CFBE05

Document: MN-CFBE05-D

Spinner Flowmeter Electronics

SPINNER FLOWMETER ELECTRONICS

$1^{11}/_{16}$", ULTRAWIRE™ TELEMETRY

Operational & Maintenance Manual

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0 ABOUT THIS MANUAL

0.1 MANUAL HISTORY

Date	Issue	Description	Auth	Chk	App
23/02/05	B	Calibration methods added & Drawing update according to ECR 1537.	FV	SA	RH
02/10/06	C	Drawing update: ECR2733, 2908, 2904, 3141 & 2853. ESD added to Chapter 2.	FV	SA	RH
27/02/07	D	Drawing update: ECR3823, 3920, 3962.	FV	FV	RH

0.2 UPDATES TO BE USED WITH THIS MANUAL

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

0.3 TECHNICAL HELP

For further technical help, contact Sondex as follows:

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0.4 FEEDBACK

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

Thank You.

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

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

1 DESCRIPTION

Both Caged Fullbore Flowmeters and Continuous Flowmeter Spinners comprise of three units:

1 Electronics Section (this manual):

- Pressure Housing.
- Ultrawire telemetry circuit board.
- Pressure tight Upper Head fitted with monoconductor pin.
- Lower End fitted with 8 pin internal connector.

2 Sensor Section (this manual).

3 Spinner Section (see Spinner Mechanical Manual (*Section 1.1*)).

This Manual discusses the operation and maintenance of the Ultrawire™ Electronics. The Electronics is used to translate the mechanical data to the software and will be sent to the surface for data processing.

For Specifications of the Spinner used, refer to the relevant Mechanical Manual, see *Section 1.1*.

1.1 TOOL COMBINATIONS

The CFBE05 can be used in combination with the following Mechanical Assemblies:

- Caged Fullbore Flowmeters (CFB): Refer to *MN-CFBM*.
- Continuous Flowmeter Spinner (CFS): Refer to *MN-CFSM*.

Throughout this manual, references are made to mechanical assembly drawings. Refer to the relevant manual as mentioned in this section. All Mechanical Assembly drawings can be found in Appendix B of the respective manual.

1.2 SPECIFICATION (ELECTRONICS ONLY)

Parameter	Specification	Remarks
Operating Voltage:		
- Nominal	+18V DC	
- Range	+13 to +23 V DC	
- Absolute Maximum	+24V DC	
Current consumption @18V	10mA	

2 SAFETY

2.1 GENERAL

Warning!

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

2.2 TOOL SPECIFIC

Caution!

When a CFBM is attached, take care when opening the arms, as the the arms act as springs when opened. The arms may open rapidly due to the spring force without warning.

2.3 LUBRICATION

High Temperature Grease

A High Temperature Grease (Castrol Spheerol L-EP2 or Castrol LMX) is used to fill the tool during maintenance. Contact with skin or eyes can be harmful.
For more details refer to the Material Safety Data Sheet for Castrol Spheerol L-EP2 or Castrol LMX respectively.

Liquid O-ring

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

2.4 ELECTRO STATIC DISCHARGE

Caution!

Electro Static Discharge (ESD)

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

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

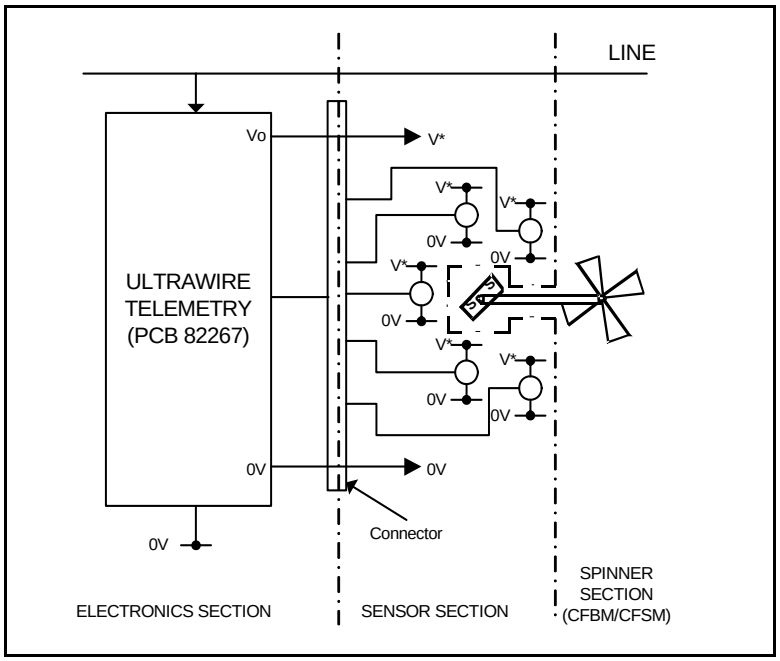
- Always ensure proper ESD precautions are taken when handling electronic parts that are ESD sensitive during maintenance.
- Avoid touching the tool electronics, unless stated otherwise in this manual.

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

3 THEORY OF OPERATION

Note: See the relevant mechanical manual for Theory of Operation of the Spinner and Sensor Section, see *Section 1.1*.

3.1 BLOCK DIAGRAM



3.2 ELECTRONICS DESCRIPTION

Tool power and Ultrawire telemetry are present on the top single connector pin.

The Hall Effect devices are not powered continuously due to their high current consumption. The FPGA Logic uses the status of the switches to determine the pulse frequency and rotation direction. Every cycle of the pulse frequency is stored in the FPGA logic and is read out over the Ultrawire toolbus in response to requests from the Telemetry Controller, e.g. MPL & XTU.

Link options determine the tool address. Various commands are supported in the protocol.

3.3 CALIBRATION THEORY

3.3.1 SPINNER ROTATION

The rotational velocity of the spinner is measured to provide the flow velocity.

The rotation frequency of a real spinner is given by *Equation 3.1* below. This assumes that the friction (i.e. around the bearings) has no viscous component and that the viscous effect is to slow fluid moving along the blade face. This equation only applies to a rotating spinner; it does not apply to a stationary spinner in a very slow flow:

$$f = aV - \left(\frac{b}{\rho}\right)V - c\sqrt{\frac{V\mu}{\rho}} \qquad \textbf{Equation 3.1}$$

where: f is the frequency of rotation of the spinner cps (Hz.)
V is the fluid velocity.
a is a constant depending on blade pitch.
b is a constant depending on ratio of friction to blade moment of inertia.
c is a constant depending on the skin friction of fluids moving over the blade surface.
ρ is fluid density.
μ is fluid viscosity.

Neglecting friction and inertia terms:

$$f = aV \qquad \textbf{Equation 3.2}$$

3.3.2 FLUID VELOCITY DETERMINATION

The operating procedure in the well allows the flowmeter to be calibrated by recording several passes at different logging speeds, see *Section 4.4* for information on tool calibration. Plots of logging speed versus tool reading enable the apparent fluid velocity (V_{app}) to be determined.

A small CFS spinner in its shroud will rotate slower, and will therefore show a lower apparent fluid velocity, than the true fluid velocity due to bearing friction and spinner pitch. These effects are taken into account by calibrating the tool using multiple logging speed passes.

The more linear the tool response, the more accurate the velocity determination. Non-linearity of *Equation 3.1*, for example bearing friction and viscosity, can be accounted for in the above plots. The plots also compensate for the alteration to flow velocity due to the insertion of the toolstring. Sondex flowmeters are linear over their full operating range under normal well conditions. Sensitivity of CFS and CFB tools is often less in downflow due to the shielding effect of the toolstring.

The CFB spinner tool is designed primarily for logging low fluid velocities in large diameter pipe. At high fluid velocities past the CFB spinner, the slope of the spinner response tends to be less. For best accuracy the fluid velocity should not be much larger than the cable speed with which the CFB spinner can be logged.

In fluid velocities much higher than possible cable velocity calibration rates, a CFS should be used to maintain accuracy of fluid velocity determination.

3.3.3 TOTAL FLOWRATE DETERMINATION

The velocity of fluids is largest at the centre of the pipe and varies to zero at the pipe wall. Spinner flowmeters mainly read a fluid velocity close to that of the centre. The true average fluid velocity (V_t) is therefore somewhat less than that indicated by the spinner flowmeter (V_{app}) and requires correction. This correction factor is a function of the spinner blade diameter with respect to the inside diameter of the pipe and the Reynolds number of the flow. **Typical approximate** corrections necessary to determine true average flow velocity (V_t) in turbulent flow from the velocity measured by the spinner are:

$$\text{CFS: } V_t = V_{app} \times 0.85 \qquad \textbf{Equation 3.3}$$

$$\text{CFB: } V_t = V_{app} \times 0.9 \qquad \textbf{Equation 3.4}$$

Total flowrate can be directly calculated by multiplying the flowrate by the casing internal cross-sectional area (and a scaling factor). The following converts directly to barrels per day (bpd).[1]

$$\text{Total Flowrate (bpd)} = 1.4 \times V_t(\text{ft/min}) \times (\text{casing I.D. (in)})^2 \qquad \textbf{Equation 3.5}$$

3.3.4 TYPICAL APPROXIMATE SPINNER ROTATION RATES

Note: The figures shown in the table below are to be used to derive the *approximate* spinner rotation rate for a given fluid velocity, or to derive the *approximate* fluid velocity for a given spinner response. *Accurate* fluid flowrate can only be derived by multipass calibration of the spinner in the flow downhole.

Spinner Type	Design pitch [in/rev]	Flow loop slope [rps/fpm]	Nominal Slope	
			[fpm/rps]	[rps/fpm]
CFB flow up		0.076	13.2	0.076
CFB flow down		0.072	13.9	0.072
CFS	4		20.0	0.050

1. For a more detailed discussion, see “Cased-hole Log Analysis and Reservoir Performance Monitoring”, R.M. Bateman, 1984. (ISBN 90-277-1922-5).

4 OPERATING PROCEDURE

4.1 PRE-LOGGING CHECKS

Note: Oil leaks out during logging to lubricate the bearings. This chamber must be filled before every logging operation. A low viscosity oil ensures minimum drag, but if the viscosity is too low, oil will leak out too quickly.

4.1.1 OIL FILLING

Ref.: CFBE General Assembly *09461*
CFB/CFS Mechanical Section (see *Section 1.1*)

Note: All item numbers **without** a reference to a drawing refer to the mechanical assembly drawings. Refer to the relevant Mechanical Maintenance & Operations manual.

Oil Filling is essential before logging to ensure bearing lubrication. The choice of oil depends on the expected operating temperature.

Below 20°C	Use WD-40®.
Between 20°C - 100ºC	Use a light lubricating oil or kerosene with a little oil dissolved in it.
Above 100°C	A light engine oil may be used.

1 If the bearings do not rotate freely, they must be replaced as described in the mechanical manual. See *Section 1.1* for the relevant mechanical manual.

2 Separate the Spinner Mechanics from the Sensor Section (item 3, 09461) and Electronics (item 2, 09461) by lifting the bent end of the Locking Spring (item 6, 09461) on the Sensor Assembly to unscrew the ring, which will release the Sensor body.

Note: Take care not to damage the Magnet Assembly (item 21) or Shaft (item 9) when pulling off the Sensor body. It is not necessary to separate the Electronics Housing (item 2, 09461) from the Upper Body of the Sensor Section (item 3, 09461).

3 Check that the O-rings (item 7, 8 & 9, 09461) are clean and greased. Replace if damaged.

4 Holding the electronics section (item 2, 09461) vertically and upside down, fill the recess inside the sensor assembly with oil.

5 Continue holding vertically, take the spinner body assembly and screw it into Sensor Section (item 3, 09461). Oil will be forced along the spinner shaft and past the bearings.

6 The filled tool can now be connected to the tool string.

Gravity and thermal expansion will assist the oil flow while logging until it is exhausted.

4.1.2 Other Mechanical Checks

Ref.: Electronics Assembly *10504*
CFBE General Assembly *09461*

1 Clean and grease upper O-ring seals (item 9, 09461). Change Pressure Isolation Head O-ring (ref 95211, 10504) if the tool experiences H_2S or temperatures equal or higher than 150°C (300°F).

2 Clean the tool thoroughly with diesel to remove wax, scale or sand, which may impair proper functioning of the tool. Flush the bearings in the sensor section.

3 Ensure the opening and closing section is lubricated.

4 Check the mechanical functioning of the tool:

- Blow the spinner in both directions to ensure the spinner runs smooth and is balanced.
- Open the assembly slowly and ansure the tool opens smoothly.
- Check that the spinner does not stop suddenly, which would indicate the presence of dirt in one of the bearings.
- With the tool horizontal, check that the spinner is balanced.
- Check that the axis of rotation does not move, which would indicate a bent shaft.

4.1.3 Electrical Checks

Ref.: Ultrawire Electronics *80292*

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

2 Using a multimeter, measure the Pin to housing resistance. The reading should be:

Pin +ve 3-4MΩ. Depends on meter.

4.1.4 Operating Checks

The flowmeter, once connected to a spinner mechanical assembly, must be electrically connected to a toolstring controller, e.g. MPL or XTU, and to a data acquisition or logging system, e.g. MEMLOG or MIDAS.

1 No counts should be observed if the spinner is not rotating.

2 Counts should occur at the rate of 10 counts per revolution when rotating.

Check both *forward* and *reverse* direction of rotation and make sure decoding by the data acquisition system is correct.

Note: Bottom tools (including CFBE05) contain an Ultrawire telemetry terminator. Flowmeter electronics from mid-toolstring spinners, such as ILS, do not contain the terminator and should thus not be interchanged.

4.2 CONNECTING TO TOOLSTRING

The electronics must be mounted to a spinner mechanical assembly. The upper tool joint seal surface should be clean, undamaged and lightly greased.

CFB and CFS flowmeters must be placed at the lower end of the toolstring, containing a telemetry controller. There is no lower tool joint, hence nothing can be fitted below.

A centraliser is desirable higher up the string to prevent tilting. This applies to all spinner flowmeters including the CFB even though the CFB tool incorporates a centraliser, as its arms will not support the weight of a full production logging tool.

For use in deviated wells, enough centralisers should be used, so that they can lift the toolstring from a horizontal surface in air. If length permits, it is preferable to use more standard (25lb ea.) strength centralisers rather than a few strongly (40lb ea.) centred ones.

4.3 LOGGING

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

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

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

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

4.4 CALIBRATION

Calibration data is not supplied with the tool as it is best performed in the well. Calibration is a standard procedure for flowmeters of this type. There is little variation between Sondex tools of the same type.

Log data must be obtained over several passes in both up and down directions at different speeds during every logging operation. More than one set of data should be collected, for example before and after a survey. This enables a cross plot of *spinner rps* against *speed* to be made at any depth. From this the apparent flow velocity (V_{app}) can be determined (see *Section 3.3*).

Calibration data may be transferred to other logging runs, but this is not recommended since the response curve of *Equation 3.1* may have altered due to a change in fluid properties or bearing friction.

Plots must be made of tool reading against cable (tool) velocity.

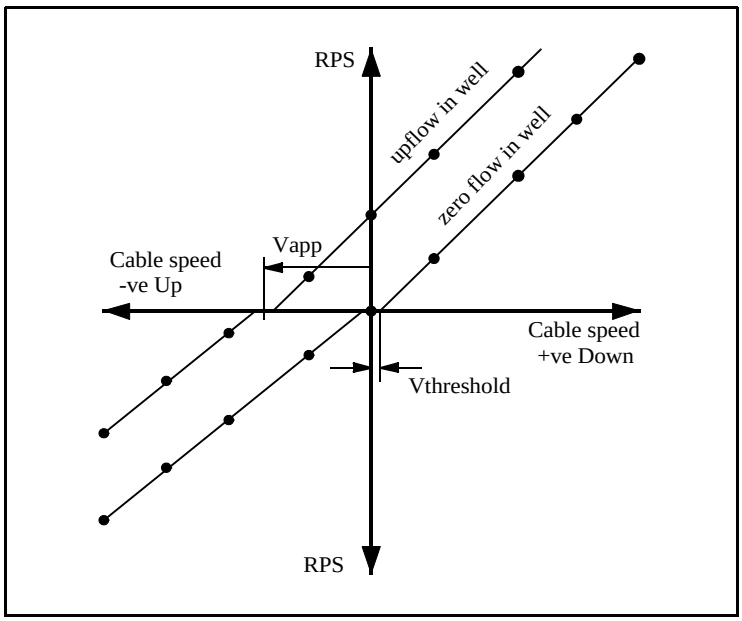


Figure 4.1 Flowmeter Fluid Velocity Response

Note: Sensitivity to flow in one direction or the other may be reduced by the shielding effect of the toolstring above or below the spinner.

Flow in the well shifts the zero rotation point along the cable velocity axis by the apparent average flow in the centre of the well V_{app}. Note that no calibration other than this crossplot is needed.

Note: In high flowrate wells it may not be possible to apply sufficient upward tool velocity to produce a zero tool reading (spinner stationary). In this case there are 2 options:

1 Since the tool response (*Figure 4.1*) is closely linear and any zero offset will be negligible, extend the best straight line through the plotted readings until it cuts the cable speed axis. The cable speed reading here will be V_{app}.

2 Refer to a calibration data set run with the well shut in. This will include readings close to zero. There may be a lower section of the same well where determination of the threshold is possible.

Note: If running a CFB, run a CFS instead of the CFB during calibration if possible. These tools require higher fluid velocity to turn the spinner, but the response curves are more reliably extrapolated over a longer velocity range.

4.5 POST-LOGGING DISASSEMBLY

4.5.1 GENERAL

- Clean the tool before the toolstring is disassembled.
- Ensure that well fluid does not reach the upper electrical connector.
- Refit upper thread protector.

4.5.2 FLUSHING

Bearings should be flushed with a solvent after logging. Flushing the bearings is possible prior to checking tool function. **However, Sondex recommends to replace the bearings before the next logging job.** It is not worth risking the quality of a survey for such an easy and inexpensive task. The flushing procedure is given below. See mechanical manual for removal of old bearings (see *Section 1.1*).

Ref.: CFBE General Assembly *09461*
CFB/CFS Spinner Mechanical Section (see *Section 1.1*)

Note: Items, which **do not** contain a reference to a drawing number, refer to the mechanical assembly drawing. Refer to the relevant Mechanical Maintenance manual.

It is not necessary to separate the Electronics Housing and Upper Body of the Sensor Section.

1 Lift the bent end of the Locking Spring on the Housing Sensor (item 3, 09461) to unscrew the ring (item 2) which will release the Sensor body. Take care when pulling off the Sensor body so as not to damage the Magnet Assembly (item 21) or Shaft (item 9).

2 Hold the Sensor body vertically and pour petrol or other solvent down the shaft past the bearings. Ensure that the spinner rotates freely.

3 Allow solvent to evaporate and lubricate bearings with a light oil[1] or complete the oil filling procedure as described in *Section 4.1.1*.

4 Grease O-rings; 2 O-rings on the Sensor assembly and 1 O-ring on the Mechanical Assembly (item 39) before reassembling and storing the tool.

5 Before transportation, remove, clean and lubricate the sensor chamber of the tool.

4.6 TRANSPORTATION, HANDLING & STORAGE

The tool should be stored with the bearings lubricated and water tight end caps. It should not be subjected to physical shock.

1. Do not use WD-40® as a lubricant.

5 MECHANICAL DESCRIPTION

Ref.: CFBE General Assembly *09461*
Electronics Chassis, Memory *10504*

5.1 DESCRIPTION

Standard Caged FullBore (CFB) flowmeters and Continuous Flowmeter Spinners comprise three main units:

Electronics Section (this Manual)

- Pressure Housing.
- Ultrawire Telemetry Board.
- Pressure tight Upper Head fitted with monoconductor pin.
- Lower End fitted with 8 pin internal connector.

Sensor Section (this Manual)

- Sensor Body containing Sensor Assembly and 8 pin internal connector.
- Locking Spring to prevent unscrewing from the Spinner Section.

Spinner Section (Mechanical Manual (see *Section 1.1*))

- Centraliser mechanism including Arms, Main Shaft, Spring Housing and Bottom Nose.
- Shaft assembly comprising Shaft, Magnet Assembly and Bearings.
- Spinner Blade Assembly.

5.2 DISASSEMBLY

1 Unscrew the Pressure Housing (item 1, 09461) from the Electronic Cartridge (item 2, 09461).

2 The Electronic Cartridge (item 2, 09461) will still be fixed to the Sensor Housing (item 3, 09461). To remove it, screw in the three grub screws (item 4, 10504). Do not force the screws in too far or the 8-way connector may be damaged.

3 If required, remove 4 off screws (item 6, 10504) and remove the larger upper cover (item 3, 10504). Note that the smaller lower cover is normally not removed.

4 The sensor (item 4, 09461) can be removed from the sensor housing (item 3, 09461) with a hammer and punch onto the pin. DO NOT push hard or punch the 8 pin connector. The sensor should not be dismantled further and should be replaced if faulty.

5.3 REASSEMBLY

1 The sensor pin on the Hall Effect Sensor Assembly (item 4, 09461) must be precisely lined up with its locating hole in the Sensor Housing (item 3, 09461). Several attempts may be required. Check that the O-rings (item 9, 09461) are not damaged when fitted in the housing (item 3, 09461).

2 Locate the Electronics Assembly (item 2, 09461) with the Sensor Section (item 3, 09461), taking care not to damage the connectors.

3 Back out the three grub screws (items 4, 10504).

4 Apply silicone grease around the O-ring seals on the Sensor Section (item 3, 09461) and the Electronics Assembly (item 2, 09461).

5 Locate and screw Pressure Housing (item 1, 09461) tightly over the Electronics Assembly.

6 ELECTRICAL DESCRIPTION

6.1 TELEMETRY CIRCUIT BOARD

Ref.: Ultrawire Circuit Diagram (PCB82267) *CD82261*

The Ultrawire™ Tool Telemetry Board is based on a common PCB (82260) which is populated and programmed according to the tool in which it is fitted. The main functional blocks of the circuit are the power supply, the Ultrawire™ interface (together with its drivers and receivers) and the sensor interface.

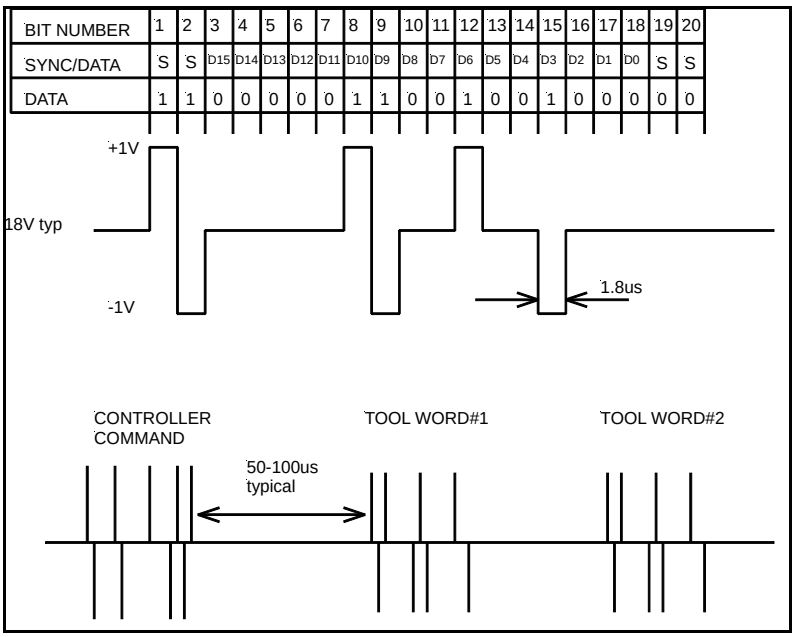
Control is implemented by a PIC microcontroller in conjunction with FPGA logic. The code in the PIC differs according to the tool.

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

The Ultrawire™ line carries 18V DC (nom). Power is supplied to the SMPS via Q7, which with associated components generates local power rails at 12V and 5V.

The tool is protected by fuse (F1), which in conjunction with diode (D1) gives overvoltage and reverse polarity protection.

The telemetry is modulated onto the line as 1V AMI (alternate mark inversion) pulses at 500kbaud, see below a typical tool response.



The Ultrawire™ telemetry is a master slave protocol. The controller, which is always the master, sends a command to the tool. This may be a global command (to all tools) or a tool specific command which contains the address of the target tool. Tool specific commands are acknowledged by the tool, global commands are executed but do not generate a response.

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

When the controller is in logging mode, it will periodically send a global sample command to all the tools and then poll each tool individually for data. The sample command causes the latest count to be frozen in a shadow register, and this count is then passed to the controller in response to the data request.

Electrically, the telemetry is a.c. coupled from the line to the drivers and receivers by capacitor (C7). The received data is removed from the line by a comparator (U4), and passed to the FPGA logic, which validates the address. The command is interpreted by the PIC which if necessary generates the response packet and passes it to the FPGA logic for placement on the line.

6.2 FLOW SENSOR

Ref.: Flowmeter Electronics Assembly *09461*

The Flow Sensor (item 4) comprises 5 Hall effect sensors, arranged in a cicle on a Titanium carrier, which acts as a pressure barrier. Two magnets, on the other side of this barrier, rotate with the spinner shaft. This results in 10 pulses per revolution.

To reduce power consumption, the sensors are powered with 5V for 7μs every 250μs. If a south pole of a magnet is close to a Hall sensor, its output will be 0V at the end of the 7μs settling time when the electronics takes the sample.

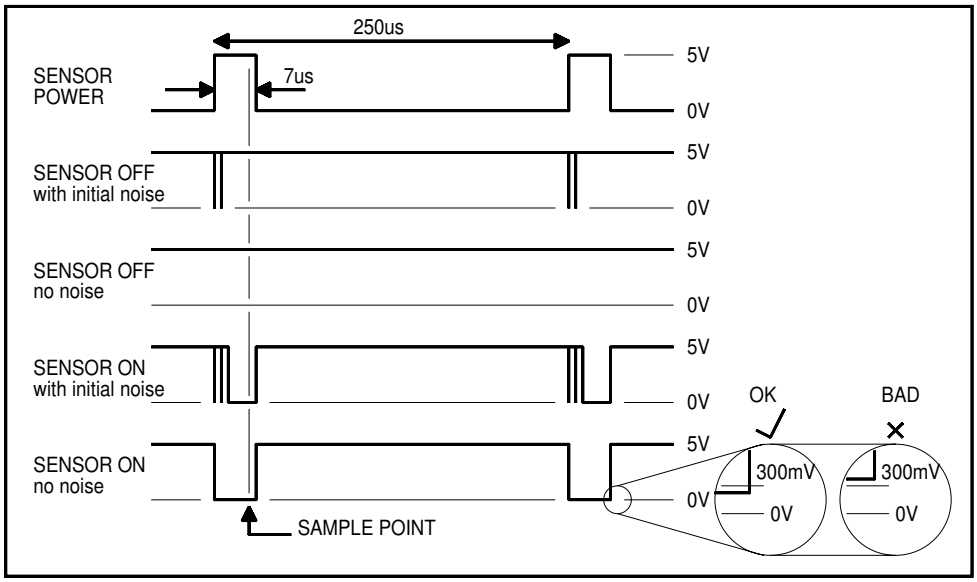


Figure 6.1 Flow Sensor

7 EXTENDED CHECKS

7.1 PREVENTATIVE MAINTENANCE

7.1.1 GREASE & LUBRICANTS

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

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

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

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

Sondex does not recommend Copper loaded greases since some types can cause electrical leaks. Some types for grease are not suitable for use on O-rings. Silicone grease may be used on O-rings, but must be kept clear of threads, especially stainless steel to stainless steel.

Cavities, e.g. spring housings, should be filled with a suitable heavy high melting point grease, such as Castrol Spheerol L-EP2 or LMX.

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

7.1.2 MECHANICAL

Ref.: Electronics Chassis, Memory *10504*

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

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

3 Check for:

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

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

- Electrical components shorting to chassis.
- Heat or chemical damage (discoloured components).
- Incorrect thread grease or excessive quantity, see *Section 7.1.1*.
- Circuit board components should not touch the covers. Check for damage to the insulating tape, replace if necessary.

4 Check connectors for cleanliness and loose/bent pins before replacing. Check the Top Connector. The Sondex Pin should be 22 ±1mm recessed into the housing.

5 Remove dirt and debris with a brush, solvent and compressed air.

6 Check all fixings for tightness.

7 Check 3 grub screws (item 4, 10504) are tight.

7.1.3 ELECTRICAL

Ref.: Ultrawire Electronics *80292*

1 Tool current 10mA @ 18V.

2 Connect to Logging System and check for correct data. Apply some gentle vibration, rotation and invert tool to expose potential failure. Check for 10 pulses per revolution (2 per sensor), and check for correct direction indication. Fault causes are:

- Damaged magnets.
- Incorrectly fitted magnet holder.
- Excessive shaft float (see relevant Mechanical manual (see *Section 1.1*)).
- Faulty sensor.

Note: Three of the five sensors are used for direction so a failure on one of the other two would only cause pulses per rev to drop to 8.

3 With an oscilloscope, check line telemetry from tool (+1V and -1V, 2μs pulses). Make sure to check tool pulses (not those from the controller which occur first). Pulses should have no ringing.

4 Check sensor output on pins 1-5 on PCB82267. When ON, sensor output at the sample point should be between 0 and 300mV.

7.1.4 AGEING OF ELECTRONICS

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

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

7.1.5 HEAT TESTING ABOVE 150°C

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

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

7.2 EXTRAORDINARY MAINTENANCE

Ref.: CFBE General Assembly *09461*
Electronics Chassis, Memory *10504*

Checks may now be carried out on the Electronics, Pressure Housing and Sensor.

Electronics Section

1 Inspect the Upper Pressure Isolation Head plug (item 1, 10504) for damage and replace if necessary.

Note: The O-rings within the Pressure Isolation Head provide a pressure seal against fluids moving through the tool string from one tool to the next should the main housing seal fail at any one tool joint. **Refer to the Pressure Isolation Head Assemblies Manual *MN-PIH.***

2 Inspect the O-ring seal (item 7, 09461) for damage and replace it if necessary.

3 Ensure that the half shell screws are secure (item 3, 10504).

4 Ensure that the three grub screws (item 4, 10504) are fitted and screwed flush. **Do not force the screws in too far or the 8-way connector may be damaged.**

Pressure Housing

1 Clean the pressure seal surfaces at both ends of the Pressure Housing. Ensure housing is free from debris.

Sensor Section

1 Inspect the O-ring seals (item 8, 09461) for damage and replace if necessary.

2 If the tool has been exposed to H_2S gas or temperatures above 177°C, the internal O-rings (item 9, 09461) must be replaced.

Note: Several main parts of the Sensor Section are made from Al/Bronze and will change colour from bronze to black as a sulphide layer is created by H_2S gas. This layer should **not** be removed by polishing.

7.3 TROUBLESHOOTING

Refer to *Section 5.2* where necessary.

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

Initial inspection	Check for: • Damaged wires. • Damaged components. • Electrical components shorting to chassis. • Heat or chemical damage (discoloured components). • Incorrect thread grease or excessive quantity. Check all fixings are tight.
Excessive Current	Unplug electronics and disconnect wires to isolate fault to: • Upper head isolation assembly. • Sensor. • 82267 circuit. Apply Line signal or 18V direct to 82267 Line connection. Fault find or replace 82267 circuit. Upper Head, Sensor line wire and Sensor body lower connector may be tested to 250V relative to chassis to check for electrical leak **(LINE connection to 82267 circuit must be disconnected)**. Resistance should exceed 100MΩ. Upper Head may be dissassembled to locate fault.
Little or no Current	Check 18V Line voltage on 82267 and 0V wire connects to chassis. Fault find or replace 82267 circuit.
No telemetry reply	Check 0V, 5V and 12V on 82267. On PCB82267, check P6 for 4MHz >3V clock. Replace X1 if faulty. Reduce R14 value if clock <3V amplitude. Check Line for +1V and -1V, 2μs pulses from Controller and similar pulses from tool. Pulses should have no ringing. If ringing, check connection to 82Ω terminator on PCB80293. Logic pulses should be present on 82267 U1 pin 1. If no tool response words on Line, fault find or replace 82267 circuit.
Incorrect Flow/ Direction data	Check power and 0V to sensor and check outputs. Check for 10 pulses per revolution (2 per sensor).
Faulty Sensor	Check for a damaged 8 pin connector. Unscrew the metal tube to expose the 8 pin connector. Check for damaged wires. Otherwise the sensor is not user serviceable and should be replaced complete.

APPENDIX A EQUIPMENT & RECOMMENDED SPARES

Item	Part No	Description	Qty	Remarks
1	CFBE05	Flowmeter Electronics Section, Ultrawire, $1^{11}/_{16}$″	1	
2		Mechanical/Sensor Flowmeter Section	1	See *Section 1.1*.

A.4 ANCILLARY EQUIPMENT

Item	Part No	Description	Qty	Remarks
None Required.				

A.5 MAINTENANCE EQUIPMENT

Item	Part No	Description	Qty	Remarks
1	*91050*	Toolkit for all $1^{11}/_{16}$″ tools	1	
2	LOR101	Grease for O-rings and threads	AR	5oz pot.
3	LOR101L	Grease for O-rings and threads	AR	16oz pot.

A.6 RECOMMENDED SPARES

Item	Part No	Description	Qty	Remarks
1	*KITB-CFBE*	Basic Spares Kit	1	To support 1 run.
2	*KITR-CFBE*	Recommended Spares Kit	1	To support 25 runs.

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

Note: See manual *MN-PIH* for tools required for Pressure Isolation Head Assemblies.

PARTS LISTING

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

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

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

PARTS LIST

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

(AR = As Required)

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
kitb-cfbe 1 11/16	A		DMO	RLH	RLH
			Date: 03/05/2002	Date: 07/05/2002	Date: 07/05/2002

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

CHANGE HISTORY					RELATED DOCUMENTS		
Iss	*Date*	*Remarks*	*Chkd*	*Appr*	*# Documents*	*Issue*	*Notes*
A	07/05/2002	Initial Release	RLH	RLH			

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	99023	-	O Ring Viton 90 Type 023		2	ea	
002	99124	-	O Ring Viton 90 Type 124		2	ea	

(AR = As Required)

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
kitr-cfbe 1 11/16	A		DMO	RLH	RLH
			Date: 03/05/2002	Date: 07/05/2002	Date: 07/05/2002

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

CHANGE HISTORY					RELATED DOCUMENTS		
Iss	*Date*	*Remarks*	*Chkd*	*Appr*	*# Documents*	*Issue*	*Notes*
A	07/05/2002	Initial Release	RLH	RLH			

PARTS LIST

Item	*Part No.*	*Issue*	*Description*	*Component Value*	*Qty*	*Units*	*Remarks*
001	01028	C	Assy, Banana Pin (4mm)		1	ea	
002	01029	-	Screw, Csk Hd(Slotted), M3 x 06mm Lg, St/Steel		2	ea	
003	01082	A	Screw Grub Skt Hd M6x5mm Lg SS MOD		3	ea	
004	01849	A	Spring, Locking, 1 11/16 Inch Tools		1	ea	
005	95211	-	O Ring Viton 75 Type 211		5	ea	
006	99023	-	O Ring Viton 90 Type 023		50	ea	
007	99124	-	O Ring Viton 90 Type 124		50	ea	

(AR = As Required)

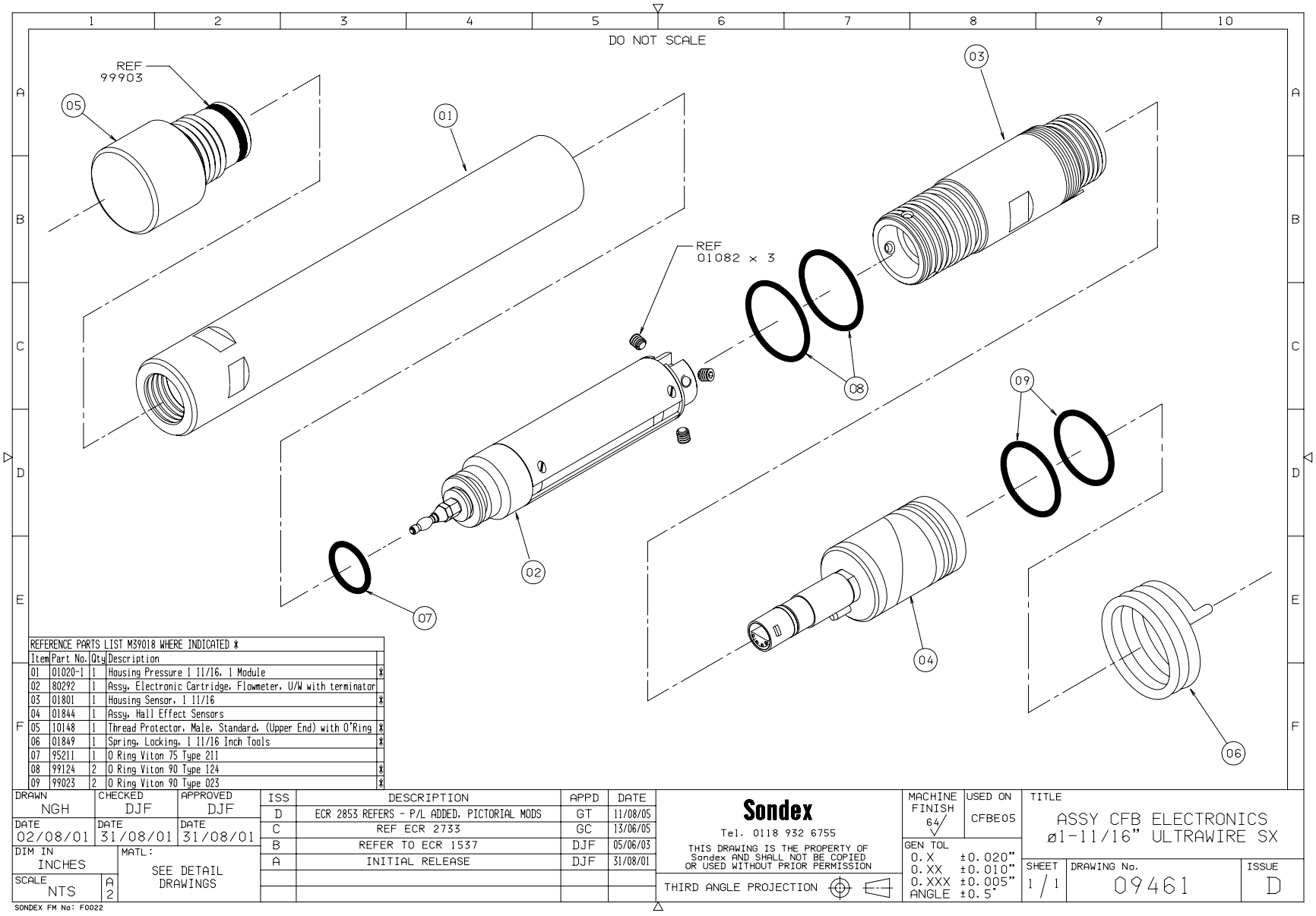
APPENDIX B DRAWINGS & PARTS LISTS

B.7 MECHANICAL DRAWINGS

Description	Drawing	Parts List
Flowmeter Electronics Assembly $1^{11}/_{16}$″ (Ultrawire)	*09461-D*	See Drawing.
Assy Electronics Cartridge, Ultrawire	*80292-B*	*80292-D*
Electronics Chassis Assembly (Memory)	*10504-F*	See Drawing.

B.8 ELECTRONIC DIAGRAMS

Description	Drawing	Parts List
Bottom Flowmeter Electronics, Ultrawire	Wiring Diagram	*WD-80292-D*
PSU/Driver Board, Ultrawire (PCB82267)	Circuit Diagram	*CD-82261-F00x*
Line Terminator Board	Circuit Diagram	*CD-80293-A*



REFERENCE PARTS LIST M39018 WHERE INDICATED *

Item	Part No.	Qty	Description	
01	01020-1	1	Housing Pressure 1 11/16, 1 Module	*
02	80292	1	Assy, Electronic Cartridge, Flowmeter, U/W with terminator	
03	01801	1	Housing Sensor, 1 11/16	*
04	01844	1	Assy, Hall Effect Sensors	
05	10148	1	Thread Protector, Male, Standard, (Upper End) with O'Ring	*
06	01849	1	Spring, Locking, 1 11/16 Inch Tools	*
07	95211	1	O Ring Viton 75 Type 211	
08	99124	2	O Ring Viton 90 Type 124	*
09	99023	2	O Ring Viton 90 Type 023	*

DRAWN	CHECKED	APPROVED
NGH	DJF	DJF
DATE 02/08/01	DATE 31/08/01	DATE 31/08/01
DIM IN INCHES	MATL: SEE DETAIL DRAWINGS	
SCALE NTS	A2	

ISS	DESCRIPTION	APPD	DATE
D	ECR 2853 REFERS - P/L ADDED, PICTORIAL MODS	GT	11/08/05
C	REF ECR 2733	GC	13/06/05
B	REFER TO ECR 1537	DJF	05/06/03
A	INITIAL RELEASE	DJF	31/08/01

Sondex
Tel. 0118 932 6755

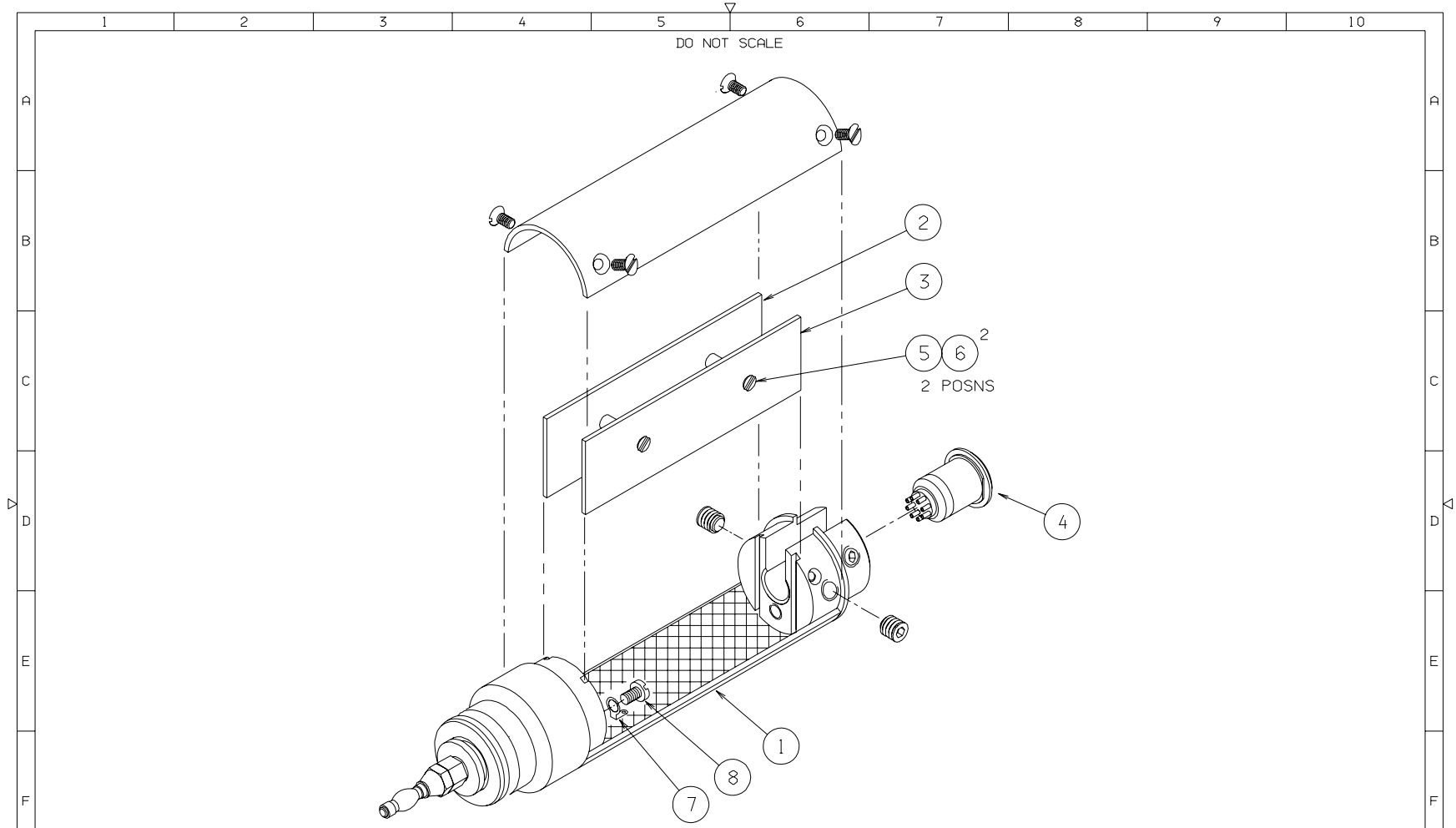
THIRD ANGLE PROJECTION

MACHINE FINISH 64	USED ON CFBE05
GEN TOL 0.X ±0.020" 0.XX ±0.010" 0.XXX ±0.005" ANGLE ±0.5°	

TITLE: ASSY CFB ELECTRONICS ø1-11/16" ULTRAWIRE SX

SHEET	DRAWING No.	ISSUE
1 / 1	09461	D

SONDEX FM No: F0022



DRAWN NGH	CHECKED AJB	APPROVED RH	ISS	DESCRIPTION	APPD	DATE	**Sondex** Tel. 0118 932 6755 THIS DRAWING IS THE PROPERTY OF Sondex AND SHALL NOT BE COPIED OR USED WITHOUT PRIOR PERMISSION THIRD ANGLE PROJECTION	USED ON DBT/ILS CFB/CFJ/CFS	TITLE ASSY - ELECTRONICS FLOWMETER - ULTRAWIRE
DATE 02/05/02	DATE 07/05/02	DATE 07/05/02	B	REFER TO ECR 1537	DJF	05/06/03		MACHINE FINISH 63	GEN TOL 0.X ±0.020" 0.XX ±0.010" 0.XXX ±0.005" ANGLE ±0.5°
DIM IN INCHES	MATL: SEE DETAIL DRAWINGS		A	INITIAL RELEASE	RH	07/05/02		SHEET 1/1	DRAWING No. 80292
SCALE 1:1	A3								ISSUE B

PARTS LISTING

Part:	Issue:		Drawn:	Checked:	Approved:
80292	D		NGH	AJB	RH
			Date: 02/05/2002	Date: 07/05/2002	Date: 07/05/2002

Description:
Assy, Electronic Cartridge, Flowmeter, U/W with terminator

CHANGE HISTORY

Iss	Date	Remarks	Chkd	Appr
A	07/05/2002	Initial Release	AB	RH
B	22/05/2003	Re: ECR 1537	DJF	DJF
C	16/06/2004	ECR1691.82267 was 82223.80293 was Iss A01,WD80292 was Iss A	PR	PR
D	26/07/2006	ECR3962 & ECR3981 Item 10 was 7/0.12	BET	VH

RELATED DOCUMENTS

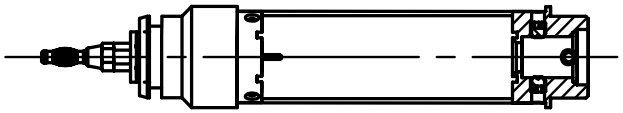
#	Documents	Issue	Notes
01	AD 80292	B	Assembly Drawing
02			
03	TP 80292	B	Test Procedures
04	TR 80292	C	Test Results
05	AI-80292	A	Assembly Instructions
06	AR-80292	A	Assembly Record

PARTS LIST

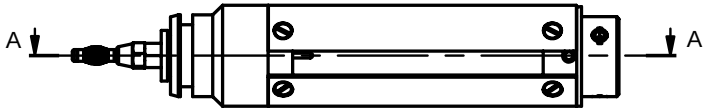
Item	Part No.	Issue	Description	Component Value	Qty	Units	Remarks
001	10504	E	Assy, Chassis, 1 Module, Memory, SX, Lemo (Mechanical)		1	ea	
002	82267	A	Assy, PCB, PSU & Telemetry, UW Single Flowmeter, Programmed		1	ea	
003	80293	E	Assy, PCB, Terminator (Ultrawire)		1	ea	
004	01132	B	Socket 8 Way Lemo MOD		1	ea	
005	01029	-	Screw, Csk Hd(Slotted), M3 x 06mm Lg, St/Steel		4	ea	
006	93261	A	Spacer Round M3 Thru 4.75mm OD x 12.7mm LG BNP		2	ea	
007	93097	-	Tag Solder M3		1	ea	
008	93048	-	Screw Pan Hd Sltd M3 x 6mm LG SS		1	ea	
009	W001-00104	-	Wire, PTFE, Type A, 300V 6A, 200C	7/0.2 Yellow		(AR)	
010	W001-00100	-	Wire, PTFE, Type A, 300V, 6A, 200C	7/0.2 Black		(AR)	
011	W001-00201	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Brown		(AR)	
012	W001-00202	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Red		(AR)	
013	W001-00203	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Orange		(AR)	
014	W001-00205	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Green		(AR)	
015	W001-00206	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Blue		(AR)	
016	W001-00207	-	Wire, PTFE, Type A, 300V, 3A, 200C	7/0.12 Violet		(AR)	
017	A006-0099C	-	Solder Wire, Alloy Sn99.3/Cu0.7, High Activity Rosin 309	Sldr Wire 99C Rosin		(AR)	
018	A004-00003	-	Sleeving Si Rubber 1mm Dia			(AR)	
019	A011-001m6	-	Heatshrink Sleeving, Polyvinylidene Fluoride, +175C	1.6mm Dia		(AR)	
900	WD-80292	D	Wiring Diagram			(AR)	

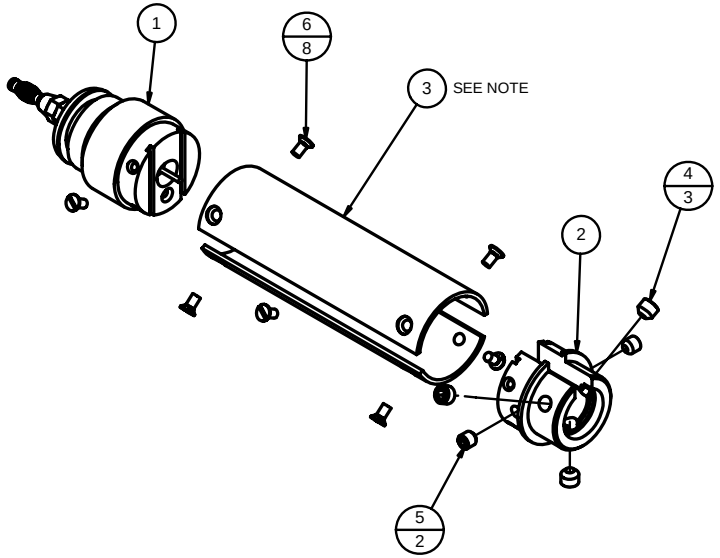
(AR = As Required)

DO NOT SCALE



SECTION A-A





ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	10537	ASSY ELECTRONICS BULKHEAD SX(ISOLATION) MEM
2	1	01021	Bulkhead, Electronics,$Lower, Standard (Lemo)
3	1	01015	Halfshells, Chassis & Cover, Electronics, 1 Module
4	3	01082	SCREW GRUB SKT HD M6 x 05mm LG SS
5	2	93011	SCREW GRUB SKT HD M5 x 05mm LG SS
6	8	01029	SCREW CSK HD SLOTTED M3 x 06mm LG SS
7	1	t004-008ap	tape tygaflor 208ap/03t 80 x 30mm

NOTE

1. APPLY TAPE (ITEM 7) TO INSIDE FACES OF HALFSHELLS (ITEM 3).

DRAWN: GC	CHECKED: GHT	APP'D: NGH	
DATE: 07/07/05	DATE: 07/07/05	DATE: 13/06/06	
DIM IN: INCHES	MATL: SEE DETAIL DRAWINGS		
SCALE: 1:1	A2	HEAT TREATMENT/CONDITION: NOT APPLICABLE	

ISS	DESCRIPTION	APPD	DATE
F	REDRAWN FROM HELIX	NGH	13/06/06

Sondex
Tel. 0118 932 6755

THIRD ANGLE PROJECTION

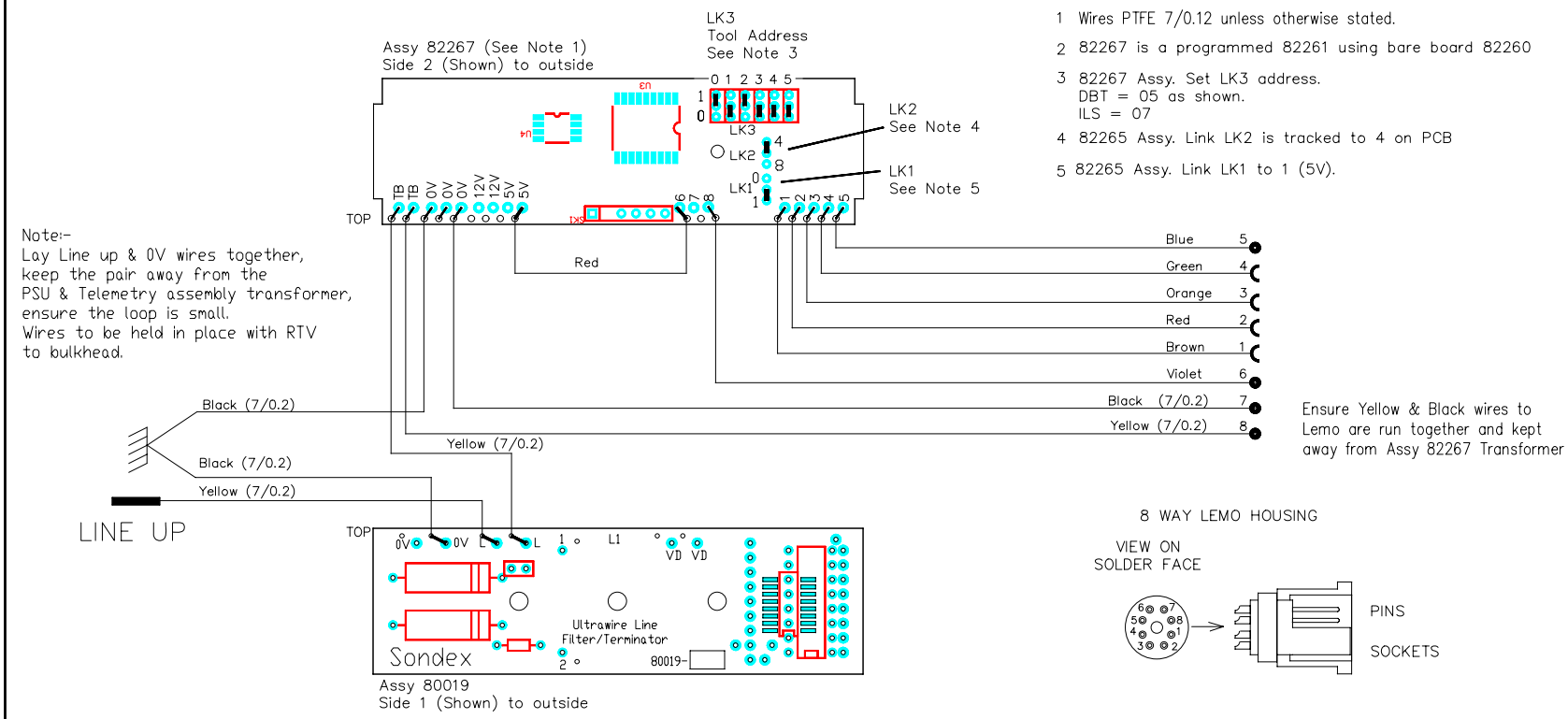
MACHINE FINISH 64 | USED ON COM

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

TITLE: ASSY - MECHANICAL CHASSIS 1 MODULE SX LEMO

SHEET 1/1 | DRAWING No. AD 10504 | ISSUE F | S W

SONDEX FM No: F0022



NOTES:

1 Wires PTFE 7/0.12 unless otherwise stated.

2 82267 is a programmed 82261 using bare board 82260

3 82267 Assy. Set LK3 address.
DBT = 05 as shown.
ILS = 07

4 82265 Assy. Link LK2 is tracked to 4 on PCB

5 82265 Assy. Link LK1 to 1 (5V).

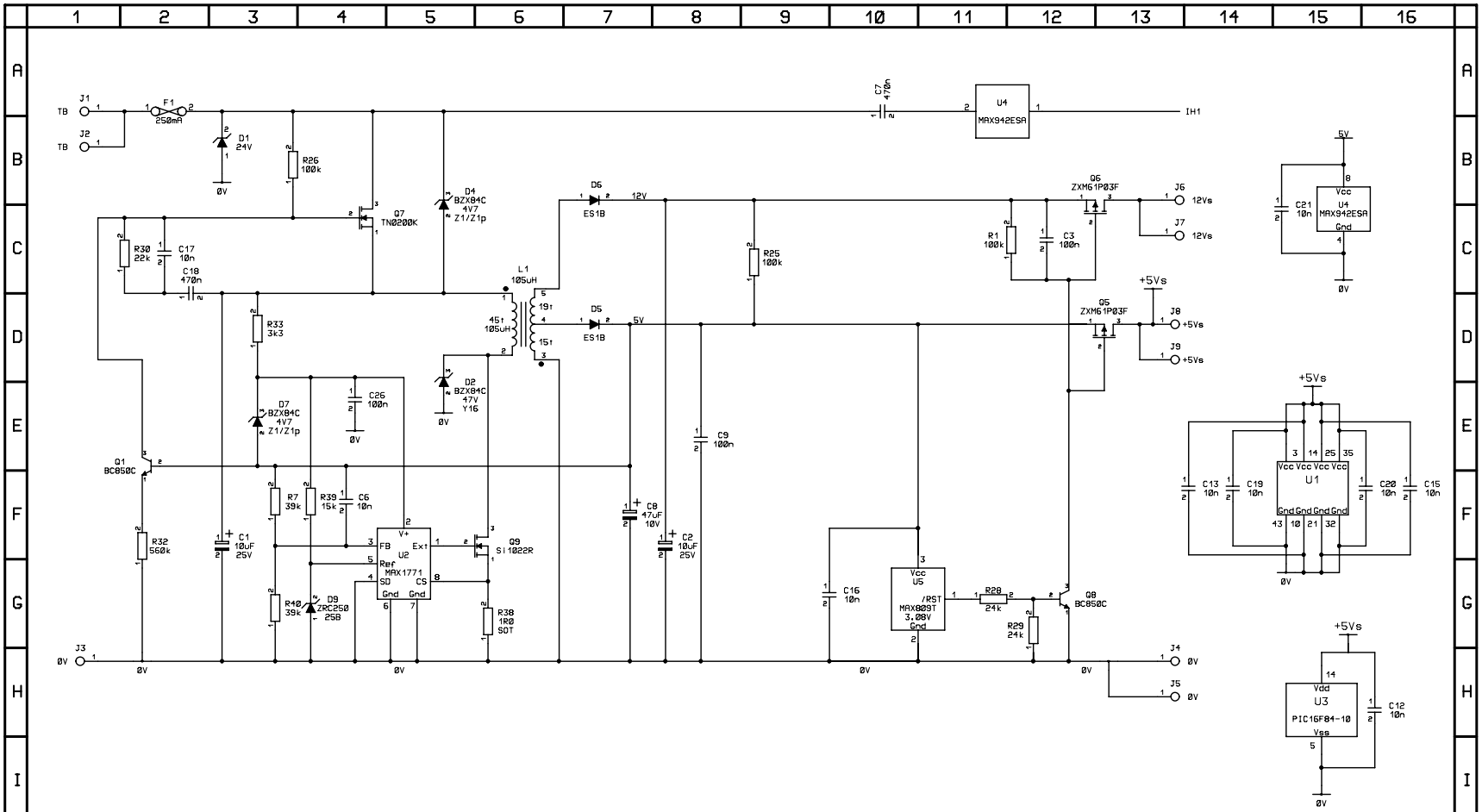
ISS	REV	DATE	CHANGES	CHKD	APPD
B		15.6.04	ECR1691. Redrawn. 82267 was 82223	(PR)	(PR)
C		18.5.06	ECR3823 Notes in error	BET	RH
D		18/07/06	ECR3962 & ECR3981 Notes added	VH	RH

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

TITLE:
WIRING DIAGRAM
Tool Electronics
Ultrawire Bottom Flowmeter

DRAWN	CHECKED	APPROVED
R Holding	(RH)	(RH)
DATE 22 April 02	DATE 7/5/02	DATE 7/5/02

DRAWING No. WD 80292 | ISSUE D | REVISION



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
C	Ø1		PR	PR	21/11/03
D	ØØ		DJ	PR	23/07/07
D	ØØ		PEJR	PEJR	Ø6/Ø1/Ø5
D	Ø1		PEJR	PEJR	Ø8/Ø6/Ø5
D	Ø2		PEJR	PEJR	Ø3/8/Ø5
F	ØØ		PEJR	PEJR	29/Ø6/Ø6

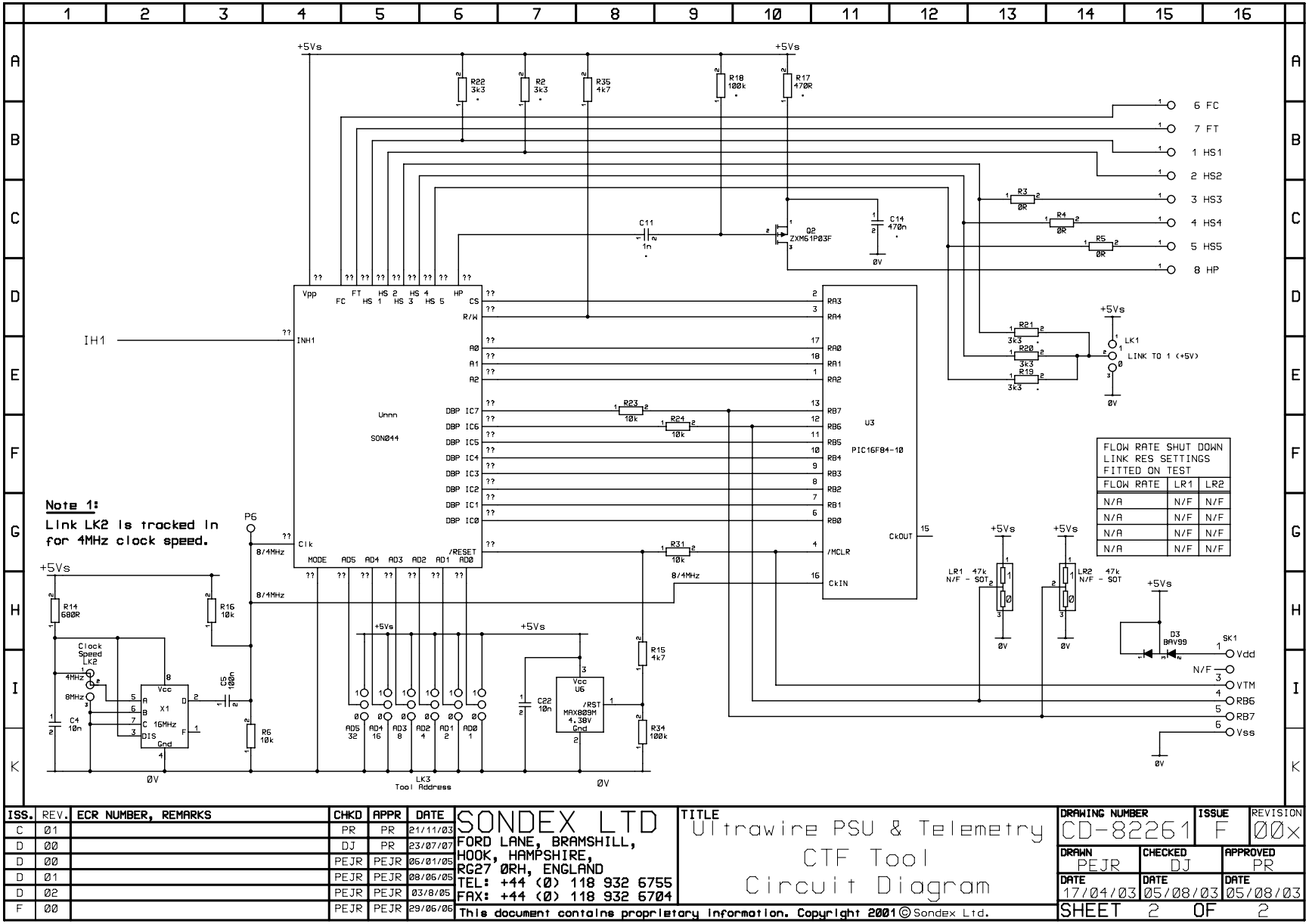
SONDEX LTD
FORD LANE, BRAMSHILL,
HOOK, HAMPSHIRE,
RG27 ØRH, ENGLAND
TEL: +44 (Ø) 118 932 6755
FAX: +44 (Ø) 118 932 6704

TITLE
Ultrawire PSU & Telemetry
CTF Tool
Circuit Diagram

DRAWING NUMBER	ISSUE	REVISION
CD-82261	F	ØØx

DRAWN	CHECKED	APPROVED
PEJR	DJ	PR
DATE 17/04/03	DATE 05/08/03	DATE 05/08/03

SHEET 1 OF 2



ISS.	REV.	ECR NUMBER, REMARKS	CHKD	APPR	DATE
C	Ø1		PR	PR	21/11/03
D	ØØ		DJ	PR	23/07/07
D	ØØ		PEJR	PEJR	Ø6/Ø1/Ø5
D	Ø1		PEJR	PEJR	Ø8/Ø6/Ø5
D	Ø2		PEJR	PEJR	Ø3/8/Ø5
F	ØØ		PEJR	PEJR	29/Ø6/Ø6

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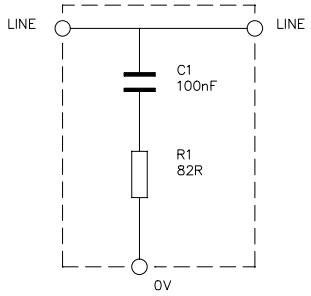
HOOK, HAMPSHIRE,
RG27 ØRH, ENGLAND
TEL: +44 (Ø) 118 932 6755
FAX: +44 (Ø) 118 932 6704

TITLE
Ultrawire PSU & Telemetry
CTF Tool
Circuit Diagram

DRAWING NUMBER	ISSUE	REVISION
CD-82261	F	ØØx

DRAWN	CHECKED	APPROVED
PEJR	DJ	PR
DATE	DATE	DATE
17/Ø4/Ø3	Ø5/Ø8/Ø3	Ø5/Ø8/Ø3

SHEET 2 OF 2



ISS	REV	DATE	CHANGES	CHKD	APPD
A		3.5.02	Initial Release		

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

TITLE:
CIRCUIT DIAGRAM
LINE TERMINATOR BOARD

DRAWN	CHECKED	APPROVED
D.Jackson	(RH)	(RH)
DATE 3/5/02	DATE 7/5/02	DATE 7/5/02

DRAWING No. CD 80293 | ISSUE A | REVISION