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MAN130–2011

# TONEOHM 950 SERVICE MANUAL

# TONEOHM 950 SERVICE MANUAL
## POLAR INSTRUMENTS LTD. HARDWARE WARRANTY

1. Product Warranty. Product hardware is warranted to be free from defects in material and workmanship during the Warranty Period (as defined below). Product hardware is warranted to conform substantially to Polar's then current (as of the date of Polar's product shipment) published user documentation during the Warranty Period. The Warranty Period is twelve (12) months. Product support beyond these periods may be available at additional cost – consult Polar for details.

2. Warranty Claims. Polar shall incur no liability under this warranty if the end user fails to provide Polar with notice of the alleged defect during the applicable Warranty Period and within seven (7) days of delivery to end user or, if the defect would not have been reasonably apparent on inspection, within seven (7) days of its discovery by end user. After receiving such notice, Polar will notify the purchaser of its designation of one of the following problem resolution methods:

   *Return to Factory*: The allegedly defective goods must be returned to Polar within seven days of Polar's notice and in accordance with Polar's instructions advised at the time.

   *Other:* Polar will use commercially reasonable efforts to repair, correct or work around the problem by means of telephone support or other means reasonably determined by Polar.

   Polar shall incur no liability under this warranty if Polar's tests disclose that the alleged defect is due to causes not within Polar's reasonable control, including alteration or abuse of the goods. Under the *Return to Factory* alternative, if a Product is determined not to be defective or to have a defect due to causes not within Polar's reasonable control, Polar reserves the right to apply a processing charge.

3. Damage in Transit. End user must notify Polar and the carrier of any claim for damage in transit within two (2) days of receipt of the damaged merchandise. Failure to do so may result in the carrier and/or Polar refusing to accept liability in which case end user must pay the purchase price as if the hardware had been delivered without damage.

4. Polar's Liability Polar's liability, and end user's sole and exclusive remedy, shall be limited to the express remedies set forth in this Polar Hardware Warranty.

5. Disclaimer of Warranties. **POLAR MAKES NO OTHER WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, REGARDING PRODUCTS. ALL OTHER WARRANTIES AS TO THE QUALITY, CONDITION, MERCHANTABILLITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT ARE EXPRESSLY DISCLAIMED.**

6. Limitation of Liability. **POLAR SHALL NOT BE RESPONSIBLE FOR DIRECT DAMAGES IN EXCESS OF THE PURCHASE PRICE PAID BY THE END USER OR FOR ANY SPECIAL, CONSEQUENTIAL, INCIDENTAL, OR PUNITIVE DAMAGE, INCLUDING, BUT NOT LIMITED TO, LOSS OF PROFITS OR DAMAGES TO BUSINESS OR BUSINESS RELATIONS, WHETHER OR NOT ADVISED IN ADVANCE OF THE POSSIBILITY OF SUCH DAMAGES, THE FOREGOING LIMITATIONS SHALL APPLY, NOTWITHSTANDING THE FAILURE OF ANY EXCLUSIVE REMEDIES.**

# DECLARATIONS

***European Community Directive Conformance Statement***

Refer to the Operator Manual to determine conformance with European Community Directives.

# SAFETY

***WARNING The service instructions contained in this manual are for use by qualified electronic service personnel only.***

## WARNING

The LIVE and NEUTRAL lines on this unit are BOTH fused.

*When the unit is connected to its supply, the opening of covers or removal of panels is likely to expose dangerous voltages.*

## GROUNDING

This unit must be earthed (grounded); do not operate the instrument with the safety earth disconnected. Ensure the instrument is connected to an outlet with an effective protective conductor terminal (earth). Do not negate this protective action by using an extension cord without a protective conductor.

*Note: This instrument is fitted with 3-wire grounding type plug designed to fit only into a grounding type power outlet. If a special local plug must be fitted to the power cord ensure this operation is performed by a skilled electronics technician and that the protective ground connection is maintained. The plug that is cut off from the power cord must be safely disposed of.*

Power cord color codes are as follows:

**Europe**

| | |
|---|---|
| brown | live |
| blue | neutral |
| green/yellow | earth (ground) |

**United States**

| | |
|---|---|
| black | live |
| white | neutral |
| green | ground |

## POWER SUPPLY

Check that the indicated line voltage setting corresponds with the local mains power supply. See the rear panel for line voltage settings. Instruments with a serial number prefixed with a letter (e.g. A1234) are configured for 90 – 110 Volts only.
*Changing the line voltage settings on this instrument must only be performed by a skilled electronics technician. Instructions for changing the line voltage settings are contained in Section 5.*

# OPERATION

*This manual contains instructions and warnings which must be observed by the user to ensure safe operation. Operating this instrument in ways other than detailed in this manual may impair the protection provided by the instrument and may result in the instrument becoming unsafe. Retain these instructions for later use.*

The unit is designed for use indoors in an electrical workshop environment at a stable work station comprising a bench or similar work surface.

Use only the accessories (e.g. test probes and clips) provided by Polar Instruments.

The instrument must be maintained and repaired by a skilled electronics technician in accordance with the manufacturer's instructions.

If it is likely that the protection has been impaired the instrument must be made inoperative, secured against unintended operation and referred to qualified service personnel.

Protection may be impaired if, for example, the instrument:

- Shows signs of physical damage
- Fails to operate normally when the operating instructions are followed
- Has been stored for prolonged periods under unfavourable conditions
- Has been subjected to excessive transport stresses
- Has been exposed to rain or water or been subject to liquid spills

# CAUTION

**Electrical Isolation**

Always disconnect the board under test from the local mains supply (including ground) before using this instrument.

***Static Sensitive Devices***

This unit contains Static Sensitive Devices. Static discharge can damage some electronic components. Care must be taken when handling these components. Observe appropriate precautions to avoid damage.

# SPECIFICATIONS

**Track Resistance**

| | |
|---|---|
| RANGES | [Ω], 200mΩ, 2Ω, 200Ω, 20KΩ. Instruments with serial numbers below 005975 have a 2KΩ range instead of 200Ω. |
| ACCURACY | ±6% in 200mΩ, ±5% in 2Ω<br>±4% in 200Ω, ±5% in 20KΩ |
| [Ω] RANGE | High sensitivity, uncalibrated.<br>Approximately 40mΩ full scale. |
| PROBE VOLTAGE | 60mV maximum. |
| INDICATION | Tone and meter in all ranges. |
| PROBE PROTECTION | Momentary contact up to 250V. |

**Track Current**

| | |
|---|---|
| RANGES | 200mA, 2A, TRACE. |
| ACCURACY | ±15% in 200mA, 2A for track resistance between 25mΩ and 500mΩ.<br>Reading proportional to current when UNCALIBRATED LED is lit.<br><br>UNCALIBRATED LED lit during ranging.<br><br>Reading in TRACE is proportional to detected magnetic field strength. |
| TRACE SENSITIVITY | Capable of detecting current flow with 200Ω resistance across Drive Source. |
| PROBE VOLTAGE | 600mV maximum in 200mA, 2A.<br>Not applicable in TRACE. |
| INJECTION CURRENT | 250mA maximum.<br>Not applicable in TRACE. |
| INDICATION | Tone and meter in all ranges. |
| PROBE PROTECTION | Momentary contact up to 250V in 200mA, 2A.<br>Not applicable in TRACE. |

**Track Voltage**

| | |
|---|---|
| RANGES | 2mV, 20mV, 20V. |
| ACCURACY | ±4%, ±15µV. |
| INPUT RESISTANCE | 120Ω in 2mV, 20mV.<br>1MΩ in 20V. |
| INDICATION | Meter in all ranges. Tone in 2mV, 20mV. |
| PROBE PROTECTION | Momentary contact up to 250V in 20V.<br>30V in 20mV, 2mV. |

**Plane Shorts**

| | |
|---|---|
| INDICATION | Tone, uncalibrated meter and fault direction arrows. |
| SENSITIVITY | Adjustable for differing plane resistance. Capable of detecting shorts up to 20Ω. |

**Plane Stimulus**

| | |
|---|---|
| OUTPUT VOLTAGE | 550mV maximum. Active only when PLANE SHORTS is ACTIVE and outputs are connected to a plane. |
| OUTPUT CURRENT | 700mA RMS maximum. |
| PROTECTION | Each output separately fused (5A Fast). |

**Drive Source**

| | |
|---|---|
| OUTPUT VOLTAGE | 0 to 550mV, adjustable.<br>AC in TRACE, DC in all other ranges. |
| PROTECTION | Protected to ± 30V. |

# ENVIRONMENTAL OPERATING CONDITIONS

The instrument is designed for indoor use only under the following environmental conditions:

| | |
|---|---|
| Altitude | Up to 2000m |
| Temperature | +5°C to +40°C ambient |
| Relative humidity | RH 80% maximum at 31°C — derate linearly to 50% at 40°C |
| Mains borne transients | As defined by Installation Category II (Overvoltage Category II) in IEC664 |
| Pollution Degree | 2 (IEC664) |

***Power Requirements***

230V ± 10%, 115V ± 10% or 100V ± 10% at 50/60Hz, 25VA.

***Fuses***

**Below Serial Nº. 11244**
One fuse

| | |
|---|---|
| 230V | 160mAT |
| 115V | 315mAT |

**Serial Nº. 11265 – 12212**
Two fuses as above

**Serial Nº. 12213 up**

| | |
|---|---|
| 230V | 125mAT |
| 115V | 250mAT |

***Physical characteristics (excluding accessories)***

| | |
|---|---|
| Dimensions | 305mm (12 in.) wide.<br>150mm (5.9 in.) high.<br>275mm (10.8 in.) deep. |
| Weight | 3.5 kg. |
| Flammability | Enclosure to UL94 V-0. |

# SYMBOLS

 REFER TO MANUAL

These sockets are for connecting only Polar Instruments probes and connectors for use as described in the Operator Manual. To prevent damage to this product and to ensure its safe use observe the specifications given in this manual when connecting to terminals marked with this symbol.

# ACCESSORIES

### *Standard Accessories*

| | |
|---|---|
| Needle Probes | ACC152 |
| 950 Plane Probe/Clip assembly | ACC113 |
| 950 Current Trace Probe assembly | ACC114 |
| 950 Stimulus Lead (Set of 4) | ACC134 |
| Lightweight Headphones | EPM115 |

### *Optional Accessories*

| | |
|---|---|
| Bare-board Stimulus Lead set (0.025") | ACC121/XG25 |
| Bare-board Stimulus Lead set (0.031") | ACC121/XG31 |
| Bare-board Stimulus Lead set (0.040") | ACC121/XG40 |
| Bare-board Lead set (universal) | ACC154 |
| Service Manual | MAN130 |

# CONTENTS

# SECTION 1 PERFORMANCE CHECK

## MAINTENANCE AND CALIBRATION OF INSTRUMENTS

For most of Polar Instruments' products there are two maintenance procedures — the **Performance Check** and the **Calibration.** Some instruments may have a single (combined) procedure.

### *Performance Check*

The Performance Check (or Checkout Procedure) is used to verify the basic functions of the instrument. This does not usually require the removal of instrument covers, but may require the use of external test equipment. This procedure is not intended to verify the calibration of the instrument.

### *Adjustment Procedure*

The Adjustment Procedure (or Calibration Procedure) is used to check and, if necessary, adjust the instrument's calibration settings. Before carrying out the Adjustment Procedure the instrument's Performance Check (if applicable) should be carried out, and any detected defects should be rectified. *The Adjustment Procedure and rectification of defects should only be carried out by qualified technician.*

### *Recommendations for Routine Maintenance*

Where a Performance Check is available for an instrument this may be used as required to confirm the basic operation of the product.

To maintain the calibration of an instrument it is recommended that its Calibration/Adjustment Procedure is carried out at intervals not exceeding 12 months.

# PERFORMANCE CHECK

***Equipment required***

- DC voltage source, variable from 1V to 10V and accurate to 0.1%.
- High tolerance resistors (0.5%) of the following values: 10KΩ, 1KΩ (serial numbers below 005975 only), 200Ω, 100Ω, 1Ω and 0.1Ω.

***Procedure***

- Switch on and allow the 950 to warm up for 15 minutes.

1. Plug in the Needle Probes and press 20V.
2. Apply 10V DC to the probes and check that the reading is 10V ± 4%.
3. Connect a 1KΩ 0.5% and a 1Ω 0.5% resistor in series.
4. Apply 10V to the series resistors. This produces 10mV across the 1Ω Resistor.
5. Press 20mV and check that the reading across the 1Ω resistor is 10mV ± 4%.
6. Adjust the voltage source from 0 to 20V and check that the tone varies in pitch. A steady warble should be generated with a negative voltage.
7. Apply 1V to the two resistors and press 2mV.
8. Check that the reading across the 1Ω resistor is 1mV ± 4%.
9. Check that varying the voltage generates varying tones. No tone should be produced below about 50uV.
10. Press 20KΩ and measure a 10KΩ 0.5% resistor. The reading should be within 4%. A warble may be generated in this range.

    (a) Serial numbers below 005975:
    Press 2KΩ and measure a 1KΩ 0.1% resistor. The reading should be within 4%.

    (b) Serial numbers 005975 up:
    Press 200Ω and measure a 100Ω 0.1% resistor. The reading should be within 4%.
11. Press 2Ω and measure a 1Ω 0.1% resistor. The reading should be within 4%.
12. Apply solder to the wire ends of a 100mΩ 0.5% resistor.
13. Press 200mΩ and measure the resistor by pressing the probe tips into the solder. The reading should be within 4%. Readings vary with the pressure applied to the probes.
14. Press TRACE and connect the Drive Source leads across a 200 Ω resistor. Turn the DRIVE SOURCE knob fully clockwise.
15. Hold the Current Trace Probe tip near to one of the Drive Source leads and align it for maximum response.
16. Check that the display shows 20 or more.
17. Connect the Blue and Yellow Stimulus lead together. Press PLANE twice — check for the warning bell and that the instrument returns to Standby. Leave leads connected.
18. Connect the Red and Green Stimulus lead together. Press PLANE once. Check for ACTIVE LED.
19. Connect the red and black Drive Source leads across a 0.1Ω resistor. Attach the Plane Clip to the black Drive Source lead. Probe the other end of the resistor with the probe.

20. Slowly turn the DRIVE SOURCE from minimum to maximum (i.e. clockwise). As the control is rotated, check that initially all direction arrow LEDs are on, then the upper LED only, then all LEDs are off. At the same time the tone goes from high to low then off.
21. Reverse the connections to the Plane Probe and Clip. Rotate DRIVE SOURCE from maximum to minimum (i.e. anti-clockwise). As the control is rotated, check initially for no arrows or tone, then rising tone and bottom arrow on, finally all arrows on.
22. Disconnect the Red and Green Stimulus lead. PLANE should automatically ring warning bell and return to standby. Disconnect the Plane Probe and Clip from the 0.1Ω resistor.
23. Turn DRIVE SOURCE to maximum. Select 20mV, connect the Needle Probes and drive source leads across the 0.1Ω Resistor and note reading.
24. Select 200mA. Check that reading is: (10x Reading noted above) ±10%
25. Turn DRIVE SOURCE to minimum. Check for 0 ±1mA.
26. Disconnect all cables.

# SECTION 2 – ADJUSTMENT PROCEDURE

## ADJUSTMENT PROCEDURE

> *WARNING: Hazardous voltages are exposed on the PCB when the cover is removed. This procedure should only be performed by a technically qualified person aware of the hazards and taking all reasonable care.*

***Equipment required***

- High tolerance(0.1%) voltage source — 10V and 10mv.
- High tolerance(0.1%) 1Ω and 100mΩ resistors.
- DVM
- Power Supply.

Before connecting to the supply:–

1. CHECK THE MAINS FUSES — see SPECIFICATIONS.
2. Connect the 950 to the appropriate line voltage and turn on.
3. CHECK the front panel lights sequence and that the 950 stops in the 20V range. PUSH 20mV.

***Display Calibration***

1. Connect the Needle Probes to the 10mV source.
2. Adjust POT R196 (top RHS of Front Panel board) for a display of 10.00mV.

***A2D Calibration***

1. Turn the power off then hold down 2mV and PLANE — re-apply power.
2. Connect needle probes to 10mV source.
3. Observe the Active and Standby (Pass and Fail) LEDs while adjusting R163 — the tone will decrease as the calibrated position is approached.
   When ACTIVE illuminates the A2D is calibrated.
4. PUSH 2mV. The 950 will beep and enter the 20V Range.

***Resistance Calibration***

1. SELECT the 2Ω range. Place the probes across the 1Ω resistor. ADJUST R713 (R30 for instruments below S/N 012213) for 1.000Ω reading ± 3 Counts.

***Current range adjustment***

(Serial Nº. 012213 and above — below this Serial Nº. there is no adjustment.)

1. Select the 200mA range. Drive source control fully clockwise.
2. Connect the drive source and the DVM across the high tolerance 1Ω resistor.
3. Note the DVM reading.
4. Apply the needle probes across the resistor and adjust R 30 for the same reading as the DVM ± 5 counts.

***Current offset calibration — Version 8 firmware and above***

1. Set the current limit to MINIMUM — switch the supply ON.
2. Select 2A on the 950.
3. Connect the power supply across the 100mΩ resistor.
4. Adjust the current limit to 1.6A.
5. Using the Needle Probes measure across the 100mΩ resistor CHECK for 1.44 to 1.76A on the 950 display.

   (Version 8 firmware and above, main board version 5 and above.)
   Select the most accurate 1.6A reading by optionally placing a jumper on one of the 4 locations adjacent to U46.

   No jumper is the mid setting, H fixes slight under-reading, HH corrects large under-reading. L fixes slight over-reading, and LL corrects large over-reading.

   (Version 8 firmware, main board version 4 or below.)
   Connect a 20 way integrated circuit test clip to U46
   Shorting Pin 17 to Gnd corresponds to HH

   | | |
   |---|---|
   | 14 | H |
   | 13 | LL |
   | 8 | L |

   No connection is nominal setting.
   Once the best setting is established solder a link from the appropriate pin (if any ) to ground.
6. Version 7 firmware and below offer no fine adjustment.

***Current Trace***

1. Connect Trace / Drive Source Probe.
2. Push TRACE. Adjust the volume as desired, short the drive source leads together and turn the drive source to MAXimum.
3. While holding the probe against the Drive Source lead ADJUST R94 for the highest displayed reading (> 500).
   Move the probe away from the Drive Source leads,
4. CHECK Tone turns off and displayed reading is less than 25.

***Plane Shorts***

1. CONNECT the 4 Plane Stimulus leads BLUE to YELLOW and RED to GREEN
2. Push PLANE twice to enter ACTIVE mode.
3. CONNECT the Plane Clip to the Plane Probe. Adjust R85 for a reading of 00.0 ± 3 counts.

   (Ser Nº 012213 up)
   Adjust R716 (located near U18, behind copper shield) for minimum (or most negative) reading.
   Re-adjust R85 for 00.0 ± 3 counts.
4. Reduce the Variac to:

   190V (240V instruments)
   95V (120V instruments)
   85V (Japanese instruments)

5. Check that PLANE remains ACTIVE
6. Remove the Green clip from the demo board and check the 950 goes to standby. Reconnect the clip and select ACTIVE.
7. Repeat for the yellow clip.
8. Disconnect all probes.

# SECTION 3 – CIRCUIT DESCRIPTION

## TONEOHM 950 THEORY OF OPERATION.

The TONEOHM 950 consists of the following functional blocks.

| | |
|---|---|
| 1. Microvolt Amplifier | Amplifies/attenuates PCB track voltages, and is used in conjunction with the internal current source for the calculation of track resistance and current. |
| 2. Trace Amplifier | Amplifies and rectifies the low level AC signal from the Trace probe to provide a DC voltage output proportional to magnetic field. |
| 3. Current source | Provides a range of currents for resistance and non-invasive current measurement. |
| 4. Plane Amplifier and Vector discriminator | Amplifies low level plane signals, separates vector and magnitude components. |
| 5. Vectored Plane Stimulus | Provides the four vectored signals for Plane Shorts mode. |
| 6. Drive Source | User adjustable constant current DC supply for non-invasive current measurement/<br>μV measurement.<br>Also operates in a.c. for non-contact current tracing. |
| 7. Tone Generator | Voltage controlled oscillator which provides varying tone proportional to meter reading. |
| 8. A2D2A | Analog to digital convertor used for providing microprocessor with data for non-invasive current measurement, also used for internal calibration and QC. Digital to analog converter provides output for tone generator in 2A and 200mA modes and output to front panel meter. |
| 9. Power Supply | ± 5V analog and digital supplies.<br>12/5V floating supply for drive source.<br>4V a.c. supply for vectored plane stimulus. |
| 10. Microprocessor | Controls hardware and performs current calculation. |
| 11. Front Panel | Keyboard and display D2A. |

***Main Operating modes.***

**Track resistance**

Current is injected into the track with the needle probes using the CURRENT SOURCE module, the μV AMPLIFIER conditions the resulting track voltage and displays the result directly on the LCD.

**Track Current**

200mA, 2A.
These ranges compute the current by measuring the voltage drop across a length of track carrying the fault current and then injecting a known current in addition to the fault current. The voltage drop is then re-measured and the resistance calculated hence the fault current can be derived.

e.g.

$$\text{Track Resistance} = \frac{\text{V due to fault I} - (\text{V due to fault I} + \text{V due to injected I})}{\text{Injected I}}$$

$$\text{Hence Fault Current} = \frac{\text{V due to fault I}}{\text{Track Resistance}}$$

The 950 first reads the track voltage with the μV AMPLIFIER and uses the A2D2A to digitise the value. The amplifier auto-ranges if necessary, then a small current is injected from the CURRENT source, the track voltage is read again, if the second voltage is not significantly different (<10% higher) the 950 injects more current. This process reiterates up to a maximum of 240mA injection at which point the microprocessor will force a calculation and send the resultant value to the D2A. This is sent both to the front panel meter and via the conditioning network on U59 (Schematic 1) to the TONE GENERATOR.

During the initial ranging and for on track resistances below approximately 25mΩ the un-calibrated indicator will illuminate. Once ranging has taken place the initial injection/ attenuation settings are held and the current is calculated continuously. The 950 will only measure positive conventional current. If the probes are reversed the condition will be indicated on the front panel and the display will blank.

**Trace**

In TRACE mode the 950 uses an inductive pick up to detect an ac current in a faulty track. The ac current is supplied from the DRIVE SOURCE leads, the detected signal is conditioned by the TRACE amplifier and then switched to the LCD and TONE GENERATOR by U25 (sheet 6) and U59 (sheet 1) respectively.

**Track Voltage**

The μV AMPLIFIER conditions the track voltage and sends it to the LCD via U25 (sheet 6) and to the TONE GENERATOR. The tone is disabled on the 20V range.

**Plane Shorts**

In Plane Shorts mode the 950 uses VECTORED PLANE Stimulus to set up a field pattern on the plane under test, the Plane Clip references the short to ground and the voltage measured on the Plane Probe is an a.c. signal providing both magnitude and position information. The PLANE AMPLIFIER and VECTOR DISCRIMINATOR resolve this into a magnitude signal (sent to the LCD and TONE GENERATOR and a vector signal for the 4 direction arrows on the front panel).

***Detailed Theory of operation.***

**Microvolt Amplifier**

JP11 is the input connection from the probe sockets. Relays K1, 2 and 3 provide ÷ 1, ÷ 10 and ÷ 1000 attenuation setting for the main Amplifier U1. K4 provides a switchable 120Ω input resistance used in 2mV and 20mV.

U1 is a low offset voltage chopper stabilised amplifier with gains of x10 or x100 (selected by the analog switch U24 on the Tone Generator schematic). The network on the output of U1 provides an idealised response for the tone generator. "HI" and "LO" are the calibrated outputs to the front panel meter (via analog switch U25 on sheet 6).

U59 and associated components provide a second nonlinear amplifier for use in TRACE, PLANE, 200mA and 2A modes.

**Trace Amplifier**

*Refer to Microvolt Amplifier schematic.*
The DRIVE Source provides PCB tracks with an 80kHz (approximately) current; this is detected by the Trace Probe. The low level signal is first amplified and filtered by U2B, further amplification and conditioning is provided by nonlinear amplifier U2A, the a.c. signal is then rectified and smoothed by active rectifier U2D; after buffering and attenuation U25 (A–D Converter schematic) directs the output to the front panel meter.

**Current Source**

*Refer to A–D Converter schematic*
The current source provides a range of known dc currents for resistance and non-invasive current measurement.
The loop formed by U5A, U62A, Q2, D13 and associated components provide a low impedance 56mV or 0.56V (approximately) source. The microprocessor is both able to select the voltage via U24 on the Tone Generator schematic, or gate the supply via Q2 and U62B. Q2 and D13 also afford protection against inadvertently connecting high voltages to the probes.

The voltage is applied via relays R1 to R7 across a series resistance and via the Kelvin connected Needle Probes, to provide a known current through the track resistance under test.

In order to correct for offsets caused in the needle probes when measuring low resistances, U4 and associated components apply offset to the μV Amplifier in order to achieve a zero reading in 2Ω and 200mΩ; in the [Ω] range offset is applied to give a stable reading but a zero is not achieved when the probes are shorted.

**Plane Amplifier and Vector Discriminator**

*Refer to Plane Input Amplifier Schematic*
The Vectored Plane Stimulus sets up a field on the plane under test such that when the plane is probed the following waveforms are detected:

| | |
|---|---|
| above the short | two positive going half sine waves |
| below the short | two negative going half sine waves |
| left of the short | a positive followed by a negative half sine wave |
| right of the short | a negative followed by a positive half sine wave |

The magnitude of the half waves detected increases with increasing distance from the short.

The 950 extracts this information as follows:
U12 Amplifies the low level signal from the Plane Probe; this chopper-stabilised amplifier is clocked by a signal synchronous with the Vectored Stimulus to minimise clock noise on the a.c. output signal. JP12 connects to the Drive Source/Sensitivity control to allow user adjustment of sensitivity.

U6 forms an active rectifier for the incoming signal which is taken to sample-and-hold gate U8, along with the unrectified component. U8 is clocked and gated so that the peak amplitudes of each halfwave in both rectified and unrectified form are sampled and held on C11, C12, C13 and C16. Magnitude signals on C11 and C12 are added then switched via U25 (A–D Converter schematic) and U59 (Microvolt Amplifier schematic) to the LCD and TONE GENERATOR respectively.

C13 and C16 hold the unrectified component of the plane signal; here only their polarities are of interest, these are detected and converted to TTL levels by comparators U10 and U14 the two resultant signals (QUADRANT0 and QUADRANT1) are taken to the front panel and decoded to illuminate the appropriate direction arrow.

Finally U17A and B monitor the level of PLANEV+ and through the control signals ARROW OFF and CENTRE...

1. Turn the arrows off when the probes are open circuit.
2. Allow the QUADRANT signals to control the arrow when the plane is being probed.
3. Turn all the arrows on when the probe is a few centimetres from the short.

**Vectored Plane Stimulus**

*Refer to Drive Source schematic*
The stimulus runs at power line frequency and provides a nominal 2A (peak) current from top left to bottom right of the plane during the first 180 degrees of the line signal followed by the same signal from top right to bottom left during the second 180 degrees.

The two halves of the stimulus circuit are identical except for the phase of the inputs which allow the steering diodes (D31, D32, D73, D35) to pass current on alternate half cycles. Relay K14 allows the microprocessor to turn the stimulus off and on.

Taking the top circuit as the example, +2A and -2A are the outputs of the 4V RMS transformer winding. As +2A goes positive D31 conducts and attempts to pass current through L1, F1 through its stimulus lead and return through the lead at the opposite diagonal of the board, during this half cycle the other stimulus circuit is inactive.

As current flows through inductor L1 Hall sensor Q12 detects its presence and the monostable U61A is repeatedly clocked, the output of the monostable is OR'd with its equivalent in the other stimulus circuit and if either inductor L1 or L2 is NOT conducting NO_PLANE_DS will be low.

NO_PLANE_DS is monitored by the microprocessor in PLANE SHORTS mode. When the user presses PLANE to activate the mode the 950 will turn on relay K14 on; if no current is detected in L1 or L2, K14 will be turned off.

In order to protect semiconductor devices, D30 and D34 are Schottky diodes which conduct if the stimulus voltage attempts to rise above approximately 0.4 volts. This will occur if the stimulus is not connected correctly. As D30 or D34 conduct, current no longer flows through L1 or L2, the microprocessor registers NO_PLANE_DS and turns off K14. This feature will turn off the stimulus at any time it is disconnected while "Active".

**Drive Source**

The Drive Source provides both an 80kHz ac low impedance output for non-contact current tracing and an adjustable DC output for non-invasive current measurement and microvolt measurement.

U13 and U19 form a gated oscillator, enabled only in TRACE mode. Q3 and Q4 provide a low impedance output, U13A monitors the output current turning on the front panel DRIVE SOURCE indicator when a current of > approximately 5mA is flowing.

U13D and Q4 comprise a protection circuit which cuts off drive to Q3 should the leads be connected to a negative voltage. D39 provides protection from positive voltages.

**Tone Generator**

U20D and Q7 form a VCO whose frequency is proportional to the voltage at TONE_GEN or its inverse if INVERT is selected. The output of the VCO is made symmetrical by U21B, which is also gated by the microprocessor to allow the tone to be turned off in the 20V range and during current auto-ranging. U64 is a voltage controlled amplifier providing volume adjustment from the front panel, U22 provides the audio power output.

The following controls are applied to the tone generator:

- 20V range — gated off by NO_TONE
- 200mA 2A — gated off below 10mA (approximately) and during auto-ranging.
- 2mV and 20mV Invert selected — U20A and B detect a band of ± 40μV and turn off the tone in this region, more negative than 40uV oscillator U17D runs causing a unique pulsing tone. Reversed signal also taken to front panel led.
- All resistance ranges — Invert is off and at low readings U20A goes high allowing U17D to oscillate and cause a pulsing tone at low readings.
- TRACE — as 2mV.

**A2D2A**

*Refer to A–D Converter Schematic*
U26 and associated logic interface the μV AMPLIFIER with the microprocessor allowing it to read the 12-bit conversion in a high and low order byte. The data is used for current calculation and system calibration. U28 8-bit D2A convertor allows the computed current to be sent to the TONE GENERATOR and the LCD.

U25 is controlled by the processor to route analog signals from the main modules to the display.

**Power Supply.**

U32 and U33 provide analog ± 5 Volt supplies. LK7 or 8 allow the Phase of the line signal to be selected in case of transformer phase change. (This will affect left and right arrows in PLANE SHORTS.)
U31 provides a separately regulated 5V supply for the digital systems and relay drive.

U30 Provides a floating +5Volts for the drive source.

+2A and -2A is a floating 4V RMS supply for the Vectored Stimulus.

Note that from Serial Nº. 011265 a line filter was fitted and the line voltage selector switch was replaced by links. The power transformer has undergone several changes — check the *REPLACEMENT PARTS* list before ordering spares.

**Microprocessor**

The system is based on a Z80 U35 which is reset and shut down by controller U38.

4MHz Resonator X1 is divided by 2 to produce a 2MHz system clock.

Firmware is held in ROM U36, and U34 provides 2K of utility RAM. The remainder of the bus related circuits provide I/O for controlling or monitoring the instrument. U43 and U37 provide appropriate address decoding.

**Front Panel (Schematics 1 and 2)**

The digital part of the front panel is an extension of the processor system providing a keyboard row and column decoder U49 and U52 and other ports for LED drive.

U57 and associated components form the drive for the Plane Direction arrows and come under the control of the Vector discriminator circuit.

D76 is a backlight array for the LCD whilst U53 provides display A2D conversion and LCD Drive, U56 provides logic level conversion for decimal points and U54 is the LCD.

# SECTION 4 – DISMANTLING INSTRUCTIONS

***WARNING  Service of this instrument should only be performed by skilled electronics service personnel.***

*There are hazardous voltages inside the instrument when connected to its power supply. REMOVE THE POWER CORD before touching any part of the line input circuit. Note that high voltages may continue to be present for 2 minutes after power is removed until internal capacitors discharge.*

***Removing the cover***

Undo the two screws in the rear of the cover, then lift the cover rear edge first and remove.

The main printed circuit board must be removed before the front moulding or feet can be removed

# SECTION 5 – LINE VOLTAGE AND FUSE CHANGING

***WARNING Service of this instrument should only be performed by skilled electronics service personnel.***

*There are hazardous voltages inside the instrument when connected to its power supply. REMOVE THE POWER CORD before touching any part of the line input circuit. Note that high voltages may continue to be present for 2 minutes after power is removed until internal capacitors discharge.*

## LINE VOLTAGE SELECTION AND FUSE CHANGING

**Note:** *When replacing fuses always use the type and rating stated in SPECIFICATIONS.*

### *Changing the line voltage setting*

When changing the line voltage it will be necessary to dismantle the instrument as described in Section 4 — changes may be made as follows:

1. Remove the two screws in the rear of the cover and lift off (lift the rear first).
2. In early instruments locate the line selector switch and change to the local line voltage.
3. In later instruments remove the gold plated links (extract the links with small pliers) and replace them in the locations corresponding to the local line voltage.
4. Locate the supply fuse (2 fuses in later instruments) and replace with the value and rating stated in SPECIFICATIONS.
5. Replace the cover.
6. Erase the marking on the label on the rear of the instrument and mark in the new voltage setting.

NOTE: 100V instruments cannot be changed.

# SECTION 6– FAULT DIAGNOSIS

***WARNING  Service of this instrument should only be performed by skilled electronics service personnel.***

*Hazardous voltages are exposed on the PCB when the cover is removed. These procedures should only be performed by a technically qualified person aware of the hazards and taking all reasonable care.*

## TROUBLESHOOTING HINTS

1. If the instrument is completely dead check the fuses and line voltage selection. Inspect carefully for signs of damage, loose wires, etc. *Rectify any faults before applying power.*
2. If there is no "beep" or flashing LED sequence at switch on, the microprocessor is not operating. Check the internal power supplies, ROM, crystal and microprocessor reset circuits.
3. If there is an OHMS fault check the input amplifier in VOLTS mode first, then check the operation of the current generator.
4. If ACTIVE cannot be engaged in PLANE SHORTS check the 5A fuses in the stimulus circuit. The connections to the plane drive sockets should also be checked, and the sense coils which should be close around the sensor IC.
5. In TRACE mode, for optimum sensitivity tune the circuit to the Trace Probe (Probes may differ).

# SECTION 7 – MAINTENANCE AND CLEANING

### *Cleaning*

Clean the unit with a cloth lightly moistened with water with a small amount of mild detergent.

Alternatively, a cloth lightly moistened with alcohol (ethanol or methylated spirit) or isopropyl alcohol (IPA) may be used.

*Do not spray cleaners directly onto the instrument.*

### *Technical Support*

For technical support contact your local Polar Instruments distributor or Polar Instruments Ltd. at the address at the front of this manual.

### *Instrument repair*

If it becomes necessary to repair the instrument, in the first instance contact the Polar Instruments distributor in your country. In case of difficulty contact Polar Instruments Ltd. at the address at the front of this manual. *Do not send the instrument until shipping instructions have been received from the repairer.*

# SECTION 8 – REPLACEMENT PARTS

To ensure correct parts are supplied, orders for replacements should include the following details:

Instrument type
Instrument serial number
Firmware version (if applicable)
Circuit reference (if applicable) and description
Note: Parts marked with an asterisk (*) have been subject to modification in later instruments.

> *Safety critical parts (listed in bold type) must be replaced with parts obtained from Polar Instruments Ltd or your Polar Instruments distributor to ensure continued safe operation.*

# FRONT PANEL KIT

| Part Nº | Qty | Description | CircuitReference |
|---|---|---|---|
| CEA103 | 3 | 10µF Electrolytic | C57, C66, C68 |
| CVD101 | 1 | 0.1µF Polyester | C61 |
| CVD102 | 1 | 0.01µF Polyester | C62 |
| CVD105 | 2 | 0.22µF Polyester | C58, C59 |
| CVD116 | 1 | 100pF Ceramic | C60 |
| CVD136 | 4 | 0.1µF Mini Ceramic | C67, C69 |
| CVD154 * | 2 | 2n2 Polyester | C700, C701 |
| ICA129 | 1 | 7106 | U53 |
| ICA130 | 1 | 4070 | U55 |
| ICA192 | 3 | 74HC374 | U50, U51, U52 |
| ICA208 | 1 | 74HCT373 | U49 |
| ICA221 | 1 | 74HC139 | U57 |
| ICA243 | 1 | 4051 | U56 |
| LDD116 | 1 | LCD | U54 |
| LDD117 | 1 | Backlight | D76 |
| LED115 | 12 | LED Red | D46-D48, D50-D52, D54, D65-D69 |
| LED116 | 10 | LED Yellow | D53, D55, D56, D57, D58, D59, D60, D61, D62, D63 |
| LED117 | 1 | LED Green | D64 |
| MKB154 | 12 | Button Cap | |
| MPP200 | 16 | 3.8mm Spacer | |
| MPP201 | 7 | 4.3mm Spacer | |
| MQX138 | 1 | 28 Pin IC Socket | |
| MQX238 | 2 | LCD Connector | |
| QNN304 | 1 | 2N3904 Transistor | Q10 |
| RCC127 | 1 | 8 x 22K Rpak | RP5 |
| RCF100K | 1 | 100K 1/4W 5% | R195 |
| RCF1M0 | 4 | 1M0 1/4W 5% | R194, R198, R199, R200 |
| RCF200R | 1 | 200R 1/4W 5% | R185 |
| RCF22K | 1 | 22K 1/4W 5% | R197 |
| RCF270R | 20 | 270R 1/4W 5% | R174, R175, R176, R177, R178, R179 R180, R181, R182, R183, R184, R216 R217, R218, R219, R220, R221, R222 R223, R224 |
| RCF330R * | 4 | 330R 1/4W 5% | R700, R701, R702, R703 |
| RCF390R | 7 | 390R 1/4W 5% | R186, R187, R188, R189, R190, R214 R215 |
| RCF39R | 7 | 39R 1/4W 5% | R227, R228, R229, R230, R231, R232 R233 |
| RVB320 | 1 | 1K Preset | R196 |
| RVP114 | 1 | 100K Panel Pot | R192 |
| RVP115 | 1 | 100K Panel Pot (Dual) | R191 |
| SWB141 | 12 | Push-Button | S2, S3, S4, S5, S6, S7, S8, S9, S10, S12, S13, S14 |
| WMA196 | 1 | Cable Assembly | JP4 |
| WMA198 | 1 | Headphone Cable | |
| WMA199 | 1 | I/P Board Cable | |
| WMA206 | 1 | Drive Source Cable | |

## MAIN BOARD KIT

| Part Nº | Qty | Description | | CircuitReference |
|---|---|---|---|---|
| CEA103 | 12 | 10µF | Electrolytic | C4, C5, C29, C41, C49, C50, C52, C53, C71, C75*, C78*, C82 |
| CEA105 | 1 | 220µF | Electrolytic | C32 |
| CEA117 | 4 | 2,200µF | Electrolytic | C40, C43, C45, C46 |
| CEA122 | 2 | 1µF 63V | Electrolytic | C75*, C79* |
| CVD101 | 24 | 0.1µF | Polyester | C1, C6, C7, C8, C9, C14, C15, C17, C18, C26, C31, C33, C56, C64, C65 C70, C72, C74, C75*, C76, C78, C79*, C85, C90* |
| CVD102 | 13 | 0.01µF | Polyester | C3, C20, C24, C27, C28, C30, C35, C39, C73, C77, C89, C705, C706 |
| CVD105 | 3 | 0.22µF | Polyester | C36, C80, C81 |
| CVD106 | 2 | 82pF | Ceramic | C19, C38 |
| CVD109 | 30 | 0.1µF | Radial Ceramic | C44, C48, C83, C86, C702, C707, C714 |
| CVD113 | 3 | 1µF | Polyester | C23, C34, C88 |
| CVD115 | 3 | 33pF | Ceramic | C21, C54, C55 |
| CVD116 | 1 | 100pF | Ceramic | C708 |
| CVD130 | 1 | 0.022µF | Polyester | C2 |
| CVD143 | 2 | 0.1µF | Polyester | C51, C91 |
| CVD144 | 5 | 0.47µF | Polyester | C11, C12, C13, C16, C37 |
| CVD146 | 2 | 1nF | Polyester | C92, C93* |
| CVD147 | 2 | 4n7 | Polyester | C703, C704 |
| CVD148 | 2 | 1nF | Polyester | C90*, C93* |
| DBA102 | 2 | Rectifier Bridge 1.2A | | D43, D44 |
| DSP101 | 40 | Diode Signal 150mA | | D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D14, D16, D18, D19 D21, D25, D37, D38, D40, D41, D42 D72, D79, D80, D81, D82, D84, D85 D86, D87, D88, D89, D90, D91, D92 D93, D94, D96, D97 |
| DSP102 | 2 | Diode Power 1A 1kV | | D13, D39 |
| DSP105 | 2 | Diode Schottky 7.5A | | D30, D34 |
| DSP107 | 6 | Diode 1N5401 | | D31, D32, D35, D73, D77, D78 |
| DZA303 | 2 | Zener Diode 3.3V | | D1, D83 |
| DZA320 | 1 | Zener Diode 5V1 | | D29 |
| EPM112 | 1 | Buzzer | | SP2 |
| FCA124 * | 4 | 5A Fuse Wire ended | | F1, F2, F3, F4 |
| FCA130 | 1 | 0.5A T Wire ended | | F7 |
| FSW122 | 1 | Firmware ROM | | U36 |
| ICA106 | 4 | LM339N | | U13, U17, U20, U61 |
| ICA116 | 1 | MC14016BCP | | U23 |
| ICA122 | 1 | MC14013BCP | | U21 |
| ICA125 | 2 | ICL7650CPD | | U1, U12 |
| ICA126 | 1 | CA3140E | | U16 |
| ICA128 | 3 | MC7805CT | | U30, U31, U32 |
| ICA158 | 1 | MC74HC00N | | U15, U18* |
| ICA161 | 1 | MC7905CT | | U33 |
| ICA162 | 1 | LF353N | | U60 |
| ICA164 | 1 | 74HC132 | | U18* |
| ICA165 | 2 | LM311N | | U10, U14 |

| | | | |
|---|---|---|---|
| ICA166 | 1 | CD74HC74E | U44 |
| ICA173 | 1 | MC74HC04N | U3 |
| ICA186 | 2 | TL084CN (or LF347N) | U2, U9 |
| ICA187 | 1 | LM386N-1 | U22 |
| ICA188 | 1 | Z80 | U35 |
| ICA189 | 1 | TL 7705 | U38 |
| ICA190 | 2 | 74HC138 | U37, U43 |
| ICA191 | 1 | 74HC08 | U41 |
| ICA192 | 6 | 74HC374 | U28, U39, U40, U46, U47, U63 |
| ICA195 | 1 | 74HC32 | U29 |
| ICA198 | 1 | 74HC245 | U45 |
| ICA208 | 1 | 74HCT373 | U48 |
| ICA212 | 1 | L272 | U62 |
| ICA234 | 1 | Quad Opto-Isolator | U19 |
| ICA239 | 1 | 6116 RAM | U34 |
| ICA241 | 3 | 4052B | U8, U25, U59 |
| ICA245 | 1 | DAC0800 | U27 |
| ICA263 | 2 | 74HC4053 | U4, U24 |
| ICA265 | 2 | Ratiometric Hall Sensor | Q11, Q12 |
| ICA266 | 1 | CA3080E | U64 |
| ICA267 | 1 | ICL7109 | U26 |
| ICA268 | 1 | REF25Z | U65 |
| ICA269 | 3 | TLC279 | U6, U7, U58 |
| ICA299 | 1 | TL082 | U5 |
| ICA305 | 1 | 74C04 | U42 |
| IND107 | 1 | 10uH | L700 |
| IND105 | 2 | Inductor 10TURN | L1, L2 |
| LDD115 | 1 | 4MHz Ceramic Resonator | X1 |
| **MAA123** | **2** | **Fuseholder** | **F5, F6** |
| MQX138 | 1 | 28 PIN IC SKT | |
| MQX139 | 2 | 40 PIN IC SKT | |
| MQX140 | 1 | PIN HEADER | JP3 |
| MQX158 | 2 | 2-Way Header | JP9,JP13 |
| MQX259P3 | 2 | 3 X 1 Pin Header | JP10, JP12 |
| MQX259P10 | 1 | 10 X 1 Pin Header | JP11 |
| MQX237 | 4 | 6.35mm Spade Connector | |
| MQX284 | 1 | Latched Header | Vertical 40 Pin |
| MQX299 * | 2 | Link | Line Select |
| MQX300 * | 5 | 1mm Socket | |
| QNN304 | 2 | 2N3904 | Q3, Q8 |
| QPP102 | 3 | 2N3906 | Q4, Q7, Q9 |
| QPP103 | 1 | MJE350 | Q2 |
| RCC103 | 1 | 120R 5% | R7 |
| RCC108 | 1 | 68R 2W 5% | R102 |
| RCC120 | 1 | 3K3 x 8 SILPAK | RP1 |
| RCC127 | 5 | 8 x 22K SILPAK | RP2, RP3, RP4, RP6, RP7 |
| RCC143 | 2 | 2R2 11W | R125, R126 |
| RCC161 | 2 | V33ZA5 | R710, R711 |
| RCF100K | 20 | 100K 5% | R6, R7,R17, R33, R72,.R78, R83, R93, R128, R130, R138, R152, R154, R158, R164,R247, R259, R264, R289, R297 |
| RCF100R | 2 | 100R 5% | R79, R298 |

| | | | | | |
|---|---|---|---|---|---|
| RCF10K | 25 | 10K | 5% | | R12, R29, R31*, R63, R64, R74, R75, R86, R88, R89, R112, R124, R127, R147, R155, R171, R207, R208, R209, R256, R260, R265, R279, R281, R282, R717 |
| RCF10M | 1 | 10M | 5% | | R251 |
| RCF10R | 1 | 10R | 5% | | R174, R714 |
| RCF150K | 2 | 150K | 5% | | R2, R244 |
| RCF15K | 1 | 15K | 5% | | R28* |
| RCF1K0 | 25 | 1K0 | 5% | | R15, R16, R18, R21, R23, R92, R100, R109, R129, R201, R206, R213, R234, R235*, R236, R237, R253, R258, R263, R266, R269, R272, R276, R286, R290 |
| RCF1K2 | 2 | 1K2 | 5% | | R140, R142 |
| RCF1K5 | 1 | 1K5 | 5% | | R288 |
| RCF1K8 | 2 | 1K8 | 5% | | R144, R274 |
| RCF1M0 | 3 | 1M0 | 5% | | R145, R161, R172, R715 |
| RCF1R0 | 3 | 1R0 | 5% | | R4, R273, R277 |
| RCF200R | 4 | 200R | 5% | | R8, R239, R245, R287 |
| RCF20K | 6 | 20K | 5% | | R22, R28*, R162, R240, R241, R246 |
| RCF22K | 6 | 22K | 5% | | R133, R134, R136, R137, R157, R165 |
| RCF22R | 1 | 22R | 5% | | R268 |
| RCF270R | 1 | 270R | 5% | | R148 |
| RCF2K2 | 2 | 2K2 | 5% | | R242, R271 |
| RCF2M2 | 1 | 2M2 | 5% | | R151 |
| RCF2R2 | 2 | 2R2 | 5% | | R5, R103 |
| RCF330R | 1 | 330R | 5% | | R235* |
| RCF360K | 2 | 360K | 5% | | R243, R280 |
| RCF390R | 3 | 390R | 5% | | R108, R122, R173 |
| RCF3K9 | 3 | 3K9 | 5% | | R104, R105, R275 |
| RCF470K | 7 | 470K | 5% | | R26*, R80, R153, R156, R249, R262 R270 |
| RCF47K | 11 | 47K | 5% | | R32, R90, R91, R131, R132, R139, R141, R149, R150, R261, R267 |
| RCF4K7 | 10 | 4K7 | 5% | | R19, R82, R110, R111, R250, R254, R255, R278, R294, R296 |
| RCF4M7 | 2 | 4M7 | 5% | | R106, R107 |
| RCF560K | 1 | 560K | 5% | | R1 |
| RCF56K | 1 | 56K | 5% | | R27* |
| RCF56R | 3 | 56R | 5% | | R20, R24, R257 |
| RCF5K6 | 4 | 5K6 | 5% | | R101, R135, R143, R248 |
| RCF68K | 1 | 68K | 5% | | R27* |
| RCF8K2 | 2 | 8K2 | 5% | | R31*, R712 |
| RCF820K | 1 | 820K | 5% | | R26* |
| RCF91K | 2 | 91K | 5% | | R123, R291 |
| RCT100K | 5 | 100K | 1/4W 1% | | R45, R58, R59, R60, R68, R99 |
| RCT10K | 8 | 10K | 1/4W 1% | | R51, R52, R53, R55, R57, R292, R293, R295 |
| RCT10R | 1 | 10R | 1/4W | % | R38 |
| RCT113K | 1 | 113K | 1/4W | 1% | R95 |
| RCT11R0 | 2 | 11R0 | 1/4W | 1% | R37, R42 |
| RCT180K | 1 | 180K | 1/4W | 1% | R87 |

| | | | | | |
|---|---|---|---|---|---|
| RCT1K | 1 | 1K | 1/4W | 1% | R3 |
| RCT1M0 | 3 | 1MO | 1/4W | 1% | R46, R54, R56 |
| RCT1R0 | 3 | 1RO | 1/4W | 1% | R36, R43, R284 |
| RCT200R | 1 | 200R | 1/4W | 1% | R203 |
| RCT20K | 2 | 20K | 1/4W | 1% | R11, R96 |
| RCT220K | 1 | 220K | 1/4W | 1% | R97 |
| RCT24K | 1 | 24K | 1/4W | 1% | R14 |
| RCT2K0 | 3 | 2K0 | 1/4W | 1% | R10, R159, 5160 |
| RCT430K | 1 | 430K | 1/4W | 1% | R204 |
| RCT470K | 1 | 470K | 1/4W | 1% | R13 |
| RCT560K | 1 | 560K | 1/4W | 1% | R41 |
| RCT56K | 1 | 56K | 1/4W | 1% | R40 |
| RCT56R | 1 | 56R | 1/4W | 1% | R39 |
| RCT75K | 1 | 75K | 1/4W | 1% | R205 |
| REL111 | 9 | Reed Relay | | | K2, K3, K6, K7, K8, K9, K10, K11, K12 |
| REL112 | 2 | 2-POLE Reed Relay | | | K1, K4, |
| REL113 | 1 | SPNO 5A Relay | | | K14 |
| RVB315 | 1 | 100K | Preset | | R94 |
| RVB316 | 2 | 10K | Preset | | R30*, R713, R716 |
| RVB319 | 1 | 10K | Preset | | R30* |
| RVB320 | 1 | 1K | Preset | | R163 |
| RVB323 | 1 | 100K | Preset | | R85 |
| **SWB133** | **1** | **Power Switch** | | | **S1** |
| **SWB143** | **1** | **Line Selector Switch** | | | **S15*** |
| **TXM125** | **1** | **Power Transformer** | | | **T2*** |
| **TXM146** | **1** | **Power Transformer** | | | **T2*** |
| WMA108 | 2 | 0.5"Link | | | LK8, R252 |

# MECHANICAL KIT

| 0Part Nº | Qty | Description | CircuitReference |
|---|---|---|---|
| CVD155 * | 5 | 470pF Polypropylene | C709, C710, C711, C712, C713 |
| EPM111 | 1 | Loudspeaker | |
| FCA112 | 2 | Fuse 250mA T | F5*, F6* 115V |
| FCA119 | 2 | Fuse 125mA T | F5*, F6* 230V |
| FCA121 | 2 | Fuse 160mA T | F5*,F6* 230V |
| FCA122 | 2 | Fuse 315mA T | F5*,F6* 115V |
| IND107 * | 1 | 10uH | L701 |
| **IND109** | **1** | **Ferrite Clamp** | |
| MCA138 | 1 | Enclosure Top | |
| MCA139 | 1 | Enclosure Bottom | |
| MCA143 | 1 | Front Moulding | |
| MKB127 | 2 | Knob – Cap grey with line | |
| MKB128 | 2 | Knob – Grey push on | |
| MKB153 | 1 | Button (Round Black) | |
| MMP107 | 5 | Nylon Cable Tie 75mm O/A | |
| MNS107 | 17 | K30 x 6 self tap | |
| MNS117 | 2 | M3 x 10 Pan Hd | |
| MNS163 | 2 | M3 x 12 Csk | |
| MNS164 | 4 | K30 x 10 self tap | |
| MNS175 | 2 | M3 Flange nut | |
| MNS176 | 2 | K30 x 8 self tap | |
| MPP142 | 2 | PCB support | |
| MPP155 | 1 | Cable Clip | |
| MPP191 | 2 | Tilt Assembly Leg | |
| MPP193 | 4 | Bumper Foot | |
| MPP198 | 2 | Tilt Assembly Base | |
| MPP210 | 1 | IEC Inlet Boot | |
| MPP230 | 3 | Cable tie | |
| MPP231 | 2 | Insert Cover | |
| MQX154 | 1 | Din Socket 5 x 45' | |
| MQX155 | 1 | Din Socket 5 x 60' | |
| MQX158 | 1 | 2-Way Header | |
| MQX179 | 1 | 4mm Red Socket | |
| MQX210 | 1 | 4mm Blue Socket | |
| MQX222 | 1 | 3.5mm Stereo PCB Jack | |
| MQX223 | 1 | 5 Pin Din "Domino", Polarised | |
| MQX224 | 1 | 4mm Yellow Socket | |
| MQX225 | 1 | 4mm Green Socket | |
| **MQX254 *** | **1** | **IEC Inlet Connector** | |
| **MQX314 *** | **1** | **IEC Filtered Inlet** | |
| MWP233 | 1 | Front Panel Label | |
| MWP234 | 1 | LCD Window Label | |
| MWP235* | 1 | Rear panel Label | |
| MWPD1057* | 1 | Rear Label | |
| **MWPD1079** | **1** | **Flexishield** | |
| RCC129 | 2 | 82ZA2 Varistor | R705, R710 |
| RCC133 | 4 | 22ZA1 Varistor | R706, R707, R708, R709 |
| WMA104 | 0.25m | Green/Yellow wire | |
| WMA108 | 1 | 0.5" Link | |

| | | | |
|---|---|---|---|
| WMA197 | 2 | Speaker Lead | |
| WMA202* | 4 | Plane Cable Blue | |
| WMA305* | 1 | Plane Drive Cable | |

# SECTION 9 – SCHEMATIC DIAGRAMS

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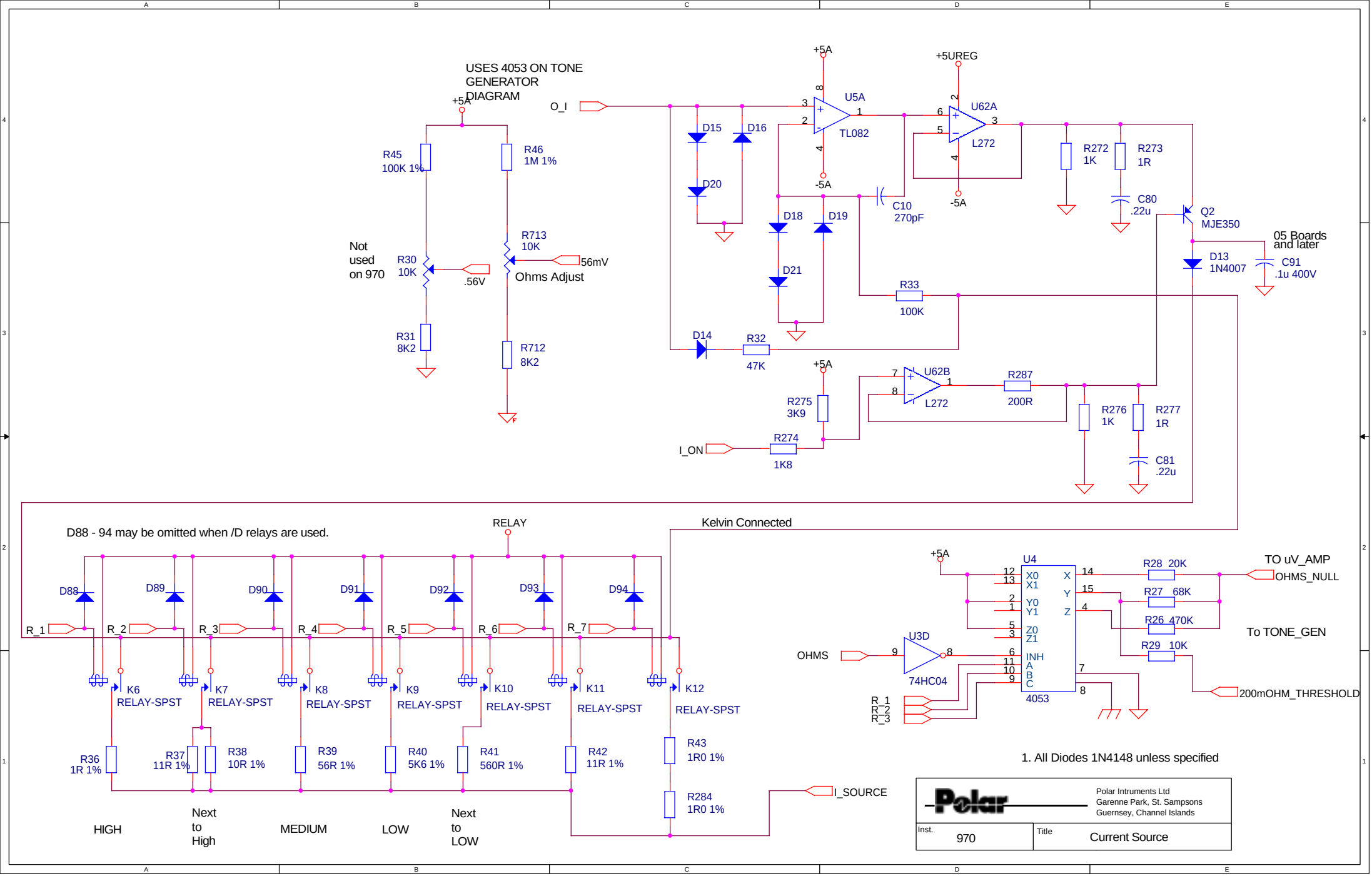
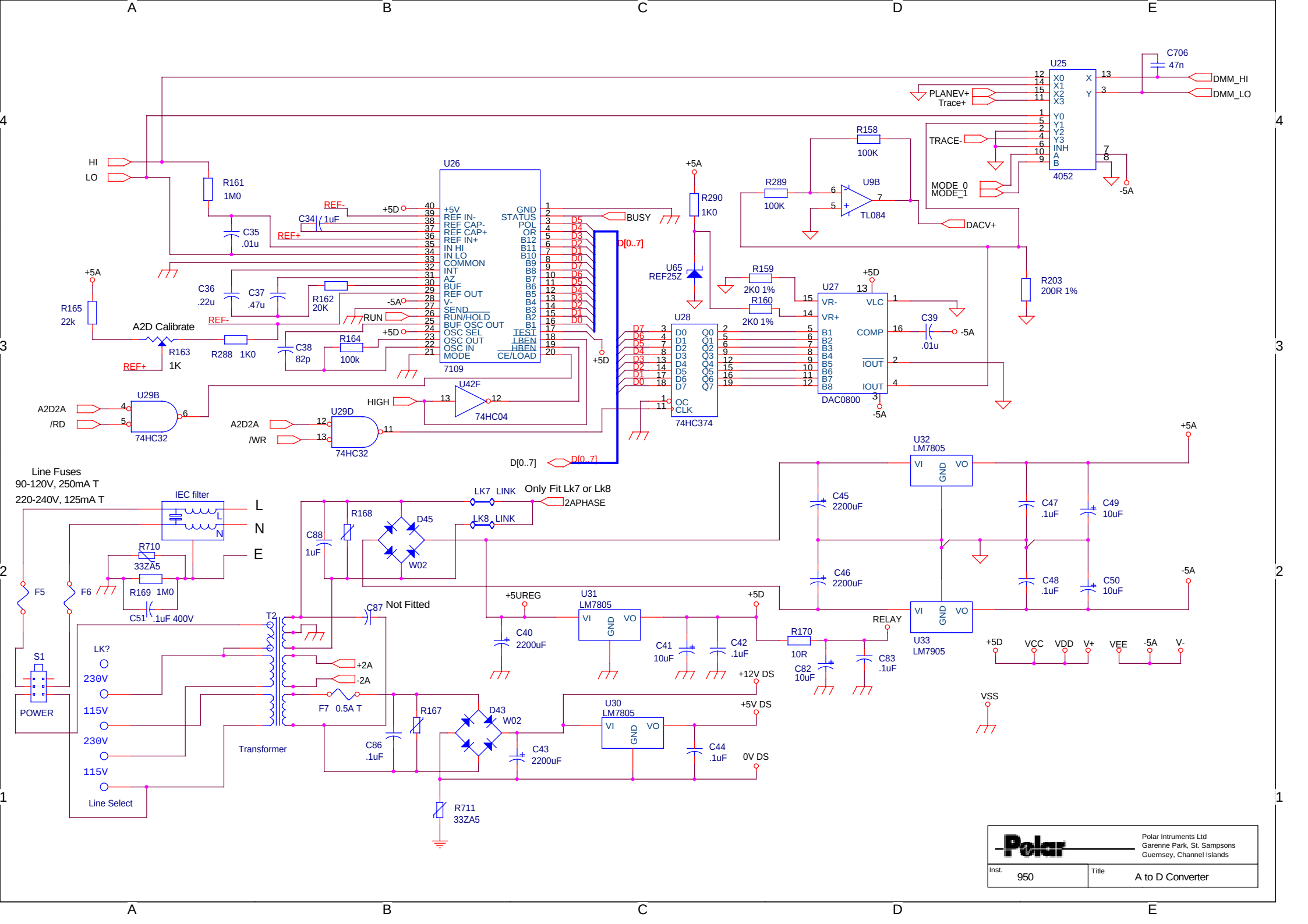
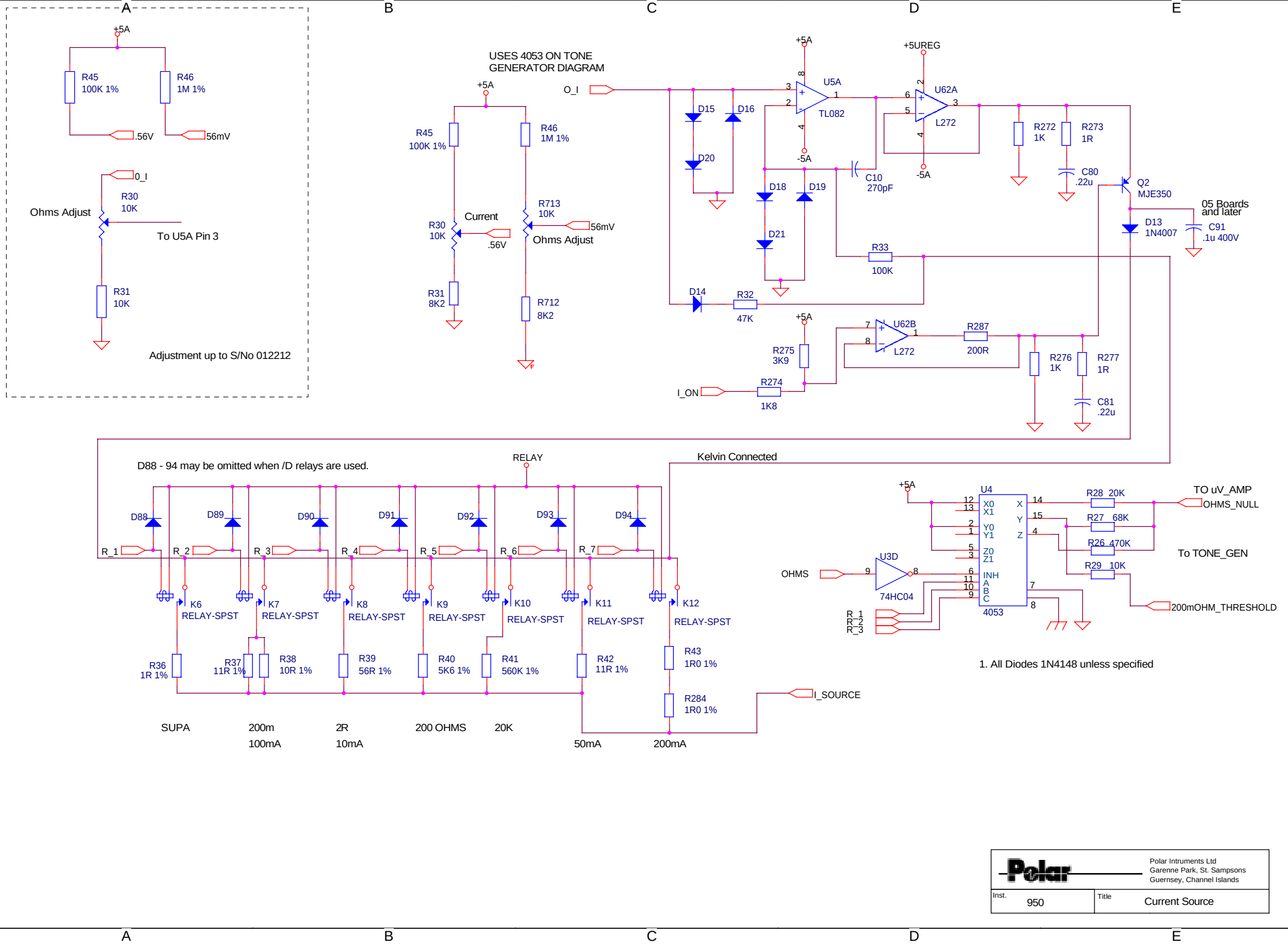
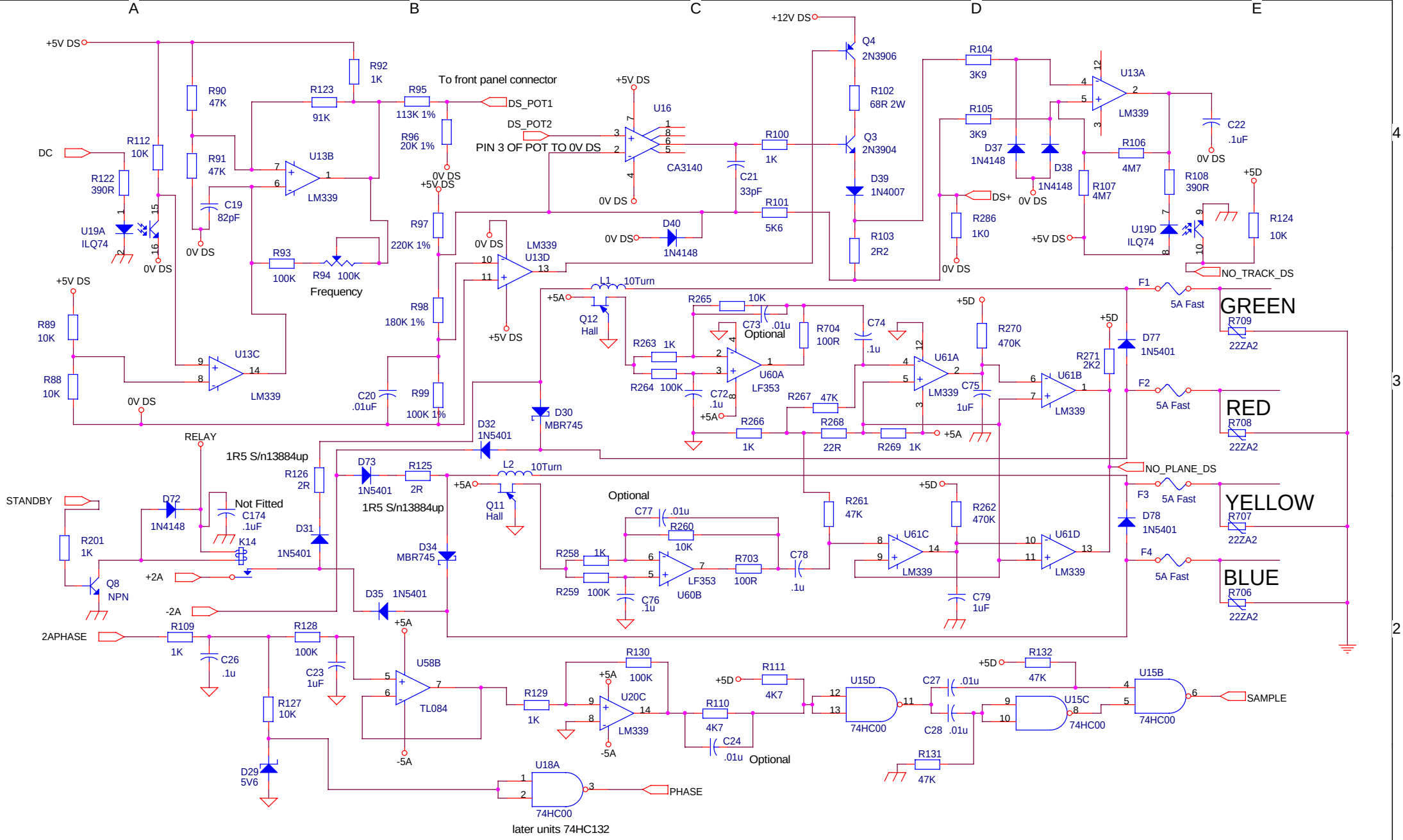
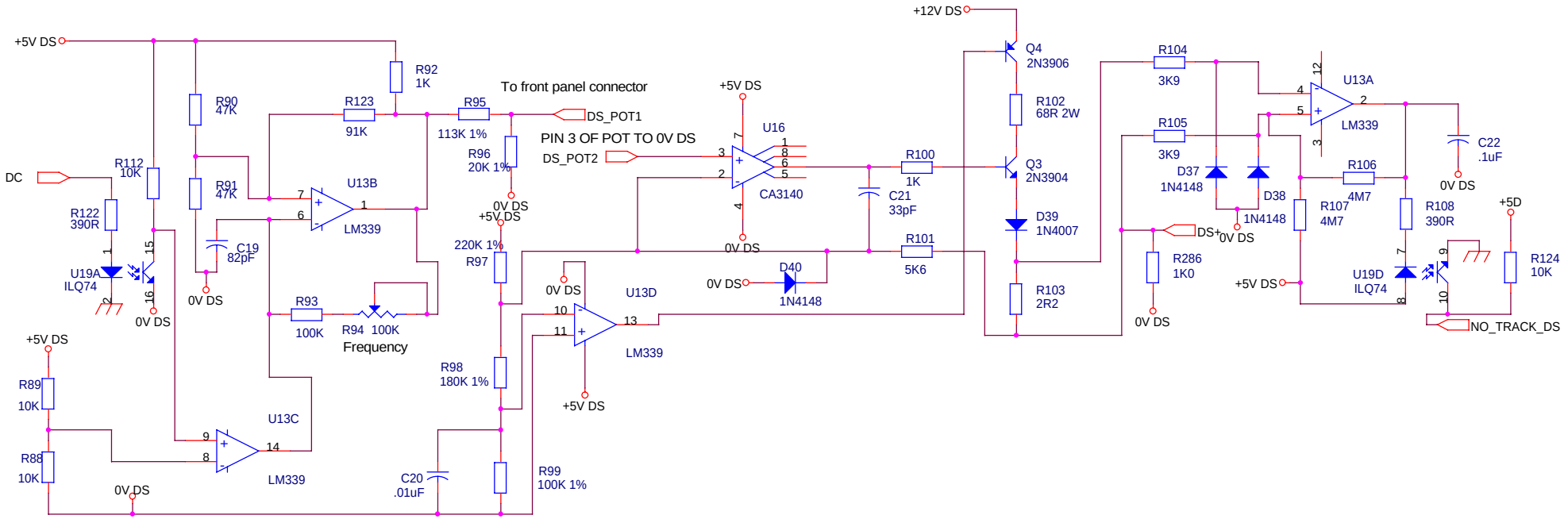

USES 4053 ON TONE GENERATOR DIAGRAM
+5A
O_I
U5A
TL082
+5UREG
U62A
L272
D15
D16
D20
D18
D19
D21
C10 270pF
R45 100K 1%
R46 1M 1%
R713 10K
56mV
Ohms Adjust
Not used on 970
R30 10K
.56V
R31 8K2
R712 8K2
R272 1K
R273 1R
C80 .22u
Q2 MJE350
05 Boards and later
D13 1N4007
C91 .1u 400V
R33 100K
D14
R32 47K
U62B
R287 200R
R275 3K9
R274 1K8
I_ON
R276 1K
R277 1R
C81 .22u
D88 - 94 may be omitted when /D relays are used.
RELAY
Kelvin Connected
D88
D89
D90
D91
D92
D93
D94
R_1
R_2
R_3
R_4
R_5
R_6
R_7
K6 RELAY-SPST
K7 RELAY-SPST
K8 RELAY-SPST
K9 RELAY-SPST
K10 RELAY-SPST
K11 RELAY-SPST
K12 RELAY-SPST
R36 1R 1%
R37 11R 1%
R38 10R 1%
R39 56R 1%
R40 5K6 1%
R41 560R 1%
R42 11R 1%
R43 1R0 1%
R284 1R0 1%
I_SOURCE
HIGH
Next to High
MEDIUM
LOW
Next to LOW
U4
4053
U3D
74HC04
OHMS
R28 20K
R27 68K
R26 470K
R29 10K
TO uV_AMP
OHMS_NULL
To TONE_GEN
200mOHM_THRESHOLD
1. All Diodes 1N4148 unless specified
Polar Intruments Ltd
Garenne Park, St. Sampsons
Guernsey, Channel Islands
Inst. 970
Title Current Source


HI
LO
R161
1M0
C35
.01u
REF-
REF+
C34
1uF
+5D
U26
+5V
REF IN-
REF CAP-
REF CAP+
REF IN+
IN HI
IN LO
COMMON
INT
AZ
BUF
REF OUT
V-
SEND
RUN/HOLD
BUF OSC OUT
OSC SEL
OSC OUT
OSC IN
MODE
GND
STATUS
POL
OR
B12
B11
B10
B9
B8
B7
B6
B5
B4
B3
B2
B1
TEST
LBEN
HBEN
CE/LOAD
7109
BUSY
D[0..7]
+5A
R290
1K0
U65
REF25Z
R289
100K
R158
100K
U9B
TL084
DACV+
TRACE-
MODE_0
MODE_1
U25
X0
X1
X2
X3
Y0
Y1
Y2
Y3
INH
A
B
X
Y
4052
PLANEV+
Trace+
C706
47n
DMM_HI
DMM_LO
-5A
R159
2K0 1%
R160
2K0 1%
U27
VR-
VR+
VLC
COMP
IOUT
IOUT
DAC0800
C39
.01u
R203
200R 1%
U28
74HC374
+5A
R165
22k
A2D Calibrate
R163
1K
R288 1K0
C36
.22u
C37
.47u
R162
20K
C38
82p
R164
100k
RUN
-5A
U29B
74HC32
A2D2A
/RD
U42F
74HC04
HIGH
U29D
74HC32
A2D2A
/WR
Line Fuses
90-120V, 250mA T
220-240V, 125mA T
IEC filter
L
N
E
F5
F6
R710
33ZA5
R169 1M0
C51 .1uF 400V
S1
POWER
LK?
230V
115V
230V
115V
Line Select
T2
Transformer
+2A
-2A
F7 0.5A T
C87 Not Fitted
R168
C88
1uF
D45
W02
LK7 LINK
LK8 LINK
Only Fit Lk7 or Lk8
2APHASE
+5UREG
C40
2200uF
U31
LM7805
C41
10uF
C42
.1uF
+12V DS
R167
C86
.1uF
D43
W02
C43
2200uF
U30
LM7805
C44
.1uF
+5V DS
0V DS
R711
33ZA5
R170
10R
C82
10uF
C83
.1uF
RELAY
U33
LM7805
U32
LM7805
C45
2200uF
C46
2200uF
C47
.1uF
C48
.1uF
C49
10uF
C50
10uF
+5A
-5A
+5D
VCC
VDD
V+
VEE
-5A
V-
VSS
Polar
Polar Intruments Ltd
Garenne Park, St. Sampsons
Guernsey, Channel Islands
Inst.
950
Title
A to D Converter

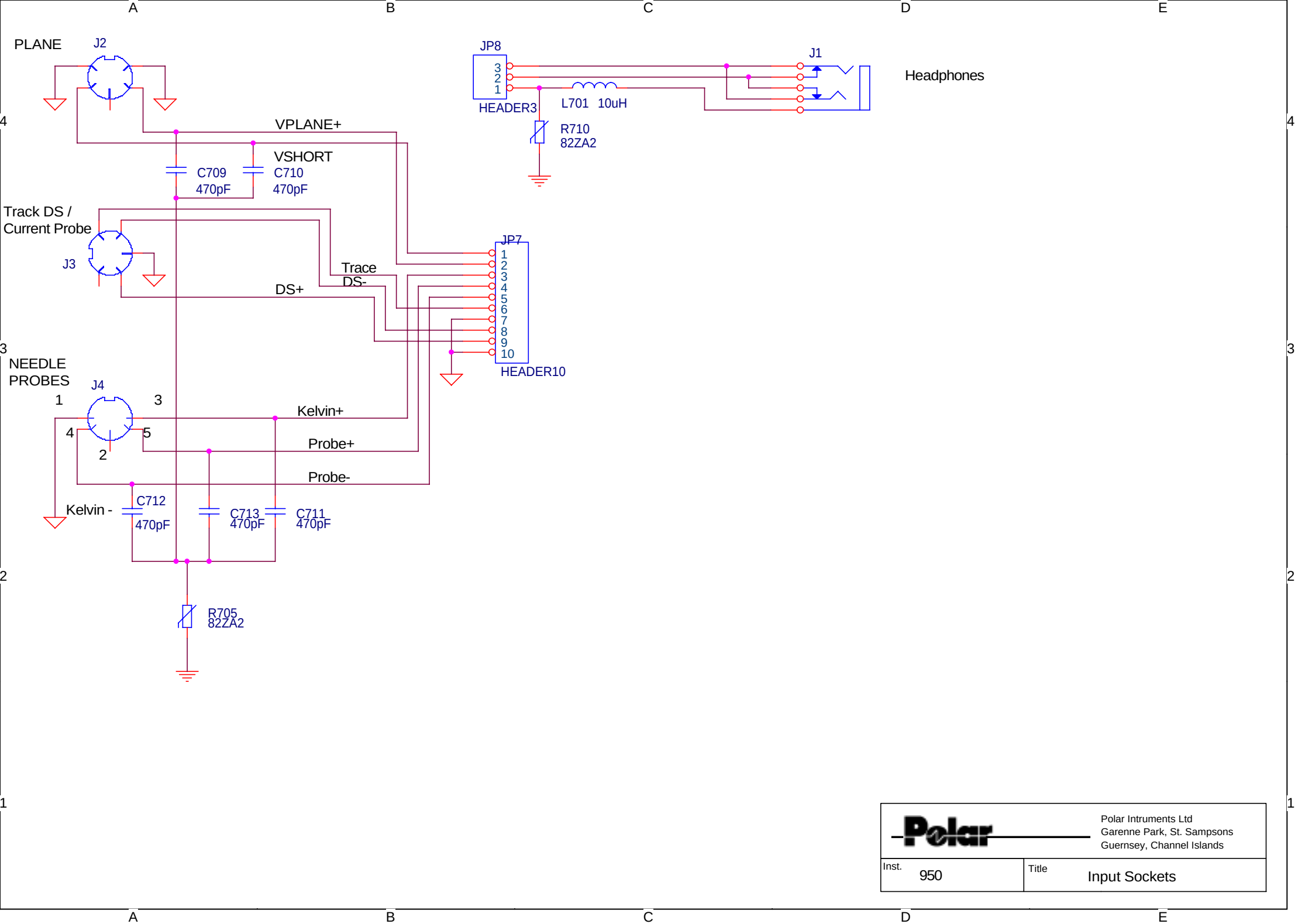

+5A
R45
100K 1%
R46
1M 1%
.56V
56mV
0_I
Ohms Adjust
R30
10K
To U5A Pin 3
R31
10K
Adjustment up to S/No 012212
USES 4053 ON TONE
GENERATOR DIAGRAM
+5A
R45
100K 1%
R46
1M 1%
R30
10K
Current
.56V
R713
10K
56mV
Ohms Adjust
R31
8K2
R712
8K2
O_I
U5A
TL082
+5UREG
U62A
L272
-5A
C10
270pF
D15
D16
D20
D18
D19
D21
R33
100K
D14
R32
47K
R272
1K
R273
1R
C80
.22u
Q2
MJE350
D13
1N4007
05 Boards
and later
C91
.1u 400V
U62B
L272
R287
200R
R275
3K9
R274
1K8
I_ON
R276
1K
R277
1R
C81
.22u
D88 - 94 may be omitted when /D relays are used.
RELAY
Kelvin Connected
D88
D89
D90
D91
D92
D93
D94
R_1
R_2
R_3
R_4
R_5
R_6
R_7
K6
RELAY-SPST
K7
RELAY-SPST
K8
RELAY-SPST
K9
RELAY-SPST
K10
RELAY-SPST
K11
RELAY-SPST
K12
RELAY-SPST
R36
1R 1%
R37
11R 1%
R38
10R 1%
R39
56R 1%
R40
5K6 1%
R41
560K 1%
R42
11R 1%
R43
1R0 1%
R284
1R0 1%
I_SOURCE
SUPA
200m
100mA
2R
10mA
200 OHMS
20K
50mA
200mA
U4
4053
U3D
74HC04
OHMS
R_1
R_2
R_3
R28 20K
R27 68K
R26 470K
R29 10K
TO uV_AMP
OHMS_NULL
To TONE_GEN
200mOHM_THRESHOLD
1. All Diodes 1N4148 unless specified
Polar
Polar Intruments Ltd
Garenne Park, St. Sampsons
Guernsey, Channel Islands
Inst.
950
Title
Current Source



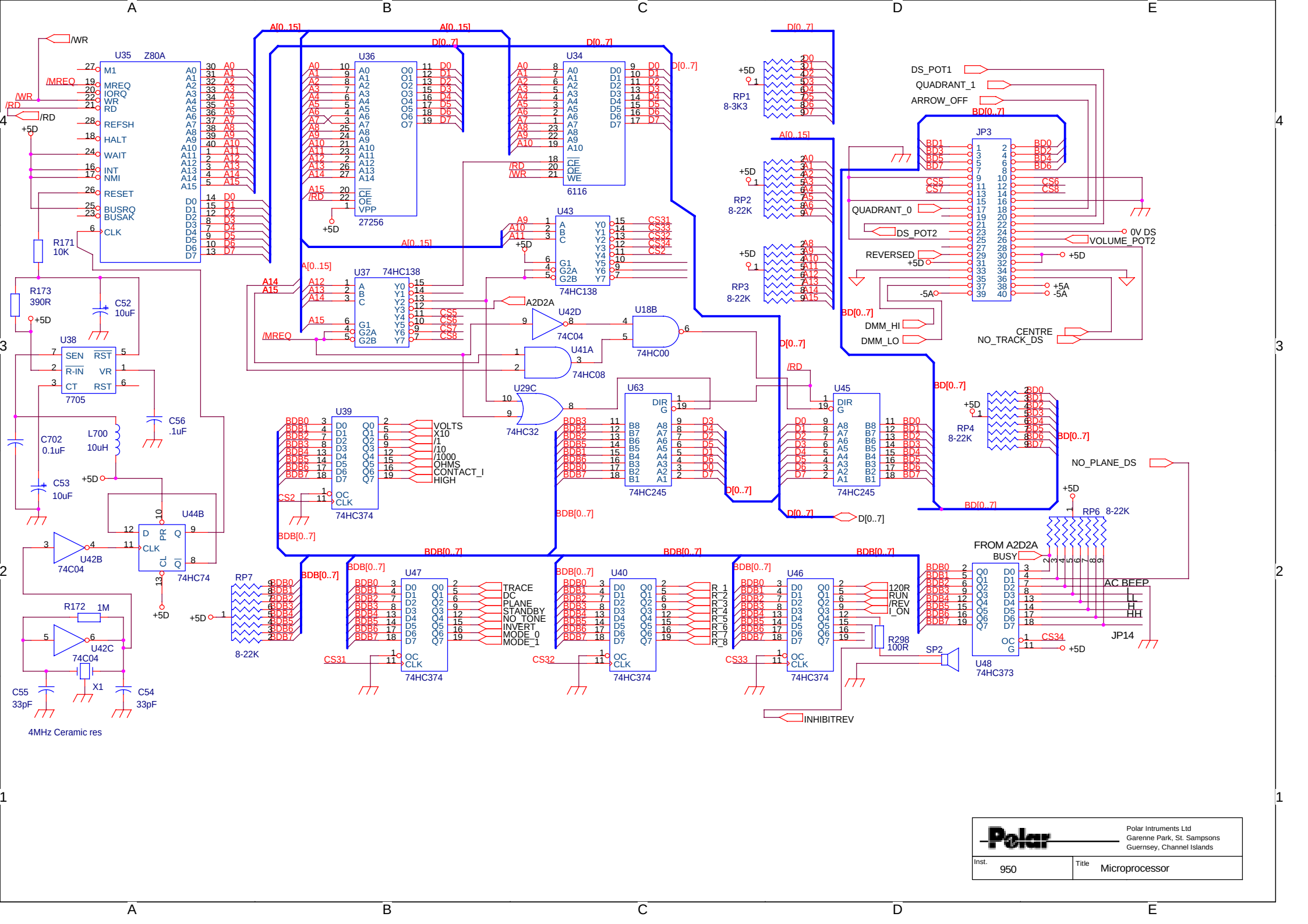

| | |
|---|---|
| Polar | Polar Intruments Ltd<br>Garenne Park, St. Sampsons<br>Guernsey, Channel Islands |
| Inst. 950 | Title Drive Source |



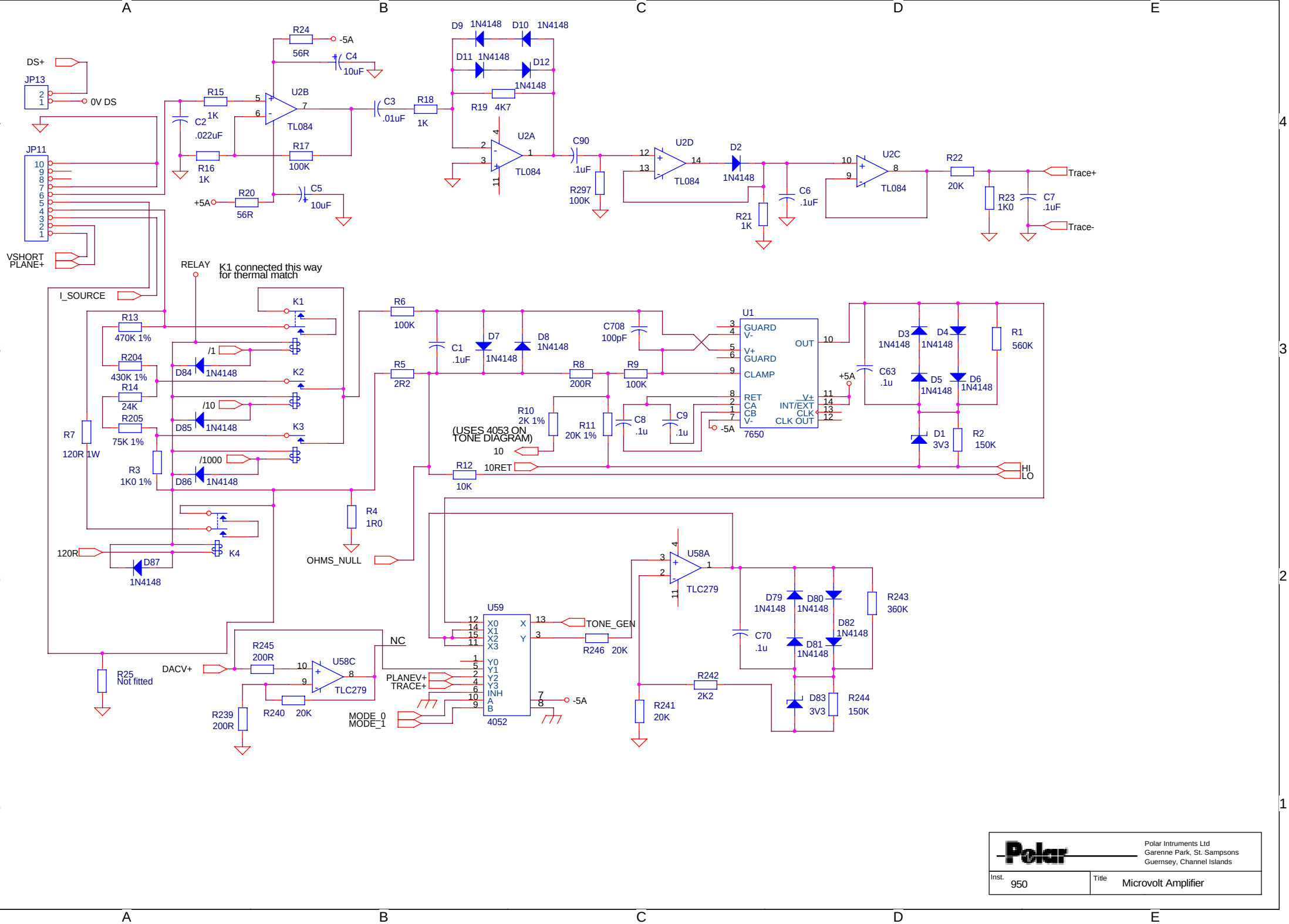

| | |
|---|---|
| Polar | Polar Intruments Ltd<br>Garenne Park, St. Sampsons<br>Guernsey, Channel Islands |
| Inst. 950 | Title Drive Source |

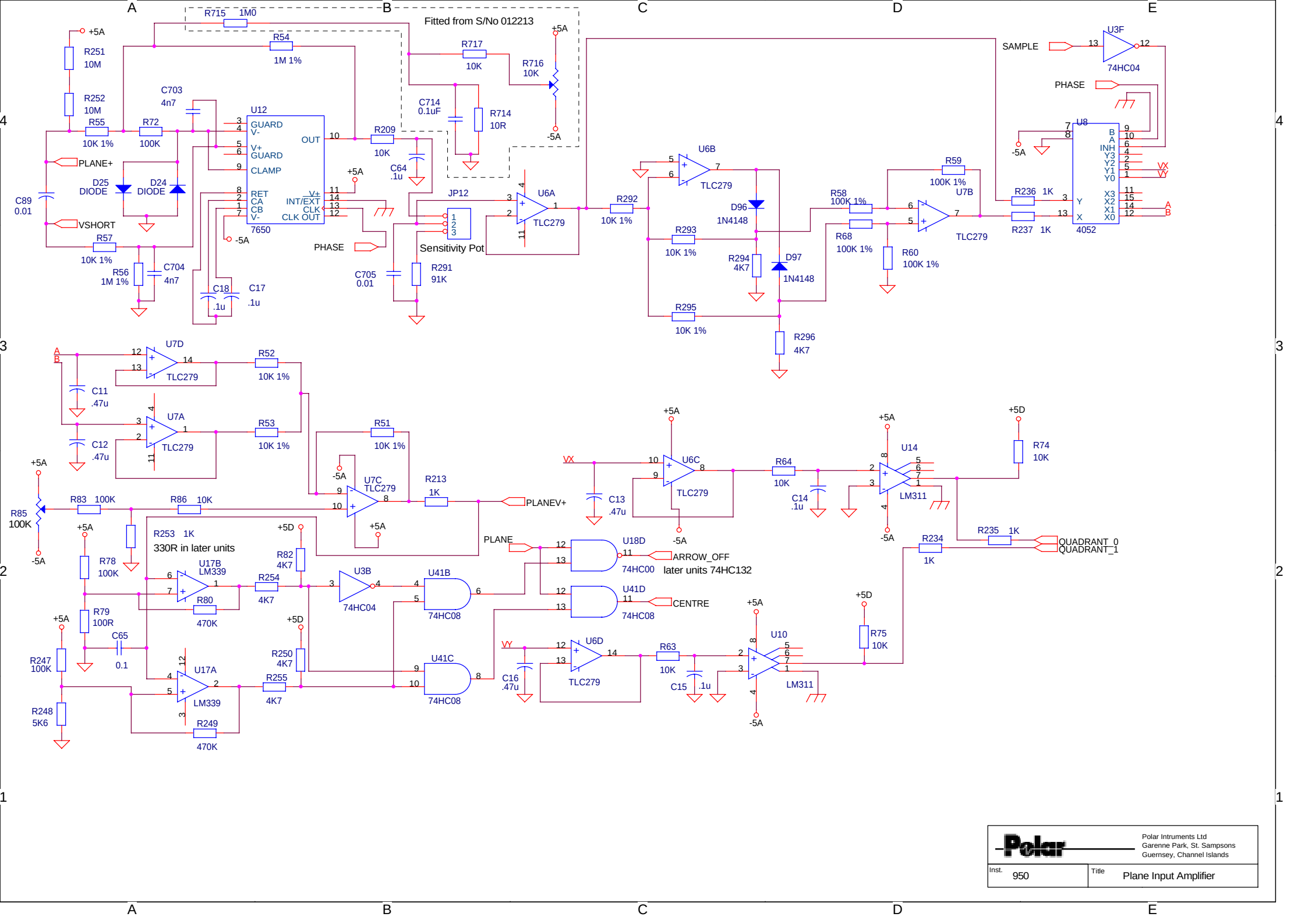


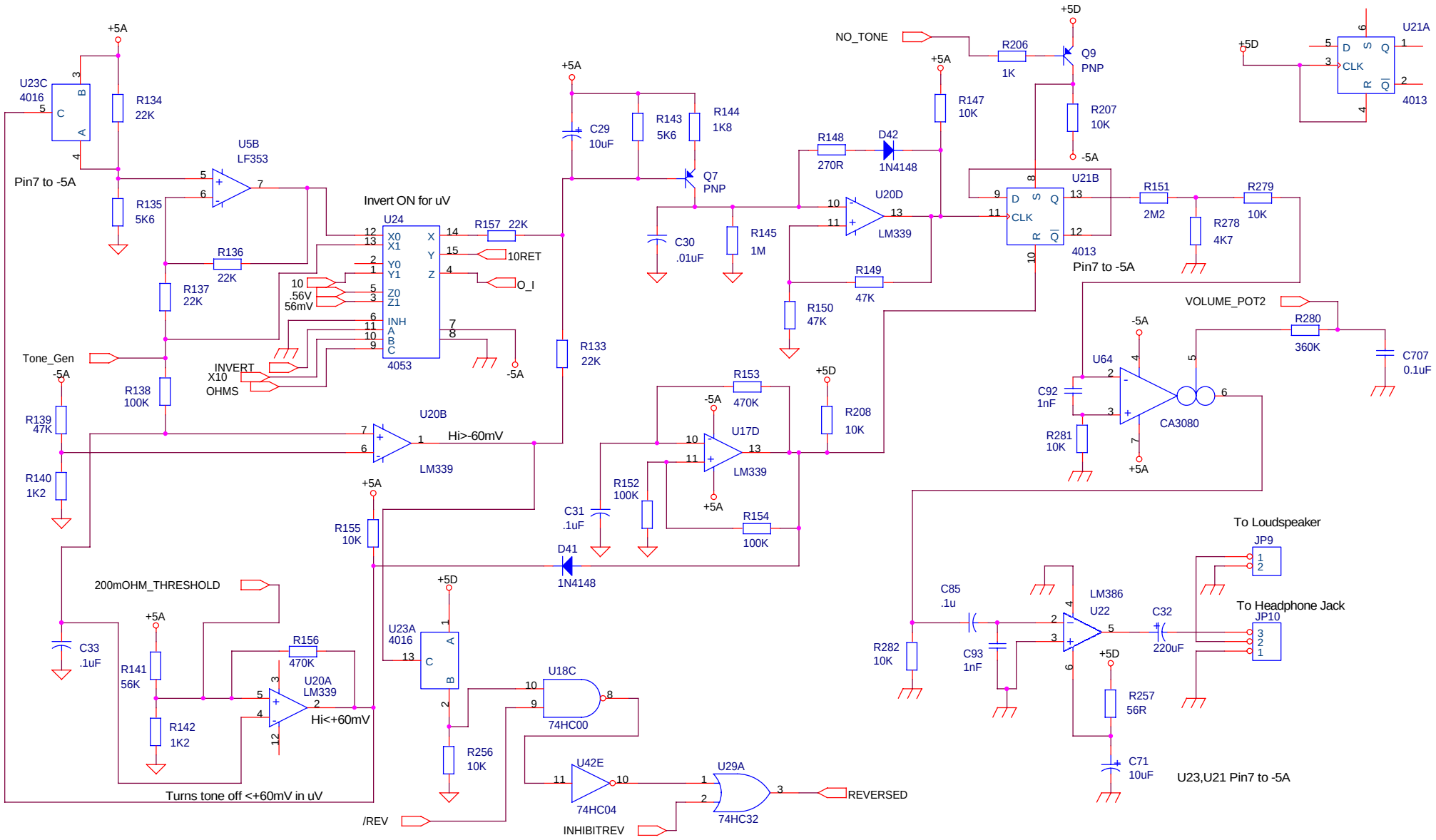

| | |
|---|---|
| Polar | Polar Intruments Ltd<br>Garenne Park, St. Sampsons<br>Guernsey, Channel Islands |
| Inst. 950 | Title Input Sockets |



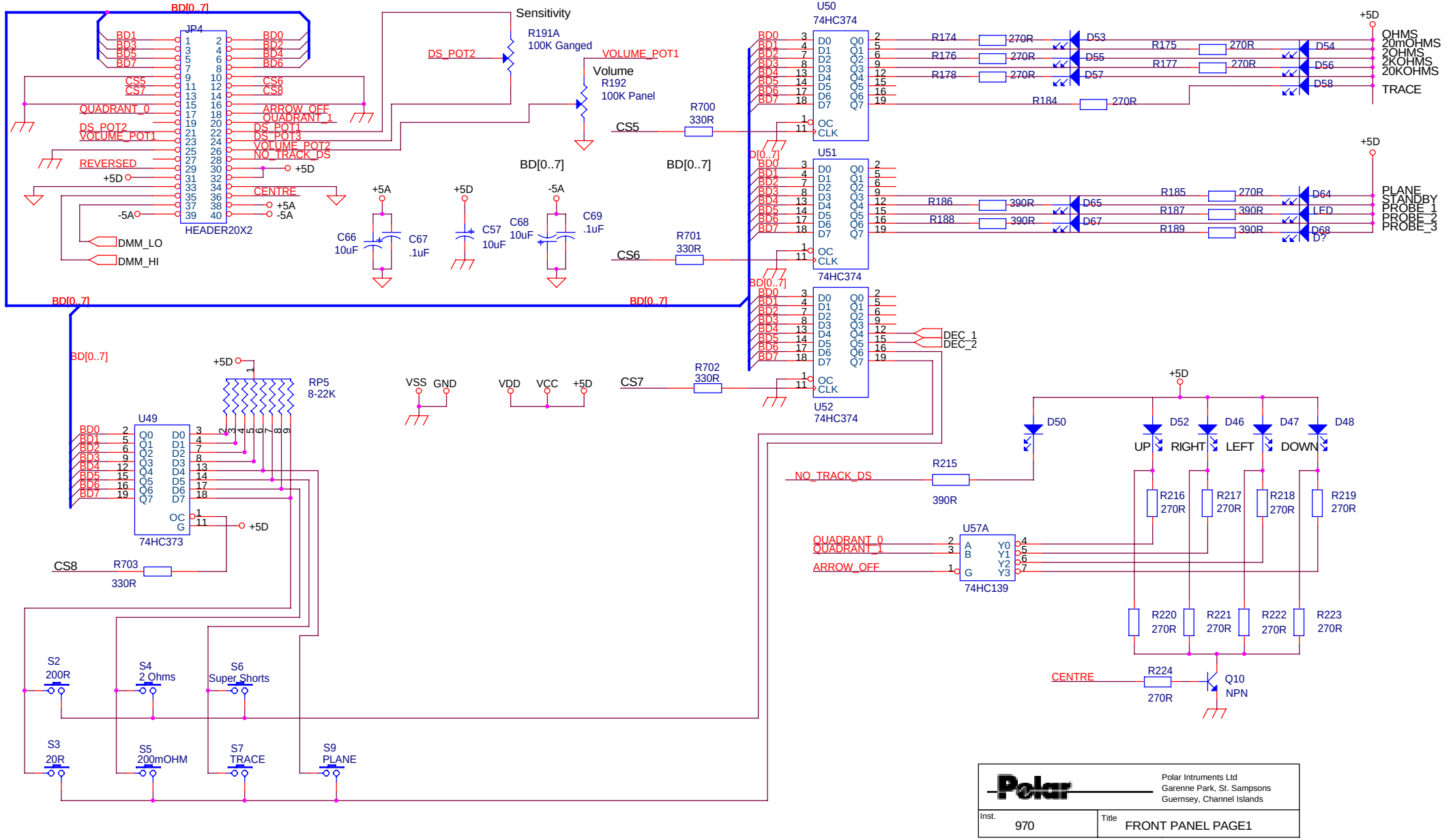

| | |
|---|---|
| Polar | Polar Intruments Ltd<br>Garenne Park, St. Sampsons<br>Guernsey, Channel Islands |
| Inst. 950 | Title Microprocessor |

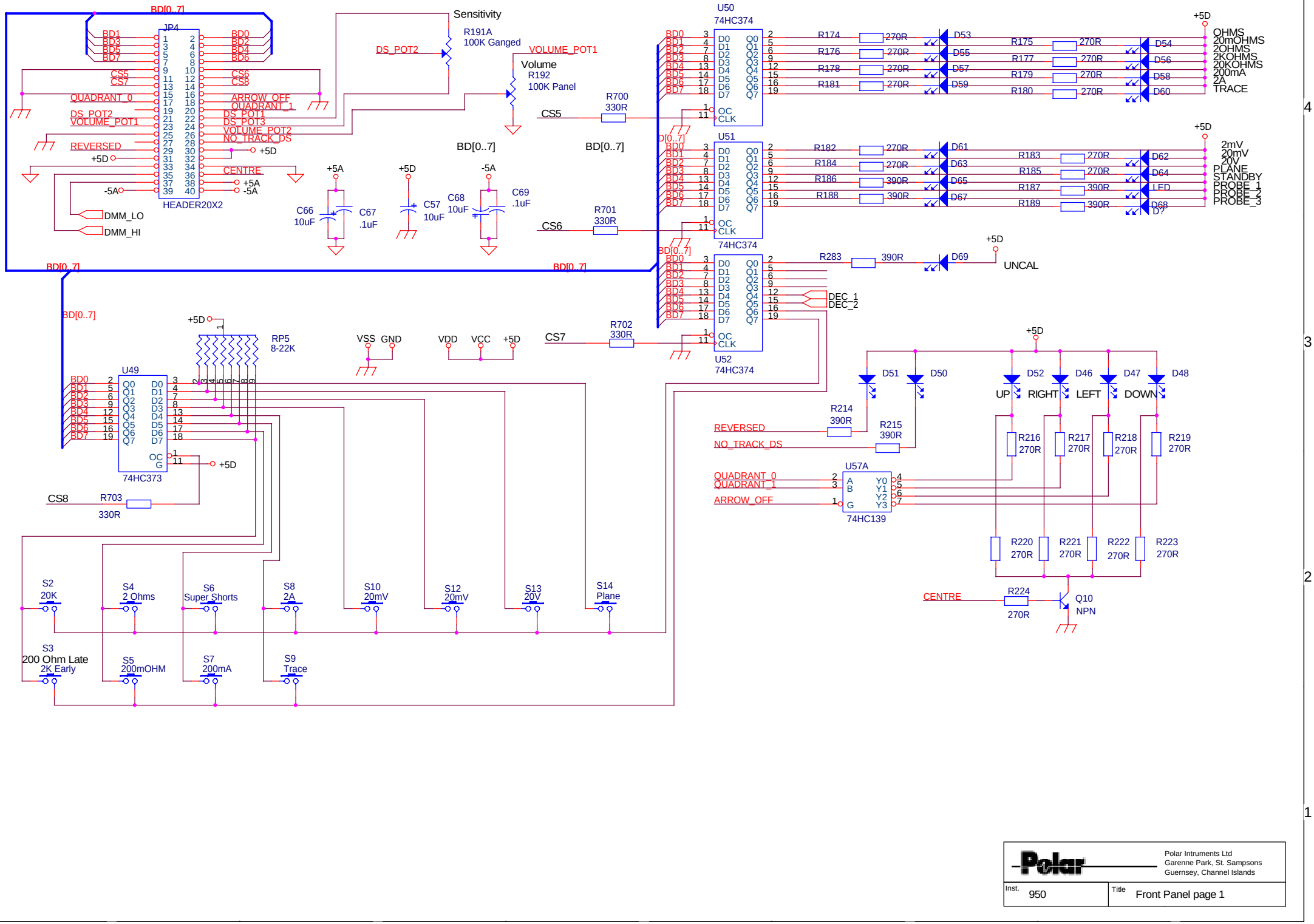

DS+
JP13
0V DS
JP11
VSHORT
PLANE+
I_SOURCE
RELAY
K1 connected this way
for thermal match
R24
56R
-5A
C4
10uF
R15
1K
C2
.022uF
R16
1K
U2B
TL084
R17
100K
C3
.01uF
R18
1K
+5A
R20
56R
C5
10uF
D9 1N4148
D10 1N4148
D11 1N4148
D12
1N4148
R19 4K7
U2A
TL084
C90
.1uF
R297
100K
U2D
TL084
D2
1N4148
R21
1K
C6
.1uF
U2C
TL084
R22
20K
R23
1K0
C7
.1uF
Trace+
Trace-
R13
470K 1%
R204
430K 1%
R14
24K
R205
75K 1%
R3
1K0 1%
R7
120R 1W
/1
/10
/1000
D84 1N4148
D85 1N4148
D86 1N4148
K1
K2
K3
K4
120R
D87
1N4148
R6
100K
R5
2R2
C1
.1uF
D7
D8
1N4148
C708
100pF
R8
200R
R9
100K
U1
GUARD
V-
V+
GUARD
CLAMP
RET
CA
CB
V-
OUT
V+
INT/EXT
CLK
CLK OUT
7650
C63
.1u
D3
D4
D5
D6
1N4148
R1
560K
D1
3V3
R2
150K
HI
LO
R10
2K 1%
R11
20K 1%
C8
.1u
C9
.1u
(USES 4053 ON
TONE DIAGRAM)
10
R12
10K
10RET
R4
1R0
OHMS_NULL
U59
4052
TONE_GEN
R246 20K
U58A
TLC279
D79
D80
D81
D82
1N4148
R243
360K
C70
.1u
R242
2K2
R241
20K
D83
3V3
R244
150K
R245
200R
U58C
TLC279
DACV+
NC
PLANEV+
TRACE+
R240 20K
R239
200R
MODE_0
MODE_1
R25
Not fitted
Polar
Polar Intruments Ltd
Garenne Park, St. Sampsons
Guernsey, Channel Islands
Inst.
950
Title
Microvolt Amplifier


Fitted from S/No 012213
R715 1M0
R54 1M 1%
R251 10M
R252 10M
R55 10K 1%
R72 100K
C703 4n7
U12
GUARD
V-
V+
GUARD
CLAMP
RET
CA
CB
V-
OUT
INT/EXT
CLK
CLK OUT
7650
PLANE+
VSHORT
D25 DIODE
D24 DIODE
C89 0.01
R57 10K 1%
R56 1M 1%
C704 4n7
C18 .1u
C17 .1u
-5A
+5A
R209 10K
C64 .1u
PHASE
JP12
Sensitivity Pot
C705 0.01
R291 91K
R717 10K
R716 10K
C714 0.1uF
R714 10R
U6A
TLC279
R292 10K 1%
U6B
TLC279
R293 10K 1%
R295 10K 1%
D96 1N4148
R294 4K7
D97 1N4148
R296 4K7
R58 100K 1%
R68 100K 1%
R59 100K 1%
R60 100K 1%
U7B
TLC279
SAMPLE
U3F
74HC04
PHASE
U8
4052
R236 1K
R237 1K
VX
VY
U7D
TLC279
R52 10K 1%
C11 .47u
U7A
TLC279
R53 10K 1%
C12 .47u
R51 10K 1%
U7C
TLC279
R213 1K
PLANEV+
R85 100K
R83 100K
R86 10K
R253 1K
330R in later units
R78 100K
R79 100R
C65 0.1
R247 100K
R248 5K6
U17B
LM339
R80 470K
U17A
LM339
R249 470K
R82 4K7
R254 4K7
R250 4K7
R255 4K7
U3B
74HC04
U41B
74HC08
U41C
74HC08
PLANE
U18D
74HC00
ARROW_OFF
later units 74HC132
U41D
74HC08
CENTRE
U6C
TLC279
C13 .47u
R64 10K
C14 .1u
U6D
TLC279
C16 .47u
R63 10K
C15 .1u
U14
LM311
U10
LM311
R74 10K
R75 10K
R234 1K
R235 1K
QUADRANT_0
QUADRANT_1
+5D
Polar Intruments Ltd
Garenne Park, St. Sampsons
Guernsey, Channel Islands
Inst. 950
Title Plane Input Amplifier

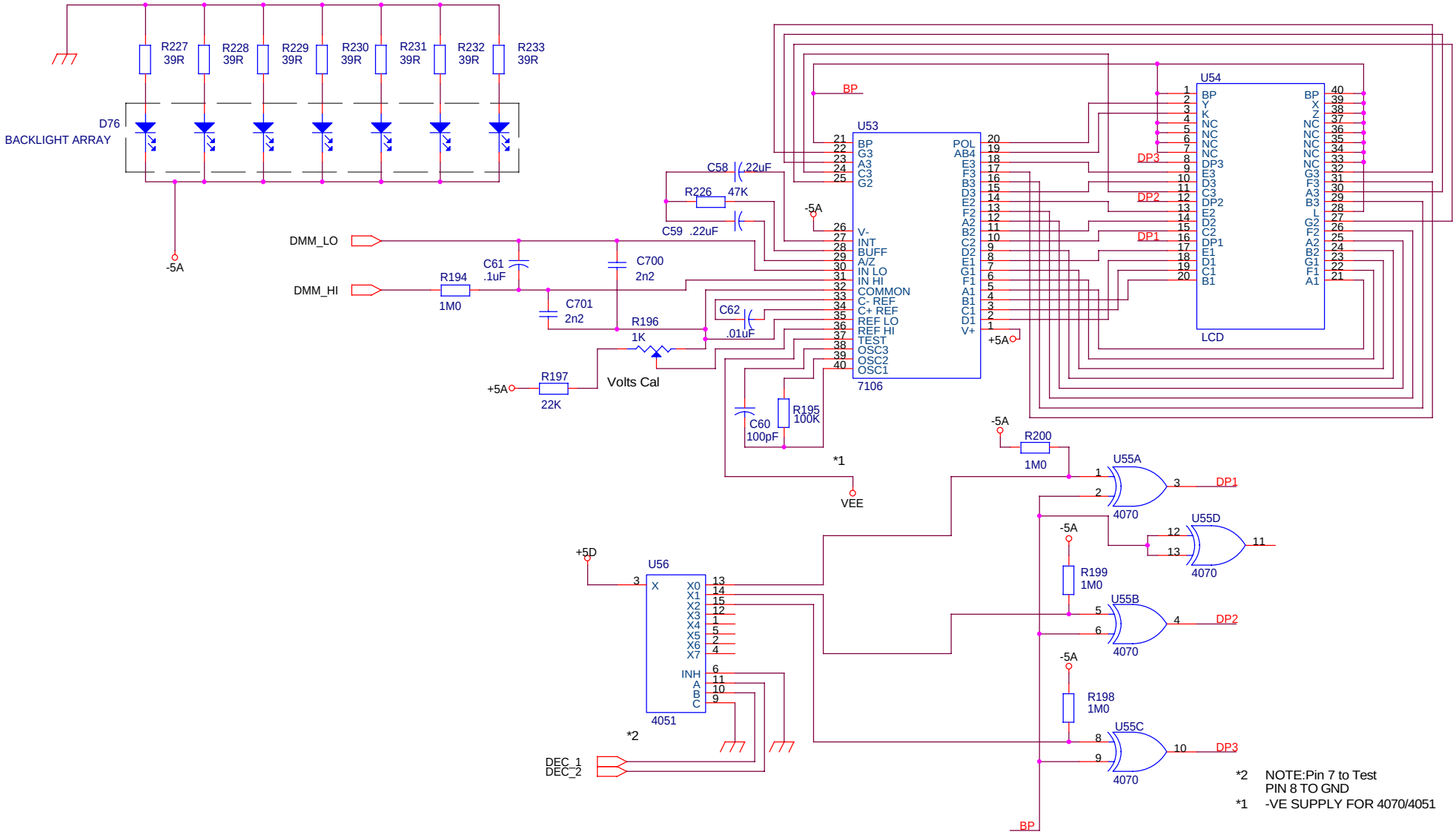



| | |
|---|---|
| Polar | Polar Intruments Ltd<br>Garenne Park, St. Sampsons<br>Guernsey, Channel Islands |
| Inst. 950 | Title Tone Generator |

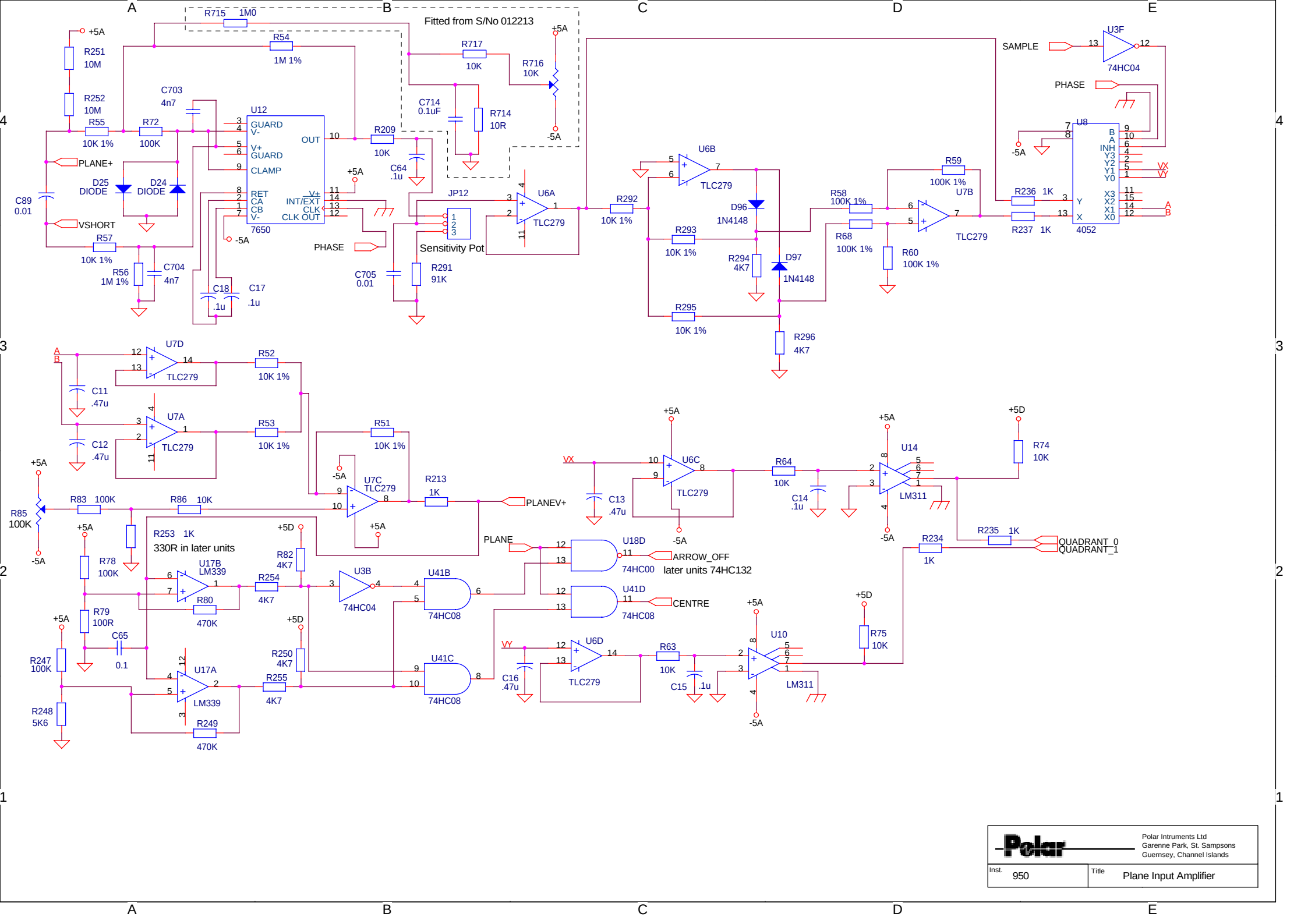

BD[0..7]
JP4
HEADER20X2
Sensitivity
R191A
100K Ganged
DS_POT2
VOLUME_POT1
Volume
R192
100K Panel
CS5
R700
330R
CS6
R701
330R
CS7
R702
330R
CS8
R703
330R
U50
74HC374
U51
74HC374
U52
74HC374
U49
74HC373
U57A
74HC139
RP5
8-22K
R174
R176
R178
R184
270R
D53
D55
D57
D54
D56
D58
OHMS
20mOHMS
2OHMS
2KOHMS
20KOHMS
TRACE
R175
R177
R185
R186
R187
R188
R189
390R
D65
D67
D64
D68
LED
PLANE
STANDBY
PROBE_1
PROBE_2
PROBE_3
DEC_1
DEC_2
D50
D52
D46
D47
D48
UP
RIGHT
LEFT
DOWN
R215
390R
NO_TRACK_DS
R216
R217
R218
R219
R220
R221
R222
R223
270R
CENTRE
R224
Q10
NPN
C66
10uF
C67
.1uF
C57
10uF
C68
10uF
C69
.1uF
S2
200R
S4
2 Ohms
S6
Super Shorts
S3
20R
S5
200mOHM
S7
TRACE
S9
PLANE
DMM_LO
DMM_HI
REVERSED
CENTRE
NO_TRACK_DS
ARROW_OFF
QUADRANT_0
QUADRANT_1
+5D
-5A
+5A
VSS
GND
VDD
VCC
Polar Intruments Ltd
Garenne Park, St. Sampsons
Guernsey, Channel Islands
Inst.
970
Title
FRONT PANEL PAGE1




| | |
|---|---|
| Polar | Polar Intruments Ltd<br>Garenne Park, St. Sampsons<br>Guernsey, Channel Islands |
| Inst. 950 | Title Front Panel page 1 |




| | |
|---|---|
| Polar Intruments Ltd<br>Garenne Park, St. Sampsons<br>Guernsey, Channel Islands | |
| Inst. 950 | Title Front Panel page 2 |


Fitted from S/No 012213
R715 1M0
R54 1M 1%
R251 10M
R252 10M
R55 10K 1%
R72 100K
C703 4n7
U12
GUARD
V-
V+
GUARD
CLAMP
RET
CA
CB
V-
OUT
INT/EXT
CLK
CLK OUT
7650
PLANE+
VSHORT
D25 DIODE
D24 DIODE
C89 0.01
R57 10K 1%
R56 1M 1%
C704 4n7
C18 .1u
C17 .1u
-5A
+5A
R209 10K
C64 .1u
PHASE
JP12
Sensitivity Pot
C705 0.01
R291 91K
R717 10K
R716 10K
C714 0.1uF
R714 10R
U6A
TLC279
R292 10K 1%
U6B
TLC279
R293 10K 1%
R295 10K 1%
D96 1N4148
R294 4K7
D97 1N4148
R296 4K7
R58 100K 1%
R68 100K 1%
R59 100K 1%
R60 100K 1%
U7B
TLC279
SAMPLE
U3F
74HC04
PHASE
U8
4052
R236 1K
R237 1K
VX
VY
U7D
TLC279
R52 10K 1%
C11 .47u
U7A
TLC279
R53 10K 1%
C12 .47u
R51 10K 1%
U7C
TLC279
R213 1K
PLANEV+
R85 100K
R83 100K
R86 10K
R253 1K
330R in later units
R78 100K
R79 100R
C65 0.1
R247 100K
R248 5K6
U17B
LM339
R80 470K
U17A
LM339
R249 470K
R82 4K7
R254 4K7
R250 4K7
R255 4K7
U3B
74HC04
U41B
74HC08
U41C
74HC08
PLANE
U18D
74HC00
ARROW_OFF
later units 74HC132
U41D
74HC08
CENTRE
U6C
TLC279
C13 .47u
R64 10K
C14 .1u
U6D
TLC279
C16 .47u
R63 10K
C15 .1u
U14
LM311
U10
LM311
R74 10K
R75 10K
R234 1K
R235 1K
QUADRANT_0
QUADRANT_1
+5D
Polar Intruments Ltd
Garenne Park, St. Sampsons
Guernsey, Channel Islands
Inst. 950
Title Plane Input Amplifier