MODEL AVS-46

RESISTANCE BRIDGE

Instruction Manual

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CONTENTS

OPTIONS

ILLUSTRATIONS

CIRCUIT DOCUMENTATION

INTRODUCTION

The AVS-46 is a self-balancing, autoranging resistance bridge, which has been designed primarily for low temperature resistance thermometry. It can be interfaced with other analog instruments through its two analog outputs, and with computers via one of the available computer interfaces: RS232 unit, IEEE-488+RS232 unit or the 150-A Picobus unit.

Normal ohmmeters or bridges are not suitable for thermometry at temperatures below 1K, as their measuring current would heat the sensor above its surroundings and the readings obtained would be more or less erroneous. The lower is the temperature, the lower must be the power dissipated by the sensor. Therefore, a cryogenic resistance bridge must use the minimum possible excitation current, and it is necessary to use alternating current (AC) for excitation in order to separate the resulting very low voltage across the sensor from other DC potentials like thermal voltages and circuit offsets. Further, a 4-wire connection is needed to eliminate errors from lead resistances, which usually are not constant but may change with helium level, gas flow or cryostat temperature.

The AVS-46 has been designed to give accurate and reproducible results at picowatt or sub-picowatt sensor dissipation levels. Yet it is as easy and convenient to use as an everyman's digital ohmmeter. It has been optimized for a wide range of sensor resistances: dynamic range goes from 10-20 $\mu\Omega$ to 2 $M\Omega$. The square-wave excitation and delayed phase-sensitive detection make the AVS-46 extremely linear for all sensor resistances. The scale factor of the AVS-46 can be quickly calibrated without external standards and without disconnecting the instrument from sensors - this internal calibration feature guarantees accurate results for years.

The best estimate of sample temperature is obtained as a result of many compromises. The most important one is the tradeoff between sensor self-heating error and signal-to-noise ratio. A similar compromise must be made between response time and resolution. Optimal grounding often contradicts easy interconnection of various instruments, and careful shielding against RF interference may lead to excessive capacitive loading at the input. In addition to the description of the bridge itself, this manual provides practical suggestions on how to avoid some of the most common problems and how to handle the extreme conditions of very low sensor resistances and very high lead resistances. Multiplexer Option is briefly described in the end of this manual whereas the optional computer interfaces have their own separate instruction manuals.

The AVS-46 provides analog outputs for graph recording and temperature control. Our Model TS-530 Temperature Controller has been specially designed for use with the AVS-46, whose computer interface, if installed, can serve also the TS-530.

We thank you for selecting the AVS-46 to be your resistance bridge. If you have questions that this manual leaves unanswered, please do not hesitate in contacting your local distributor or RV-Elektroniikka Oy directly.

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i WARRANTY

RV-Elektroniikka Oy warrants this product to be free from defects in material and workmanship. Our liability under this warranty is limited to repairing or replacing any instrument or part thereof which, within one year after the shipment to the original purchaser, proves defective. This warranty is void if the instrument has not been used according to the instruction manual, or if it has been used under exceptional environmental conditions (see below).

In need of warranty repair, the instrument must be returned to RV-Elektroniikka Oy, by prepaid airfreight, and with a detailed description of the fault or misfunction following the instrument.
The name, address and telex or telephone number of a person who is able to give supplementary information should be included whenever possible. RV-Elektroniikka Oy will take responsibility of charges for returning the instrument, if the repair was covered by warranty.

If no fault is found, or if there is a strong indication that the warranty is void, the purchaser is charged for all freight and shipping costs in addition to the repair. Therefore it is recommended that RV-Elektroniikka be contacted prior to shipment, so that we can give instructions for additional tests or simple component replacements and unnecessary shipments may be avoided.

CAUTION: THE AVS-46 IS A DELICATE LABORATORY INSTRUMENT. IT HAS BEEN DESIGNED ONLY FOR THE PURPOSE OF MEASURING THE RESISTANCES OF PASSIVE RESISTIVE NETWORKS. USING THIS INSTRUMENT FOR ANY OTHER PURPOSE WILL VOID THE WARRANTY AND MAY CAUSE PERMANENT DAMAGE TO THE INSTRUMENT.

BY NO MEANS SHOULD THE AVS-46 BE USED TO MEASURE INTERNAL RESISTANCES OF POWER SUPPLIES, BATTERIES, CAPACITORS OR ANY OTHER DEVICES WHICH CAN SUPPLY ENERGY TO THE BRIDGE INPUT.

THE AVS-46 HAS BEEN DESIGNED TO OPERATE IN A LABORATORY ENVIRONMENT, WHICH MEANS NORMAL LIVING ROOM ATMOSPHERE, TEMPERATURE, HUMIDITY AND PURITY OF AIR. THE UNIT DOES NOT TOLERATE CONTINUOUS VIBRATION OR HARD SHOCKS.

ii PRINCIPLE OF OPERATION

The operation of the AVS-46 is described with the aid of a simplified block diagram.

Basically, the instrument consists of two identical sections of feedback amplifiers, one for the reference R_R and the other for the unknown resistor R_X. The purpose of the first section is to produce an AC current of accurately known amplitude. This current flows through R_R and R_X, which are connected in series. The purpose of the second section is to measure the resulting voltage across the unknown resistor.

A stable 2.5 V reference voltage (1), called V_E is converted to a square-wave AC voltage by a chopper circuit (2). This is further attenuated by a precision attenuator (3) down to microvolt level (kV_E, where k is the attenuation constant). The excitation preamplifier (4) has three inputs and a special construction which yields zero output only when the signal amplitude of input C equals the difference of signal amplitudes at inputs A and B. In other words, zero output indicates that the AC voltage drop across reference resistor is equal to a reference AC voltage.

The output of (4) is synchronously rectified by (5). Synchronous, or phase-sensitive, detection means that any signal which has a frequency equal to the sychronizing frequency, and phase other than 90 degrees, will result in a DC output whereas any other signal frequency will produce an AC output with a long term average equal to zero. The opening of the detector gate has been delayed by one fourth of the operating cycle. During this delay the transient part of the signal, which is due to nonzero input time constant, will decay to zero and only signal caused by sensor resistance is detected. The output of (5) is integrated by an integrator (6). This provides a very high DC gain for the in-phase detector output, but effectively attenuates all other frequencies. The integrator output, which is a DC voltage, is again converted to square-wave by a second chopper (7). This waveform is attenuated by an attenuator (8), similar to (3), before it is applied to the reference resistor as the excitation voltage.

The signal polarities have been selected so that as long as the differential voltage across R_R is less than V_E, the integrator output continues to rise. So this feedback loop adjusts the excitation voltage in order to keep the excitation current constant, that is $I_{EXC} = kV_E/R_R$.

The excitation current is fed to the unknown, or sensor resistor R_X. A preamplifier (9), identical to (4) compares the differential signal voltage with an attenuated feedback voltage kV_X. The output of (9) is synchronously rectified and integrated by (10) and (11). Integrator output (V_X) is chopped to a square-wave (12) and attenuated (13) to obtain kV_X. So this second feedback loop adjusts the feedback voltage so that it equals the differential signal voltage across the sensor.

Ripple from the 25/30 Hz carrier frequency is removed by low-pass filter (14) and the result of a measurement is finally obtained by calculating the ratio V_X/V_E. This is made by the ratiometric A/D converter (15).

All attenuators provide six selectable attenuation coefficients in 1:3:3:3:3:3 sequence, corresponding to decade steps in sensor dissipation power. Attenuators (3) and (8) are fixed whereas attenuator (13) is adjustable, so that corresponding coefficients of (3) and (13) can be trimmed to be exactly equal. Any unbalance here would be seen as differences in readings obtained using various excitations.

The AVS-46 has a self-calibration facility for rapid checking and adjustment of scale factor. In calibration mode, sensor R_X is short-circuited to ground by the CAL switch and the A and B inputs of both preamplifiers are connected together. Both amplifier chains now measure the same differential voltage, and V_E should be equal to V_X. Due to component tolerances they will, however, be different and the A/D converter must be scaled to display 1.0000.

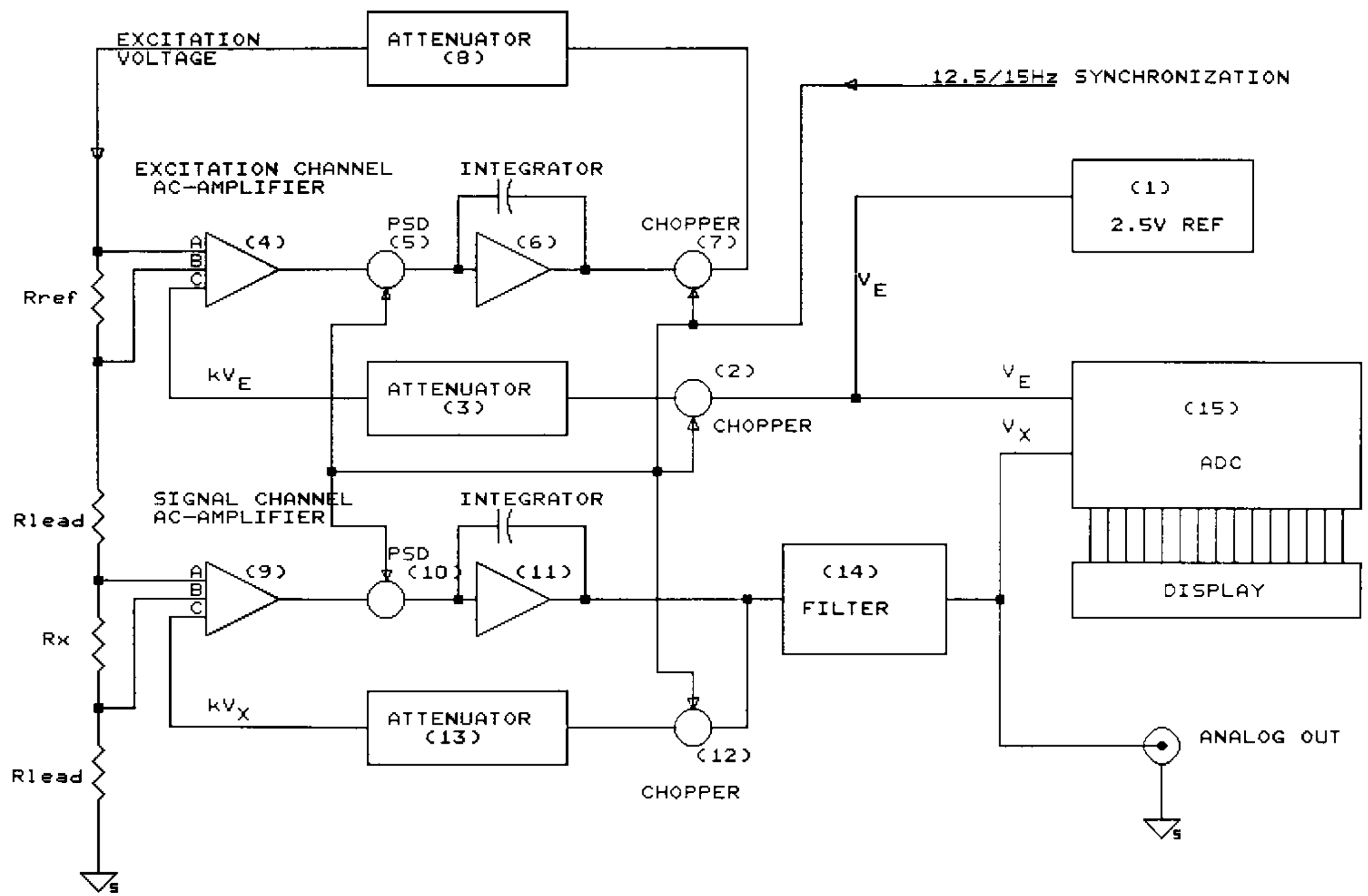


Fig ii-1: Simplified block diagram of the AVS-46

iii SPECIFICATIONS

RESISTANCE RANGES	0-2, 0-20 and 0-200 Ω 0-2, 0-20 and 0-200 kΩ 0-2 MΩ In magnified deviation display mode, corresponding ranges are 0-0.2 Ω etc. Decimal point in the magnified display mode corresponds to the original basic range setting.
EXCITATION RANGES	10, 30, 100 and 300 µV, 1 and 3 mV. Excitation current = excitation range/half of the selected resistance range.
EXCITATION FREQUENCY	12.5/15 Hz, divided from the mains frequency. No adjustments are needed when changing from one mains frequency to another. Excitation waveform is a symmetrical square-wave.
DISPLAY	Red 4 1/2 digit display, 15 mm high, with decimal point and polarity. Can be switched to show resistance, resistance deviation, or deviation reference voltage (to facilitate accurate dialing of the reference potentiometer).
ANALOG OUTPUT	Analog output ranges from 0 to 4 Volts (2 Volts corresponds to full 19999 display). With an external DVM connected to the analog output it is possible to exceed the above specified display ranges by 100%. There is a 3rd order, 1 Hz Bessel low pass filter between the primary self-balancing loop and the analog output. This eliminates residuals of carrier frequency and mains hum from the output.
DEVIATION OUTPUT	Deviation output ranges from -2 to +2 V and represents the difference between measured resistance and the reference potentiometer setting. The gain of the difference amplifier may be increased by a factor of 10 (deviation magnifier switch) to obtain higher resolution within a narrow subrange.
SENSOR CONNECTION	4-wire connection. Current return lead = circuit ground and must be connected to mains ground at some point. 2-wire measurement is possible by connecting the corresponding current and voltage leads together. Input socket is a 5-pole DIN type (mating plug PREH 71430-250 or equivalent). Because of 4-wire measurement and AC excitation, the AVS-46 is insensitive to contact potentials and contact resistances, as long as these do not produce appreciable noise or saturate the preamplifier.

LINEARITY

Maximum linearity error for end-point calibration is:

RANGE	ERROR
2 Ω - 200 kΩ	± 1 digit
2 MΩ	± 5 digits

NOTE: Input time constant (RC) less than 1 ms.

TEMPERATURE STABILITY

100 ppm/°C ± 0.1 dig/°C typical if internal calibration is not used.

10 ppm/°C maximum if internal calibration is used after temperature change.

LONG-TERM STABILITY

35 ppm/year maximum with internal calibration.

ACCURACY

Basic scale accuracy is 0.02% after internal calibration for ranges 20 Ω to 200 kΩ, 0.05% for 2 Ω range, and 0.1% for 2 MΩ range. Add linearity error, lead resistance error and possible temperature drift to obtain error limits for the mean value of infinite number of readings.

The scale conformity of various excitation ranges is adjusted to be within 0.01%, and this can be recalibrated without external standards.

RESOLUTION

Typical RMS resolution (standard deviation) at middle range, using slow response mode and sensor at room temperature:

	EXCITATION μV					
RESISTANCE	10	30	100	300	1000	3000
0.1 Ω [1)]	700μΩ	200μΩ	50μΩ	20μΩ	10μΩ	10μΩ
1 Ω	700μΩ	200μΩ	100μΩ	50μΩ	30μΩ	20μΩ
10 Ω	7mΩ	2mΩ	800μΩ	300μΩ	150μΩ	100μΩ
100 Ω	70mΩ	30mΩ	10mΩ	4mΩ	1mΩ	500μΩ
1 kΩ	700mΩ	300mΩ	100mΩ	40mΩ	10mΩ	5mΩ
10 kΩ	10Ω	4Ω	2Ω	600mΩ	300mΩ	100mΩ
100 kΩ	300Ω	100Ω	40Ω	15Ω	5Ω	2Ω
1 MΩ	-	3000Ω	1000Ω	400Ω	150Ω	50Ω

NOTE 1: 2 Ω range, magnified deviation display mode.
NOTE 2: As a rule of thumb, peak-to-peak noise is about 5 times the RMS noise.
NOTE 3: These figures are defined as standard deviation of a sufficiently large number of A/D conversion results.

MAXIMUM LEAD RESISTANCE Setting for high or low lead resistances is selected by a circuit board jumper.

Maximum overall current path resistances (including sensor resistance) for low and high jumper settings are as follows:

RANGE	MAX RESISTANCE (low res)	MAX RESISTANCE (high res)
2 Ω	6 Ω	200 Ω [1)]
20 Ω	100 Ω	1 kΩ [2)]
200 Ω	1 kΩ	1 kΩ

NOTE 1: Excitation range <= 300 μV
NOTE 2: Excitation range <= 1 mV

Common mode error resulting from maximum allowed lead resistance for HIGH setting is

Offset change < ± 2 digits
Scale error < ± 0.05%

In LOW lead resistance mode the error always stays below 1 digit and there are no limitations regarding excitation range.

Because of the better dynamic behaviour, the LOW mode shall be used whenever possible.

LEAD CAPACITANCES SENSOR INDUCTANCE In order to keep linearity error below ± 5 digits, the input time constant (RC or R/L) must be less than 1 ms.

SPEED OF BALANCE Response speed depends on excitation as shown by the recorder graph below, and will vary slightly from one unit to another. Typically, settling time for a step from 0 to middle range (10000) is less than 10 s in slow mode and less than 2 s in fast mode (to final accuracy, highest excitation).

Because of the output low-pass filter, there may be a small overshoot in fast response mode (about 1%).

Speed of balance is specified only for the LOW lead resistance mode.

AUTORANGING SPEED There is a fixed delay between two autoranging actions, and it can be selected to be either 1 or 5 s by a circuit board jumper.

OPERATING POSITION The AVS-46 can be used in any position.

OPERATING TEMPERATURE 0...+35°C

MAINS INPUT 90-110 V, 110-120 V, or 220-240 V, 50-60 Hz, 15VA RFI filtered input.

DIMENSIONS 88 mm(H), 483 mm(W=19"), 305 mm (D)
Weight 5kg.

OPTIONS AND OPTIONAL ACCESSORIES

MUXA	Input Multiplexer Option for the AVS-46. Seven 4-wire sensor inputs. Both front panel and remote operation through the computer interface.
MUXB	Second Multiplexer Option (channels 9-15). Excludes the data interface for the TS-530 temperature controller, but is possible if the TS-530 has been equipped with its own Picobus interface (150-T).
150-A	Picobus Interface Option for the AVS-46. Optically isolated, synchronized serial interface, which has been implemented without a microprocessor nor fast digital circuits, and is therefore extremely quiet. The 150-A has been designed especially for applications at very low temperatures where RF interference can be a problem. Allows a maximum of 15 mutually isolated instruments to be connected to a single bus.
PB-100	Intelligent Picobus/IEEE-488 converter. Interfaces the proprietary Picobus to the IEEE-488 bus. Provides a physical distance between sensitive instruments and the noisy IEEE bus. Offers many commands that help handling then AVS-46 as a time independent instrument.
DC900	IEEE-488+RS232 Computer Interface Option. Internally isolated from the bridge circuits. Cheaper way to interface the AVS-46 with the IEEE-488 than by using Picobus and PB100. Care must be taken if problems with RF interference are likely to occur.
AVSI2	RS232C Interface Option for the AVS-46. Lowest cost.
CALIBRATOR PLUG	1kΩ 0.01% resistor plug for calibrating the magnified deviation mode.
INPUT PLUG SET	A set of five DIN input plugs for the AVS-46
MUX CONNECTOR SET	A set of five DC37P connectors for connecting sensors to the Input Multiplexer Option, including metallized plastic shields.
PICOBUS EXTENSION CABLE	1 meter cable with piggyback connectors at both ends for Picobus wiring between instruments.

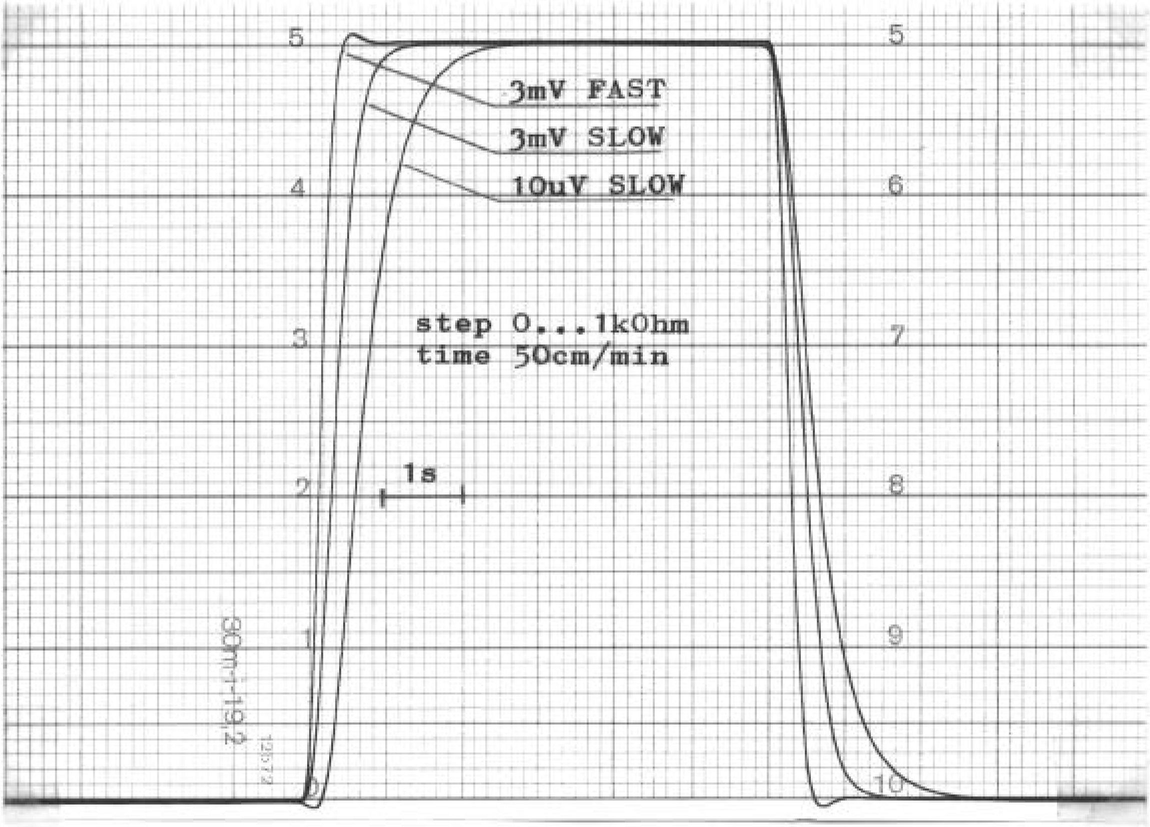


FIG iii-1: Typical settling time

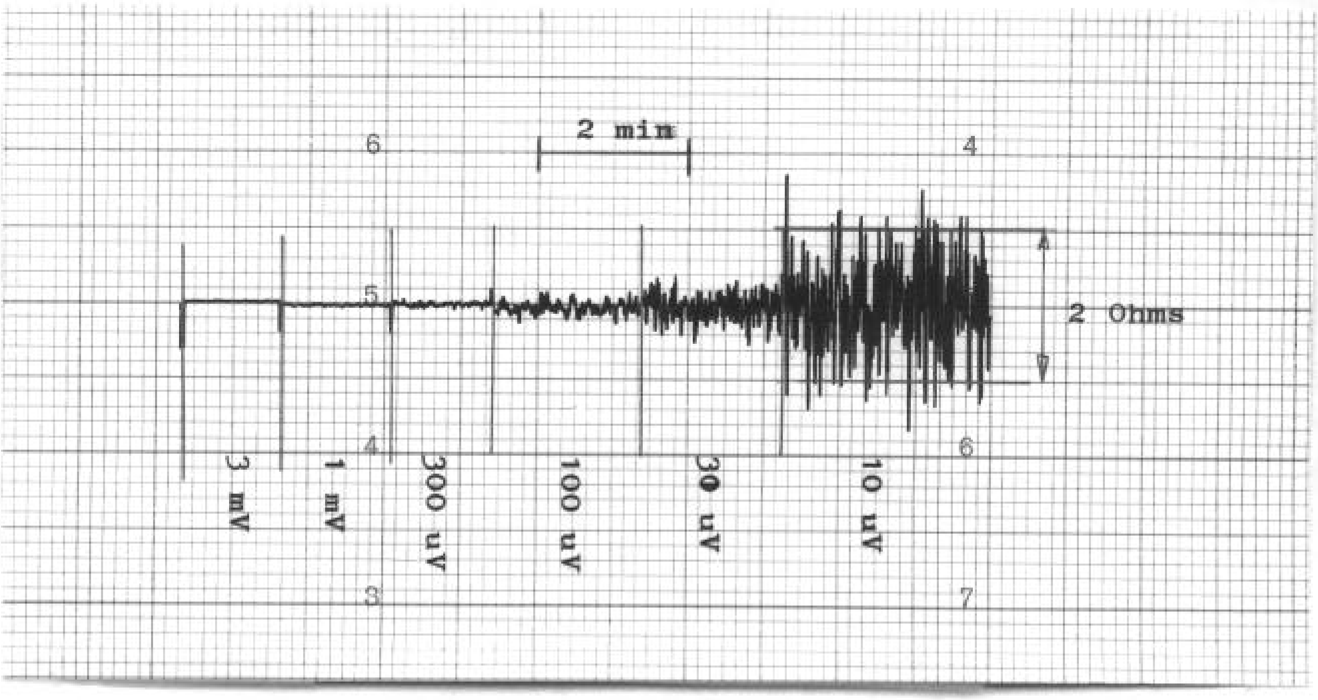


FIG 2-1: Typical noise graph

1. CONTROLS AND FUNCTIONS

1.1 FRONT PANEL

DISPLAY	The 4 1/2 digit display is equipped with -sign for deviation display mode. Full range 19999 corresponds to 1.9999 Volts at the analog output.
OVERLOAD INDICATOR	Distortion of the AC amplifier output is indicated by red light. This distortion may result from excessive mains pickup in the sensor leads, from ground currents, from very high uncompensated lead or sensor capacitances at high resistance levels or from a broken sensor lead.
LEAD RESISTANCE INDICATOR	Excessive sensor current lead resistance is indicated by red light. Effective only in low lead resistance mode. You can change the lead resistance mode to allow for higher resistances.
FAST/SLOW	This switch affects the gain of the integrators. In FAST position, the bridge circuit is approximately ten times faster than in SLOW mode, but the output noise level is about three times higher. However, the output low-pass filter will limit response speed in FAST mode to some extent. Note also that the A/D converter makes only 2 1/2 conversions in a second.
AUTO/MANUAL RANGE	In autorange mode, readings higher than 19999 or lower than 1800 activate an autoranging action. There is a fixed delay of about 1 sec before the next autorange operation can take place, and its purpose is to reserve time for the bridge to find balance. When the measured resistance is changed stepwise for several orders of magnitude, the AVS-46 will make one extra change of range and then come back to the final range. If this iteration cycle is unacceptable, you can change the delay jumper for 5 sec delay (JP401 in front position).
RANGE UP/DOWN	Lift or press the switch to change range up or down.
AUTO/MANUAL EXCITATION	In the autoexcitation mode, each autoranging action will shift excitation by one step, and thereby prevent the sensor dissipation power from changing more than one order of magnitude even though the sensor resistance changes several decades. In manual range mode, this switch has no meaning.
EXCITATION UP/DOWN	Lift or press this switch to change excitation up or down.
DEV/NORM	In DEV position, the quantity displayed is the analog output voltage minus a reference voltage, determined by the REFERENCE potentiometer. In NORM position, the analog output voltage is displayed.
MAG/NORM	The deviation voltage (analog output minus potentiometer setting) is amplified by 10 in the magnified deviation display mode (MAG). This permits enhanced resolution within a ± 10% subrange, whose origin may be set using the REFERENCE potentiometer.
SET/NORM	The A/D converter measures the deviation reference voltage when this switch is in SET position. You can dial the REFERENCE potentiometer accurately with the aid of this switch.

CHANNEL DISPLAY	The extra display LED will show the input channel currently selected by the optional multiplexer (if installed). When no multiplexer channel is selected, this LED is blanked.
MUX UP/DOWN	Lift or press this switch to scan the multiplexer input channel number up or down.
REAR/MUX/FRONT	In FRONT position, the front panel DIN socket acts as bridge input. If there is no multiplexer installed, an auxiliary rear panel connector can be selected as an alternative input (REAR/MUX). If the AVS-46 is equipped with a multiplexer unit, REAR/MUX will connect the input to the multiplexer.
CAL/MEAS/ZERO	In CAL mode the AVS-46 measures its own reference resistor, and the scale factor can be checked and calibrated. The internal ZERO reference is accurate to 100 μΩ, which makes possible to check zero offset accurately even for measurements on the lowest ranges.
REFERENCE POTENTIOMETER	Determines the deviation reference for the deviation display and for the deviation analog output. Range from 0 to 2 V, corresponding to full display range.
SCALE TRIMMER	Used for internal calibration of scale factor. Calibrates the primary analog output. If digital display and analog output are inconsistent, the display can then be adjusted using a circuit board trimmer.
ZERO TRIMMER	Used for offset adjustment when the input switch is in ZERO position. This trimmer affects the analog output, and thereby also to the display offset. After selecting magnified deviation mode, always check zero and use this trimmer if necessary.

1.2 REAR PANEL

MONITOR	This is the output of the signal channel AC amplifier, just before phase-sensitive detector. It is used for monitoring the mains interference level and for other trouble-shooting purposes. Note that connecting an oscilloscope to this BNC establishes a new grounding point to the system, and may therefore change the actual operating conditions.
ANALOG	Analog voltage output. It is linear to above +4 V, so that you can use this output far beyond the display range of the AVS-46. ANALOG output can be self-calibrated and is as accurate as the digital display. You can obtain 5 1/2 digit resolution at higher excitations, if you use a suitable external digital voltmeter to measure the analog output.
DEVIATION	Deviation output for graph recording and temperature control applications. Ranges from ± 4 Volts in normal mode to ± 10 Volts in magnified deviation mode.
AUX IN/MUX 1	If there is no multiplexer option installed, this 37-way connector acts as an auxiliary input. Only pins 1-5 have been used, and pin numbering corresponds to that of the front panel input socket. If the multiplexer (MUXA) has been installed, this connector slot is occupied by it.
MUX 2/PROG OUT	This connector provides data interface to the TS-530 Temperature Controller (Male D-type 37-pole connector upside down (/______\ ) . This slow can also be used for installation of a second multiplexer unit (Female connector).

1.3 SENSOR CONNECTION

Sensor connections for front and rear panel sockets are shown in Fig. 1-1 and Fig. 1-2.

At least I+ and V+ leads must be shielded, and if the resistance of sensor leads is very high, it is recommended that a shielded cable be used also for V-. It is not necessary to use a shielded cable for the current return, I-, as this wire is always connected to the circuit ground of the AVS-46 and it must always be grounded to mains ground at some (single) location. Cable shields can sometimes be used as current return lead, which reduces the number of cables from 4 to 3. For more about grounding, please refer also to Section 7.

From low to moderate sensor resistance values you can use a low cost 4-lead shielded cable. Higher resistances (> 20 kΩ) require a cable with low leakage isolator. Coaxial cables with PTFE isolator are suitable.

You can make a two-wire measurement, if necessary, by simply connecting input pins 1-2 and 4-5 together inside the input plug. Use offset trimmer to cancel lead resistance, or if adjustment range is too small, use the deviation display mode.

1.4 MAINS VOLTAGE AND FREQUENCY

The AVS-46 is portable between sites using 50 and 60 Hz mains frequencies without any adjustments or modifications. The mains voltage setting must be selected according to local mains voltage. If the voltage label on the rear panel does not correspond to that of your mains supply, refer to Fig. 1-3 for rewiring the mains transformer. After changing the mains voltage, also the fuse must be changed:

230 V	100 mA slow
115 V	200 mA slow

NOTE: Pins 3 and 5 = signal ground

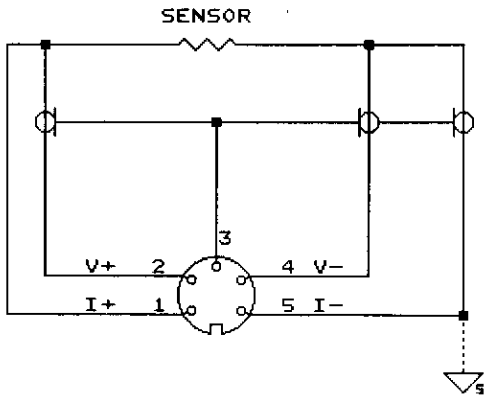


FIG 1-1: FRONT PANEL INPUT SOCKET

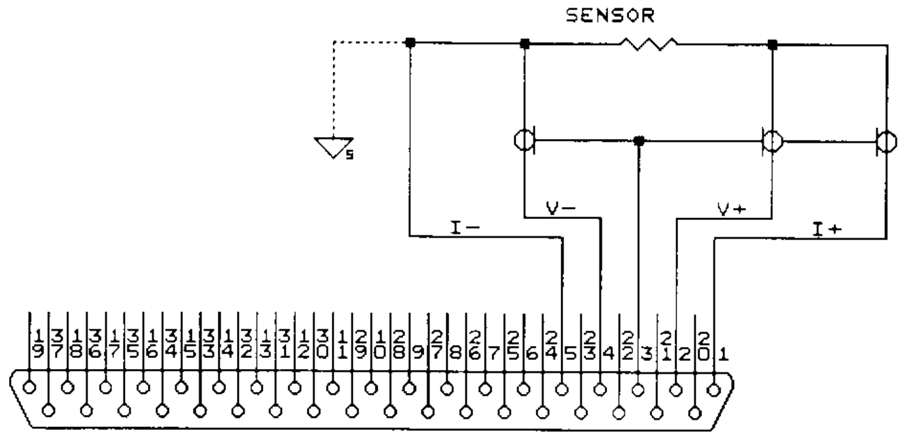


FIG 1-2: AUXILIARY INPUT CONNECTOR
(REAR PANEL)

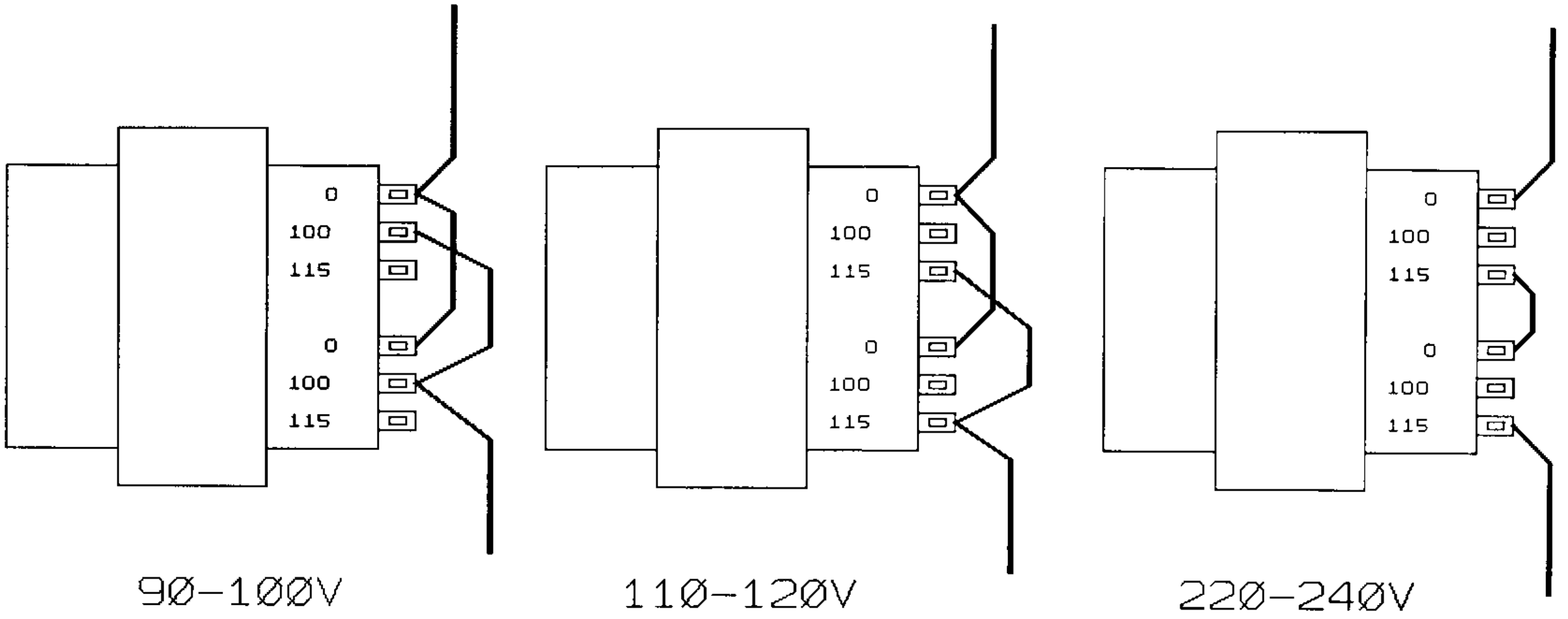


Fig 1–3: Mains input voltage setting

2. QUICK CALIBRATION

You can restore the original calibration of the AVS- 46 quickly and conveniently by using the internal calibration facility. Proceed as follows:

1. Select highest excitation, slow response and 2 kΩ range. You can calibrate the AVS-46 using any range, except the lowest 2 Ω and highest 2 MΩ range. All other ranges will then be calibrated to 0.02%.

2. Let the unit warm up and stabilize in CAL mode for at least one hour. If the unit has been unused for several months, let it stabilize overnight. During this time the leakage currents of electrolytic capacitors decrease to their final value. For the same reason you will not be able to use the lowest excitation levels for some tens of minutes after power-on.

3. Turn the mode switch to ZERO and null the display using the front panel trimmer. The display will then blink between values 0.000 and -0.000.

4. Turn the mode switch to CAL position and adjust middle-scale reading to 1.0000 using the SCALE trimmer.

5. Check lower excitations (only few components separate the excitation ranges from each other and the drift between these ranges is usually a fraction of the overall scale factor drift. Therefore this step will rarely be needed). 1 mV and 300 μV excitations are still easy to check by just looking at the display, but on the lowest excitation ranges there will be noise and one should determine the average. Then either of the following procedures is recommended, depending whether you have a computer interface installed or not.

A) **With computer interface:** A program called AVERAGE or FLAVE was supplied on a diskette following the interface. Connect the AVS-46 to an IBM PC or compatible and run this program. It will measure a floating average on any excitation range that you select. Start a new measurement by pressing any key.

B) **Without computer interface:** Connect a chart recorder to the deviation output and center the pen with REFERENCE potentiometer (highest excitation range). Then decrease excitation step by step and estimate the center lines of each record. If center lines deviate from the 3 mV line, re-adjust the corresponding excitation ranges. See also Fig 2-1, page 13.

For the adjustment it is necessary to remove the top cover of the AVS-46. Open the four cross-head screws at the corners of the cover plate, and with the aid of a knife or a small screwdriver, gently lift the cover at either side so that you can get a grip of it with fingers. It will come out in the right position without excessive force. Locate trimmers P301-305.

3 mV - (front panel trimmer)
1 mV P301
300 μV P302
100 μV P303
30 μV P304
10 μV P305

Turning these trimmers clockwise increases the display.

The digital display of the AVS-46 has now been calibrated to maximum accuracy. The calibration of analog outputs is described in section 6.

3. RANGE

3.1 MANUAL CHANGE

Range can be changed manually when the AVS-46 is not under computer control by lifting or pressing the RANGE UP/DOWN switch. If the bridge is connected to a computer through any of the computer interfaces, please observe the following:

1) If the interface has received a Remote Mode command from the computer, this command tells the interface to control range, and then manual ranging will not be possible. If you attempt to change range manually, the original range will be restored immediately.

2) If the interface has received a Local Mode command, or its state has not been altered since power- on. The interface can only tell to the computer which range has been selected, but it does not control range. Now you can use manual switches normally.

3.2 AUTOMATIC RANGING

Select autorange mode, and the AVS-46 will change range whenever display exceeds 19999 or falls below 1800. Autoranging can only be used when the computer interface has been set into Local mode (this is the initial mode after power-on). If you try to use autoranging in the Remote mode, a race condition will arise between the bridge and the interface.

3.3 DELAY TIME SETTING

The AVS-46 needs a finite time for balancing after a new range has been selected. Therefore making a new autoranging action without waiting for a while would lead to oscillation between the highest and lowest range. A fixed delay has been added to separate successive autorangings. You can select one of two alternatives, 1 second or 5 seconds, using circuit board jumper JP401. Initial setting is 1 sec (jumper in rear position). When the input resistance is step- changed for several decades, the AVS-46 will make one extra change of range before coming back to the final, correct range. If this iteration is not desirable, select 5 sec delay (jumper in front position). The first autoranging is always done immediately. If the input resistance change is slower than one decade in five seconds, then the delay time setting has no effect.

4. EXCITATION

4.1 MANUAL CHANGE

You can change excitation manually by lifting or pressing the EXC UP/DOWN switch, provided that the optional computer interface is in the Local mode (see also sections 3.1 and 3.2).

4.2 AUTOMATIC CHANGE

Set the AUTO/MAN EXC and the AUTO/MAN RANGE switches both in the AUTO position, and each autoranging action will also change the excitation (downranging selects the next lower excitation range and vice versa). This will limit the variations in sensor power dissipation, as the resistance changes with temperature, to one order of magnitude.

4.3 EXCITATION BUFFER

The excitation is selected using a binary counter having 16 states. Six lowest states from 0 to 5 are all decoded to select 10 μV excitation, states 6,7,8 and 9 select excitations from 30 μV to 1 mV, and finally the highest six states from 10 to 15 are decoded to select 3 mV excitation. Counting below the lowest state and above the highest state is inhibited. This arrangement provides a kind of "memory", so that the range-excitation relationship once established, is not lost when the AVS-46 autoranges downwards while the excitation already is 10 μV or upwards with excitation = 3 mV.

4.4 DISSIPATION POWER

The AVS-46 uses a constant-amplitude AC current for excitation. The magnitude of this current is obtained by dividing the excitation range (as indicated by front panel LEDs) by the value of the reference resistor (=middle range resistance). For example, if you use 20 kΩ range and 30 μV excitation, then the sensor current is 30 $\mu V/10^4$ = 3 nA.

Once the sensor current has been calculated, the dissipation power is $P = I^2 * R$.

5. SPECIAL DISPLAY MODES

5.1 REFERENCE DISPLAY

This mode, selected by changing SET/NORM switch in SET position, serves for accurate dialing of the REFERENCE potentiometer. Use this mode to set the control point, if you use the DEVIATION output for temperature control. Or use it to shift the origin of scale if you are in the deviation or magnified deviation display mode.

Digital information transferred to a computer through any of the optional computer interfaces always corresponds to displayed data. If you collect data with computer, be careful that the readings taken during SET mode are not misinterpreted by your program.

5.2 DEVIATION DISPLAY

In this mode, the deviation output voltage is measured and displayed by the A/D converter. You can shift the origin of the scale using the REFERENCE potentiometer, from 0 to 20000.

You can extend a range to 30000 by first nulling the deviation display in CAL mode (use the highest excitation). Of course, you must then add 10000 to all readings. You can also extend the range to 40000 by dialing the potentiometer to 19999 in SET mode, and then adding 19999 to all readings.

5.3 MAGNIFIED DEVIATION DISPLAY

In this mode the deviation output voltage is amplified by a factor of ten before A/D conversion. You can use this mode to achieve an increased resolution within a narrow subrange, whose origin is determined by the REFERENCE potentiometer. Although digital readout resolution is improved, this will not be useful if the signal-to-noise ratio of the bridge circuit is the limiting factor.

You can realize a 0.2 Ω range to measure very low resistances. This will be explained in section 9.

Notice that also the DEV analog output exhibits tenfold sensitivity in this mode.

5.4 INDIRECT READOUT MODE

This mode can only be used with a computer and is therefore explained in the separate manuals for the optional computer interfaces. In this mode the computer can send numeric data to be displayed by the AVS-46.

6. ANALOG OUTPUTS

6.1 MONITOR

This rear panel BNC output provides access to the signal channel AC amplifier, and it is only used for testing and trouble shooting. If you connect an oscilloscope to this output, you can see the unbalance signal (for some seconds after changing the input resistance). You can also see the noise level increasing when excitation is decreased (the gain of the amplifier is increased to compensate for lower excitation).

You can monitor the level of 50/60 Hz interference from this output. Note, however, that when you connect an oscilloscope to the BNC, you also connect the circuit ground of the AVS-46 to the ground of the oscilloscope. This can drastically change the amount of interference. Depending on situation, you may not see something that was there, or you see something that will not be there any more when you disconnect the scope again. The only way to be sure that grounding conditions are not altered by the oscilloscope is to use it in differential input mode, that is A+B(inverted) with one probe connected to the center pin of the BNC and the other to the ground pin.

The preamplifier compares two waveforms, which may have slightly different shapes. You can see short spikes resulting from this, and the spikes will become larger and more noticeable if the capacitance of the input circuit is enlarged. However, the delayed detection excludes these spikes.

There is a DC potential present at this output, which may vary from about 5 Volts to about 12 Volts, and for some time after power-on, this output will remain saturated. Especially at the lowest excitations a long time is needed before the amplifier comes to linear region, which is due to the initial leakage in electrolytic capacitors.

6.2 ANALOG OUTPUT

This is the primary output of the AVS-46. Whereas the digital display goes only to 2 Volts, the analog output can go to above 4 Volts without saturating, and while the digital resolution is limited by the number of digits available, the resolution of the analog output is limited only by noise. At the highest excitation, analog output yields a resolution corresponding to 5 1/2 digits. The output impedance is about 10 Ω.

The high resolution of the analog output makes a difference between bridges using analog and digital balancing. Bridges with digital balancing need a D/A converter to produce the analog output. At best this has a resolution of 16 bits, whereas a bridge with analog balancing can provide a continuous, stepless analog output.

6.3 DEVIATION OUTPUT

The deviation output is formed from the analog output by a differential amplifier whose inverting input is connected to the REFERENCE potentiometer. This amplifier has two selectable gains, 1 and 10 for normal and magnified mode.

Output range is from -10 to +10 Volts.

Because of the extra amplifier, the DEVIATION output is not quite as stable as the ANALOG output.

6.4 OUTPUT FILTER

The primary output of the self-balancing loop contains some amounts of the 25/30 Hz carrier frequency. Whereas the A/D converter and most commercial DVMs are constructed to completely reject this frequency by means of a suitable signal integration time, recording with an analog chart recorder could be difficult on a sensitive range. Therefore a 3rd order Bessel low-pass filter has been added to the AVS-46, between the primary loop and the analog output. This filter has a 3 dB corner at 1 Hz, and it attenuates the 25 Hz signal by three decades. This filter will limit the settling time of the AVS- 46 in FAST mode, but not in SLOW mode.

6.5 CALIBRATION OF THE ANALOG OUTPUT

To calibrate the analog output you need an external DVM. Calibration accuracy will be eventually limited by the 0.01% reference resistors of the AVS-46, but the results can never be better than your DVM.

1. Select highest excitation, slow response and 20 kΩ range. Connect the external DVM to ANALOG output and open the top cover of the AVS-46.

2. Let the unit warm up and stabilize in CAL mode for at least one hour. If the unit has been unused for several months, let it stabilize overnight. During this time the leakage currents of electrolytic capacitors decrease to their final value.

3. Turn the mode switch to ZERO, and null the reading of the external DVM using the front panel ZERO trimmer. The display will then show values 0.000 and -0.000 with equal probability. The AVS-46 should also display 0.0000 to ± 1 digit.

4. Turn the mode switch to CAL position and adjust the reading of the external DVM to 1.0000 using the SCALE trimmer. If the digital display of the AVS-46 deviates from 1.0000, you can now readjust it using trimmer P401 on the main circuit board, so that the display and the analog output have the same calibration. The analog output and the digital display are now calibrated.

5. Switch the input back to zero and select magnified deviation mode. Null the reading by trimmer P203. Then select deviation display mode (gain 1) and switch the input to CAL. Adjust reading to 1.0000 using trimmer P202.

6. In order to calibrate also the magnified deviation mode, you need a 1 kΩ, 0.01% precision resistor. Such calibrator plugs are available from RV-Elektroniikka Oy.

Connect the AVS-46 to the calibrator standard and switch the input to MEAS. Adjust reading to 10.000 using trimmer P201.

7. HOW TO PREVENT EXTRA HEATING OF SENSOR

Perhaps one of the most common problems encountered with low temperature resistance thermometry is the heating effect of RF interference. High frequencies can couple to the sensor in many ways, and you should check at least the points described below.

7.1 GROUND LOOPS

It is a consequence of the transformerless design of the AVS-46 that the sensor current return lead is connected to the AVS-46 circuit ground. Except for operation on the very lowest resistance ranges you cannot keep the bridge circuit floating, but it is necessary to connect the circuit to the mains ground (the enclosure of the AVS-46 is connected to mains ground via the power cord). You must decide, where to have this ground point.

There should be no more than one single path from the AVS-46 circuit ground to the mains ground. If you first ground the sensor to the cryostat, and then the bridge circuit via the analog outputs or computer interface, a ground current will probably flow in the sensor ground lead or cable shields and you can perhaps see the interference either from overload LED or monitor output.

The next thing to avoid are any loops through which a magnetic flux can pass. These loops would act as a transformer winding, picking up high frequency interference and coupling it to the sensor. Keep all sensor leads close together. Also take care that there are no alternate ground paths from the bridge to the sensor. These paths will make a loop, and a part of the voltage drop around this loop can couple to the sensor.

Check if any of the following rules applies to your case:

1) If you do not use the analog outputs nor the AVSI2 computer interface, you should be able to ground the sensor to the cryostat. You can use a floating DVM or recorder to measure the analog outputs.

2) If you connect a grounded instrument (oscilloscope, computer) to any of the outputs, then do not ground the sensor. Try whether results are best with the on-board ground jumper on or off (see below).

3) If you must ground the sensor to the cryostat, and you use any of the analog outputs, try a differential input connection (see 6.1, 11.2).

4) If you must ground the sensor to the cryostat and you use the AVSI2 computer interface, try the optoisolated current loop mode (see 7.4.)

7.2 MAINS GROUND JUMPER

The AVS-46 is equipped with a mains ground jumper, JP601. When this jumper is in rear position, then circuit and mains grounds are connected together, and when the jumper is in front position, the two grounds are separated.

The grounds are joined by default setting of JP601. If you ground the sensor to the cryostat, change jumper position.

7.3 SHIELDING OF CABLES

It is almost self-evident that every millimeter of the leads to the sensor must be shielded. This applies especially to the I+ and V+ leads, which have a high impedance. It is not necessary to shield the "I-" lead, as this is always connected to AVS-46 ground. If lead resistances are not exceptionally high, it may be possible to use an unshielded cable also for V- (lead resistance determines the impedance level of this wire).

The old AVS-45 bridge was highly sensitive to capacitances in the input circuit, and active guarding (bootstrapping) of the cable shields was needed for linear response. The shields could not be grounded, but they had to be connected to a guard output with a 10 Ω impedance. Obviously, a cable shield which is separated from ground by 10 Ω is not an ideal guard against RF interference.

The AVS-46, on the contrary, utilizes a method called delayed phase-sensitive detection to reject the transient part of the signal. This reduces the nonlinearizing error from stray capacitances by a factor more than 200 without need to use active guarding. This means that if the distance between AVS-46 and the sensor does not exceed 5 meters, and if sensor resistance stays below 200 kΩ, error will be nondetectable. It is also possible to insert small RF chokes in the input leads (make sure the Q-value is low and time constant well below 1 ms) to prevent RF from entering the cryostat.

There are many possible ways to connect the cable shields and it may need some experiments to find the best arrangement. There should not be any potential difference between the cable shields and the input leads, but the shielding must not cause ground loops either. If you plan to use a grounded sensor, start by using the shields as current return lead so that they connect the AVS-46 circuit ground to the cryostat body to which your sensor is also grounded. If you use a floating sensor, then start by using the shields to connect the cryostat body and the AVS-46 mains ground together. If the result is a ground loop, disconnect the shield from cryostat and if this does not help, try to connect the shields only to AVS-46 signal ground (pin 3 or 5 of the DIN socket).

7.4 ISOLATING THE COMPUTER INTERFACE

A computer interface is a potential source of high-frequency interference. Therefore the fast IEEE-488 interface has been isolated from the bridge circuitry in order to prevent grounding problems. However, because the IEEE-488 is a very fast interface, the DC900 unit is not recommended for work at extremely low temperatures, but one should use the Picobus interface instead.

The older, lower-cost AVSI2 serial interface has not been isolated, but has such a design that it can be used either in the normal way, according to the RS232C standard, or in a current loop mode with optical isolation. A simple RS232-to-current-loop converter is described in Fig. 7-1. Please note that only the two data transmission lines, RXD and TXD need isolation, if software handshaking is used.

NOTE: Jumper J4 on the AVSI2 board must be connected between pins 2 and 3 for current loop operation.

The Picobus interface is quite slow, and the interface line can be filtered at the boundary of the shielded cryostat room. In addition, the interface unit itself is very quiet (it does not contain fast electronics) and the interface line is optically isolated from the bridge circuit. It should be possible to use this interface even at the lowest temperatures measurable with resistance thermometry.

7.5 THERMAL VOLTAGES

The AC operating principle of the AVS-46 completely rejects all DC input voltages. Therefore thermoelectric potentials created in the sensor lines do not have any direct effect on readings. However, large thermal voltages can cause extra heating, and you should make sure that this effect is not significant in your application.

The mechanism is described with the aid of Fig. 7-2, which shows the essential components of the AVS-46 input, the sensor and the effective thermal emf V_T, which is the sum of all thermoelectric voltages around the closed path shown by arrows. The thermal current is then $V_T/(R_X+R_{REF}+10\ \Omega)$. Assume values $R_X=R_{REF}=1\ k\Omega$ and $V_T=100\ \mu V$, and the power dissipated in the sensor would be 2.5 pW, whereas the lowest 10 μV excitation would heat by just 0.1 pW.

You can test the thermoelectric heating in a simple way as follows:

1) Make sure that the magnified deviation mode is calibrated (Section 6.5). Dial the reference potentiometer to zero.

2) Measure the sensor using the lowest excitation that gives reasonable signal to noise ratio.

3) Switch input to ZERO. Select magnified deviation mode, ten times higher excitation voltage, next higher range and null the possible zero offset. Switch the input to MEAS.

Readings are now taken at the same excitation current, so that heat input from the bridge has remained unchanged. However, the sum of resistances in the loop is about tenfold, and thermoelectric heating is reduced by a factor of ten, and it occurs almost entirely in the reference resistor R_R, which has the highest impedance. If there has been any significant heating caused by V_T, you should obtain a new reading that indicates a lower temperature.

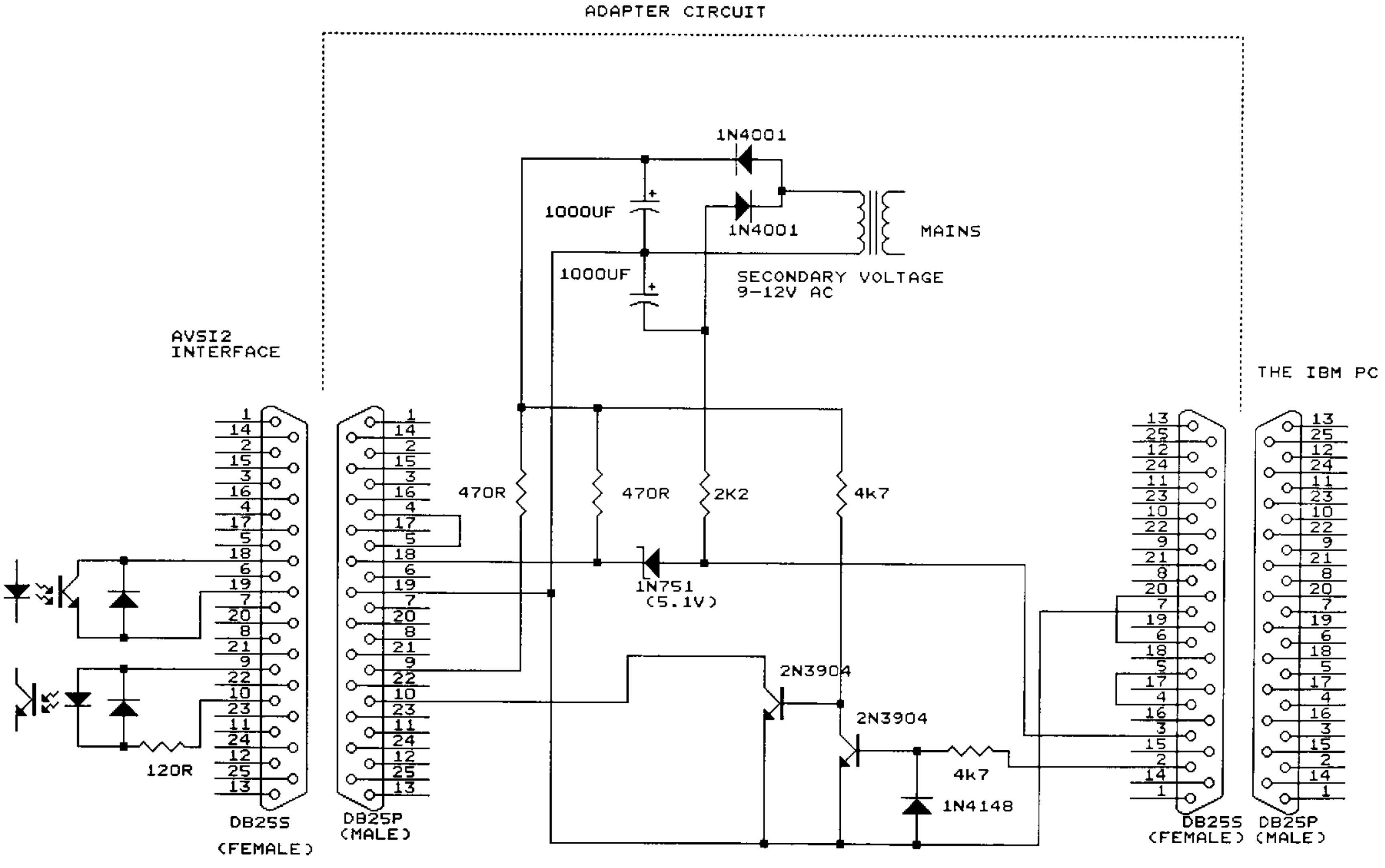


FIG 7-1: RS232 TO CURRENT LOOP ADAPTER
Note that jumpers 6-20 and 4-5 apply to the IBM PC. Refer to AVSI2 manual for jumpers suitable for an AT computer.

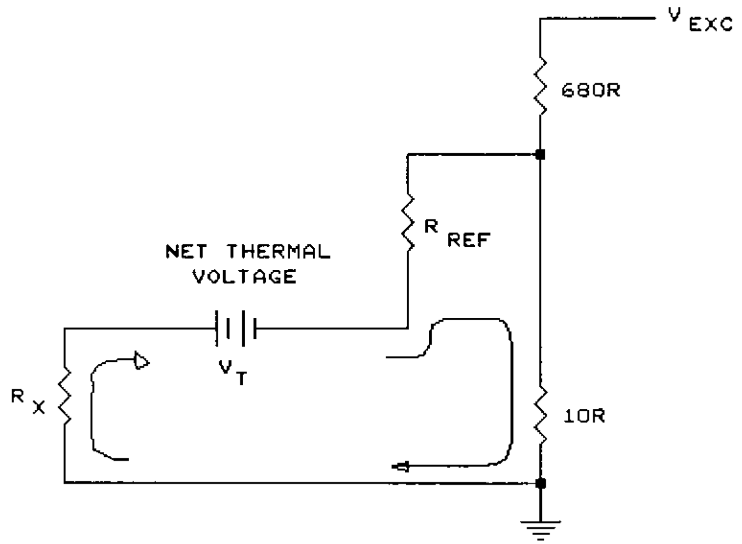


Fig 7-2: Heating by thermal voltages

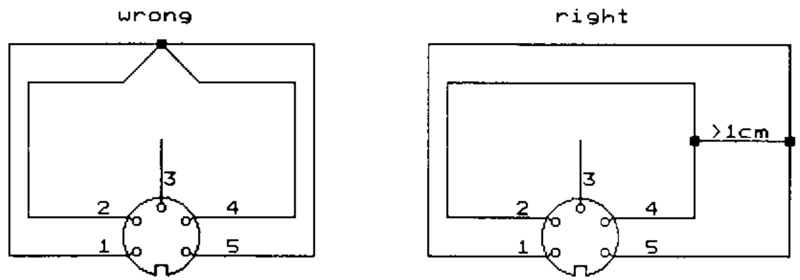


Fig 9-1: A non-superconducting zero-ohm reference

8. HOW TO HANDLE VERY HIGH LEAD RESISTANCES

The ability of the AVS-46 to measure a sensor with very high lead resistances is limited by two factors: The finite compliance voltage of the excitation source and the common-mode rejection ratio (CMRR) of the preamplifier. If the product of excitation current and overall current path resistance exceeds the maximum compliance voltage, response of the bridge will be highly nonlinear, and the user is alerted by a red warning light (this is useful in LOW lead resistance mode only).

Common-mode signals are caused by resistances in the current leads. The AVS-46 has a high but finite CMRR of about 110dB, and very high lead resistances will produce both gain and offset errors which are difficult to predict and take into account. Whereas the compliance voltage limitation can be circumvented, little can be done to common-mode errors (except keeping lead resistances as low as possible).

If you use germanium or carbon sensors, there will be no problems. Platinum resistors (PT100) are typically measured using 200 Ω range, and maximum allowed total lead resistance is in this case as high as 1 kΩ. Actual lead resistance seldom rises to this level.

Rhodium-Iron sensors require 2 Ω range at the low end of their temperature range, and if the current path resistance exceeds 6 Ω, you have to change a circuit board jumper J102, as described below, to allow for higher lead resistances.

A still worse problem is posed by superconductivity measurements with the new ceramic high-temperature superconductors. Bonding the current and voltage leads to their surface is not easy and the contact resistance, although low before cooling, may be quite different at final temperature.

8.1 HIGH/LOW RESISTANCE SETTING

Operational amplifier U307D, which buffers the output of the excitation channel attenuator, has a small DC offset. In order to prevent this offset from heating the sensor, a network consisting of resistors R150 and R152 (preamplifier board) is used to further scale down the attenuator output before feeding it to the reference resistor. This voltage divider limits the available compliance voltage, and therefore the AVS-46 is equipped with a circuit-board jumper JP101 for high lead resistance setup.

Remove power cord from the rear panel connector before proceeding. To change the jumper position, remove the top cover. This is done by unscrewing the four screws at the corners, and then lifting the cover with the aid of a sharp knife (a scalpel or similar) at either side, not front or rear. The next step is to remove also the preamplifier shield. Unscrew again four screws, push the cover backwards and lift its front edge first. See component layout picture in the end of this manual. Locate jumper J102 in the preamplifier section at the left. Use pliers to gently lift the jumper, which initially is in front position, and insert it in rear position for HIGH lead resistance mode.

There are several things you must take into account when using the HIGH lead resistance mode.

1) The DC offset from excitation source goes directly to the sensor. This offset should remain below 100 µV, but even then it is clear that use of this mode must be limited to excitations not lower than 100 µV. Otherwise the heating by the DC current can be higher than that from the measuring current. In practice, this should not be a serious limitation, as all low-ohm sensors tolerate rather high excitation currents, and high-resistance sensors, on the other hand, do not need this mode.

2) Dynamic response is not as good in HIGH lead resistance mode than in the normal mode.

3) The lead resistance indicator light does not operate in HIGH resistance mode.

4) The maximum allowed lead resistance depends on selected excitation range, so that the higher is the excitation the lower must be total lead resistance.

IF THE MAGNITUDE OF THE LEAD RESISTANCE IS NOT KNOWN, AND IF IT MIGHT BE TOO HIGH, ALWAYS VERIFY THE READING BY USING TWO DIFFERENT EXCITATIONS. IF THE READINGS ARE CLEARLY DIFFERENT, THE ONE OBTAINED WITH LOWER EXCITATION IS LIKELY TO BE MORE ACCURATE.

In special, if you get a non-zero resistance for a sample that should be a superconductor, reduce excitation.

The common mode error has been minimized by individual trimming of each AVS-46 unit. Should there be any need to replace the preamplifier FETs, this adjustment must be repeated. Consult factory for instructions.

8.2 MAGNIFIED DEVIATION DISPLAY

You can also allow high lead resistances without changing internal settings if you use the AVS-46 in the magnified deviation mode. This method will extend the compliance range, but it does not reduce common- mode error. Remember to dial and lock the potentiometer to zero, and to check the offset before and also between measurements.

9. HOW TO MEASURE VERY LOW RESISTANCES

The magnified deviation display enables you to measure resistances below 100 µΩ with the AVS-46. Once again, remember to check zero offset frequently. A resolution of about 10-20 µΩ can be expected on the 3 mV excitation range (3 mA measuring current).

9.1 OFFSET ADJUSTMENT

It was recommended above that zero offset be checked every time you switch from normal display to the magnified deviation mode. Before doing so, verify that the REFERENCE potentiometer is locked to zero.

The AVS-46 has an internal zero reference which is accurate to about 10 µΩ, so that you can null the offset even for the 0.2 Ω range without external "short-circuit" standards. If you first null the offset on a higher range and then come down with the range, you will see that offset stays at zero for all ranges except the lowest one. This is due to the bridge, not to the zero reference, and it means that when you go to the lowest (0.2 Ω) range, you have to re-adjust the offset.

If you have a multiplexer, you can possibly afford one channel for a zero-ohm reference, and then measure and subtract the offset under computer control.

9.3 HOW TO MAKE A ZERO-OHM REFERENCE

To check the offset when the AVS-46 is controlled manually, you need but switch the input to ZERO and adjust the trimmer, if necessary.

The input switch cannot be computer controlled, and a remotely activated zero-check requires an external "short-circuit" standard which is connected to one of the multiplexer input channels. It would be very difficult to build a non-superconducting short- circuit having a resistance lower than 10 μΩ. Fortunately, this is not necessary. By making use of the high common-mode rejection of the AVS-46, you can easily build an accurate zero-ohm reference as shown in Fig. 9-1.

The idea of this circuit is to connect the V+ and V- inputs together so that there cannot be any voltage difference between them. The common-mode voltage should be as low as possible, but it needs not be zero.

10. INPUT MULTIPLEXER OPTION

The input multiplexer option is a circuit board consisting of 14 two-contact reed relays and a channel selection logic. One multiplexer has seven input channels and the AVS-46 may be equipped with one or two multiplexer cards. If there is only one multiplexer, this is called MUXA, and the second is called MUXB. (Installation of MUXB excludes computer interfacing of the temperature controller).

In most cases the AVS-46 is purchased with the multiplexer option installed. It is also possible to install them later.

10.1. FIELD INSTALLATION OF MUXA

The multiplexer kit consists of

1) Multiplexer card with cable and 8-pin connector.
2) A 26-pole ribbon cable
3) A set of screws, spacers etc.
4) One 37-way input connector.

A) Remove top and bottom plates of the AVS-46. To remove the top cover use a sharp knife at the side of the unit to lift the edge of the plate.

THE TOP COVER PLATE WILL COME OUT WITHOUT FORCE IF IT ONLY IS IN RIGHT POSITION.

B) Remove the black preamplifier shield. It is held by four cross-head plate screws at top side. Push it first backwards and then lift the front edge up.

C) Remove the two screws holding the AUX IN/MUXA connector. Unsolder the five leads coming to the DC37 connector (marked MUXA/AUX IN). Discard the connector, it will not be needed any more.

D) Fix the long screw from bottom side as shown by figure 10-2.

E) Solder the five wires to multiplexer board in the order shown by figure 10-1. Check that jumper JP1 is in REAR position.

F) Install the ribbon cable as indicated by Fig. 10-1. Coloured strip should be on the input connector side (rear side).

G) Install the circuit board according to Fig. 10- 2. Insert the 8-pin connector into J803 on the AVS-46 main board and the 26-pin connector into the vertical row connector on the display board. Coloured strip is now upwards.

H) Slide the preamplifier shield back into its place. Take care not to damage the multiplexer cables which go between main board and the shield. Tighten the plate screws gently without excessive force.

I) Switch power on. Use the multiplexer toggle switch to verify that everything is OK.

L) Install top and bottom cover plates.

10.2. INSTALLATION OF MUXB

Multiplexer board that is intended to be MUXB has one difference. It has jumper JP1 in FRONT position, and five wires (brown, red, yellow, green and orange) have been soldered to its output terminals. MUXB kit for field installation contains:

1) MUXB circuit board with two wire harnesses.
2) A ribbon cable with three connectors instead of two.
3) A set of spacers and screws.
4) A LED display digit.
5) One 37-way input connector.

A) Remove top and bottom covers, preamplifier shield, and the front panel.

B) Solder the MUXB display digit to its place. Note the position of decimal point (down right). Then install front panel again.

C) Remove the old ribbon cable coming to MUXA. It will no longer be needed.

D) Remove MUXA and replace the mounting screw by the longer one in the package

E) Solder the five input leads and the 8 control signal leads from MUXB to corresponding terminals of MUXA.

F) Install MUXA and tighten the screw. Install the new ribbon cable so that the lonely connector goes to display board (coloured strip upwards) and the connector in the middle goes to MUXA (coloured strip on rear side).

G) Insert 3 spacers into the long screw and then MUXB. Tighten with a M3 nut.

H) Insert the remaining 26-way connector. Note that coloured strip must now be on FRONT SIDE (the cable is reversed between MUXA and MUXB).

I) Fix the shield, panels and cover plates.

J) Turn power on. Lift and release the MUX toggle switch. First seven times should increment MUXA channel, as before. Eighth operation should cause both LEDs to be blanked (no channel is selected). Then MUXB should increment from 1 to 7.

10.3. SENSOR CONNECTIONS

Both MUXA and MUXB have identical sensor connections.

pin No.			signal	
1	*		current hi	channel 1
20		*	voltage hi	
2	*		voltage lo	
21		*	current lo	
3	*		ground for shields	
22		*	current hi	channel 2
4	*		voltage hi	
23		*	voltage lo	
5	*		current lo	
24		*	ground for shields	
6	*		current hi	channel 3
25		*	voltage hi	
7	*		voltage lo	
26		*	current lo	
8	*		ground for shields	
27		*	current hi	channel 4
9	*		voltage hi	
28		*	voltage lo	
10	*		current lo	
29		*	ground for shields	
11	*		current hi	channel 5
30		*	voltage hi	
12	*		voltage lo	
31		*	current lo	
13	*		ground for shields	
32		*	current hi	channel 6
14	*		voltage hi	
33		*	voltage lo	
15	*		current lo	
34		*	ground for shields	
16	*		current hi	channel 7
35		*	voltage hi	
17	*		voltage lo	
36		*	current lo	
18	*		ground for shields	
37		*	not used	
19	*		not used	

Note that the ground for shields -outputs are not switched by multiplexer but they are all simultaneously connected. You can simplify connector wiring and save space in the connector if you join all cable shields together, and then connect these by one single wire to any of the guard outputs.

10.4. FRONT PANEL CHANNEL SWITCH

The front panel channel switch works in the same way as those for range and excitation.

Lift and release the switch lever to scan input channel upwards.

Press and release the switch lever to scan input channel downwards.

The multiplexer counter has 16 states which are decoded as follows:

0 multiplexer(s) disabled, display blanked
1 MUXA=1
2 MUXA=2
.
.
7 MUXA=7
8 multiplexer(s) disabled, display blanked
9 MUXB=1
10 MUXB=2
.
.
15 MUXB=7

If you scan above state 15 you come to state 0 and vice versa.

NOTE: If a computer interface has been installed and is in the Remote Control Mode, then you cannot use the MUX toggle switch. The interface will always return multiplexer either to default state 0 or to some other state if a mux channel has been remotely selected.

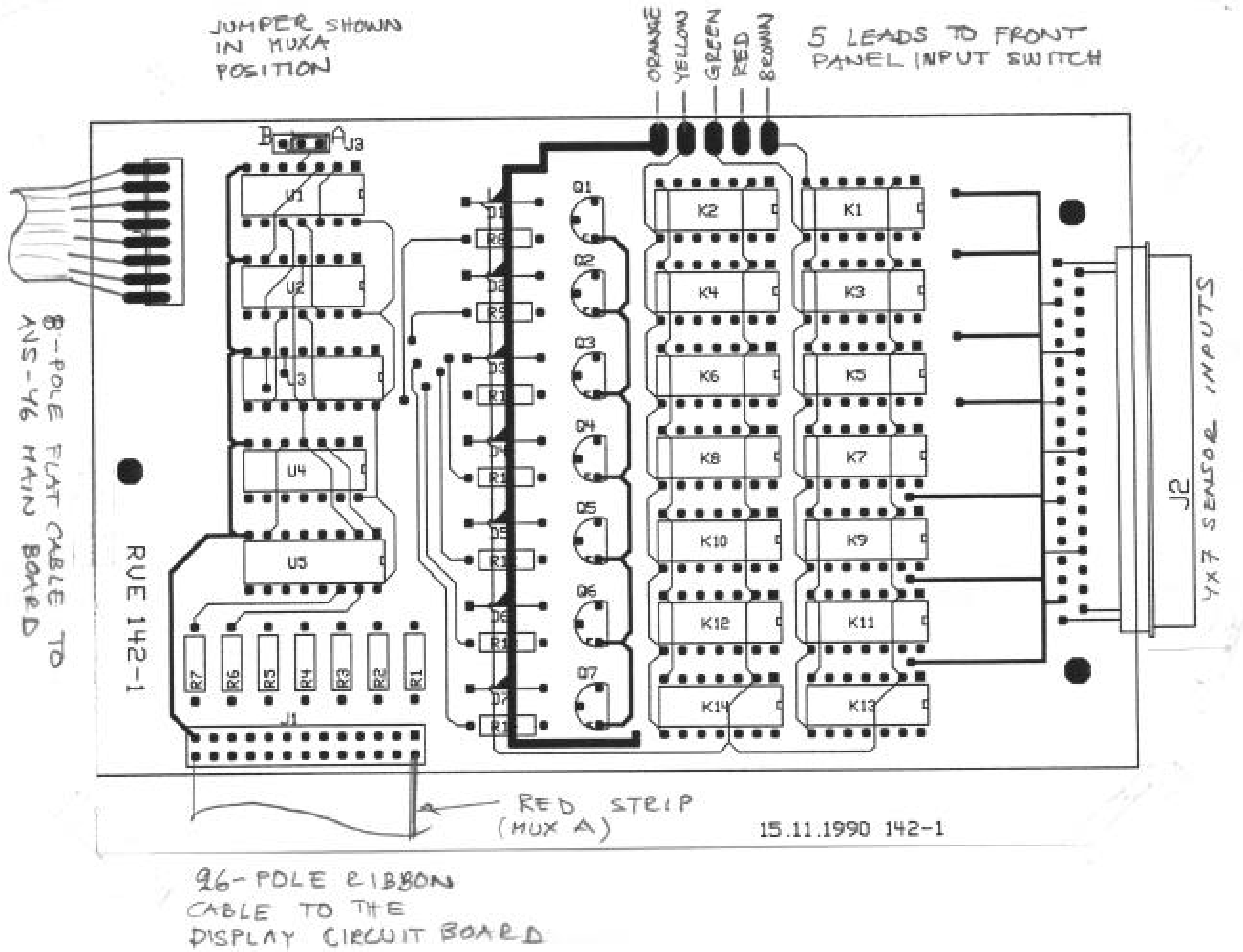


FIG 10-1: Multiplexer Board

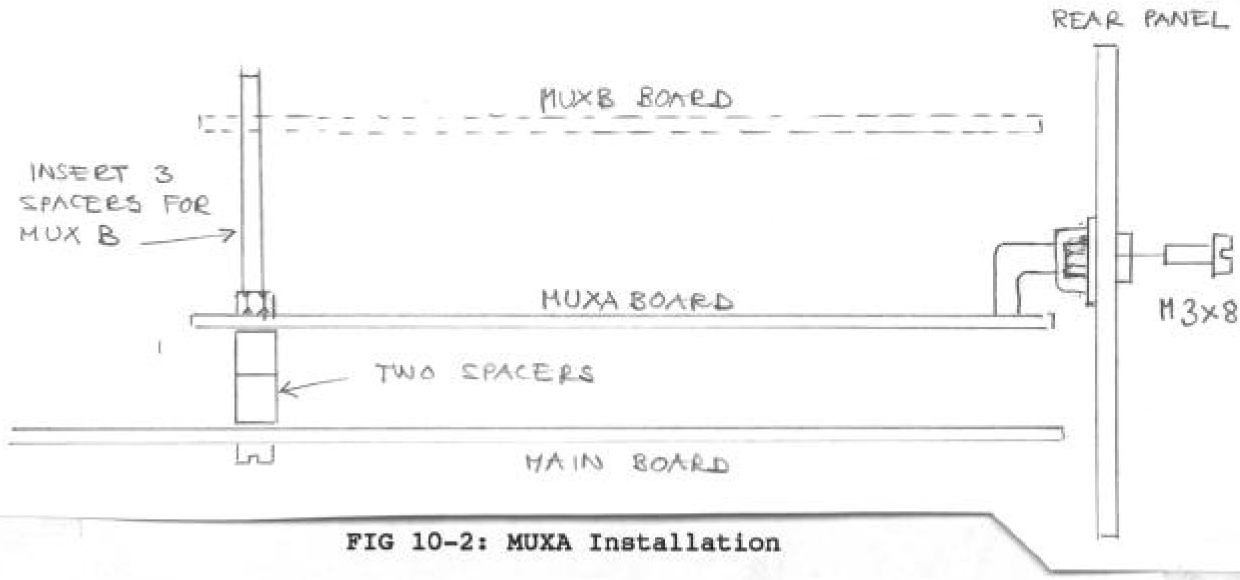
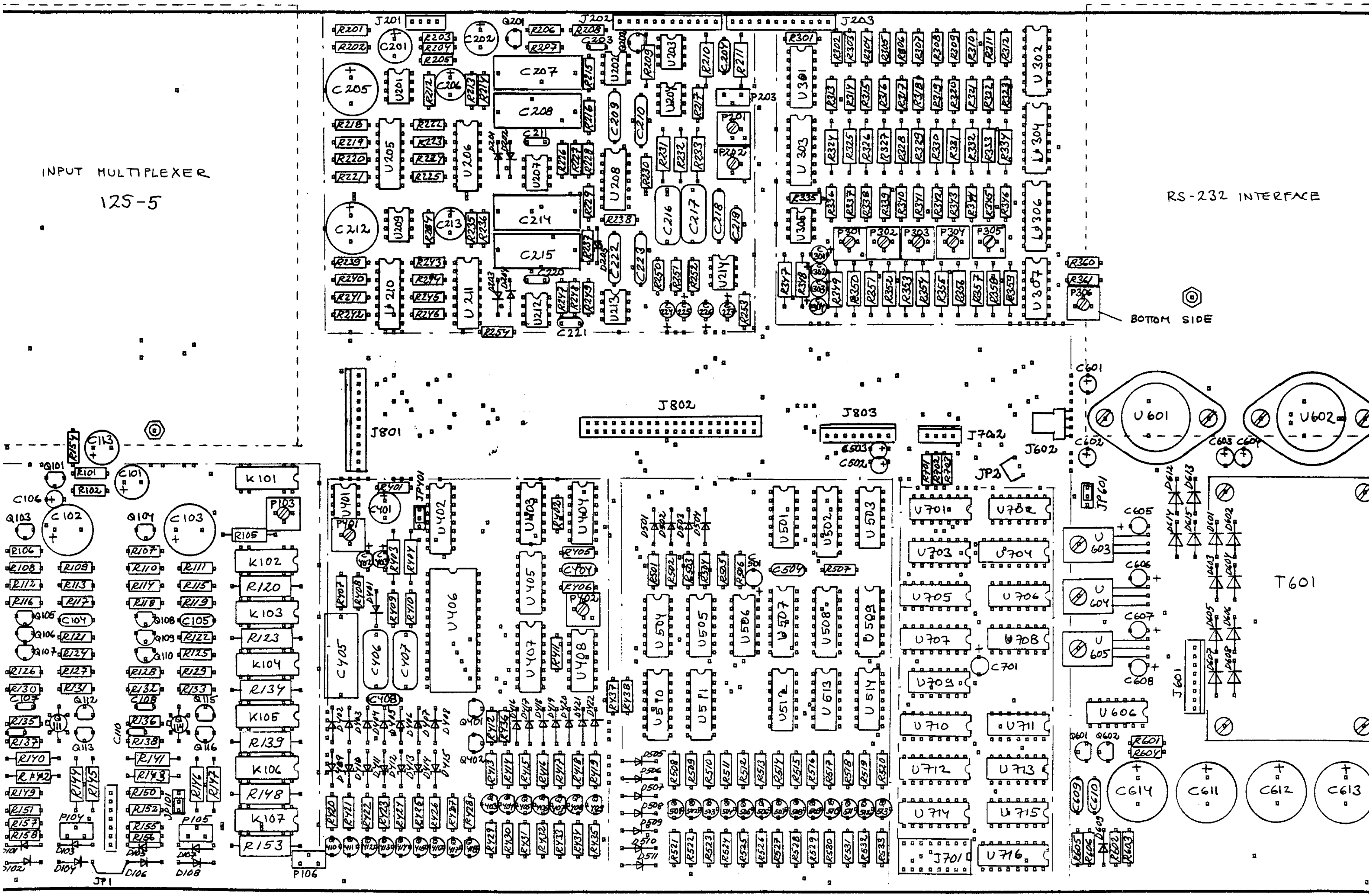
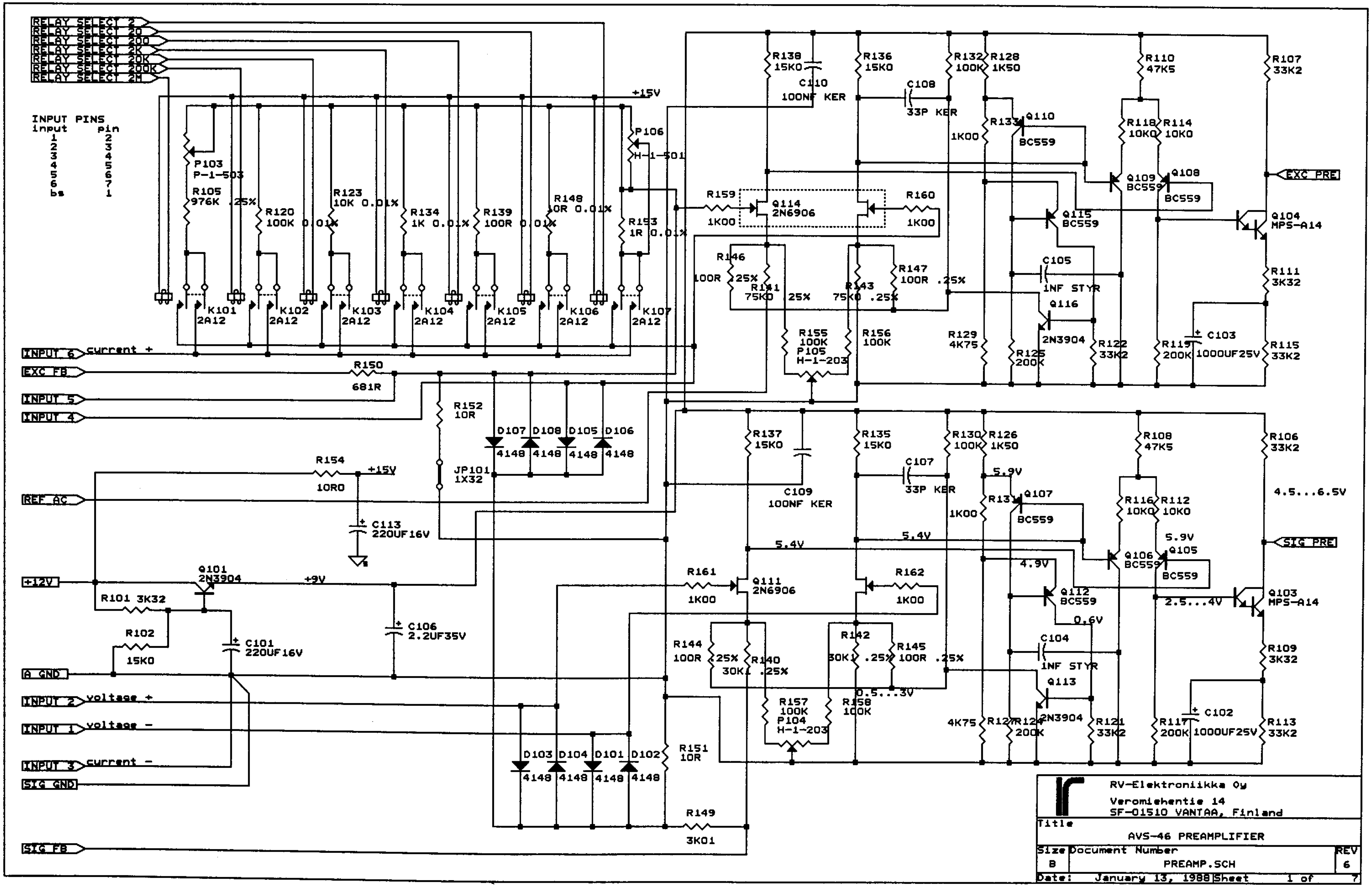


FIG 10-2: MUXA Installation

INDEX



INPUT MULTIPLEXER
125-5
RS-232 INTERFACE
BOTTOM SIDE



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Veromiehentie 14
SF-01510 VANTAA, Finland

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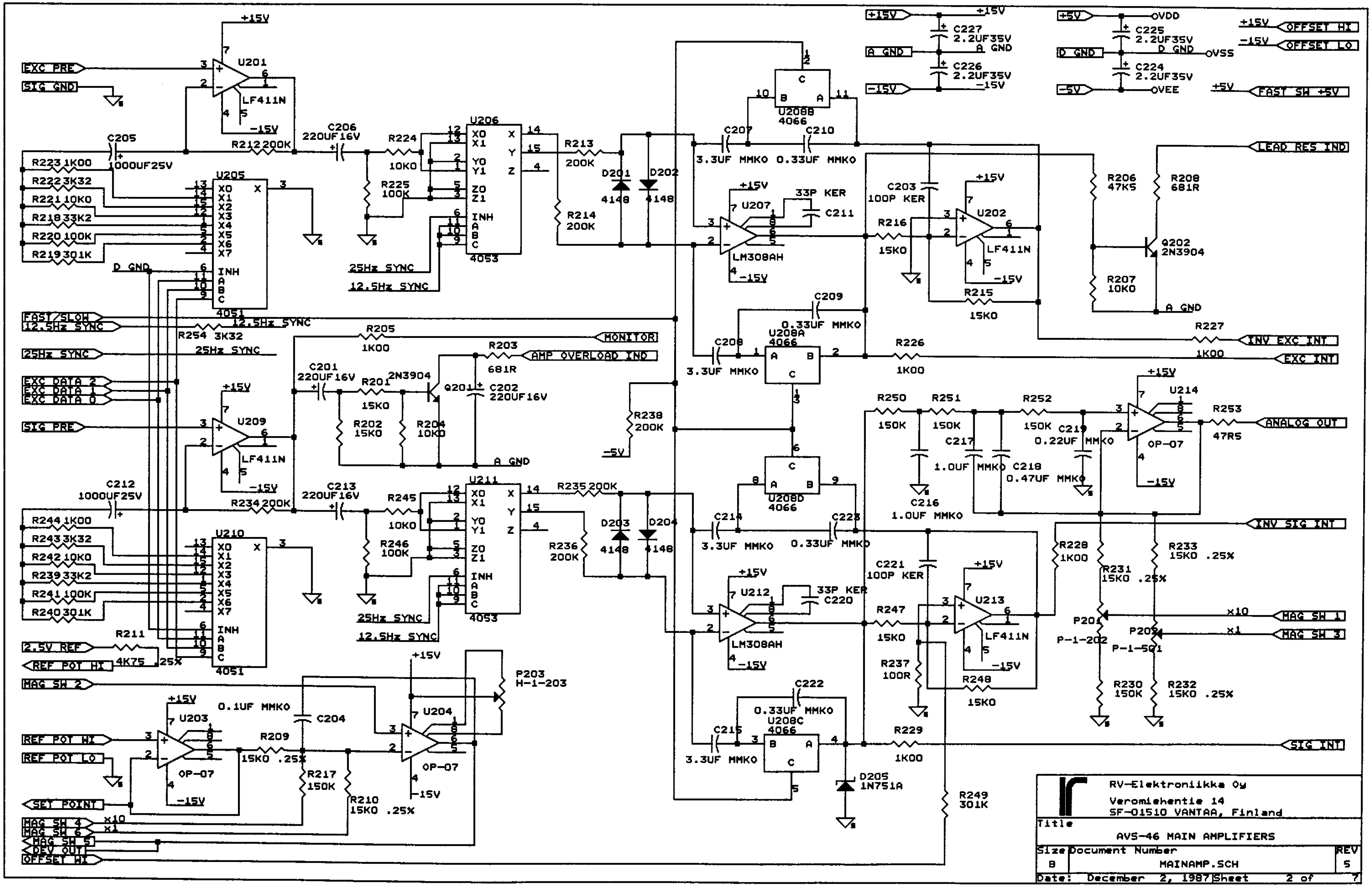

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Title
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Size B
Document Number MAINAMP.SCH
REV 5
Date: December 2, 1987
Sheet 2 of 7
EXC PRE
SIG GND
SIG PRE
FAST/SLOW
12.5Hz SYNC
25Hz SYNC
EXC DATA 2
EXC DATA 1
EXC DATA 0
2.5V REF
REF POT HI
REF POT LO
MAG SW 2
SET POINT
MAG SW 4
MAG SW 6
MAG SW 5
DEV OUT
OFFSET HI
OFFSET LO
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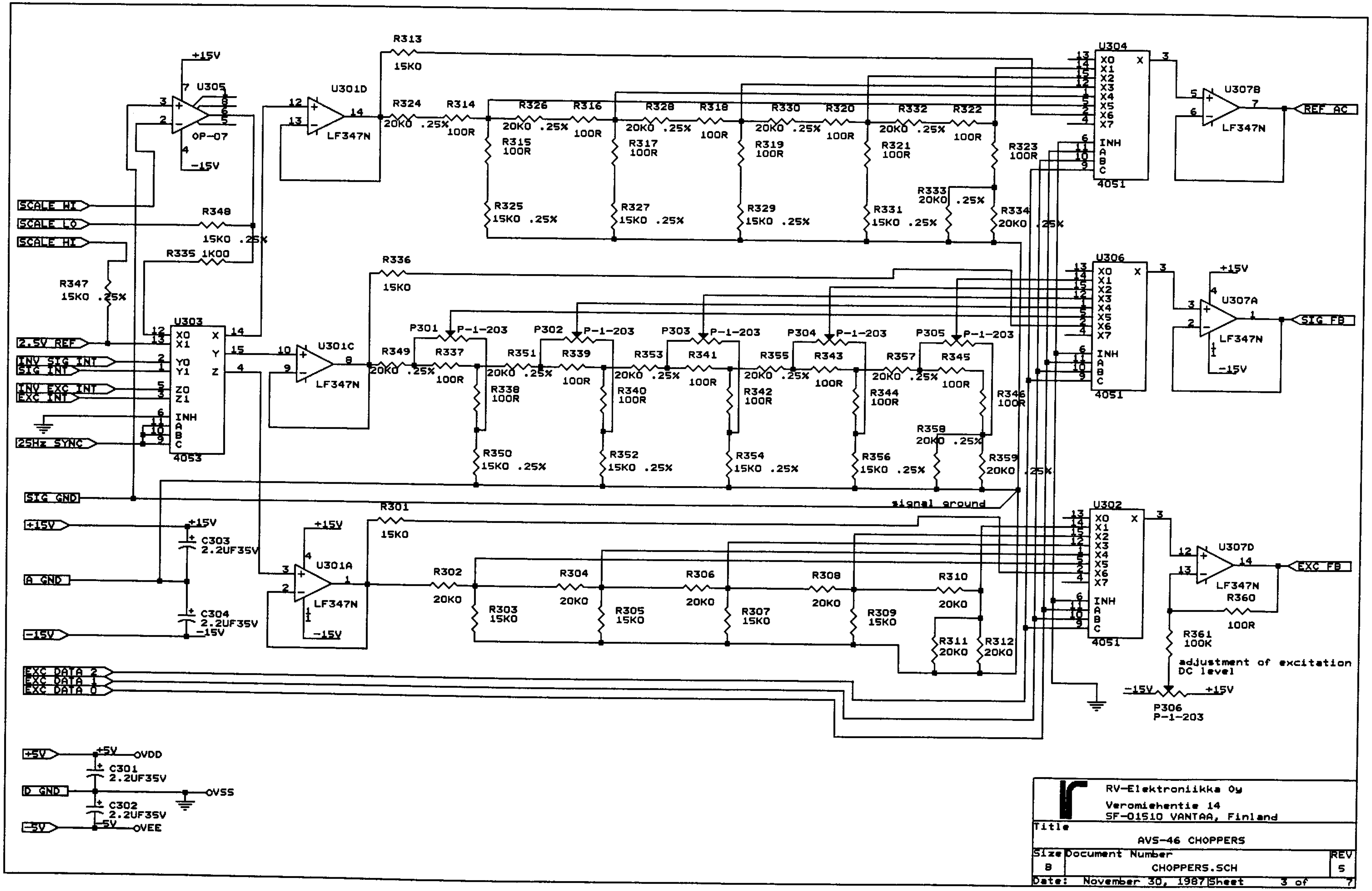
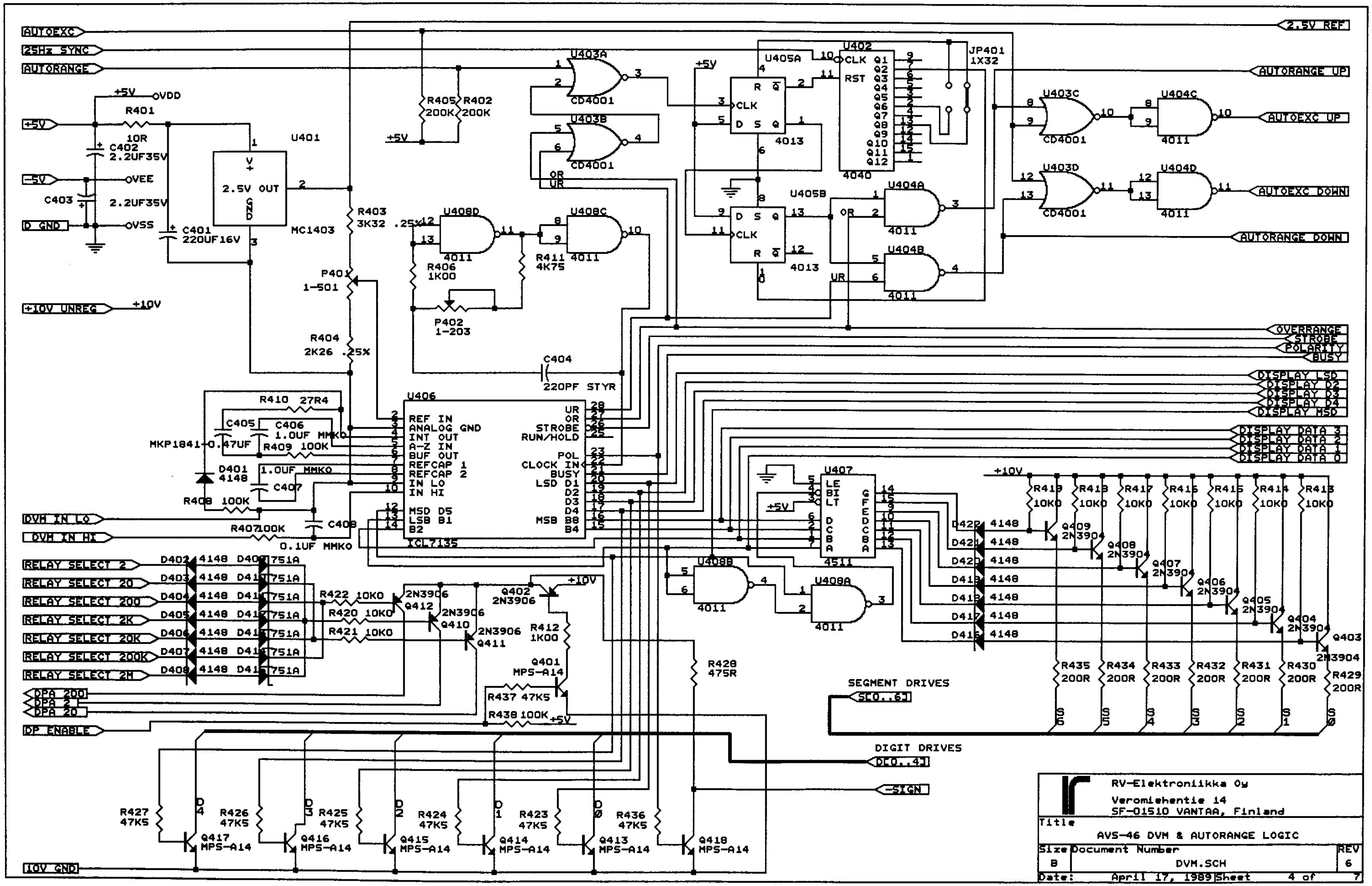
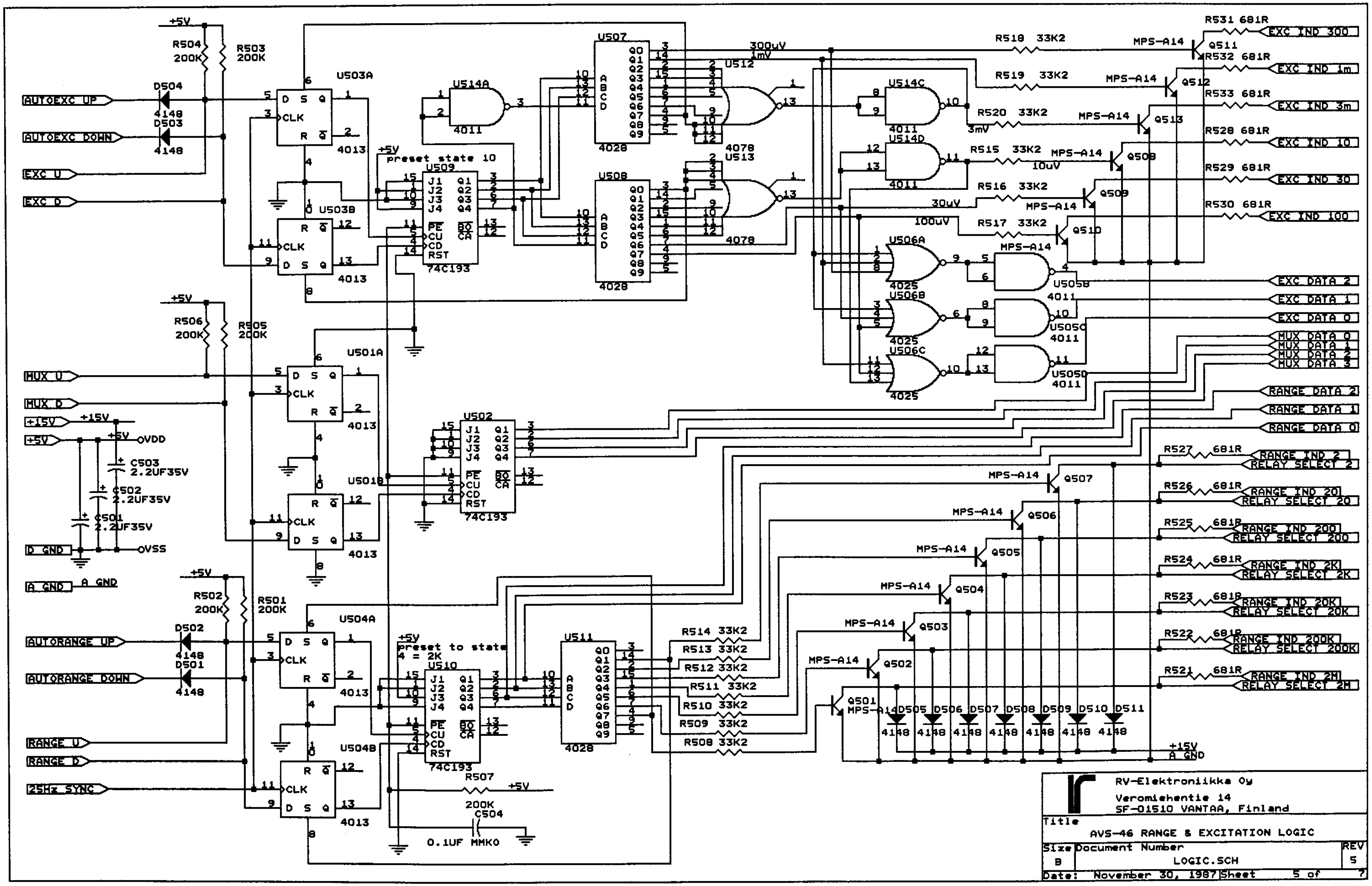
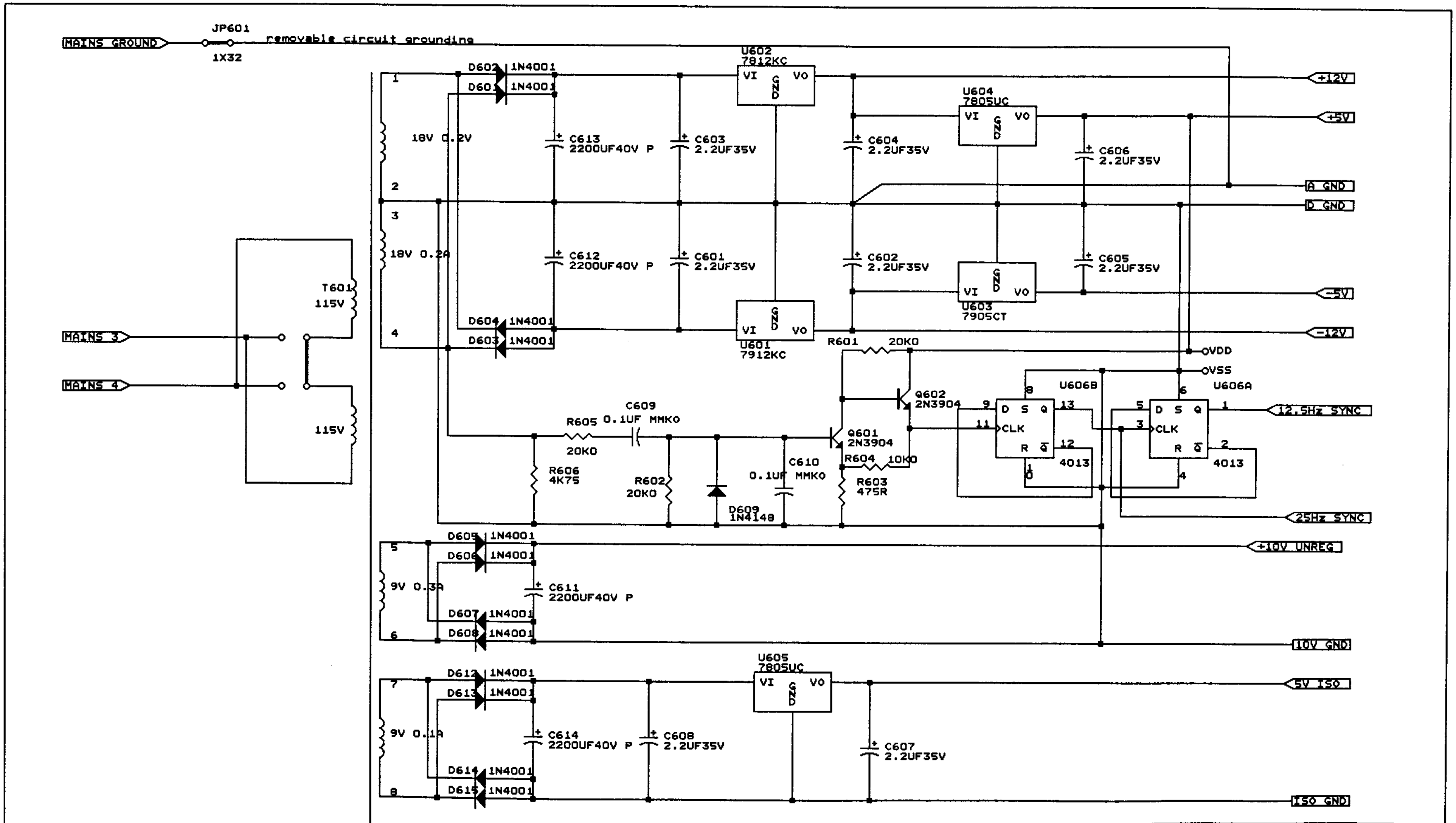
INV EXC INT
EXC INT
ANALOG OUT
INV SIG INT
MAG SW 1
MAG SW 3
SIG INT
MONITOR
AMP OVERLOAD IND


RV-Elektroniikka Oy
Veromiehentie 14
SF-01510 VANTAA, Finland
Title
AVS-46 CHOPPERS
Size B
Document Number CHOPPERS.SCH
REV 5
Date: November 30, 1987
Sheet 3 of 7
SCALE HI
SCALE LO
SCALE HI
2.5V REF
INV SIG INT
SIG INT
INV EXC INT
EXC INT
25Hz SYNC
SIG GND
+15V
A GND
-15V
EXC DATA 2
EXC DATA 1
EXC DATA 0
+5V
D GND
-5V
REF AC
SIG FB
EXC FB
signal ground
adjustment of excitation DC level

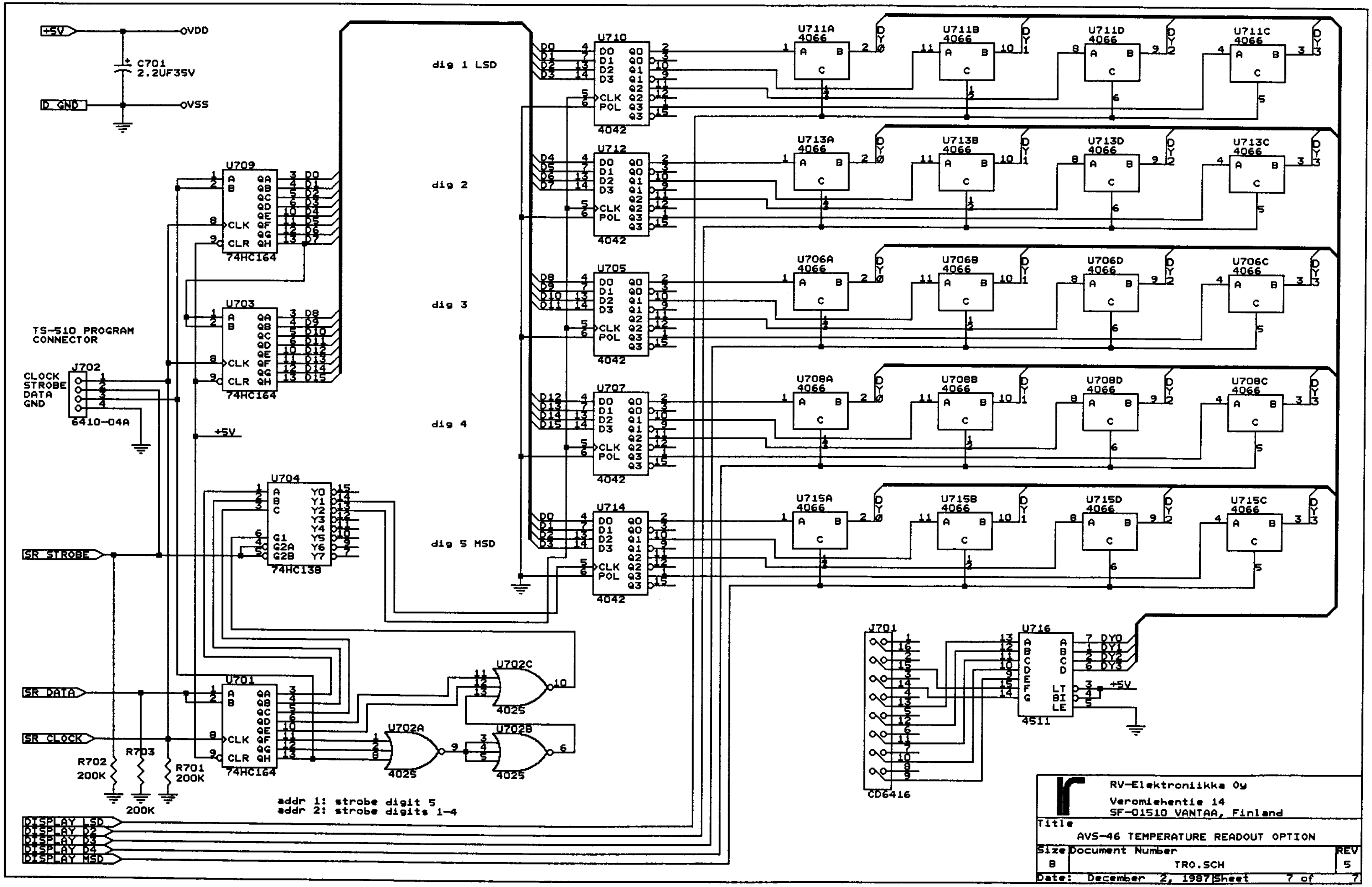


RV-Elektroniikka Oy
Veromiehentie 14
SF-01510 VANTAA, Finland
Title
AVS-46 DVM & AUTORANGE LOGIC
Size B
Document Number DVM.SCH
REV 6
Date: April 17, 1989
Sheet 4 of 7
AUTOEXC
25Hz SYNC
AUTORANGE
+5V
-5V
D GND
+10V UNREG
DVM IN LO
DVM IN HI
RELAY SELECT 2
RELAY SELECT 20
RELAY SELECT 200
RELAY SELECT 2K
RELAY SELECT 20K
RELAY SELECT 200K
RELAY SELECT 2M
DPA 200
DPA 2
DPA 20
DP ENABLE
10V GND
2.5V REF
AUTORANGE UP
AUTOEXC UP
AUTOEXC DOWN
AUTORANGE DOWN
OVERRANGE
STROBE
POLARITY
BUSY
DISPLAY LSD
DISPLAY D2
DISPLAY D3
DISPLAY D4
DISPLAY MSD
DISPLAY DATA 3
DISPLAY DATA 2
DISPLAY DATA 1
DISPLAY DATA 0
SEGMENT DRIVES
SC0..6
DIGIT DRIVES
DC0..4
-SIGN
U401 MC1403
U402 4040
U403A CD4001
U403B CD4001
U403C CD4001
U403D CD4001
U404A 4011
U404B 4011
U404C 4011
U404D 4011
U405A 4013
U405B 4013
U406 ICL7135
U407 4511
U408A 4011
U408B 4011
U408C 4011
U408D 4011
JP401 1X32

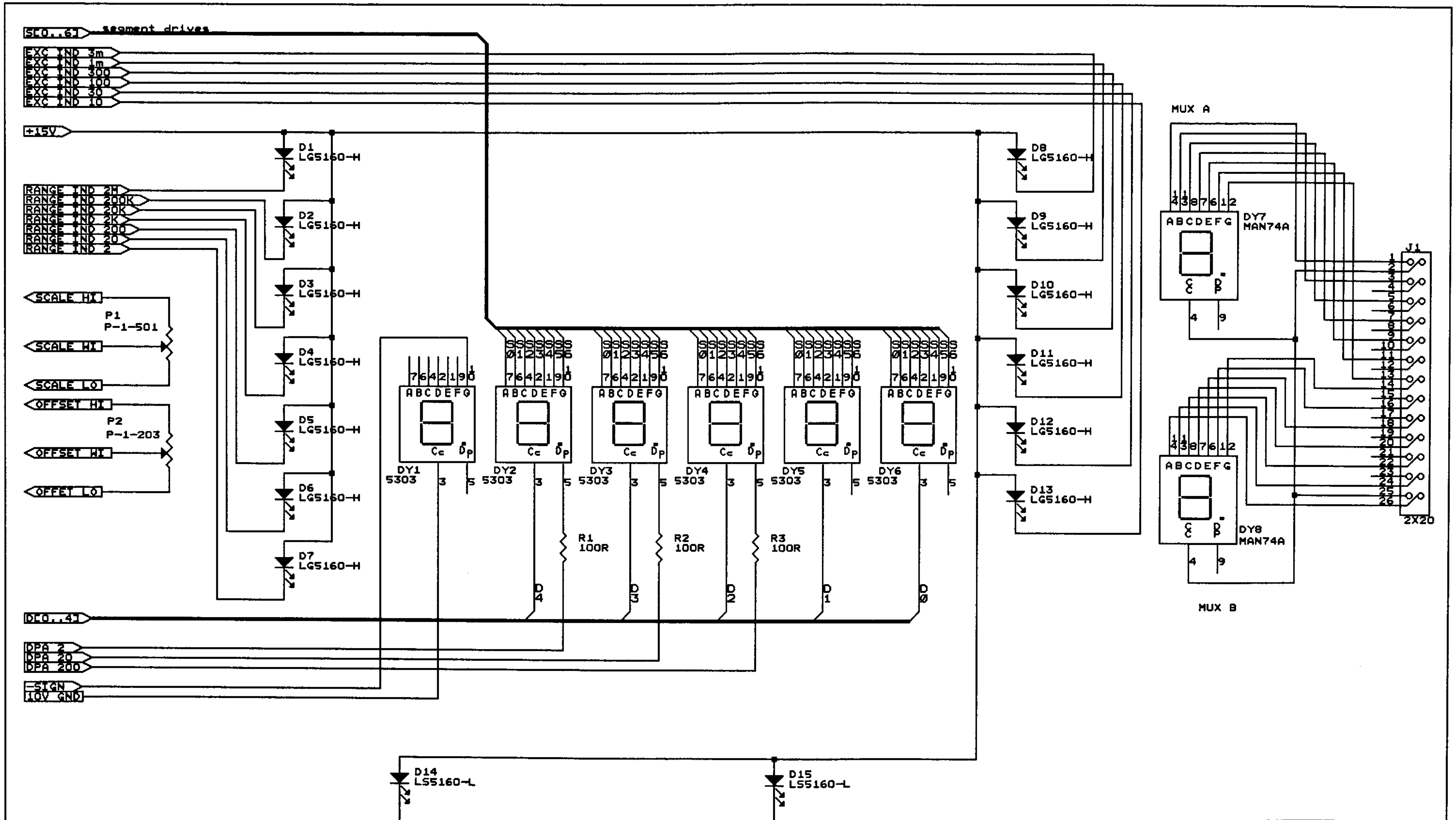

AUTOEXC UP
AUTOEXC DOWN
EXC U
EXC D
MUX U
MUX D
+15V
+5V
D GND
A GND
AUTORANGE UP
AUTORANGE DOWN
RANGE U
RANGE D
25Hz SYNC
EXC IND 300
EXC IND 1m
EXC IND 3m
EXC IND 10
EXC IND 30
EXC IND 100
EXC DATA 2
EXC DATA 1
EXC DATA 0
MUX DATA 0
MUX DATA 1
MUX DATA 2
MUX DATA 3
RANGE DATA 2
RANGE DATA 1
RANGE DATA 0
RANGE IND 2
RELAY SELECT 2
RANGE IND 20
RELAY SELECT 20
RANGE IND 200
RELAY SELECT 200
RANGE IND 2K
RELAY SELECT 2K
RANGE IND 20K
RELAY SELECT 20K
RANGE IND 200K
RELAY SELECT 200K
RANGE IND 2M
RELAY SELECT 2M
preset state 10
preset to state 4 = 2K
RV-Elektroniikka Oy
Veromiehentie 14
SF-01510 VANTAA, Finland
Title
AVS-46 RANGE & EXCITATION LOGIC
Size B
Document Number LOGIC.SCH
REV 5
Date: November 30, 1987
Sheet 5 of 7



RV-Elektroniikka Oy Veromiehentie 14 SF-01510 VANTAA, Finland	
Title: AVS-46 POWER SUPPLY & SYNC LOGIC	
Size: B · Document Number: POWER.SCH	REV: 5
Date: November 30, 1987 · Sheet 6 of 7	



+5V
VDD
C701
2.2UF35V
D GND
VSS
TS-510 PROGRAM CONNECTOR
CLOCK
STROBE
DATA
GND
J702
6410-04A
U709
74HC164
U703
74HC164
U704
74HC138
U701
74HC164
SR STROBE
SR DATA
SR CLOCK
R702 200K
R703 200K
R701 200K
U702A 4025
U702B 4025
U702C 4025
addr 1: strobe digit 5
addr 2: strobe digits 1-4
dig 1 LSD
dig 2
dig 3
dig 4
dig 5 MSD
U710 4042
U712 4042
U705 4042
U707 4042
U714 4042
U711A 4066
U711B 4066
U711D 4066
U711C 4066
U713A 4066
U713B 4066
U713D 4066
U713C 4066
U706A 4066
U706B 4066
U706D 4066
U706C 4066
U708A 4066
U708B 4066
U708D 4066
U708C 4066
U715A 4066
U715B 4066
U715D 4066
U715C 4066
J701
CD6416
U716
4511
DISPLAY LSD
DISPLAY D2
DISPLAY D3
DISPLAY D4
DISPLAY MSD
RV-Elektroniikka Oy
Veromiehentie 14
SF-01510 VANTAA, Finland
Title
AVS-46 TEMPERATURE READOUT OPTION
Size B
Document Number TRO.SCH
REV 5
Date: December 2, 1987
Sheet 7 of 7



RV-Elektroniikka Oy
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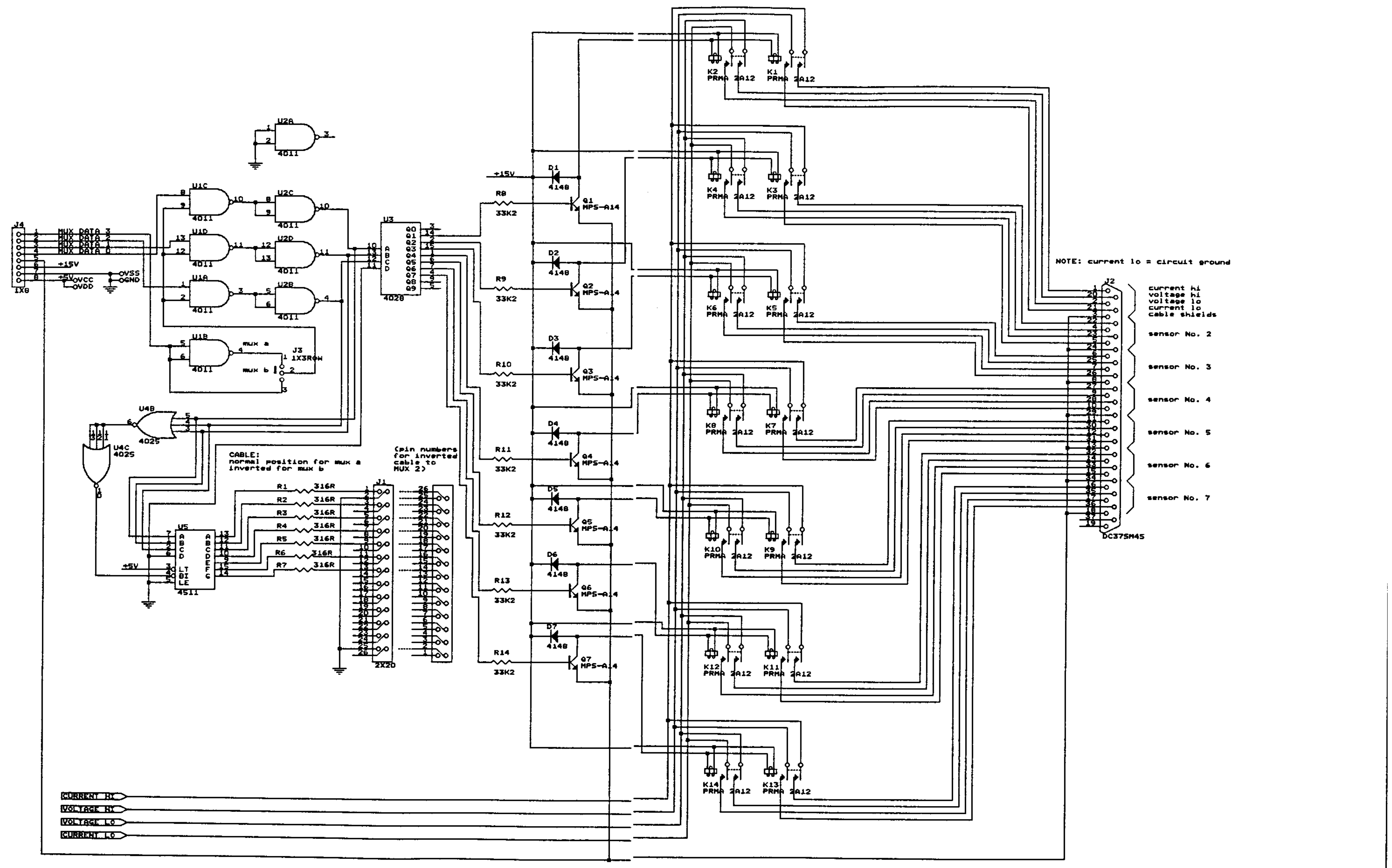
Title	AVS-46 RESISTANCE & RANGE DISPLAY	
Size B	Document Number DISPLAY.SCH	REV 1
Date: January 30, 1987	Sheet 1 of 1	



	RV-Elektroniikka Oy Veromiehentie 14 SF-01510 VANTAA, Finland
Title	AVS-46 INPUT MULTIPLEXER
Size C	Document Number 142-1.SCH
Date:	May 30, 1991 Sheet 1 of 1