E200 SERIES

# LASER SPECTRUM ANALYSER

user guide

Heraeus Noblelight

Q5202
ISO 9001

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## FIGURES

# SECTION 1 - INTRODUCTION

## INTRODUCTION

***This manual has been written to enable you to quickly and easily start using your LSA - please read it before operating the equipment.***

1. The E200 Series Laser Spectrum Analysers (LSA) from are designed to be used for real time diagnostics, tuning and continuous monitoring of the spectral output of ultrafast and CW laser systems. The LSA operates with the user's oscilloscope to provide a real time display of the laser spectrum and a 'wavelength' measurement scale. These features make it easy to immediately see the effects of any changes made to the laser's optical system and to measure the laser's peak wavelength and FWHM optical bandwidth.

2. E200 series LSA's comprise a compact remote optical head and a control unit which links to the user's oscilloscope. The optical head is provided with an FC connector for use with fibre delivery lasers, alternatively radiation may be coupled directly into the input when using free standing/optical bench laser systems. A full set of coaxial cables is provided to enable the LSA to be linked to the user's oscilloscope.

3. Two versions of the Laser Spectrum Analyser are available:

   (a) The E201 LSA offers 0.3nm HPBW optical resolution and is suitable for use with ultrafast and CW laser systems operating in the 350 - 1100nm range, such as Ti: Sapphire, dye , Pr:YLF, Cr: LiSaF diode pumped, and AIGaInP Semiconductor lasers.

   (b) The E202 LSA operates over the range 750 - 1650nm with an optical resolution of 0.4nm HPBW and is suitable for use with ultrafast and CW laser systems, such as fibre soliton, colour centre, semiconductor DFB, OPO and Er:Yb fibre lasers.

***It should be noted that the LSA is not suitable for monitoring lasers with low pulse repetition rates. Minimum acceptable pulse repetition rates are around 2MHz for narrow band (FWHM ≤1nm) lasers and 200kHz for broadband (FWHM ≥10nm) lasers.***

# SECTION 1 - INTRODUCTION

4. If you have any questions regarding the application, installation or operation of the LSA please call

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5. If there are any general improvements or extra information we could put into the manual to assist you, please contact the above offices detailing the changes or information required.

## SECTION 1 - INTRODUCTION

### TERMINOLOGY

6. The following terminology has been used in this user guide:

| Term | Meaning |
|---|---|
| Controller | LSA Controller Unit |
| FC Connector | Fibre optic connector (NTT/NEC type) |
| LSA | Laser Spectrum Analyser |
| Optical Head | The LSA remote detector unit |
| BNC to BNC | Coaxial cable using BNC connections |
| ADC | Analogue to Digital Converter |
| DAC | Digital to Analogue Converter |

## SECTION 2 - SPECIFICATIONS

### SPECIFICATIONS

#### Remote Optical Heads

1. Dimensions:
   Height............................................ 70mm
   Length ............................................ 115mm
   Width............................................. 80mm

2. Wavelength range .......................... Model E201 ......... 350 - 1000nm (optimised)
   1000 - 1100 nm (reduced sensitivity)
   Model E202 ......... 1000 - 1650nm (optimised)
   750 - 1000nm (reduced sensitivity)

3. Best wavelength resolution ............ Model E201 ......... 0.3nm FWHM ± 10%
   Model E202 ......... 0.4nm FWHM ± 10%
   ***Note...***
   ***Some degradation in resolution can occur at longer wavelengths - see Section 6.12.***

4. Wavelength accuracy ...................... ± 0.5nm - see Section 6.15

5. Input coupling ................................ FC connector or direct coupling

6. Spectral scan rate ........................... 18 scans per second

7. Mounting......................................... $^1/_4$ x 20 UNC and M6 bench rod mounting holes

8. Input power level requirements* ...... Model E201 (350-1000nm) 10μW (min) → 2mW (max)
   Model E202 (1000-1650nm) 10μW (min) → 2mW (max)

| | |
|---|---|
| Model E201 (1000-1100nm) | 10µW (min) → 2mW (max) |
| Model E202 (750-1000nm) | 10µW (min) → 2mW (max) |

***Note...***

***Theoretical values for narrowband 'picosecond or CW lasers' calculated assuming a 2mm diameter uniform collimated input beam. Input power requirements for broadband 'femtosecond lasers' depends on the natural FWHM of the laser spectrum but typically will be around 10x higher than specified above. In both cases higher sensitivity (lower input power levels) are achievable by use of suitable external focusing optics or a higher input power density.***

**Controller**

9. Dimensions:
   Height............................................. 65mm
   Length ............................................ 285mm
   Width.............................................. 188mm

10. Electrical
    Power Requirements ........................ Factory preset to 90 - 132 or 180 - 264V, 50/60Hz.

11. Controls............................................ **GAIN** - fixed and continuously variable sensitivity controls (maximum signal output level to oscilloscope +5V).
    **PRE TRIG** - This switch makes the oscilloscope trigger either 1nm (Led off) or 20nm (Led on) before the cursor wavelength.

**CURSOR WAVELENGTH ▼▲-** control moves flashing cursor pulse through the l scale in 1nm steps.

***Note...***

***The oscilloscope trigger pulse is also moved by the same amount with the result that the cursor pulse appears to stay in the same position on the oscilloscope display whilst the spectrum and wavelength scale move.***

**HOLD** - enables storage/repeat display of spectrum on standard (non storage) oscilloscope.

**SPAN** - enables continuous expansion/compression of displayed spectrum and l scale.

12. Calibration........................................Rear panel controls provide fine l calibration adjustment.

13. Outputs............................................**TRIGGER, SIGNAL & MARKERS** - BNC outputs for connection to user's oscilloscope. **MARKERS** comprises wavelength measurement pulses at 0.2, 1.0 and 10nm intervals throughout spectrum range with a superimposed cursor pulse positioned by up/down control.

14. Display............................................Digital display of user selected cursor wavelength, 1nm resolution.

15. Minimum oscilloscope requirements....................................Standard laboratory oscilloscope with 2 display channels and Ext trigger input, recommended $\geq$20MHz BW.

16. Trigger output rate to oscilloscope......................................36Hz

17. Operating conditions ........................ Normal laboratory use (10°C → 40°C operating ambient temperature range).

## SECTION 3 - INSTALLATION

### INSTALLATION

1. This section tells you how to install the laser spectrum analyser into your laser system.

2. For optimum LSA performance use the system with an oscilloscope that meets the following minimum requirements:

- 2 input channels
- ≥20MHz minimum bandwidth
- 1 external trigger input

3. A stable HeNe laser is required for λ calibration. (LSA's are calibrated during manufacture. However, it is recommended that the λ calibration is checked and if necessary readjusted before using for the first time, this will compensate for any changes introduced during shipping).

### UNPACKING

4. The LSA packaging which is identified as E201 or E202 contains the following items:

- 1 x Laser Spectrum Analyser Controller - *Please check that the voltage rating on the serial number label corresponds to the local AC supply voltage before using.*
- 1 x Remote Optical Head
- 1 x ac Supply Power Lead
- 1 x Controller to Head Connector Lead
- 3 x BNC to BNC Connector Leads
- 1 x User Guide Manual (this document)
- 1 X Trimmer tool (used for l calibration adjustment)

***Please retain the customised shipping box supplied with the LSA. This has been designed to provide maximum protection for the LSA during shipment and should therefore be used whenever the equipment has to be shipped to another site or, in the event of a malfunction, returned for repair.***

# SECTION 3 - INSTALLATION

## CONNECTING THE LSA TO YOUR OSCILLOSCOPE

5. Connect the optical head to the control unit using the multi pin cable supplied. (The connectors on this cable are polarised and will only fit to the mating sockets in one orientation).

6. Use the three coaxial cables supplied to connect the control unit and the oscilloscope as shown in Figure 1. The oscilloscope should initially be set as follows:

| | |
|---|---|
| ch1 (signal): | dc coupling, 1V/div |
| ch2 (markers): | dc coupling, 1V/div |
| ext trig (trigger): | +ve edge, hf reject, dc coupling |
| timebase: | 1ms/div |

Once the system is operating correctly, you may wish to change the sensitivity of ch1/ch2 and the timebase to look at the measured spectrum in greater or less detail. It is recommended however that you do not increase ch1 sensitivity to more than 0.2V/div (use the controller's gain control to amplify the signal instead) and that you do not use a slower timebase than 1ms/div (multiple spectrum scans are displayed at slower timebase settings).

## INTERFACING THE LSA TO YOUR LASER SYSTEM

### Installing the Optical Head into an Existing Laser Configuration

*Optical Bench Configurations*

7. Ideally, the optical head should be fitted either to an $^1/_4$ x 20 UNC or an M6 bench rod fitted to an optical rail or table. The optical head should be positioned so that the centre of the FC connector is at the same height as the laser beam to be measured. The latter should be horizontal and be directed normally into the FC connector. In certain cases, eg, use of either the E202 near its lower wavelength limit around 750nm, or the E201 near its upper wavelength limit around 1100nm, it may be advantageous to use simple external focusing optics to image the laser beam into the optical head. This will significantly improve the signal to noise ratio of the displayed laser spectrum (the optimum input coupling will be achieved if the laser is focused at the input slit in an F/7 input cone).

8. In most cases, however, the existing laser beam need only be directed normally into the centre of the FC connector and the head moved slightly whilst observing the laser spectrum on the oscilloscope. Optimum coupling is achieved when the amplitude of the displayed spectrum is maximized.

9. Due to the scanning method employed in the optical head, it is unlikely that even high input power levels will cause any damage to the internal optics or the detector. It is however possible that extremely high input power levels could damage the input slit if this is exposed to the laser radiation for a long period of time. The user should therefore take steps to reduce the input power level if at any time the displayed spectrum is seen to be saturated when the controller gain is also at its minimum setting.

*Note..*

> ***If the laser input is too high it will cause the displayed spectrum to saturate (flat top) and it will be necessary to attenuate the input level (eg use ND filter, or low %R reflector etc) in order to achieve an acceptable spectrum display. Under no circumstances should the laser be purposely misaligned with respect to the input slit in order to achieve a lower signal level as this can lead to spurious reflections inside the optical head possibly giving rise to secondary or 'ghost' peaks on the spectrum display.***

**Fibre Delivery Laser Systems**

10. In this situation, the fibre should be fitted with an FC connector which is then screwed into the mating FC connector on the optical head. Under normal circumstances no adjustment is necessary, however, if the unit has recently been shipped (eg, just delivered and set up for the first time), it may be necessary to reset the position of the internal mirror in the optical head to optimize the output signal. Adjustment of the mirror is described in Section 6.

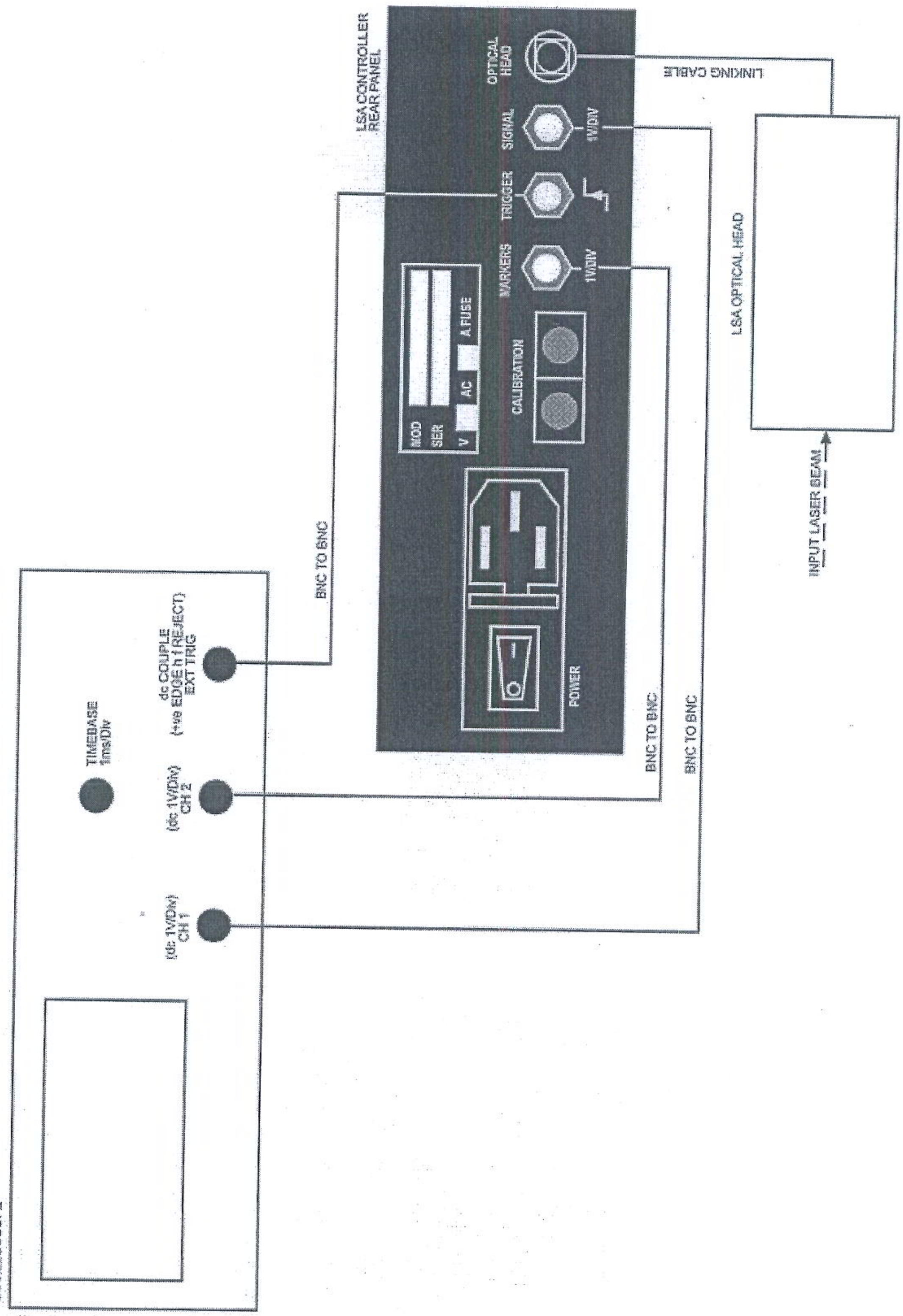



**Figure 1 – Connecting the LSA to your Oscilloscope**

# SECTION 4 – OPERATING THE CONTROLLER

## OPERATING THE CONTROLLER

1. Figure 2 shows the front panel layout of the controller. The following is a brief description of the operating controls and their uses.

### Cursor Wavelength

2. This digital display shows the wavelength (nm) location of the flashing cursor on the Ch2 'markers' display. To ensure that the cursor wavelength is correct it is first necessary to wavelength calibrate the LSA. See Section 5 for details.

*Note...*

***On switch on the cursor wavelength always defaults to 800nm.***

3. The ▲ & ▼ controls are used to move the cursor wavelength to lower or higher wavelength locations respectively. Each time these controls are momentarily pressed the cursor wavelength changes by 1nm. Holding the control button down will cause the cursor wavelength to scan through the wavelength range until the control button is released.

4. It should be noted that these controls can be used to select any number in the range 0 - 9999 on the cursor wavelength display. However, only numbers in the range 350 - 1100 (E201) and 750 - 1650 (E202) will produce valid cursor pulses on the markers display.

### Gain

5. This rotary control changes the amplitude of the laser spectrum on the oscilloscope display. Whenever possible this control should be set fully clockwise and the oscilloscope sensitivity control for Ch1 (signal input) adjusted in the range 0.2V/div to 2V/div to achieve a display amplitude with a maximum level as near as possible to +5V. In situations where the laser input power is too high the displayed spectrum may saturate (flat top) at a level much less than 5V. In such cases the only way to correct this will be to reduce the power level at the input slit.

# SECTION 4 – OPERATING THE CONTROLLER

**Span**

6. This rotary control acts like the timebase control on the oscilloscope enabling the laser spectrum and the l scale to be expanded or compressed as required.

*Note...*

> ***The scope timebase should always be set to 1ms/div or faster. Slower scope timebase settings will result in the display of multiple spectrum scans thereby making it difficult to interpret the spectral data.***

**Hi Gain**

7. This function is selected by depressing the switch so that it locks in place and the integral Led turns on. When selected the signal amplification is increased by x 6 and the electrical bandwidth of the signal pre-amplifier is reduced by a similar amount.

8. Due to the reduction in electrical bandwidth the Hi Gain function should only be used when monitoring ***very weak broadband eg 'fs' (FWHM ≥ 10nm)*** lasers where it will increase the signal amplitude and at the same time reduce the noise level (ie, improve the signal to noise ratio). With such broadband lasers the slight increase in the measured FWHM of the laser spectrum caused by the reduced electrical bandwidth should be insignificant.

***The Hi Gain switch should not be used when monitoring narrow band, eg, 'ps' or CW (FWHM ≤ 1nm) lasers since the reduced electrical bandwidth will produce a significant broadening and distortion of the displayed laser peak.***

**Pre-Trig**

9. When the integral Led in this switch is off (switch de-selected) the trigger pulse sent to the oscilloscope is generated 1nm before the flashing cursor pulse, ie, the 1st l scale pulse displayed corresponds to a wavelength 1nm lower than the selected cursor wavelength. When the integral Led is on (switch selected) the trigger pulse is generated 20nm before the flashing cursor pulse.

10. The default selection on 'switch on' is a 1nm pre-trigger. This is particularly useful when looking at narrow band laser peaks (eg, ≤ 1nm FWHM) since it is possible to expand the spectrum and the associated l scale display using the "Span" and timebase controls so that a range of only 1 or 2nm is shown whilst still being able to see the flashing cursor and therefore make accurate wavelength measurements.

11. The 20nm pre-trigger setting is useful when monitoring much broader spectral peaks for the same reasons.

12. In either case it will be noted that the flashing cursor pulse will always remain at the same distance (1nm or 20nm) from the 1st (left hand) l scale pulse regardless of the cursor wavelength setting.

**Hold**

13. Selecting this function (Led on) causes the last acquired spectrum to be held in RAM in the controller and "played back" to the oscilloscope at 36Hz. De-selecting this function (Led off) causes the real time laser spectrum to be once again displayed on the oscilloscope.

14. The Hold function therefore enables a non-storage oscilloscope to be used as if it was a storage oscilloscope. The spectrum and the l scale being played back can be expanded/compressed by using the "Span" and timebase controls and the signal amplitude can be changed by using the Ch1 sensitivity control on the oscilloscope.

15. This feature is particularly useful when monitoring rapidly changing spectra and for accurately measuring FWHM and peak wavelengths.

16. It should be noted that since the controller digitizes, stores and then plays back the laser spectra (in both the normal 'real time' operating mode and in the 'Hold' mode) via an ADC/DAC circuit the resulting spectrum display will show ADC/DAC quantizations steps. In order to minimise the significance of the quantization steps it is recommended that the rotary "Gain" control is used either in its fully clockwise position or adjusted so that the displayed laser spectrum is amplified to as near as possible a peak amplitude of +5V. This will result in the full dynamic range of the ADC/DAC being used with minimum noticeable quantisation steps on the scope display.

# SECTION 4 – OPERATING THE CONTROLLER

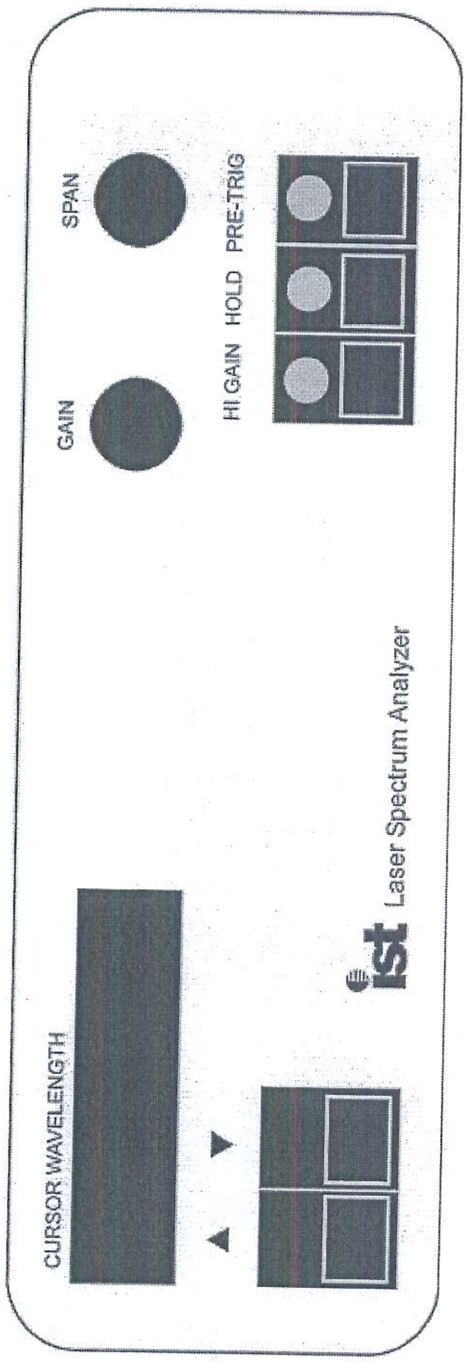



**Figure 2 – LSA Controller Front Panel**

# SECTION 5 – WAVELENGTH CALIBRATION

## WAVELENGTH CALIBRATION

1. To ensure the accuracy of the LSA, the system must be wavelength calibrated after the following events:

- Initial unpacking
- Physical shock of the optical head
- Use of the optical head in non horizontal orientations
- Changing from the E201 optical head to the E202 optical head with the same controller
- Exchanging the Optical Head

**Calibration Procedure**

2. Use the following procedure to calibrate the laser spectrum analyzer:

(1) Interconnect the system as described in Section 3.

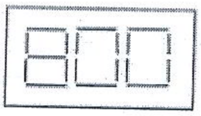
(2) Couple the optical head to a stable laser source with a known emission wavelength. In the following instructions it is assumed that the $\lambda$ calibration source is a HeNe. The first order output (632.8nm) is used to calibrate the E201 LSA and the second order output at 1265.6nm is used to calibrate the E202 LSA.

It is possible to use any other laser of known wavelength as the calibration source by simply substituting the new laser wavelength or 2 x this wavelength (2nd order) in place of 632.8/1265.6nm used here - and setting the cursor wavelength accordingly.

(3) Switch the LSA on via the mains power switch on the controller rear panel. (For highest accuracy the LSA should be allowed to warm up for at least 15 minutes before carrying out any $\lambda$ calibration adjustments.

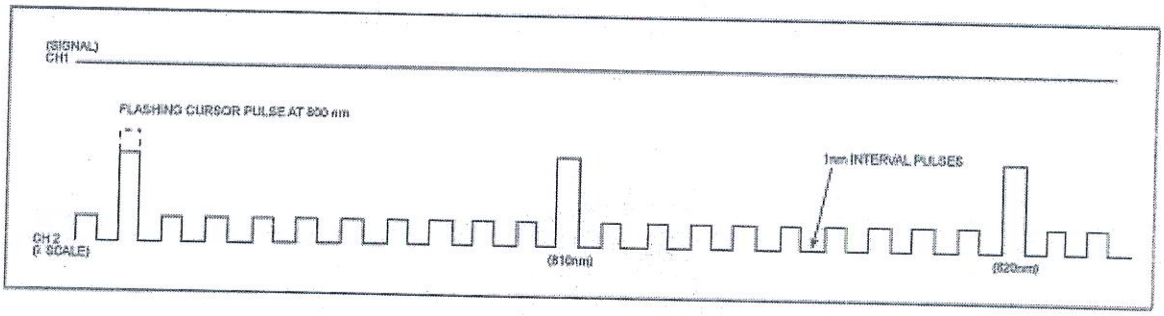
Set the LSA controller GAIN and SPAN controls fully clockwise

The cursor wavelength digital display will show:




(4) Check that the **HI GAIN, HOLD** and **PRE TRIG** switches are not activated (ie, indicator LED's are off).

The oscilloscope display should be similar to:

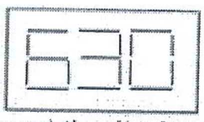



It may be necessary to adjust the trigger level control on the oscilloscope to obtain a steady display as shown.

*Note...*

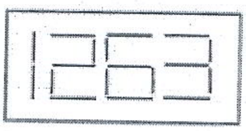
***In addition to the 1nm and 10nm pulses shown the I scale also contains pulses at 0.2nm intervals. For the sake of clarity these have not been included in the above diagram.***

(5) Use the ▲ or ▼ controls to set the **CURSOR WAVELENGTH** display to 630 for E201 systems:




cursor wavelength display

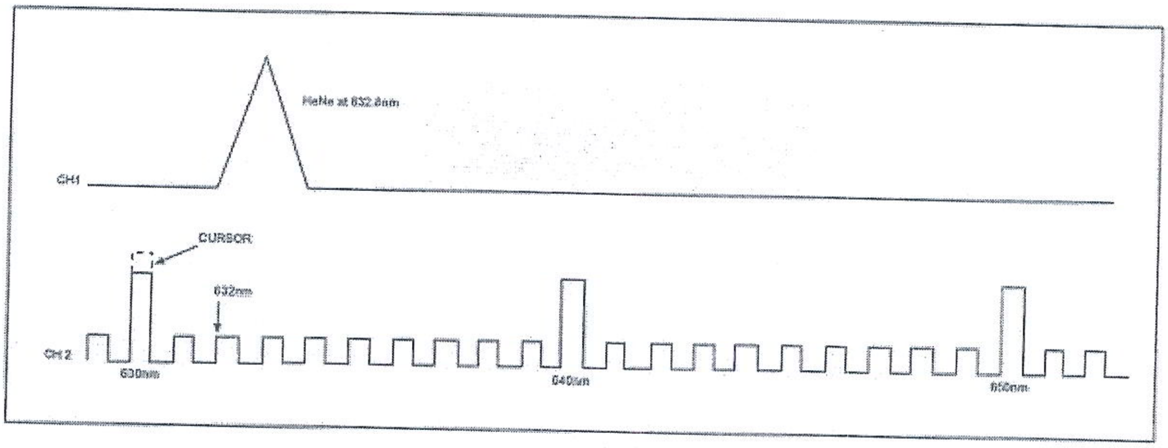
or set the display to read 1263 for E202 systems:



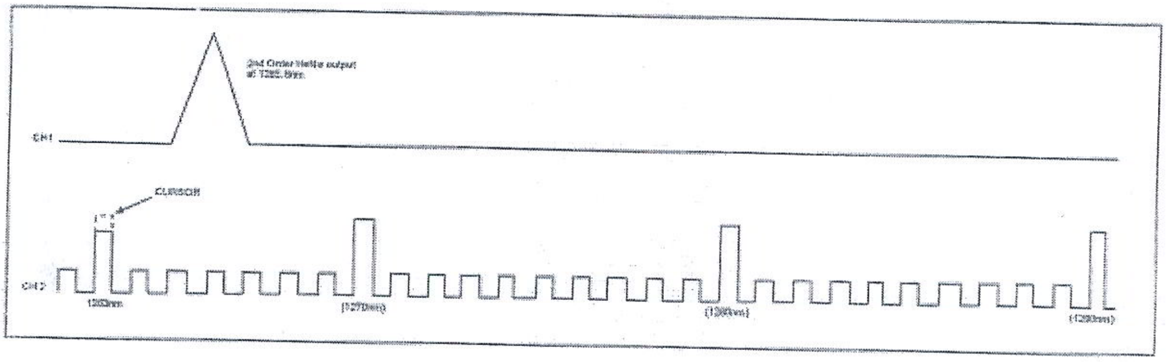

cursor wavelength display

## SECTION 5 – WAVELENGTH CALIBRATION

(6) The E201 oscilloscope display should be similar to:




(7) The E202 oscilloscope display should be similar to:



(8) In both cases use the SPAN control or the scope timebase to expand the spectrum and wavelength scale until the 0.2nm marker pulses are clearly visible. It may also be worth changing the Cursor Wavelength to a value nearer the laser peak.

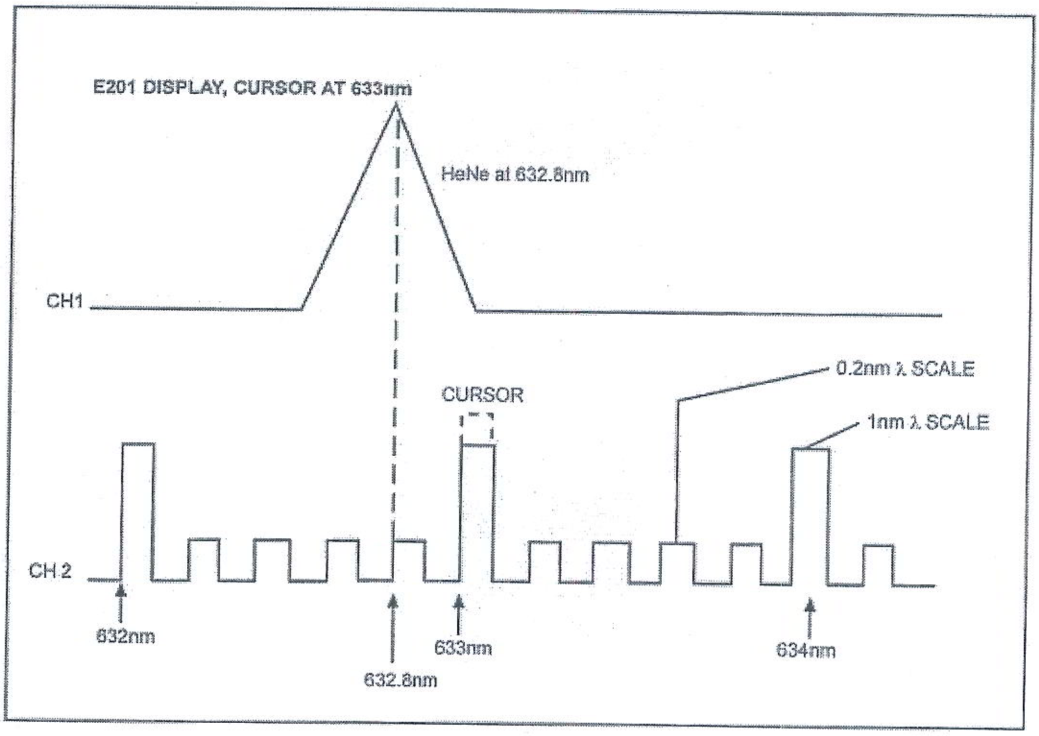
(9) Locate the LSA controller rear panel calibration switches (shown on Figure 1).

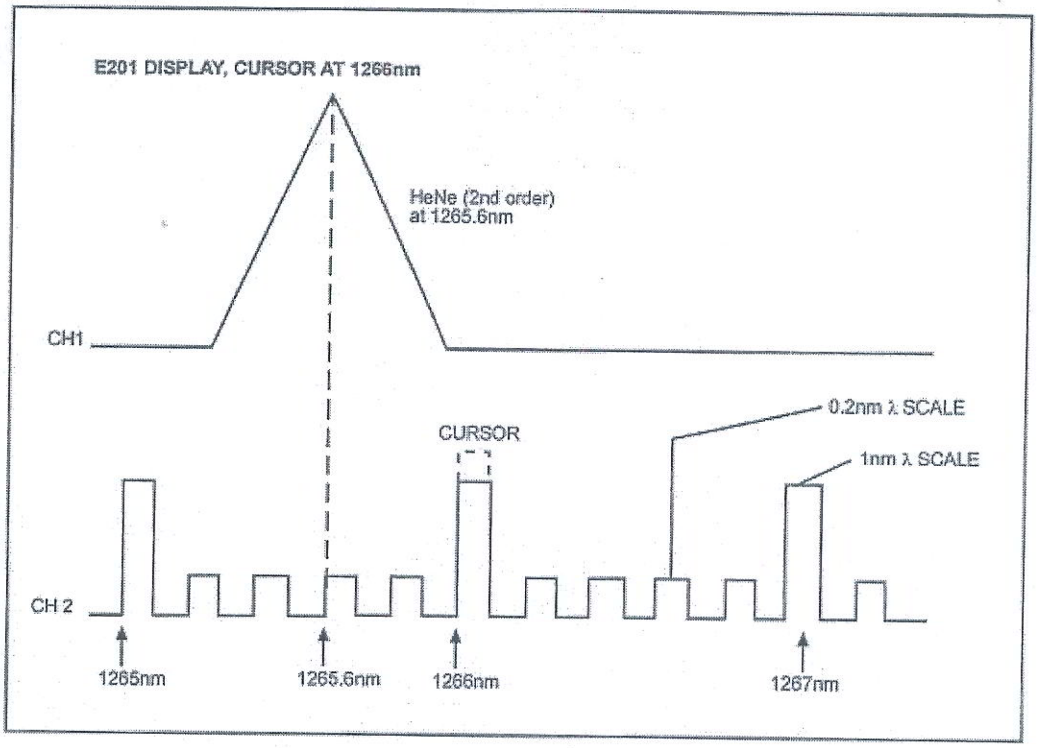
(10) Use the trimmer tool to adjust the left hand (coarse) and right hand (fine) switches to place the peak wavelength as near as possible to the 632.8nm (E201) or 1265.6 (E202) marker.

***The coarse and fine switch adjustments move the signal output (laser peak) approximately 0.225nm and 0.014nm per step respectively.***

## SECTION 5 – WAVELENGTH CALIBRATION

11) When correctly calibrated the E201 and E202 scope displays should be similar to:



## SECTION 5 – WAVELENGTH CALIBRATION

*Notes..*

*(1)* *It is recommended that the leading edge (+ve going edge) of the l scale pulses is used as the wavelength calibration and measurement edges as indicated in the above diagrams.*

*(2)* *Due to the mechanical scanning technique used by the LSA there will be a small amount of variation from scan to scan in the position of the HeNe (or any other laser peak) with respect to the l scale pulses. This should typically be no more than ±0.2nm. Any variations which are consistently larger than this may indicate that the LSA is faulty and should be reported to IST.*

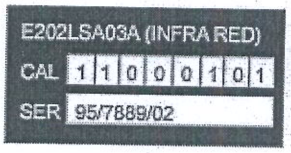
## SECTION 6 – SYSTEM RE-CONFIGURATION, ADJUSTMENTS AND APPLICATIONS INFORMATION

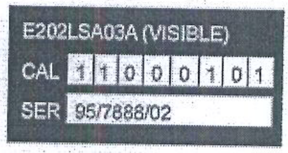
### SYSTEM RE-CONFIGURATION, ADJUSTMENTS AND APPLICATIONS INFORMATION

1. The E201 and E202 LSA's are supplied as factory calibrated "controller/optical head" pairs. Serial number labels on both the controller and the optical head identify the LSA type (E201/E202). The optical head label also contains a wavelength calibration (CAL) number and a serial number (SER). The controller label contains a serial number (SER) and a supply voltage rating V/AC.

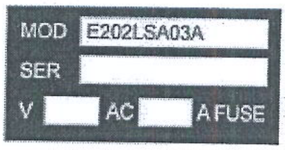
2. The labels are of the form:

Optical Head:




Controller:




3. Factory calibration of E201/E202 LSA's consists of setting a bank of DIL switches on the controller main pcb and also the rear panel coarse/fine calibration switches so that a HeNe laser input produces a peak wavelength at 632.8nm (E201) and 1265.6nm (E202). The CAL number shown on the optical head label corresponds to the digital code set on the DIL switches on the controller main pcb. By re-setting this switch bank it is therefore possible to recalibrate an LSA system should it ever become necessary - See Section 5.1.

4. Before carrying out any of the following calibration procedures it is necessary first of all to totally disconnect the controller from the ac supply.

# SECTION 6 – SYSTEM RE-CONFIGURATION, ADJUSTMENTS AND APPLICATIONS INFORMATION

## LSA Controller Re-configuration (same wavelength range)

5. Use this procedure if the original LSA Optical Head is exchanged for one of the same type, to measure across the same wavelength range.

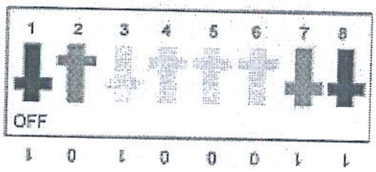
    (1) Remove the four screws that secure the top of the LSA Controller.

    (2) Locate the DIL switch block located on the main circuit board - see Fig 3.

    (3) Refer to the Optical Head label.

6. Enter the CAL number on the DIL switch bank ["1" in the CAL number corresponds to a DIL switch "OFF" setting, "0" corresponds to a DIL switch "ON" position].

7. The CAL number 11000101 shown on the label in Section 6.2 would therefore be set as:




    (1) Replace the top cover of the LSA Controller and refit the four securing screws.

    (2) Interconnect system and carry out the calibration procedure as specified in Section 5.

## LSA Controller Re-configuration (different wavelength range)

8. Use this procedure if the original LSA Optical Head is exchanged for one of a different type to measure a different wavelength range (ie, when changing from an E201 head to an E202 or vice versa).

# SECTION 6 – SYSTEM RE-CONFIGURATION, ADJUSTMENTS AND APPLICATIONS INFORMATION

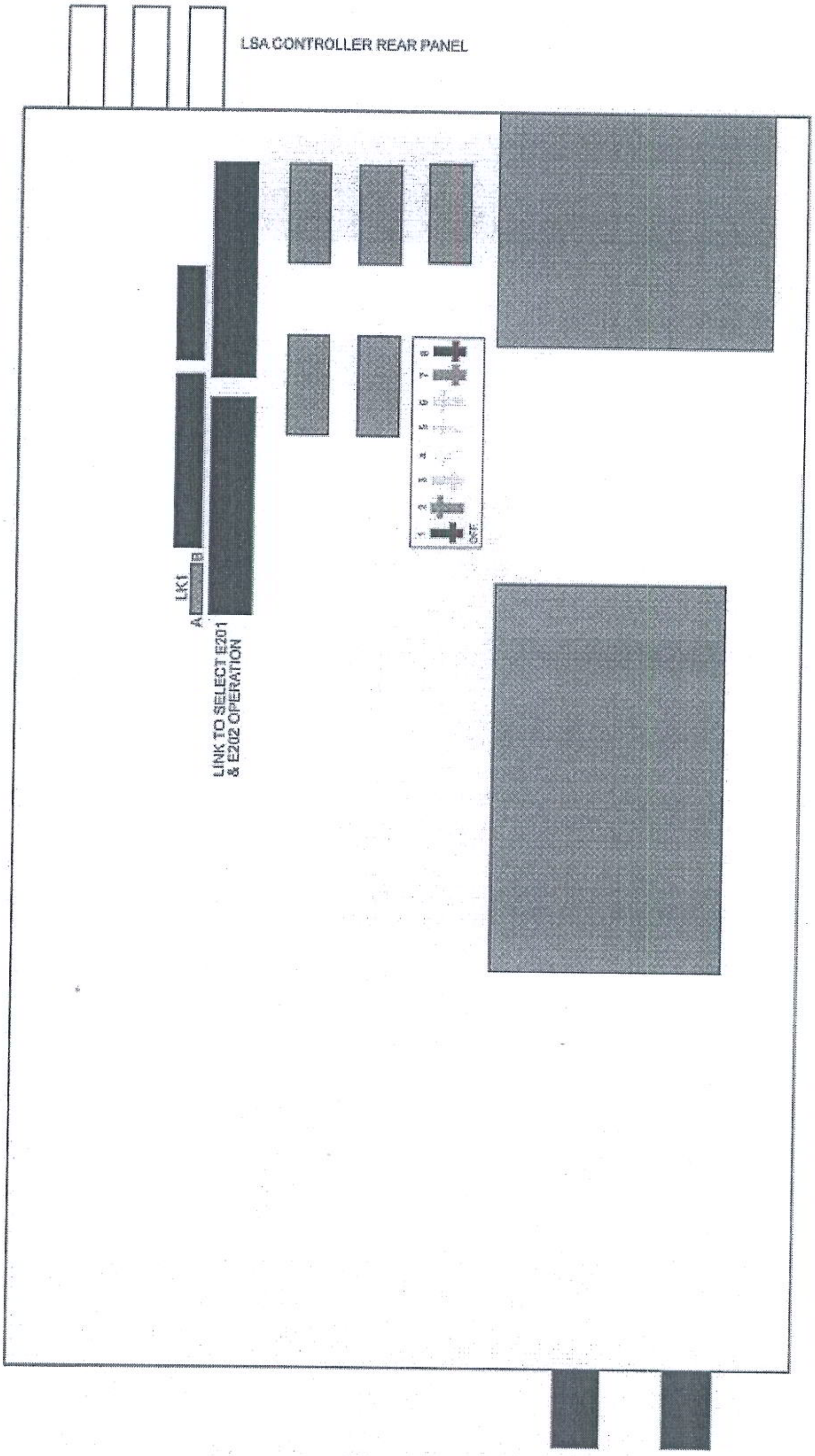
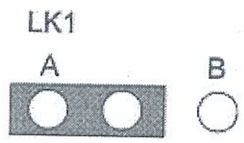



**Figure 3 – Main Circuit Board**

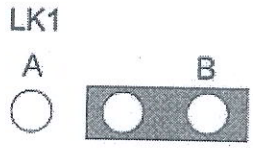
## SECTION 6 – SYSTEM RE-CONFIGURATION, ADJUSTMENTS AND APPLICATIONS INFORMATION

9. Proceed as in paragraphs 5 - 7. In addition change the position of link "LK1" on the main pcb (see Figure 3) to either "A" when setting up for use with and E202 LSA or to position "B" when setting up for use with an E201 LSA - see diagram on page 27.




This position for use with E202 LSA (infrared)

or




This position for use with E201 LSA (visible)

### ADJUSTMENT OF THE MIRROR IN THE OPTICAL HEAD

10. Under normal circumstances it should not be necessary to make any adjustments to the components inside the optical head. However, it is sometimes possible, especially if the unit is subjected to mechanical shock during shipping that the collimating/focusing mirror in the optical head can move slightly from its factory preset position. If this happens the sensitivity of the LSA can be significantly reduced.

11. If you find that your LSA is particularly insensitive, it may be beneficial to readjust the mirror position as instructed below. ***It should be noted however that this procedure should only be carried out after discussing your problem with a Rees Instruments applications engineer who may be able to suggest alternative causes and solutions to your particular problem. (See also the technical specifications, Section 2.8, "Input Power Level Requirements".)***

> **Caution...**
> **Do not touch any of the optical surfaces with bare fingers or tamper with electrical components. Damage caused by mishandling will invalidate the warranty.**

(i) Remove the cover of the optical head (2 screws).

(ii) Connect or couple the laser to the optical head and switch the system power on.

(iii) Refer to Figure 4. With a small Allen key adjust the bottom mirror screw by no more than + or - $^1/_2$ turn to maximise the signal amplitude.

*Note...*

***Some wavelength shift may occur during this procedure. To correct this, carry out the l calibration procedure specified in Section 5.***

(iv) Refit the outer cover.

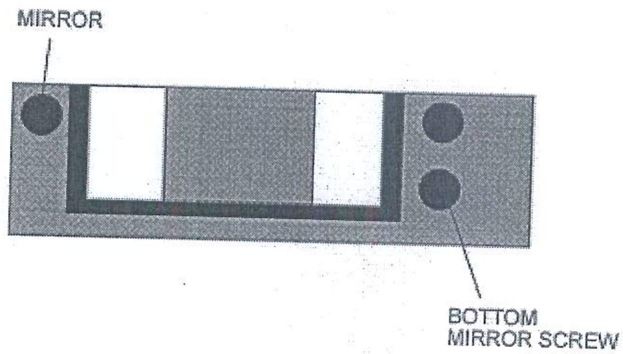
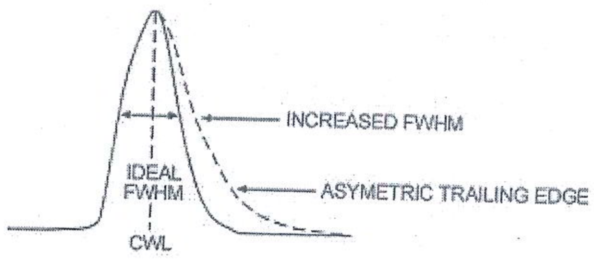



**Figure 4 - Mirror Adjustment Screw**

**Wavelength Resolution**

12. The wavelength resolution (FWHM) of the LSA's is essentially constant over the major part of their operating wavelength ranges and is defined by the width of the input/output slits (see Section 2.3). However, at wavelengths above approximately 1000nm (E201) and 1550nm (E202) the photodiode detectors used in these LSA's exhibit a charge storage effect which results in a slightly degraded resolution. Narrow band, eg, "ps laser", spectral peaks can also show an asymmetrical shape with a long trailing edge as shown below:



13. This effect should **not** give rise to any significant errors in the measurement of the peak wavelength (CWL) and will make only a very slight difference to the spectrum shape of broadband (≥10nm FHWM) laser pulses.

14. In order to avoid this particular problem and whenever using the LSA's to make accurate FWHM measurements it is recommended that E201 LSA's are only used over the 350 - 1000nm range and E202 LSA's only used over the 750 - 1550nm range.

## PEAK WAVELENGTH AND FWHM MEASUREMENTS

15. The wavelength accuracy quoted in Section 2 is the accuracy of the displayed l scale assuming that a HeNe laser has been used to wavelength calibrate the system at 632.8nm (E201) and 1265.6nm (E202).

16. In practice this means that the peak wavelength of lasers having very small natural spectral widths (ie, <1nm) can be measured to an accuracy of ±0.5nm across the full operating wavelength range of the LSA.

17. When measuring lasers with broad spectral widths (ie, ≥10nm FWHM) peak wavelength and FWHM measurements may not be as accurate due to the distorting effect of the LSA's spectral sensitivity response on the broad input spectrum. The peak wavelength shift caused by this effect will vary across the operating wavelength range and will be most significant near the extremes of this range. Typical peak wavelength measurement errors are likely to be in the range ±1nm, although larger errors are possible in certain spectral regions. This error, whilst undesirable is not usually a major problem since the broad laser spectra which are affected often have "relatively flat" peaks covering 1-2nm, thereby making "very precise" peak wavelength measurements less important.

18. The distortion of the shape of broad laser spectra due to the non uniform spectral sensitivity response of the LSA will also make FWHM measurements less accurate. This effect will be most significant for very broad spectra (eg, FWHM >30nm) but even here the error is unlikely to amount to any more than ±1nm.

19. If you have any queries or concerns regarding the spectra displayed by the LSA you should in the first instance contact an applications engineer at one of the Rees Instruments offices listed on page 4 of this manual for advice.

## PRODUCT CONFORMITY

This product has been designed and manufactured by a Quality Management System independently approved by BS EN ISO 9001:1994.

The product complies with the relevant European Community (EC) Directives which allows us to label this equipment with the ' CE ' mark. Enclosed is a copy of the declaration of conformancy which specifically details the applicable standards.

Additional question or enquiries should be addressed to:

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