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RM-25

Radiation Monitor

RM-25 Radiation Monitor

Technical Manual

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March 2003

Manual Insert

RM-25

This instrument includes a front panel alarm lamp, a red LED, which is not described in the Technical Manual. The lamp is mounted in the upper left corner of the front panel. The lamp will light whenever the instrument count rate exceeds the alarm set point and will extinguish when the Alarm Acknowledge button is pressed.

The lamp is Eberline part number OPLP26.

The schematic on the next page shows the lamp circuit.

Ref No. 2297/MI2297/**January 1997**

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Table of Contents

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Section 1

Introduction

General Description

The RM-25 is a low cost general purpose radiation monitor/frisker station, which can operate with a variety of GM, gas proportional, and scintillator/PM tube detectors. It is a microcomputer based, enhanced capability RM-14/RM-20 replacement. WinRM25 is the PC-based Calibration and Interface Program which is dedicated to the RM-25 instrument. Setup and calibration is accomplished through a PC serial port to the RM-25. Response time, dead time, voltage thresholds, alarm settings, and high voltage are set through the host PC, reducing conventional hardware in the RM-25. The Windows host program has the ability to save and restore the instrument parameters, edit instrument and system parameters, run and display plateaus, and generate a calibration report.

The RM-25 software runs in the multi-tasking Windows® operating system allowing the operator to run other applications while simultaneously performing a plateau calibration.

A tool bar supports single button access to the more frequently used features such as editing configuration parameters, running plateaus and displaying graphs.

A simulator mode is built-in to facilitate demonstration and training.

Specifications

Mechanical

Width - 7.18 in. (18.24 cm)
Depth - 6.88 in. (17.48 cm)
Height -5.00 in. (12.70 cm)
Weight - 4.4 lbs. (2.0 Kg)

Temperature

Operating - 0° C to 50° C (32° F to 122° F)
Storage - -20° C to 85° C (-4° F to 185° F)

Power

AC Input for Power Module - 110 to 130 VAC, 60 Hz, 11 Watts max. or
DC Input - 12 to 14 VDC, 0.5 Amp max. Connector shell +, center pin -.

Analog Meter

Movement - 0 to 200 μadc, high torque taut band, temperature compensated.
Scale length - 3.35 in. marked 0 to 500 linearly.
Accuracy - within ±2% of full scale.
Range Multipliers - x1, x10, x100, x1K

Speaker

Two inch, two watt voice coil type for audible indication of counts and alarms. Volume control does not affect alarm annunciation.

Detectors Supported

Eberline GM, gas proportional and scintillation detectors, 500 to 2500 vdc, MHV detector connector.

Input Sensitivity

Thresholds are software adjustable through a Windows-based PC program to provide approximately 0 to 5 millivolts input sensitivity for the lower threshold and approximately 0 to 60 millivolts input sensitivity for the upper threshold, referred to the input.

Section 2

Operation

Description of Controls and Connectors

Detector Connector

MHV bulkhead connector.

Power Input Jack

Miniature D.C. Power jack, 2.1 mm, 12 to 14 VDC. Center conductor negative, shell positive. Accessible through rear panel.

Range Switch

Integrates power on/off, HV display, and Alarm setpoint display with X1, X10, X100, and X1K range multipliers.

Volume

Potentiometer which controls the sound level of the speaker clicks.

Response

Toggle switch which selects fast or slow meter response times, as set in the instrument parameters through the Windows PC program.

Alarm Ack

Momentary dome type pushbutton switch which acknowledges alarm indications. Actuation silences the audible alarm but does not reset the meter.

HV/Alarm

This momentary, center off toggle switch adjusts the high voltage up or down if the function switch is in the HV position. It also adjusts the alarm setting if the function switch is in the Alarm position.

H. V. Tracking

This internal trimpot, R19, next to the high voltage shield, is set during manufacture to fine-tune the high voltage feedback ratio to 1000:1 and match the indicated high voltage on the WinRM25 program PC screen and on the meter with the actual high voltage. It need not be adjusted.

Charging Voltage

This internal trimpot, R25, next to the DC input jack, sets the charging voltage for the optional battery pack. This is set during manufacture to 9.8 VDC and need not be adjusted.

Battery Test

This rear panel momentary pushbutton switch is included when installed with the optional battery pack, and it is used to indicate the battery condition on the front panel meter.

Preparation For Use

Power

Connect the DC Power Module output plug into the Power jack, then plug the Power Module into a 115 VAC outlet. Alternatively, 12 to 14 VDC, such as from a car battery, can be used. Note polarity--center pin -, shell +. Leave the range/function switch in the OFF position for now.

Setup

If the RM25 has been set up and calibrated with a particular detector, connect that detector to the MHV Detector connector. A different detector should be left disconnected until the RM-25 is set to accommodate it, otherwise you risk damage to the probe with the last parameters set into the RM-25. The high voltage and alarm setting can be set from the RM25 front panel, but threshold settings, dead time, response time, etc. must be set from the WinRM25 program. Refer to the RM25 Calibration and Interface Software Operation Manual, which is a companion to this Technical Manual, for setup and calibration of the RM25 with the WinRM25 program. Plateauing and calibration should be performed with a new or unknown detector.

Using the Instrument

Initializing

Power up the instrument by rotating the range/function switch from Off to HV to check the high voltage setting. The HV/Alarm switch can be used to adjust the high voltage while the range/function switch is in the HV position. Rotate the switch to the Alarm position to see if it is set appropriately. The HV/Alarm switch can be used to adjust the alarm setting while the range/function switch is in the Alarm position. Now rotate the range/function switch to the desired range position. If a calibrated probe is connected, that's all there is to setting it up and running. The non-volatile EEPROM memory in the RM25 commands the appropriate high voltage, threshold settings, dead time, alarm rate setpoint, and response times as determined at the most recent calibration.

Frisking

Assume that the RM-25 and detector are calibrated and ready for use. Move the probe slowly over the surface to be frisked and in contact with it or very close to it so as to provide the best obtainable counting efficiencies. Alpha counting efficiency especially is reduced by even one or two centimeters between the probe face and surface being measured. Commonly, frisking is accomplished by moving the probe over body areas and listening to the speakers. It is easier to frisk properly if you don't have to keep one eye on the displays. Count rates which exceed the preset alarm level produce a 2000 Hz alarm tone from the speaker. The RM-25 is most useful when employed to locate and quantify specific "hot-spots" of contamination which have been localized to a general area by large area contamination monitors, such as the Eberline PCM-1 and PCM-2 Personnel Contamination Monitors, and the PM-4, PM-6, and PM-7 Portal Monitors.

Low Count Fail

Whenever zero counts are registered within the low fail time selected from the WinRM25 program, the meter deflects upscale once per second, accompanied by an intermittent alarm tone.

Theory Of Operation

General

The RM-25 detector, gas proportional or scintillator type, provides very small energy proportional pulses to the amplifier and discriminator circuitry in the U7 module. The separated upper threshold and lower threshold pulses are sent to counters T0 and T1 in U1, the microcomputer, which also controls the high voltage and threshold levels through U7, drives the meter through U6 and the speaker through U15, U13, Q2, Q3, Q5, and Q8. The switch and logic inputs are interfaced through U2, which provides expanded I/O, RAM, ROM, and "glue logic" for U1. GM tube detectors provide large energy-independent pulses which trigger both lower and upper thresholds, and the RM-25 is usually set to count the upper threshold pulses.

Functional Theory

Microcontroller

The microcontroller subsystem of the RM-25 is comprised of U1, an 80C51FA microcomputer; U2, a PSD311 programmable system device; U12, a serial EEPROM; U3, a CMOS to RS232 converter for serial communications; U7, a hybrid amp-discriminator/high voltage controller module, plus ancillary input/output devices and circuitry. When power is applied, the computer's initialization routine sets all outputs to a safe condition, sets up the timer/counters, I/O ports, the pulse width modulators, initializes U2, and sets global variables. Once all the peripherals are set up, the non-volatile memory, U12, is read to determine the setup to be loaded into RAM. The last used setup will normally be loaded. If it is determined to be invalid because of an incorrect checksum, a set of defaults are loaded, and the main program loop runs.

High Voltage

Three pulse width modulator outputs from U1 set the upper and lower thresholds, and the high voltage reference in the U7 module, where the amplifier gains are fixed, but the computer controls the discriminator settings. The computer controlled HV reference sets the high voltage setpoint. The feedback circuitry in the module drives the high

voltage oscillator chip, U8, which drives power transistor Q4, which drives the high voltage transformer, T1, and the rectifier/quadrupler components.

Counters

The upper and lower threshold output pulses from the U7 module are counted by counter-timers T0 and T1 in U1. One or the other is sent to the meter and speaker, as selected by the WinRM25 PC program.

Meters

A pulse width modulator in U1 drives a voltage to current converter amplifier in U6. The meter range switch is input to U2 as additional input bits read by U1, which controls the count rate to PWM output conversions.

Audio

Dual one-shot multivibrator U15 provides the duration of the speaker "clicks", which is a 30 millisecond burst of 2000 Hz. tone, generated by U14, and volume controlled by R36. The alarm output is a continuous 2000 hz tone at a max output of 85 dB at 30 cm., not affected by the volume control.

L.V. Power

The low voltage D.C. (12 to 14 vdc unregulated) for the RM-25 is provided by an external wall plug-in type power module, which converts the AC line voltage to DC at the wall socket. There is no line voltage inside the unit. Pre-regulation to the correct battery charging voltage, if the battery option is installed, is provided by adjustable regulator U9, which feeds the fixed 5 volt regulators, U10 and U11, through Q6, the power on/off switch transistor, which is controlled by Q7 and the range/function switch, S5.

Section 4

Maintenance

Disassembly

The RM-25 cover is secured by two 10-32 screws, one on each side of the chassis. The circuit board may be removed after removing the front panel knobs and nuts on the switches and MHV connector, then removing the rear panel, which is held in place by three 4-40 screws, then removing the four 4-40 screws which secure the board to the chassis. Unplug P1 and lift the board out. Take care with the MHV connector and the components soldered to it.

Reassembly

The instrument should be reassembled in reverse order to the disassembly instructions in the preceding paragraph.

Calibration

General

Calibration should be performed whenever there is doubt as to the accuracy of the RM-25 or after it has been repaired. After changing the detector it is good practice to obtain a check reading with a known source to verify proper response, but complete calibration is not called for unless the detector type is different or something in the response check indicates a problem. Conventional probes of like type may exhibit some differences in optimum high voltage, dead time, efficiencies, and/or background count rates.

Meters

The RM-25 count rate meter should be calibrated with the "meter calibration" function available under the WinRM25 PC program.

Conventional Probes

Gas Proportional

Thin window gas proportional detectors, sealed or flow type, may be alpha and/or beta source calibrated with the RM-25. Since the meter is calibrated to true count rate, calibration consists of setting an appropriate operating voltage for the detector, and of

setting the upper (alpha) and lower (beta) thresholds so as to maximize efficiency for each with minimum crosstalk if both are to be calibrated for. The default threshold settings provide a good starting point and adequate results in most cases. Starting at less than 1000 volts, obtain an alpha plateau and/or a beta plateau, as desired. The Run Plateau button under the WinRM25 PC program is included for this purpose. Pick an operating voltage on the basis of this data. Adjust thresholds as desired. If available, higher emission rate sources, usually beta, may be used to check linearity at higher count rates. The dead time in the Instrument Parameters screen may be adjusted to improve linearity by compensating for response droop at higher activity.

Scintillators

Scintillator/photomultiplier detectors are treated similarly to gas proportional types, but the range of high voltages which may be required is generally much more broad because of the spread of PM tube characteristics. For this reason, and because PM tubes can be easily damaged permanently by excessive high voltage, to a much greater extent than gas proportional detectors, plateaus should be started with high voltage less than 800 volts. The plateau characteristics can also vary a great deal depending on the types of scintillant used.

Smart Probes

The RM-25 is not configured to communicate with Eberline smart probes, but they may be calibrated for use with the RM-25 as conventional probes with an appropriate cable.

Specific Eberline Probes

HP-320, HP-330, SHP-330:

On the Instrument Parameters screen, set high voltage to zero, dead time to 5 μs, upper (alpha) threshold to 25.0 mv and lower (beta) threshold to 1.0 mv.

On the Voltage Plateau screen set count time to 10 secs and run consecutive background plateaus for alpha and beta, starting at 1300 volts, then 20 volt steps up to a maximum of 1800 volts, or until the onset of noise, whichever is lower.

Expose the detector to a ^{99}Tc 20K to 200K cpm 47mm plated source and run a beta plateau with the same voltages used in the background plateau.

Pick an operating voltage where the beta in the alpha channel is no more than 5% of the beta in the beta channel. Take a 300 second background count in a low background area, and verify that the alpha background is less than 2 cpm. Record this. Also record the beta background count rate, which should be less than 50 cpm. Set this high voltage in the Instrument Parameters.

Determine that the beta 2π efficiency is greater than 0.19.

Expose the detector to a 47 mm ^{239}Pu source of approx. 50K cpm and take a 60 second count. The alpha 2π efficiency should be greater than 0.20.

HP-100 Series, SHP-100BGS:

On the Instrument Parameters screen, set high voltage to zero, dead time to 10 μs, upper (alpha) threshold to 25.0 mv and lower (beta) threshold to 1.0 mv.

Flush the probe for 30 minutes at 25 to 50 cc/min. Maintain at least 25 cc/min. flow during counting operations.

On the Voltage Plateau screen set count time to 10 secs and run consecutive background plateaus for alpha and beta, starting at 1300 volts, then 20 volt steps up to a maximum of 1800 volts, or until the onset of noise, whichever is lower.

Expose the detector to a 20 K to 200K cpm (40K to 400K dpm) 100 cm^2 source of ^{137}Cs and run a beta plateau with the same voltages used in the background plateau.

Pick an operating voltage where the beta in the alpha channel is no more than 1% of the beta in the beta channel. Take a 120 second background count in a low background area, and verify that the alpha background is less than 5 cpm. Also the beta background count rate should be less than 600 cpm. Set this high voltage.

Determine that the beta 2π efficiency is greater than 0.52.

Expose the detector to a 100 cm^2 ^{241}Am source of approx. 50K cpm ($\approx$ 100K dpm) and take a 60 second count. The alpha 2π efficiency should be greater than 0.45.

Disconnect the gas from the probe. For gas seal (GS) versions, perform the following:

a. Seal the probe by disconnecting the inlet and then the outlet.

b. Wait 4 hours and then measure the beta 2π efficiency. It should be within 5% of the value obtained previously.

ABP-100, SABP-100,
SHP-340:

On the Instrument Parameters screen, set high voltage to zero, dead time to 10 μs, upper (alpha) threshold to 16.0 mv and lower (beta) threshold to 2.0 mv.

On the Voltage Plateau screen set count time to 10 secs and run consecutive background plateaus for alpha and beta, starting at 700 volts, then 20 volt steps up to a maximum of 1100 volts, or until the onset of noise, whichever is lower.

Expose the detector to a 100 cm^2 ^{137}Cs source of approx. 50K cpm ($\approx$ 100K dpm) and run a beta plateau with the same voltages used in the background plateau.
Pick an operating voltage where the beta in the alpha channel is no more than 1% of the beta in the beta channel. Take a 300 second background count in a low background area, and verify that the alpha background is less than 7 cpm. Also the beta background count rate should be less than 600 cpm. Set this high voltage.

Determine that the beta 2π efficiency is greater than 0.27.

Expose the detector to a 100 cm^2 ^{241}Am source of approx. 50K cpm ($\approx$ 100Kdpm) and take a 60 second count. The alpha 2π efficiency should be greater than 0.11.

Section 5
Parts Lists

The following tables list the electronic items incorporated in the RM-25 and should contain any part necessary for normal electronic repair. Unless otherwise specified, callouts of manufacturers and manufacturers' part numbers are to be considered typical examples only. There are no restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

PC Board Assembly, EIC Part No. YP11605003

Reference Designation	Description	Eberline Part Number
U1	Microcontroller	ICCMAC51FA
U2 (requires install. of PGMRM25 prog.)	Prog. System Device	SICCPSD311
U3	RS-232 Converter	ICXXMAX233
U4, U5	Quad NAND Gate	ICHCA00
U6	Dual Op Amp	ICACA272
U7	Hybrid Module	VEBD14A
U8	Voltage Converter	ICVCMAX630
U9	IC National LM317T.	ICAVA0317T
U10	5 Volt Regulator	ICAVA2950C
U11	5 Volt Regulator	ICAVAL4941
U12	Serial EEPROM	ICCMA24C01
U13	CMOS NOR Gate	ICHCA00002
U14	CMOS Timer	ICCMA7555I
U15	Dual Monostable	ICCMA4538B

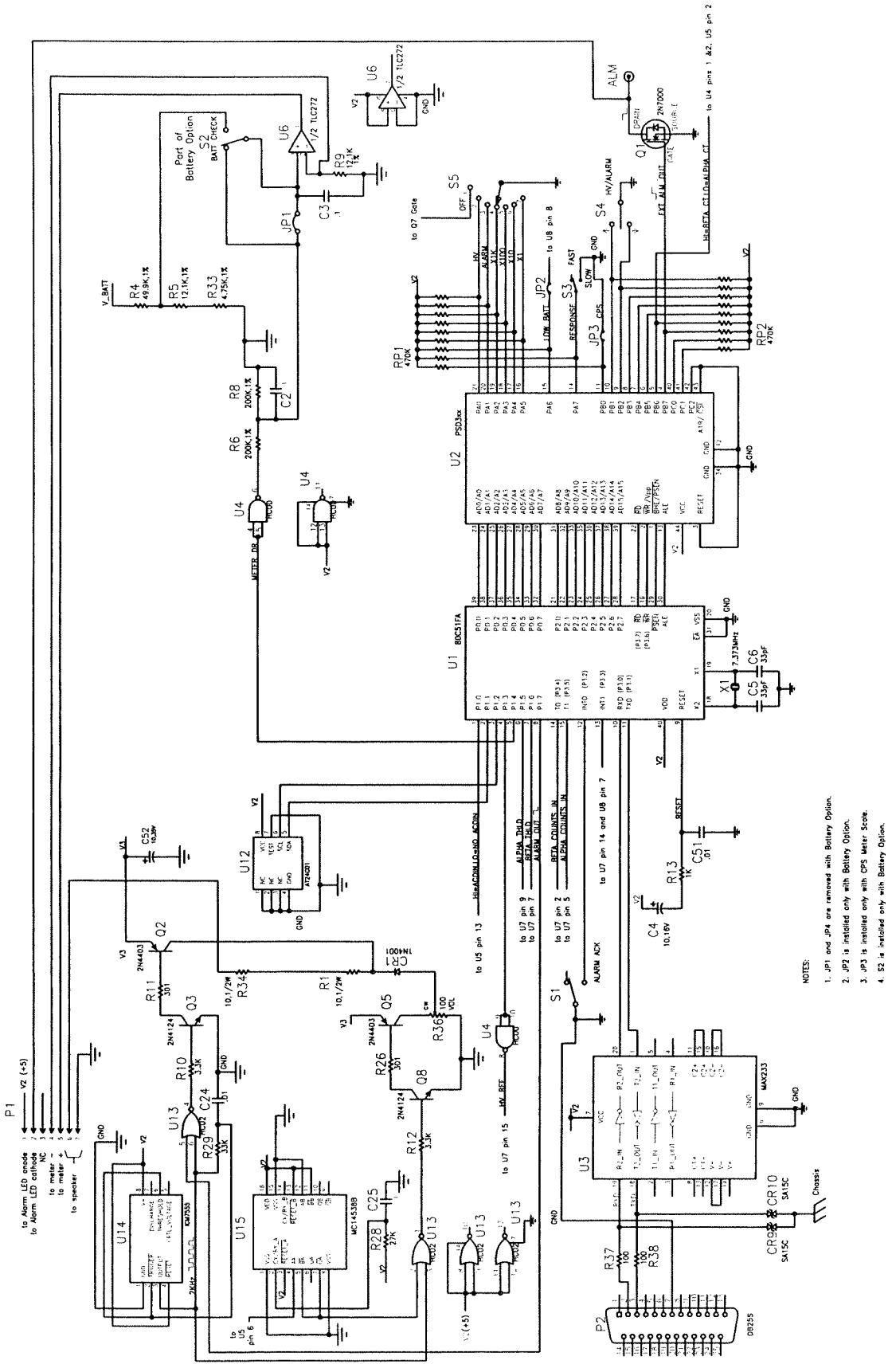
Reference Designation	Description	Eberline Part Number
C2,3,18,19,21,22,25, 55	0.1 mfd, 50v cap.	CPCE104P3N
C4, C15, C17, C20, C53, C54	10 mfd, 16v capacitor	CPTA100M4X
C5, C6	33 pf, 100v cap	CPCE330P3P
C7	.01 mfd, 1.6 KV cap. DD16-103	CPCE103PXV
C8, C9, C10, C11	.01 mfd, 3.0 KV cap.	CPCE103P4Y
C11, C50	0.047 mfd, 4 KV cap	CPPF503PXY
C12, C13	220 pf, 3 KV cap	CPCE221P3Y
C14, C16, C52, C56	10 mfd, 35v capacitor	CPTA100M3L
C23	.0033 mfd, 200 v.	CPPF332P3P
C24, C51	0.01 mfd, 50 v cap	CPCE103P3N
CR1, CR6, CR8	Silicon Diode	CRSI1N4001
CR2,3,4,5	VA25 Rectifier	CRSIVA0025
CR7	Schottky Diode	CRSC1N5817
CR9, CR10	15 Volt TVS Diode	CRXXSA15C
CR20	SA20C Volt TVS Diode	CRXXSA20C
Q1, Q7	MOSFET	TRMN2N7000
Q2, Q5	Transistor, PNP	TRSP2N4403
Q3, Q8	Transistor, NPN	TRSN2N4124
Q4, Q6	Transistor, PNP	TRSPMJE371
R1, R34	10 ohms, 1/2 w, 5%	RECC100B23
R4, R20	49.9 K, 1/4 w, 1%	RECE493B12
R5, R9	12.1 K, 1/8 w, 1%	RECE123B11
R6, R8	200 K, 1/4 w, 1%	RECE204B12
R10, R12	3.3 K, 1/4 w, 5%	RECC332B22
R11, R26	301 ohms, 1/4 w, 1%	RECE301B12
R14	8.2 K, 1/4 w, 5%	RECC822B22

Reference Designation	Description	Eberline Part Number
R15	1.3 K, 1/4 w, 5%	RECC132B22
R16, R17	3 Mego, 1/4 w, 5%	RECC305B22
R18, R30	1 Mego, 1/4 w, 5%	RECC105B22
R19	200 K Trimpot	PTCE204B13
R21	10 K, 1/4 w, 1%	RECE103B12
R22	6.8 ohm, 2w, 5%	REWW681N25
R23	150 Ohms, 1/4 w, 1%	RECE151B12
R24	1 K, 1/4 w, 1% RN55D	RECE102B12
R25	200 Ohm Trimpot	PTCE201B03
R28	27 K, 1/4 w, 5%	RECC273B22
R29	33 K, 1/4 w, 5%	RECC333B22
R31	1.5 K, 1/4 w, 5%	RECC152B22
R33	4.75 K, 1/4 w, 1%	RECE472B12
R36	100 Ohm pot	PTXX101B0X
R37, R38	100 Ohms, 1/4 w, 5%	RECC101B22
R39	5.1 Ohms, 1/4 w, 5%	RECC511N22
RP1, RP2	9 Res. Array, 470 K	REAR474B21
S1, S2	SPDT Mom. PB Sw.	SWPB31
S3	SPDT Toggle Switch	SWTO41
S4	SPDT Ctr Off, Mom. Toggle Sw.	SWTO42
S5	71BDF30-01-1-AJN	SWRO60
T1	HV Transformer	TFHV5
X1	7.373 MHz Crystal	CYOS12

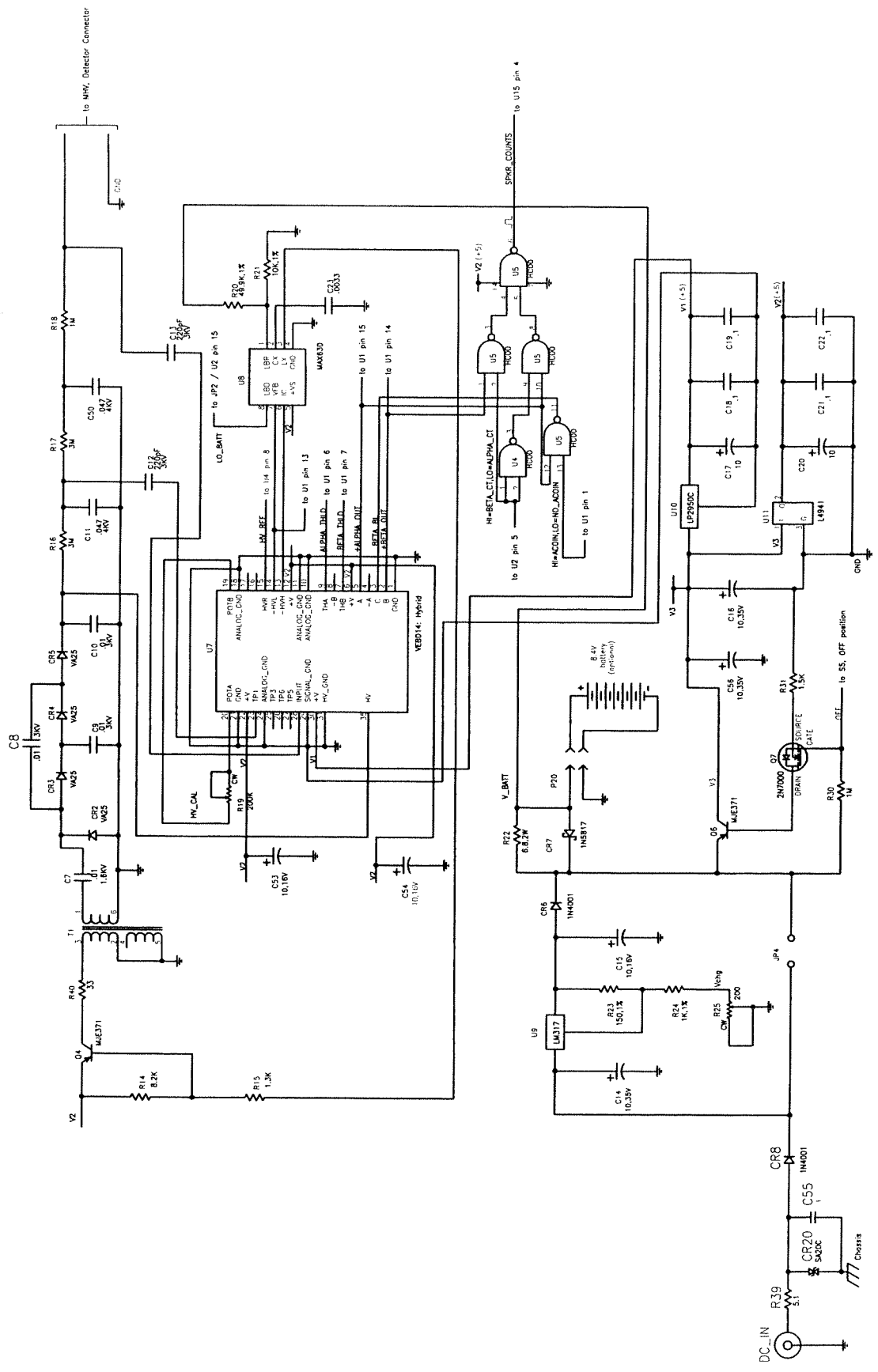
Reference Designation	Description	Eberline Part Number
	2" Speaker	ADSP3
	0-200 μadc meter	MTPA42
	4 pin Molex conn.	COMR1004
	Molex crimp pin	COHD64
	Knob	HDKN42
	Knob	HDKN30
	12 VDC, 0.5 AMP Power Module	MEVE177
	Red Led 5V W/RESISTOR	OPLP26
	LED CLIP & ring	MMCL47

Section 6

Drawings



Schematic, Main P.C. Board: 11605 D01, rev. E Sheet 1 of 2



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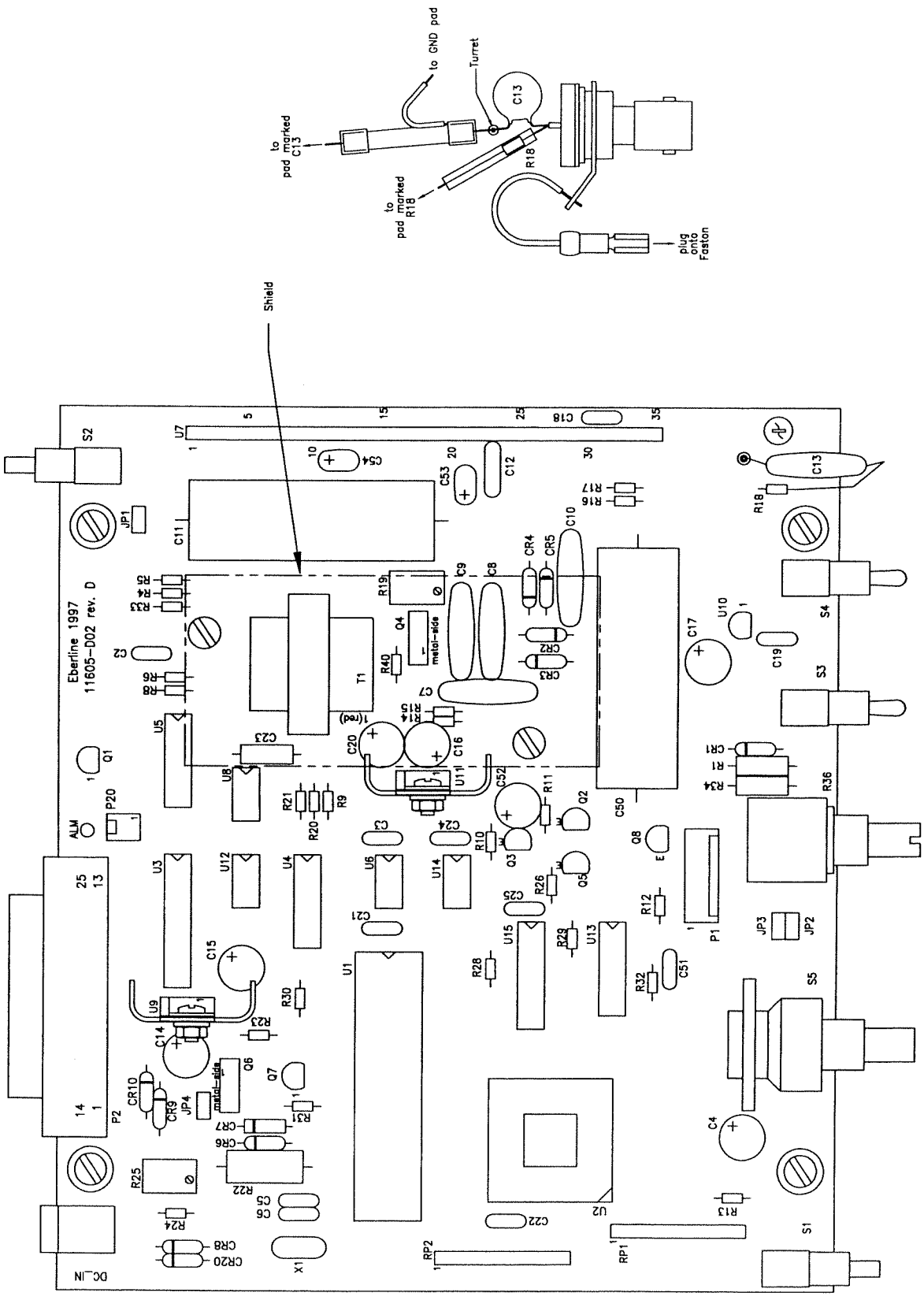

Component Layout, Main P.C. Board: rev. B