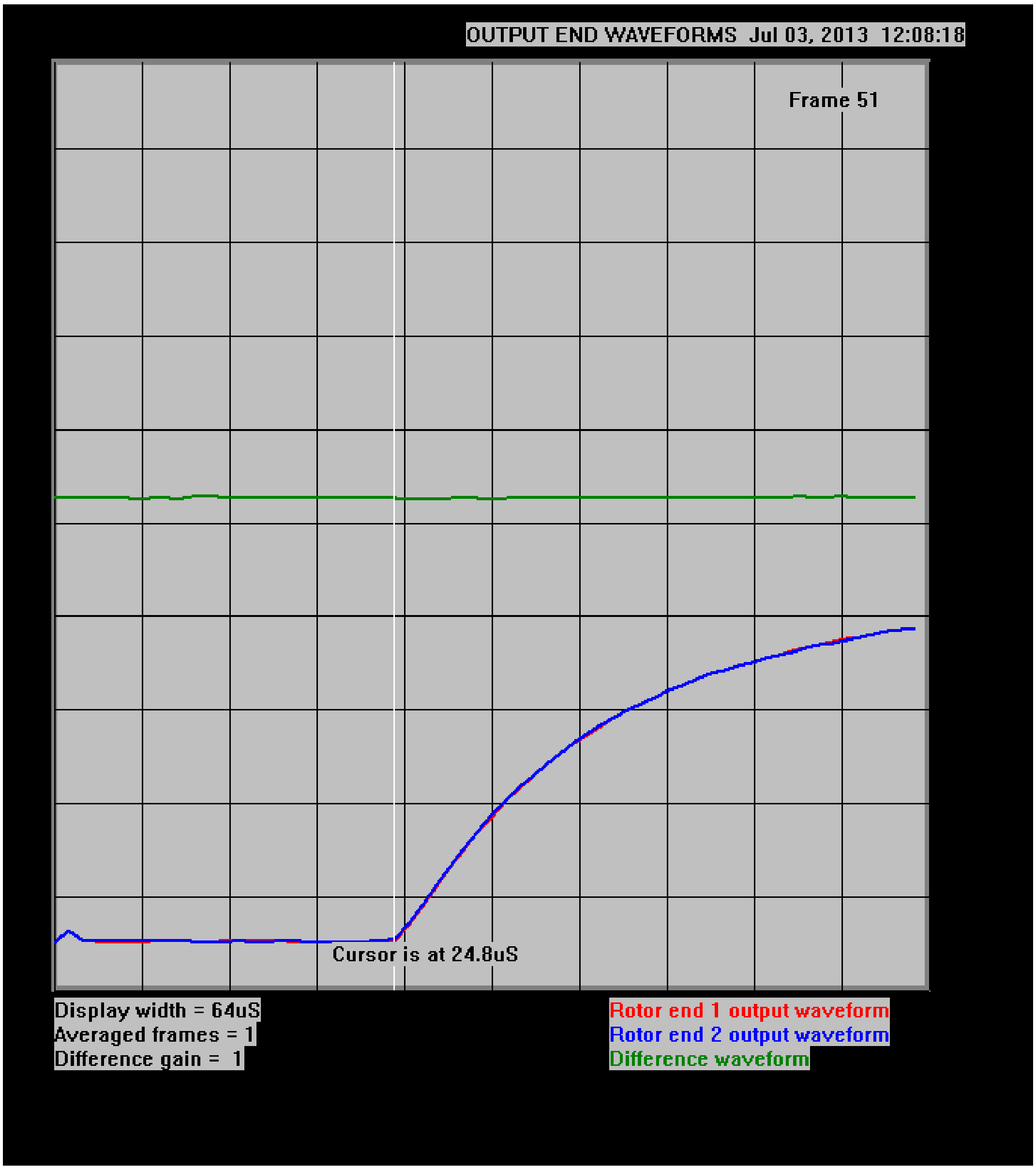



**FIGURE 10.1.2 FAULT-FREE 660 MW ROTOR**

**OUTPUT END WAVEFORMS**

**Comments:**

This shows the use of the cursor button to measure the single-pass transit time (in this case 24.8uS) of the rotor winding.

### 10.1 RESULTS FOR A ROTOR WINDING DURING REPAIR

The following results were obtained from a 660MW rotor winding during repair. One end-ring had been removed, which allowed simulated faults to be applied to the half-winding connected to the end 1 slip ring (red waveforms)..

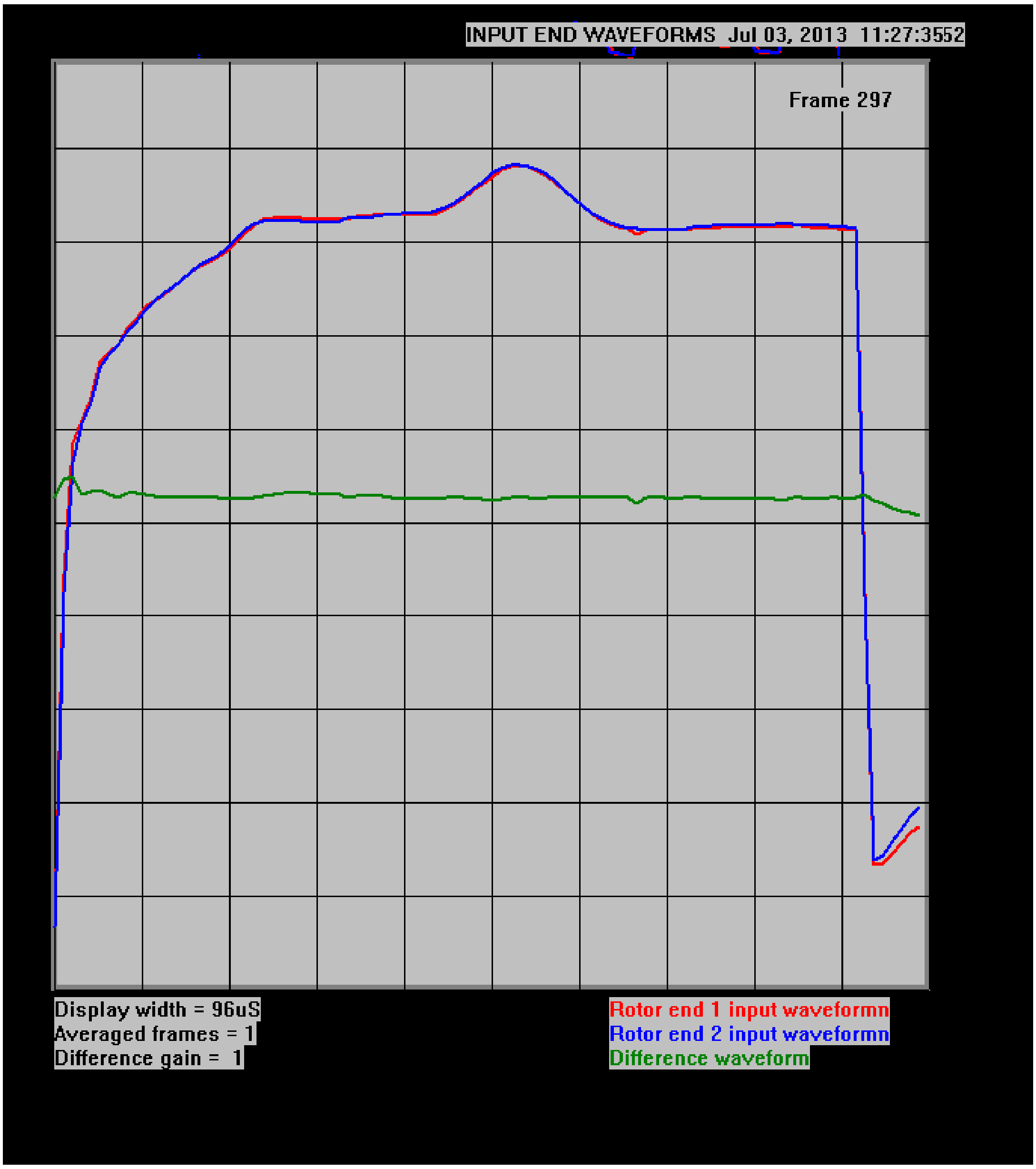



**FIGURE 10.2.1 INPUT END WAVEFORMS WITH END RING NEXT TO SLIP RINGS REMOVED**

**Comments:**

With one end ring removed, the characteristic impedance of the rotor winding changes at these points in the winding, resulting in a peak in the input end waveforms as shown above. However, note that both the red and blue waveforms remain identical as there is no winding fault.

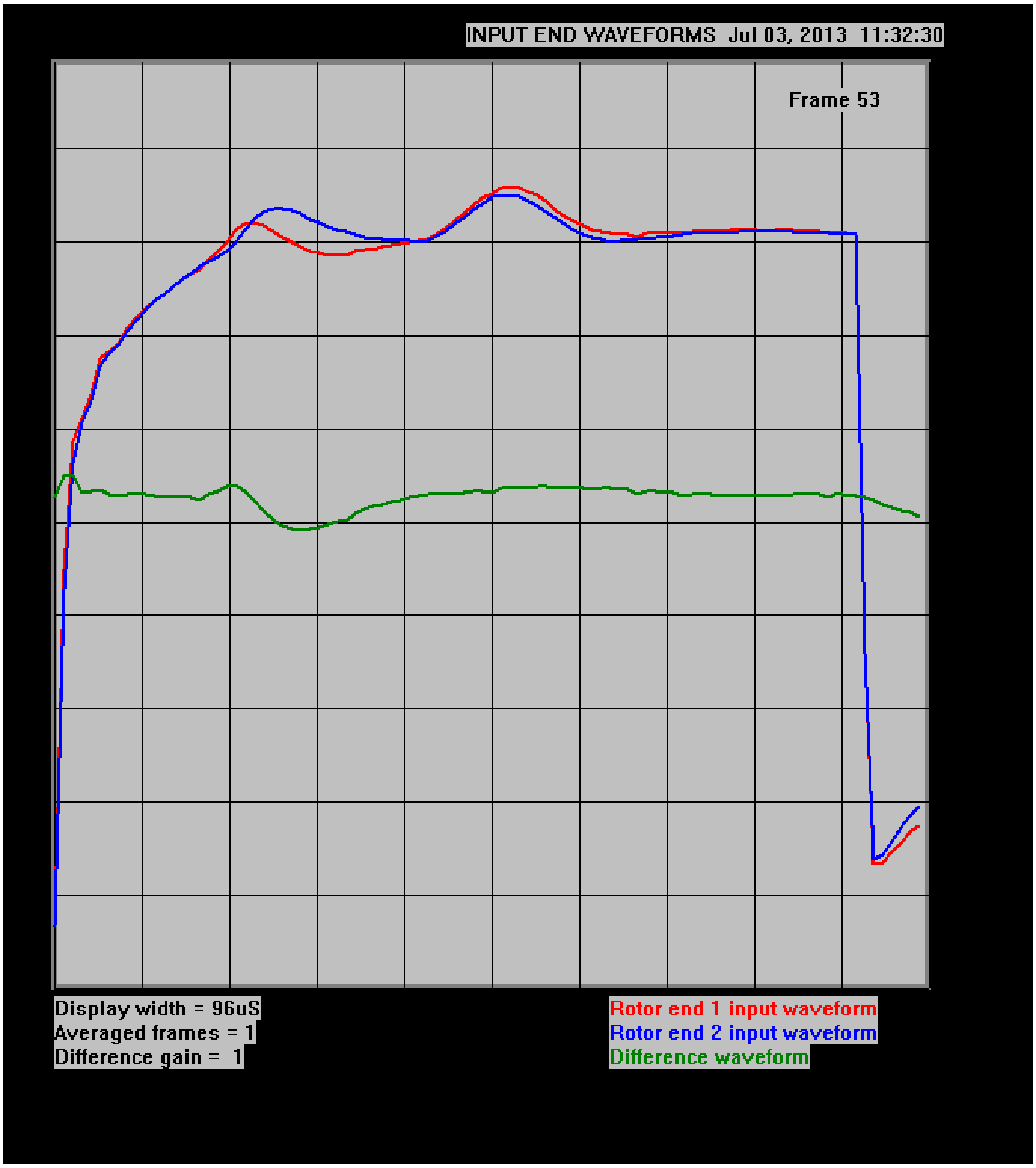



**FIGURE 10.2.2 INPUT END WAVEFORMS**
**WITH END RING NEXT TO SLIP RINGS REMOVED**

**SHORT CIRCUIT APPLIED TO LAST COIL BEFORE END OF HALF-WINDING**

**Coments:**

Shorting out a complete set of windings in a slot coil causes a characteristic loop to appear between the red and blue waveforms. Note that the applied fault is nearest to the end 1 (red waveform) and that the red waveform first increases, then decreases at the fault location.

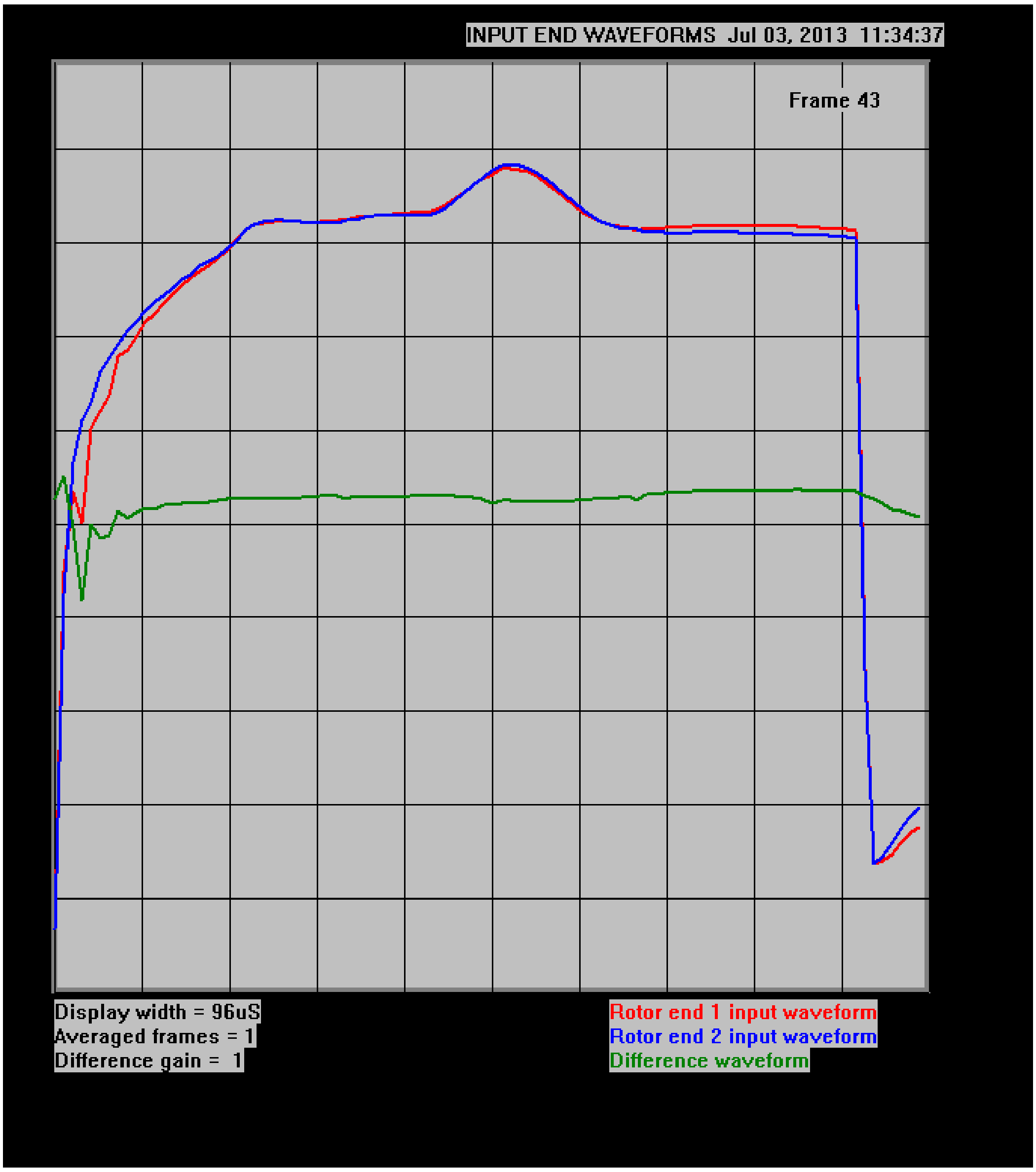



**FIGURE 10.2.3 INPUT END WAVEFORMS**
**WITH END RING NEXT TO SLIP RINGS REMOVED**

**1 SHORTED TURN APPLIED TO FIRST COIL FROM END 1 SLIP RING**

**Comments:**

The effect of shorting out a single turn produces a maximum difference in the input end waveforms when the shorted turn is close to the start of the winding as shown above.

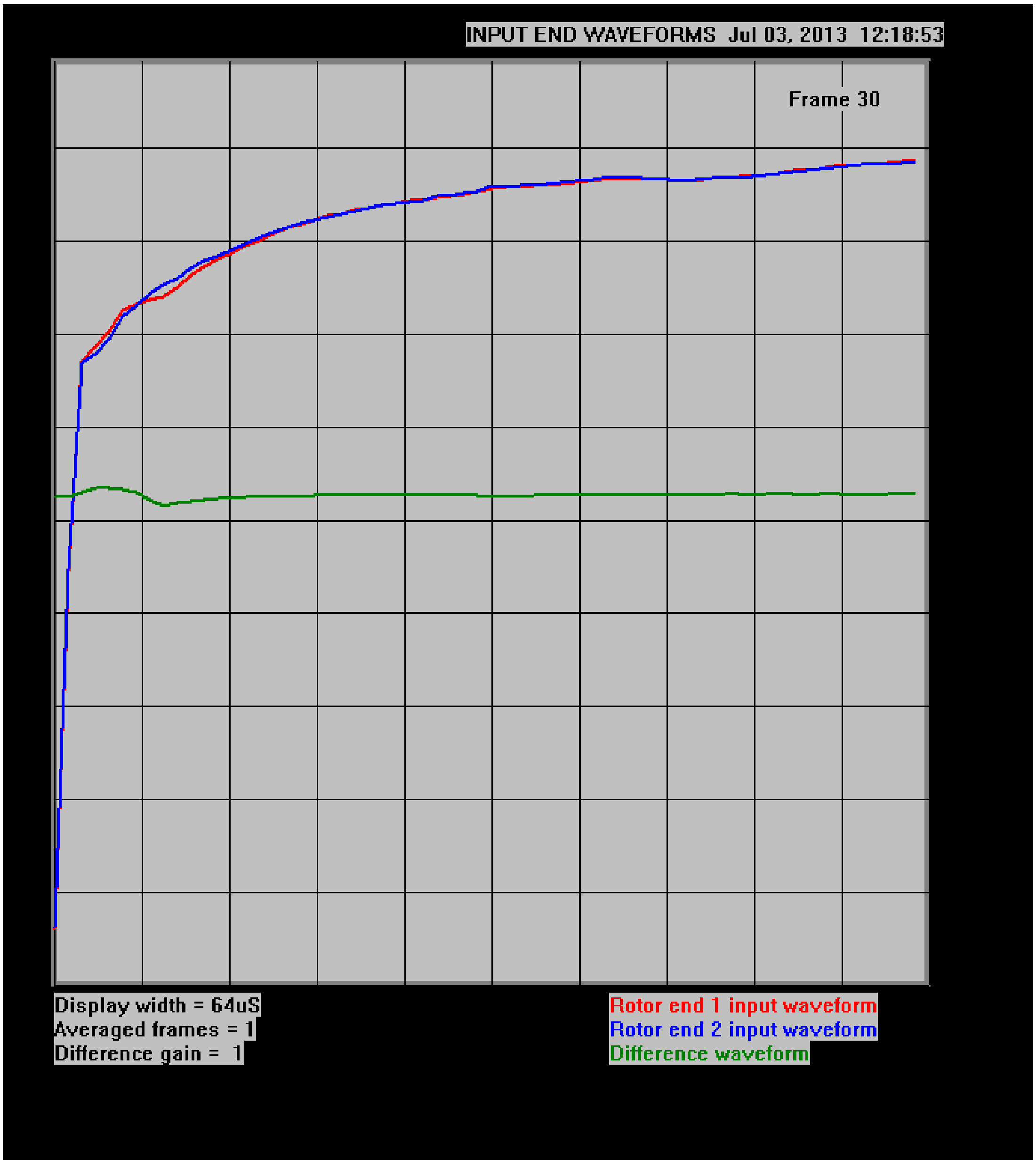



**FIGURE 10.2.4 INPUT END WAVEFORMS**
**WITH END RING NEXT TO SLIP RINGS REMOVED**

**SHORTED TURN APPLIED TO THIRD COIL FROM END 1 SLIP RING**

**Comments:**

As the location of the fault is moved towards the centre of the winding, the measurement sensitivity decreases.

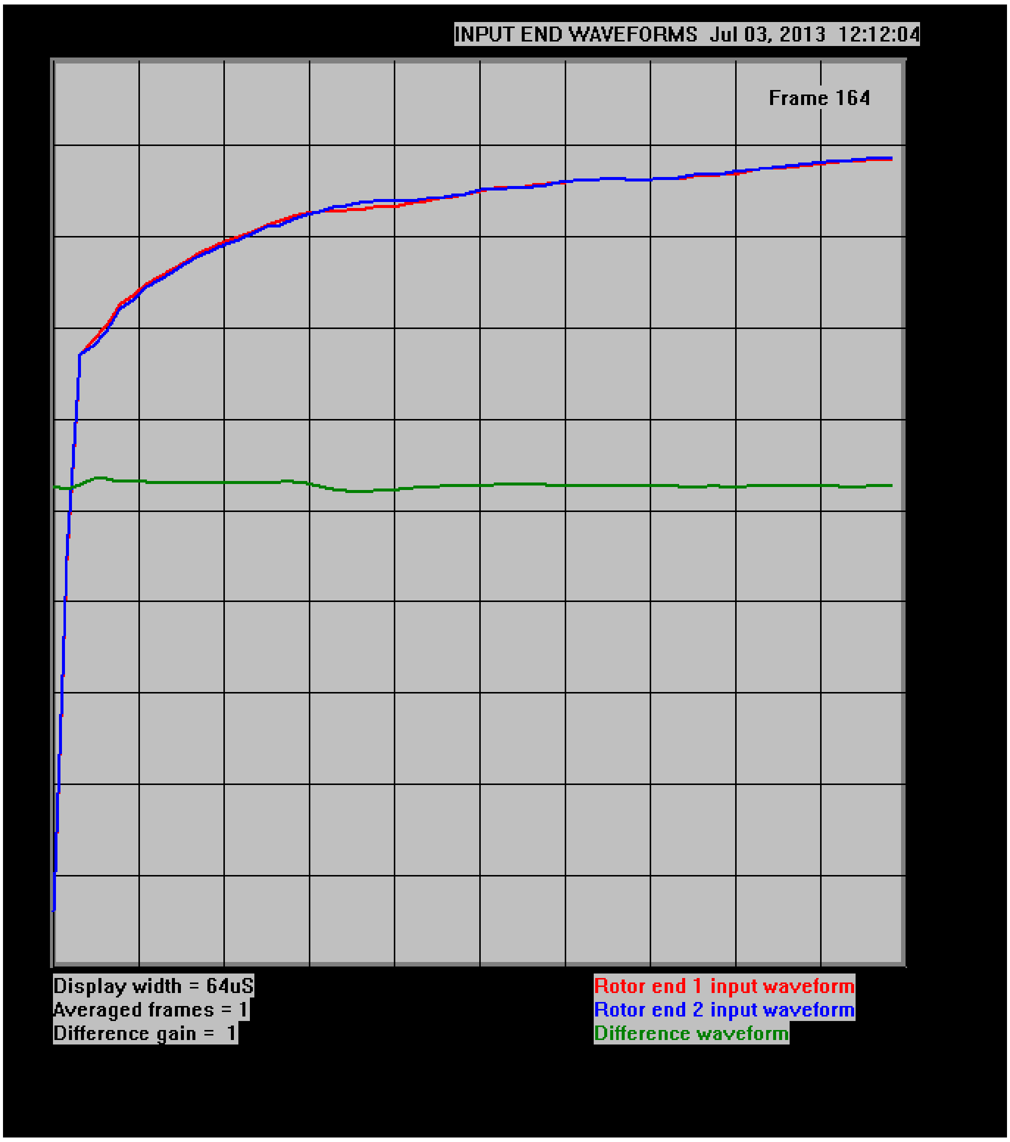



**FIGURE 10.2.5 INPUT END WAVEFORMS**
**WITH END RING NEXT TO SLIP RINGS REMOVED**

**SHORTED TURN APPLIED TO LAST COIL IN END 1 HALF-WINDING**

**Comments:**

Although the measurement sensitivity has decreased, figure 10.2.5 shows that it is still possible to detect a shorted turn close to the centre of the rotor winding.

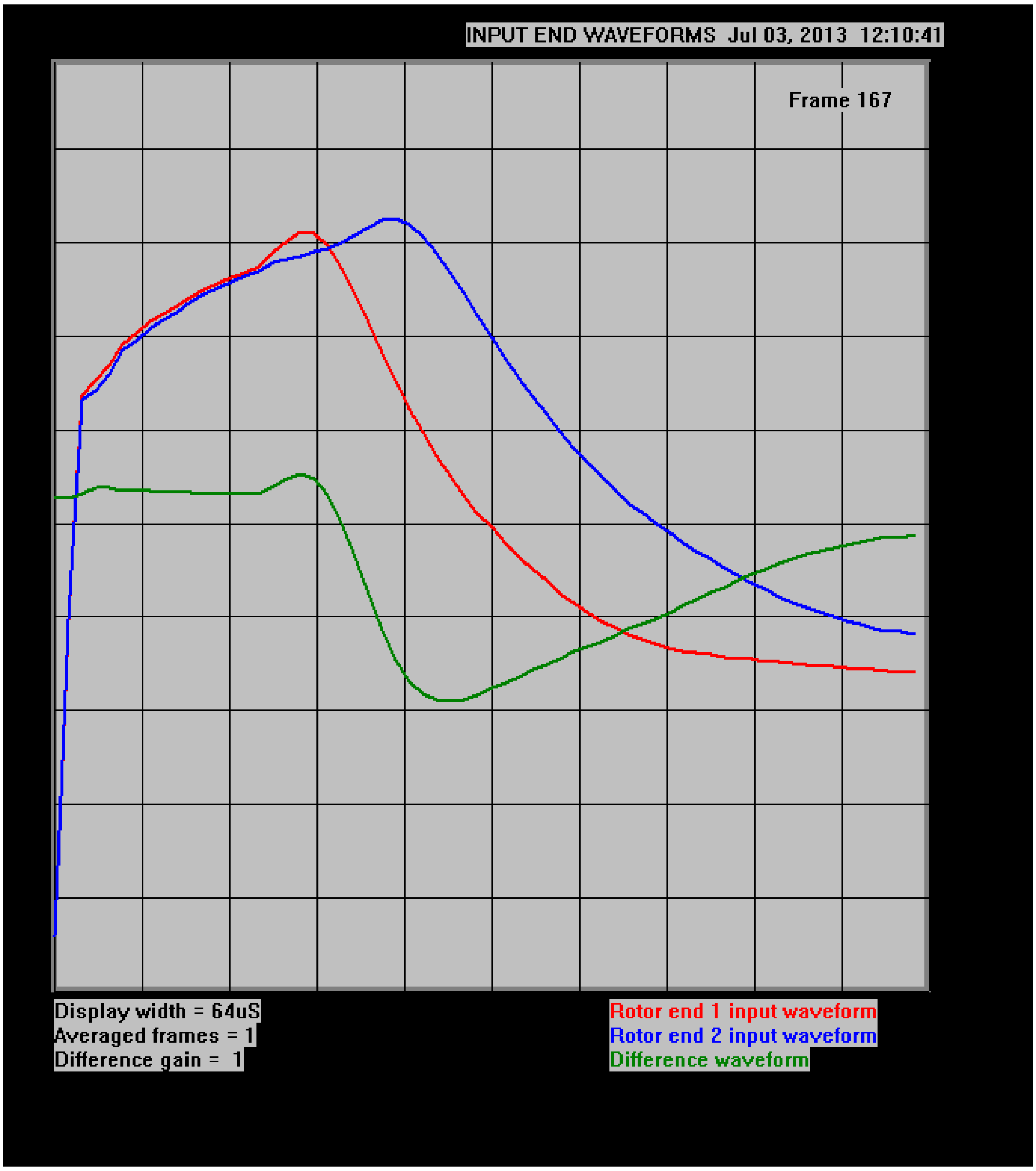



**FIGURE 10.2.6 INPUT END WAVEFORMS WITH END RING NEXT TO SLIP RINGS REMOVED**

**EARTH FAULT APPLIED TO LAST COIL IN END 1 HALF-WINDING**

**Comments:**

An earth fault is easily detected and located using the RSO test. In this case, a fault has been applied to the half-winding closest to end 1 (red waveform).

## APPENDIX 1

## FOLDER STRUCTURE FOR SOFTWARE AND DATA FILES

All of the software and data files are installed to a **(Default) Master folder C:\TDRPlot.** This folder also contains **subfolders** for **Program files**, **Output data files** and **Documentation**.

### MASTER FOLDER

The **Master folder** contains the following sub-folders:

Program Files
Data Files
Documentation

### PROGRAM FILES SUB-FOLDER

The Program Files folder contains the following files:

**TDRPlot.exe** : The main program file and associated DLLs
**T200ini.txt** : A data file containing the last-used values for the control parameters.

### DATA FILES SUB-FOLDER

The **Data Files** sub-folder contains the following files:

**Lastframe.bmp** File containing a bit-map image of the last plot image window before the program was terminated.

**Lastframe.txt** File containing the ADC readings for the 3 waveforms in the last frame of data before the program was terminated.

**Custom.bmp** which is similar to **TDRPlot.bmp** but has a file name (in this case, **Custom**) which can be chosen by the user.

**Customini.txt** which contains the set of measurement configuration data defined by the user and can be used instead of the standard **T200ini.txt** initialisation file.

In both cases, the Custom text will be the full file name as specified in the Configuration window.

### DOCUMENTATION SUB-FOLDER

The **documentation folder** contains a set of **User manuals** and other related documentation.

## APPENDIX 2

## FILE FORMATS

### A2.1 CONTROL PARAMETER FILE FORMAT

These ASCII files (eg **T200ini.txt)** contain the set of parameters in the **Control window**. A typical example follows:

| | |
|---|---|
| DL100 | The Rotor ID |
| 4 | PC comport number |
| Input ends | Data type |
| 48 | Plot window width (uS) |
| 0.5 | Data resolution (uS) |
| 500 | Scan-rate (pps) |
| 1 | Number of frames to average |
| 1 | Difference Channel gain |
| C:\TDRPlot\Data Files\DL100-ini.txt | Control Parameter file name |
| None | Averaging method |
| C:\TDRPlot\Data Files\DL100.txt | Output data file name |
| 5 | Frame plot skip parameter |
| 1.7 | Vertical scaling parameter |
| C:\TDRPlot\Data Files\DL100.txt | Input data file name |

### A2.2 DATA FILE FORMATS

The ASCII data file contains a header section consisting of the data in the relevant Control parameter file, together with a data section containing sets of ADC readings for the waveforms at each end of the rotor winding and also the difference between these ADC values.

Each line of data contains a set of 4 integer values for each data frame. Each set of frame data is terminated in a **Carriage Return** character. The individual data fields in each frame are separated by a single SPACE character.

The data for each frame consists of the folowing items with typical values shown below:

| FRAME NUMBER | END1 ADC VALUE | END2 ADC VALUE | END1 - END2 ADC ADC VALUES |
|---|---|---|---|
| 1 | 5135 | 4751 | 384 |

A sample data file is shown on the following sheets.. Note that the frame number, date and time are also included before the end (**Header End**) of the header section.

Both of these text files can be viewed using the **Windows Notepad** program.

## Example of data file

```
DL100
4
Input ends
48
0.5
500
1
1
C:\TDRPlot\Program Files\T200ini.txt
None
C:\TDRPlot\Data Files\Lastframe.txt
5
1.7
C:\TDRPlot\Data Files\Lastframe.txt
15
Nov 16, 2015
17:45:23
Header End
1 4758 4763 -5
2 4776 4798 -22
3 7520 7521 -1
4 11754 11823 -69
5 18993 18986 7
6 24644 24638 6
7 27182 27186 -4
8 28645 28642 3
9 29119 29106 13
10 29301 29277 24
11 29495 29472 23
12 29706 29701 5
13 29800 29866 -66
14 29701 29925 -224
15 29389 29907 -518
16 28925 29921 -996
17 28341 29985 -1644
18 27692 30097 -2405
19 27102 30183 -3081
20 26741 30205 -3464
21 26794 30169 -3375
22 27331 30117 -2786
23 28256 30092 -1836
24 29277 30075 -798
25 30079 30043 36
26 30437 29938 499
27 30381 29738 643
28 30108 29419 689
29 29890 28990 900
30 29897 28503 1394
31 30132 28023 2109
32 30469 27681 2788
33 30797 27611 3186
34 30911 27923 2988
35 30898 28550 2348
36 30826 29357 1469
37 30711 30123 588
38 30526 30638 -112
39 30311 30766 -455
40 29969 30555 -586
41 29587 30045 -458
42 29244 29412 -168
43 28972 28831 141
44 28767 28403 364
```

45 28545 28135 410
46 28265 27983 282
47 27966 27901 65
48 27774 27898 -124
49 27835 28033 -198
50 28229 28391 -162
51 28900 28963 -63
52 29666 29655 11
53 30317 30307 10
54 30710 30749 -39
55 30839 30906 -67
56 30777 30843 -66
57 30663 30708 -45
58 30607 30650 -43
59 30642 30749 -107
60 30770 30971 -201
61 30939 31185 -246
62 31111 31270 -159
63 31235 31173 62
64 31274 30934 340
65 31168 30596 572
66 30950 30378 572
67 30671 30283 388
68 30427 30325 102
69 30325 30476 -151
70 30405 30697 -292
71 30583 30884 -301
72 30884 31103 -219
73 31138 31263 -125
74 31260 31317 -57
75 31216 31280 -64
76 31052 31162 -110
77 30832 31005 -173
78 30646 30845 -199
79 30347 30497 -150
80 7327 7142 185
81 5220 5152 68
82 5679 5586 93
83 6244 6118 126
84 8491 8333 158
85 9145 8971 174
86 9533 9353 180
87 9848 9657 191
88 10101 9900 201
89 10304 10088 216
90 10473 10227 246
91 10625 10348 277
92 10757 10448 309
93 10881 10533 348
94 10991 10612 379
95 11076 10670 406
96 11126 10709 417
End of ADC data

## A2.3 PLOT WINDOW IMAGE FILE

This file is a screen-shot of the Plot window in bit-map (.bmp) format. A typical example is shown below.

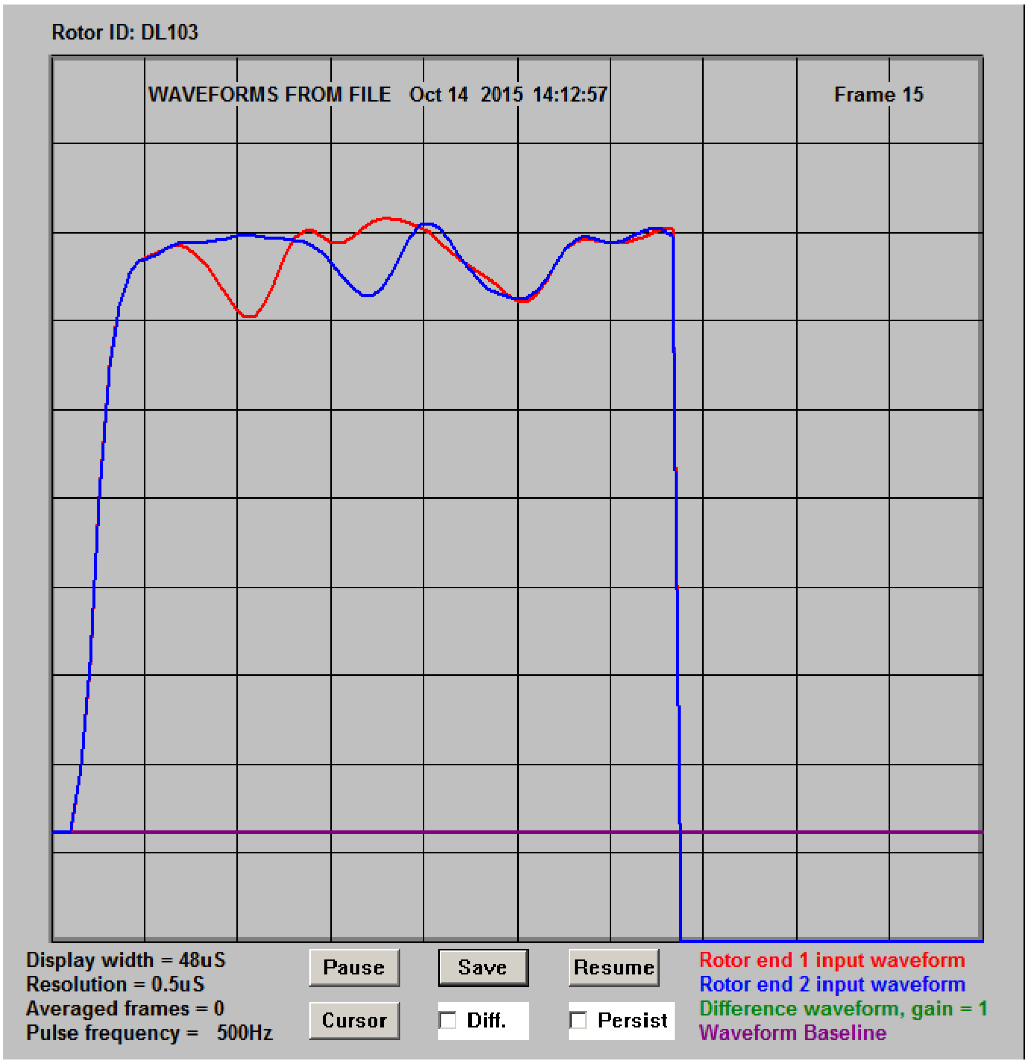



**Figure A2.3.1 Typical Plot window image file**

The .bmp files can be viewed using a suitable image display program such as **Irfanview**.

## A2.4 VIEWING TYPE 1 DATA FILES

Data files generated using the TDRPlotv1.0 software do not contain a header section containing the control parameters. The simplest way to view the data from these files is to generate a dummy data file using the TDRPlot software and then use a text-editor to replace the data section in this dummy file with the data from the type 1.0 file. This modified file can then be saved and read into the TDRPlot program in the normal way. The control data in the **Control window** will be incorrect, but can be editted manually if the settings used to produce the original data file are known.

## APPENDIX 3

## IMPORTING THE OUTPUT DATA INTO A SPREADSHEET

Basic information describing how to import data from a **TDRPlot output text file** into **Excel** is given below.

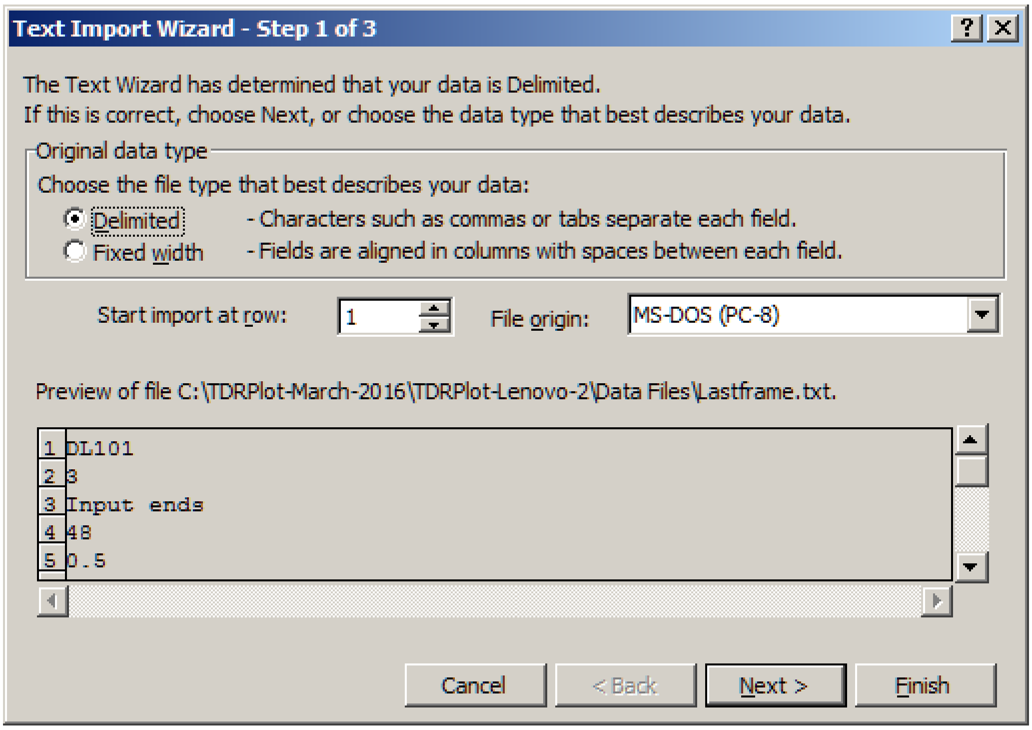
Open Excel

File > Open

Browse for eg **Lastframe.txt** file

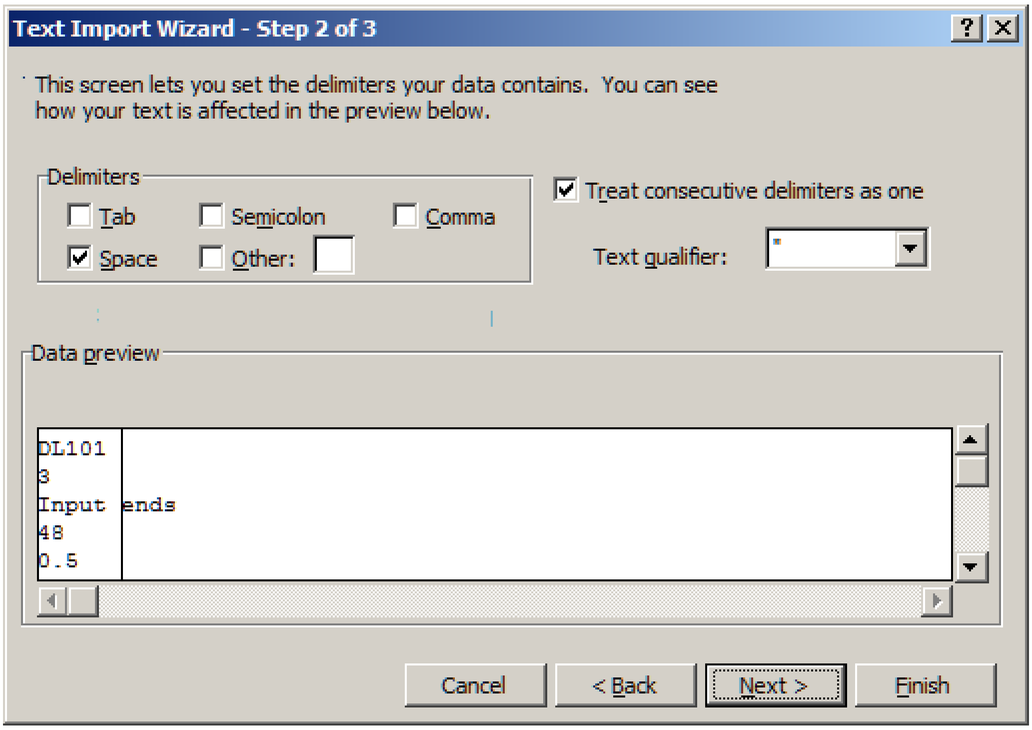
Open file

Text import wizard window 1 opens

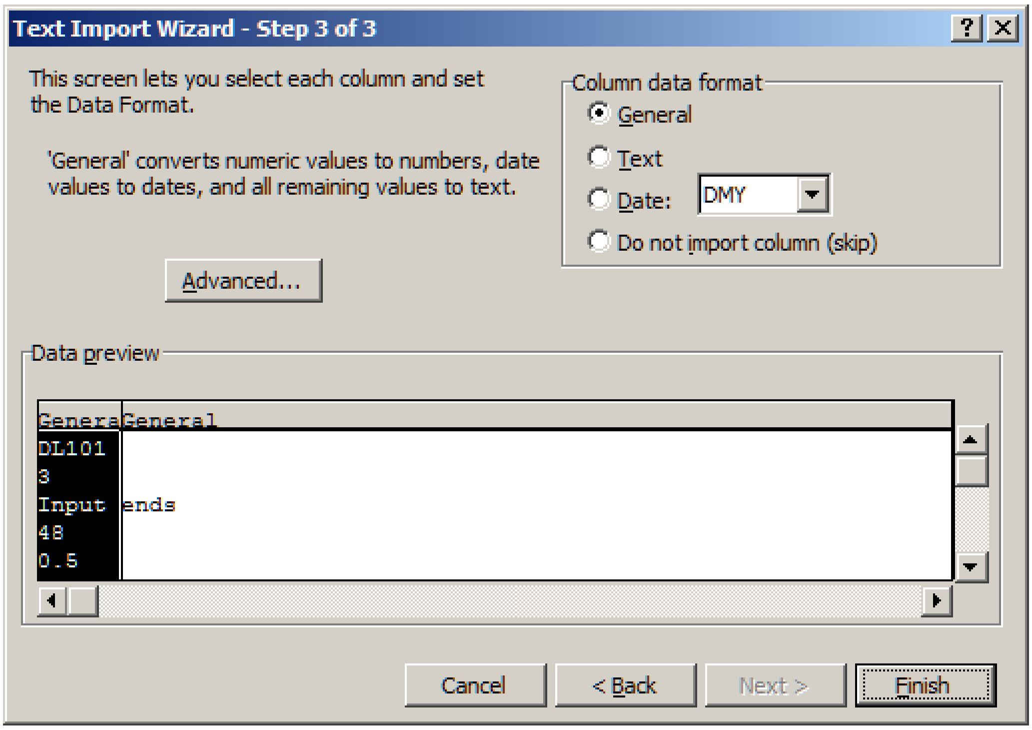



Click **Next**

Text import wizard window 2 opens

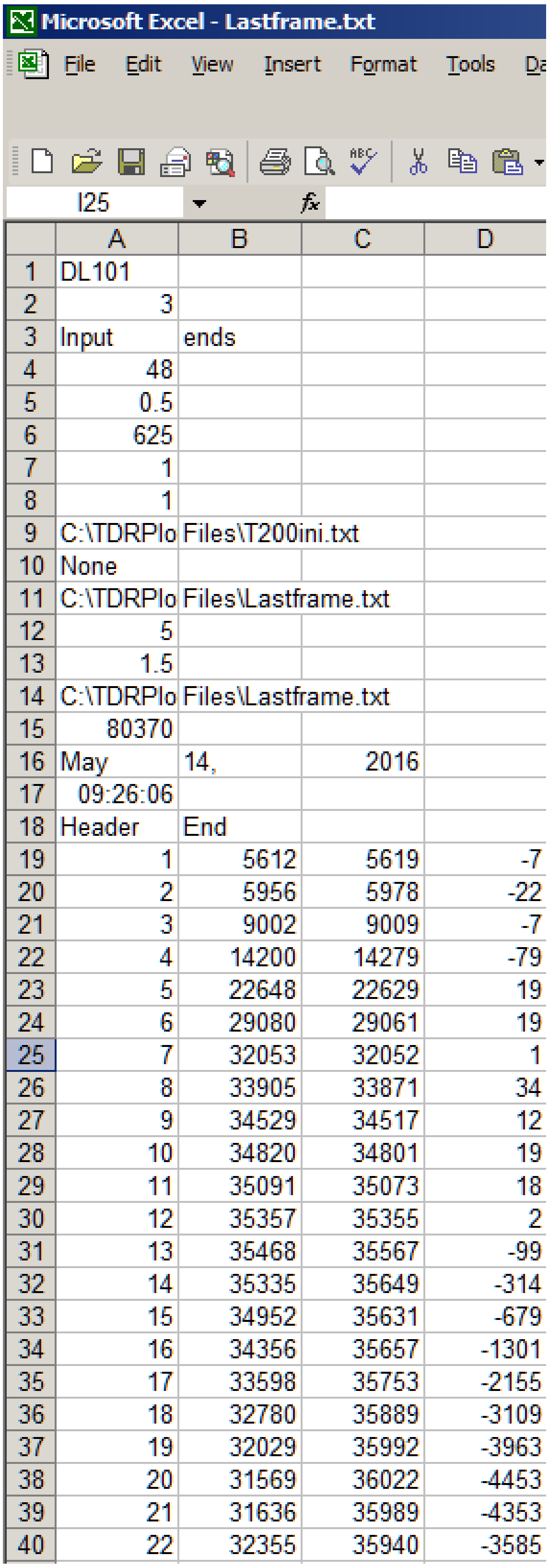



Select **Space** delimiter and click Next



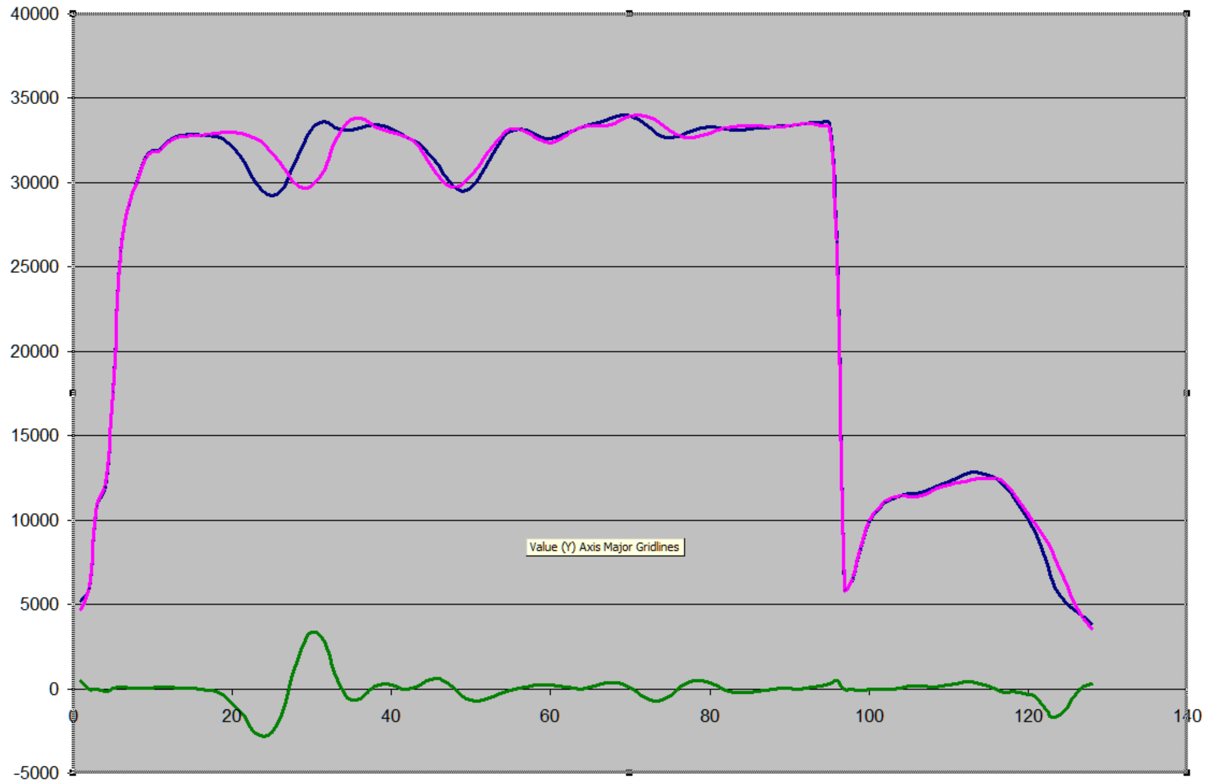

Select **General** option for column data format then click **Finish**.

The data is imported to the spreadsheet. A typical example is shown below, where the first 18 lines contain header data and the remaining lines of data can be used to plot graphs etc.




| | A | B | C | D |
|---|---|---|---|---|
| 1 | DL101 | | | |
| 2 | 3 | | | |
| 3 | Input | ends | | |
| 4 | 48 | | | |
| 5 | 0.5 | | | |
| 6 | 625 | | | |
| 7 | 1 | | | |
| 8 | 1 | | | |
| 9 | C:\TDRPlo | Files\T200ini.txt | | |
| 10 | None | | | |
| 11 | C:\TDRPlo | Files\Lastframe.txt | | |
| 12 | 5 | | | |
| 13 | 1.5 | | | |
| 14 | C:\TDRPlo | Files\Lastframe.txt | | |
| 15 | 80370 | | | |
| 16 | May | 14, | 2016 | |
| 17 | 09:26:06 | | | |
| 18 | Header | End | | |
| 19 | 1 | 5612 | 5619 | -7 |
| 20 | 2 | 5956 | 5978 | -22 |
| 21 | 3 | 9002 | 9009 | -7 |
| 22 | 4 | 14200 | 14279 | -79 |
| 23 | 5 | 22648 | 22629 | 19 |
| 24 | 6 | 29080 | 29061 | 19 |
| 25 | 7 | 32053 | 32052 | 1 |
| 26 | 8 | 33905 | 33871 | 34 |
| 27 | 9 | 34529 | 34517 | 12 |
| 28 | 10 | 34820 | 34801 | 19 |
| 29 | 11 | 35091 | 35073 | 18 |
| 30 | 12 | 35357 | 35355 | 2 |
| 31 | 13 | 35468 | 35567 | -99 |
| 32 | 14 | 35335 | 35649 | -314 |
| 33 | 15 | 34952 | 35631 | -679 |
| 34 | 16 | 34356 | 35657 | -1301 |
| 35 | 17 | 33598 | 35753 | -2155 |
| 36 | 18 | 32780 | 35889 | -3109 |
| 37 | 19 | 32029 | 35992 | -3963 |
| 38 | 20 | 31569 | 36022 | -4453 |
| 39 | 21 | 31636 | 35989 | -4353 |
| 40 | 22 | 32355 | 35940 | -3585 |

A simple **Excel graph plot of RSO data** is shown below.



## APPENDIX 4

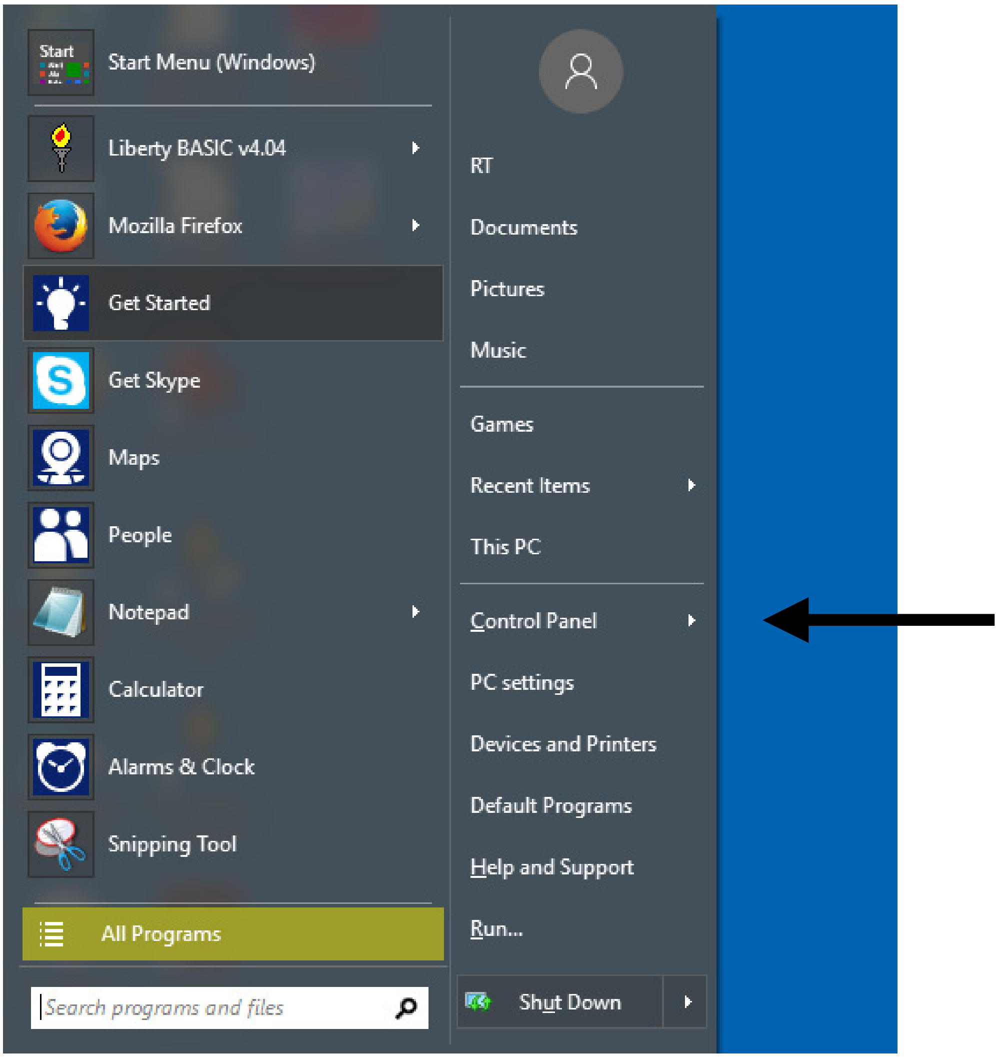
### A4.1 FINDING THE PC COMPORT NUMBER

### (WINDOWS 10 with Classic Shell)

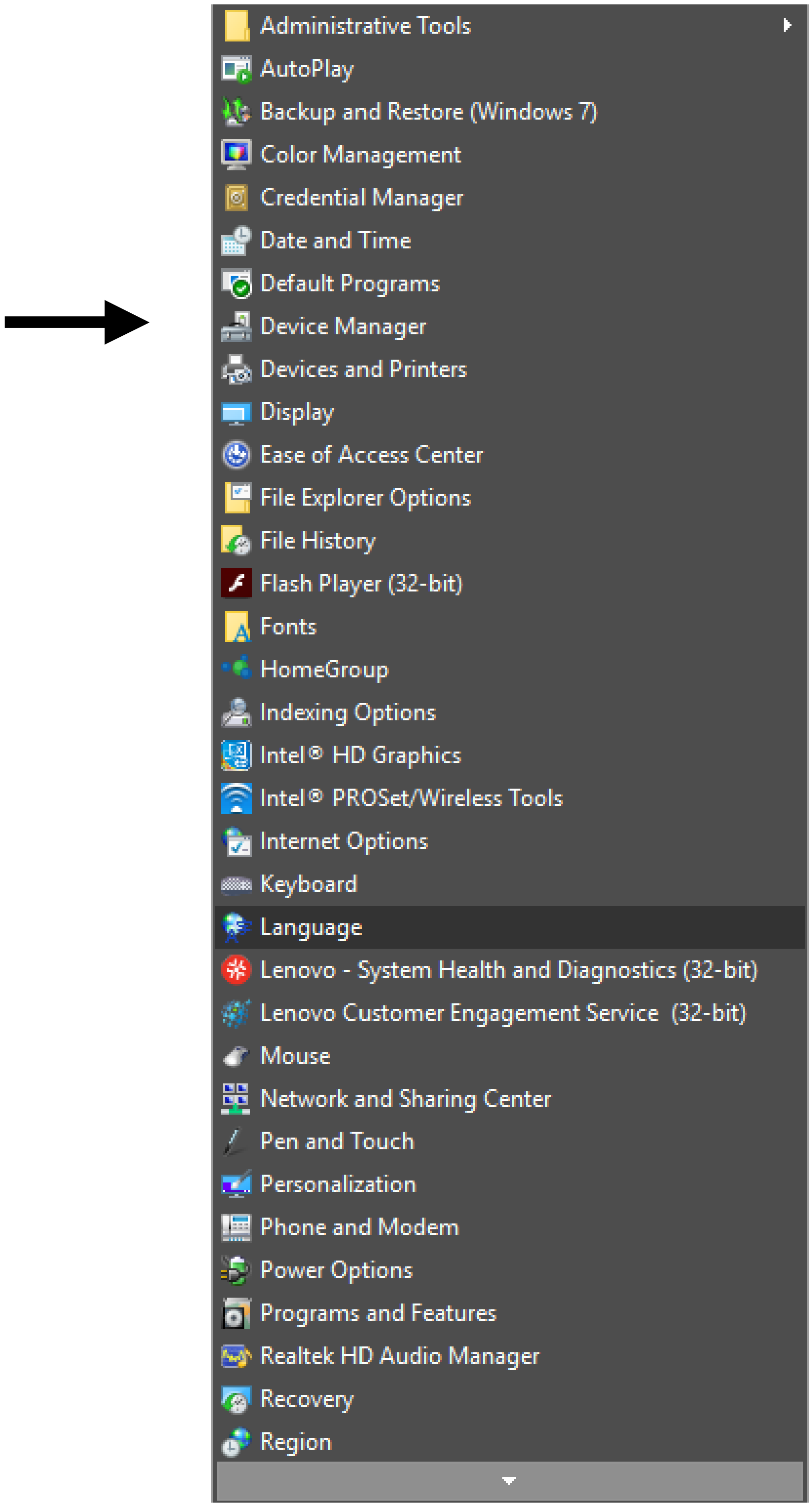
Connect the **Reflectometer** to the **PC** via the **USB cable** and switch it on.

Click on the **PC Start button**

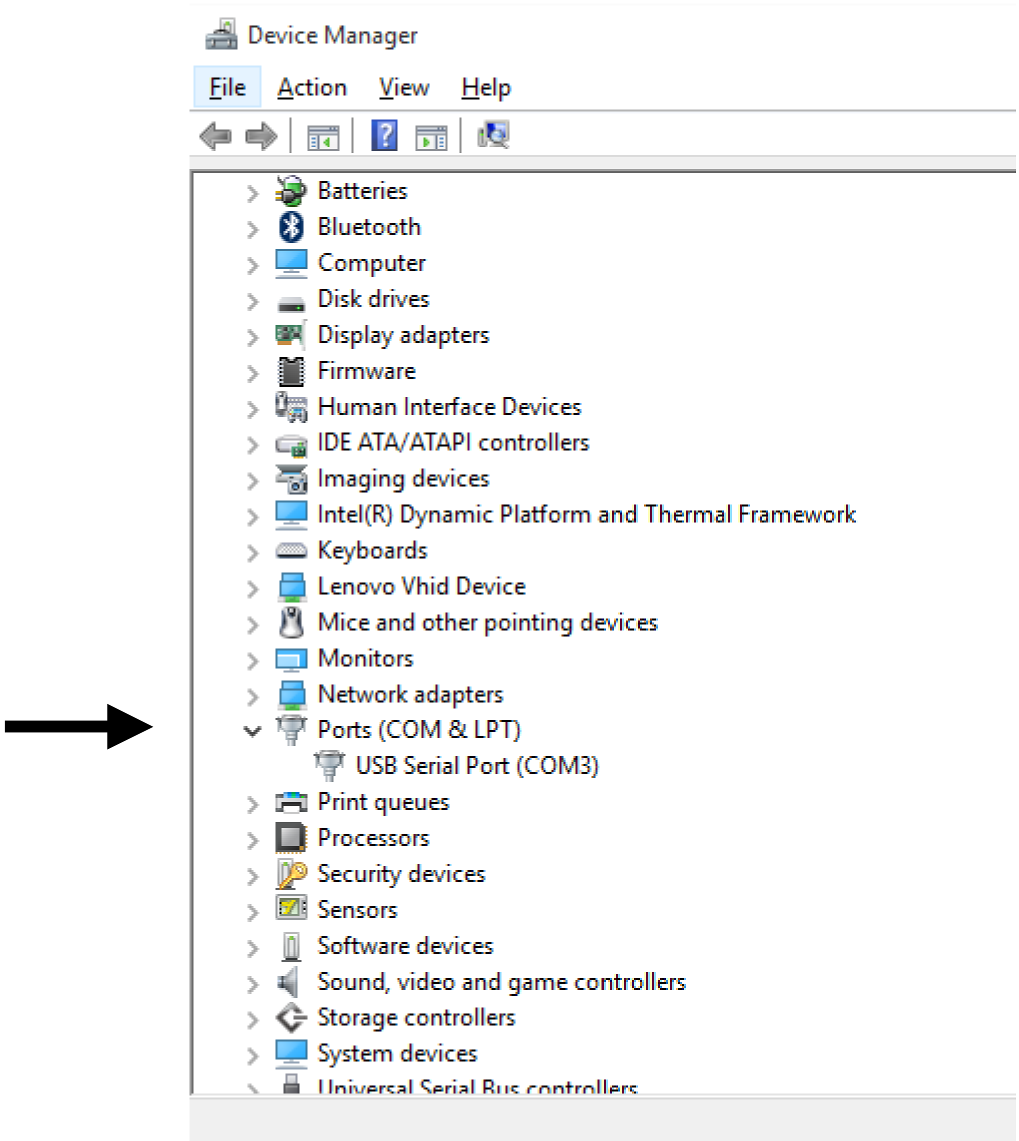
The **Start menu** shown below appears



Select the **Control Panel** option. A new window appears as shown below.



Select the **Device Manager** option. The following window is then displayed.




Then expand the Ports (COM & LPT) option by clicking on the > arrow. The list of com ports in use is displayed.

If only one port is shown, as in the case above) this is the comport number in current use ( **COM3**).

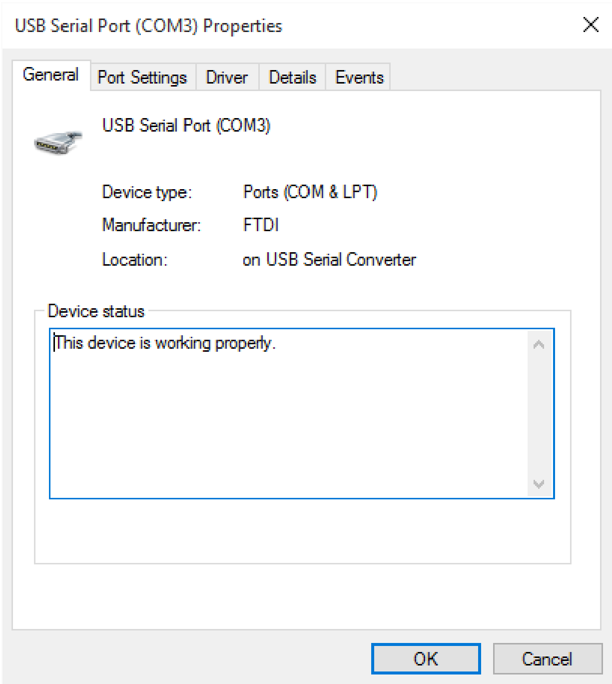
This number should be entered in the comport parameter box in the **TDRPlot Control window.**

.

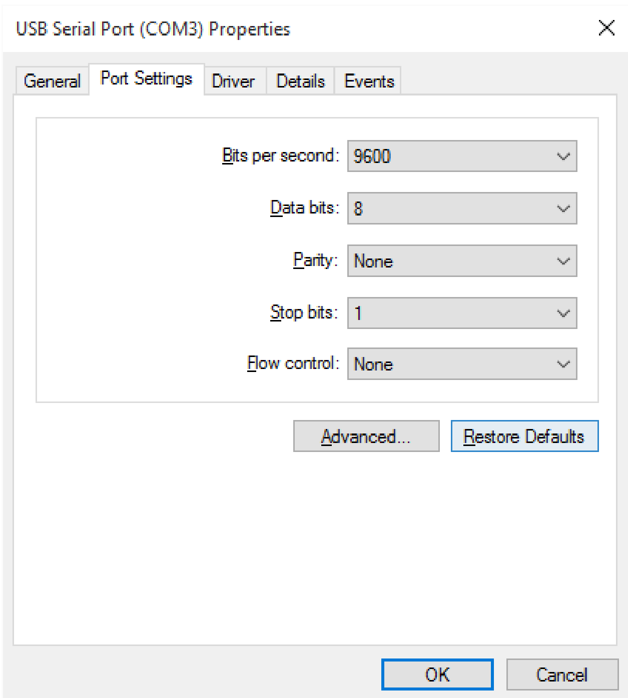
## A4.2 CHANGING THE COMPORT NUMBER

If necessary, it is possible to change the allocated **COM port number** as follows:

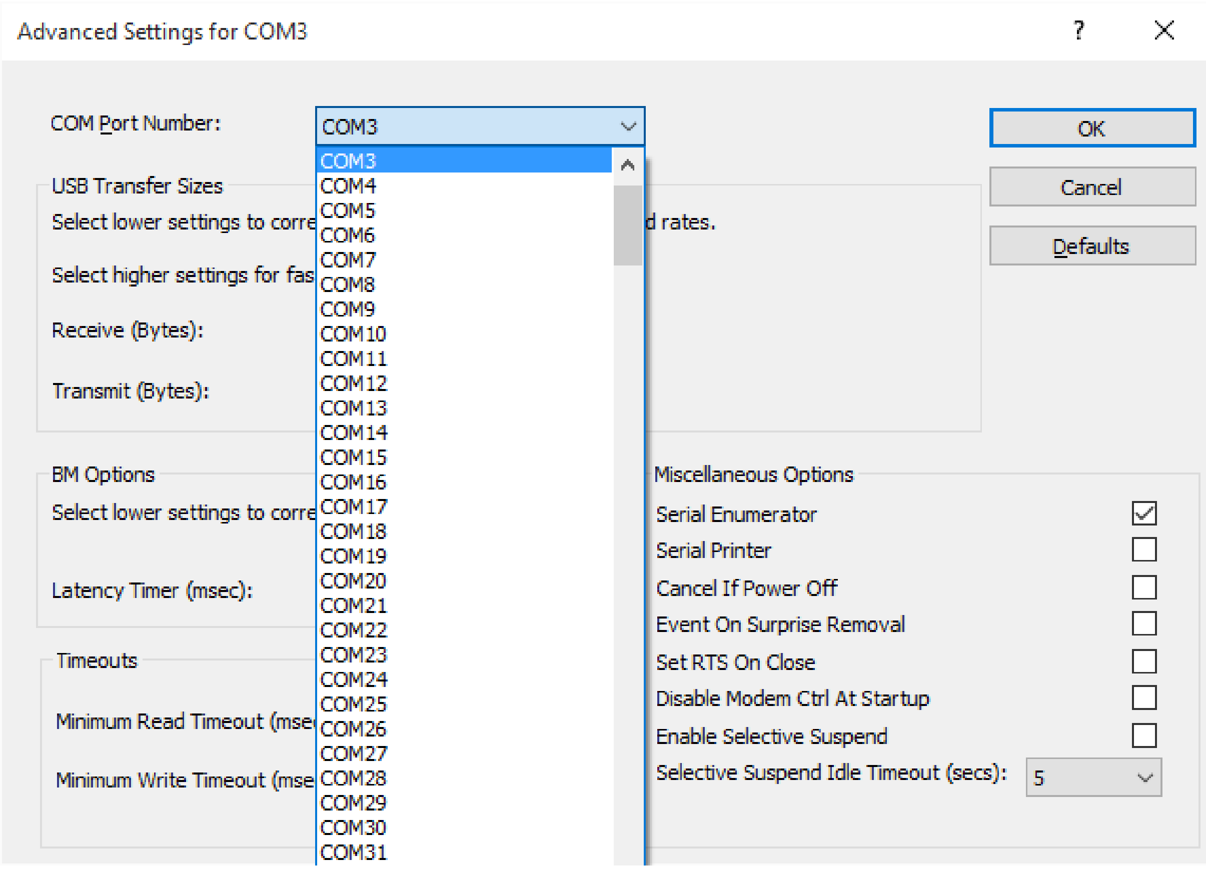
In the **Device Manager** window (see above) right-click the **USB Serial Device** and select **Properties.**




Then select the **Port Settings** Tab.



Now click on the **Advanced** button and click on the drop-down menu arrow next to the **COM Port Number** box. The list of available COM Port numbers appears




.

Select the required port number and clock OK.

**Important Note:** Do not change any of the other parameters in this window.

# APPENDIX 5

## SOFTWARE INSTALLATION AND INITIALISATION (New PC only)

### A5.1 SOFTWARE INSTALLATION

The **TDR200** instruments are suplied with a custom **Control Laptop PC** with pre-installed software. No further software installation is required other than posted upgrades. Note that the **TDRPlot** software is copy-protected and will only run on the PC to which it has been installed. If the software is to be installed on an additional PC, this will require an **unlock code** to be obtained for each new PC.

### A5.2 INSTALLATION INSTRUCTIONS

1. If this software is to be **installed as an upgrade**, first rename your existing **TDRPlot** folder to the new name **TDRPlotv1.0** to avoid losing any existing data files etc. Note that version 2 data files have a different format from those in version 1.

2. Copy the folder named **TDRPlot** from the **software CD or USB memory Stick** to the **C\: folder** on the PC.

4. Open the **TDRPlot** folder and then open the **Program files** sub-folder.

5. Make a shortcut to the **TDRPlot.exe** file and move this shortcut to the **PC Desktop**.

6. Close the **TDRPlot** folder.

7. Make a shortcut to the **TDRPlot** folder.

8. Change the 2 **new shortcut icons** to the default versions. These can be found in the C:\TDRPlot\Program files\icons folder.

### A5.3 FTD DRIVERS

Install the FTD serial port drivers as follows:

Open the **C:\TDRPlot\Program files\FTD\Virtual Com Port** folder.

Run the **CDM20814_Setup.exe** file.

This will install the required driver files.

### A5.4 COM PORT NUMBER

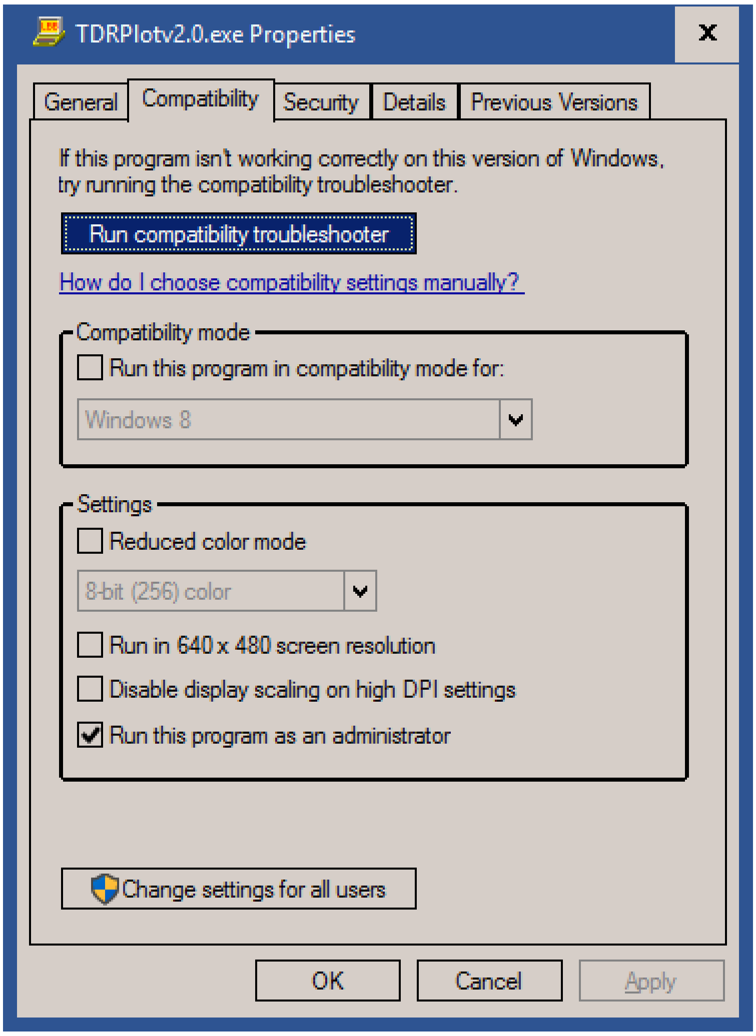
Carry out the instructions listed in **Appendix 4** to establish the number of the communications port in use on the **Control PC**.

### A5.5. PROGRAM COMPATIBILITY SETTINGS

The programs **TDRPlot.exe** and **Usercode.exe** must be set to "**Run as administrator**" mode. For each program above, this is done as follows:

Right click on the required .exe file in the **Programs sub-folder** and click on the **Properties** option.

When a new window appears, click on the **Compatibility** tab




Click on the "**Run this program as an administrator**" option in the **Settings** box.

Click **OK** to exit the window.

The **TDRPlot software** can now be run by double-clicking on the **TDRPlot shortcut icon**. However, it will be necessary to obtain an **Unlock code** as described in Appendix 6 before the software can be used for each new PC.

## A5.6 SETTING UP WINDOWS 10

The following modifications have been made to the **Windows setup** on the Laptop PC supplied with the **TDR200** system:

### 1. Change to standard Desktop view by default

By default **Windows 10** boots to the **Tiles screen**, which is optimised for consumer use. It is preferable for the PC to boot to the normal **Windows Desktop** for commercial use and this can be done by installing the free **Classic Shell** program. This has been included and can be installed by running the **Setup** file in the **Classic Shell sub-folder** within the TDRPlot **Program files** folder.

### 2. Set the Classic screen Theme.

A close approximation to the **Classic Windows** theme, which gives a high-contrast-type display, can be implemented by copying the file **classic.theme** (located in the **Classic Shell** sub-folder) to the **C:\Windows\Resources\Ease of Access Themes** folder. Then right click on the **Desktop window** > **Personalise** and select the **Classic Theme** option.

Note that this theme may not work correctly for all programs (eg Libre Office). In this case, users can easily switch back to a standard **Windows 10 theme** by right-clicking on the **Windows Desktop,** selecting the **Personalise** option and then selecting another Theme.

### 3. **Disable Hot Keys** (to stop accidental screen rotation (ALT + arrow keys)).

Right click on Desktop > Graphics Options > Hot Keys > Disable

### 4. Set Default applications for file types

This allows files to be opened with a specific program by double-clicking on the file name.

**Start button > Control Panel >Default Programs >**

**Associate a file type or protocol with a program**

Now click on the required file extension type and select the program you want to use to open the file.

**5. The following additional programs have been installed**

Libre Office (for editting text files)

Irfanview (for viewing image files)

Firefox (internet browser)

Foxit Reader (for viewing pdf files)

**6. User account settings.**

The following changes need to be made in the User Acount Settings section of the Control panel to allow the TDRPlot program to run without generating a security query:

Control Panel > User Acounts > Change user account control settings >

Now set the vertical slider to the **Never notify** setting.

If this change is not made, the PC will always ask permission before running the TDRPlot program.

# APPENDIX 6

## UNLOCKING THE TDRPLOT PROGRAM

The **TDRPlot** software is copy-protected and will only run on the PC to which it has been installed. If the software is to be installed on an additional PC, this will require an **Unlock code** to be obtained for each new PC.

Please note that the PC containing the **TDRPlot** software must contain a standard **mechanical** (not solid-state) hard disk drive.

Authorised users can obtain an **Unlockcode.txt** file by running the program **Usercode.exe**, which writes a usercode to the file **Usercode.txt**. This file must be emailed to **Rowtest** who will email back a file with the name **Unlockcode.txt**. This file must be copied to the **Program files** folder before the **TDRPlot** software can be run.

The detailed unlock procedure is as follows:

1. Install the **TDRPlo**t software to a new PC as described in **Appendix 5**.

2. Follow the instructions in **Appendix 5.5** and then run the program **Usercode.exe** in the **Programs** subfolder.

This will generate a text file with the name **Usercode.txt**. in the **Programs** sub-folder.

3. Email this file (**Usercode.txt**), together with the **serial number of the TDR200 unit** (on the rear panel) and your **full contact details** to enquiries@rowtest.com.

4. The unlock file **Unlockcode.txt** will be sent to you by return email (usually within 24 hours).

5. Copy **Unlockcode.txt** to the Programs sub-folder.

The **TDRPlot** program should now run correctly on the specified PC.