

OPERATION MANUAL Resonance Mini DOAS Spectrometer

Model # RMD I

October 2005

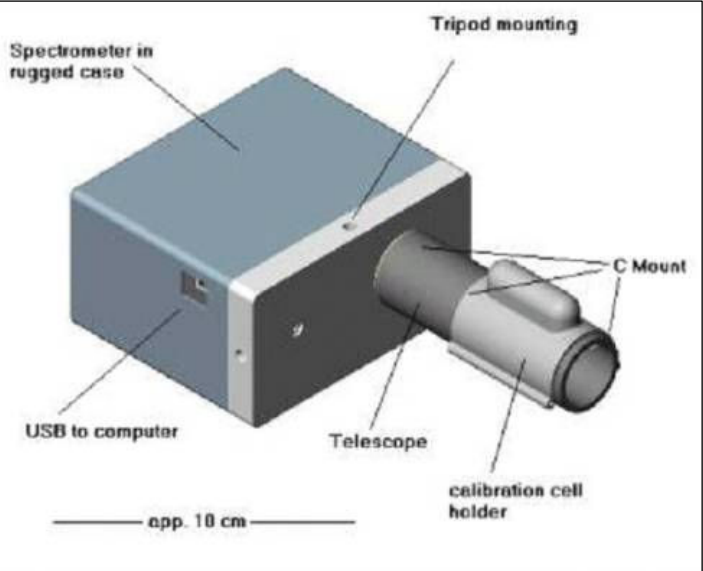


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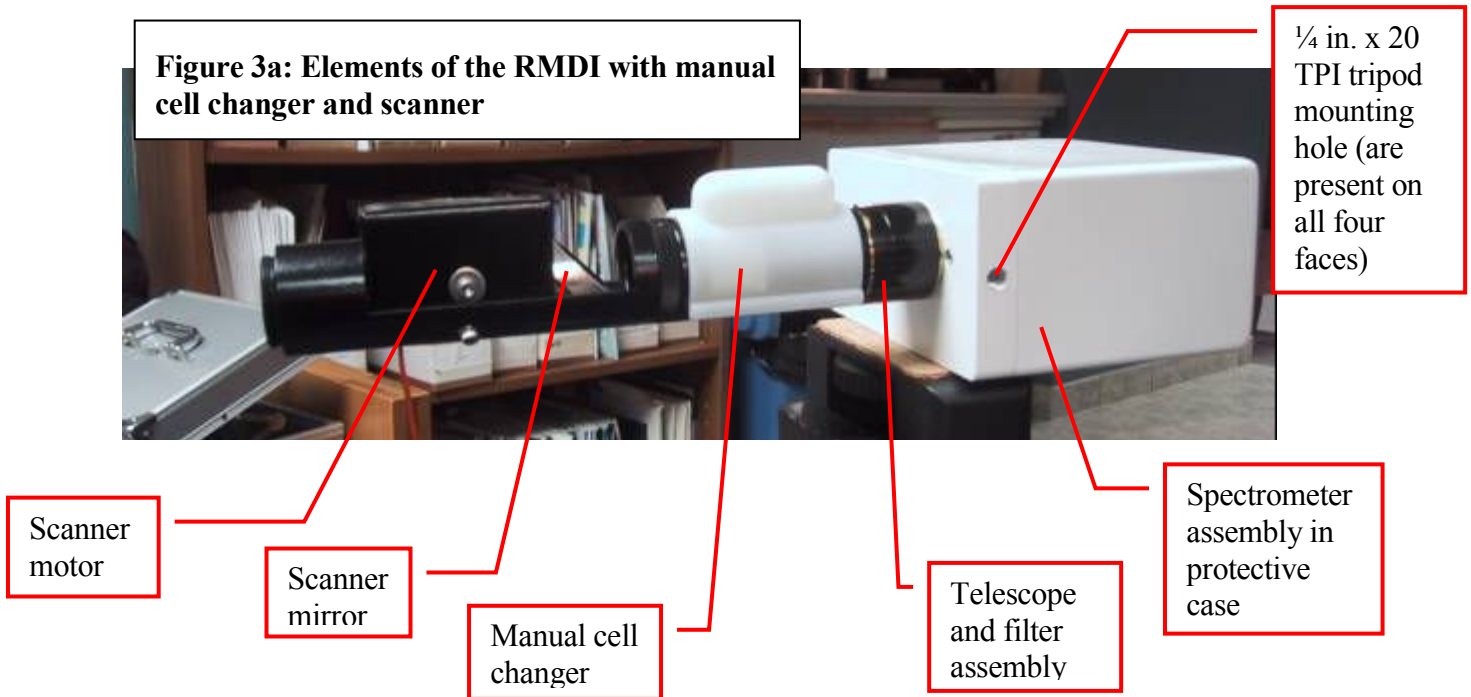
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1. GENERAL INFORMATION

RMDI is a compact UV/visible spectrometer system designed for remote sensing of atmospheric gases. It employs a miniature CCD array spectrometer, which recovers a spectrum from 280 to 420 nm and is small enough to be readily backpacked into remote locations for volcanic plume characterization. RMDI consumes so little energy that it is completely powered by USB connection to a laptop computer. The system, designed for volcanic gas monitoring, is normally supplied with SO₂ and/or NO₂ calibration cells with cell holder, a laptop computer with installed software, calibrations and a miniature tripod.

Analysis software uses a script file compatible with Ocean Optics' OOIBase32 software. RMDI is also compatible with DOASIS University of Heidelberg, which can be downloaded from their website. The figures on the cover page show RMDI with laptop in use at the Tungurahua volcano in Ecuador.

The elements of RMDI optical assembly are shown in Figures 3a and 3b below:



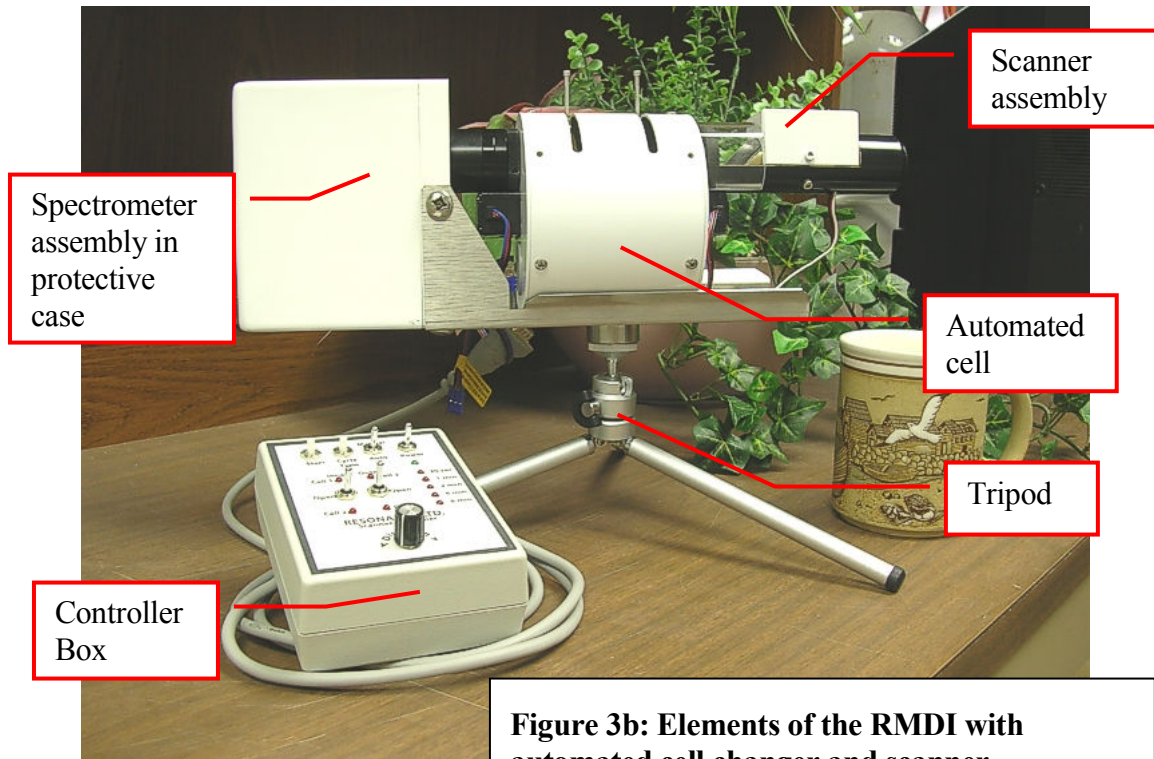


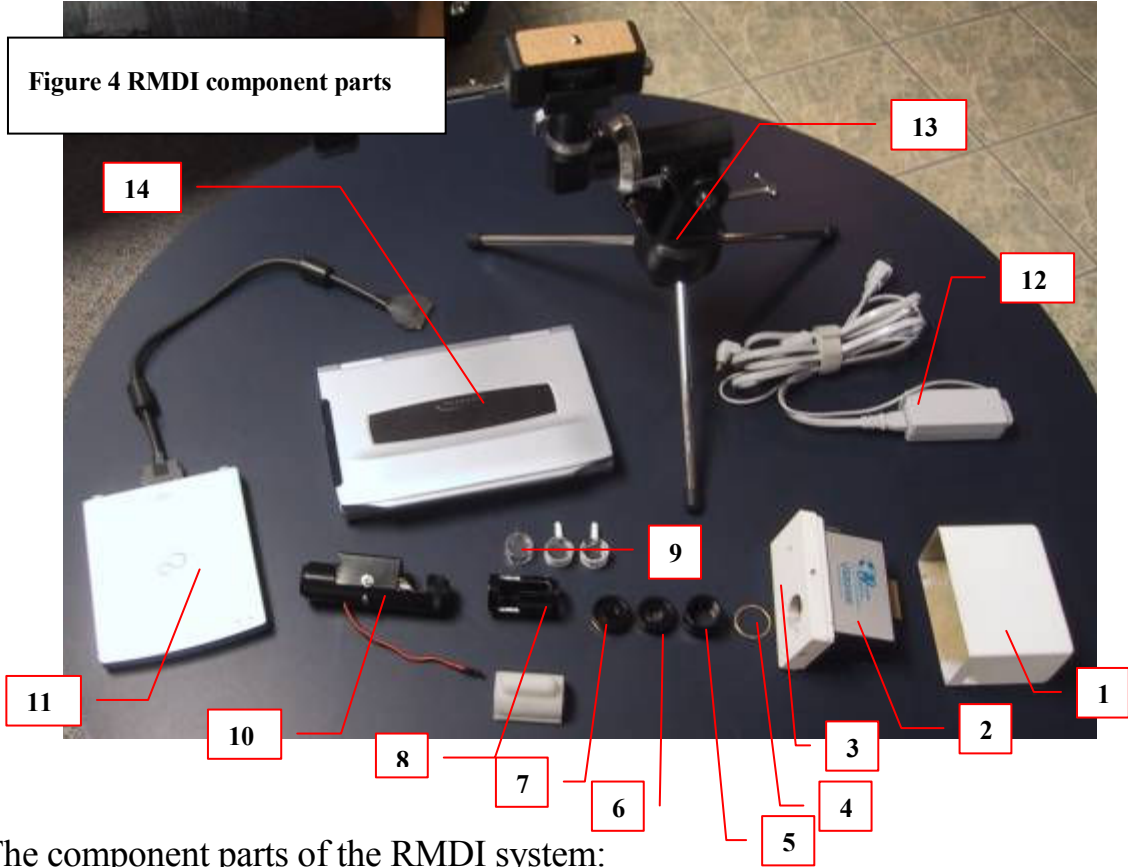
Figure 3b: Elements of the RMDI with automated cell changer and scanner

RMDI can be positioned in any orientation to look directly at the sky along the telescope axis or through a right angle turn using the optional scanner. Four mounting holes in the spectrometer assembly case (Fig. 3a) are provided to attach to any standard lightweight tripod. The optical scanner can also be used to select the look direction with a scanner.

2. SPECIFICATIONS

2.1. Component Parts

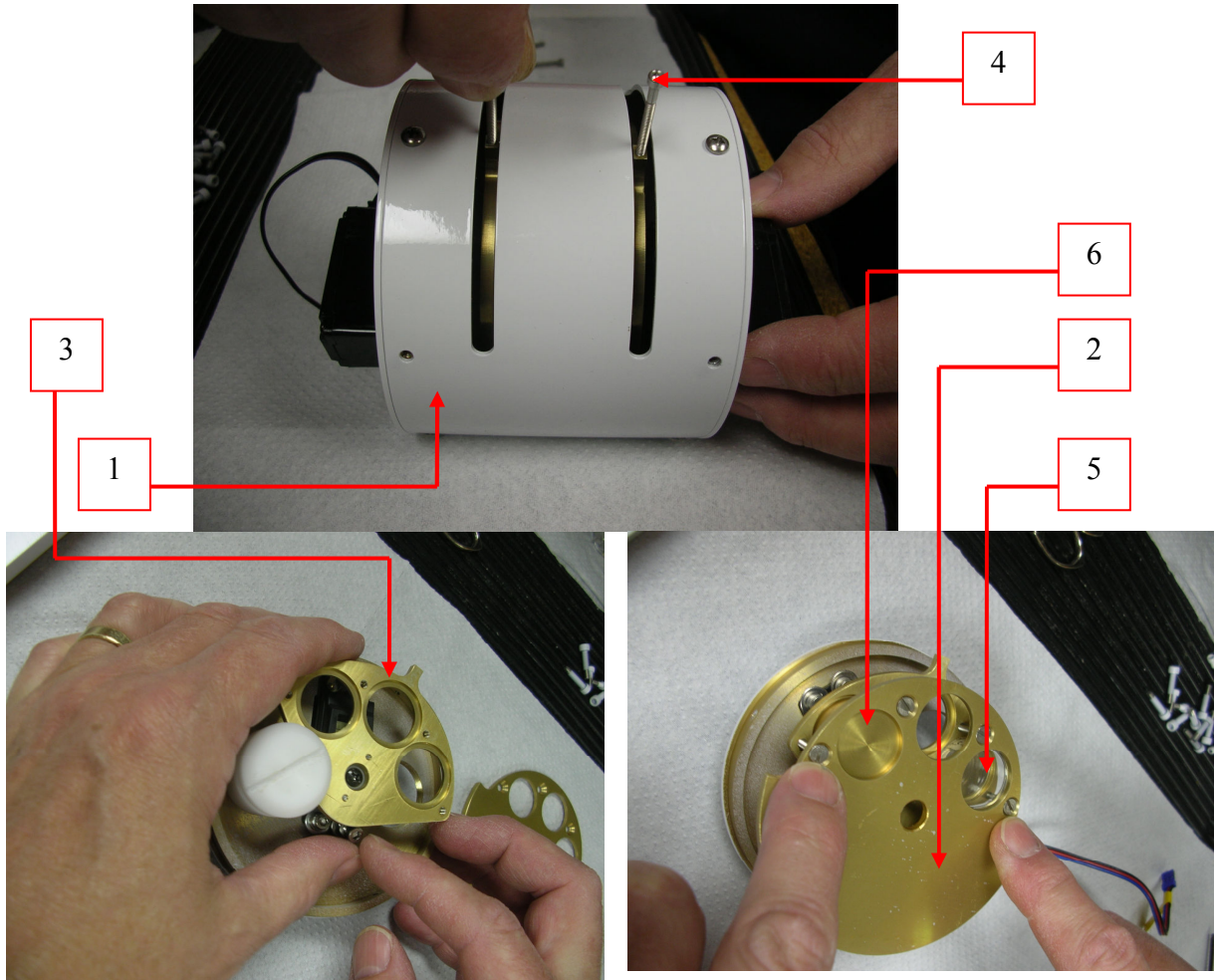
2.1.2. RMDI Components



The component parts of the RMDI system:

- (1) Spectrometer protective housing, **(when used with automated scanner or cell changer, 6 AA batteries are housed inside and can be replaced when necessary)**
- (2) Ocean Optics USB 2000 spectrometer,
- (3) Spectrometer mounting flange,
- (4) Spacer for the telescope tube,
- (5) Telescope tube,
- (6) Telescope lens in C mount holder,
- (7) UV blocking filter in C mount holder **(NOT USED WITH NO₂ CELLS, AS WILL INTERFERE WITH NO₂ SPECTRA)**
- (8) Calibration cell holder and cover
- (9) Calibration cells
- (10) Scanning mirror assembly
- (11) Palmtop computer CD drive
- (12) RMDI palm top computer AC power supply
- (13) RMDI mini tripod
- (14) RMDI palmtop computer.

2.1.2. Cell Changer Components



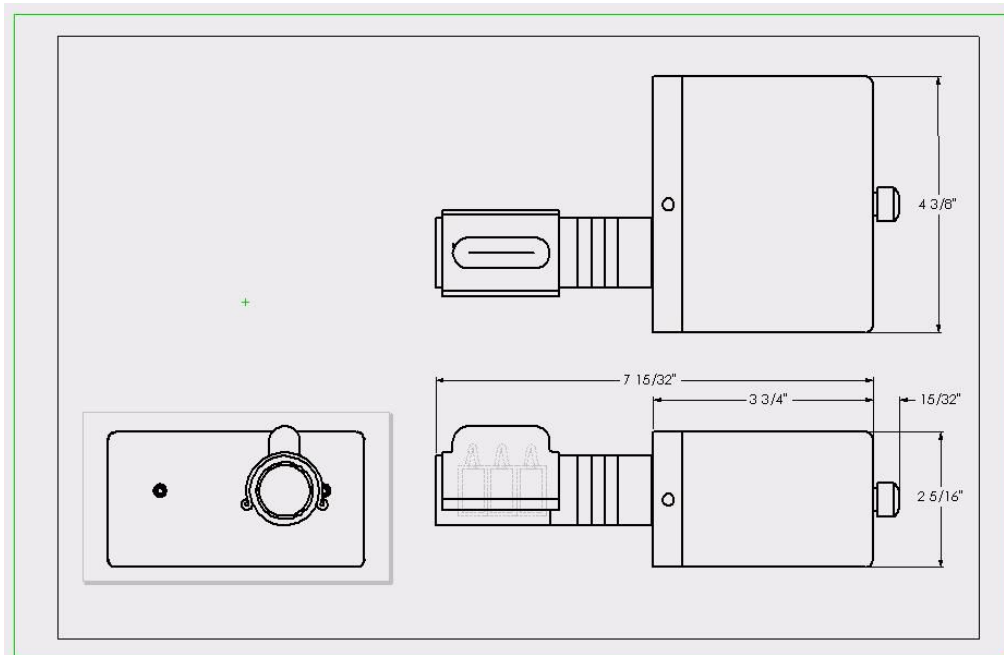
The component parts of the Cell Changer:

- (1) Cylindrical Body
- (2) Cell Face Plates
- (3) Cell Mounts
- (4) Position Indicators
- (5) Cells
- (6) Blanks

2.2. Physical Specifications

Interface to computer	
The spectrometer includes a plug-and-play high-speed analog to digital converter with USB interface to control the linear CCD detector. This interface provides full control of the CCD detector and allows 12-bit data acquisition. It is powered by the USB line and provides all the power and control lines to the CCD detector.	
Dimensions of spectrometer	3.75" w x 4.375" d x 2.3" h (9.5 x 11.1 x 5.8 cm)
Dimensions of telescope with VIS blocking filter and cell holder	3.75 x 1.5 inches
Gas cells supplied with unit	Typically 3 SO ₂ cells allowing 7 points of calibration
Weight	Less than 1 kg (not including laptop)
Tripod	Mini tripod
Tripod interface	4 ¼ 20 tpi threaded blind holes
Interface Cable	USB cable (can be 5 meters long)
Power requirements	Draws 0.45 W power from PC through USB
Software supplied	OOIBase32 (Ocean Optics), OO Script (Resonance)
Available software	DOASIS from U of Heidelberg (freeware download)

2.3. Mechanical Drawing



2.4. Electrical Specifications

Electrical /Optical Specifications:				
Specification	Min	Typ	Max	Units
Standard Telescope field of view	-	2	-	degrees
Spectral resolution	-	0.4	-	nm
Sensitivity for SO ₂ (zenith sky 1 sec.)	5 (noon)	10	30 (twilight)	ppm-m
Spectral range 2400 l/mm gtg (with visible spectrum blocking filter)	-	295 to 380	-	nm
Spectral. range 2400 l/mm gtg (no filter)	-	295 to 437	-	nm
Integration time	0.03	0.1	10	seconds
Sensitivity	-	90	-	Photons per A/D count
Full scale	-	4095	-	A/D counts
Max.signal to noise for one average	-	250	-	-
Dark noise	-	2.5	-	RMS counts
Corrected linearity	-	99.8	-	%

3. GETTING STARTED

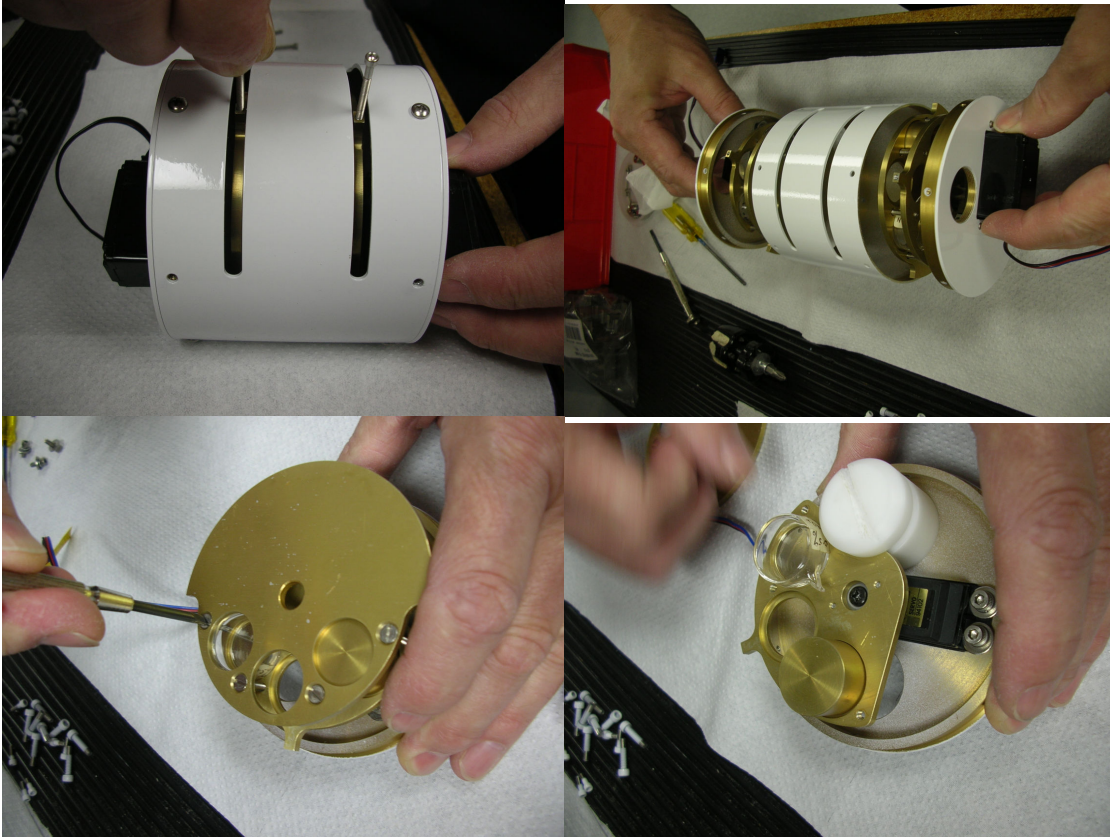
3.1. Assembly of RMDI

Assembly of RMDI is carried out by first securing the spectrometer protective housing onto the spectrometer with the rear captive nut. The telescope and calibration subassembly can be assembled by carefully screwing parts (5), (6), (7) and (8) together. If you have purchased a Cell Changer, it takes the place of part (8) cell holder. Read section 3.2. for instructions on assembly/disassembly of the Cell Changer. Once this is assembled it can be attached to the spectrometer mounting flange (3) by placing the spacer rings (4) over the threaded projection and gently screwing the assembly into the mounting flange (3). **If the threaded pieces bind or jam during threading process do not force threads. The piece may be loosened by applying about 10 drops of isopropyl alcohol to the bottom of the thread. After capillary action has drawn the liquid up into the thread the piece may be unscrewed.**

Depending on the orientation of RMDI it may be desirable to rotate the calibration cell holder (8) so that the slot for the cells faces upwards. Spacers can be inserted to allow one to lock the assembly in this orientation (spacers are provided to allow orientation of the slot facing upwards on RMDI set up on a typical tripod). Once the scanner assembly is coupled to the telescope the whole RMDI assembly can be coupled to the tripod.

Connecting RMDI to the electronics involves plugging the USB cable into the computer and into the USB connector receptacle on the small face of the RMDI protective cover, as well as plugging the flying lead into the scanner controller hand module.

3.2. Disassembly of Cell Changer



- i. Remove the cell position indicating screws.
- ii. Remove the screws from the cylindrical body of the cell changer.
- iii. Carefully remove each end of the cell changer from the cylindrical body.
- iv. Remove the screws from each cell face plate. Carefully remove the face plate.
- v. When placing a cell in a selected holder, note which cell position holds which cell and arrange them radially so that the cell-stem points toward the axis of rotation.
- vi. When all cells and blanks have been placed, replace the cell face plate and fasten into place.
- vii. Replace the ends into the cylindrical body and replace all screws.
- viii. Attach the cell changer to the front of the RMDI between the UV blocking filter (Figure 4, part 7) and scanning mirror assembly (Figure 4, part 10).
- ix. Connect electrical leads to the Scanner Controller box.

3.3. Checking for spectrometer/spectral acquisition functionality

To verify the function of RMDI:

Plug the RMDI USB cable into the computer and RMDI then start the Ocean Optics OOIBase32 program. This program is delivered with extensive help files, which serve as an instruction manual for operation. After about a minute the program will be ready for acquiring the spectrum.

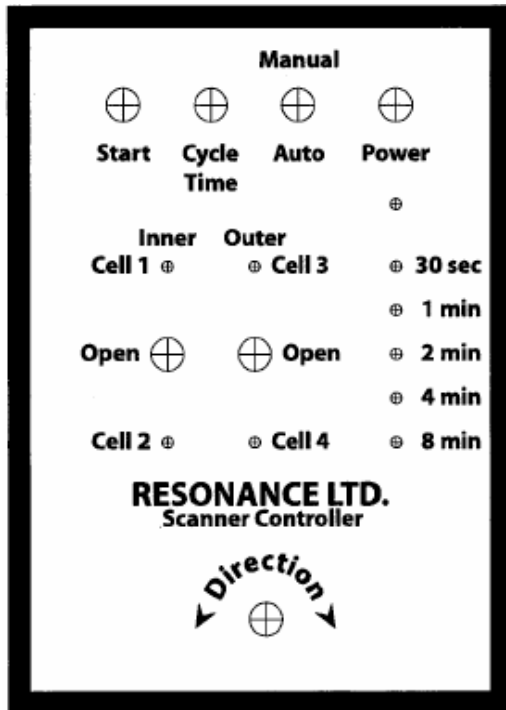
A quick way to verify operation is to point the spectrometer at a fluorescent light and view the spectrum. The spectrum should be similar to the illustration below (although the peaks might be at different heights).



4. OPERATING THE SCANNER CONTROL BOX

4.1. Standard Operation

The scanner provides a selectable scan rate of 120 degrees in 30 seconds, 1 min, 2 min, 4 min and 8 min intervals. The front panel of the scanner controller is pictured below (with cell changer option):



To scan automatically:

1. Set manual/auto switch to Auto.
2. Switch on power.
3. Select speed using cycle time button.
4. LED will light up next to speed selected.
5. Press start button to scan.
6. Scanner will begin immediately to scan back and forth.
7. To change speed switch off power and repeat 1 to 6.

To manually select mirror position:

1. Set manual/auto switch to Manual.
2. Switch on power.
3. Set mirror position with direction dial

4.2. Operation With Cell Changer

Before operating the scanner with cell changer, the set-up process must be performed. This set-up process is performed at the factory, however, it may become misaligned during shipment, at which point this procedure would be necessary. Misalignment can be seen by observing the position indicating screws and noting if they are aligned within 1mm of each other, at the center top of the cylindrical body:

Set-up Process:

1. Depress and hold down the cycle time switch
2. Turn on the power.
3. After 5 seconds, release the cycle time switch.
4. Using the direction knob, set the cell holder to center a clear hole (open cell) in the light path. Use the position indicating screw as a guide.
5. Press and release the cycle time switch.
6. Repeat steps 4 and 5 for the second open cell.
7. Press and release the cycle time switch.
8. Switch off the power.
9. Switch on the power to begin normal operation.

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Mini DOAS RMDI		RMDI system.doc

Normal Operation:

1. Set manual/auto switch to Auto.
2. Switch on power.
3. Press start button.
4. Select cell position by toggling switches to Cell 1, 2, 3, 4, Open or any combination.

To manually select cell position:




1. Set manual/auto switch to Manual.
2. Switch on power.
3. Use the position indicating screws to push the cells into place.

5. OPERATING THE SPECTROMETER WITH SOFTWARE

The operation of the RMDI requires the installation of the Ocean Optics and Resonance software. This is pre-installed and ready for operation.

5.1. Operating with Resonance Supplied Script File

Resonance provides a Sax Basic Script file for calculation, display and acquisition of SO₂ and/or NO₂ data. To operate this script:

1. Select the script to run by clicking on the  button or using the Script menu, then selecting Open and Execute Script from the drop down.
2. Select **ResonanceLtdRMDIsw.bas** (for use without UV filter) or **ResonanceLtdRMDIsw SO₂ only.bas** (for use with UV filter) from the directory C:\Program Files\Ocean Optics\OOIBase32 when prompted and click on Open. Exact file names may vary in more recent software versions. SO₂ and or NO₂ data are now being acquired and should begin to display. Use the  button to pause and the  button to stop acquisition, or use the Script menu. Refresh the spectral window after starting or stopping any script by maximizing or restoring it.

The software file is heavily commented and can be modified by the user. It is set up to measure the absorbance due to SO₂ and/or NO₂ at selected absorption peaks. For SO₂, these are centered on the absorption bands at 310.8, 313.1, and 315.4 nm. The absorbance at these bands is computed using the Beer Lambert equation:

$$pl\alpha = -\ln(I/I_0)$$

Where:

pl = the target gas (SO₂) concentration x path length (in ppm-m)
 α = the absorption coefficient of SO₂ at the chosen band in (ppm-m)⁻¹

1

I/I₀ = the transmission of the gas at the chosen band





I₀ is found by taking the average of the intensities at either side of the chosen band and I is found by taking the intensity at the band center. This simple method corresponds to the use of a simplified COSPEC mask. It is intended for evaluation purposes and as the instrument is perfected free upgrades on the mask (through macro uploads) will be provided.

3. When the script begins to run, SO₂ and/or NO₂ data will be acquired and saved to the default file **C:\DefaultSO2Data.txt**. To select a different file name/location, click on the SO₂ NO₂ Data menu (refresh your window if the menu is not visible), then Specify File and enter the desired file name/location when prompted. **NOTE: This file must have the extension .txt and no other.** For example, if you wished to store the data in a file called "Test1" in the "MyDocuments" folder on the C:\ drive, you would type "C:\MyDocuments\Test1.txt". The file name may be changed at any time during spectral acquisition.
4. Raw spectra may also be saved by using the save option in the Ocean Optics menu. Another way to automatically save spectra is by using the Time Acquisition menu item in the Ocean Optics menu. See the Ocean Optics Help files to assist using this module.
5. You may also want to modify the spectral acquisition settings. Generally, for outdoor observations, an integration time of 200 msec with 1 average (sky near noon) or up to 6 averages (sky near dusk or very cloudy) works best.

5.2. Calibrating the Instrument

Calibrations must be performed before each session and at least once every hour. This involves subtracting dark noise from the instrument, as well as gas cell calibrations. Calibrations must be repeated frequently due to instrument drift caused by time, temperature and changes in spectral composition of the observed sky light.

5.2.1 Performing the Dark Calibration:

- a. Standard RMDI
 - i. Cover the entrance aperture of RMDI. The spectral display should go flat.
 - ii. Keep the aperture covered and click on the  button. This acquires a base dark noise reading for the CCD array.
 - iii. Uncover the aperture and click on the  button. This subtracts the base dark noise reading from the spectral display. Your spectra should now appear slightly less intense and less noisy.
- b. RMDI with Cell Changer:
 - i. Cover the entrance aperture of RMDI by toggling the “Outer” switch to a blank cell (see sticker on control box). The spectral display should go flat.
 - ii. Click on the  button, then the  button. You are now ready to perform the next calibration.

5.2.2. Gas Cell Calibration:

- i. Point RMDI at a clear sky (free from presence of plume) and take a baseline measurement for 30 seconds to 5 minutes.
- ii. Position the each gas cell in front of the entrance aperture in sequence and allow to dwell 30 seconds to 2 min each time. Depending on your system set up, you may be placing cells manually in a holder, or using an automated Cell Changer. A typical calibration using three SO₂ cells of differing pressures would be performed like this:
 1. Lowest pressure cell. Duration of 1 minute.
 2. Intermediate pressure cell. Duration of 1 minute.

3. High pressure cell. Duration of 1 minute.
4. Both Low and High pressure cells (possible if you have a Cell Changing unit). Duration of 1 minute.
5. Both High and Intermediate cells. Duration of 1 minute.

If you have cells of two different gas types, complete step 5.2.2.ii. for each set of cells in sequence, i.e. Low to high pressure SO₂ followed by low to high pressure NO₂ cells.

iii. Repeat the baseline measurement as in 5.2.2.i.

Appendix 1. SPECTROMETER SPECIFICATIONS

Date:

Initial:

Identification:

Spectrometer Model/Serial Number:

Entrance Slit:

Type	Fixed	
Height/Width	1 mm/	mm

Exit Detector:

Type	Linear CCD
Pixel	200 x 14 microns
Array Width	28 mm
Spectral coverage	295 to 437 nm
Spectral coverage with UV filter	295 to 385 nm

Grating:

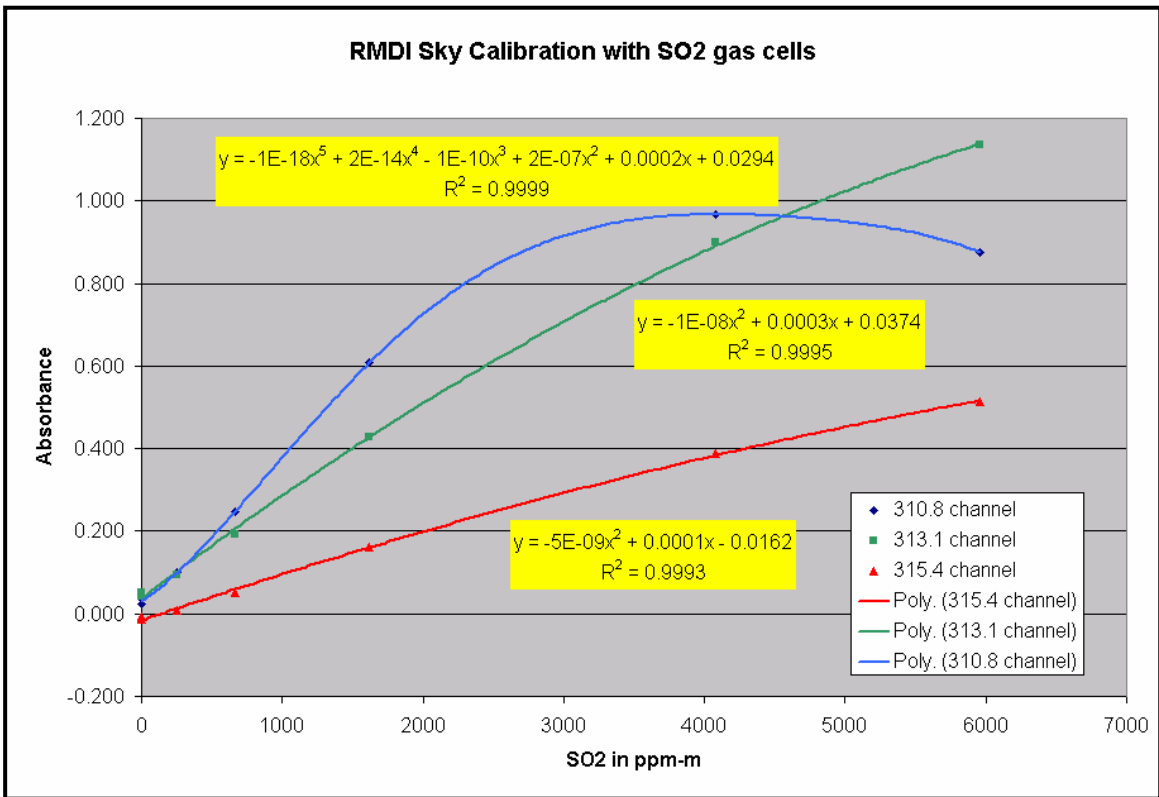
Grooves/mm	2,400/mm
UV type	
Resolution/System	< 0.4 nm first order

Appendix 2: SPECTROMETER CALIBRATION

Date: Initial:

Equipment:

Spectrometer Model/Serial Number RMDI /
Fixed micron slit



Appendix 3: SCRIPT FILE LISTING

```
'SCRIPT FILE NAME ResonanceLtdRMDIsw20.bas
'version 2.0
'date Dec. 15, 2005
' The following script processes spectral data for RMDI and RMD-2
'
'=====
'=====
' DO NOT MODIFY THE FOLLOWING BLOCK OF CODE
Option Explicit
'#uses "classes\menuverify.bas"
Global ooi As OOIBase32Platinum
Global Ready As Integer
Global Const INITDONE=66
Global InEvent As Boolean
' END NONMODIFYABLE BLOCK
'=====
'=====

Global i As Integer
Global j As Integer
Global jmax As Integer
Global NWL1 As Integer
Global NWL2 As Integer
Global filename As String
Global SWfilename As String
Global ovslot As OVERLAYSLOT
Global PixCount As Integer
'Global wl(3648) As Double
'Global data(3648) As Double
Global wl(2048) As Double
Global data(2048) As Double
'Global TimeSeries1(3648) As Double
'Global TimeSeries2(3648) As Double
Global TimeSeries1(2048) As Double
Global TimeSeries2(2048) As Double
Global Spect_StWL As Double
Global Spect_EnWL As Double
Global Spect_StWL_2 As Double
Global Spect_EnWL_2 As Double
Global Spect_StWL_3 As Double
Global Spect_EnWL_3 As Double
Global Spect_Stpix As Integer
Global Spect_Enpix As Integer
Global Spect_Stpix_2 As Integer
Global Spect_Enpix_2 As Integer
Global Spect_Stpix_3 As Integer
Global Spect_Enpix_3 As Integer
'Global Spect_Array(3648) As Integer
Global Spect_Array(2048) As Integer
Global chan As SPECCHANNEL
Global WLO As Double 'Wavelength offset parameter
Global WLM As Double 'Wavelength multiplier parameter
Global CWL1(24) As Double 'Center Wavelength array for slit set (nanometer units)
Global SHW1(24) As Double 'Slit HALF width array for SO2 slit set (nanometre units)
Global Stpix1(24) As Integer
Global Enpix1(24) As Integer
```

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Global CWL2(15) As Double 'Center Wavelength array for Ozone slit set (nanometre units)
Global SHW2(15) As Double 'Slit HALF width array for Ozone slit set (nanometre units)
Global Stpix2(15) As Integer
Global Enpix2(15) As Integer
Global MinWL As Integer
Global MaxWL As Integer
Global BaseRat313 As Double
Global BaseRat355 As Double
Global BaseRat369 As Double
Global BaseRat419 As Double
Global BaseRat328 As Double
Global BaseRatO3 As Double
Global BaseRatNO2 As Double
Global StartTimer As Double
Global SO2Scale As Double
Global NO2Scale As Double
Global SO2Offset As Double
Global NO2Offset As Double

Public Sub EventGenerator_MacroBegin(ByVal modname As String)

```

=====
'
' DO NOT MODIFY THE FOLLOWING BLOCK OF CODE
'   If Ready=INITDONE Then Exit Sub
'   InEvent=False
'   Set ooi=New OOIBase32Platinum
'   END NONMODIFYABLE BLOCK
=====

```

```

'allocate variables for menus
Dim SpecMenu As Long
Dim SpecFileMenu As Long
Dim NewPopupMenu As Long
SpecMenu = ooi.Menu.GetSpectrumMenu()
'print out all the members of menu
Dim i
For i=0 To ooi.Menu.GetMenuItemCount(SpecMenu)-1
    Debug.Print ooi.Menu.GetMenuString(SpecMenu, i, mfByPosition)
Next i
'get the file submenu
SpecFileMenu=ooi.Menu.GetSubMenu(SpecMenu,0)
'add two items to the end of the file menu
ooi.Menu.AppendMenu(SpecFileMenu,mfSeparator,0," ")
ooi.Menu.AppendMenu(SpecFileMenu,mfString,umFirst,"F&irst new menu")
ooi.Menu.AppendMenu(SpecFileMenu,mfString,umFirst+1,"Se&cond new menu")
'create a popup menu to add to the main spectrum menu
NewPopupMenu=ooi.Menu.CreatePopupMenu()
'add items to the new popup
ooi.Menu.AppendMenu(NewPopupMenu,mfString,umFirst+2,"&Specify File")
'insert new menu into file menu, after help
ooi.Menu.InsertMenu(SpecMenu,11,mfByPosition+mfPopup,NewPopupMenu,"&SO2 NO2 Data")

' get the wavelength array
ooi.SpectralData.GetWavelengths(chan,wl(0))

jmax = 2047

```


CWL1(14) = 414.78*WLM+WLO 'Center wavelength 20 hi NO2 absorption
 SHW1(14) = .25*WLM 'Slit 20 half width ...

CWL1(15) = 326.79*WLM+WLO 'Center wavelength 15 low CS2 9 pixels from line center
 SHW1(15) = 0.35*WLM 'Slit 15 half width ...

CWL1(16) = 327.51*WLM+WLO 'Center wavelength 16 hi CS2 absorption
 SHW1(16) = .35*WLM 'Slit 16 half width ...flanking slits +.72 -.72

CWL1(17) = 328.23*WLM+WLO 'Center wavelength 17 hi CS2 absorption
 SHW1(17) = .35*WLM 'Slit 17 half width ...

CWL1(18) = 411.89*WLM+WLO 'Center wavelength 18 low NO2 x pixels from line center
 SHW1(18) = 0.25*WLM 'Slit 18 half width ...

CWL1(19) = 413.34*WLM+WLO 'Center wavelength 19 hi NO2 absorption
 SHW1(19) = .25*WLM 'Slit 19 half width ...flanking slits +1.44 nm - 1.45

CWL1(20) = 414.78*WLM+WLO 'Center wavelength 20 hi NO2 absorption
 SHW1(20) = .25*WLM 'Slit 20 half width ...

CWL1(21) = 331.8*WLM+WLO 'Center wavelength 21 low O3 x pixels from line center
 SHW1(21) = 0.35*WLM 'Slit 21 half width ...

CWL1(22) = 333.78*WLM+WLO 'Center wavelength 22 hi O3 absorption
 SHW1(22) = .35*WLM 'Slit 22 half width ...flanking slits +1.98 -1.96

CWL1(23) = 335.74*WLM+WLO 'Center wavelength 23 hi O3 absorption
 SHW1(23) = .35*WLM 'Slit 23 half width ...

BaseRat313 = 1.0
 BaseRat328 = 1.0
 BaseRat355 = 1
 BaseRat369 = 1
 BaseRat419 = 1
 BaseRatO3 = 1
 BaseRatNO2 = 1
 SO2Scale = 6000
 NO2Scale = 25000
 SO2Offset = 0
 NO2Offset = -1000
 SWfilename = "ResonanceLtdRMDIsw20.bas"

'put data in overlay slot 1
 ooi.Overlay.Active(ovSlot1)=True
 ooi.Overlay.Active(ovSlot2)=True

ooi.Overlay.ClearOverlay(ovSlot1)
 ooi.Overlay.ClearOverlay(ovSlot2)

j=0

'OZONE MASK: These are the wavelengths and slit widths of a Brewer Spectrometer mask

NWL2 = 5
 CWL2(1) = 306.3*WLM+WLO
 SHW2(1) = 0.25*WLM 'Slit 1 half width corr for wave length span

```

CWL2(2) = 310.0*WLM+WLO
SHW2(2) = 0.25*WLM           'Slit 2 half width...

CWL2(3) = 313.5*WLM+WLO
SHW2(3) = 0.25*WLM           'Slit 3 half width...

CWL2(4) = 316.8*WLM+WLO
SHW2(4) = 0.25*WLM           'Slit 4 half width...

CWL2(5) = 320*WLM+WLO
SHW2(5) = 0.25*WLM           'Slit 5 half width...

```

```

' set spectrometer channel
  chan=chMaster

' get starting and ending pixel from wavelengths

  'For compressed spectrum
    Spect_Stpix = ooi.Spectrometer.wavelength.GetPixel(chan,Spect_StWL)
    Spect_Enpix = ooi.Spectrometer.wavelength.GetPixel(chan,Spect_EnWL)
  'For SO2 mask
    For i = 1 To NWL1
      Stpix1(i) =ooi.Spectrometer.wavelength.GetPixel(chan,CWL1(i)-SHW1(1))
      Enpix1(i) =ooi.Spectrometer.wavelength.GetPixel(chan,CWL1(i)+SHW1(1))
    Next i

```

```

=====
' DO NOT MODIFY THE FOLLOWING BLOCK OF CODE
  Ready=INITDONE
' END NONMODIFYABLE BLOCK
=====

```

```

End Sub

Public Sub EventGenerator_NewSpectraReady(ByVal windowname As String, ByVal channels As Integer)

```

```

=====
' DO NOT MODIFY THE FOLLOWING BLOCK OF CODE
  If Ready<>INITDONE Then Exit Sub
  If ooi.InNextScanWait=True Then
    ooi.InNextScanWait=False
    Exit Sub
  End If
  If ooi.InTimeWait=True Then Exit Sub
  If InEvent=True Then Exit Sub
  InEvent=True
' END NONMODIFYABLE BLOCK
=====

```

```

' define local variables
  Dim M As Double
  Dim X As Double
  Dim B As Double
  Dim RFlux1(24)
  Dim CRFlux1(24)

```

```
Dim CRFlux2(5)
Dim RFlux2(5)
Dim CurPix As Integer
```

```
'Update Time Tic
' get processed spectral data
ooi.SpectralData.GetProcessedSpectrum(chMaster,data(0))
```

```
***** Create compressed spectrum *****
```

```
'Create average
' integrate
For i=1 To NWL1
    RFlux1(i) = 0
    For CurPix = Stpix1(i) To Enpix1(i)
        RFlux1(i) = RFlux1(i) + data(CurPix)
    Next CurPix
    RFlux1(i) = RFlux1(i)/(Enpix1(i)-Stpix1(i))
Next i

For i=1 To NWL2
    RFlux2(i) = 0
    For CurPix = Stpix2(i) To Enpix2(i)
        RFlux2(i) = RFlux2(i) + data(CurPix)
    Next CurPix
    RFlux2(i) = RFlux2(i)/(Enpix2(i)-Stpix2(i))
Next i

M = (RFlux1(2)-RFlux1(1))/(CWL1(2)-CWL1(1))
B = 0          'RFlux1(1)  remove reference to reduce noise

For i = 1 To 2
    CRFlux1(i) = RFlux1(i)
Next i

For i = 3 To NWL1
    CRFlux1(i) = RFlux1(i) - B
Next i
```

```
' USE CODE BELOW To put Data into chart and save file
```

```
TimeSeries1(j) = SO2Scale*(-Log(2*CRFlux1(4)/(CRFlux1(3)+CRFlux1(5)+0.00001)/BaseRat313)) +
SO2Offset
TimeSeries2(j) = NO2Scale*(-Log(2*CRFlux1(19)/(CRFlux1(18)+CRFlux1(20)+0.00001)/BaseRatNO2)) +
NO2Offset
```

```
'append timeseries1(j) and timeseries2(j) to file
```

```
Open filename For Append As #1
```

```
If j= 0 Then
    Print #1,
    Print #1, "filename"& Chr$(9) & filename & "
    Print #1, "Script file"& Chr$(9) & SWfilename & "
    Print #1, "Date  "& Chr$(9) & Date & "
    Print #1, "Time  "& Chr$(9) & Time & "
    Print #1, "Int Time"& Chr$(9) & ooi.AcquisitionParameters.IntegrationTime
    Print #1, "Averages"& Chr$(9) & ooi.AcquisitionParameters.Averages
    Print #1, "Boxcar "& Chr$(9) & ooi.AcquisitionParameters.Boxcar
```

```

Print #1, "BaseRat313"& Chr$(9) & BaseRat313

Print #1, "SO2Scale " & Chr$(9) & SO2Scale
Print #1, "SO2Offset " & Chr$(9) & SO2Offset
Print #1, "Valley SO2 wl" & Chr$(9) & CWL1(3)
Print #1, "Peak SO2 wl " & Chr$(9) & CWL1(4)
Print #1, "Valley SO2 wl" & Chr$(9) & CWL1(5)
Print #1, "SO2 signal = SO2Scale*(-Log(2*UVpeak/(UVvalley+UVvalley+0.00001)/BaseRat313)) +
SO2Offset"
Print #1, "Create custom Excel number type for column 2 <hh:mm:ss.00> to show sub second timing"
Print #1
Print #1, " # " & Chr$(9)& "Day since midnite" & Chr$(9)& "SO2 signal " & Chr$(9)& "Int
313.08 nm"

End If

'tab separated data tab is ascii character 9

Print #1, ""& j & Chr$(9) & Timer/24/3600 & Chr$(9) & TimeSeries1(j) & Chr$(9) & CRFlux1(4)
Close #1

Debug.Print (TimeSeries2(j))

ooi.Overlay.ClearOverlay(ovSlot1)
ooi.Overlay.ClearOverlay(ovSlot2)

ooi.Overlay.SetOverlayWavelength(ovSlot1, wl(0))
ooi.Overlay.SetOverlayIntensity(ovSlot1, TimeSeries1(0))
ooi.Overlay.SetOverlayWavelength(ovSlot2, wl(0))
'SO2 only comment this out
'
ooi.Overlay.SetOverlayIntensity(ovSlot2, TimeSeries2(0))

j = j+1

If j > jmax-1 Then
ooi.Overlay.ClearOverlay(ovSlot1)
ooi.Overlay.ClearOverlay(ovSlot2)
For j=0 To 2047
TimeSeries1(j) = 0
TimeSeries2(j) = 0
Next j

j=0

End If

=====
' DO NOT MODIFY THE FOLLOWING BLOCK OF CODE
InEvent=False
END NONMODIFYABLE BLOCK
=====
End Sub

Public Sub EventGenerator_UserMenu(ByVal menuid As Long)

Select Case menuid

```

```

Case umFirst+2
    ' Enter a file name to save the SO2 and NO2 data
    filename = InputBox("Enter File Name For Saving Data Using The Form
Directory\FileName.txt" , filename, "C:\Data.txt",,)
    Debug.Print filename

End Select

End Sub

Public Sub Errorreport()

End Sub

Public Sub EventGenerator_MacroEnd()
    ' when the macro exists, restore the default spectrum menu adn clear overlays
    ooi.Menu.ReloadDefaultSpectrumMenu()
    ooi.Overlay.ClearOverlay(ovSlot1)
    ooi.Overlay.ClearOverlay(ovSlot2)
    ooi.Overlay.ClearOverlay(ovSlot3)
    ooi.Overlay.ClearOverlay(ovSlot4)
    ooi.Overlay.ClearOverlay(ovSlot5)
    ooi.Overlay.ClearOverlay(ovSlot6)
    ooi.Overlay.ClearOverlay(ovSlot7)
    ooi.Overlay.ClearOverlay(ovSlot8)
    ooi.Menu.RedrawAllSpectrumMenus()

End Sub

```

Appendix 4: EXAMPLE DATA FILE

filename C:\Documents and Settings\Administrator\Desktop\DefaultSO2Data.txt

Script file ResonanceLtdRMDIsw20.bas

Date 12/16/2005

Int Time 1000

Averages 1

Boxcar 0

BaseRat313 1

SO2Scale 6000

SO2Offset 0

Valley SO2 wl 312.1

Peak SO2 wl 313.08

Valley SO2 wl 314.16

SO2 signal = SO2Scale*(-Log(2*UVpeak/(UVvalley+UVvalley+0.00001)/BaseRat313)) + SO2Offset

Create custom Excel number type for column 2 <hh:mm:ss.00> to show sub second timing

#	Day since midnite	SO2 signal	Int 313.08 nm
0	0.39200023509838	186.990793078869	953.333333333333
1	0.392012080439815	231.479905471265	952.166666666667
2	0.392023880570023	255.782722897831	952.333333333333
3	0.392035725911458	208.27392983724	955.5
4	0.392047661675347	226.475216762721	955.666666666667
5	0.392059461805556	251.083913031656	957.166666666667
6	0.392071307146991	234.170380655137	957.166666666667
7	0.392083107277199	181.771259684327	963.333333333333
8	0.392095043041088	216.976520895107	965
9	0.392106888382523	187.674193570121	968.166666666667
10	0.392118688512731	289.185471789466	958.833333333333
11	0.392130533854167	214.23691767031	962.5
12	0.392142333984375	239.665461239804	962.833333333333
13	0.392154269748264	214.337114143955	964.333333333333
14	0.392166115089699	246.545155580532	959.833333333333
15	0.392177915219907	247.019621920148	963.333333333333
16	0.392189760561343	233.373313636719	960.5
17	0.392201696325231	249.984508598134	958.666666666667
18	0.39221349645544	213.246462248931	958.166666666667
19	0.392225341796875	222.372312593151	958.5
20	0.392237141927083	179.382760957104	967.333333333333
21	0.392249077690972	304.39456327988	951.166666666667
22	0.392260923032407	242.266589068422	960.666666666667
23	0.392272723162616	286.850002022535	849.166666666667
24	0.392284568504051	842.232667802835	547.833333333333
25	0.392296368634259	908.583021851191	542.166666666667
26	0.392308304398148	938.975666330216	540.333333333333
27	0.392320149739583	891.745805016442	542.5
28	0.392331949869792	952.466406547435	546.666666666667
29	0.392343795211227	926.516067058531	544.333333333333
30	0.392355730975116	881.093076927447	544.666666666667
31	0.392367531105324	941.383022873723	544.166666666667
32	0.392379376446759	888.176935641735	545.666666666667
33	0.392391176576968	912.008749926688	548.166666666667
34	0.392403157552083	892.471614769026	547.666666666667
35	0.392414957682292	875.050084416549	550
36	0.392426803023727	904.666510729982	548.5
37	0.392438603153935	934.893932788075	545
38	0.39245044849537	925.689004071144	546

