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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.

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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 ±4% in 200Ω, ±5% in 20KΩ
[Ω] RANGE	High sensitivity, uncalibrated. 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. Reading proportional to current when UNCALIBRATED LED is lit. UNCALIBRATED LED lit during ranging. 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. Not applicable in TRACE.
INJECTION CURRENT	250mA maximum. Not applicable in TRACE.
INDICATION	Tone and meter in all ranges.
PROBE PROTECTION	Momentary contact up to 250V in 200mA, 2A. Not applicable in TRACE.

Track Voltage

RANGES	2mV, 20mV, 20V.
ACCURACY	±4%, ±15µV.
INPUT RESISTANCE	120Ω in 2mV, 20mV. 1MΩ in 20V.
INDICATION	Meter in all ranges. Tone in 2mV, 20mV.
PROBE PROTECTION	Momentary contact up to 250V in 20V. 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. 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. 150mm (5.9 in.) high. 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

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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/ μV measurement. 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. 12/5V floating supply for drive source. 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

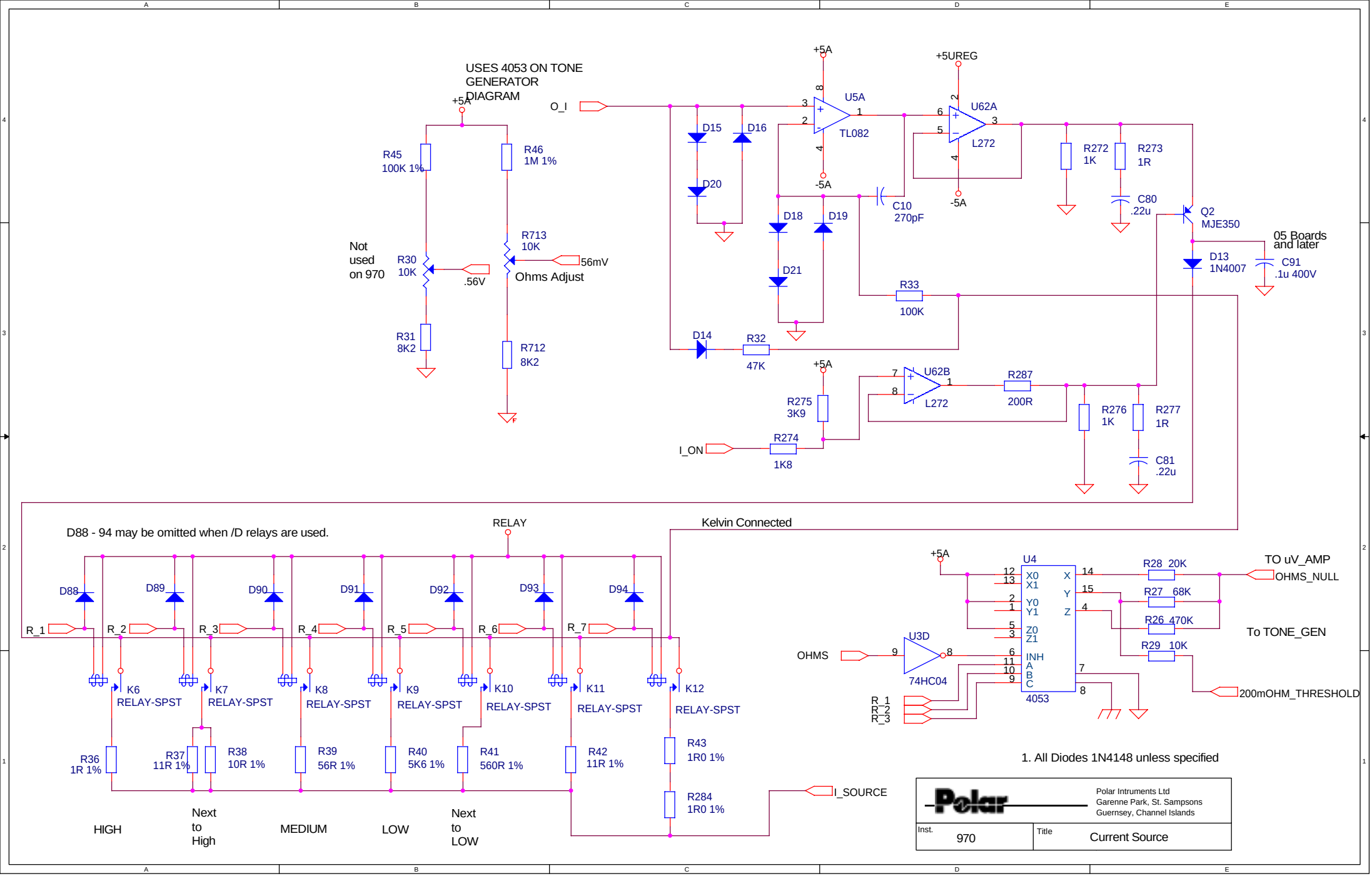
MECHANICAL KIT

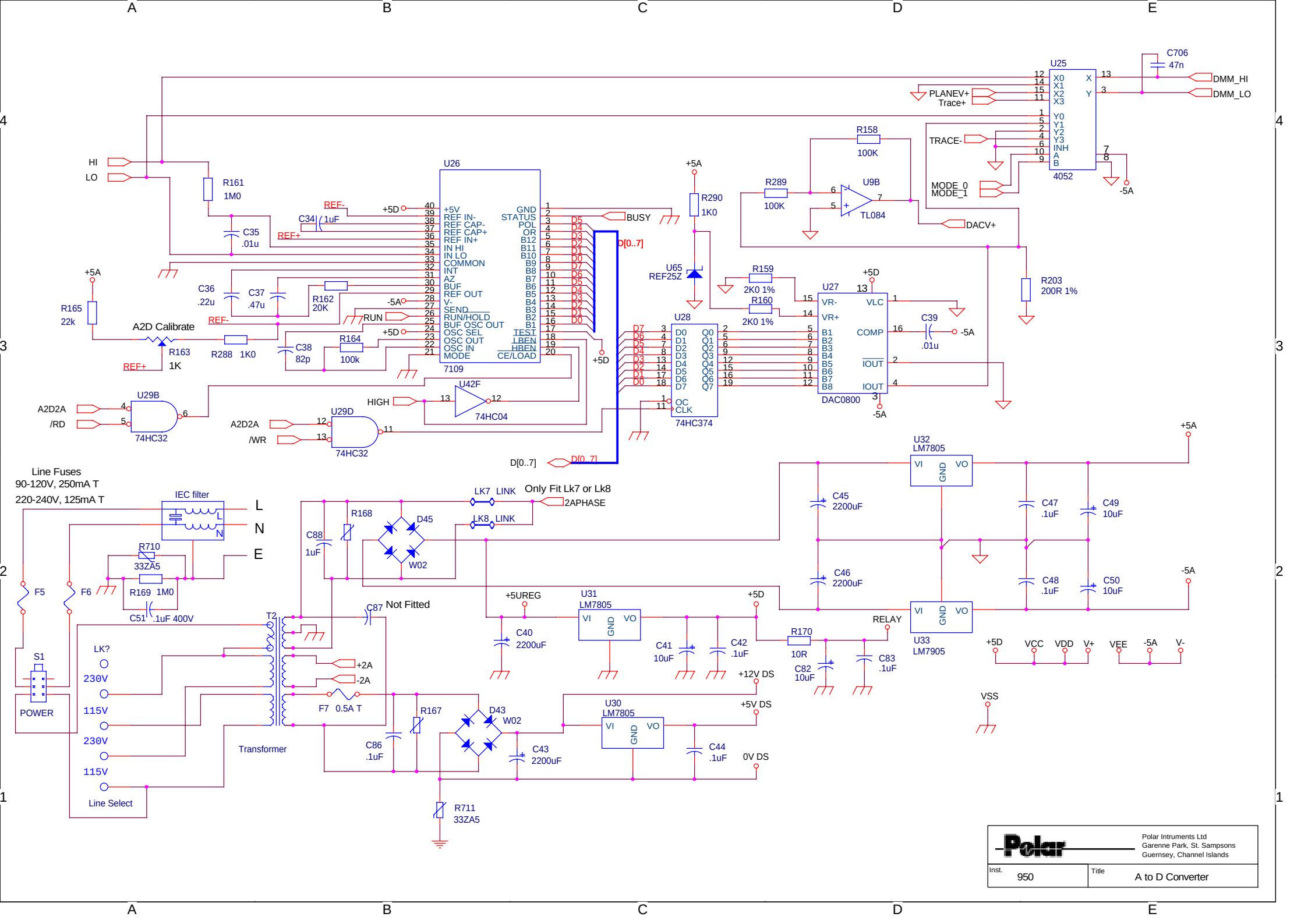
0Part Nº	Qty	Description	CircuitReference
CVD155 *	5	470pF Polypropylene	C709, C710, C711, C712, C713
EPM111	1	Loudspeaker	
FCA112	2	Fuse 250mA T	F5*, F6* 115V
FCA119	2	Fuse 125mA T	F5*, F6* 230V
FCA121	2	Fuse 160mA T	F5*,F6* 230V
FCA122	2	Fuse 315mA T	F5*,F6* 115V
IND107 *	1	10uH	L701
IND109	**1**	**Ferrite 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	

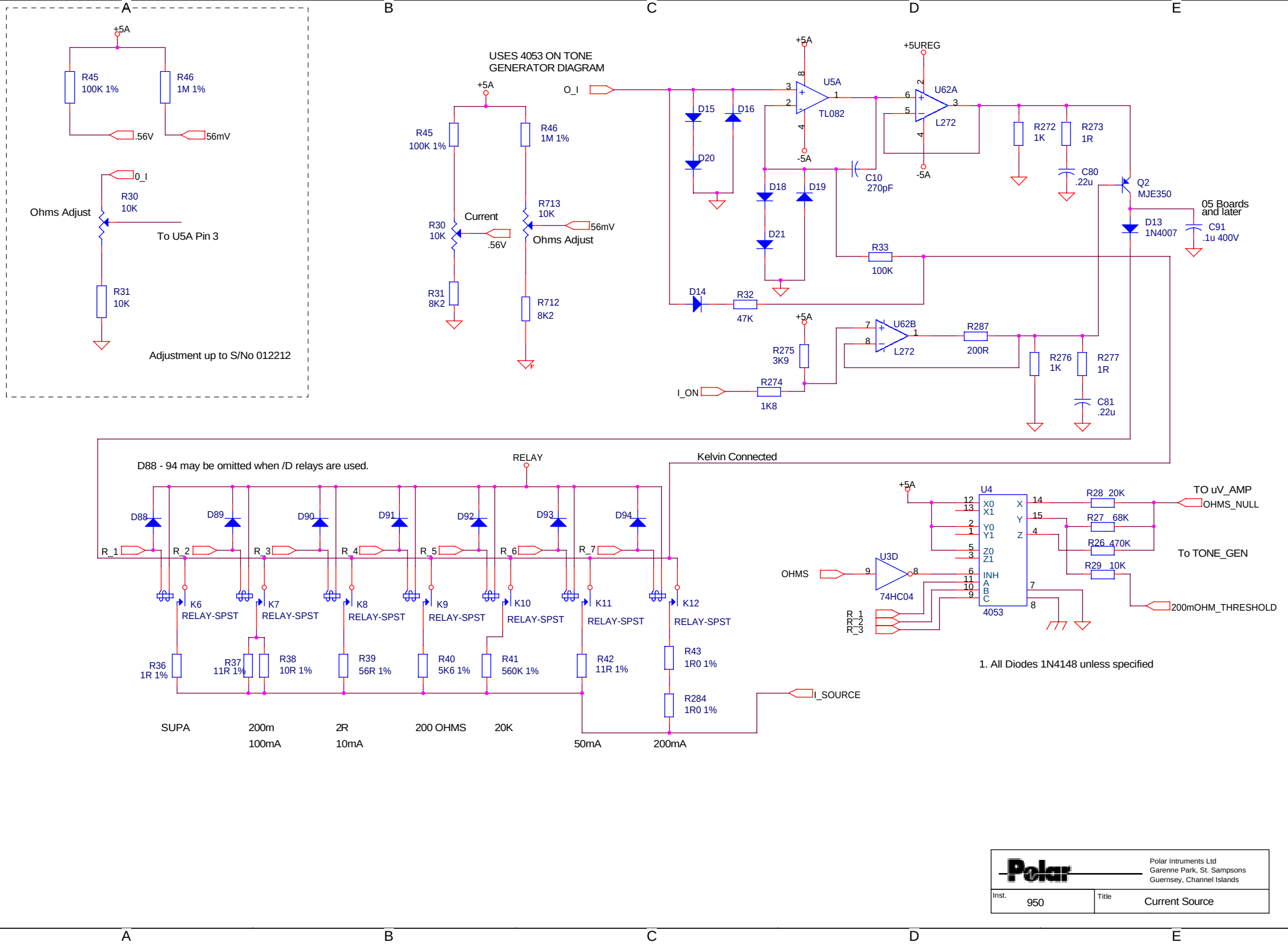
WMA197	2	Speaker Lead	
WMA202*	4	Plane Cable Blue	
WMA305*	1	Plane Drive Cable	

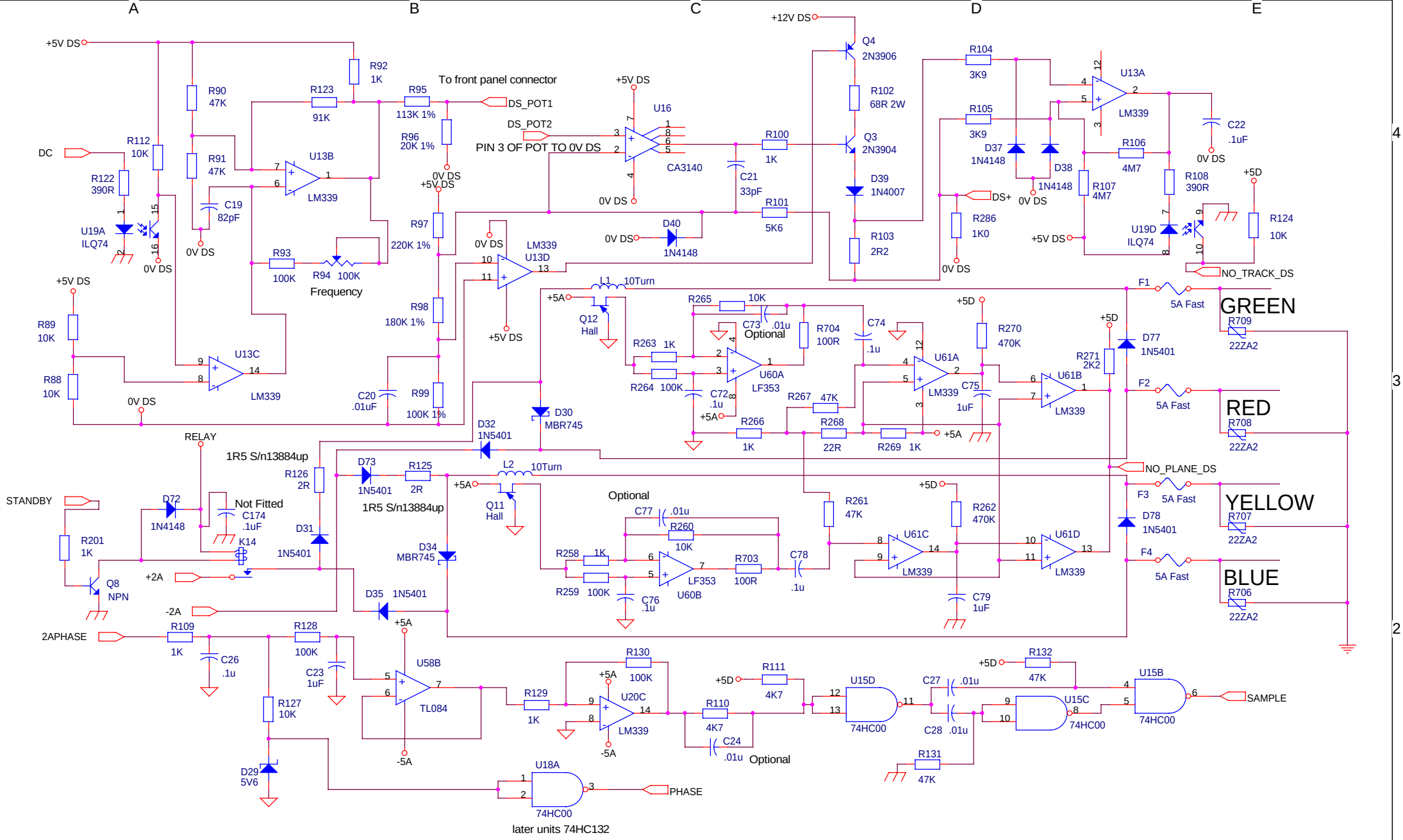
SECTION 9 – SCHEMATIC DIAGRAMS

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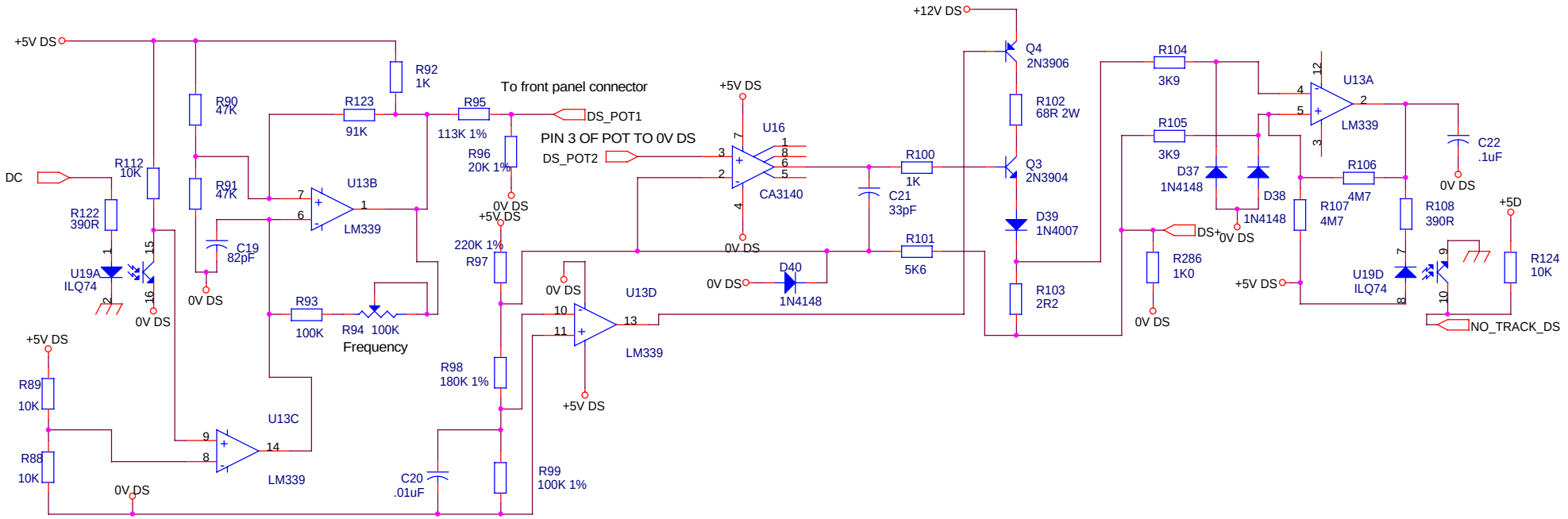

USES 4053 ON TONE GENERATOR DIAGRAM
+5A
O_I
U5A
TL082
+5UREG
U62A
L272
D15
D16
D20
D18
D19
D21
C10 270pF
R45 100K 1%
R46 1M 1%
R713 10K
56mV
Ohms Adjust
Not used on 970
R30 10K
.56V
R31 8K2
R712 8K2
R272 1K
R273 1R
C80 .22u
Q2 MJE350
05 Boards and later
D13 1N4007
C91 .1u 400V
R33 100K
D14
R32 47K
U62B
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

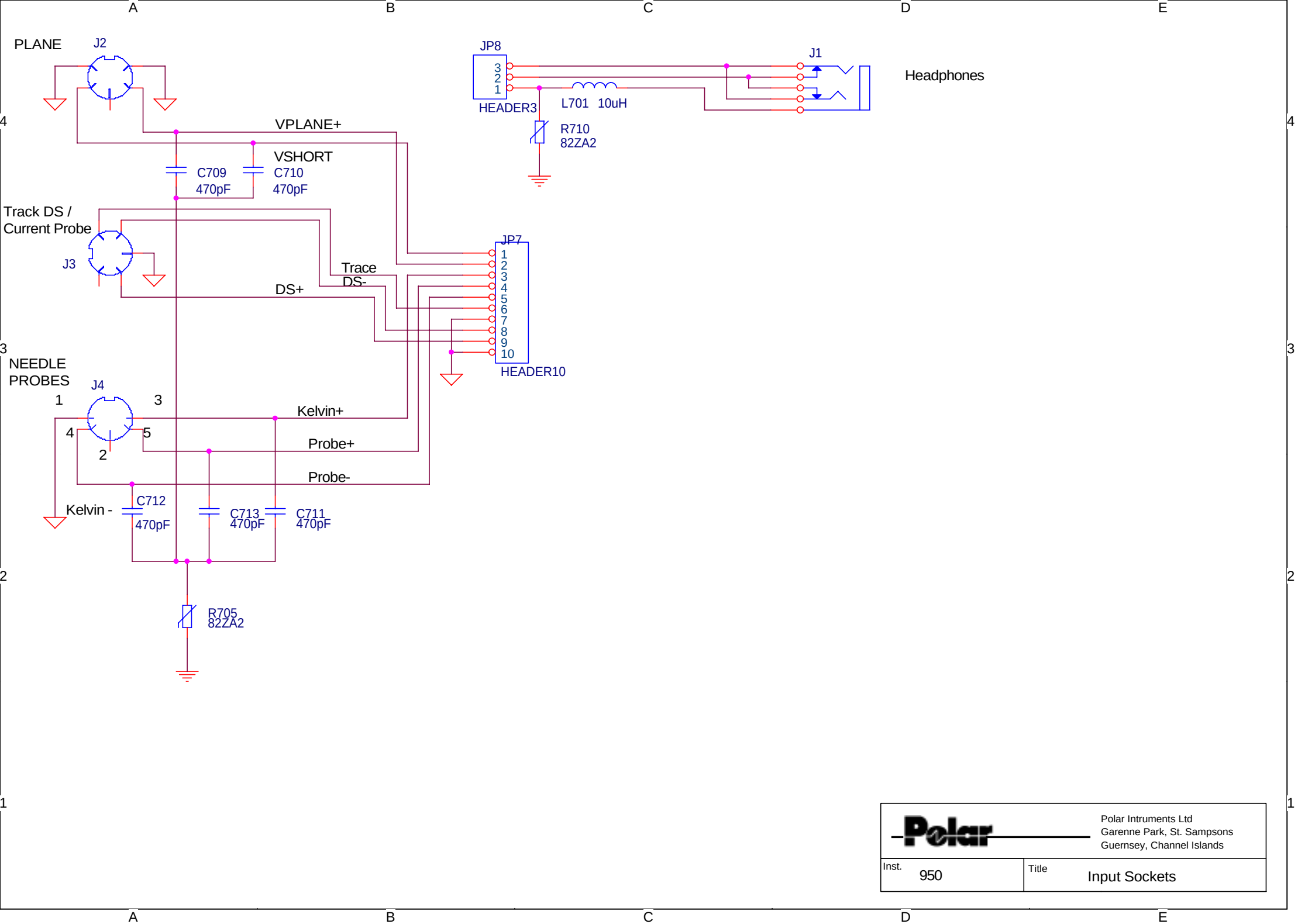

+5A
R45
100K 1%
R46
1M 1%
.56V
56mV
0_I
Ohms Adjust
R30
10K
To U5A Pin 3
R31
10K
Adjustment up to S/No 012212
USES 4053 ON TONE
GENERATOR DIAGRAM
+5A
R45
100K 1%
R46
1M 1%
R30
10K
Current
.56V
R713
10K
56mV
Ohms Adjust
R31
8K2
R712
8K2
O_I
U5A
TL082
+5UREG
U62A
L272
-5A
C10
270pF
D15
D16
D20
D18
D19
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



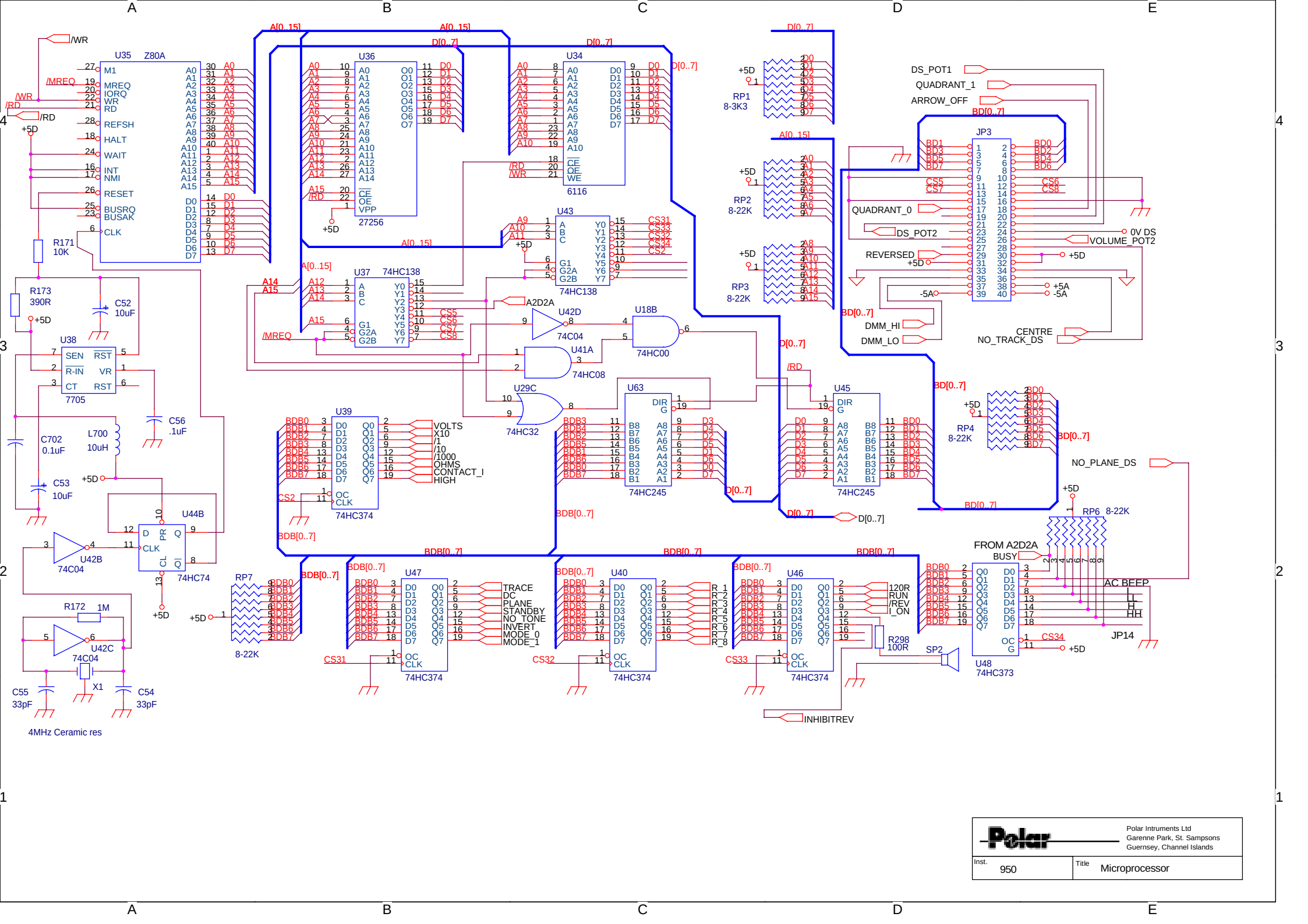
Polar	Polar Intruments Ltd Garenne Park, St. Sampsons Guernsey, Channel Islands
Inst. 950	Title Drive Source



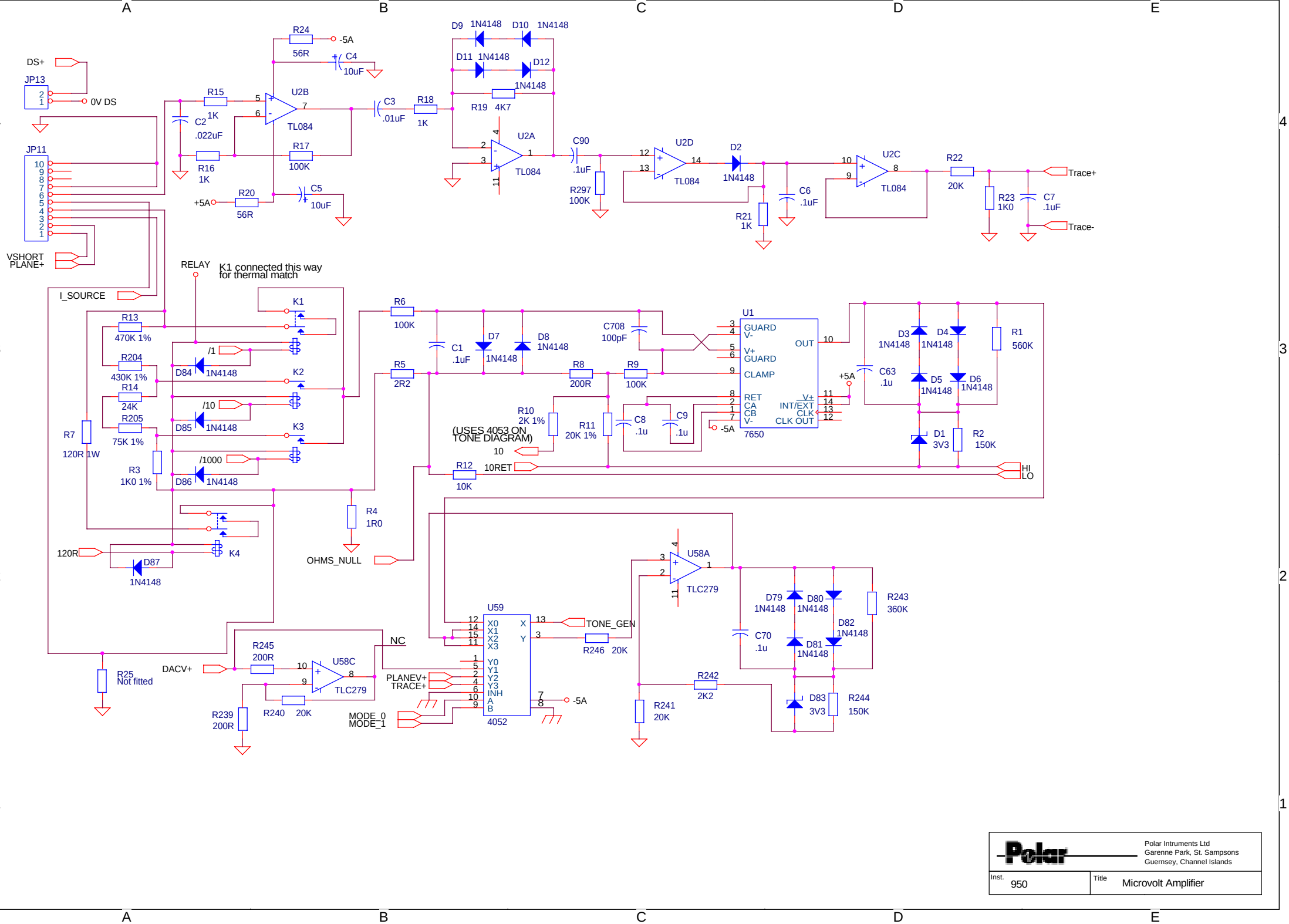
Polar	Polar Intruments Ltd Garenne Park, St. Sampsons Guernsey, Channel Islands
Inst. 950	Title Drive Source

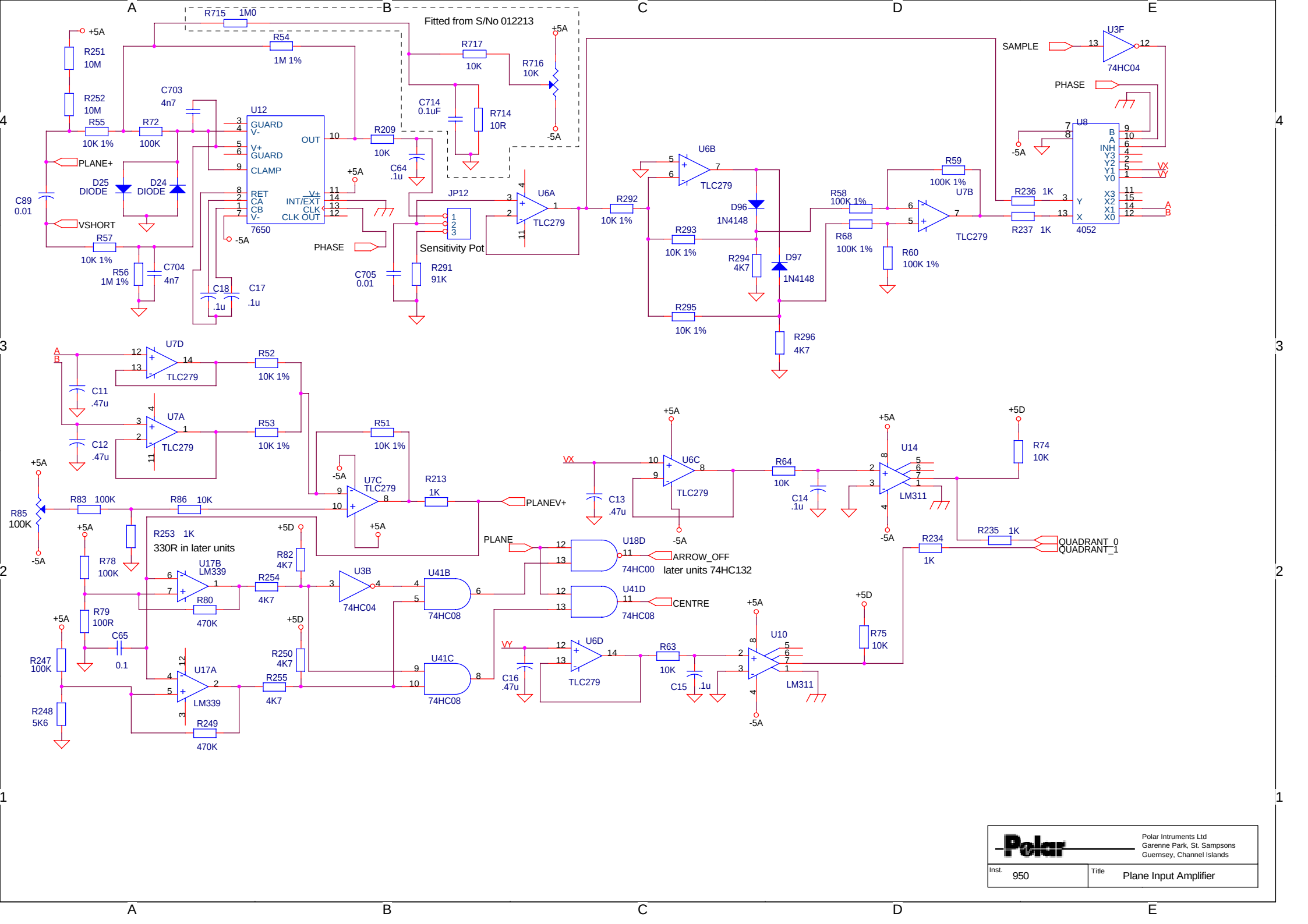


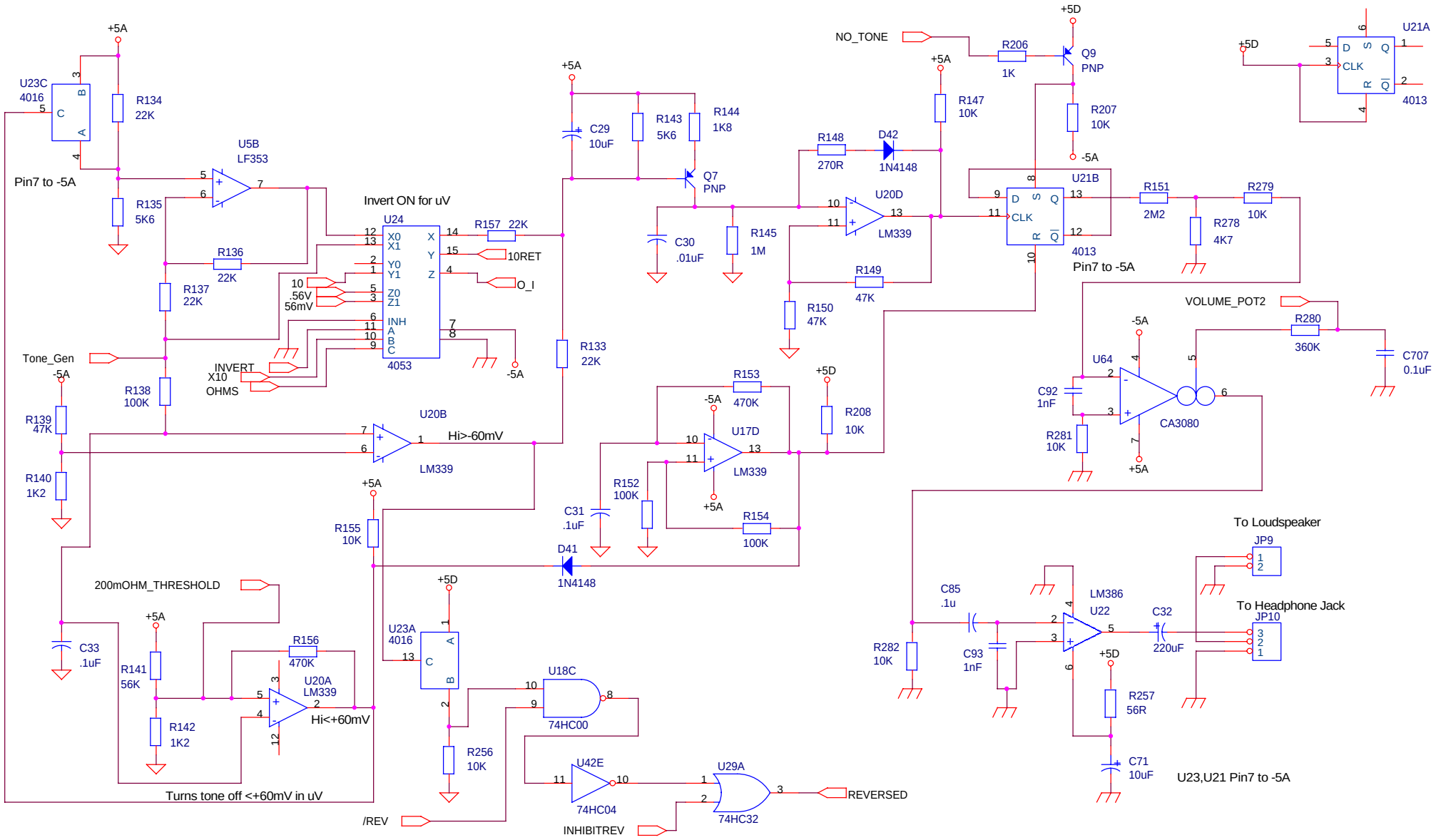
Polar	Polar Intruments Ltd Garenne Park, St. Sampsons Guernsey, Channel Islands
Inst. 950	Title Input Sockets



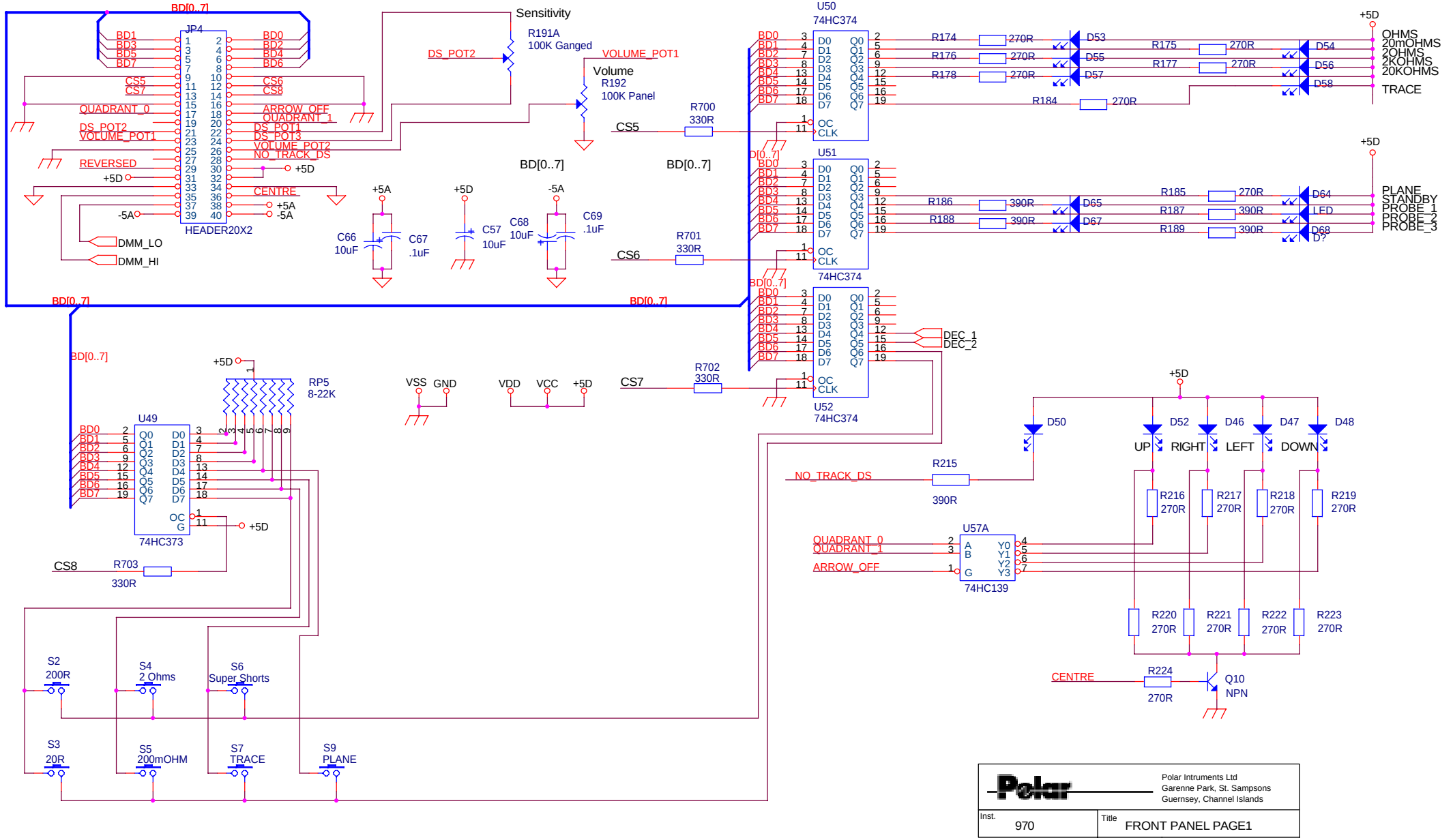
Polar	Polar Intruments Ltd Garenne Park, St. Sampsons Guernsey, Channel Islands
Inst. 950	Title Microprocessor

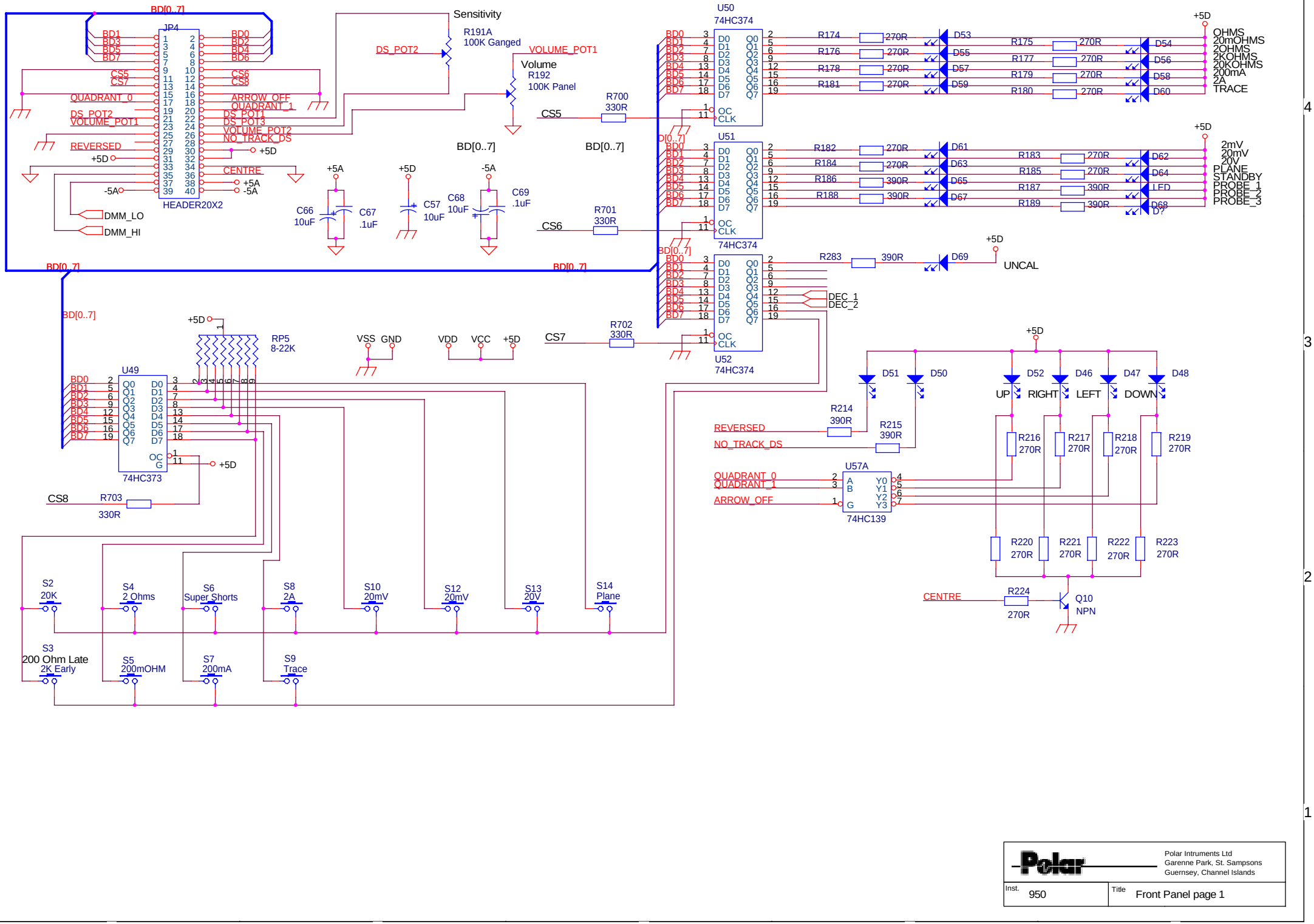

DS+
JP13
0V DS
JP11
VSHORT
PLANE+
I_SOURCE
RELAY
K1 connected this way
for thermal match
R24
56R
-5A
C4
10uF
R15
1K
C2
.022uF
R16
1K
U2B
TL084
R17
100K
C3
.01uF
R18
1K
+5A
R20
56R
C5
10uF
D9 1N4148
D10 1N4148
D11 1N4148
D12
1N4148
R19 4K7
U2A
TL084
C90
.1uF
R297
100K
U2D
TL084
D2
1N4148
R21
1K
C6
.1uF
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

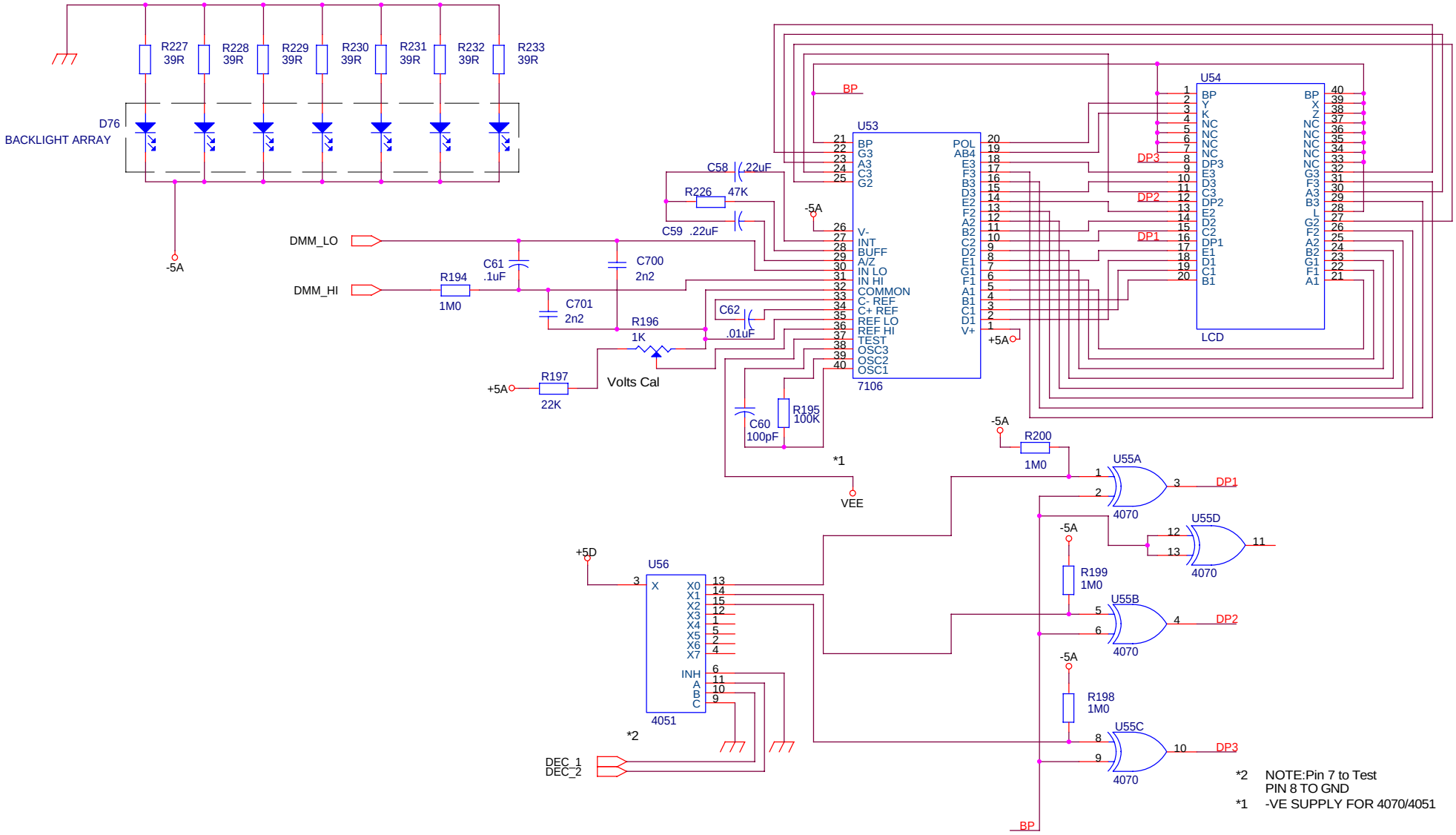


Polar	Polar Intruments Ltd Garenne Park, St. Sampsons Guernsey, Channel Islands
Inst. 950	Title Tone Generator

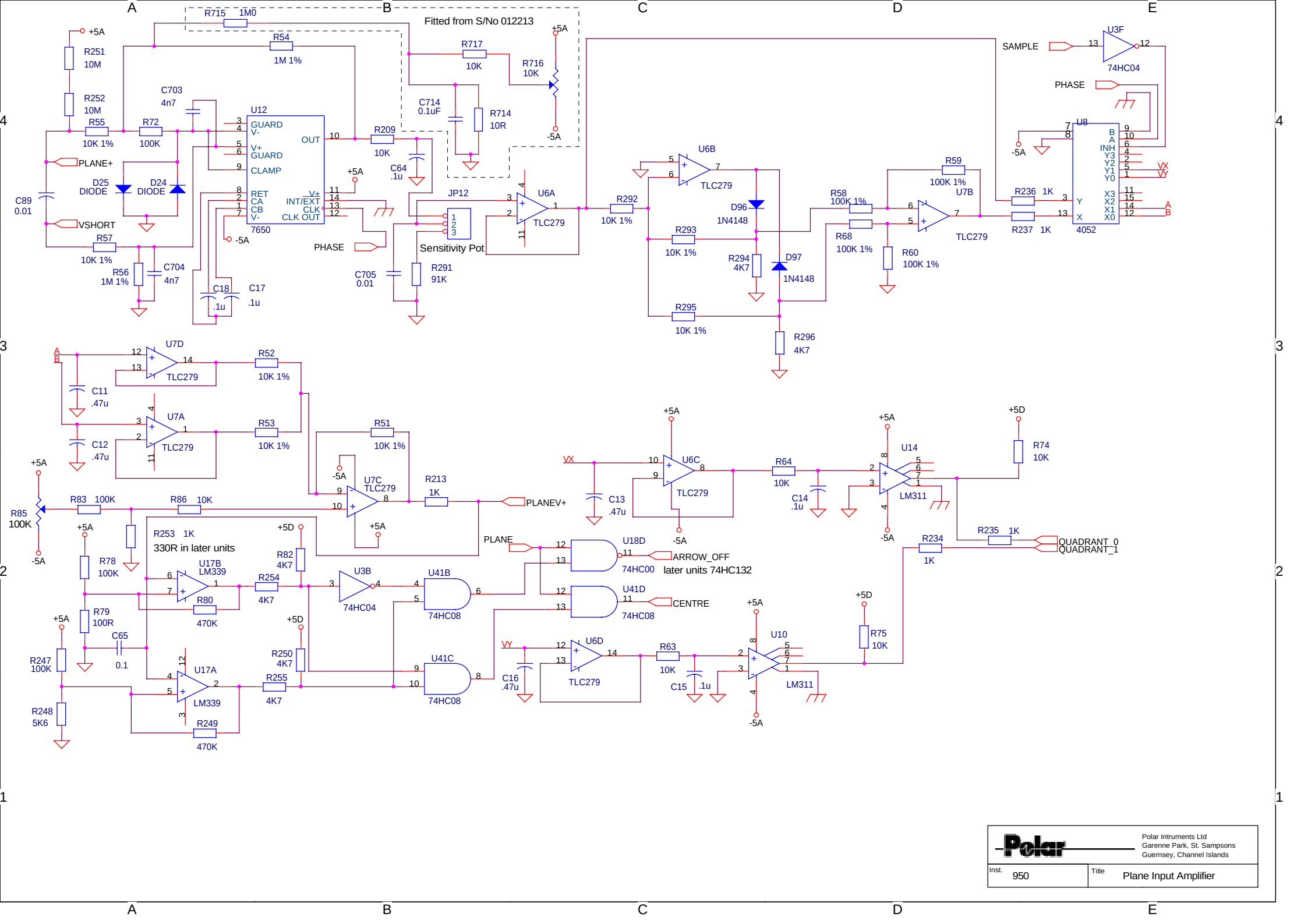

BD[0..7]
JP4
HEADER20X2
Sensitivity
R191A
100K Ganged
DS_POT2
VOLUME_POT1
Volume
R192
100K Panel
CS5
R700
330R
CS6
R701
330R
CS7
R702
330R
CS8
R703
330R
U50
74HC374
U51
74HC374
U52
74HC374
U49
74HC373
U57A
74HC139
RP5
8-22K
R174
R176
R178
R184
270R
D53
D55
D57
D54
D56
D58
OHMS
20mOHMS
2OHMS
2KOHMS
20KOHMS
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 Garenne Park, St. Sampsons Guernsey, Channel Islands
Inst. 950	Title Front Panel page 1



Polar Intruments Ltd Garenne Park, St. Sampsons 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

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