Tool Code: CAT007

Document: MN-CAT007-C

Capacitance Array Tool
(Client Adaptation)

CAPACITANCE ARRAY TOOL

CAT007: 12 Sensors on 2 diameters, $1^{11}/_{16}$″, HES 1553 Telemetry

Operational & Maintenance Manual

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C o n t e n t s

0 ABOUT THIS MANUAL

0.1 MANUAL HISTORY

Date	Issue	Description	Auth	Chk	App
15/10/01	A	First Issue	DH/DO	(DH)	(DH)
07/02/02	B	ECR1286: Keyway redimensioned to avoid O'ring damage (part no 08767 upissued to C). ECR1249: K section seal replaces 99113 backup O'ring. O'ring kits and check list updated. ECR1243: Lemo Bypass Location Housing modified (part no 05834, on parts list 08775))	DO	PL	PL
30/09/04	C	Drawing update. Ref: ECR 1627	FV	DO	DH

0.2 UPDATES TO BE USED WITH THIS MANUAL

Date[a]	Update	Description
none		

[a.] Note: this chapter shall be updated to include information on manual updates to be used with this manual, irrespective of current manual issue.

0.3 TECHNICAL HELP

For further technical help contact Sondex as follows:

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0.4 FEEDBACK

Please help us to improve future issues of this manual by sending comments or corrections to Sondex as above.

In your feedback please make reference to:

- The manual title, version and section
- Misprints, errors or unclear explanations
- General comments and suggestions.

Thank you.

Photographs and sketches are for illustration purposes only. Certain features or dimensions may differ from those shown.

1 EQUIPMENT

1.1 DESCRIPTION

The Capacitance Array Tool (CAT) is the first of Sondex's next-generation fluid identification tools designed specifically for horizontal wells. The CAT consists of an array of 12 capacitance sensors deployed radially around the well bore.

Each sensor is held within a finger similar to that used on Multifinger Imaging Tools (MIT). Every sensor gives an independent readout and indicates whether it is in oil, water or gas. The total oil/ water/gas fractions over the cross-section of the well can then be determined.

The CAT is particularly useful for visualising stratified flows in horizontal wells. Sensors are closed inside the tool body to protect them while running in-hole. The fingers are opened at the bottom of the interval to be logged, and the tool pulled upwards whilst logging takes place. The tool can be opened and closed any number of times during the log, allowing repeat logs of zones of special interest to be made. Due to the finger design, the tool cannot log downwards.

The tool mates with the H.E.S. Thru Tubing Telemetry Cartridge-B (TTTCB) and supports bi-directional quasi-1553 communications.

The CAT007 is normally supplied with all 12 sensors on a single diameter. There is also an option to have the sensors staggered over two diameters. Contact Sondex for futher information.

The downhole tool includes a pendulum-based relative bearing device to indicate the high side of the pipe. There is also a simple sensor which gives an indication of electronics temperature.

1.2 PURPOSE

The Capacitance Array Tool (CAT) is designed for use in horizontal and highly deviated wells. In such cases, there is often a separation of the oil, water and gas components, and traditional production logging tools are notoriously unreliable in this situation.

The CAT can identify such distributions, thereby providing previously unattainable information for PL interpretation. H.E.S. surface software is able to use this data to display cross-sectional images of the water/oil/gas distributions.

1.3 SPECIFICATION

Parameter	Specification	Remarks
Tool Address	0x59 (hex)	Set by links on telemetry board
Max. Pressure	10,000psi	
Max. Temperature	150°C	
Diameter	$1^{11}/_{16}$″ nom.	Fingers fully closed[a]
Make-up Length	67.035″	
Depth Offset	23.5″	from bottom of tool to sensors
Weight	12.5kg	
Number of Fingers	12	1 sensor per finger.
Width of fingers	0.102″	
Finger Contact Force	½lb	
Operating Voltage		
Maximum	200 Volts DC	
Operating Current (logging mode)		
Minimum Typical Maximum:	5 10mA 15	
Operating Current (to open/close fingers)		
Typical Maximum:	65mA 80mA	
Recommended Casing sizes	3 - 7″	
Accuracy of Water Holdup Measurement	±3% typ.	With 5% water volume fraction, horizontal stratified.
Accuracy of Water Holdup Measurement	±5%[b] typ.	With 50% water volume fraction, horizontal stratified.
Frame Rate	20 Hz	Polling interval set by bus controller.
Frames per poll	1 (default), 2, 3 or 4	2,3 and 4 frames of data per poll are set by a MODE command.
Scan time per sensor	260µs	Time over which the pulses from each sensor are counted
Inter-scan delay	26µs	Time delay between the end of the scan for one sensor and the start of the scan for the next sensor.
Relative Bearing accuracy (Rotation)	5°	
Relative Bearing Range	>5° <175°	from vertical

Parameter	Specification	Remarks (Continued)
Logging Speed minimum: typical: maximum (not recommended):	0 30 ft/min 60	Some stationary measurements are recommended. Lower speeds affect the flow less.
End Connectors (top/bottom)	H.E.S. 6-pin connector	
Thread (top/bottom)	H.E.S. 6-pin connector	

[a.] Actual max.O.D. = 1.715″ without protective sleeve covering sensor tubes, and 1.770″ when protective sleeve is fitted.

[b.] Accuracy in horizontal stratified flow is worst with approx. 50% water volume fraction due to finite number of probes available to detect the interface.

2 SAFETY

In normal use, there are few specific safety instructions for the safe handling of the tool. The following are guidelines only and should be followed in addition to any specific company and regional regulations.

Warning! **High Voltages**
Ensure there is no power to the line when rigging up or down production logging tools. Operators should take care not to expose themselves or others to the potentially lethal high voltage power supply that powers the tool.

Warning! **Moving Parts**
The tool's fingers have the potential to open/close unexpectedly. Hence be careful to keep your own fingers outside of the tool's fingers. Any cables around the tool should also be kept well clear of the tool's fingers and any other moving parts. Otherwise the tool may crush the cables.

Warning! **Heavy Equipment**
The tool is heavy and appropriate safe handling procedures should be followed when moving it.

Warning! **Beryllium Copper**
BeCu sensor fingers are supplied as standard. The hazard from this material is very low unless dust is created by grinding, filing or other machining processes. Discarded fingers should be returned to Sondex for disposal in the correct manner. Refer to your local Health and Safety guidelines for the correct handling of BeCu.

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

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.

There are no springs inside the tool which could pose a hazard through high compression/tension. There is one spring visible from the outside which is under low compression and therefore poses very little hazard to the operator.

There are no mercury or radioactive sources in the CAT tool.

3 HANDLING OF TOOL

The CAT007 contains some very sensitive electronic sensors and circuitry. Consequently the tool should be handled with care. Treat it as if it were for example, a gamma tool containing a delicate glass photo-multiplier tube. In particular:

Warning!

1. The sensors are made of ceramic and may be cracked by dropping the tool. When being transported, pieces of foam or similar shock-absorbing material should be placed between the sensors. The transportation sleeve should then be secured in place to protect the sensors from damage. The tool should then be carried in a transportation tube and/or flight case which has suitable protective padding.

2. The capacitance sensors require high impedance circuitry. Hence, the tool should not be opened in an atmosphere of high humidity.

3. The internal Secondary Pressure Barrier is also made of ceramic. Even though it is partially protected by O-rings, it should not be subjected to unncessary shocks.

4 THEORY OF OPERATION

4.1 BLOCK DIAGRAM

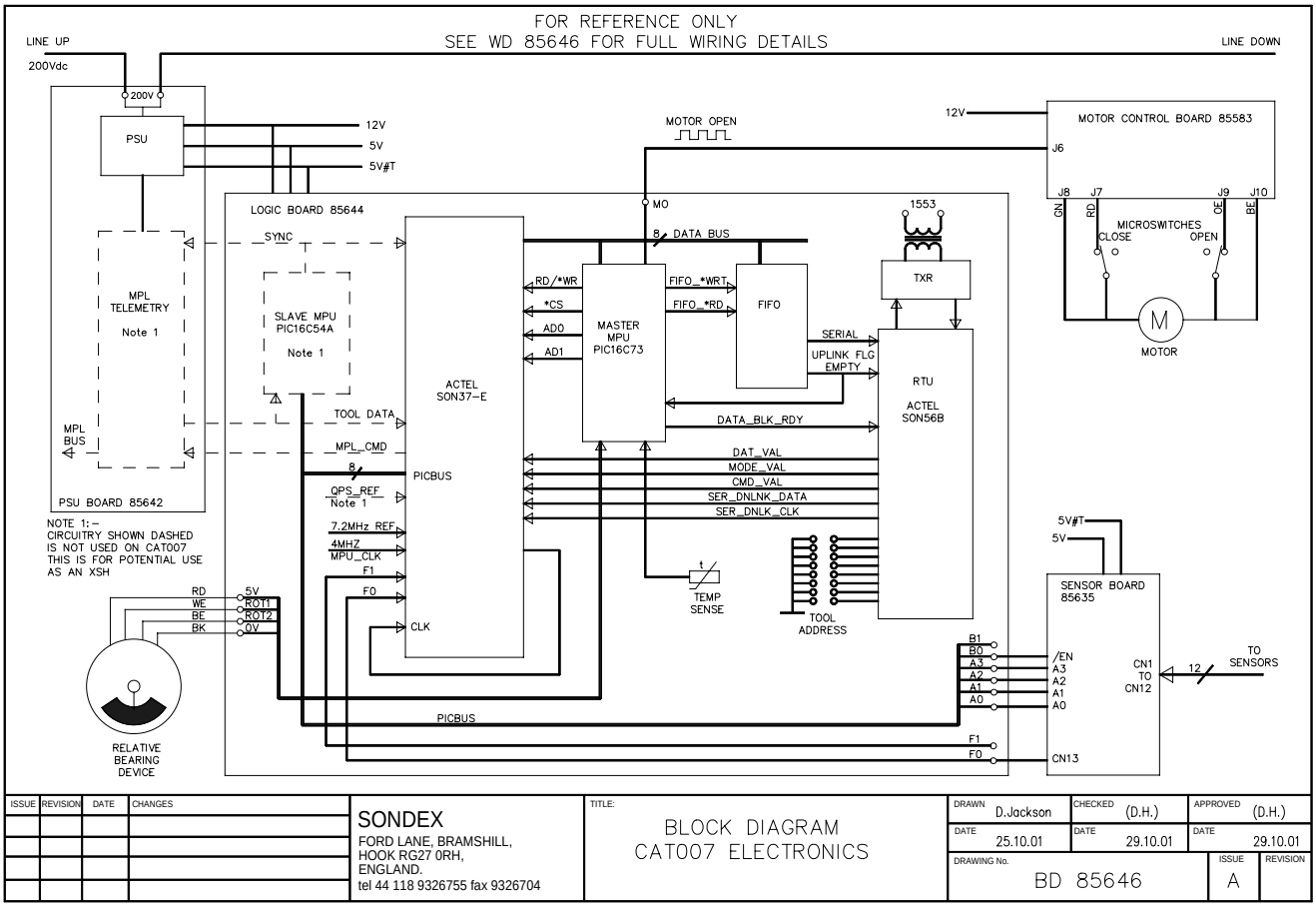


Figure 4.1 Block Diagram of the CAT007

4.2 DESCRIPTION

The CAT007 Capacitance Array Tool consists of a set of 12 fingers that open radially outwards from the tool body to the casing. The fingers are opened and closed using a motor at the lower end of the tool. The motor is controlled by sending "open" and "close" commands to the tool. See *Section 7.6 Telemetry Format*.

The principle of operation is similar to conventional capacitance water-holdup tools. However, a novel measurement circuit has been developed using the same principles to take capacitance measurements from 12 localised sensors. An oil/water calibration curve can then be fitted to the measurements to determine the fluid surrounding each sensor. Qualitatively, gas produces the highest frequencies, oil slightly lower frequencies, and water produces frequencies approximately one third of the air frequency.

Within each of the fingers, near the tip, is a miniature capacitance sensor. Each sensor, with its associated measurement circuitry, produces a frequency output that is related to the permittivity of the surrounding fluid. Hence the fluid (oil,water or gas) surrounding each of the sensors can be

determined. The total oil/water/gas component fractions over the cross section of the well can then be calculated.

The TTTCB should poll the CAT007 for its measurements 20 times per second (50ms intervals). After each poll from the TTTCB, the CAT007 takes another set of measurements, and these will be ready for the next poll.

By default, the tool will collect one frame of data after each poll. However, it can also be configured to collect up to 4 frames of data between polls, resulting in 80 frames per second when polled at 50ms intervals. This requires a suitable "MODE" command to be sent to the tool.

The next section gives a brief description of the various sensors in the tool. More complete details can be found in *Section 7 Electrical Description*.

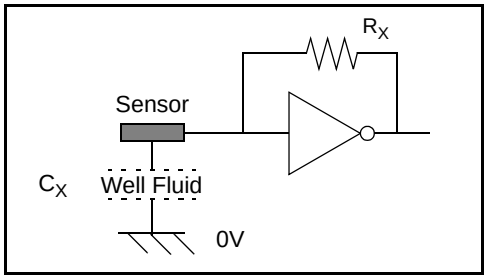
4.3 SENSOR OPERATION

There are three types of sensor on the Capacitance Array Tool. The primary measurement is obtained from an array of capacitance sensors. There is also a relative bearing device and a temperature sensor. The operation of these are described next.

4.3.1 CAPACITANCE SENSOR

Figure 4.2 shows the principle of the sensor operation. Essentially, the sensor consists of a logic inverter gate configured as an oscillator circuit. There is a fixed feedback resistor R_X from the output to the input. The sensor is connected to the input of the gate and the capacitance of this sensor C_X is charged and discharged through resistor R_X. The capacitance C_X of the sensor is dependent upon the permittivity of the fluid surrounding the sensor. This principle is repeated for each of the 12 sensors.

Figure 4.2 Sensor Equivalent Circuit



The gas, water and oil permittivities have the following values:

Gas: low permittivity (ε_r =1).

Water: highest permittivity ($\varepsilon_r \approx 80$, but it has a complicated function).

Oil: intermediate permittivity dependent on the precise nature of the oil, but $\varepsilon_r \approx 5$.

Thus, the fluid surrounding each sensor can be identified from the oscillation frequency. It is worth noting that due to stray capacitance, amongst other things, the oscillation frequency is not 80 times less for water than it is for air. In practice, the water frequency tends to be around 30% of the air frequency and the oil frequency tends to be approximately 85% of the air frequency.

As a first step in interpretation, the readings from each sensor are normalised with respect to the air and water readings. i.e.

$$\text{Normalised Reading}|_{AW} = \frac{\text{Raw Reading} - \text{Water Reading}}{\text{Air Reading} - \text{Water Reading}} \qquad \textbf{Equation 4.1}$$

This produces normalised readings in the range 0-1. There are then two possibilities for interpreting the data further.

1 Two thresholds can be applied to the normalised readings: an air-oil threshold and an oil-water threshold. A normalised reading below the oil-water threshold will be interpreted as water, and a reading between the air-oil and oil-water threshold will be interpreted as oil. This approach is used on the CAT1 software.

2 An oil-water calibration curve can be used to determine the water fraction. This is more general than 1 and is used in the CATVIEW software. Note that the full accuracy of a calibration curve can only be realised if the oil-water mixture forms a fine oil-continuous emulsion.
This is the recommended method because it automatically includes the "simple" threshold approach.

If it is known that the tool is in two-component oil-water flows (i.e. below the bubble point so no gas is present), then it may be more useful to use an oil-water calibration, i.e.

$$\text{Normalised Reading}|_{OW} = \frac{\text{Raw Reading} - \text{Water Reading}}{\text{Oil Reading} - \text{Water Reading}} \qquad \textbf{Equation 4.2}$$

4.3.2 RELATIVE BEARING DEVICE

The relative bearing device is a pendulum-based device which is used to measure the rotation of the tool. It is not intended to be a survey instrument, but merely to indicate which capacitance sensor on the tool is uppermost.

4.3.3 TEMPERATURE SENSOR

The temperature sensor is designed to be a coarse but simple indicator of circuit board temperature. It provides a possible means of software temperature compensation for residual electronic drifts with temperature. It is not intended as an indicator of well temperature. A dedicated well temperature tool such as the Sondex Platinum Resistance Thermometer (PRT) should be used for this purpose. A PRT will also give a more accurate measurement of the actual probe temperature should this be desired.

5 OPERATING PROCEDURE

5.1 BEFORE LOGGING CHECKS

5.1.1 MECHANICAL CHECKS

1 Check that O-rings and sealing surfaces are undamaged, clean and greased.

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

3 Remove the transportation sleeve that protects the sensors.

4 Check that all fingers and sensors locate correctly in place with the fingers closed. When the fingers are opened (see *5.1.3*), they should be checked carefully for any mechanical damage.

5.1.2 ELECTRICAL CHECKS

1 Check the through-resistance between the top and bottom LINE connections. It should be a short-circuit. <0.5Ω.

The resistance of the connecting leads should be taken into account when taking this measurement.

2 Check the resistance between the LINE connections and the chassis (effectively the D.C. resistance of the internal electronics). >10KΩ.

Warning! Do NOT use an instrument that generates high voltages (>100V) for this test.

5.1.3 VERIFICATION OF CORRECT OPERATION

1 Connect the TTTCB and the TTCB to a logging system via a wireline cable.

2 Switch on the logging system, applying 200V to the CAT.

3 The CAT tool current should be approximately **10mA**. If it takes substantially more than this, the motor may be operating. If this happens when the tool is already closed, but the current returns to normal after about 1 second, the motor current trip may have been activated. This suggests that the close microswitch may need adjusting.

4 Send the command to open the fingers.

Tool current (with motor opening): < 80 mA.

5 Check that the motor cuts out when the tool is fully opened. If the motor does not switch off cleanly, but labours, see *Section 6.6 Microswitch Adjustment* for adjustment procedures.

6 Check that all fingers have opened correctly and that the sensors are held correctly within the fingers. Manually close each finger individually, checking that they all close correctly and spring back open freely. In particular, check that the tips of the sensors slide correctly

within the holes at the end of the fingers. If they do not, the sensor tubes may be seen to buckle. Also check each sensor carefully for any damage.
If there are any problems, the tool needs a full service before use. See *Section 9 Maintenance.*
Close the tool by sending the appropriate command. Check that all fingers close down to their original closed position. Check that the motor cuts out cleanly when the tool is fully closed.

7 Check that the air readings for each sensor are within specification. See *Section 8.2.1 Capacitance Sensor Readings Checks*. **However, do not take any water readings at this stage**.

8 Perform a sensor calibration (see *Section 5.2 Calibration*). A water and rotation calibration may not be necessary if this has recently been done. However, an air calibration should always be done. This is because air readings are the most sensitive. When complete, check that the tool logs correctly. Open the sensors in air, ensuring that each sensor responds when the permittivity of the surrounding fluid is changed. This is most easily done by simply surrounding each sensor in turn with your fingers.

5.2 CALIBRATION

The following comments are initial guidelines only, that may be revised with experience. They may be useful during the initial field trials.

Sensor calibrations should always be performed with the fingers open. This is because there is more grounding around the sensors when they are closed, and this can affect the readings by a few bits.

As a minimum it is recommended that an Air-Water calibration is carried out at base. This provides a sufficiently accurate calibration allowing the tool to return useful data during logging. If facilities permit, an oil calibration can also be carried out, because it is useful to know what readings the sensors give in oil.

At the well site it may only be practical to carry out an air calibration. The permittivity of fluids vary slightly with both temperature and pressure, therefore a down-hole calibration in water at the bottom of the well should be performed if possible. In the case of oil/gas wells with no water, an oil calibration will be very helpful.

In cases where there is a zone of 100% oil, an oil calibration will be very useful. In general, there will often be a zone at the bottom of the well where there may be an accumulation of the denser fluid, e.g. water in an oil/water well. Similarly, when the well is shut in, it may be possible to perform an oil calibration since there will often be a region of 100% oil near the surface.

Note that oil readings may be slightly dependant on the amount of dissolved gas.

Note: **The surface air calibration of the well site will usually be the most reliable air calibration, and must always be done as a minimum. However, great care must be taken to ensure that the sensors are perfectly dry. In some cases, environmental conditions may make this difficult (eg rain), if not impossible (high humidity, resulting in condensation on the sensors).**

Before performing a calibration the sensors should be cleaned and thoroughly dried. This is particularly important for an air calibration.

It is also recommended that calibrations are performed in order of decreasing permittivity. i.e. air calibration followed by an oil calibration, followed by water. During logging, the calibration files created at base should be used, unless **great care** has been taken for the on-site calibration.

Any downhole calibrations should be for post-log analysis only.

Where a reliable air calibration has been performed at the well-site, it is recommended that this calibration is used during logging.

It is not generally necessary to perform any other calibrations (such as a relative bearing calibration) at the well site. These should all have been done back at base. However, the logging engineer should be familiar with the calibration procedure.

FLUID	BASE	WELL SITE	DOWN HOLE
Air	Essential Minimum	Highly Recommended	Not recommended
Water	Essential Minimum		Where conditions permit
Oil	Highly Recommended		Where conditions permit

Figure 5.1 Recommended Calibration Procedure

5.3 CONNECTING TO TOOLSTRING

5.3.1 GENERAL

In terms of measurement, the position of the CAT within the toolstring is not particularly critical. However, other tools can affect where the CAT can be placed. This is mainly where other PL tools, any XSH and/or a tractor are used. Note that although manufactured by Sondex, the CAT007 runs on H.E.S. telemetry and hence is connected above any XSH that may be in use. The main criterion is to ensure that the CAT is centralised.

5.3.2 CENTRALISATION

Centralisation is very important, and becomes a critical issue in horizontal wells. If the CAT is below centre, all of the sensors will be below their desired positions, resulting in an overestimate of the water fraction. If the tool is very significantly de-centralised, the uppermost finger may not reach the casing (in 7″ casing); in such cases, any oil flowing along the top side of the well may go undetected.

A common mistake is to believe that just because a toolstring supports itself on the ground, then it will centralise in a horizontal well. This is not necessarily the case, for the following reasons:

1 Firstly, the supporting force from centralisers decreases as they close further. Thus, centralisation becomes more difficult as the casing diameter decreases. However, even in 7″ casing, de-centralisation can still be very significant if care is not taken.

2 Secondly, toolstrings flex as they become longer. This can cause significant decentralisation of the CAT if there are too many tools between the CAT and its centralisers.

3 Thirdly, when self-supported on the ground, there will be two arms of a centraliser supporting the tool. In a horizontal well, the centraliser may be oriented such that only one arm is supporting the tool.

4 Finally, it is believed that the supporting force of centralisers decreases when moving. This is due to the frictional component between the casing and centraliser roller being less when moving than when stationary. i.e the static friction is greater than the dynamic friction.

As a minimum therefore:

- Strong centralisers (eg 70-100lbs) should be used at each end of the CAT; 40lb centralisers will not be sufficient.
- There should be no tools between the CAT and its nearest centraliser.

Great care must be taken when other tools are added to the toolstring. If possible, assemble the string in sections of casing of the same diameter as that found in the well to be logged. If this cannot be done, use more centralisers than thought to be absolutely necessary.

Knuckle joints may also be used as appropriate, particularly if weight bars are used.

It is a useful exercise to assemble the tool horizontally in sections of 6″casing to see the effect of adding extra tools. Even the effect of adding an extra tool between the CAT and a centraliser is usually quite significant. In 3″ casing or tubing the centralisation problems are even greater.

5.4 LOGGING

Recommended logging speed: 30 ft/minute (upwards only).

Logging can (and normally would) be done whilst logging **upwards**; however, due to the unique design of the tool, it is recommended that stationary measurements are taken at zones of particular interest.

Warning! Great care should be taken to ensure that the fingers are closed when lowering the tool down the well. The tool and/or well will be damaged if the fingers are open during descent.

5.5 POST LOGGING DISASSEMBLY

1 Clean the tool before disassembly, paying particular attention to the sensors. Use a damp cloth to clean the sensors initially. Then wipe them **carefully and thoroughly** dry with paper tissue or a dry cloth.

2 Keep electrical connectors clean and dry.

3 Refit thread protectors.

6 MECHANICAL DESCRIPTION

Ref.:	CAT007 Top Level Assembly	*09388*
	Electronics Section Assembly	*85646*
	Motor Section General Assembly	*08774*
	Sensor Section Assembly	*08775*

6.1 OVERVIEW

This CAT tool consists of three main sections: the Electronics section, Motor section and Sensor section. The key components of the tool are listed below.

CAT007 Top Level Assembly (09388)

- Motor Section (item 1)
- Sensor Section (item 3)
- Pressure Barrier, coax (item 4)
- Electronics Section (item 5)
- Yoke Shaft (item 13)
- Yoke (item 16)
- Yoke Housing (item 17)

Electronics Section (85646)

- Relative Bearing Device (item 5)
- Sensor Circuit Board (item 23)
- Motor Control Circuit Board (Item 24)
- PSU/Telemetry Line Driver Circuit Board (item 25)
- Processor Circuit Board (item 26)

Motor Section (08774)

- Drive Nut (item 2)
- Motor Sub (item 3)
- Micro-switch Sub (item 10)
- Leadscrew (item 14)
- Anti-Rotation Blocks (item 13)
- DC Electric Motor (item 29)
- Pair of Open/Close Micro-switches (items 31)

Sensor Section (08775)

- Bypass Tube (item 1)

Finger Section (item 6) (08776)

- Sensor Head (item 2)
- Pivot Block (item 3)
- Finger Support Cone (item 6)
- Actuator Sleeve (item 7)
- Central Shaft (item 8)
- Sensor Fingers (items 9 & 10)

The motor section is situated in the lower end of the tool and is housed within its own housing. The rotational motion of the motor is transformed into linear motion by a leadscrew and anti-rotation

block arrangement, which is transferred to the Drive Nut and Yoke Shaft. Here the linear motion of the Yoke Shaft is transferred to the slotted Actuator Sleeve by a guided Yoke arrangement.

The sensor fingers are positioned within the Pivot Block and are held in place by the Finger Support Cone, Central Shaft and Actuator Sleeve. This arrangement ensures that the fingers are permanently energised/sprung with a natural tendency to “deploy”. This deploying force acts on the top end of the slots on the Actuator Sleeve. Hence, any linear motion of the Actuator Sleeve causes the fingers to either deploy or close.

The Sensor Head acts as a hub for the 12 CAT Sensors. The 12 flexible tubes each carry cables to the sensors. A metal-to-metal seal seals each tube to the Sensor Head. The applied torque on the seal Gland is pre-set during tool assembly.

Warning! Under no circumstances should any of the glands be adjusted after leaving Sondex**. Adjusting these Glands may cause catastrophic pressure failure.**

6.2 ELECTRONICS SECTION ACCESS/REMOVAL

Ref.: General Assembly Drawing *09388*

The electronics section should only be removed when this is necessary for maintenance, or for testing without the sensors attached.

When removing the electronics assembly, it is very important to secure the tool horizontally on V-blocks at all times. **Particular care should be taken to fully support the electronics assembly when the Pressure Housing is removed**. Otherwise too much stress will be placed on the screws that secure it to the Seal Sub; this may result in the electronics chassis being very difficult to remove and replace.

The sensor boards in particular are very sensitive and should be handled with care. **The PCB tracks should not be touched by hand**.

1 Support the tool with a minimum of three V-blocks.

2 Remove the Hermetic Retaining Ring (item 31). A special hermetic wrench tool (Sondex part number 03917) is required for this.

3 Screw the special hermetic wrench tool onto the top hermetic connector (item 30), and pull the connector out of the tool.

4 Unscrew the electronics Pressure Housing (item 28).

As mentioned above, care should be take to support the electronics chassis when the Electronics Pressure Housing has been removed. It may be necessary to raise the level of the V-blocks under the electronics assembly in order to ensure the two assemblies are aligned correctly.

The electronics boards are now accessible by removing the appropriate half-shells that retain the circuit boards in place. Note that a single half-shell extends along the "bottom" of the electronics chassis, and two separate half-shells are used for the top half of the chassis. One half-shell (at the upper end) covers the relative bearing device and power supply and telemetry boards, and the other covers the sensor and motor control boards. Only the top two half-shells should normally be removed; the single half-shell along the entire "lower" side of the chassis should not normally be removed because this holds the boards in place.

5 If the electronics assembly needs removing, remove the half shell that covers the sensor and motor control boards (the half-shell nearest the Seal Sub (item 26)). Note that PTFE tape is sometimes wrapped around the electronics assembly to keep the various wires inside the chassis. If this is the case, it may be necessary to remove this PTFE tape.

6 Very carefully, remove any RTV that may be around the coaxial connections on the sensor PCB. A pair of pliers and a scalpel will be useful for this. The RTV is used to prevent vibrations from breaking/damaging the coaxial connection to the PCB and will need replacing later.

7 When the RTV is removed, very carefully unplug the coaxial connectors from the PCB. This task should be done with great care; any non-axial force on the connectors can damage/impair the connection, which may not be immediately obvious. Any damage may result in an intermittent sensor reading. A pair of suitable pliers should be used for this. **The connectors should never be removed by hand alone.**

8 Remove any more PTFE tape that may be securing the coaxial cables to the chassis.

9 Finally, using a suitable Allen key, unscrew the four screws (items 37) that secure the electronics assembly to the Seal Sub (item 26).

The electronics assembly can now be carefully unplugged. **However care must be taken to ensure that the coaxial cables are not damaged in any way during removal**.

The electronics removal is now complete.

6.3 ELECTRONICS SECTION REASSEMBLY

This is essentially the reverse of disassembly. However, even more care is required when making the connection between the electronics assembly and the connector on the bypass tube. The coaxial cables can be easily damaged if sufficient care is not taken.

As mentioned in disassembly, the sensor boards in particular are very sensitive and should be handled with care. **The PCB tracks should not be touched by hand**.

1 Support the electronics assembly and the rest of the tool on V-blocks. It may be necessary to raise the level of the V-blocks under the electronics assembly in order to ensure the two assemblies are aligned correctly.

2 Separate the bundles of co-axial cables into four quadrants. Bend the four bundles over the outside of the seal sub and keep them in place with a rubber band.

3 Now align the Lemo Housing end of the Electronics Section (item 5) to the bypass that is visible from the end of the Seal Sub. Ensure that the each of the four bundles of cables is positioned within the specially machined slots on the Lemo Housing (item 12 on 85646).

4 Carefully engage the two connectors and bring the two parts together.

TAKE GREAT CARE DURING THIS WHOLE PROCESS NOT TO DAMAGE THE COAX CABLES.

5 When the two parts are together, screw on the M3 screws (item 37) and Spring Washers (item 38) onto the Lemo Housing/Seal Sub. Take care to support the electronics assembly so that the screws securing it to the Seal Sub do not become bent.

6 Remove the appropriate half-shell on the Electronics Section, and removing the temporary rubber band, connect each of the labelled MMCX plugs onto its appropriate channel on the Sensor Board. Sensor 1 plugs into Connector 1 etc. In doing this, the four bundles of wires should be combined into two bundles, with a bundle passing through each of the two slots in the sides of the Lemo housing (item 3 on 85646).

7 If possible, it is advantageous to give the tool a quick electrical test at this point to ensure that the each of the sensor connections is good. This will require a suitable mating connector to plug into the top of the tool.

8 If the tool is working satisfactorily, apply RTV3145 to the coaxial connectors that plug into the sensor PCB. This will hold the connectors to the PCB and provide some shock absorbance. **Do NOT apply RTV of any kind to the non-connector side of the sensor board (PCB 85635)**. This is high impedance circuitry and care is required when handling these boards. The tracks should certainly not be touched by hand.

9 Ensure that the coaxial cables (and any others) are secured inside the assembly with PTFE tape, and screw the half-shells back on. Apply more PTFE tape if required, but this should be limited to a single layer; otherwise it may interfere with the pressure housing.

The tool should now be left for 24 hours with the sensor boards horizontal to allow the RTV to cure.

10 Check the condition of the O-rings (items 44) on the Seal Sub (item 26) and replace if necessary. Ensure that they are well greased.

11 Screw on the pressure housing, ensuring that it is fully tightened.

12 Check the condition of the O-rings (items 41) on the hermetic connector (item 30) and replace if necessary. Ensure that they are well greased.

13 Screw the hermetic connector onto the special hermetic wrench tool tool (Sondex part number 03917), and insert this into the top of the pressure housing. This requires some care because the connector at the top of the electronics assembly will need aligning with the tang in the hermetic connector. This requires a little practice to get the desired technique. Ensure that the hermetic connector is fully inserted (it should not protrude beyond the end of the Pressure Housing).

14 Screw the Hermetic Retaining Ring (item 31) into the top of the Pressure Housing to secure the Hermetic connector in place. The special hermetic wrench tool will be required for this also.

15 Check that the tool functions correctly.

16 Check the condition of the O-rings (items 45) at the top of the electronics Pressure Housing, replace if necessary, and grease them.

17 Finally, screw on the upper Thread Protector (item 33).

Assembly is now complete.

6.4 MOTOR SECTION DISASSEMBLY

Ref.: General Assembly drawing *09388*

6.4.1 REMOVE THE YOKES

It is important to get the Yokes (items 16) as far from the motor end as possible. This will allow them to be pushed out when the Retaining Ring (item 19) is unscrewed. This is achieved by opening the fingers, hence moving the Yoke Shaft (item 13) and Yokes away from the motor end.

If it is found that after opening the tool there is still not enough clearance to remove the Yokes, the setting of the "Open" limit switch may need adjusting to allow the tool to open further. If the Yokes are too far away from the motor end, the tool may need closing slightly.

1 Position the tool horizontally on V-blocks and open the fingers.

2 Open the tool fully and then remove power from the tool.

3 Unclip the Locking Spring (item 20) from the Retaining Ring (item 19), and unscrew the Retaining Ring from the Locknut (item 15).

4 Slide the Retaining Ring towards the motor assembly, and the sensor section away from the motor assembly.

The Yokes should now be visible.

5 If there is sufficient clearance, push the Yokes out using a small punch, blunt screwdriver or similar tool.

Note: The Actuator Sleeve can now be slid away from the Motor Section in order to provide more room.

If the Retaining Ring is preventing the Yokes from coming out, the Yoke Shaft (item 13) needs motoring further out of the motor assembly. See the end of this disassembly procedure for details of how to do this. When the Yokes have been removed continue on to the next step.

6.4.2 SEPARATE MOTOR FROM SENSOR

1 Loosely screw the Retaining Ring back onto the Locknut (item 15). This allows room to uncouple the motor section from the main assembly.

2 Using a suitable Allen Key, unscrew the two grub screws (items 21) that secure the Clamp Ring (item 18) to the Motor Sub.

3 Unscrew the Clamp Ring from the Motor Sub.

4 The motor assembly (complete with Yoke Shaft) can now be pulled out of the sensor section. Remove and store the Motor Sub Key (item 14).

6.4.3 REMOVE YOKE SHAFT

The Yoke Housing (item 17) should now be removed from the Central Shaft, and the Yoke Shaft unscrewed from the motor assembly. This will allow the O-rings and sliding seals to be inspected and changed if required.

1 Remove the 3 grub screws (item 35) securing the Locknut (item 15) to the Actuator sleeve.

2 Loosen the Locknut and align its C spanner bores to the 3 grub screws (items 21) found below it. Remove these screws.
Unscrew the Yoke Housing and remove it along with the Yoke Retaining Ring and Clamp Ring.

3 Unscrew and remove the Locknut.

4 Unscrew the Yoke Shaft from the motor assembly.

5 Check the condition of the K seal (item 42) and Variseal (item 23) inside the Motor Sub. Replace if required. If this is a general service, then these should be replaced as a matter of course at this stage. Ensure both seals are fitted in the correct orientation, and are greased.

The motor removal is now complete.

Adjusting the Position of the Yokes to Allow Their Removal

If the Yoke Retaining Ring prevents the Yokes from coming out, the Yoke Shaft (item 13) needs motoring further out of the motor assembly. This is done as follows:

1 Remove the Motor Housing.

2 Keep the "Close" microswitch activated. This can be done by hand, but initially, it is best done with tape. This will prevent the motor from closing the fingers when power is applied.

3 Apply power to the tool. The motor should not operate because the "close" microswitch has been activated as described above. The "close" microswitch should not be released.

4 With your fingers, activate the "Open" microswitch. This will prevent the tool from opening the instant the "Open" command is sent to the tool.

5 Send the "Open" command to the tool. Wait a couple of seconds for the command to be received. Then, very briefly release the "Open" microswitch so that the motor operates for a fraction of a second. This will move the Yoke Shaft and hence Yokes further away from the motor assembly. Repeat the process of briefly releasing the "Open" microswitch until the Yokes are clear of the Yoke Retaining Ring and can be pushed out.

6 Remove power from the tool, and remove any tape used to activate the "close" microswitch.

7 Continue from *6.4.2*.

6.5 MOTOR SECTION REASSEMBLY

The tool should be well supported on V-blocks for this procedure. A minimum of 4 V-blocks are necessary (two for supporting the Motor assembly, and two for the Sensor / Electronics Section).

6.5.1 REPLACE YOKE SHAFT

1 Check the condition of the K seal (item 42) and Variseal (item 23) inside the Motor Sub. Replace if required. If this is a general service, then these should be replaced as a matter of course at this stage. Ensure both seals are fitted in the correct orientation, and are greased.

2 Check the condition of the K seal (item 42) and Variseal (item 23) inside the Central Shaft of the Sensor Section. Replace if required. If this is a general service, then these should be replaced as a matter of course at this stage. Ensure both seals are fitted in the correct orientation, and are greased.

3 Slide the Seal Support (item 22) onto the threaded end of the Yoke Shaft (item 13). Lightly grease the threaded end of the shaft along the whole of its outer length. Then screw the threaded end of the Shaft into the motor assembly. Use a 19mm Spanner to tighten the shaft down securely.

4 Loosely screw the Locknut (with its locking spring) onto the Actuator Sleeve on the main sensor assembly. Do not tighten at this stage.

5 Slip the Clamp Ring (item 18) and Retaining Ring (item 19) onto the Yoke Housing (item 17). Then screw the threaded end of the Yoke Housing onto the Central Shaft. Do not excessively tighten the Yoke Housing to the Central Shaft. If excessive torque is placed on the Yoke Housing it will twist the Central Shaft very slightly relative to the Actuator Sleeve. This will result in friction between the fingers and Actuator Sleeve, causing the fingers to stick.

When the Yoke Housing has been screwed onto the Central Shaft, check that the fingers still open and close manually. If there is any friction, it may be necessary to slacken the Yoke Housing which will reverse the excessive torque that was applied to the Central Shaft.

Note: The Central Shaft does not necessarily have to rotate visibly to give this problem. Indeed, if it rotates visibly, then this is a much more serious problem, which is more difficult to correct. In such cases, try securing the Central Shaft down tighter using the grub screws near the Sensor Head.

Only a well-trained person should be dealing with the tool should these difficulties arise.

6 Align the thru' holes in the Locknut (which is only loosely screwed onto the Actuator Sleeve) to the threaded holes on the Yoke Housing. Then screw the three Grub Screws (items 21) through the Locknut and into the Yoke Housing with an appropriate Allen Key. Tighten the three screws equally, but nor excessively, in order to secure the Yoke housing to the Central Shaft.

7 Tighten the Actuator Sleeve Locknut onto the Actuator Sleeve by hand. **Do not use C spanners, as the Actuator Sleeve may deform, causing the fingers to stick.**

8 Secure the Locknut to the Actuator Sleeve by screwing on the three M4 Grub Screws (items 35) into the Locknut. Tighten the grub screws equally with a suitable Allen Key.

6.5.2 REASSEMBLE MOTOR AND SENSOR

1 Insert the Key (item 14) into the slot on the Motor Sub. This is not locked into place with anything, so should be kept uppermost until the Yoke Housing covers it.

2 Grease the exposed ends of the Yoke Shaft protruding from the Motor Section. Look into the Yoke Shaft of the Motor Section, and align the connector on the bypass tube protruding from the Sensor Section with the connector at the bottom of the Yoke Shaft.

Insert the Bypass tube into the Yoke Shaft and carefully mate the two connections. Just before the connection is fully made, the Yoke Housing should be aligned with the Key in the Motor Sub. A little practice is required to get the correct technique and to be sure that the two parts have mated correctly. Do not apply excessive force to accomplish this.

3 Tighten the Clamp Ring onto the Motor Sub with C Spanners.
Insert the two remaining M5 Grub Screws (items 21) into the Clamp Ring, and tighten with an Allen Key to secure the Clamp Ring to the Yoke Housing.

6.5.3 REPLACE THE YOKES

4 Slide the Retaining Ring back against the Clamp Ring. The Yokes should now pass through the gap between the Retaining Ring (item 19) and the Locknut (item 15), and between the machined slots in the Yoke Shaft (item 13).

If the Yoke Shaft is not in the correct position, it will need adjusting in a similar way to that described in *6.4.1*. However, if the tool needs to open further and the "Open" microswitch is already operated, it may be necessary to adjust the setting of the appropriate microswitch slightly.

5 When the Yokes have been inserted, slip the Retaining Ring over the Yokes and screw it onto the Locknut. When doing this, raise the protruding part of the locking spring until the Retaining Ring is locked securely to the Locknut. Then realign the spring until the protruding spike sits in the slot on the Retaining Ring.

The Retaining Ring should not be tightened excessively. Otherwise the torque may produce excessive friction between the Actuator Sleeve and fingers.

When the Retaining Ring has been screwed into place, manually close each of the fingers to check that there is no excessive friction.

6 Finally, adjust the limit switches as described below.

6.6 MICROSWITCH ADJUSTMENT

The two microswitches are used to switch off the motor when the fingers have opened/closed to the correct position. The microswitches are closed to operate the motor and when the limit of travel has been reached, the appropriate microswitch opens to turn off the motor.

If one/both of the microswitches are set to activate too early, the fingers may not open or close fully.

If the microswitches are set to activate too late, this will put undue stress on the mechanical components. This would usually be a temporary situation because the current drawn by the motor would rise to the factory-set current limit of the Motor Control board. After about a second the current should automatically switch off. However, this is a backup mechanism and undue stress still gets applied to the mechanical components. This situation should therefore be avoided if possible, although it is acceptable if it happens occasionally when setting up the "Close" microswitch. There is no excuse for it happening when setting up the "Open" microswitch and this should **never** happen.

The microswitch adjustment is usually an iterative procedure, adjusting the actuating screws a little at a time until perfect.

1 Remove the Motor Pressure Housing to expose the microswitches

2 Power up the tool. The fingers should start to close, so carefully watch for the "Close" microswitch being activated by the appropriate Activating Screw. The "Close" microswitch is at the lower end of the motor assembly.

Monitor the current drawn by the tool. If the fingers fully close before the appropriate microswitch has activated, the tool will still be drawing a high motor current when the fingers have stopped moving; after about 1 second, the current will then return to normal, indicating that the motor current trip has activated. If there are any problems with the limit switch activating too late, then be prepared to operate the "Close" switch manually.

3 If the "Close" microswitch is not set correctly, adjust the corresponding Actuating Screw on a trial and error basis until it is set correctly. Note that relatively small adjustments to the Actuating Screw have a significant effect on the closing of the fingers, so the adjustment is quite sensitive.

Note: To adjust the "Close" microswitch, it will probably be necessary to open the fingers, by setting the "Open" microswitch:

4 Send the command to "Open" and watch for the "Open" microswitch being activated. Be prepared to operate it manually.

The "Open" microswitch is less critical than the "Close" microswitch, but do not allow the Actuator Sleeve to move further back than necessary for the fingers to open fully. There should a maximum gap of typically 2mm (min 1mm, max 3mm) between the Actuator Sleeve and the back of the fingers. Excessive opening can damage the tool, and also prevent sensors from being replaced.

5 Repeat steps 3 and 4 until the fingers open and close correctly.

6 With the fingers open, manually check that the fingers close properly, and that there is no undue friction between the fingers and the Actuator Sleeve.

6.7 CHANGING SENSOR FINGERS

This procedure should be carried out only as part of major maintenance, or if one or more sensor fingers are worn or damaged. This is an operation that requires some degree of technique and skill. Training by Sondex is mandatory.

Ref.:	Sensor Section Assembly	*08775*
	Finger Section Assembly	*08776*

6.7.1 DISASSEMBLY OF SENSOR FINGERS

Unless otherwise specified, item numbers refer to drawing 08776.

1 Remove the electronics section (see *Section 6.2 Electronics Section Access/Removal)*.

2 Remove the motor section (see *Section 6.4 Motor Section Disassembly*).

3 Remove the seal sub (item 26, drawing 09388) and slide it away from the sensor head.

4 Remove the circlip (item 39, drawing 09388) on the low pressure side of the Secondary Pressure Barrier

5 Slip a large Jubilee/Hose Clip, opened to a diameter of approximately 3″, over the tip of the fingers.

6 Slide the actuator sleeve to allow access to the three ball ended thrust screws (items 4).

7 Loosen the 3 Ball Ended Thrust Screws (item 4). Remove one of them completely so that the Central Shaft can be seen through the threaded hole. Leave the other two screws sufficiently clear of the male thread on the central shaft, but still within the Pivot Block (item 3). This will prevent the Pivot Block from separating from the Sensor Head (item 2).

8 With a couple of C spanners, uncouple the central shaft from the sensor head. Keep a lookout for the male thread on the central shaft through the hole described in the previous step. Stop when the male thread reaches the middle of the threaded hole. **Ensure that the wires to the secondary Pressure Barrier do not become twisted or trapped when doing this.**

For the following stages, extreme care is required so as not to damage any of the sensors.

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9 Release one of the fingers from under the Jubilee Clip. Make sure none of the other fingers pop out when this is being done.

10 Unclip the sensor from the tang on the lower end of the finger with a small flat head screwdriver.

11 Now carefully unhook the finger from the Pivot Block. **This requires great care and training. A sensor tube can easily be damaged during this process.**

Note: Whilst unthreading the sensor, be very careful not to damage the sensor when withdrawing the finger.

12 If required, repeat steps *1* to *9* for the remaining eleven fingers.

The remaining steps should only be followed if the central shaft if to be removed.

13 Carefully disconnect all the sensor cables connected to the Secondary Pressure Barrier (item 4, 09388). Then remove the barrier from the shaft. Also remove the circlip (item 39, 09388), O-rings (item 40, 09388) and the aligning spirol pin (item 36, 09388).

14 The Finger Support Cone is secured to the Central Shaft by three grub screws (item 17). Locate these screws through the slots on the actuator sleeve and then unscrew them. Do not remove them completely, because the Actuator sleeve will not be completely removed unless every sensor is to be replaced. As a result, it would be very difficult to re-insert these screws.

15 The central shaft can now be uncoupled completely from the sensor head.

The O-rings (items 13) on the Central Shaft must always.be replaced when this operation is carried out. **These must be of the correct Perfluoroelastomer type**. Any other O-rings that have been exposed must also be replaced as described in the appropriate assembly/disassembly procedures.

6.7.2 REASSEMBLY OF SENSOR FINGERS

Warning! It is highly recommended that fingers are only replaced by experienced and Sondex-trained personnel. A small mistake can result in a pressure failure and destroy the entire tool. The following instructions are provided for use as a last resort only, and only after training has been given.

1 To reassemble the tool, carefully secure the sensor assembly vertically with the sensor head on the vice.

2 Carefully seat the Finger Support Cone on the pivot block, and then unscrew the three grub screws so that they do not rotate within the pivot block. This operation is done with an Allen key through the slots on the actuator sleeve.

3 Ensure that the O-rings on the central shaft have been replaced and are greased. **It is important that the correct Perfluoroelastomer O-ring is used.**

4 Now slip the central shaft through the actuator sleeve and screw it all the way into the sensor head.

5 Tighten the three grub screws on the Finger Support Cone. Do not over-tighten.

6 Now unscrew the central shaft from the sensor head. Look for the male thread on the central shaft through the hole described in Section *6.7.1* item *8*. Stop when the male thread reaches the middle of the threaded hole.

7 Carefully thread a sensor through a finger. Then try to position the tip of the spring onto the finger support cone. When this is done, hook the finger into position and carefully clip the sensor back into its position. Use the Jubilee Clip to avoid it popping out again.

If it does pop out, the sensor tube will almost certainly be permanently damaged. The sensor will then need replacing.

8 Repeat this step for the other eleven fingers.

9 When this is complete, tighten the central shaft to the sensor head before locking the whole assembly together by tightening the three ball ended thrust screws (item 4).

10 Replace the circlip (item 39, 09388) onto the central shaft. Then put on new O-rings (items 40, 09388) and grease them.

11 Prior to slipping the Secondary Pressure Barrier over the O-rings, reconnect the sensor connectors to the appropriate feedthrough on the Barrier. All connectors must be insulated with appropriately sized heatshrink. When this is done, slide the Barrier into place.

12 Align the slot on the Barrier to the keyway on the shaft, and slip in the spirol pin (item 36, 09388). Finally, insert the second circlip.

13 Replace the seal sub and Electronics Assembly.

Take care at all times not to damage the cables.

The operation is now complete.

6.8 SENSOR REPLACEMENT

Warning! It is highly recommended that sensors should only be replaced by experienced and Sondex-trained personnel. Incorrect installation can result in a pressure failure and destroy the entire tool. The following instructions are provided for use as a last resort only, and only after training has been given.

Any new sensor should already have successfully passed a pressure test before installing onto a tool. This is done by Sondex. After installing a new sensor, the tool should be pressure tested again before using it to log a well.

6.8.1 OLD SENSOR REMOVAL

1 Position the CAT horizontally on V-blocks.

2 Open the fingers until the fingers are just fully open. Do not allow the spline housing to come nearer to the sensor head than is necessary for the fingers to open fully; otherwise there will be too little room around the sensor head to replace the sensor.
Switch off the power to the tool. It may be necessary to do this before the Actuator sleeve has stopped moving.

3 Remove the Electronics section as described in *6.2*.

4 Remove the Seal Sub (item 26, drawing 09388) to expose the secondary Pressure Barrier.

5 Remove the circlip on the low pressure side of the secondary Pressure Barrier and slide the Barrier away from the Sensor Head.

6 Unplug the sensor to be replaced from the high pressure (sensor head) side of the secondary pressure barrier. Cut off the MMCX connector on the coax cable.

7 Using heavy duty cutters, cut the sensor tube near to the gland that secures it into the sensor head.

8 Remove the sensor by sliding it out of the finger.

9 Unscrew the gland and remove it using an M6 spanner.

6.8.2 NEW SENSOR REPLACEMENT

1 De-oxidise approximately 2″ of the end of the sensor tube (the end where the cable exits the tube). This should be done using a very mild abrasive material. Sondex recommends Scotchbrite™.

2 Degrease the de-oxided end thoroughly using isopropanol.

3 Insert the sensor tube into the finger, and slide it through the finger until it reaches the sensor head. Do not insert the tube or the cable into the sensor head. The sensor is not clipped fully into place at this stage. Take great care not to damage the sensor cable as it is passed through the finger.

4 Slide a gland that has been tinned with 96S solder over the sensor tube. (The solder joint will later be covered with a protective covering).

5 Next slide a **new** olive over the sensor tube. The tapered end will go into the sensor head first. Olives should never be re-used once they have been tightened.

6 Insert the coax cable into the sensor head, and then slide the sensor tube into the sensor head. The gland should not be screwed into the sensor head at this stage.

7 When the cable and tube are threaded through the sensor head, very carefully clip the sensor into the finger. Great care should be taken when doing this so as to avoid placing excessive lateral stress on the sensor joints.

8 Slide the sensor tube with its olive into the sensor head. Very loosely screw the gland into the sensor head; do not tighten it at this stage because the tube should be free to slide within the sensor head.

9 Cut the coax cable to the desired length and add an MMCX connector to the cable, along with a length of heatshrink sleeving. Plug the cable into the secondary pressure barrier and shrink the sleeving to insulate the connection.

10 Temporarily connect the sensor to the appropriate channel on the Electronics Assembly. Power up the tool and check that the sensor gives sensible readings before proceeding any further. Be sure to connect the chassis of the Sensor Assembly and Electronics Assembly together via a short length (< 6″) of thick cable (7/0.2 or greater).

11 The positioning of the sensors depends on whether the sensor is on an outer or inner diameter. (Tools can be configured with all the sensors on a single outer diameter, or alternatively, with every second sensor on an inner diameter). **When tightening the glands, the sensor tubes will usually be pulled slightly into the sensor head, so allowance should be made for this.**

Sensor on an outer diameter	**Sensor on an inner diameter**
With the finger fully open, slide the sensor such that the spike at the end of the sensor slides fully into the hole at the tip of the finger.	If the sensor is to be on an inner diameter, the spike of the sensor should not be inserted fully into the hole at the tip of the finger. This is because if the finger is later replaced by one that opens to an outer diameter, the sensor will prevent the finger from fully opening. The easiest way to set up such a sensor is by comparing it to the others and ensuring that the spike is still in the hole at the tip of the finger when the finger is fully closed.

Tighten the gland using a modified M6 pipehead spanner. This is a special tool which must be supplied by Sondex (pt/no. 08738). Tightening is best done judging by experience, but as a guide, 6lbft of torque should be applied. The tightening of the gland should be done extremely carefully. Whilst tightening, the tubes will be pulled into the sensor head slightly; this point should be taken into consideration when initially positioning the sensor on an inner diameter.

Warning! If a gland has been tightened to any significant extent, it cannot be released and tightened again without replacing the sensor and olive with new ones. Otherwise a pressure failure may result!

12 Replace the O-rings (items 43, drawing 09388) on the Sensor Head.

13 If desired, also remove the Secondary Pressure Barrier and replace the O-rings underneath it (Items 40, drawing 09288).

14 Secure the Secondary Pressure Barrier in place with the circlip (Item 39).

15 Apply RTV3145 to the new MMCX connection on the high pressure side of the secondary Pressure Barrier. The RTV should circle all 12 connectors, providing some shock absorbance.

16 Assemble the Seal Sub (Item 26, drawing 09388) onto the Sensor Head.

17 Screw the electronics chassis back on and hold the tool vertically in a vice, with the fingers pointing upwards.

18 Solder the gland to the tube with 96S solder. This solder joint is not a primary seal, but is intended to provide additional mechanical strength to prevent the sensor tube from being forced into the sensor head at high pressures. Degrease the solder joint with isopropanol or similar.

19 Power up the tool again and check that the sensor readings are sensible.

20 The tool should now be pressure tested to check the integrity of the new sensor. This is best done with the electronics removed.

21 After a successful pressure test, the glands should be dried and Viton paint applied to protect the soldered joints around the glands from well fluid. Refer to *APPENDIX E Viton Application*.

7 ELECTRICAL DESCRIPTION

7.1 GENERAL COMMENTS

See *Figure 4.1 Block Diagram of the CAT007*.

There are four PCBs in the tool:

- Power Supply PCB *CD-85642*
- Telemetry and Processing PCB *CD-85644*
- Sensor Interface PCB *CD-85635*
- Motor Control PCB *CD-85583*

In terms of power supply and telemetry, the CAT electronics is derived from the Sondex to Halliburton crossover (XSH).

The power supply is modified to provide an additional supply (5V#T) for the sensor interface board. It also has the current limit set slightly higher, so that the CAT motor can be operated.

The telemetry board is also very similar to the XSH. The main difference from the XSH is that it has new software and Actel circuitry.

7.2 POWER SUPPLY

Ref.: *CD-85642*

Starting at the top left of the block diagram, the majority of the power supply circuitry consists of a switching power supply designed to convert the 200V supply into 12V.

A second tap from the switching transformer is used to generate approximately 8V. A simple linear power supply is then used to convert this into the main 5V supply for most of the digital circuitry.

A second nominal 5V supply (5V#T) is also generated. This is used to power the capacitance oscillator circuits and is designed with a specific temperature characteristic. Hence, at room temperature, it will not necessarily be at 5V.

The telemetry electronics on this board is not used on the CAT. It is used on the XSH for putting Sondex Sync and Data Pulses onto the Sondex toolbus.

7.3 TELEMETRY AND PROCESSOR CIRCUITRY

Ref.: *CD-85644*

This is the main Processing PCB in the tool. It performs all the CAT telemetry functions, and acquires the measurements from the various sensors.

The Master MPU controls the overall operation of the tool. The slave MPU has no function on the CAT. It is only used on the XSH.

The Master MPU selects each sensor in turn, via the Son-37 Actel. The oscillator pulses are fed into the Son-37 (F0 and F1) and then into the PIC where they are counted. The PIC also measures tool rotation and electronics temperature. These values are then written into a FIFO and the PIC then sets a DataBlockReadyFlag for the RTU Actel. This Actel is a Halliburton design and sends out the FIFO data when it is polled by the TTTCB or similar controller.

Commands from the surface are received by the RTU Actel, and sent into the Son-37 Actel. The master MPU PIC polls the Son-37 Actel for these received commands.

The tool is designed to be polled for data every 50ms.

It can be configured to have 1, 2, 3 or 4 frames of data on each poll. The tool defaults to providing a single frame of data per poll. If it is told to collect more than 1 frame per poll, the tool assumes that it is polled at 50ms intervals and will take the 2, 3 or 4 sets of measurements evenly distributed over a 50ms interval.

7.4 FRONT-END SENSOR CIRCUITRY

Ref.: *CD-85635*

The front end of the circuit consists of 12 individual oscillator circuits, each connected to a sensor. The output from each of the oscillators is fed into a multiplexer. The sensor circuitry for the 12 sensors is contained on a single PCB. The multiplexers are controlled via an Actel by the Master MPU on the main logic board (see section *7.3*), which selects which of the 12 sensors it wishes to measure.

7.5 MOTOR CONTROL CIRCUITRY

Ref.: *CD-85583*

The motor control circuitry contains all of the switching transistors needs to operate the motor, and hence open/close the fingers. It also contains current limiting circuitry that will limit the current drawn by the motor from the main power supply PCB. If the factory-set current limit is exceeded for a pre-set period of time, the current limiting circuitry will then trip out completely, turning off the motor. The typical current limit is approximately 0.8A, and this will trip out completely after approximately 1s. However, these figures are only guidelines, not specifications, and are subject to change.

The motor control circuitry will only open the fingers when it receives a square wave from the processor PCB. If this square wave disappears, the motor will close the fingers. This provides some degree of fail-safe operation.

7.6 TELEMETRY FORMAT

Tool Address

By default, the CAT is set to address 0x59. This is set using links and can be changed if required. See *APPENDIX C Link Settings*.

Commands Accepted

The CAT will accept the following "Mode commands without Data":

Command	Description
59E1	Acquire 1 frame of data on each poll (default)
59E2	Acquire 2 frames of data on each poll
59E3	Acquire 3 frames of data on each poll
59E4	Acquire 4 frames of data on each poll
59E5 - 59ED	Invalid command
59EE	Open Fingers
59EF	Close Fingers

By default, the tool will collect a single frame of data on each poll.

Polling for Data

The CAT is normally polled for a single frame of data by sending it the command:

D908:

This will request 8 16-bit data words from the CAT.

If more than one frame of data is required, then the appropriate mode command should first be sent to the tool. The tool should subsequently be polled for the correct number of words (8 words per frame of data). e.g. to collect 4 frames of data on each poll, the tool should be sent the command sequence:

59E4	mode command without data to tell the CAT to collect 4 frames per poll
D920	request for 32 words (8 words x 4 frames)
D920	... repeated every 50ms

Frame Format

Each frame of data consists of 8 16-bit words as follows:

Word Number	MSByte (8 bits)	LSByte (8 bits)
0	Sensor 1	Sensor 2
1	Sensor 3	Sensor 4
2	Sensor 5	Sensor 6
3	Sensor 7	Sensor 8
4	Sensor 9	Sensor 10
5	Sensor 11	Sensor 12
6	Reference (reserved)	bits 7,6 = Motor Status bits 5 - 0 = Temperature - 100 (dec.)
7	IncX	IncY

As can be seen in the above table, each 16-bit word contains two 8-bit readings:

Sensor 1 - Sensor 12

Each of these 8-bit values is simply the number of capacitance oscillator periods that have been counted in a fixed time period. See the tool specification for the actual time period over which the pulses are measured.

Reference

This is not used in the current version of the CAT.

It is reserved for future versions of the tool that may require a reference oscillator. The idea is that the temperature drift of a reference sensor that is in a fluid of known permittivity (e.g. air) can be used to compensate for the temperature drift of the sensors in the well fluid.

As it is not currently used, it has been given a fixed value of 0x80h. This way, if the existing surface software is designed to use the reference, when the CAT does eventually use this value, the surface software will continue to work in the same way.

Motor Status and Temperature

This byte contains both Motor Status and Electronics Temperature. The temperature reading is only a very rough guide to the electronics temperature. It is not a measurement of well temperature.

Bit 7 is set to "1" if power is being applied to the motor.

Bit 6 is set to "1" if the logic circuitry is attempting to OPEN the fingers.

Hence, the two most significant bits (bits 7 and 6) indicate the status of the motor as follows:

Bit 7	Bit 6	Motor Status
0	0	CLOSED
0	1	OPENED
1	0	CLOSING
1	1	OPENING

Bits 5-0 are the temperature reading (in bits) with 100 (dec.) subtracted from the raw reading. At room temperature, the raw temperature reading is approximately 128. Hence, in this case the value in bits 5-0 would be 128 - 100 = 28. 100 is subtracted from the raw reading so that the temperature reading can fit into the 6 remaining bits.

IncX, IncY

IncX and IncY are measurements of tool rotation (relative bearing). These have a range of 0-255 and vary linearly with tool rotation. At the time of writing, tool rotation is measured with 2 x 360° potentiometers with a pendulum attached to them.

Each of the potentiometers has a "dead band" where there is a gap in the tracks. Hence, to provide a reading in the "dead band", two potentiometers are used (on the same axis), but rotated 90° relative to each other. Due to this rotation, the reading will differ by approximately 64 bits.

If one of the readings is 0, 255 or close to 128 (120 - 136), the value from the other potentiometer should be used to calculate tool rotation; otherwise the average rotation from the two potentiometers should be calculated.

8 EXTENDED CHECKS

8.1 MECHANICAL

1 Screws and nuts etc may be fixed with RTV 9140 if vibration loosening could be a problem. This is particularly appropriate with the screws that hold the boards together.

2 Ensure that there is no dirt or debris within the tool. Compressed air could be used to aid this. However, compressed air must not be directed at the sensor circuitry. This is because the sensor circuitry is very sensitive to moisture vapour, and any condensation resulting from use of compressed air could affect the sensor readings.

3 Check that all wires are undamaged and contained within the chassis.

4 Check that the fingers, sensors, sensor tubes, and actuator sleeve are undamaged.

5 The exposed solder joints around the glands and sensors should be covered with Viton paint. If any of the solder is exposed, the remaining Viton should be removed and new primer and Viton applied. This protects the solder from well fluid. This is not particularly necessary for the silver-soldered joints that secure the Sensor to the Sensor Tube. However, it **is** necessary for the joints around the ceramic part of the sensors. See *APPENDIX E Viton Application*.

6 The glands that secure the sensor tubes into the Sensor Head should be locked in place with Duralco 4525N Epoxy. See *APPENDIX F Epoxy Application*.

7 Ensure that the fingers open and close correctly, without labouring unduly. Also check that the sensors are correctly located at the end of the finger.

8 Before and after use, check that the sensors are clean and dry.

9 During transit, pieces of suitable shock-absorbing material should be placed between the sensors. Sondex uses short lengths of neoprene sleeving (p/n A017-0005M) but any similar material would suffice.

8.2 ELECTRICAL

The following tests can be used to check that the tool is operating correctly:

8.2.1 CAPACITANCE SENSOR READINGS CHECKS

Air Readings

Power up the tool, open the fingers, and check that each of the sensors is clean and thoroughly dry. Verify that the sensor readings are all within the range specified.

Limits for air readings: 0x64 - 0x8C hex
100 - 140 dec.

If any reading is below specification, first check that there is no moisture in any of the sensors. This could be caused by the guard connection to the corresponding sensor becoming disconnected.

If the reading is very low, e.g. 0, then the sensor electrode could be short-circuited. This is not necessarily in the electrode itself, although this is a definite possibility. Verify that the problem is not within one of the coaxial connections before replacing a sensor. This should only be done as a last resort. If the fault is found to lie within a sensor, this suggests that fluid has leaked into it.

If any reading is above specification, this suggests that a sensor electrode has become disconnected from the sensor electronics. As before, verify that the all the coaxial connections are satisfactory before replacing a sensor. It is most unusual for a sensor electrode to become detached within the sensor. The most likely cause of the problem is in one of the right-angled connectors on the sensor circuitry PCB. If care is not taken plugging the sensors into the board, the female socket may become frayed and make a poor contact with the mating male connector. This can also happen after many repeated insertions/removals of the coaxial connections.

These connections are also present on the leads to the secondary pressure barrier, so these are also susceptible to this potential problem.

Water Readings

Holding the tool vertically, slide the calibration jig around the sensors and fill the jig with water until the sensors are completely covered. The water readings should all be with the range specified.

Limits for water readings: 0x19 - 0x32 hex
25 - 50 dec.

If any of the readings give zero, check that the sensors are undamaged. If a reading is acceptable in air, but is 0 or 1 in water, this suggests that there is either a grounding problem or that one of the sensors has a leak and water has got into it.

Incidentally, if a reading falls significantly in a pressurised water test, this is also characteristic of a leak. It may be wise to abort the test to prevent further damage. If the reading is intermittent, however, this is more suggestive of a faulty connection.

8.2.2 POWER SUPPLY CHECKS

Measure the current taken by the tool when powered from a 200V D.C. supply. This should be measured when the motor is not operating.

Tool Current Limits: 5mA - 15mA

If there is a problem, measure the internal 5V, 5V#T and 12V supplies. These should be within the following limits:

5V Limits: 4.8V - 5.3 V

5V#T Limits: 5.1V - 5.4V

12V Limits: 12.0V - 13.3V

If the tool draws significantly more than this, e.g. 60mA, check that the motor control circuit is tripping out. The microswitches should normally be set to switch off the motor when fully closed, but if this was not the case, and the current trip was not tripping out either, then the tool would continue drawing current of up to about 80mA. This may be temporarily solved by re-adjusting the close microswitch to activate earlier. However, further investigation is needed to explain why the current trip is not activated.

If the motor circuit and microswitches are functioning properly, but the tool is drawing too much current, then use fault-finding procedures to find out which board is drawing the excess current. The most likely source is the power supply board itself, but a trapped wire (e.g. 5V, 5V#T or 12V) could also produce the symptom.

If the tool is drawing too little current then the problem is likely to be the power supply board, but verify that the other boards are indeed connected.

The 5V#T supply powers the oscillator circuits.

The 5V supply powers the rest of the digital circuitry.

The 12V supply powers the motor control board and motor.

8.2.3 Relative Bearing Checks

The relative bearing outputs increase linearly with tool rotation. They each have a range of 0 - 255. The absolute readings for zero rotation (finger 1 uppermost) will vary from tool to tool. However, this is taken care of during calibration.

Check that there is not excessive friction on the pendulum. A certain amount of hysteresis is acceptable because any natural vibration as the tool is moving down the well will cause the pendulum to sit on the low side. If the friction is excessive or the pendulum gets obstructed (e.g. by a wire), then this needs correcting.

The difference in reading between the two sensors should be approximately +/-64 (the roll-over from 0 - 255 should also be taken into account). If the difference is significantly more than this (e.g. +/- 54 bits) then there is a problem.

The first thing to check are the connections. If these are good, re-adjust the pendulum position by undoing one of the grub screws that secure the pendulum to one of the potentiometer shafts, rotating the pendulum until the difference is within specification, and then re-tightening the grub screw. This will need to be done on a trial-and-error basis.

8.2.4 Motor Operation Checks

The motor should be opened and closed four or five times to check that it operates correctly without labouring. The maximum current drawn by the tool when opening or closing should be within the following limit:

Maximum tool current when opening / closing: < 80 mA

Note: The tool will normally take more current when closing because it has to exert more effort against the spring of the fingers. Nevertheless, the current when closing should still be within the above limit.

The fingers should also stow correctly and the close microswiitch should operate when the fingers have closed. However, check that the current trip operates when the fingers have closed but the close microswitch has not been adjusted correctly.

When the fingers are open, manually verify that the fingers close down fully into the Actuator sleeve and spring fully open again by themselves without undue friction.

The open microswitch should be set so that the gap between the back of the finger and the Actuator Sleeve when fully open is approximately 2mm (min 1mm, max 3mm).

For each of the Closed, Opening, Opened and Closing operations, verify that bits 7 and 6 of the motor status / temperature word indicated the correct motor status (see *Section 7.6 Telemetry Format*).

8.2.5 TEMPERATURE CHECKS

The temperature reading is a very rough indicator of tool electronics temperature. It should be close to 128 at room temperature and increase by one bit approximately every 6 degrees centigrade. On all but the very first tools, the precise figure can be found in the test results sheet supplied with the tool.

A quick check for correct operation can be made by heating the electronics housing or temperature sensor with a hot air gun, or more thoroughly by heating the whole tool in an oven. The latter is not normally required. The temperature sensor is R15 on the processor board (85644).

9 MAINTENANCE

9.1 GENERAL COMMENTS

General maintenance of the tool will usually be limited to changing a few O-rings periodically.

The most complicated operations are replacing sensors and fingers. This requires a certain level of skill and technique. Training by Sondex is mandatory for these operations, because any mistake can result in the destruction of all the sensors. It can also result in catastrophic pressure failure.

The tool should be well supported on V-blocks for all servicing procedures. A minimum of 4 V-blocks will be necessary when the tool is broken into its separate sub-assemblies. Damage can easily result if this is not adhered to.

9.2 O-RING REPLACEMENT

9.2.1 GENERAL

There are a large number of O-rings in the CAT007, and some are more easily changed than others. These are general guidelines, and should be used in conjunction with company-specific procedures.

1 Replace any O-ring which has seen pressure and subsequently had the seal broken (e.g. by removing a pressure housing).
The most relevant O-rings in this category are the two O-rings at the top of the tool (items 45, drawing 09388), which mate with the tool above. Hence, these O-rings should be replaced after every job.

2 Replace all O-rings after the tool has been exposed to high temperatures (177°C) or high pressures (12500 psi).

3 Replace O-rings that have been exposed in gas wells.

4 Replace O-rings that have been exposed to H_2S.

5 Replace O-rings prior to a campaign of wells (e.g. every 5-6 jobs).

Exception

There are two O-rings on the central shaft that provide a seal with the sensor head (items 13, drawing 08766). These are a very high specification perfluoroelastomer and should normally **only** be replaced when replacing a complete set of fingers or sensors. The procedure required to change these O-rings is complex and requires complete removal of every finger. See Section *9.2.5*.

9.2.2 EASILY REPLACED O-RINGS

The following O-rings are easily replaced because only a pressure housing needs to be removed:

- The 2 externally visible O-rings at the top of the tool (items 45, drawing 09388). These seals will be broken each time the tool is connected to the tool above it. **Hence, they should be replaced after every job.**

- The 2 O-rings on the Seal Sub (items 43, drawing 09388).
  When checking these, also check the environmental/backup O-rings on the hermetic connector at the top of the tool (items 41, drawing 09388). These do not normally see pressure, except in the case of main O-ring failure, but it takes little effort to check these at the same time.
  Note that the O-ring at the top of the electronics assembly (item 17, drawing 85646) has no sealing function and does not need replacing unless very badly damaged.

- The two O-rings on the Motor Sub (items 55, drawing 08774).
  Note that the O-ring at the lower end of the motor assembly (item 57, drawing 08774) has no sealing function and does not need replacing unless very badly damaged.

9.2.3 O-RING REPLACEMENT REQUIRING MODERATE DISASSEMBLY

The following O-rings and dynamic seals require a moderate level of disassembly to replace. However, there is relatively little risk of damage to the sensors or associated electrical connections. The O-rings and seals should also be replaced according to the guidelines set out above.

- The two K seals which form the backup seals between the Yoke Shaft and (a) the Central Shaft, and (b) the Motor Sub (items 42, drawing 09388)

- The two variseals (dynamic/sliding seals) (items 23). These are the primary seals for the backup seals (items 42).

9.2.4 O-RING REPLACEMENT REQUIRING SUBSTANTIAL DISASSEMBLY

The following O-rings require a substantial level of electronics disassembly:

- The two O-rings that provide the seal between the Sensor Head and Seal Sub (items 44, drawing 09388).

- The two external O-rings on the secondary pressure barrier (item 3, drawing 11538).

Great care must be taken when replacing them. They should be replaced according to the guidelines set out above, but not any more frequently than necessary due to the procedures involved.

One of the risks is that too much off-axis strain can be put onto the coaxial connectors, resulting in a poor or intermittent connection when the connection is re-made. The connections should only ever be made or broken with a suitable pair of pliers. The connections should never be made/broken by hands alone, as this will almost certainly result in damage.

9.2.5 O-RING REPLACEMENT REQUIRING TOTAL DISASSEMBLY

The following O-rings require total disassembly of the tool, and should not be changed except when a major service is undertaken. Indeed, these should only be changed if all of the fingers or sensors need replacing, or there is some other major problem which requires removal of the central shaft. C**omprehensive training by Sondex is mandatory for this procedure.**

- The two O-rings on the central shaft that provide a seal with the sensor head (items 13, drawing 08766). These are a very high specification perfluoroelastomer and should normally only be replaced when replacing a complete set of fingers or sensors. The procedure required to change these O-rings is complex and requires complete removal of every finger, in addition to the electronics assembly. See *Section 6.7 Changing Sensor Fingers*.

9.2.6 GREASING OF O-RINGS

Sondex recommends greasing all of the seals and sliding surfaces with type 101 Liquid O-ring manufactured by Oil Center Research Inc. This is superior to silicone grease in certain areas of the tool (where stainless steel parts are close to each other), and does not have loose conductive particles that may cause problems near electrical connections. Hence it is used throughout the tool.

Note that prolonged contact with Liquid O-ring may be harmful. Refer to *Section 2 Safety*.

9.3 ROUTINE SERVICE

Ref.: General Assembly Drawing *09388*

After every job, the two O-rings on the Upper Pressure Housing must be changed:

- O-ring Viton 90 Type 217 (item 45 on 09388)

9.4 INTERMEDIATE LEVEL SERVICE

Ref.: Sensor Section Assembly *08775*
General Assembly Drawing *09388*

An intermediate level service should be carried out after every 5-6 jobs, or if the tool has seen service of 177ºC (350ºF) or pressure of more than 12500psi. However, the guidelines in *9.2.1* should also be taken into account.

1 Disassemble the motor section from the tool (see *Section 6.4 Motor Section Disassembly*) and replace the Dynamic Seal and O-ring on the Central Shaft (items 22 & 23 on 08775) and Motor Section (items 23 & 42 on 09388).

2 Remove the Seal Sub (Item 26, 09388).

3 Remove the circlip on the low pressure side of the Secondary Pressure Barrier, and slide the Barrier away from the Sensor Head.

4 Carefully remove the RTV from the Secondary Pressure Barrier, slide off (or remove) the heat shrink sleeving, and unplug the connectors on the high pressure side. Remove the Secondary Pressure Barrier.

5 Replace the O-rings on the Sensor Head, on the secondary Pressure Barrier, and on the Central Shaft underneath the secondary Pressure Barrier.

6 Reassemble the Motor Section (see *Section 6.5 Motor Section Reassembly*).

7 Reassemble the Electronics Section (see *Section 6.3 Electronics Section Reassembly*).

9.5 MAJOR SERVICE

This should only be carried out once a year, or whenever the sensor's fingers are worn out or damaged and need to be changed.

All O-rings should be changed. Remove all the fingers as described in *Section 6.7 Changing Sensor Fingers*. This will involve almost a total disassembly of the tool and allow every O-ring to be replaced.

APPENDIX A EQUIPMENT & RECOMMENDED SPARES

Item	Part No	Description	Qty	Remarks
1	CAT007	Capacitance Array Tool, $1^{11}/_{16}$″, HES 1553 Telemetry	1	Single/Dual radius options available

A.1 RECOMMENDED SPARES

Part No	Description	Remarks
KITO-CAT007	O-ring Redress Kit	O-ring Kit only
KITB-CAT007	Basic Spares Kit	O-ring Kit + Calibration Jig
KITR-CAT007	Kit, Spares, Recommended (25 run)	O-ring kit + Spare sensors, fingers etc. + special tools required

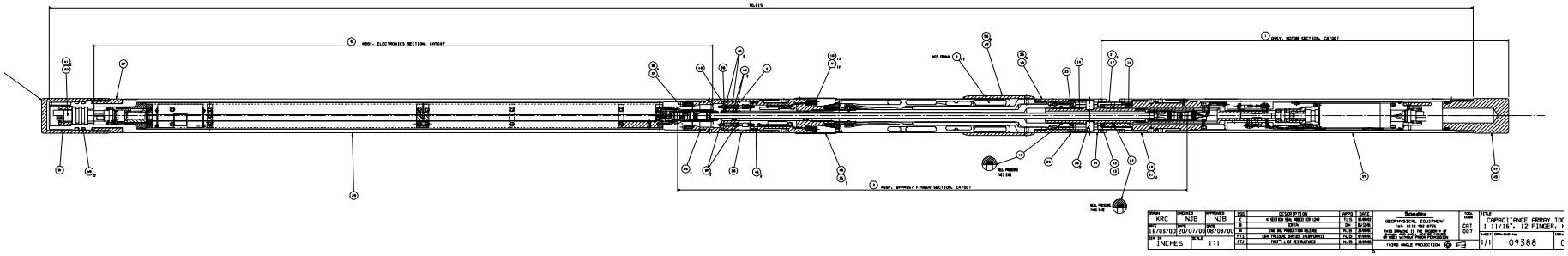
APPENDIX B DRAWINGS AND PARTS LISTS

B.1 MECHANICAL ASSEMBLIES

CAT 12f $1^{11}/_{16}$″ 1553 Client Adaptation, General Assembly	Drawing/Parts List	*09388-C*
Motor Section Assembly	Drawing/Parts List	*08774-B*
Sensor Section Assembly	Drawing/Parts List	*08775-A*
Electronics Section Assembly	Drawing/Parts List	*85646-A*
Finger Section Assembly	Drawing/Parts List	*08776-A*

B.2 ELECTRICAL DRAWINGS

Power Supply PCB	Circuit Diagram	*CD-85642-B03*
Telemetry and Processing PCB (2 sheets)	Circuit Diagram	*CD-85644-B*
Sensor Interface PCB (4 sheets)	Circuit Diagram	*CD-85635-D*
Motor Control PCB	Circuit Diagram	*CD-85583-E*
Electronics Section (2 sheets)	Wiring Diagram	*WD-85646-C*
Sensor Section	Wiring Diagram	*WD-08775-A*
Motor Section	Wiring Diagram	*WD-08774-A*



PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
09388	C		KRC	NJB	NJB
			Date: 16/03/2000	Date: 20/07/2001	Date: 08/08/2001

Description:
CAT007, 1 11/16, 12 FINGER, 1553 CLIENT ADAPTATION

CHANGE HISTORY

Iss	*Date*	*Remarks*	*Chkd*	*Appr*
A	20/09/2001	Initial Production Release	DH	NJB
B	05/12/2001	ECR974. 85646 was Iss A. TP & TR 09388 were Iss A	DH	DH
C	03/09/2002	K Section Seal added ECR1249	AJB	TLS

RELATED DOCUMENTS

#	*Documents*	*Issue*	*Notes*
01	09388	C	Assembly Drawing
02	TP-09388	C	Assembly Instructions
03	TR-09388	C	Test Results Sheet
04	TC-09388	B	Test Checkout Sheet

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	08774	A	Assy, Motor Section, CAT007		1	ea	
002							
003	08775	A	Assy, Sensor Section, CAT007		1	ea	
004	11538	PT1	Assy, Pressure Barrier, Coax Feedthru'		1	ea	
005	85646	D	Assy, Electronics Section, CAT007		1	ea	
006							
007							
008							
009							
010	J016-65BFP	-	MMCX Micro Miniature Straight Coax Cable Jack		12	ea	
011	J016-00201	-	MMCX Micro Miniature Straight Coax Cable Plug		12	ea	
012	W005-0OMCX	-	Cable Coaxial MMCX, 50 ohm			(AR)	
013	05828	B	Shaft		1	ea	
014	05846	B	Key, Motor Sub		1	ea	
015	05850	A	Locknut Actuator Sleeve		1	ea	
016	05827	A	Yoke		2	ea	
017	05826	B	Yoke Housing		1	ea	
018	05843	A	Yoke Housing Clamp Ring		1	ea	
019	06583	A	Retaining Ring Yoke		1	ea	
020	01849	A	Spring, Locking, 1 11/16 Inch Tools		1	ea	
021	14250	A	FDD Modified M5 Grub Screw		5	ea	
022	05823	A	Seal Support		1	ea	
023	91267	-	Seal Variseal (Use 91567)		1	ea	
024							
025							
026	08767	C	Seal Sub		1	ea	
027	10729	A	Assy Ring Threaded Split HES 1553 Connection		1	ea	
028	08762	A	Housing Pressure Electronics		1	ea	
029	08763	A	Housing Pressure Motor		1	ea	
030	10720	C	Housing Connector Assy 6 Way Hermetic (1553 Connection)		1	ea	
031	10710	A	Ring Hermetic Retaining (HES Pt No 3 80128)		1	ea	
032	93016	-	Screw, Grub Skt Hd, M4 x 5mm Lg, SS		3	ea	

PARTS LISTING

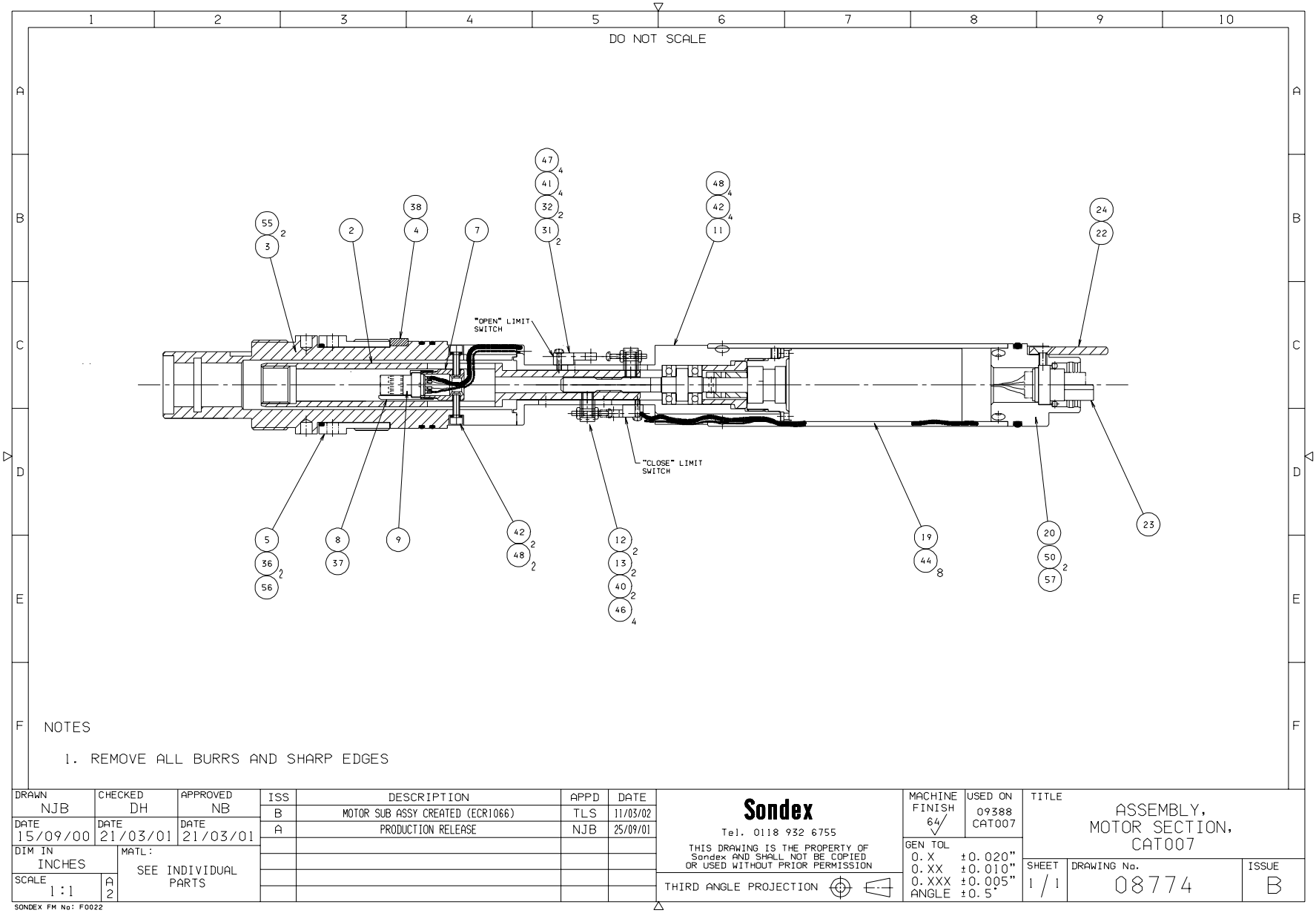
Part:	Issue:		Drawn:	Checked:	Approved:
09388	C		KRC	NJB	NJB
			Date: 16/03/2000	Date: 20/07/2001	Date: 08/08/2001

Description:
CAT007, 1 11/16, 12 FINGER, 1553 CLIENT ADAPTATION

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
033	10144	B	Protector Thread Female 1 560-12TPI Stub Acme		1	ea	
034	10145	A	Protector Thread Male 1 560-12TPI Stub Acme		1	ea	
035	93036	-	Screw Grub Skt Hd M4x06mm Lg SS		3	ea	
036	93122	-	Pin Spirol 2mm x 04mm Long St/Steel		1	ea	
037	93041	-	Screw, Skt Cap Hd, M3 x 10mm Long, St/Steel		4	ea	
038	93039	-	Washer Spring M3 SS (Single Coil)		4	ea	
039	93570	-	Circlip, External, 0.50", Light Duty	St Stl 302	2	ea	
040	99012	-	O Ring Viton 90 Type 012		2	ea	
041	99115	-	O Ring Viton 90 Type 115		2	ea	
042	99930	-	BS116 K Section Seal		2	ea	Alt. 99116
043	99124	-	O Ring Viton 90 Type 124		3	ea	
044	99125	-	O Ring Viton 90 Type 125		2	ea	
045	99217	-	O Ring Viton 90 Type 217		3	ea	
046	99027	-	O Ring Viton 90 Type 027		2	ea	
047	99908	-	O'Ring Perfluoroelastomer Type 012		1	ea	
048	08784	A	Protective Sleeve	AlBr	1	ea	
049							
050	93157	-	Screw Grub Skt Hd M4x08mm Lg SS		2	ea	
051							
052							
053							
054							
055	A017-0005m	-	Neoprene Sleeve (Cable Binding) 5 0mm ID x 25mm Lg H50		12	ea	
056	08798	A	Flight Case, CAT007, 1 11/16", HES		1	ea	
057	08732	A	Assy, Carry Tube, CAT007		1	ea	
058							
059							
060							
061							
062	KITB-CAT007	PT1	Kit, Spares, Basic, CAT007, CA		1	ea	

(AR = As Required)



DRAWN NJB	CHECKED DH	APPROVED NB	ISS	DESCRIPTION	APPD	DATE	Sondex	MACHINE FINISH 64	USED ON 09388 CAT007	TITLE ASSEMBLY, MOTOR SECTION, CAT007	
DATE 15/09/00	DATE 21/03/01	DATE 21/03/01	B	MOTOR SUB ASSY CREATED (ECR1066)	TLS	11/03/02	Tel. 0118 932 6755	GEN TOL 0.X ±0.020" 0.XX ±0.010" 0.XXX ±0.005" ANGLE ±0.5°		SHEET 1/1	DRAWING No. 08774 ISSUE B
DIM IN INCHES	MATL: SEE INDIVIDUAL PARTS		A	PRODUCTION RELEASE	NJB	25/09/01	THIS DRAWING IS THE PROPERTY OF Sondex AND SHALL NOT BE COPIED OR USED WITHOUT PRIOR PERMISSION				
SCALE 1:1	A2						THIRD ANGLE PROJECTION				

SONDEX FM No: F0022

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
08774	B		NJB	DH	NJB
			Date: 15/09/2000	Date: 21/03/2001	Date: 21/03/2001

Description:
Assy, Motor Section, CAT007

CHANGE HISTORY					RELATED DOCUMENTS		
Iss	*Date*	*Remarks*	*Chkd*	*Appr*	*# Documents*	*Issue*	*Notes*
A	25/09/2001	Production Release	DJ	NJB	01 WD-08774	A	Wiring Diagram
B	11/03/2002	MOTOR SUB ASSY ADDED (ECR 1066)	TLS	TLS	02 AI-08774	A	Assembly Instructions

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001							
002	05822	A	Drivenut		1	ea	
003	05825	B	Motor Sub		1	ea	
004	05846	B	Key, Motor Sub		1	ea	
005	05824	A	Split Nut		1	ea	
006							
007	08785	A	Locknut, 10-pin Lemo	AlBr	1	ea	
008	05841	A	LEMO Housing Female		1	ea	
009	05848	A	10 Way LEMO Modification		1	ea	
010							
011	05860	A	MOTOR SUB ASSEMBLY		1	ea	
012	06627	A	Screw AntiRotation Block		2	ea	
013	06599	B	Anti-Rotation Block		2	ea	
014							
015							
016							
017							
018							
019	08766	A	Motor Chassis		1	ea	
020	08772	A	Body, Female Connector-MOD		1	ea	
021							
022	10721	A	Tang Alignment Female Body		1	ea	
023	10719	A	Connector 6Pin MOD (HES Pt No 3 40407)		1	ea	
024	10725	A	Screw MOD		1	ea	
025							
026							
027							
028							
029							
030							
031	94100	-	Switch Basic (Was 05707) Micro Switch 4SX1-T		2	ea	
032	94101	-	Switch Actuator JX45		2	ea	
033							
034							

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
08774	B		NJB	DH	NJB
			Date: 15/09/2000	Date: 21/03/2001	Date: 21/03/2001

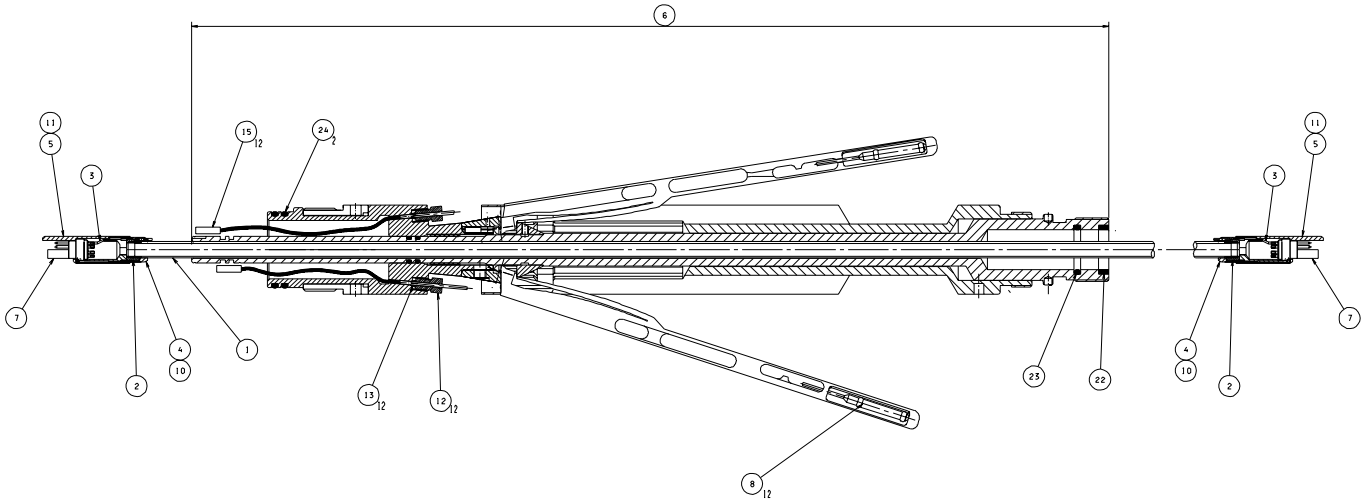
Description:
Assy, Motor Section, CAT007

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
035							
036	93321	-	Screw Skt Cap Hd M2 5 x 10mm LG		2	ea	
037	93393	-	Screw Grub Skt Hd M1 6 x 02mm Lg SS		1	ea	
038	93400	-	Screw Csk Hd Slotted M2 5x 5 mm Lg SS		1	ea	
039							
040	93318	-	Screw Pan HD Slotted M2 x 16mm		2	ea	
041	93246	-	Screw Pan Hd Slotted M2x08mm Lg SS		4	ea	
042	93041	-	Screw, Skt Cap Hd, M3 x 10mm Long, St/Steel		6	ea	
043							
044	93221	-	Screw Csk Hd Slotted M3x6mm Lg SS (Duplicate-Refer to 01029)		8	ea	
045							
046	93152	-	Nut Hex M2 SS		4	ea	
047	93258	-	Washer Spring M2 SS (Single Coil)		4	ea	
048	93039	-	Washer Spring M3 SS (Single Coil)		6	ea	
049							
050	93005	-	Pin, Spirol, 2 5mm x 16mm Lg, SS		2	ea	
051							
052							
053							
054							
055	99028	-	O Ring Viton 90 Type 028		2	ea	
056	99026	-	O Ring Viton 90 Type 026		1	ea	
057	95124	-	O Ring Viton 75 Type 124		1	ea	
058							
059							
060							

(AR = As Required)

DO NOT SCALE



NOTES
1. REMOVE ALL BURRS AND SHARP EDGES

DRAWN	CHECKED	APPROVED
NJB	DH	NJB
DATE	DATE	DATE
15/09/00	07/09/01	07/09/01

DIM IN INCHES
SCALE 1:1 A1
MATL: SEE INDIVIDUAL COMPONENTS

ISS	DESCRIPTION	APPD	DATE
A	PRODUCTION RELEASE	NJB	25/09/01

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THIRD ANGLE PROJECTION

USED ON: 09388 CAT007
MACHINE FINISH: 63
GEN TOL: 0.X ±0.020" 0.XX ±0.010" 0.XXX ±0.005" ANGLE ±0.5°

TITLE: ASSY, SENSOR SECTION
SHEET 1/1
DRAWING No. 08775
ISSUE A

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
08775	A		NJB	DH	NJB
			Date: 15/09/2000	Date: 07/09/2001	Date: 07/09/2001

Description:
Assy, Sensor Section, CAT007

CHANGE HISTORY

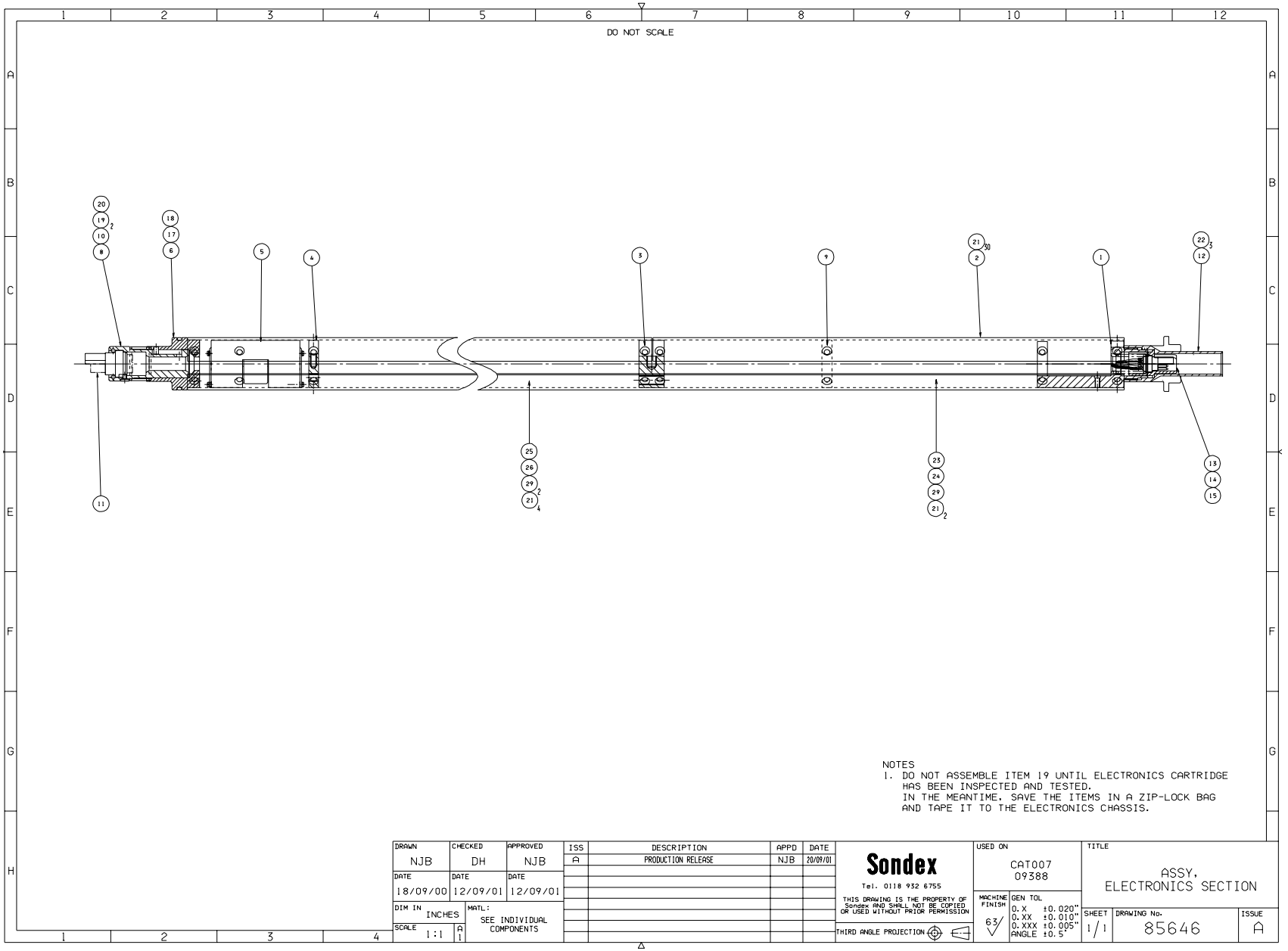
Iss	*Date*	*Remarks*	*Chkd*	*Appr*
A	25/09/2001	Production Release	DH	NJB

RELATED DOCUMENTS

#	*Documents*	*Issue*	*Notes*
1	08775	A	Assembly Drawing
2	TP-08775	A	Assembly Instructions
3	WD-08775	A	Wiring Diagram
4	TR-08775	A	Test Results Sheet

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	08771	A	Bypass Tube		1	ea	
002	05831	A	Bypass Tube End Nut		2	ea	
003	05832	A	Lemo Housing		2	ea	
004	05833	A	Lemo Housing Clamp Ring		2	ea	
005	05834	B	Lemo Bypass Location Housing		2	ea	
006	08776	A	Assy, Finger Section, CAT007		1	ea	
007	05848	A	10 Way LEMO Modification		2	ea	
008	08739	B	Assy, MK3 CAT Sensor, Pinned		12	ea	
009							
010	93115	-	Pin, Spirol, 1mm x 10mm Long, St/Steel		2	ea	
011	93393	-	Screw Grub Skt Hd M1 6 x 02mm Lg SS		2	ea	
012	08743	A	M6 Gland, Tinned		12	ea	
013	08734	B	Sleeve (Olive)		12	ea	
014							
015	J016-65BFP	-	MMCX Micro Miniature Straight Coax Cable Jack		12	ea	
016	W008-00005	-	Wire, 2 X 24AWG, 250V, PTFE Twisted White/Blue			(AR)	
017	W008-00001	-	Wire, 24AWG, 600V, PTFE White			(AR)	
018	W008-00002	-	Wire, 26AWG, 250V, PTFE White			(AR)	
019	W008-00003	-	Wire, 26AWG, 250V, PTFE White SHD + White PTFE JKT			(AR)	
020	W008-00004	-	Wire, 2 X 26AWG, 250V, PTFE White/Blue SHD + PTFE JKT			(AR)	
021							
022	91267	-	Seal Variseal (Use 91567)		1	ea	
023	99116	-	O Ring Viton 90 Type 116		1	ea	
024	99124	-	O Ring Viton 90 Type 124		2	ea	
025							
026							
027							
028							
029							
030							
031							
032	94004	-	(Use A006-0096S)			(AR)	



PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
85646	A		NJB		
			Date: 18/09/2000	Date: --/--/--	Date: --/--/--

Description:
Assy, Electronics Section, CAT007

CHANGE HISTORY

Iss	*Date*	*Remarks*	*Chkd*	*Appr*
A	24/08/2001	ECR906. Production Released.		

RELATED DOCUMENTS

#	*Documents*	*Issue*	*Notes*
01	AD-85646	A	Assembly Drawing
02	WD-85646	A	Wiring Diagram (2 sheets)
03	AI-85646	A	Assembly Instructions

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	08769	A	Bulkhead, Lemo Housing		1	ea	
002	08765	A	Electronic Chassis		1	pr	
003	08713	A	Bulkhead, Transistor		1	ea	
004	01002	G	Bulkhead, Electronics, Intermediate, Standard		1	ea	
005	11517	A	Assy, Relative Bearing Device		1	ea	
006	03912	B	Bulkhead Upper XSH 1553 Connection		1	ea	
007							
008	03913	A	Housing Connector Spring Loaded (HES 1553)		1	ea	
009	03696	A	Chassis Bulkhead		1	ea	
010	91126	-	Spring Compression St/St 0.845(OD) x 2.000(FL) 5.1(lbs/in)		1	ea	
011	10731	A	Connector Hermaphrodite 6 PIn Modified		1	ea	
012	08770	A	Lemo Housing		1	ea	
013	05836	A	Lemo Housing Spring		1	ea	
014	05837	A	Spring / Lemo Housing		1	ea	
015	05963	A	Modified 10 Way Lemo		1	ea	
016							
017	95122	-	O Ring Viton 75 Type 122		1	ea	
018	03915	A	Pin Spirol 3mm x 4 5mm Long St/Steel		1	ea	
019	93289	-	Pin Spirol 2 5mm x 10mm Long St/Steel		2	ea	
020	03916	A	Screw, Pan head M2 5x3 5 lg		2	ea	
021	93221	-	Screw Csk Hd Slotted M3x6mm Lg SS (Duplicate-Refer to 01029)		36	ea	
022							
023	85635	D	Assy,Sensor Board, 12 Sensor CAT		1	ea	
024	85583	E	Assy Motor Control & Current Trip ***(Change R20 to 8K2. See Assy Instruction)***		1	ea	
025	85642	B-01	Assy CAT-HES Data Converter, PSU and Telemetry ***(Check that board has been modified as shown on AI 85642 IssA)***		1	ea	
026	85644	A	PCB Assy MPL/CAT-1553 Data Converter		1	ea	
027							
028	85645	A-01	Bare PCB Dummy ***(Cut blank board down as shown on Assy Instructions)***		1	ea	
029	93261	-	Spacer, Round, M3 Thru, 4.75mmOD x 12.7mmLG, Brass/NickelP		3	ea	
030							

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
85646	A		NJB		
			Date: 18/09/2000	Date: --/--/--	Date: --/--/--

Description:
Assy, Electronics Section, CAT007

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
031	Q013-30P05	-	RFP30P05, P channel power MOSFET 120W (TO220) ***(Mount on lower bulkhead. see Assy Instructions.)***	RFP30P05	1	ea	Q1 on Assy 85583
032	D014-0100V	-	Power Soft Recovery BYW29E- 8 0A TH 100V ***(Mount on central bulkhead. See assy instructions)***	BYW29E-100	1	ea	D6 on Assy 85642
033	A008-00220	-	(Use Q101-00220)		2	ea	Q1, D6 mounting
034	A007-00220	-	(Use Q100-00220)		2	ea	Q1, D6 Mounting
035	93028	-	Washer Serrated M3 SS (DIN6798A)		2	ea	Q1, D6 mounting
036	93223	-	Screw, Pan Hd, Slotted, M3x08mm Lg, St/Steel	Screw M3x8mm	2	ea	Q1, D6 mounting
037							
038	93086	-	Tag Solder M4		3	ea	2 off on upper bulkhead 1 off on lower bulkhead
039	93173	-	Screw Pan Hd Slotted M4x08mm Lg SS		2	ea	Earth Tag Fixing
040	93029	-	Washer Serrated M4 SS (DIN6798A)		2	ea	Earth Tag Fixing
041							
042	R002-008K2	-	Resistor, RC01, 5%, 0W25, Thick Film, Ni Barrier, (DH, SM)	8k2	1	ea	R20 on assy 85583 Motor Current Limit
043							
044	W001-00100	-	Wire, 7/0.2, PTFE Type A, Black			(AR)	
045	W001-00103	-	Wire, 7/0.2, PTFE Type A, Orange			(AR)	
046	W001-00104	-	Wire, 7/0.2, PTFE Type A, Yellow	7/0.2		(AR)	
047							
048	W001-00200	-	Wire, 7/0.12, PTFE Type A, Black			(AR)	
049	W001-00201	-	Wire, 7/0.12, PTFE Type A, Brown			(AR)	
050	W001-00202	-	Wire, 7/0.12, PTFE Type A, Red			(AR)	
051	W001-00203	-	Wire, 7/0.12, PTFE Type A, Orange			(AR)	
052							
053	W001-00205	-	Wire, 7/0.12, PTFE Type A, Green			(AR)	
054	W001-00206	-	Wire, 7/0.12, PTFE Type A, Blue			(AR)	
055	W001-00207	-	Wire, 7/0.12, PTFE Type A, Violet			(AR)	
056	W001-00208	-	Wire, 7/0.12, PTFE Type A, Grey			(AR)	
057	W001-00209	-	Wire, 7/0.12, PTFE Type A, White			(AR)	
058	W001-00210	-	Wire, 7/0.12, PTFE Type A, Pink			(AR)	
059							
060	W008-00004	-	Wire, 2 X 26AWG, 250V, PTFE White/Blue SHD + PTFE JKT			(AR)	
061	W005-0178B	-	Cable, Coax, RG178B/U 50R, Brown, PTFE Insulated	7/0.1mm		(AR)	
062							
063	A012-00000	-	Sleeving, Silicone Rubber, Class H, 180C, Wall 0.5mm, Black	1mm ID		(AR)	
064	A013-00000	-	Sleeving, Silicone Rubber, Class H, 180C, Wall 0.5mm, Black	2mm ID		(AR)	
065							

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
85646	A		NJB		
			Date: 18/09/2000	Date: --/--/--	Date: --/--/--

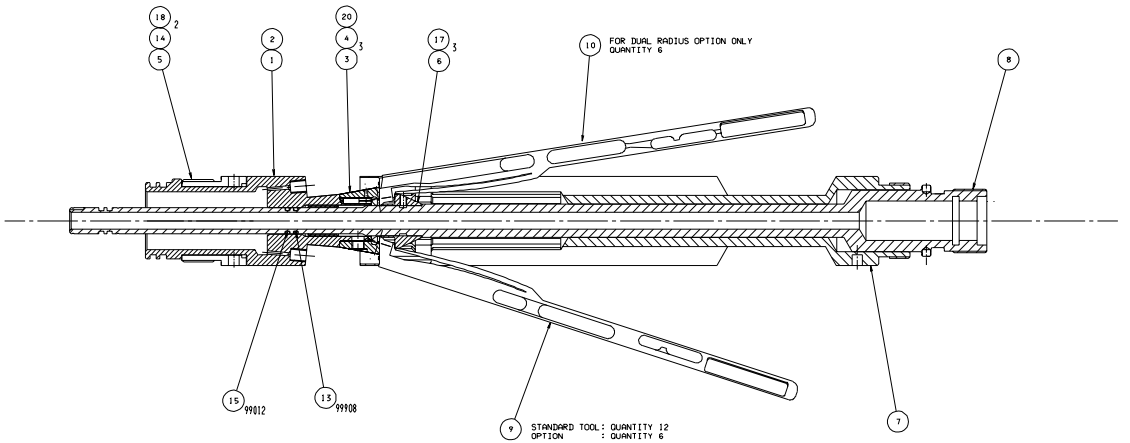
Description:
Assy, Electronics Section, CAT007

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
066	A025-00060	-	(Use T004-00060)			(AR)	
067	A025-008AP	-	(Use T004-008AP)			(AR)	

(AR = As Required)

DO NOT SCALE



NOTE:
1. ITEM 11 AND ITEM 16 NOT SHOWN ON DRAWING.

DRAWN	CHECKED	APPROVED
NJB	DH	NJB
DATE 12/09/00	DATE 18/09/01	DATE 25/09/01

DIM IN INCHES | MATL: SEE INDIVIDUAL COMPONENTS
SCALE 1:1 | A1

ISS	DESCRIPTION	APPD	DATE
A	PRODUCTION RELEASE & SEE ECR 1128		

Sondex
Tel. 0118 932 6755

THIRD ANGLE PROJECTION

USED ON 09388 CAT007

MACHINE FINISH 63

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

TITLE: ASSY, CAT007 FINGER SECTION

SHEET 1/1 | DRAWING No. 08776 | ISSUE A

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
08776	A		NJB	DH	NJB
			Date: 18/09/2000	Date: 18/09/2001	Date: 25/09/2001

Description: Assy, Finger Section, CAT007

CHANGE HISTORY

Iss	*Date*	*Remarks*	*Chkd*	*Appr*
A	25/09/2001	Production Release & See ECR 1128	DH	NJB

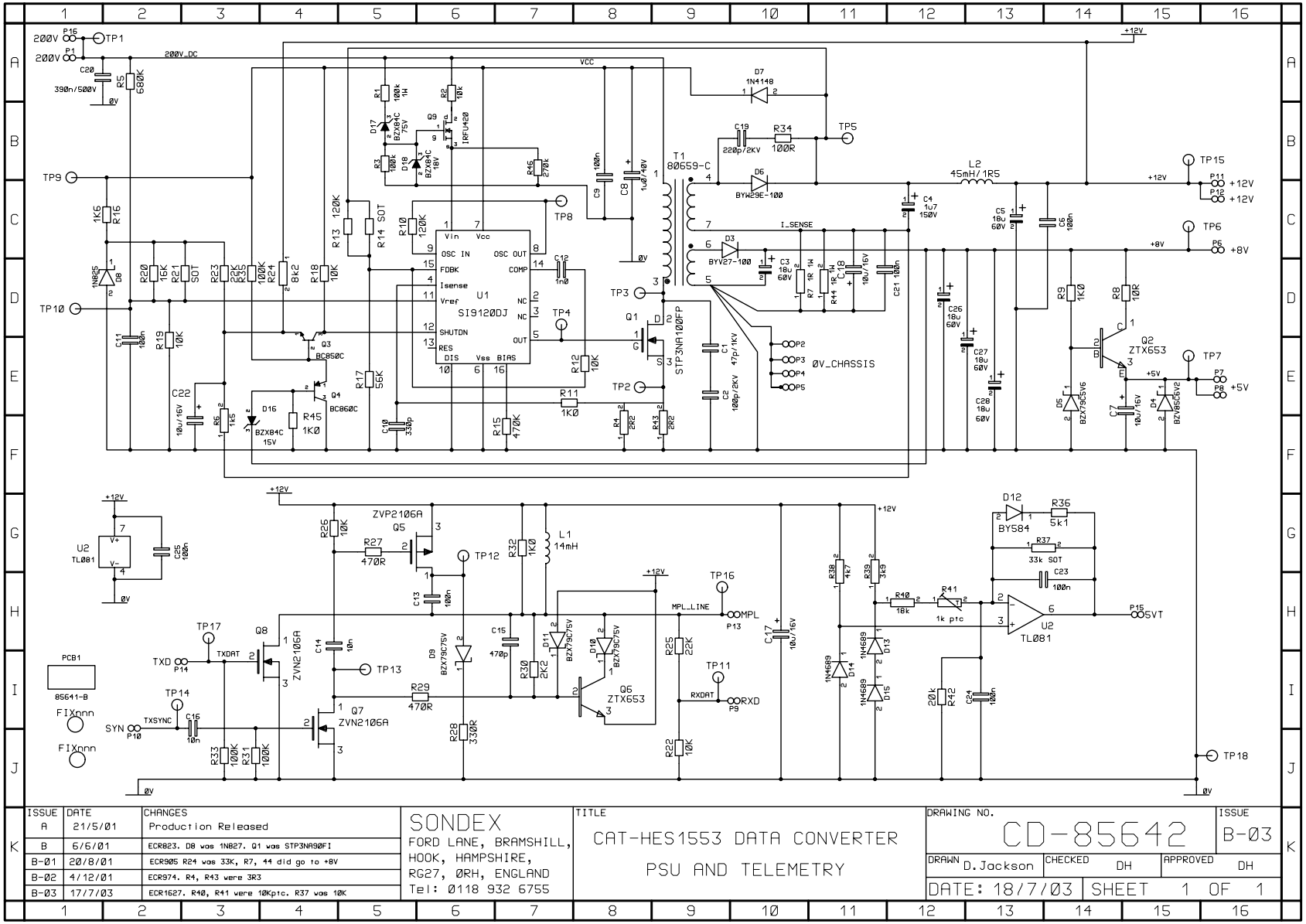
RELATED DOCUMENTS

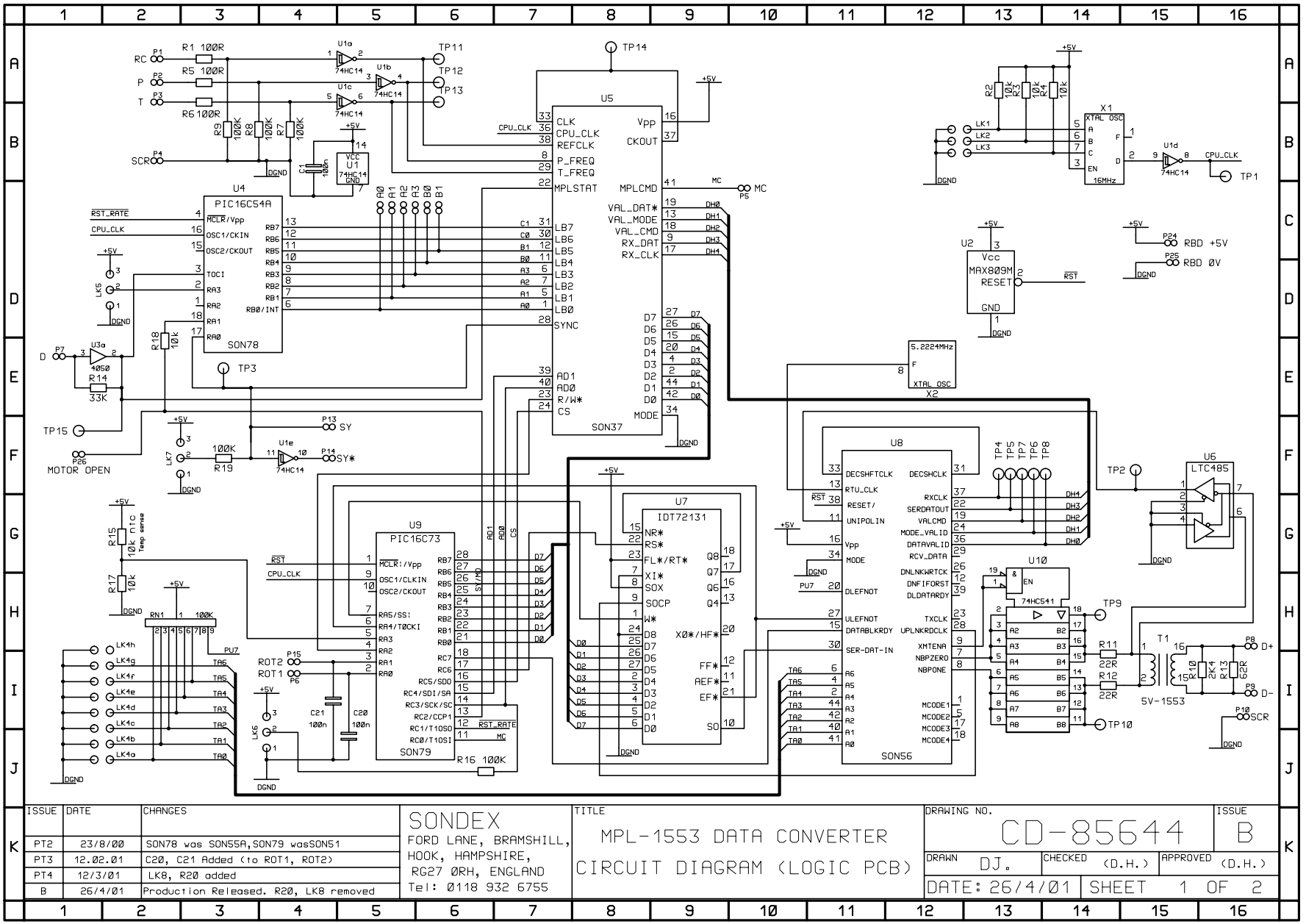
#	*Documents*	*Issue*	*Notes*
1	08776	A	Assembly Drawing
2	AI-08776	A	Assembly Instructions

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	06624	A	Key Sensor Hub		1	ea	
002	08768	A	Sensor Head		1	ea	
003	08744	A	Pivot Block		1	ea	
004	06629	A	Ball Ended Thrust Screw M6		3	ea	
005	05824	A	Split Nut		1	ea	
006	08708	A	Finger Support Cone		1	ea	
007	08745	D	Actuator Sleeve		1	ea	
008	08764	A	Central Shaft		1	ea	
009	08746	D	Sensor Finger I (full deployment)		12	ea	
010	08747	C	Sensor Finger II (Part Deployment, Dual Radius Option only)		6	ea	
011	08786	A	Transportation Sleeve		1	ea	
012							
013	99908	-	O'Ring Perfluoroelastomer Type 012		1	ea	
014	99026	-	O Ring Viton 90 Type 026		1	ea	
015	99012	-	O Ring Viton 90 Type 012		1	ea	
016	93157	-	Screw Grub Skt Hd M4x08mm Lg SS		3	ea	
017	93047	-	Screw Grub Skt Hd M3x05mm Lg SS		3	ea	
018	93321	-	Screw Skt Cap Hd M2 5 x 10mm LG		2	ea	
019							
020	93077	-	Pin Spirol 1/16 x 1/4 Long St/Steel		1	ea	

(AR = As Required)





ISSUE	DATE	CHANGES
PT2	23/8/00	SON78 was SON55A,SON79 wasSON51
PT3	12.02.01	C20, C21 Added (to ROT1, ROT2)
PT4	12/3/01	LK8, R20 added
B	26/4/01	Production Released. R20, LK8 removed

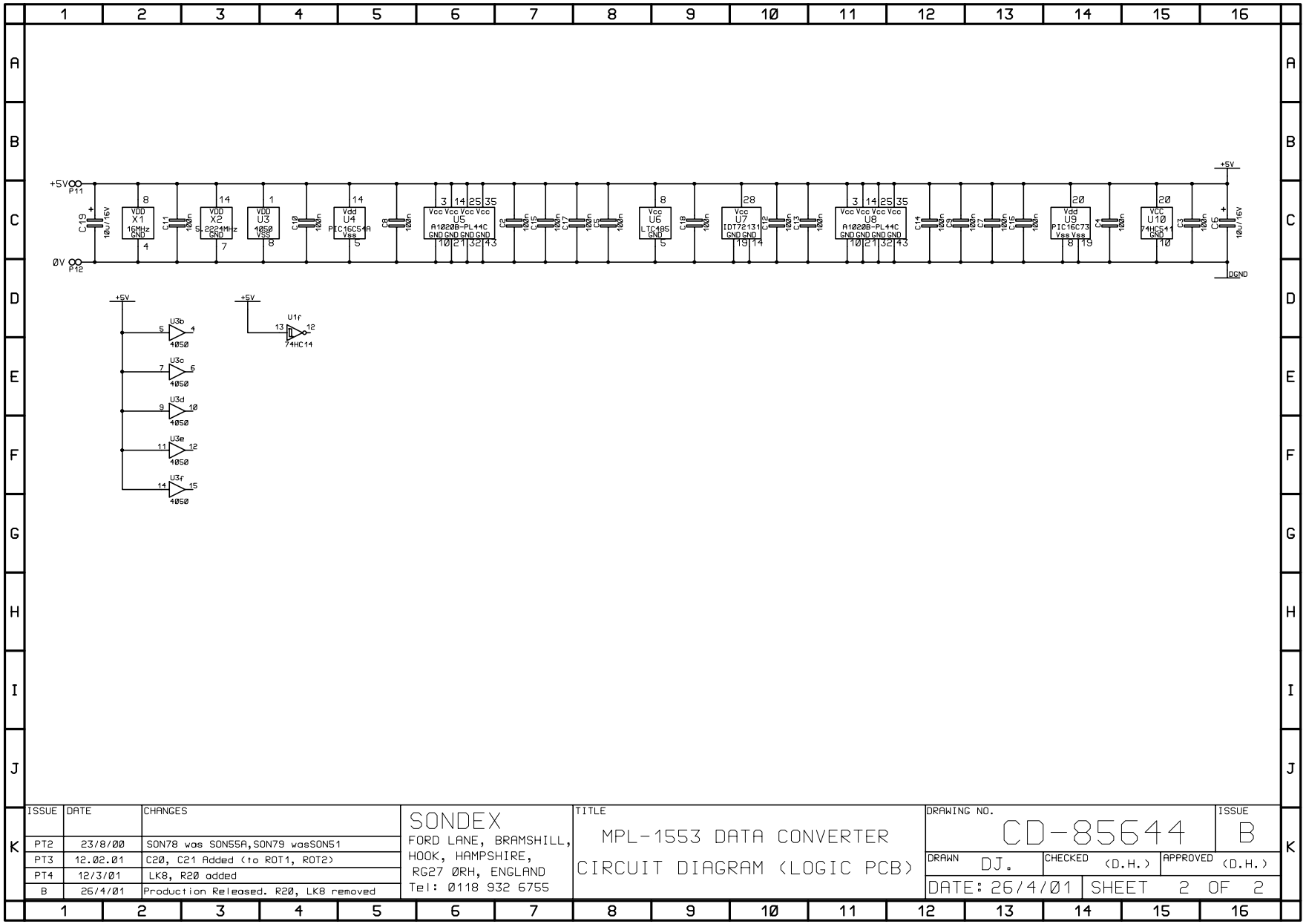
SONDEX
FORD LANE, BRAMSHILL,
HOOK, HAMPSHIRE,
RG27 0RH, ENGLAND
Tel: 0118 932 6755

TITLE
MPL-1553 DATA CONVERTER
CIRCUIT DIAGRAM (LOGIC PCB)

DRAWING NO. CD-85644 ISSUE B

DRAWN DJ. CHECKED (D.H.) APPROVED (D.H.)

DATE: 26/4/01 SHEET 1 OF 2



ISSUE	DATE	CHANGES
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PT3	12.02.01	C20, C21 Added (to ROT1, ROT2)
PT4	12/3/01	LK8, R20 added
B	26/4/01	Production Released. R20, LK8 removed

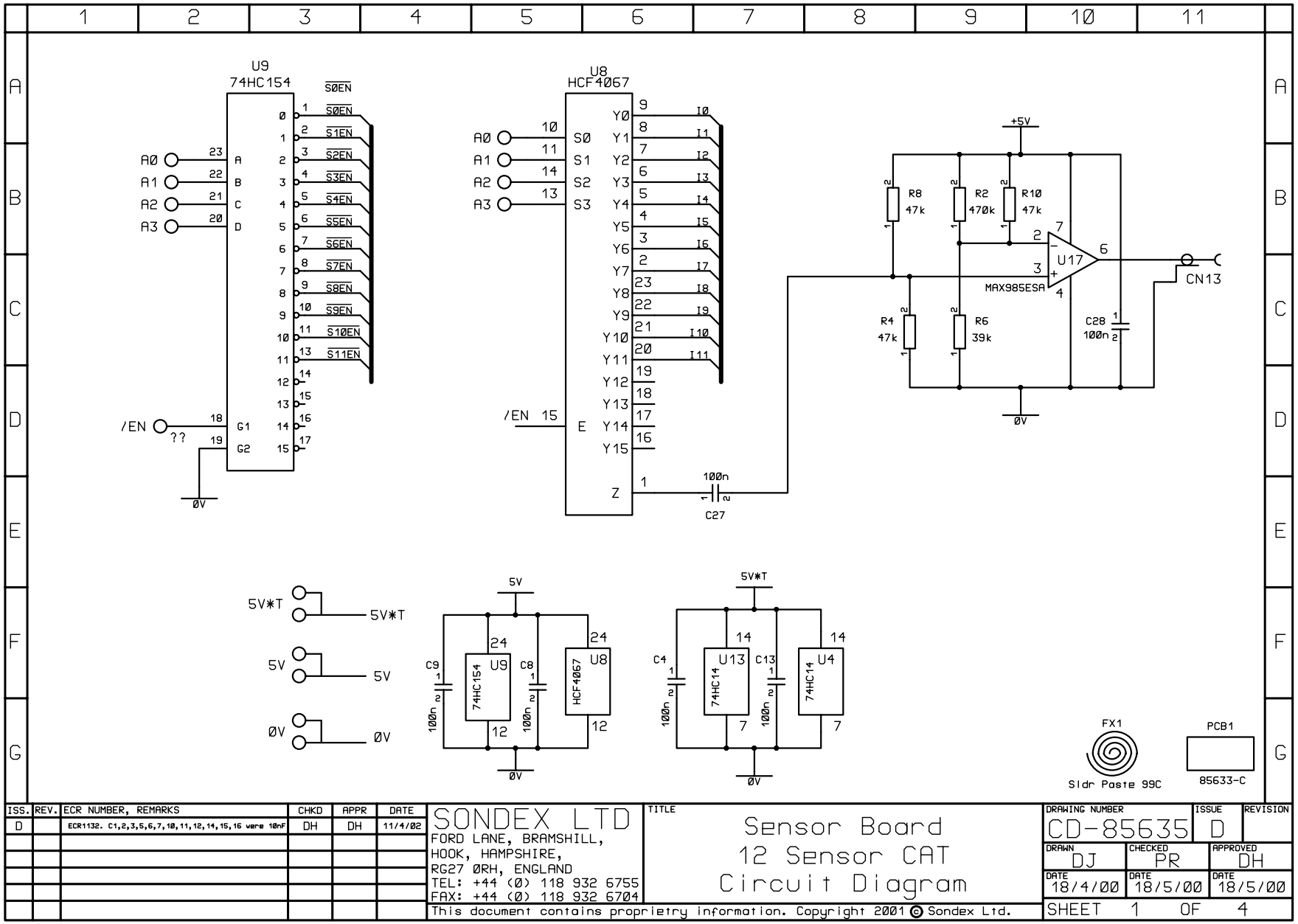
SONDEX
FORD LANE, BRAMSHILL,
HOOK, HAMPSHIRE,
RG27 0RH, ENGLAND
Tel: 0118 932 6755

TITLE
MPL-1553 DATA CONVERTER
CIRCUIT DIAGRAM (LOGIC PCB)

DRAWING NO. CD-85644 ISSUE B

DRAWN DJ. CHECKED (D.H.) APPROVED (D.H.)

DATE: 26/4/01 SHEET 2 OF 2



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
D		ECR1132. C1,2,3,5,6,7,10,11,12,14,15,16 were 10nF	DH	DH	11/4/02

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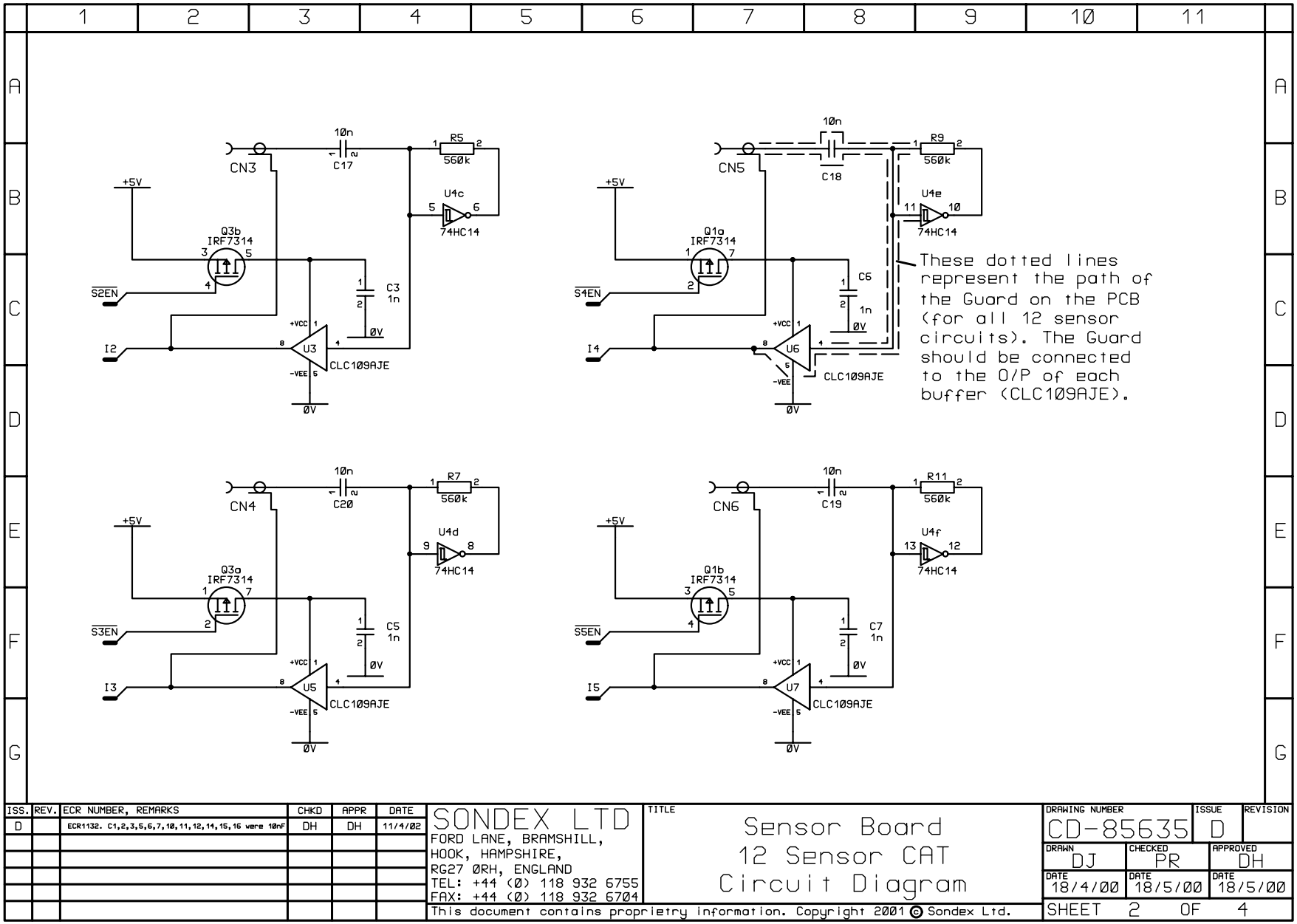
HOOK, HAMPSHIRE,
RG27 0RH, ENGLAND
TEL: +44 (0) 118 932 6755
FAX: +44 (0) 118 932 6704

TITLE: Sensor Board
12 Sensor CAT
Circuit Diagram

DRAWING NUMBER	ISSUE	REVISION
CD-85635	D	

DRAWN	CHECKED	APPROVED
DJ	PR	DH
DATE 18/4/00	DATE 18/5/00	DATE 18/5/00

SHEET 1 OF 4



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
D		ECR1132. C1,2,3,5,6,7,10,11,12,14,15,16 were 10nF	DH	DH	11/4/02

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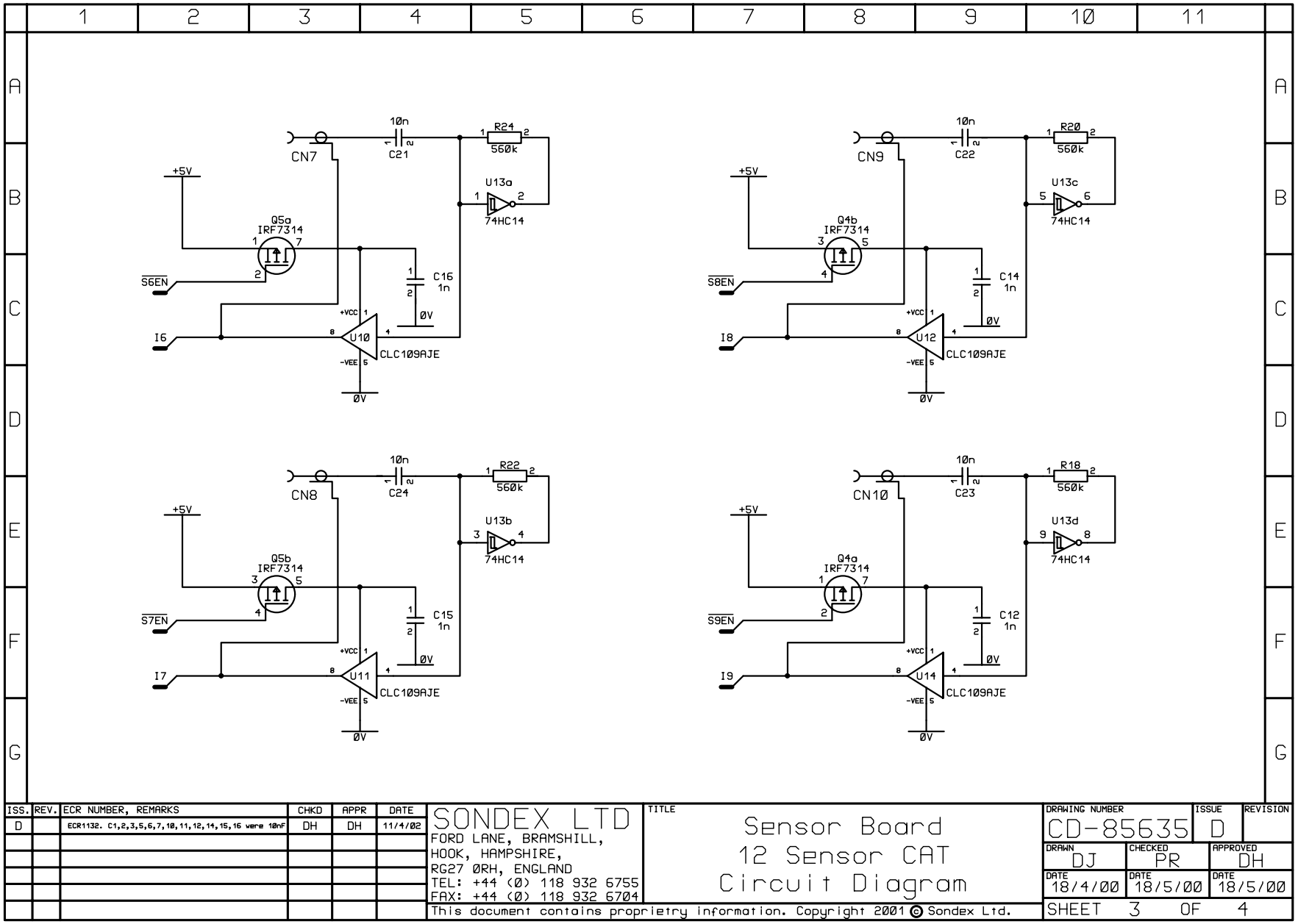
FAX: +44 (0) 118 932 6704

TITLE: Sensor Board 12 Sensor CAT Circuit Diagram

DRAWING NUMBER	ISSUE	REVISION
CD-85635	D	

DRAWN	CHECKED	APPROVED
DJ	PR	DH
DATE 18/4/00	DATE 18/5/00	DATE 18/5/00

SHEET 2 OF 4



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
D		ECR1132. C1,2,3,5,6,7,10,11,12,14,15,16 were 10nF	DH	DH	11/4/02

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HOOK, HAMPSHIRE,
RG27 0RH, ENGLAND
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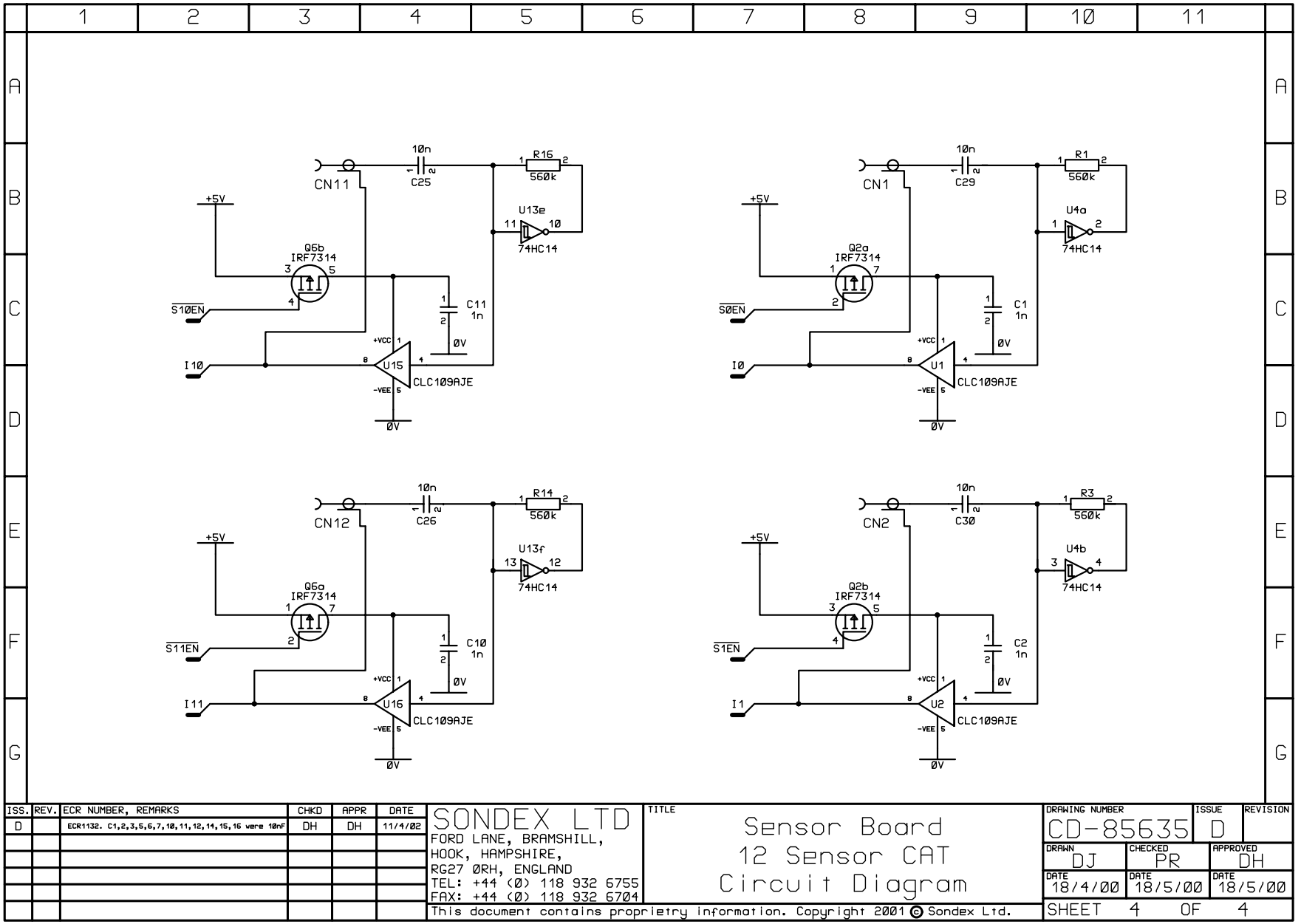
FAX: +44 (0) 118 932 6704

TITLE
Sensor Board
12 Sensor CAT
Circuit Diagram

DRAWING NUMBER	ISSUE	REVISION
CD-85635	D	

DRAWN	CHECKED	APPROVED
DJ	PR	DH
DATE 18/4/00	DATE 18/5/00	DATE 18/5/00

SHEET 3 OF 4



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
D		ECR1132. C1,2,3,5,6,7,10,11,12,14,15,16 were 10nF	DH	DH	11/4/02

SONDEX LTD
FORD LANE, BRAMSHILL,
HOOK, HAMPSHIRE,
RG27 0RH, ENGLAND
TEL: +44 (0) 118 932 6755
FAX: +44 (0) 118 932 6704

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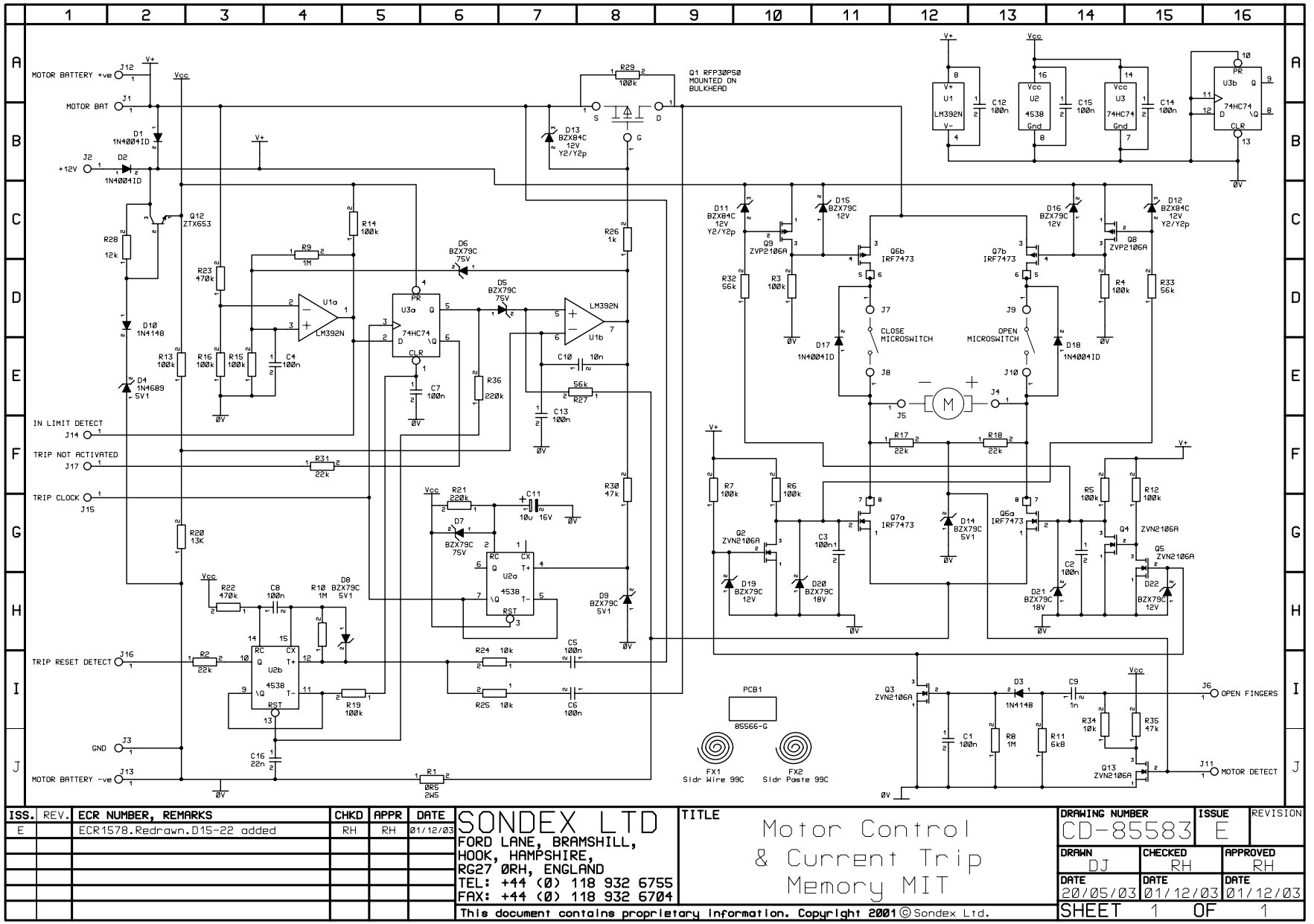
TITLE
Sensor Board
12 Sensor CAT
Circuit Diagram

DRAWING NUMBER	ISSUE	REVISION
CD-85635	D	

DRAWN	CHECKED	APPROVED
DJ	PR	DH
DATE 18/4/00	DATE 18/5/00	DATE 18/5/00

SHEET 4 OF 4



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
E		ECR1578.Redrawn.D15-22 added	RH	RH	01/12/03

SONDEX LTD
FORD LANE, BRAMSHILL,
HOOK, HAMPSHIRE,
RG27 0RH, ENGLAND
TEL: +44 (0) 118 932 6755
FAX: +44 (0) 118 932 6704

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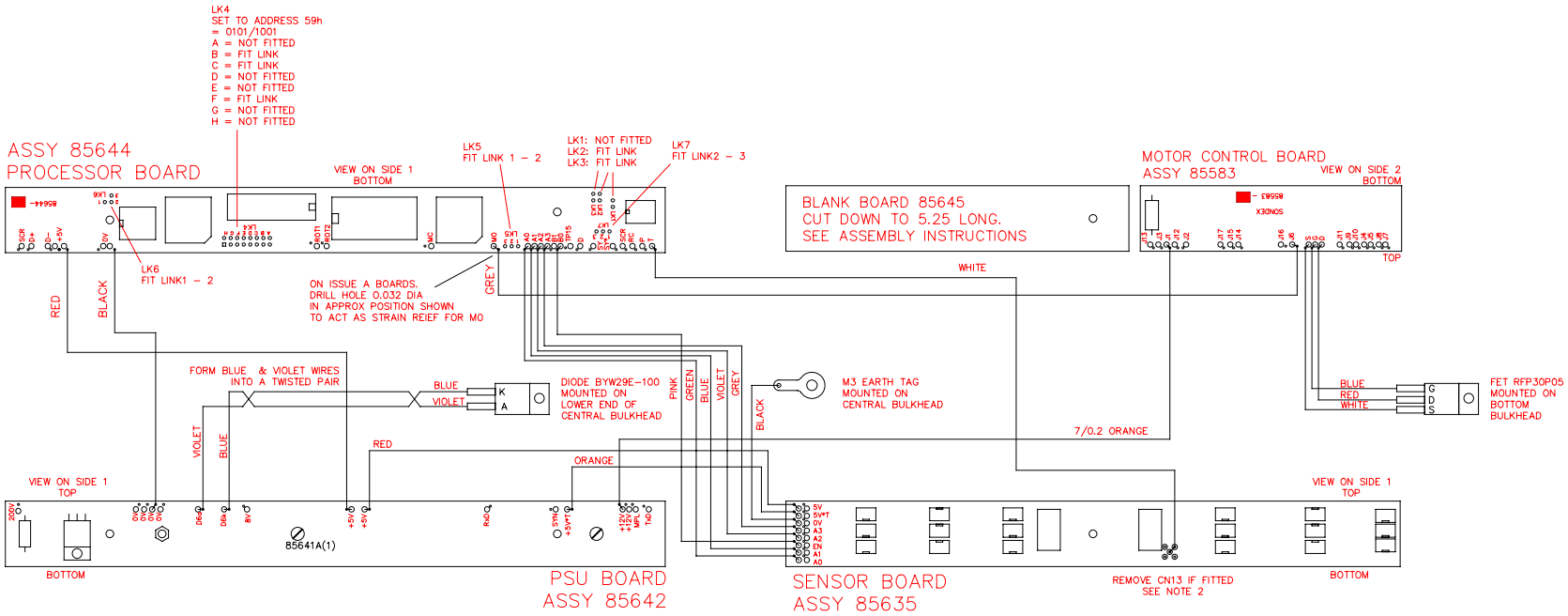
TITLE: Motor Control & Current Trip Memory MIT

DRAWING NUMBER	ISSUE	REVISION
CD-85583	E	

DRAWN	CHECKED	APPROVED
DJ	RH	RH
DATE 20/05/03	DATE 01/12/03	DATE 01/12/03

SHEET 1 OF 1



NOTES

1:
ALL WIRES 7/0.12 UNLESS OTHERWISE STATED.

2:
PASS WHITE WIRE TO CN13 THROUGH ONE OF
THE CORNER HOLES TO USE AS STRAIN RELIEF,
THEN BACK THROUGH CENTRE HOLE.
SOLDER CENTRE HOLE ONLY.
ENSURE SLEEVING OF WIRE THROUGH
STRAIN RELIEF HOLE IS NOT DAMAGED.

3:
THIS DIAGRAM IS TO BE READ IN CONJUNCTION
WITH SHEET 2 OF DIAGRAM,
& ASSEMBLY INSTRUCTION DRAWING
AI 85646

ISS	REV	DATE	CHANGES	CHKD	APPD
A		24/8/01	ECR906. Prod released. Was PT3. Be/Vt wires shown twisted		
B		5.12.01	ECR974. Ref Check R20 changed deleted.	(DH)	(DH)
C		11.4.02	ECR1132. 0V to sensor board was from psu board	(DH)	(DH)

SONDEX
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HOOK RG27 0RH,
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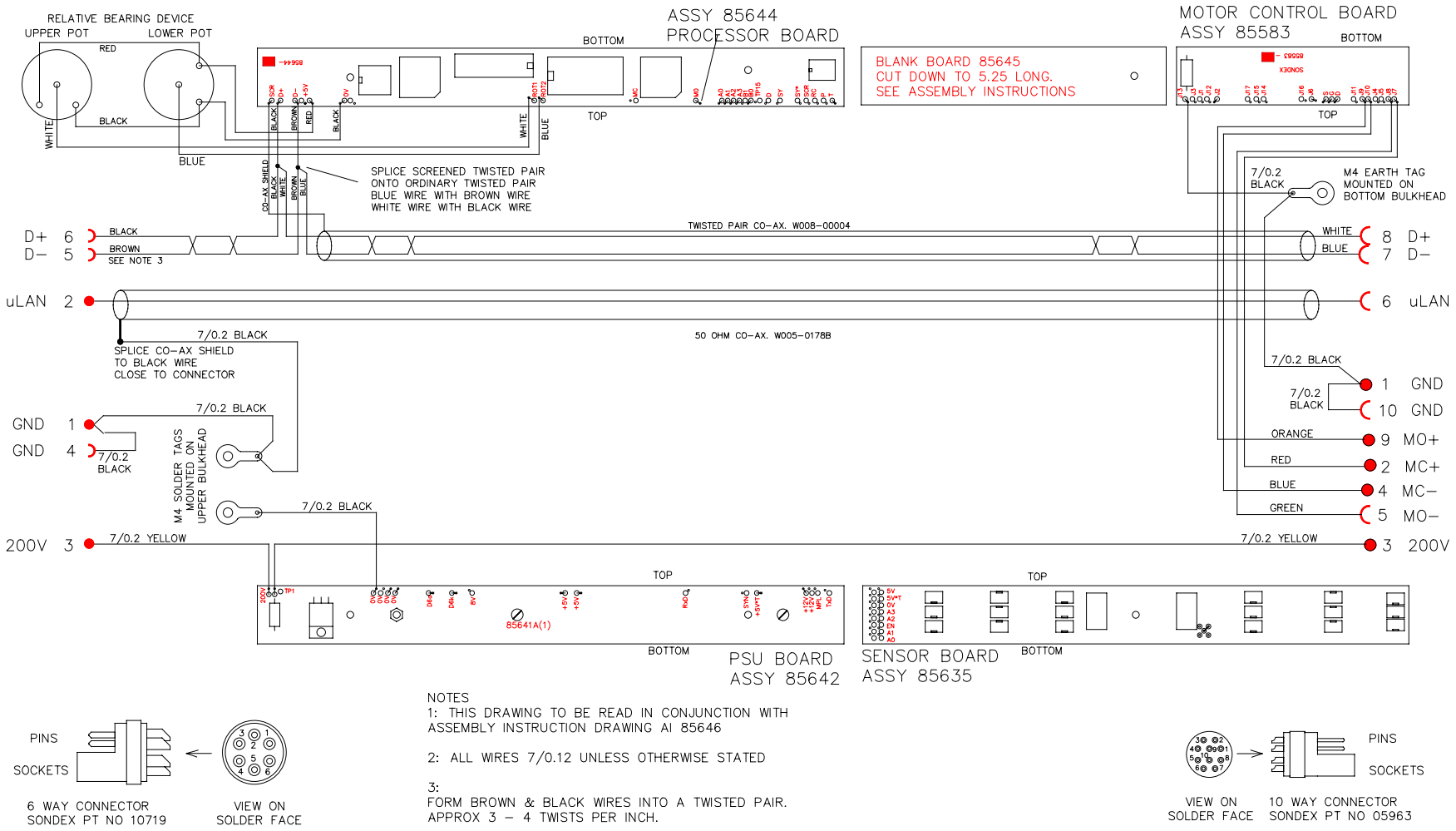
TITLE:
WIRING DIAGRAM
ELECTRONICS ASSEMBLY
12 SENSOR CAT
INTER–BOARD WIRING. SHEET 1 of 2

DRAWN	CHECKED	APPROVED
D.Jackson	(D.H.)	(D.H.)
DATE 24.8.01	DATE 7/9/01	DATE 7/9/01

DRAWING No. WD 85646 | ISSUE C | REVISION



NOTES
1: THIS DRAWING TO BE READ IN CONJUNCTION WITH ASSEMBLY INSTRUCTION DRAWING AI 85646

2: ALL WIRES 7/0.12 UNLESS OTHERWISE STATED

3:
FORM BROWN & BLACK WIRES INTO A TWISTED PAIR.
APPROX 3 – 4 TWISTS PER INCH.

ISS	REV	DATE	CHANGES	CHKD	APPD
A		24/8/01	ECR906. Production released. Was Iss PT3		
B		5.12.01	ECR974. Ref check R20 changed deleted	(DH)	(DH)
C		11.4.02	ECR1132. See Sheet 1	(DH)	(DH)

SONDEX
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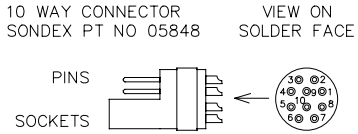
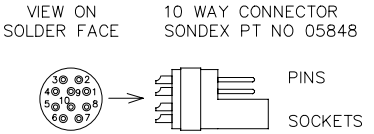
TITLE:
WIRING DIAGRAM
ELECTRONICS ASSEMBLY
12 SENSOR CAT
THROUGH WIRING. SHEET 2 of 2

DRAWN	CHECKED	APPROVED
D.Jackson	(D.H.)	(D.H.)
DATE 24.8.01	DATE 7/9/01	DATE 7/9/01

DRAWING No. WD 85646
ISSUE C
REVISION

ALL WIRES 7/0.12 TYPE A UNLESS OTHERWISE SPECIFIED





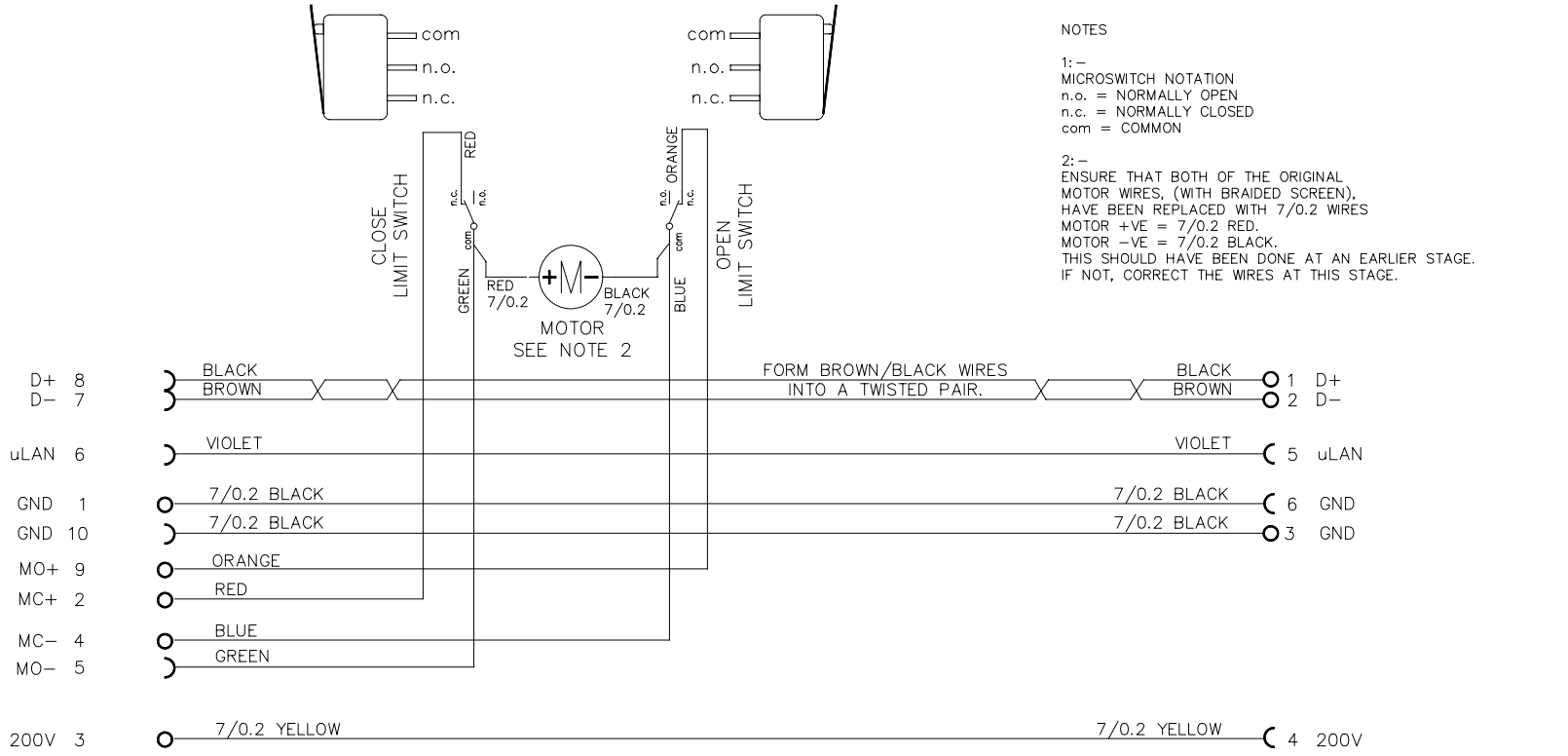
ISSUE	REVISION	DATE	CHANGES
A		25.9.01	Production Release. Was Iss PT1

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

TITLE:
WIRING DIAGRAM
FINGER BYPASS SECTION
CAT007

DRAWN	CHECKED	APPROVED
D.Jackson	(D.H.)	(D.H.)
DATE 26/9/01	DATE 26/9/01	DATE 26/9/01

DRAWING No. WD 08775 | ISSUE A | REVISION



ISSUE	REVISION	DATE	CHANGES
A		26.9.01	Production Release. Was Iss PT4

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

TITLE:
WIRING DIAGRAM
MOTOR SECTION
CAT007

DRAWN	CHECKED	APPROVED
D.Jackson	(D.H.)	(D.H.)
DATE 26.9.01	DATE 26.9.01	DATE 26.9.01

DRAWING No. WD 08774 | ISSUE A | REVISION

APPENDIX C LINK SETTINGS

Refer to Circuit Diagram *CD85644.*

LK1-3: These set the master MPU Clock Speed as follows:

LK3	LK2	LK1	
x	x	x	62.5 KHz
x	x	√	125 KHz
x	√	x	250 KHz
x	√	√	500 KHz
√	x	x	1 MHz
√	x	√	2 MHz
√	√	x	4 MHz (Use this setting)
√	√	√	8 MHz

LK4a-h: These set the tool address as follows:

LK4h	LK4g	LK4f	LK4e	LK4d	LK4c	LK4b	LK4a
Not used	A6(MSB)	A5	A4	A3	A2	A1	A0(LSB)

The links are active-low. Hence, to set a bit to 0, the link should be made.

e.g. To set address 0x59h, first convert this to binary:

5				9			
0	1	0	1	1	0	0	1
-	A6	A5	A4	A3	A2	A1	A0

This indicates that bits A1, A2 and A5 need to be 0.

Hence links 4b, 4c and 4f should be made, i.e. logic 0.

Links 4a, 4d, 4e and 4g should be left un-made, i.e. logic 1.

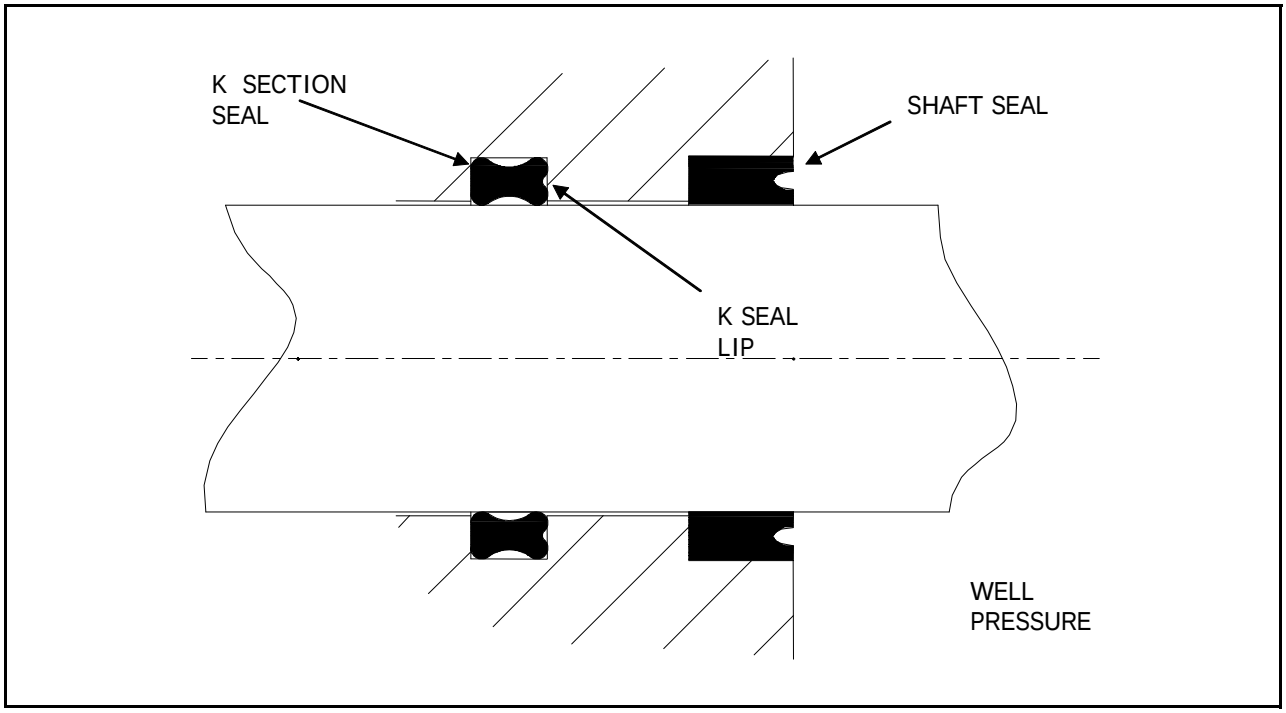
Link 5: This should be set to position 1-2

Link 6: This should be set to position 1-2

Link 7: This should be set to position 2-3

APPENDIX D O-RING CHECK SHEET

O-ring	Part no	Material	Hardness	Qty	Fitted to
1	99908	Isolast J9509	90	2	Central Shaft (under sensor head) - must be specified type
2	99026	Viton	90	2	Under Split Nuts
3	99028	Viton	90	2	Motor Sub
4	95124	Viton	75	1	Motor Electrical Chassis
5	95217	Viton	75	1	Lower thread Protector
6	95122	Viton	73	1	Electronics Chassis
7	99012	Viton	90	2	Central Shaft under Secondary Pressure barrier
8	99027	Viton	90	2	Secondary Pressure Barrier
9	99115	Viton	90	2	6 pin hermetic connector
10	99930	Viton	90	2	K section seal - Central Shaft and Motor Sub
11	99124	Viton	90	2	Sensor Head
12	99125	Viton	90	2	Seal Sub
13	99217	Viton	90	2	Top of Electronics Pressure Housing
14	91267	-	-	2	Variseal - Central Shaft and Motor Sub



APPENDIX E VITON APPLICATION

All soldered joints around the sensors, including those that secure the Sensor Tube to the glands, should be covered with Viton paint. For sensors in which metalised ceramic is soldered to a metal part, this involves 4 soldered joints. Two of these are at each end of the ceramic tube; one joins the Sensor Tube to the Sensor, and the other secures the Sensor Tube to the Gland.

These notes assume that there is no Viton already present. If old Viton is present, then this should be removed before new Viton is applied. i.e. New Viton should not be painted over old Viton.

The application of Viton paint produces undesirable vapours and hence, must be done in a well ventilated area.

1 Clean the soldered joint and surrounding area with iso-propanol. Allow sufficient time for the iso-propanol to dry

2 Using a small paintbrush (such as that used for model painting), apply a coat of Viton Primer (Sondex pt/no. 91281) to the soldered joints. Allow the primer to dry for 30 minutes

3 Prepare the Viton Paint (or PR-1791 Class A High Temperature Sealant), by mixing the Base Paint and Accelerator according to a 20:1 ratio.

4 When the primer is dry, carefully paint the Viton onto the soldered joints, ensuring that no solder is exposed.

5 If any epoxy needs applying this can be done now. Otherwise allow the Viton to set for 48 hours at room temperature, followed by 24 hours at 50°C.

APPENDIX F EPOXY APPLICATION

Epoxy should be applied around the entire base of the glands. This would normally only need doing if a sensor had been replaced. Note that the epoxy is not the primary seal around the glands. This is accomplished by the olives inside the sensor head. However, if placed around the entire base of the glands, it will provide additional sealing ability, and also acts as a form of threadlock. **If a sensor has been replaced, the tool should be pressure tested before the epoxy is applied**.

Note that the best way to remove epoxy is by applying the tip of a soldering iron to it.

1 Using the special-purpose syringe and mixer tube, apply a small portion of Duralco 4525N epoxy completely around the base of each gland. This is just a security measure to aid with the pressure sealing and to prevent the gland from coming loose.

2 Cure the epoxy for 24 hours at room temperature.

Note that if epoxy is to be applied at the same time as the Viton, the curing times for Viton should be followed because this will also cure the epoxy.