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Production Gamma Ray Tool

PRODUCTION GAMMA RAY TOOL

$1^{11}/_{16}$", ULTRAWIRE™

Operational & Maintenance Manual

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0 ABOUT THIS MANUAL

0.1 MANUAL HISTORY

Date	Issue	Description	Auth	Chk	App
05/02/02	A	Initial Release.	SCA	DMO	RLH
24/09/03	B	ECR1519: drawing and BOM updates.	DMO	SCA	RLH
07/07/04	C	ECR1846/1917; CD-86002 & KITRem updated.	SCA	SCA	RLH
05/10/06	D	ECR2632, 2383, 2792, 1846, 1917, 2904.	FV	FV	RLH
14/05/08	E	ECR4723 & 3865 (CD-86002 & 86004 updated)	RS	RH	RH

0.2 UPDATES TO BE USED WITH THIS MANUAL

Consult the CD Directory for the appropriate Manual Updates to be used with this Manual.

0.3 TECHNICAL HELP

For further technical help contact Sondex as follows:

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0.4 FEEDBACK

Please help us improve future issues of this manual by sending your comments or corrections to Documentation-UK@sondex.com, referencing the document number.

Thank you.

Photographs and sketches are for illustration purposes only. Depending on the tool model that you have, certain features or dimensions may differ from those shown.

Documents from external sources (i.e. MSDS), supplied with/referenced in this manual, are considered the latest version at time of manual issue. However, the document can be altered by the external source without prior notice to Sondex.

1 DESCRIPTION

The Sondex Production Gamma Ray Tool (PGR) measures gamma radiation from the formation surrounding the wellbore or for particular applications. The tool comprises a Sodium Iodide scintillation crystal and photomultiplier to measure incident gamma radiation. The electronics interfaces to the Sondex Ultrawire™ tool bus.

The single conductor passing through the tool carries telemetry and power. The detector is unshielded and will thus accept radiation from any direction.

All models are compact, rugged and combine excellent sensitivity with high resolution for cased hole production logging applications.

Tools can be combined for tracer work and, with the addition of a gamma source, used for gravel pack investigations.

Figure 1.1 PGR

1.1 OPERATING PRINCIPLE

Gamma rays are detected by a high temperature sodium iodide crystal and amplified using a 10 stage photo-multiplier to a measurable level. The detector is temperature compensated to minimise photomultiplier drift. Calibration is effected by a wrap-around Sondex Calibrator with a distributed thorium source of very low radioactive content. The difference between background and calibrator levels provides a ratio between tool count rate and API units. Using the calibrator also monitors tool performance.

1.2 APPLICATIONS

Passive Gamma Detection provides:

- Lithology Identification.
- Depth Correlation.
- Identification of Radio Active Scale.
- Tracer Monitoring.
- Gravel Pack Monitoring (with addition of a gamma source).

1.3 INTERFACING & TOOL COMBINATIONS

- Simultaneous Operation with other Tools.
- Ultrawire™ toolbus (UW) or Memory toolbus (Mbus).
- Slickline memory or surface readout mode (with suitable telemetry controller).

1.4 SPECIFICATIONS

Parameter	Specification	Remarks
Temperature	350ºF (177ºC)	
Pressure	15,000psi (103.4MPa)	
Diameter	$1^{11}/_{16}$″ (43mm)	
Make Up Length	23.1″ (586.7mm)	
Overall Length	26.9″ (683.3mm)	Including Thread Protectors
Depth offset	5.3″ (134.6mm)	Measure point above lower tool joint.
Weight	4.3kg (9.4lbs)	
Operating Voltages:		
Nominal	+18V DC	
Range	+13-23V DC	
Maximum	+24V DC	
Current consumption at 18V	20mA	
Max Count Rate (API)	2000 cps	Reads higher subject to dead time.
Dead Time	Negligible	Below 1000 API
Nominal Calibration	1 count/API	
Depth Resolution	6″ typ.	
End threads (top/bottom)	$1^{3}/_{16}$″ UNF (female/male)	
End connectors (top/bottom)	4mm Banana single conductor (pin/socket)	

2 SAFETY

2.1 GENERAL

Warning!

HOT WORK! Sondex equipment may, under certain circumstances or failure modes, become a potential source of ignition. Using it must therefore be considered "HOT WORK" and appropriate precautionary procedures should be followed when testing at surface in areas where there is a risk of gas leaks or other potentially explosive atmospheres.

Liquid O-ring

LOR101 is used for lubricating the tool during maintenance. Contact with skin or eyes can be harmful. For more details, refer to the Material Safety Data Sheet for Liquid O-ring.

2.2 HIGH VOLTAGE HAZARD

Warning!

High voltages (1.6kV) are generated in the Detector section HV PSU sufficient to cause unpleasant shocks.

Care should be taken not to touch exposed HV components if power is applied when the electronics is removed from the housing. Test probes should only be moved when the line power is off. The tool retains its voltage for several hours; carefully discharge it before touching.

A short circuit may also cause serious damage to the tool.

2.3 CHEMICAL HAZARD

Warning!

The scintillation detector contains Thallium doped Sodium Iodide.

Thallium is a poison and should the detector become cracked or otherwise leak it must be packed in a sealed container and disposed of properly according to local regulations in force. Old detectors which are no longer in use must also be disposed of properly.

2.4 CARE OF PHOTOMULTIPLIER TUBE

Caution!

The Photo Multiplier Tube (PMT) **must be kept in total darkness whenever the tool is powered** up or the tube will be harmed.

The PMT is a glass vacuum tube device which can be damaged by severe shock particularly when dismantled from the Detector Pressure Housing.

Caution!

Do not store PGR with CCL or other tools with magnets. Keep at least 1 foot apart. Magnetic field may magnetise pressure housing and seriously reduce PGR sensitivity. Demagnetising the housing will restore the tool.

If high voltage is lingering in the HV PSU (see above) then there is a risk that the PMT could be damaged when it is exposed to light as the housing is removed.

2.5 ELECTRO STATIC DISCHARGE

Caution!

Electro Static Discharge (ESD)

All tools with electronic boards that contain solid state circuits (transistors, diodes, semiconductors) may become damaged when contacted with an electrostatic charge.

When handling tools, which contain electronic parts that are ESD sensitive, the following guidelines should be followed to reduce any possible electrostatic charge build-up on the user's body and the electronic parts:

- Always ensure proper ESD precautions are taken when handling electronic parts that are ESD sensitive during maintenance.
- Avoid touching the tool electronics, unless stated otherwise in this manual.

Note that ESD is less likely to affect tools when the housing is fitted.

3 THEORY OF OPERATION

3.1 BLOCK DIAGRAM

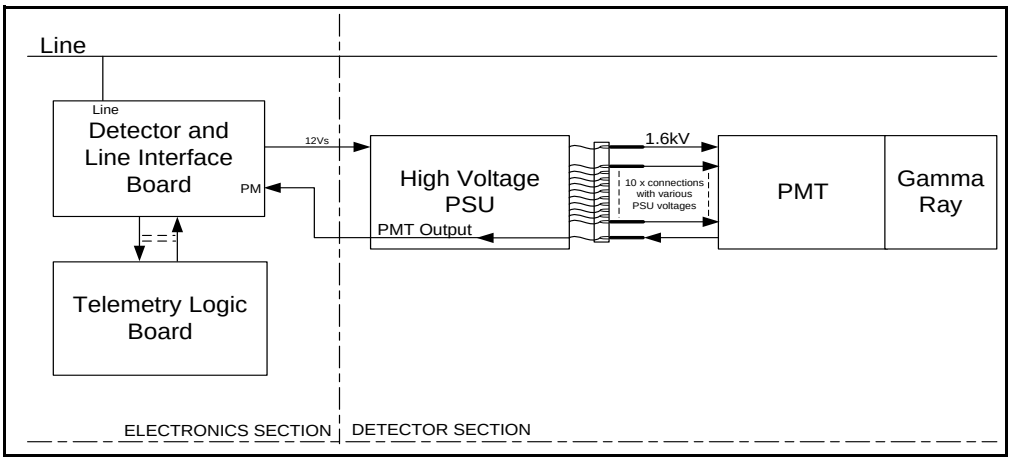


Figure 3.1 PGR Block Diagram

3.2 DESCRIPTION

3.2.1 GAMMA DETECTION

A gamma ray passing through the sodium iodide crystal may excite an atom, sufficiently to cause a number of photons of light to be emitted. These are collected by mirrors inside the crystal and exit through an optical window at the end, which is attached to the photomultiplier (PMT). Photons, striking the photocathode of the PMT, cause electrons to be emitted. As there is a potential difference of approximately 130V between dynodes in the PMT chain, the electrons are accelerated onto the next and the collision causes many more electrons to be emitted. These are accelerated onto the third and multiplied as well. The 10 stage multiplication will thus provide in the order of 5^{10} electrons per gamma ray detected. This is now a measurable charge pulse, which can be detected by the electronics. Higher energy gamma rays produce more photons in the detector crystal, which converts to a larger electrical pulse to the electronics.

Note that gamma radiation is attenuated by rock formation, casing, tubing and tool pressure housing. Steel with a thickness of 0.6″ may reduce the count rate by 50%.

3.2.2 ELECTRONICS

The HV PSU generates the -1.6kV Cathode potential and the voltage taps for the PMT Dynodes. The PMT anode output is at ground potential.

The output charge pulse is wired through the HV PSU to the detector electronics where it is amplified and detected by a comparator.

Gamma detections are stored in FPGA logic and read out over the Ultrawire toolbus in response to requests from the Telemetry Controller e.g. MPL, XTU or other Crossover. Various commands are supported in the protocol.

3.3 STATISTICAL VARIATION

The PGR tool is subject to the normal statistics associated with radioactive decay.

Note: The statistics refer to the 'raw' detected counts. The PGR normally outputs 'raw' counts but these may be divided down if very high count rates are experienced, e.g. for radioactive scale or gravel pack operation.

Statistical variation depends on the square root of the number of counts received and defines a 95% confidence level on the measurement.

Example 1: If 225 raw counts were detected in a 1 second sampling interval, you would be 95% confident that the true long term count rate was in the range 210 - 240 counts/sec.

Example 2: If 9 raw counts were detected in a 0.25 second sampling interval, you would be 95% confident that the true long term count rate was in the range 24 - 48 counts/sec.

Example 2 shows a large uncertainty due to the low number of counts in the sampling interval which would occur if logging speed was high. Time and depth filtering is required for best results.

The detector crystal is 4″ long therefore the minimum depth filter should be 6″. Depth resolution is also limited by the non directional nature of the detector and lack of geological contrast.

4 OPERATING PROCEDURE

4.1 PRE-LOGGING CHECKS

4.1.1 MECHANICAL

1 Clean and grease upper and lower O-ring Seals. Replace O-rings if damaged.

2 Ensure that upper and lower electrical connectors are clean, dry and undamaged.

4.1.2 ELECTRICAL

1 Using a Multi-meter, measure Upper to lower pin resistance. The reading should be less than 0.5Ω.

4.1.3 OPERATING

The PGR must be connected to a suitable Ultrawire™ telemetry controller, e.g. XTU or UMT, and to a data acquisition or logging system e.g. MEMLOG or MIDAS.

The prevailing background count should be observed. This varies with geographical location, typically between 10 and 100 API counts.

4.2 CALIBRATION

1 A suitable calibration jig containing a radioactive source should produce a fixed increase in count rate. The Sondex GCJ series produce count rate increases of 100, 200 or 400 API depending on type. The jig is attached with its lower edge 1□ below the lower tool joint make-up point, see *MN-GCJ001* (Gamma Ray Calibration Jig manual).

1 COUNT ≈1 API unit (approx.)

Note: The lower end of the calibration jig should be 1″ **below** the lower tool joint.

4.3 CONNECTING TO TOOLSTRING

Upper and lower tool joint O-rings and seal surfaces should be clean, undamaged and lightly greased.

The PGR may be inserted in any position below the telemetry controller.

The tool does not require any centralising since performance is independent of borehole position.

4.4 LOGGING

The following are guidelines only and must be used in conjunction with local policy and specific well site conditions both downhole and at surface. The table below is appropriate for near vertical wells and must be adjusted accordingly when in deviated wells. Use of a Head Tension Unit is highly recommended.

Note: Do not exceed the calculated safe working load of your selected weakpoint. If in doubt, use a head tension unit, especially in deviated wells where calculation from surface tension is less accurate.

Depth (ft)	Speed Pulling Out of Hole	Speed Running in Hole
In/out of catcher (pressure rig up only)	Dead slow or manual.	
30 to 150	30ft/min	
150 to 400	60ft/min	
>400 clear cased hole	Surface tension not to exceed 120% of tension when tool stationary. Speed not to exceed 150ft/min.	Surface tension should not be less than 80% of tension when tool stationary. Speed not to exceed 150ft/min.
>400 clear open hole	Surface tension not to exceed 130% of tension when tool stationary. Speed not to exceed 150ft/min.	Surface tension should not be less than 70% of tension when tool stationary. Speed not to exceed 150ft/min.
Approaching potential obstacles[a]	30ft/min	
Logging Data	**Do not exceed the above speeds.** Recommended speed is <30ft/min.	

a. For example: Reduced diameters, gas lift mandrels, fluid levels, valves, tubing shoes, packers, cross overs and other downhole equipment.

Note: Speeds, higher than 30ft/min, may introduce unacceptable statistical variation in recorded count rate.

4.5 POST LOGGING DISASSEMBLY

The toolstring should be cleaned before disassembly.

Ensure that well fluid does not reach the electrical connectors. Disassemble in a horizontal position wherever possible. Refit thread protectors immediately after disassembly to prevent damage.

4.6 TRANSPORT, HANDLING & STORAGE

Store with end threads lightly greased and with water tight thread protectors fitted.

Caution! Do not store PGR with CCL or other tools with magnets. Keep at least 1 foot apart. Magnetic field may magnetise pressure housing and seriously reduce PGR sensitivity. Demagnetising the housing will restore the tool.

Do not subject tool to extreme shock, such as dropping or hitting with a hard object. Side impact is especially likely to damage the detector.

5 MECHANICAL DESCRIPTION

The PGR comprises two main units which remain screwed together unless access to the interior is required:

Electronics Section:

- Pressure Housing.
- PSU/Telemetry Circuit Board.
- Detector Circuit Board.
- Upper Head fitted with monoconductor Pin and Pressure Isolation Seal.
- Lower End with 10 pin 'Lemo' Connector socket.

Detector Section:

- Pressure Housing.
- High Voltage PSU with 10 pin 'Lemo' Connector.
- Photomultiplier/Sodium Iodide Crystal Assembly.
- Lower End with Monoconductor Socket and Pressure Isolation Seal.

5.1 DISASSEMBLY

Warning! **Read *Section 2 Safety* prior to disassembly of the tool. Important safety information. Failing to adhere to the information in *Section 2* can cause serious personal injury and/or damage to the tool!**

5.1.1 ELECTRONICS SECTION

5.1.1.1 Accessing Electronics Boards

Ref.: General Assembly *09406*
Electronics Assembly *82111*

Caution! **DO NOT** unscrew Lower Pressure Housing (item 3) from the Lower Sub (item 6) unless the Electronics Assembly (item 2) has been removed. Failing to to do so, will cause damage to the Internal Connector.

Note: All item numbers refer to the General Assembly, unless stated otherwise.

1 Unscrew Upper Pressure Housing (item 1) from the Lower Pressure Housing (item 3).

Note: The Electronics Chassis (item 2) remains fixed to the Lower Pressure Housing (item 3).

2 The Electronics Boards in the Electronics Chassis (item 2) can be accessed by unscrewing the Screws (4x p/n01029, 82111), securing the top (larger) Half Shell (item 1, 82111) and removing the Half Shell.

5.1.1.2 Servicing Pressure Isolation Head

Ref.: General Assembly *09406*

The Electronics Section (item 2) contains a Pressure Isolation Head. Refer to *MN-PIH* for servicing this assembly.

5.1.2 DETECTOR SECTION

5.1.2.1 Separating Detector Section from Lower Sub

Ref.: General Assembly *09406*

1 Unscrew Upper Pressure Housing (item 1) from the Lower Pressure Housing (item 3).

2 Remove the Electronics Chassis (item 2) from the Lower Pressure Housing (item 3) by screwing the 3 Grub Screws approximately 2 turns inwards. The Electronics Chassis (item 2) can now be pulled off the Lower Pressure Housing (item 3).

Note: Do not screw in the Grub Screws too far, as this may damage the Connector.

3 The Lower Pressure Housing (item 3) can now be unscrewed from the Lower Sub Assembly (item 6) and the Lower Sub Assembly (item 6) can be pulled away.

Note: Take care not to damage the wiring on the Detector Assembly.

5.1.2.2 Removal of HV PSU

Ref.: General Assembly *09406*

Note: Except for repairing simple wiring faults, the HV PSU (item 4) and Detector Assembly (item 5) are not field serviceable and should be replaced completely if faulty.

1 Remove the PTFE Tape (item 10) locating the feedthrough wire on the HV PSU (item 4).

2 Unscrew the Lemo Connector Cover of the HV PSU (item 4) and remove its inner shell to reveal the cables.

3 Unsolder the yellow feedthrough wire and pull through the HV PSU Assembly.

4 Remove 2 Screws (item 16), connecting the HV PSU (item 4) and Detector Assembly (item 5).

5 Gently separate the PCB Connector Assembly on the HV PSU (item 4) from the pins on the PMT Assembly (item 5).

Further disassembly of the Detector Section is not recommended.

5.1.3 LOWER SUB

Ref.: General Assembly *09406*
Lower Sub Assembly *00884*

1 Separate the Lower Sub from the Detector Assembly as described in *Section 5.1.2.1*.

2 The Lower Sub Assembly (item 6, 09406) can be disassembled by removing the Circlip (item 4, 00884) from the Sub (item 1, 00884) and pulling out the Connector Assembly (item 3, 00884).

Note: The Connector Assembly (item 3, 00884) has a groove to facilitate Spirol Pin (item 5, 00884).

5.1.4 SHOCK PROTECTOR ASSEMBLY REPLACEMENT

Ref.: Crystal & PGR Connector Assembly *03006*

This can be achieved without removing the HV PSU Assembly from the Detector Assembly.

1 Separate the Lower Sub from the Detector Assembly as described in *Section 5.1.2.1*.

2 Unsolder the feed through wire from the Connector (item 4) and remove.

3 Holding Connector (item 4) with a spanner, unscrew the Insulator (item 3) and loosen Lock Nut (item 6). Unscrew the Connector (item 4) from the Insulator (item 2).

4 Support the Insulator (item 2) and tap out Pin (item 7).

5 Unscrew the Insulator (item 2).

6 Replace the Shock Protector Assembly (item 5).

7 Screw the Insulator (item 2) back in place and secure with Pin (item 7).

8 Refit the Connector (item 4) to the Insulator (item 3).

Note: The distance between the Crystal Housing (item 1) and the end of Connector (item 4) should be 57mm. This distance can be altered by adjusting Connector (item 4) in Insulator (item 2) and locking in position with the Nut (item 6).

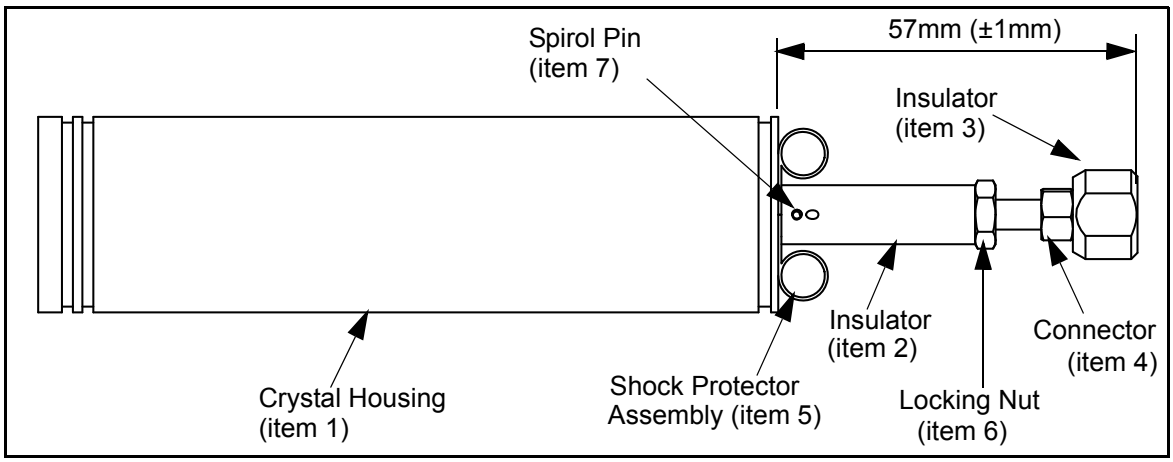


Figure 5.1 Crystal Assembly & Connector

9 Refit the Insulator (item 3).

10 Solder the feed through wire back onto the Connector (item 4).

5.2 REASSEMBLY

5.2.1 LOWER SUB

Ref.: General Assembly 09406
Lower Sub Assembly 00884

1 Lightly grease the O-ring on the Connector Assembly and screw the Connector Assembly (item 2, 00884) home into the Sub (item 1, 00884).

2 Locate Spirol Pin (item 5, 00884) in pre-drilled hole in Sub (item 1, 00884) and drive home.

Note: Replace Pin if damaged.

3 Locate Connector Assembly (item 3, 00884) into Sub (item 1, 00884), with Spirol Pin (item 5, 00884) engaged in slot, and push fully home.

Note: Ensure both Nuts on the Connector Assembly (item 3, 00884) are tight before fitting.

Note: A light tapping may be required to push fully home. Ensure it can be easily removed by inserting a 4 mm connector pin and pulling out.

4 Secure the assembly with Circlip (item 4, 00884).

5 Refit new O-rings (item 14 & 15) to the Lower Sub (item 6, 09406).

Note: Ensure Circlip is seated with the smooth side facing down.

5.2.2 DETECTOR SECTION

5.2.2.1 Refitting HV PSU

Ref.: General Assembly 09406

1 Gently locate the PCB Connector Assembly of the HV PSU (item 4) to the pins on the PMT Assembly (item 5).

Note: The Connector Assembly and the pins should only fit one way.

However for ease of connection, the pin with the wire wrapped around it should be connected to the socket with the black wire.

2 Secure HV PSU (item 4) to the PMT Assembly (item 5) with 2 Screws (item 16).

3 Thread the yellow feed through wire back through the HV PSU Assembly.

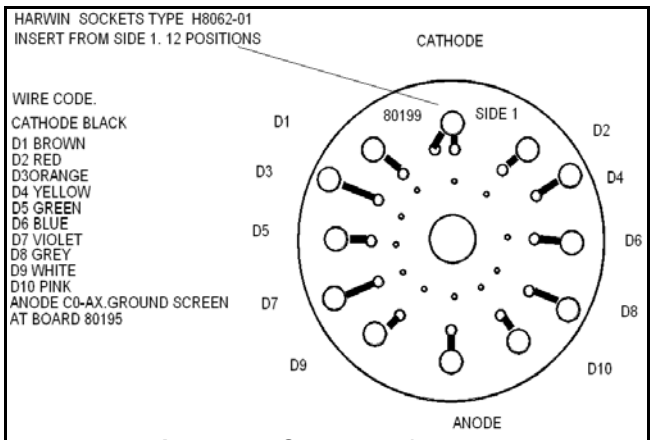


Figure 5.2 Connector Layout

Note: If unable to thread the wire through the Upper Bulkhead of the HV PSU Assembly (item 4), it can be removed as follows:

i. Remove the 4 Screws, located around the Upper Bulkhead of the HV PSU Assembly (item 4).
ii. Gently pull the Upper Bulkhead clear. The feed through wire can then be threaded through.
iii. Gently push the Bulkhead back into position, ensuring the wires are not being trapped.
iv. Screw the 4 Screws back into position.

4 Resolder the line wire into pin 6 of the Lemo Connector, sleeving joint with heat shrink cover.

Note: Only use high temperature solder 96S or 99C.

5 Replace the Lemo Inner shell and screw on the Lemo connector Cover.

6 Secure the wiring to the Assembly, using PTFE Tape (item 10) and Silicone Rubber Shock Protector (item 11). Replace Tape and Silicone if damaged.

7 Lubricate a new O-ring (item 12) and fit onto the HV PSU Assembly.

Note: Check the Shock Protector Assembly on the PMT Assembly (item 5) and replace if required, see *Section 5.1.4*.

5.2.2.2 Connecting Detector Section to Lower Sub

Ref.: General Assembly *09406*

1 Push the Lower Sub Assembly (item 6) in place and screw the Lower Pressure Housing (item 3) onto the Lower Sub Assembly (item 6)

Note: Take care not to damage the wiring on the Detector Assembly.

2 Push the Electronics Chassis (item 2) onto the Lower Pressure Housing (item 3). Ensure the Connector on the Electronics mates with the Connector on the Detector.

3 Secure the Electronics Chassis (item 2) to the Lower Pressure Housing (item 3) by screwing the 3 Grub Screws until tight.

Note: The Electronics may be slightly rotated to ensure the Screws line up with the Pressure Housing. Do not rotate more than 90º and do not use excessive force.

4 Lubricate and fit a new O-ring (item 13).

5 Screw Upper Pressure Housing (item 1) tight onto the Lower Pressure Housing (item 3).

6 ELECTRICAL DESCRIPTION

Ref.: Wiring Diagram *WD-*82111

6.1 TELEMETRY LOGIC CIRCUIT BOARD

Ref.: Telemetry Logic Circuit Diagram *CD-86004*

The main function of the Telemetry Board is the power start up circuitry and telemetry logic comprising a PIC micro-controller in conjunction with an Actel FPGA.

Communication between the Telemetry Controller and the tool is via the Ultrawire toolbus. This is a single pin bus, which carries power to the tool in addition to its telemetry function. The return for both power and signal is via the chassis.

The telemetry is modulated onto the line as 1V AMI (alternate mark inversion) at 500kbaud.

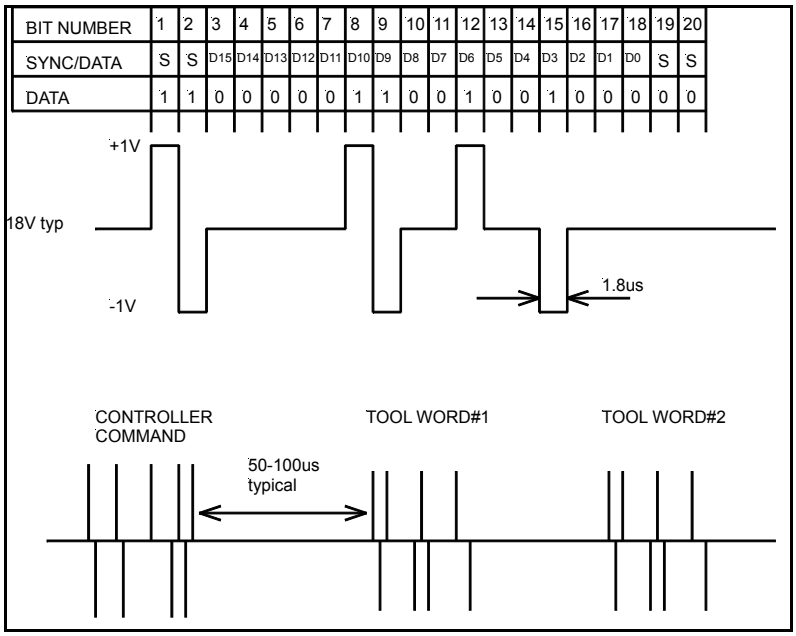


Figure 6.1 Ultrawire Signal Shape example

The Ultrawire telemetry is a master slave protocol. The controller, which is always the master, sends a command to the tool. This may be a global command (to all tools) or a tool specific command which contains the address of the target tool. The tool's 'hard' address is set in the range 0-63 by links AD0 - AD5. Tool specific commands are acknowledged by the tool, global commands are executed but do not generate a response.

For rate-meter type tools, count pulses are collected from the sensor on inputs 1-7 of the PCB. These are counted in hardware by the Actel, (U1) and accumulated by the PIC (U3).

When the controller is in logging mode, it will periodically send a global 'Sample Now' command to all the tools and then poll each tool individually with a 'Send Data' command. The 'Sample now' command causes the latest count to be frozen in a shadow register, and this count is then passed to the controller in response to the 'Send Data' command.

Ultrawire words are 20 bits long. The first and last two bits are for synchronisation. The first bit is always ‘1’. The intervening 16 bits are tool data.

6.2 DETECTOR & LINE INTERFACE CIRCUIT

Ref.: Circuit Diagram *CD-86002*

The main functions of the Sensor board is the PSU, Line Driver and Detector circuits.

The Ultrawire line carries 18V DC (nom). Power is removed from the line by transistors Q1, Q2, Q6 and Q7 (with associated components) generating local power rails at 12V and 5V.

Electrically, the telemetry is a.c. coupled from the line to the drivers and receivers by C1. The received data is removed from the line by a pair of comparators, U1, and passed to the Actel, which validates the address. The command is interpreted by the PIC on PCB86004, which if necessary generates the response packet and passes it to the Actel also located on PCB86004. The Actel drives Q3 and Q5, which modulate the line.

Amplifier U2A (pins 1, 2 and 3) is a charge amplifier for the PMT pulses. It gives a positive output voltage pulse on U2A pin 1 proportional to the energy of the incident gamma-ray. C8 controls the pulse height and is set to produce an output pulse of 0.6 ±0.1V for a 60keV source (Americium 241). Pulse width depends on the speed of the op amp, C8 and R9. R9 is adjusted for a pulse width of 1 to 1.5μs. Typical values are C8 = 22pF, R9 = 47kΩ. Adjust C8 first for pulse height. Then adjust R9 to set pulse width, see *Figure 6.2*.

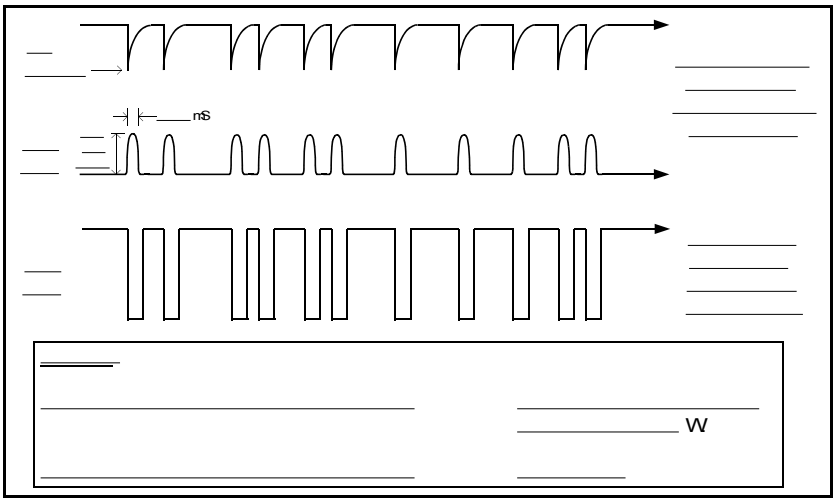


Figure 6.2 Detector Analogue Waveforms

U2B (pins 5, 6 and 7) is a comparator with a discriminination level of 0.3±0.1V, set by D2, R11 and R12. This level drops with increasing temperature to compensate for reduced PMT efficiency. F1 is “Raw” logic level counts.

6.3 HIGH VOLTAGE POWER SUPPLY

The photomultiplier tube (PMT) is glued to the Scintillation Crystal with optically clear adhesive.

The HV switching PSU (running at 10kHz approx.) provides PMT dynode voltages ranging from 0V on the Anode up to -1.6kV on the photo-cathode. A Mu metal screen is wrapped around the PMT to protect the sensitive photo-cathode from electrical and magnetic interference. This screen is electrically connected to the Cathode hence it is at -1.6kV when powered. It is therefore important that there is no electrical leak from this screen to the Detector chassis which is at 0V.

The PMT charge output pulse from the Anode is at 0V and is AC coupled through a 100pF capacitor in the HV PSU and taken to the 10 pin connector. 12V power and Line telemetry also pass through this connector. Unused pins are grounded to 0V in the electronics to reduce interference on to the PMT signal.

Warning! The high voltages produced by the HV PSU, if detached from the PMT section and powered up, can give an electrical shock!.

Caution! The Photo Multiplier Tube (PMT) **must be kept in total darkness whenever the tool is powered** up or the tube will be harmed.

7 EXTENDED CHECKS

7.1 PREVENTATIVE MAINTENANCE

7.1.1 GREASE & LUBRICANTS

Sondex recommends the use of “Liquid O-ring type 101” (p/n LOR101) on threads and O-rings.

All O-rings and housing threads are assumed to be and must be lightly greased, unless specifically indicated otherwise.

Correct use of grease and lubricants is essential to the maintenance of all Sondex downhole equipment.

Note that some threads are internal, which can cause grease to get inside the tool. Do not use excessive quantities.

Sondex does not recommend Copper loaded greases since some types can cause electrical leaks. Some types for grease are not suitable for use on O-rings. Silicone grease may be used on O-rings, but must be kept clear of threads, especially stainless steel to stainless steel.
Cavities, e.g. spring housings, should be filled with a suitable heavy high melting point grease. like Castrol Spheerol L-EP2 or Castrol LMX.

Caution! The use of certain greases, which contain volatile content, (e.g. some types of Lubriplate) can cause electrical failure due to production of corrosive gasses inside the tool when burned off.

7.1.2 MECHANICAL

1 Remove dirt and old grease from pressure housing threads and O-rings and replace with fresh.

2 Inspect O-rings for damage or ageing/hardening and replace where required.

3 Check for:

- Damaged wires.
- Wires that are loose and likely to be crushed on re-assembly.
- Damaged components.
- Loose screws/nuts/components/connectors.

Note: If RTV or similar compound is used to secure loose components, it must be fully cured before housing is replaced.

- Electrical components shorting to chassis.
- Heat or chemical damage (discoloured components).
- Incorrect thread grease or excessive quantity.
- Cleanliness of connectors and loose/bent pins before replacing.

4 Check all fixings and grub screws for tightness.

7.1.3 ELECTRICAL

1 Using a Multi-meter, measure Upper to lower pin resistance. The reading should be less than 0.5Ω.

2 Check Tool current at 18V. The reading should be 20mA.

3 Connect to Logging System and check for correct data. Apply some gentle vibration and rotation to expose potential failure.

7.1.4 DETECTOR SENSITIVITY/CALIBRATION CHECK

The PGR detector which includes the HV PSU, PMT and Crystal, leave Sondex with a known sensitivity for that particular tool. Any failing or ageing of any of these 3 components reduces the sensitivity. The PMT ageing and dynode circuit leakage have the most effect. Heat also reduces sensitivity. Loss of sensitivity may be obvious from previous logs.

1 Place an Americium source (60keV), e.g. from the Sondex FDR tool, close to the PGR Detector housing. Monitor PCB86002 charge amplifier output, U2A pin 1. This is set to give a 0.6V pulse for the Americium source at room temperature.

If the pulse is less than 0.6V at room temp, sensitivity has dropped and downhole counts may be lower than expected. It will still work, especially if not hot but preventative action is required. See *Section 7.3 Troubleshooting*.

2 Check calibration, see *Section 4.2 Calibration*. This should be within 5% of previous check and within 10% of original calibration check.

7.1.5 AGEING OF ELECTRONICS

At 150°C, significant electronic ageing failures are expected after 4000hrs typical use, hence PCB replacement should be considered at this point. Every additional 10°C halves the time. Also accelerated by vibration and corrosive gas inside the chassis. Visual inspection and logging previous history is recommended, but is unlikely to predict premature failure.

Tools that may be suspected of reliability problems due to age or unusual log response may be heated to 120°C, which would not normally age the electronics, and then subjected to moderate vibration. A moderately hard blow from a wooden hammer is recommended. **DO NOT USE METAL HAMMERS**.

Ageing of scintillation crystals and PMT can be measured directly, so can be caught before failure, see Section 7.1.4. Detector pulse height naturally drops to as low as 20% of 20°C value at 177°C but should recover. Logged counts are expected to drop up to 10% at 177°C. If they drop more, the Detector is faulty.

7.1.6 HEAT TESTING ABOVE 150°C

This is not generally recommended since it shortens tool life expectancy.

Heat testing may be required for contractual reasons, tool out of use for a long period or job with unusually high well temperature. The test should be carried out only slightly above expected well temperature and the tool should not be kept at temperature for more than 1 hour.

Detector sensitivity reduces with increasing temperature.

This should not cause detected counts to drop by more than 10% at 177°C. This should be monitored from previous logs or an occasional heat test. Background or GCJ calibrator may be used.

7.2 EXTRAORDINARY MAINTENANCE

Ref.: General Assembly *09406*

The following O-rings require replacement after every run:

- 2x item 15.

If the tool experiences H_2S gas or temperatures above 150°C, the following O-rings must be replaced:

- 2x item 15.
- 4x item 14.
- 1x item 13.

It is adviseable to check and O-ring (item 12) while the tool is disassembled.

Note: Ensure the disassembly procedure in *Section 5.1* is followed carefully. Failing to do so may cause damage to the connectors.

No other special maintenance is required.

7.3 TROUBLESHOOTING

Refer to *Section 5.2 Reassembly* and *Appendix B* where necessary.

An oscilloscope, multimeter and other basic test equipment will be required.

Initial inspection	Check for: • Damaged wires. • Damaged components. • Electrical components shorting to chassis. • Heat or chemical damage (discoloured components). • Incorrect thread grease or excessive quantity, see *Section 7.1.1*. Also check all fixings are tight.
Excessive current	Unplug Detector and disconnect wires to isolate fault to: • Upper head isolation assembly. • Detector. • Line wire through Detector and lower connector. • Upper electronics. Upper Head and Detector line wire can be disassembled to locate fault. Apply up to 250V relative to chassis on isolated Line Up and Down to check for electrical leak. Resistance should exceed 100MΩ. Separate HV PSU (item 4, 09406) from PMT (item 5, 09406). HV PSU takes 5mA approx., attaching PMT should not increase the current. Check HV PSU and PMT Base for wire damage. Otherwise HV PSU and PMT are not user serviceable, replace complete if faulty. Isolate high current to either PCB or PCB86004. Fault find or replace PCB.
Little or no current	On PCB86002 and 86004 check LINE = 18V, V+ = 12V and Vc = 5V and 0V wire connects to chassis. Fault find or replace PCB. Check that HV PSU is supplied with 12V on pin 7 and 0V on pins 3, 4, 5, 7, 9, 10.
No telemetry counts	On PCB 86002 and 86004 check LINE = 18V, V+ = 12V and Vc = 5V and 0V wire connects to chassis. Fault find or replace PCB. On PCB 86004 check TP5 for 4MHz clock. Replace U2 if faulty. Reduce R11 value if clock <3V amplitude. Check line for +1V and -1V, 2μs pulses from the controller and similar pulses from the tool. Logic pulses should be present on PCB 86004 TP1 - 4. If no tool response words on the Line, fault find or replace PCB86002.

Faulty detector 	Replace HV PSU or measure -1.6kV HV output with a 1:1000 HV probe. The PMT base must be completely clean and dry. Probes of a lower resistance will not measure correctly. **Do not power up PMT except in complete darkness.** Check sensitivity, see *Section 7.1.4*, with a 60keV source (Americium 241). On PCB 86002, C8 can be reduced to increase 60keV pulse to its correct value of 0.6Vpk. If a value of 10pF or less is required, the PMT is faulty or other fault. If C8 is changed, the temperature drift must be checked and R9 may need adjusting for drift and noise interference. U2A pin 1 will normally show some telemetry interference and from the HV PSU switching frequency of 10-12kHz. Gently check that the PMT to Crystal joint is firmly glued. This joint is not field repairable, replace PMT/Crystal assembly complete. If 60keV sensitivity is correct, but calibrated counts are low, the scintillation crystal is broken.

APPENDIX A EQUIPMENT & RECOMMENDED SPARES

Item	Part No	Description	Qty	Remarks
1	PGR020	Production Gamma Ray Tool, $1^{11}/_{16}$″, Ultrawire™	1	

A.1 ANCILLARY EQUIPMENT

Item	Part No	Description	Qty	Remarks
1	GCJ001	Gamma Calibration Jig, $1^{11}/_{16}$″ , 400 API.	1	See *MN-GCJ001*.

A.2 MAINTENANCE EQUIPMENT

Item	Part No	Description	Qty	Remarks
1	*91050*	Tool Kit for all $1^{11}/_{16}$″ Tools SX and GO	1	
2	LOR101	Grease for O-rings & threads	1	5oz. pot
3	LOR101L	Grease for O-rings & threads	AR	12oz. pot

A.3 RECOMMENDED SPARES

Item	Part No	Description	Qty	Remarks
1	*KITB-PGR1 11/16*	Basic Spares Kit	1	Supports 1 run in hole.
2	*KITR-PGR1 11/16*	Recommended Spares Kit	1	Supports 25 runs in hole.

Note: Spares kits suitable for remote logging operation can be supplied upon request.

Note: Refer to *MN-PIH* for Equipment & Recommended Spares for the Pressure Isolation Head.

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
91050	-		NGH	PD	DJF
			Date: 14/01/2002	Date: 14/01/2002	Date: 14/01/2002

Description:
Tool Kit for all 1 11/16 Tools SX and GO

CHANGE HISTORY					RELATED DOCUMENTS		
Iss	*Date*	*Remarks*	*Chkd*	*Appr*	*# Documents*	*Issue*	*Notes*
-	14/01/2002	Initial Release	PD	DJF			

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	91005	-	Spanner Open Ended 42mmx38mm		2	ea	
002	91019	-	Spanner C 50mm 35mm		1	ea	
003	10038	A	Spanner Box 3/8 x 5/16 Modified		2	ea	
004	91028	-	Spanner 3/8x5/16		1	ea	
005	91027	-	Spanner Single Open End 18mm		1	ea	
006	91029	-	Key Hex Metric		1	ea	
007	91030	-	Punch Pin Parallel set		1	ea	
008	00615	A	Assy Spanner PKJ		1	ea	
009	91293	PT1	Screwdriver Parallel tip (3 0 x 75)		1	ea	
010	91105	-	Toolroll With SX Badge Large Black		1	ea	
011	91104	-	Screwdriver Parallel tip (5 5 x 200)		1	ea	
012	91103	-	Pliers Circlip 812 Chrome/Van		1	ea	
013	91102	-	Pliers Mini Flat Nose 5 Inch		1	ea	
014	10037	A	Bar Tommy		2	ea	
015	10051	A	Kemlon tool Sondex - 4BA Hex Socket		1	ea	
016	91280	-	Hammer, 4oz ball pein		1	ea	
017	91130	-	Pin C Spanner 35-50mm		1	ea	

(AR = As Required)

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
kitb-pgr1 11/16	-		SA	RLH	RLH
			Date: 24/01/2002	Date: 24/01/2002	Date: 24/01/2002

Description:
Kit, Spares, Basic, PGR, 1 11/16

CHANGE HISTORY					RELATED DOCUMENTS		
Iss	*Date*	*Remarks*	*Chkd*	*Appr*	*# Documents*	*Issue*	*Notes*
-	23/01/2002	Initial release	RLH	RLH			

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	99124	-	O Ring Viton 90 Type 124		4	ea	
002	99211	-	O Ring Viton 90 Type 211		2	ea	

(AR = As Required)

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
kitr-pgr1 11/16	-		SA	RLH	RLH
			Date: 23/01/2002	Date: 23/01/2002	Date: 23/01/2002

Description:
Kit, Spares, Recommended(25Run), PGR(1 11/16)

CHANGE HISTORY					RELATED DOCUMENTS		
Iss	*Date*	*Remarks*	*Chkd*	*Appr*	*# Documents*	*Issue*	*Notes*
-	23/01/2002	Initial release	RLH	RLH			

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	99124	-	O Ring Viton 90 Type 124		100	ea	
002	99901	-	O Ring 310 Silicon		2	ea	
003	99211	-	O Ring Viton 90 Type 211		50	ea	

(AR = As Required)

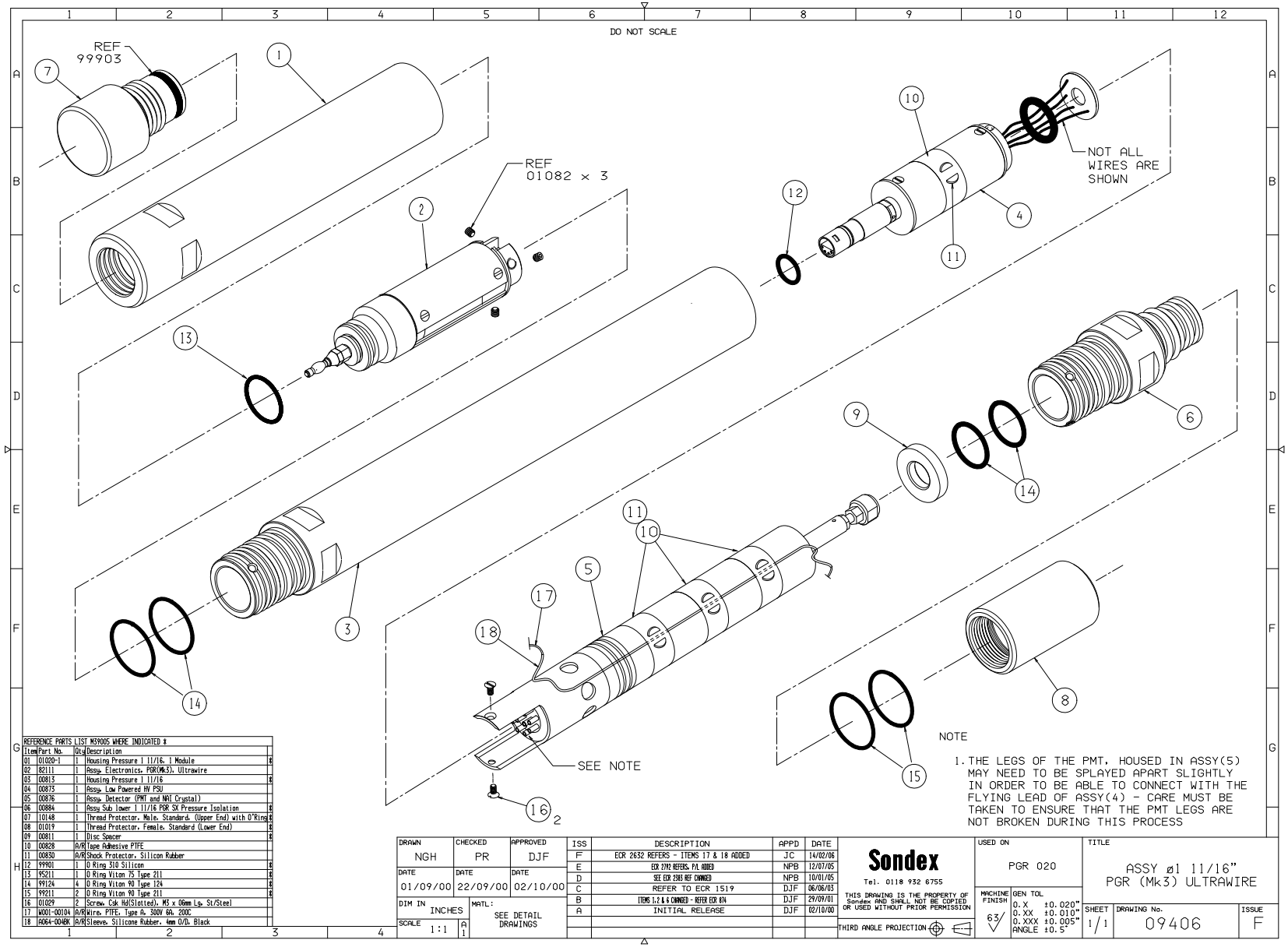
APPENDIX B DRAWINGS & PARTS LISTS

B.1 MECHANICAL DRAWINGS

Description	Drawing	Parts List
General Assembly	*09406-F*	See Drawing.
HV PSU Assembly	*00873-F*	See Drawing.
Electronics Assembly	*82111-D*	*82111-D*
Crystal & Connector Assembly	*03006-C*	See Drawing.
Lower Sub Assembly	*00884-A*	*00884-A*

B.2 ELECTRICAL DIAGRAMS

Description	Type	Drawing
Tool Electronics Assembly, Ultrawire™	Wiring Diagram	*WD-82111-A*
Ultrawire™ Sensor Board (2 sheets)	Circuit Diagram	*CD-86002-Fxx*
Ultrawire™ Telemetry (2 sheets)	Circuit Diagram	*CD-86004-Cxx*



REFERENCE PARTS LIST M39005 WHERE INDICATED *

Item	Part No.	Qty	Description	
01	01020-1	1	Housing Pressure 1 11/16, 1 Module	*
02	82111	1	Assy. Electronics, PGR(Mk3), Ultrawire	
03	00813	1	Housing Pressure 1 11/16	*
04	00873	1	Assy. Low Powered HV PSU	
05	00876	1	Assy. Detector (PMT and NAI Crystal)	
06	00884	1	Assy Sub Lower 1 11/16 PGR SX Pressure Isolation	*
07	10148	1	Thread Protector, Male, Standard, (Upper End) with O'Ring	*
08	01019	1	Thread Protector, Female, Standard (Lower End)	*
09	00811	1	Disc Spacer	*
10	00828	A/R	Tape Adhesive PTFE	
11	00830	A/R	Shock Protector, Silicon Rubber	
12	99901	1	O Ring 510 Silicon	*
13	95211	1	O Ring Viton 75 Type 211	*
14	99124	4	O Ring Viton 90 Type 124	*
15	99211	2	O Ring Viton 90 Type 211	*
16	01029	2	Screw, Csk Hd(Slotted), M3 x 06mm Lg, St/Steel	
17	W001-00104	A/R	Wire, PTFE, Type A, 300V 6A, 200C	
18	A064-0048K	A/R	Sleeve, Silicone Rubber, 4mm O/D, Black	

DRAWN	CHECKED	APPROVED
NGH	PR	DJF
DATE	DATE	DATE
01/09/00	22/09/00	02/10/00

DIM IN INCHES | MATL: SEE DETAIL DRAWINGS | SCALE 1:1 | A1

ISS	DESCRIPTION	APPD	DATE
F	ECR 2632 REFERS - ITEMS 17 & 18 ADDED	JC	14/02/06
E	ECR 2392 REFERS, P/L ADDED	NPB	12/07/05
D	SEE ECR 2383 REF CHANGED	NPB	10/01/05
C	REFER TO ECR 1519	DJF	06/06/03
B	ITEMS 1, 2 & 6 CHANGED - REFER ECR 874	DJF	29/09/01
A	INITIAL RELEASE	DJF	02/10/00

Sondex
Tel. 0118 932 6755

THIRD ANGLE PROJECTION

USED ON: PGR 020

MACHINE FINISH 63

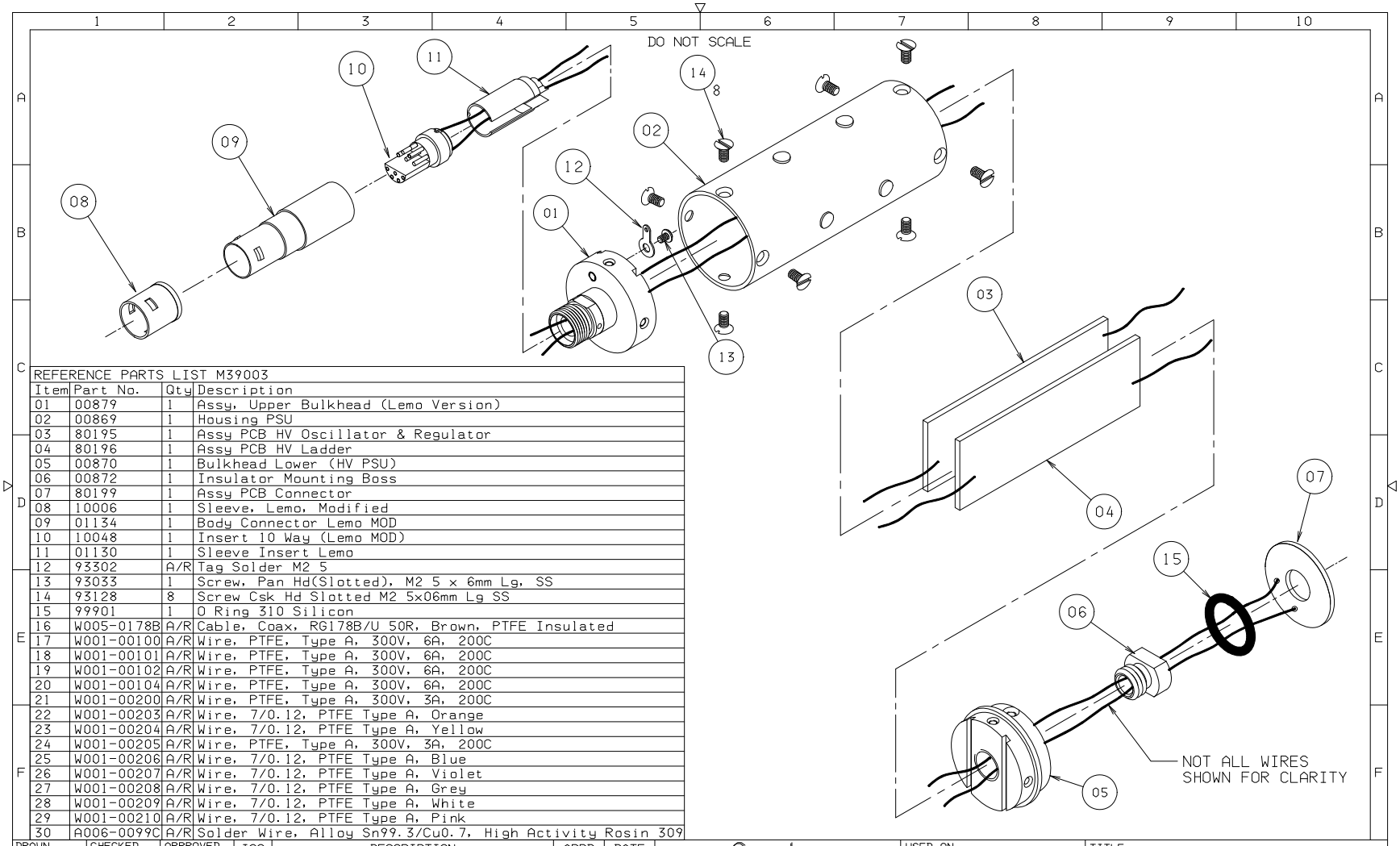
GEN TOL
0.X ±0.020"
0.XX ±0.010"
0.XXX ±0.005"
ANGLE ±0.5°

TITLE: ASSY ø1 11/16" PGR (Mk3) ULTRAWIRE

SHEET 1/1 | DRAWING No. 09406 | ISSUE F

Production Gamma Ray Tool

PGR020



REFERENCE PARTS LIST M39003

Item	Part No.	Qty	Description
01	00879	1	Assy, Upper Bulkhead (Lemo Version)
02	00869	1	Housing PSU
03	80195	1	Assy PCB HV Oscillator & Regulator
04	80196	1	Assy PCB HV Ladder
05	00870	1	Bulkhead Lower (HV PSU)
06	00872	1	Insulator Mounting Boss
07	80199	1	Assy PCB Connector
08	10006	1	Sleeve, Lemo, Modified
09	01134	1	Body Connector Lemo MOD
10	10048	1	Insert 10 Way (Lemo MOD)
11	01130	1	Sleeve Insert Lemo
12	93302	A/R	Tag Solder M2 5
13	93033	1	Screw, Pan Hd(Slotted), M2 5 x 6mm Lg, SS
14	93128	8	Screw Csk Hd Slotted M2 5x06mm Lg SS
15	99901	1	O Ring 310 Silicon
16	W005-0178B	A/R	Cable, Coax, RG178B/U 50R, Brown, PTFE Insulated
17	W001-00100	A/R	Wire, PTFE, Type A, 300V, 6A, 200C
18	W001-00101	A/R	Wire, PTFE, Type A, 300V, 6A, 200C
19	W001-00102	A/R	Wire, PTFE, Type A, 300V, 6A, 200C
20	W001-00104	A/R	Wire, PTFE, Type A, 300V, 6A, 200C
21	W001-00200	A/R	Wire, PTFE, Type A, 300V, 3A, 200C
22	W001-00203	A/R	Wire, 7/0.12, PTFE Type A, Orange
23	W001-00204	A/R	Wire, 7/0.12, PTFE Type A, Yellow
24	W001-00205	A/R	Wire, PTFE, Type A, 300V, 3A, 200C
25	W001-00206	A/R	Wire, 7/0.12, PTFE Type A, Blue
26	W001-00207	A/R	Wire, 7/0.12, PTFE Type A, Violet
27	W001-00208	A/R	Wire, 7/0.12, PTFE Type A, Grey
28	W001-00209	A/R	Wire, 7/0.12, PTFE Type A, White
29	W001-00210	A/R	Wire, 7/0.12, PTFE Type A, Pink
30	A006-0099C	A/R	Solder Wire, Alloy Sn99.3/Cu0.7, High Activity Rosin 309

DRAWN	CHECKED	APPROVED
NGH	AJB	NE
DATE 17/04/98	DATE 20/04/98	DATE 30/04/98
DIM IN INCHES	MATL: SEE DETAIL DRAWINGS	
SCALE 1:1	A3	

ISS	DESCRIPTION	APPD	DATE
F	ECR 2792 REFERS, P/L ADDED	NPB	12/07/05
E	REFER TO ECR 1519	DJF	30-06-98
C	ITEM 2 UPISSUED	NE	30-06-98
B	ITEMS 1, 2, 6 & 7 UPISSUED	NE	30-06-98

Sondex
GEOPHYSICAL EQUIPMENT
Tel. 0118 932 6755

THIRD ANGLE PROJECTION

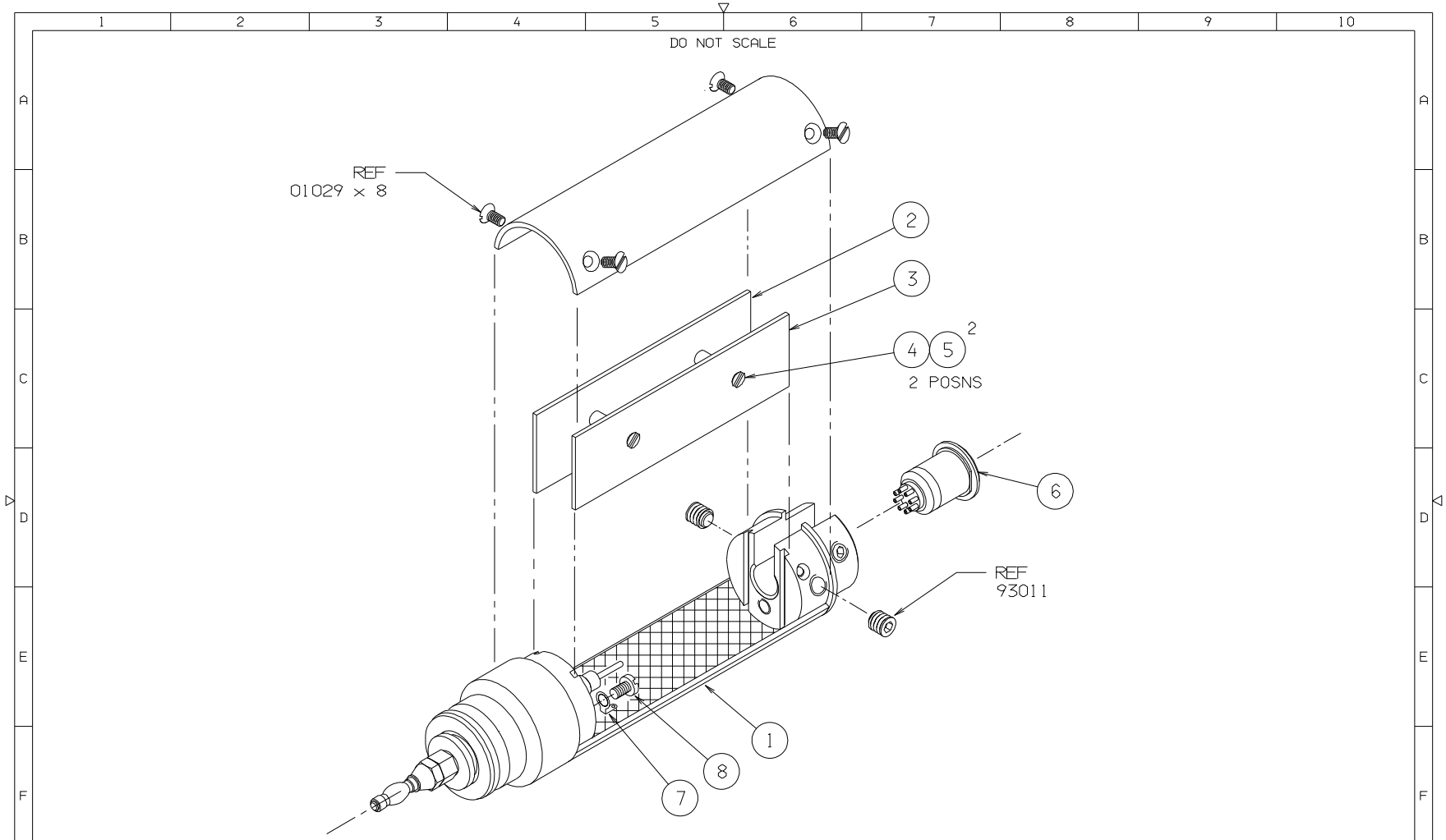
USED ON: FDR & PGR

MACHINE FINISH 63

GEN TOL
0.X ±0.020"
0.XX ±0.010"
0.XXX ±0.005"
ANGLE ±0.5°

TITLE: ASSY HIGH VOLTAGE PSU

SHEET 1/1 | DRAWING No. 00873 | ISSUE F



DRAWN NGH	CHECKED PR	APPROVED DJF	ISS	DESCRIPTION	APPD	DATE	**Sondex**	USED ON 09406	TITLE ASSY - ELECTRONICS PGR(Mk3) - ULTRAWIRE
DATE 04/09/00	DATE 22/09/00	DATE 02/10/00	D	REF ECR1519	DJF	06/06/03	Tel. 0118 932 6755 THIS DRAWING IS THE PROPERTY OF Sondex AND SHALL NOT BE COPIED OR USED WITHOUT PRIOR PERMISSION		
DIM IN INCHES	MATL: SEE DETAIL DRAWINGS		A	INITIAL RELEASE	DJF	02/10/00		MACHINE FINISH 63	GEN TOL 0.X ±0.020" 0.XX ±0.010" 0.XXX ±0.005" ANGLE ±0.5°
SCALE 1:1	A3						THIRD ANGLE PROJECTION	SHEET 1/1	DRAWING No. 82111 ISSUE D

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
			NGH	PR	DJF
82111	D		Date: 04/09/2000	Date: 28/09/2000	Date: 02/10/2000

Description:
Assy, Electronics, PGR(Mk3), Ultrawire

CHANGE HISTORY

Iss	Date	Remarks	Chkd	Appr
A	02/10/2000	Initial Release	PR	DJF
B	21/12/2000	ECR681. Solder 99C added.	DJ	PR
C	29/09/2001	Chassis Changed - Refer ECR 874	DJF	DJF
D	22/05/2003	Re: ECR 1519		

RELATED DOCUMENTS

#	Documents	Issue	Notes
01	WD-82111	A	Wiring Diagram - Initial Release
02	82111	D	Assembly Drawing. Mechanical Layout
03	AI 80144	PT1	Assembly Instructions
04	AR 80144	PT1	Assembly Records

PARTS LIST

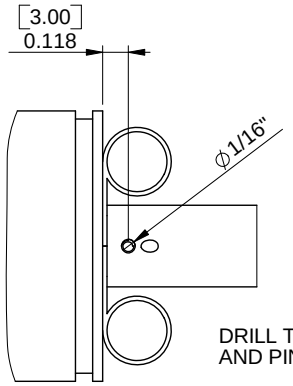
Item	Part No.	Issue	Description	Component Value	Qty	Units	Remarks
001	10504	E	Assy, Chassis, 1 Module, Memory, SX, Lemo (Mechanical)		1	ea	
002	86002	C-02	Assy, Sensor PCB, GAMMA Tools		1	ea	
003	86004	B-03	Assy;		1	ea	
004	01029	-	Screw, Csk Hd(Slotted), M3 x 06mm Lg, St/Steel		4	ea	
005	94171	-	(Use 93261)		2	ea	
006	10049	A	Plug 10 way Lemo modified		1	ea	
007	93097	-	Tag Solder M3		1	ea	
008	93048	-	Screw, Pan Hd Slotted, M3 x 6mm Long, St/Steel		1	ea	
009	w001-00200	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Black		(AR)	
010	w001-00201	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Brown		(AR)	
011	w001-00202	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Red		(AR)	
012	w001-00203	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Orange		(AR)	
013	w001-00205	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Green		(AR)	
014	w001-00207	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Violet		(AR)	
015	w001-00208	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Grey		(AR)	
016	w001-00209	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 White		(AR)	
017	w001-00210	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Pink		(AR)	
018	w001-00104	-	Wire, PTFE, Type A, 300V 6A, 200C	7/0.2 Yellow		(AR)	
019	w005-0178B	-	Cable, Coax, RG178B/U 50R, Brown, PTFE Insulated	7/0.1mm		(AR)	
020	A006-0099C	-	Solder Wire, Alloy Sn99.3/Cu0.7, High Activity Rosin 309	Sldr Wire 99C Rosin		(AR)	

(AR = As Required)

DO NOT SCALE

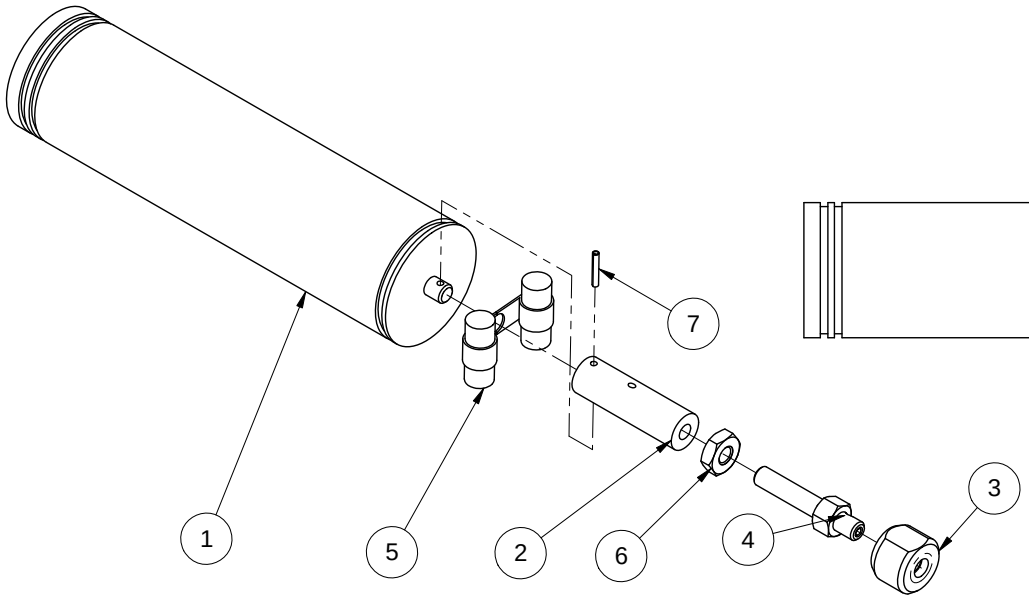
REFERENCE PARTS LIST M39004 WHERE INDICATED THUS:- *

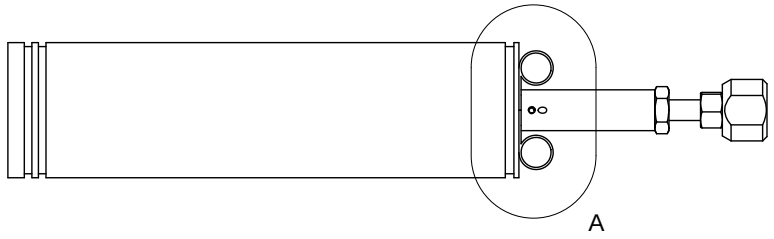
ITEM NO.	QTY.	PART NUMBER	DESCRIPTION	REF
1	1	94144	CRYSTAL$NAI 1F4-X BICRON	
2	1	00809	INSULATOR XTAL	*
3	1	00856	INSULATOR CENTRALISER	*
4	1	00857	ASSY, CONNECTOR, FEMALE ADJUSTABLE, WITH SOCKET	*
5	1	00826	ASSY - SHOCK ABSORBER	*
6	1	01026	NUT HEX 10-32UNF SS	*
7	1	93235	PIN SPIROL ø1/16 x 3/8" LG SS STD DUTY	*



DRILL THRU ITEMS 1 & 3
AND PIN USING ITEM 7.

DETAIL A
SCALE 2 : 1





NOTES

1. REMOVE ALL BURRS & SHARP EDGES.
2. ASSEMBLE IN ACCORDANCE WITH SONDEX ASSEMBLY INSTRUCTIONS AI-03006.

DRAWN: GHT	CHECKED: NPB	APP'D: NPB
DATE: 18/11/04	DATE: 12/07/05	DATE: 12/07/05
DIM IN: INCHES	MATL: SEE PARTS LIST	
SCALE: 1:1	A3	HEAT TREATMENT/CONDITION:

ISS	DESCRIPTION	APPD	DATE
C	ECR2792 REFERS	NPB	08/02/06

Sondex
Tel. 0118 932 6755

THIRD ANGLE PROJECTION

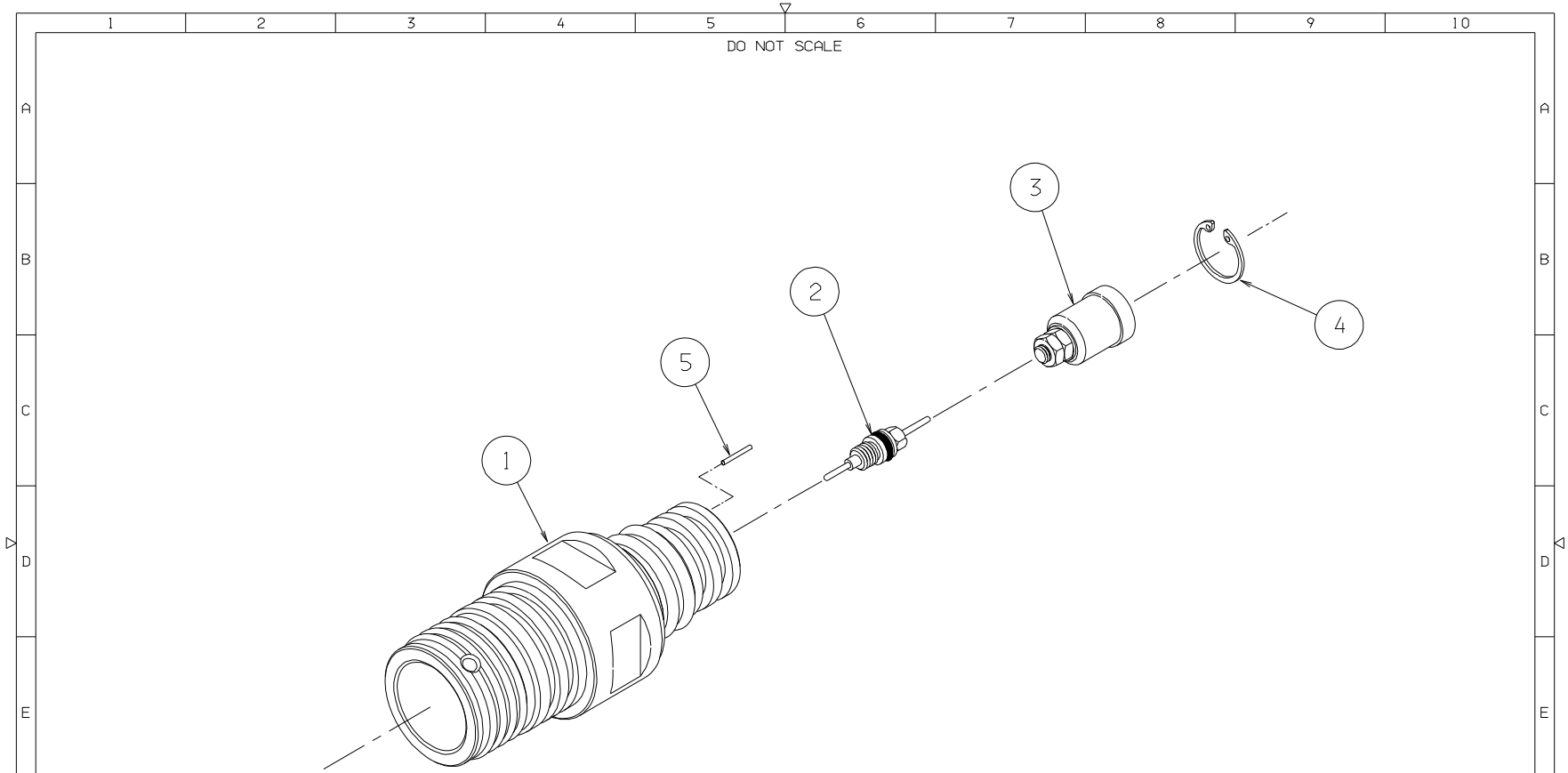
USED ON: PGR 00876

MACHINE FINISH: 63

GEN TOL: 0.X 0.020" | 0.XX 0.010" | 0.XXX 0.005" | ANGLE ±0.5°

TITLE: ASSY CRYSTAL WITH CONNECTOR PGR

SHEET 1/1 | DRAWING No. AD 03006 | ISSUE C | S W



DRAWN MT	CHECKED GS	APPROVED DJF	ISS	DESCRIPTION	APPD	DATE	Sondex GEOPHYSICAL EQUIPMENT Tel. 0118 932 6755	USED ON PGR	TITLE ASSY SUB LOWER 1 11/16" PGR SX PRESSURE ISOLATION
DATE 28/03/03	DATE 28/03/03	DATE 20/05/03	A	INITIAL RELEASE	DJF	20/05/03	THIS DRAWING IS THE PROPERTY OF Sondex AND SHALL NOT BE COPIED OR USED WITHOUT PRIOR PERMISSION	MACHINE FINISH 63	GEN TOL 0.X ±0.020" 0.XX ±0.010" 0.XXX ±0.005" ANGLE ±0.5°
DIM IN INCHES	MATL: SEE PARTS LIST						THIRD ANGLE PROJECTION		SHEET 1/1 · DRAWING No. 00884 · ISSUE A
SCALE 1:1	A3								

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
			MT	GS	DJF
00884	A		Date: 28/03/2003	Date: 28/03/2003	Date: 20/05/2003

Description:

Assy Sub lower 1 11/16 PGR SX Pressure Isolation

CHANGE HISTORY

Iss	*Date*	*Remarks*	*Chkd*	*Appr*
A	20/05/2003	Initial Release	GS	DJF

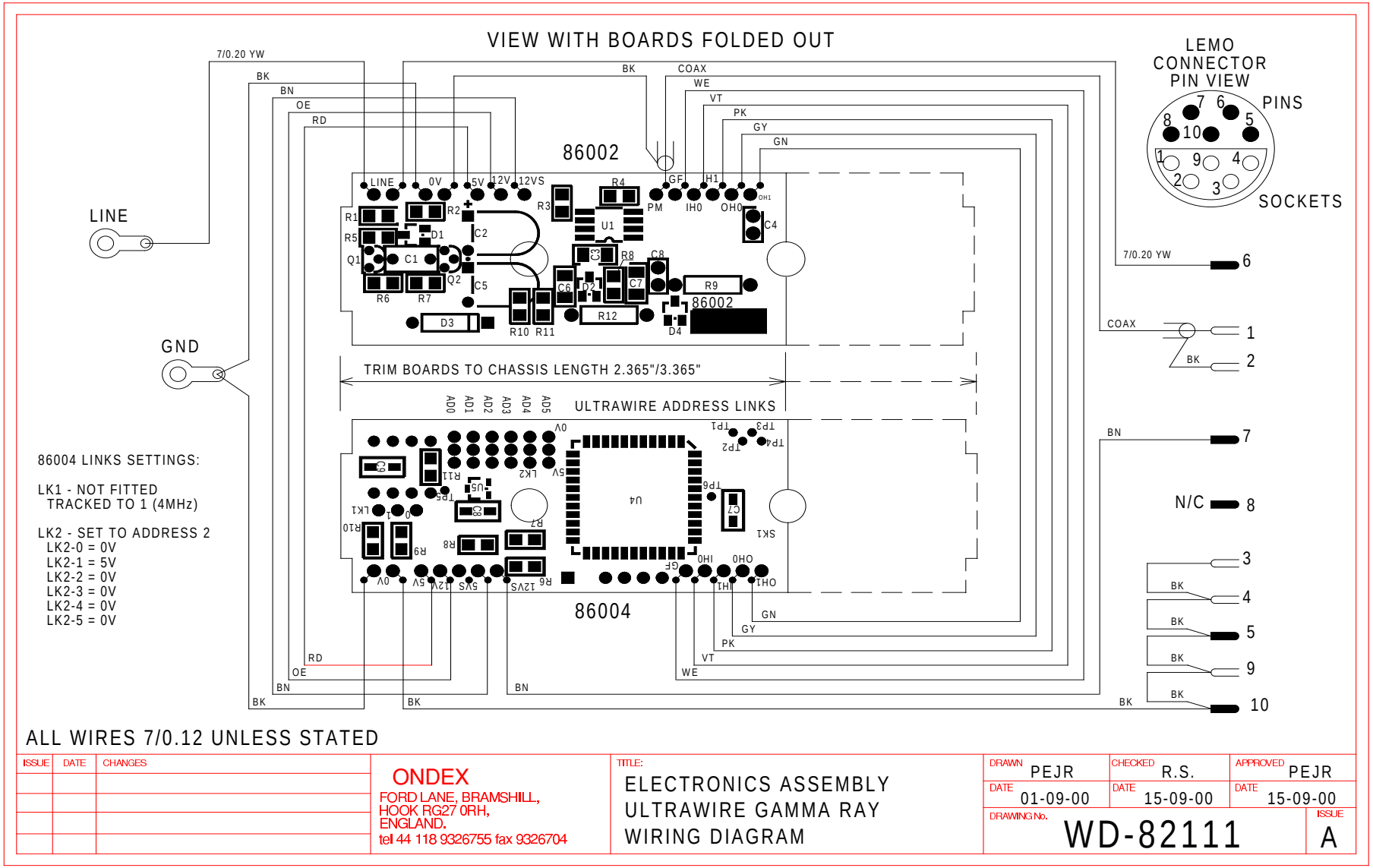
RELATED DOCUMENTS

#	*Documents*	*Issue*	*Notes*
01	AI-00884	PT1	Assembly Instruction
02	AR-00884	PT1	Assembly Record

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	00834	E	Sub Lower		1	ea	
002	j030-01505	-	Connector Pressure Isolation Mono Short (was 92030)		1	ea	
003	10036	C	Assy Connector Lower SX With Socket		1	ea	
004	01047	-	Circlip, Internal, 5/8, St/Steel		1	ea	
005	93019	-	Pin, Spirol, 1mm x 8mm Lg, SS		1	ea	

(AR = As Required)



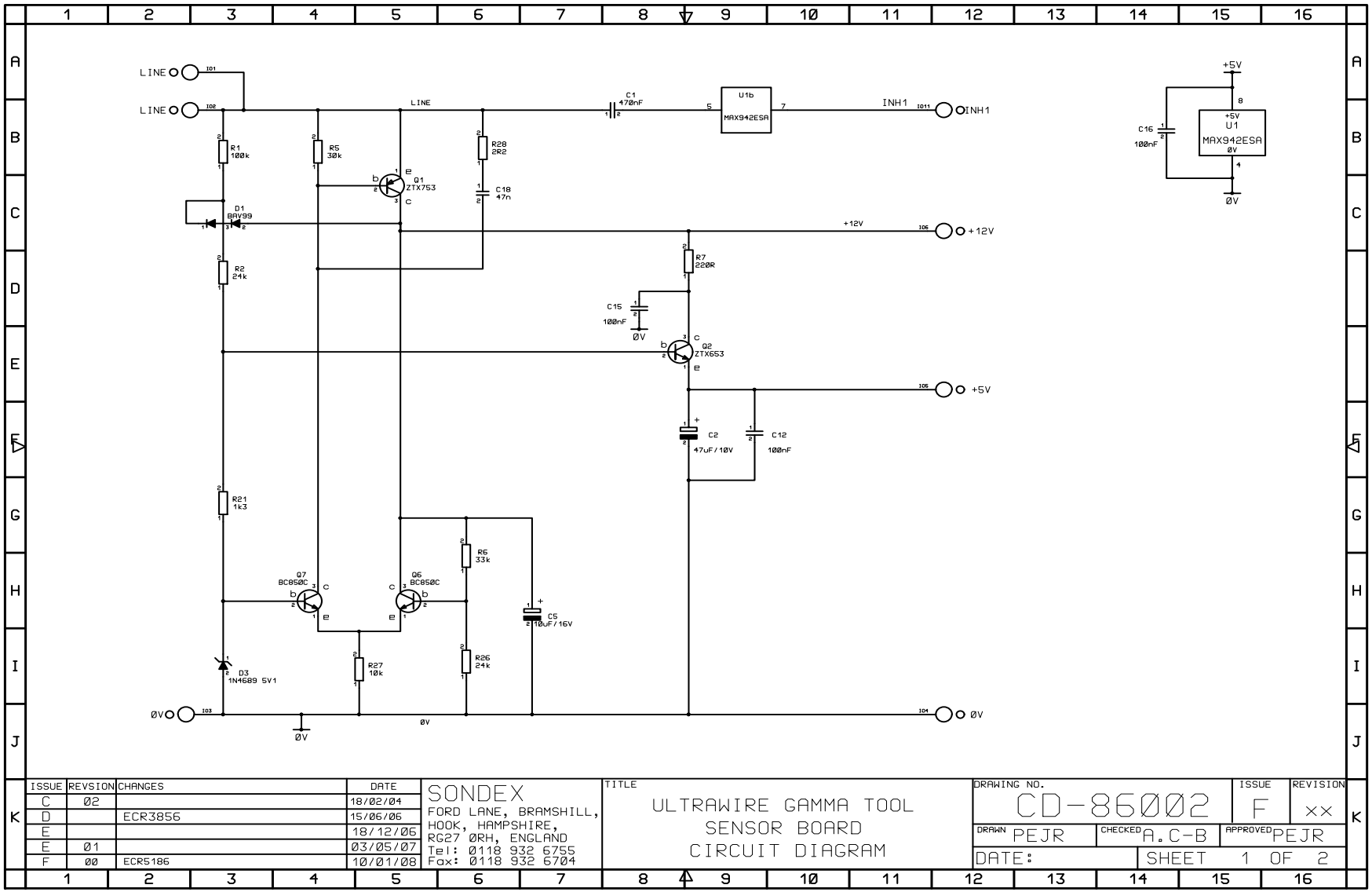
ISSUE	DATE	CHANGES

ONDEX
FORD LANE, BRAMSHILL,
HOOK RG27 0RH,
ENGLAND.
tel 44 118 9326755 fax 9326704

TITLE:
ELECTRONICS ASSEMBLY
ULTRAWIRE GAMMA RAY
WIRING DIAGRAM

DRAWN	CHECKED	APPROVED
PEJR	R.S.	PEJR
DATE 01-09-00	DATE 15-09-00	DATE 15-09-00

DRAWING No. WD-82111 ISSUE A



ISSUE	REVSION	CHANGES	DATE
C	02		18/02/04
D		ECR3856	15/06/06
E			18/12/06
E	01		03/05/07
F	00	ECR5186	10/01/08

SONDEX
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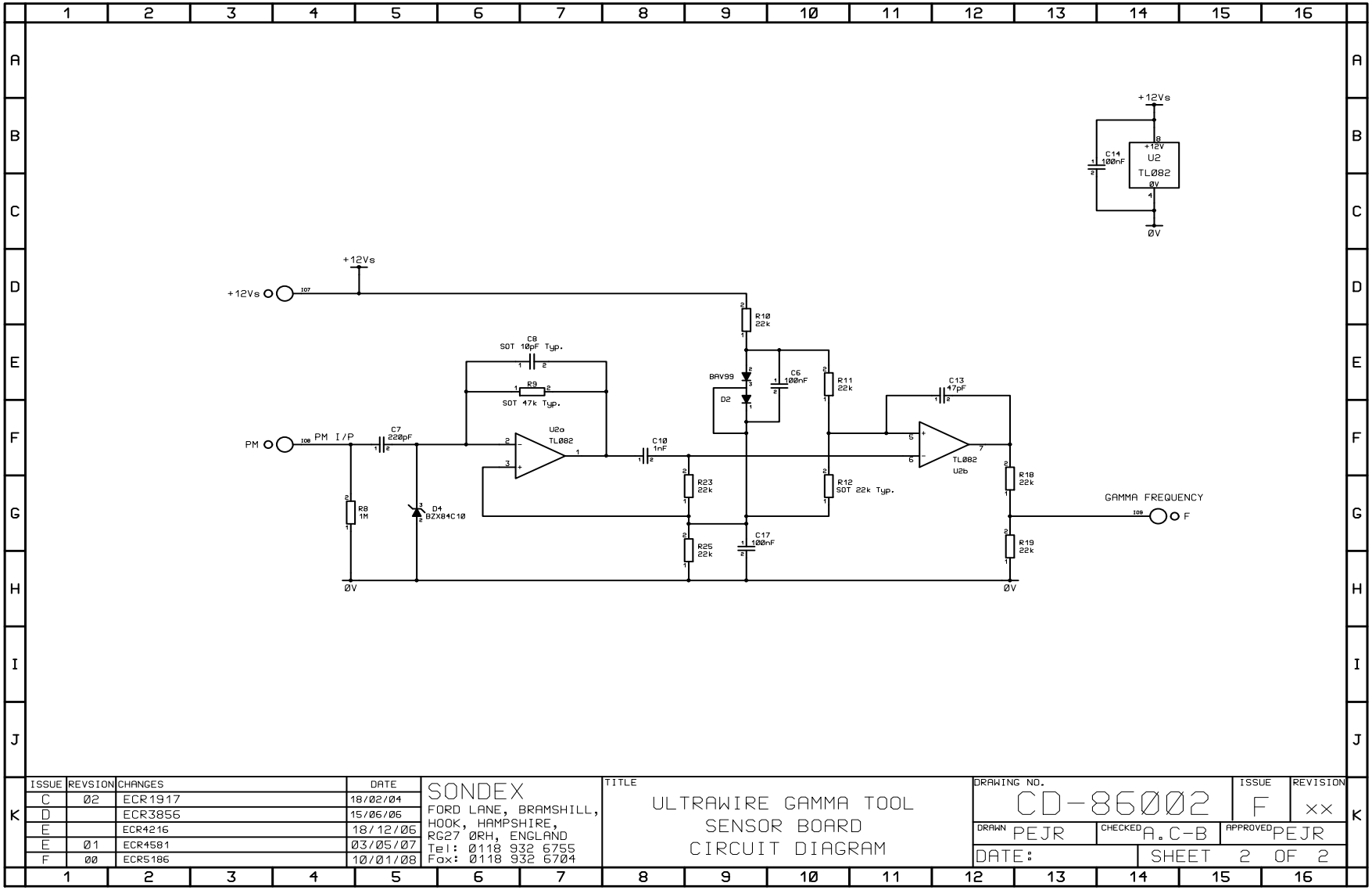
TITLE
ULTRAWIRE GAMMA TOOL
SENSOR BOARD
CIRCUIT DIAGRAM

DRAWING NO. CD-86002 | ISSUE F | REVISION xx
DRAWN PEJR | CHECKED A.C-B | APPROVED PEJR
DATE: | SHEET 1 OF 2



ISSUE	REVSION	CHANGES	DATE
C	Ø2	ECR1917	18/02/04
D		ECR3856	15/06/06
E		ECR4216	18/12/06
E	Ø1	ECR4581	Ø3/Ø5/Ø7
F	Ø0	ECR5186	10/01/08

SONDEX
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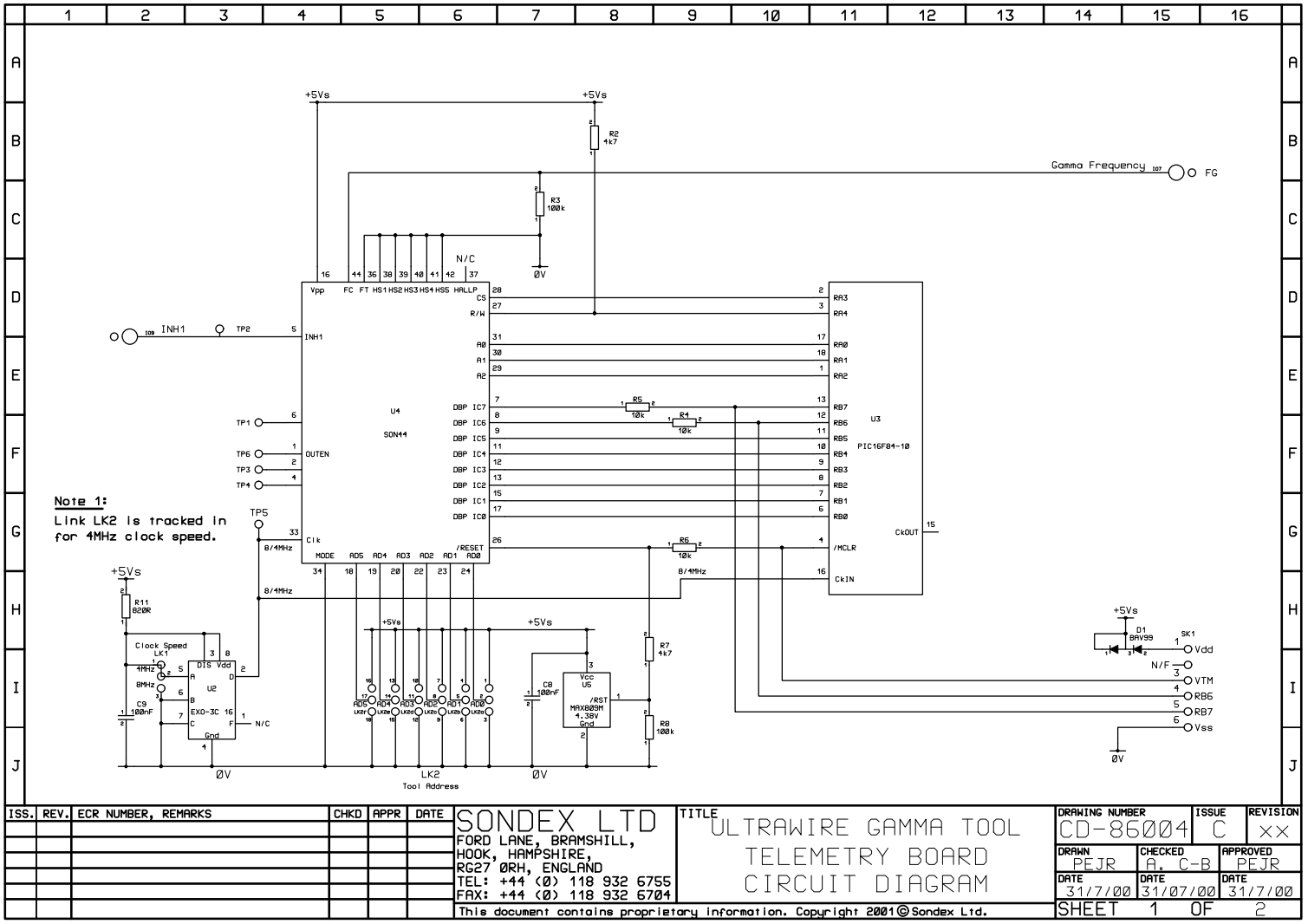
TITLE
ULTRAWIRE GAMMA TOOL
SENSOR BOARD
CIRCUIT DIAGRAM

DRAWING NO.	ISSUE	REVISION
CD-86ØØ2	F	xx

DRAWN	CHECKED	APPROVED
PEJR	A.C-B	PEJR

DATE: SHEET 2 OF 2



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE

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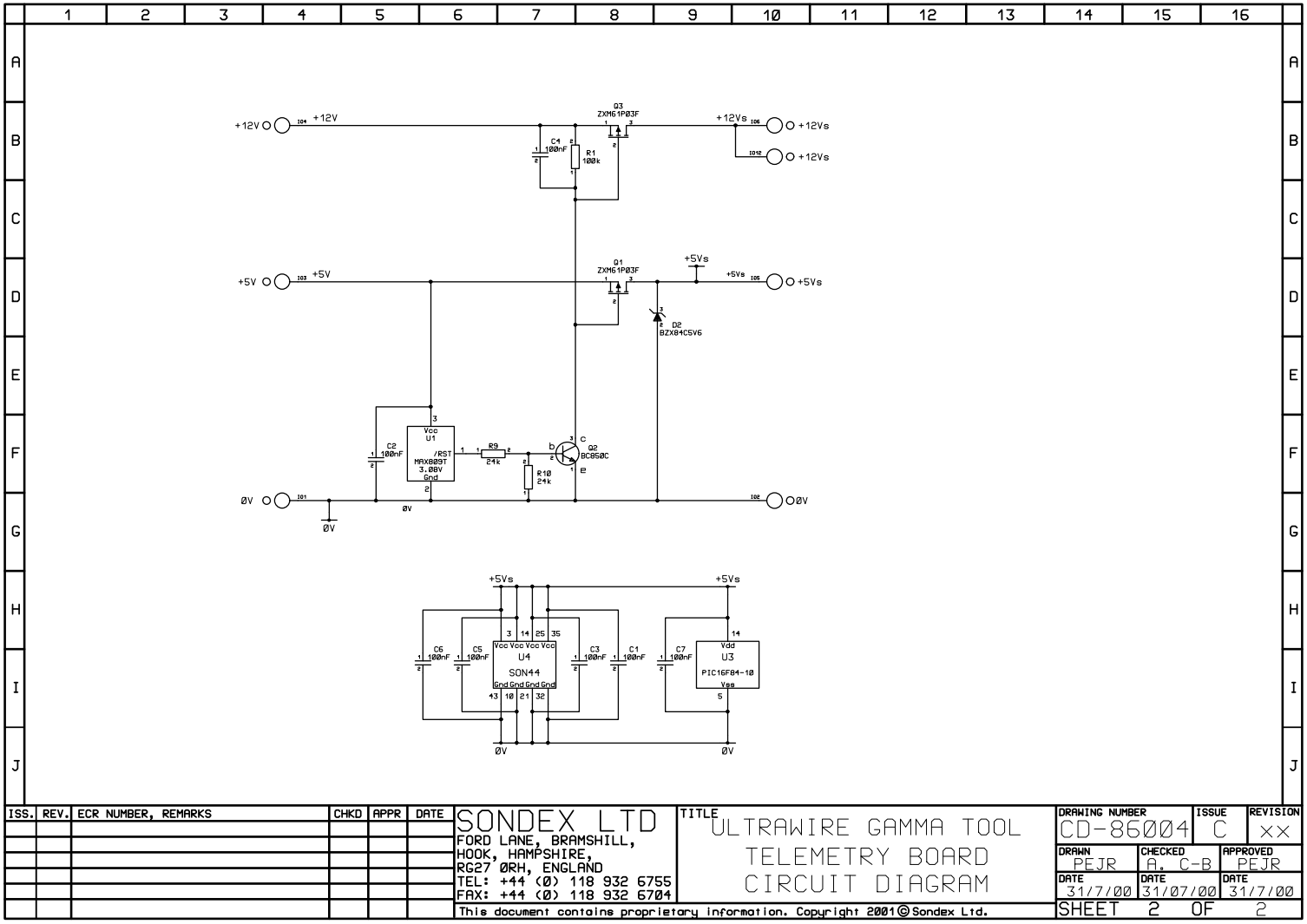
TITLE: ULTRAWIRE GAMMA TOOL TELEMETRY BOARD CIRCUIT DIAGRAM

DRAWING NUMBER	ISSUE	REVISION
CD-86004	C	xx

DRAWN	CHECKED	APPROVED
PEJR	A. C-B	PEJR
DATE 31/7/00	DATE 31/07/00	DATE 31/7/00

SHEET 1 OF 2



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE

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TITLE
ULTRAWIRE GAMMA TOOL
TELEMETRY BOARD
CIRCUIT DIAGRAM

DRAWING NUMBER	ISSUE	REVISION
CD-86004	C	XX

DRAWN	CHECKED	APPROVED
PEJR	A. C-B	PEJR
DATE 31/7/00	DATE 31/07/00	DATE 31/7/00

SHEET 2 OF 2