Chapter 2
Characteristics

Title	Page

Introduction

Specifications apply after 30 minutes warm-up time
For timer / counter functions, the minimal frequency specified is valid with manual trigger setting. When using AUTO TRIGGER or AC-coupled inputs, the minimal frequency is 20 Hz.

Presentation Modes

Waveform:	Displays recurrent signals and trigger settings. Eliminates the need for a separate oscilloscope to verify the input signal and correct triggering. Displays additionally one selected timer/counter read-out with up to 10 digits resolution plus the input signal's Vp-p value.
Values:	Up to 10 simultaneous readings of frequency, time and voltages like on a Counter, DVM and Phasemeter.
Statistics (163)**:**	Mean, Maximum, Minimum plus Peak-to-Peak and Standard Deviation of a selected number of samples; sample size: 2 to 10^6.

Timer / Counter Functions

Frequency

Range:	
Input A & B:	1µHz to 160 MHz
Input C:	70 MHz to 1300 MHz (models 164H / 164T only)
Resolution:	9 digits/s measuring time, max. 10 digits resolution

Burst Frequency, Burst Repetition Rate (163)

Synchronization timing:	
Manual:	Manually set timing parameter
Automatic:	AUTO SET sets suitable timing parameters for bursts with a duration of 50 µs to 100 ms, min. 3 cycles on Input A or B and min. 192 cycles on Input C.
Burst duration:	
Input A & B:	0.5 µs to 1.5 s, min. 2 cycles in burst
Input C:	50 µs to 1.5 s, min. 128 cycles in burst.
Burst ON/OFF ratio:	< 1:1
Burst Frequency Range:	
Input A & B:	1 Hz to 70 MHz
Input C:	70 MHz to 1300 MHz (models 164H / 164T only)
Resolution:	9 digits/s burst measuring time, max. 10 digits resolution
Burst repetition rate:	
Input A & B:	Up to 1 MHz
Input C:	Up to 20 kHz

Rise/Fall Time

Range (Input A or B):	6 ns to 10^7 s
Frequency Range:	up to 50 MHz
Pulse Width:	≥ 6 ns at set trigger level
Resolution:	1 ns

Duty Cycle

Range:	0.000 1 to 99.999 9%
Frequency Range:	10 mHz to 50 MHz
Pulse Width:	≥ 6 ns at set trigger level
Resolution:	0.000 1% or $(Frequency / 1GHz \times 100)$ % whichever is greatest

Phase

Range:	-180.00° to +360.00°
Measurement Modes:	Input A to B or Input B to A
Frequency Range:	10 mHz to 50 MHz
Resolution:	0.01° or $(Frequency / 1GHz \times 360)$ ° whichever is greatest

Totalize with manual control and / or set measuring time

Range:	0 to 10^{14} counts
Measurement modes:	Counts simultaneously pulses on inputs A and B
Pulse-count displayed:	Counts on input A, B, A-B or A+B
Start/Stop:	- With Run/Hold key - Totalize during the set time 200 ns to 15 s
Frequency Range:	0 Hz to 100 MHz
Pulse Width:	≥ 5 ns at set trigger level

Totalize with external control signal

Range:	0 to 10^{14} counts
Measurement modes:	Counts pulses on Input A (or B), starts and stops counting via external control signal on input B (or A)
Start/Stop:	- By two consecutive pulses - Totalize during presence of gating signal
Frequency Range:	0 Hz to 100 MHz
Pulse Width:	≥ 5 ns at set trigger level

Uncertainty:

20 Hz to 2 kHz:	2% + 0.2% of range
2 kHz to 5 MHz	4% + 0.2% of range
5 MHz to 20 MHz	10% + 1% of range
20 MHz to 50 MHz	25% + 1% of range

DC Voltage (DC or DC-component from AC-signal)

Range:	500 mV, 5.00 V, 50.0 V
Resolution:	1, 10, 100 mV
Uncertainty:	2% + 0.2% of range

AC or AC+DC True-RMS Voltage

Range:	300 mV, 3.00 V, 30.0 V
Peak voltage limits:	±500 mV, ±5 V, ±50 V
Resolution	1 mV, 10 mV, 100 mV
Uncertainty (sinewaves):	
20 Hz to 50 Hz:	2% + 0.2% of range (DC +AC), 4% + 0.2% of range (AC)
50 Hz to 2 kHz:	2% + 0.2% of range
2 kHz to 5 MHz:	4% + 0.2% of range (4% + 2% of range in 300 mV range)
5 MHz to 10 MHz:	10% + 1% of range (10% + 2% of range in 300 mV range)
RMS-principle:	The rms-value is calculated from input signal volt-vs-time samples. Specified uncertainty applies only when triggering is correct, resulting in a correctly displayed waveform.
Crest Factor:	Any crest factor tolerated for signals within Vp limits. The instrument is calibrated to the rms value of a sinewave input. For non-sinusoidal input signals, with crest factors up to 3.0, add 2% + 2% of range (typically).

Multiple Parameter Display

Automatic waveform characterization with simultaneous display of all parameters, relevant for selected signal type:

Signal type Parameters displayed simultaneously

SINE and similarcontinuous symm. signals:

Frequency, Period, Vmax, Vmin, Vp-p

PULSE and similar cont. asymm. signals:

Frequency, Period, Positive Pulse Width, Negative Pulse Width, Rise Time, Fall Time, Duty Cycle, Vmax, Vmin, Vp-p.

BURST and similar Burst Frequency, Burst Repetition Rate, Vmax, Vmin, Vp-p. (163)

Horizontal deflection

Time Coefficients:	5 ns/div. to 0.2 s/div. in a 1-2-5-sequence, auto-scaling (2 cycles of signal) or manually set
Accuracy:	1 ns + 1 pixel (vertical sampling) 25 µs + 1 pixel (horizontal sampling)
Number of divisions:	8 divisions with post trigger data 2 divisions with pre trigger data (vertical sampling mode only)
Pixels/division:	21
Max. display length:	5 input signal cycles

Waveform (Scope) Triggering

Sources:	Input A or B, AUTO selected, depending on set measuring function
Trigger sensitivity:	60 mVp-p to 10 MHz 90 mVp-p to 50 MHz 120 mVp-p to 75 MHz
Trigger Point:	AUTO SET or manually set trigger level and slope
Pre-trigger:	2 divisions, max. 1 cycle (vertical sampling mode only)

Display

Trace:	Dot or dot-joined line
Grid graticule:	Dotted or full line

Input A & B

Coupling:	DC or AC
Frequency Range:	0 Hz to 160 MHz (DC-coupled) 20 Hz to 160 MHz (AC-coupled) Frequency limits for MEASURE FUNCTIONS and WAVEFORM display are separately specified (see Timer/Counter, Voltage and Waveform Functions).
Trigger Level Range:	± 500 mV, ± 5.00 V or ±50.0 V
Resolution:	1, 10 or 100 mV
Uncertainty:	± 1% + resolution
Setting:	AUTO, Manual
Read-out:	Digital read-out, or with trigger lines on WAVEFORM display.

Trigger sensitivity, manual trigger setting:

± 0.5 V / ± 5 V range:	20 mVrms sine (up to 50 MHz) 40 mVrms sine (50 MHz to 160 MHz)
± 50 V range:	200 mVrms sine (up to 50 MHz) 400 mVrms sine (50 MHz to 160 MHz)

AUTO Trigger:

Output levels:	Fixed TTL: low ≤0.4 V, high ≥1.8 V into 50 Ω:

RS232 Data in/output (163)

Connector:	Isolated optical connector, for use with optional optical-to-RS232 adapter PM9080/001
Input:	Full programmability via LEARN data strings and RECALL of up to 10 complete instrument settings. Full description available on PM9080 software diskette.
Output:	Measurement data, bitmap screen dump etc., see also Flukeview™

FlukeView™ (163)

SW 160/011	Optional FlukeView™; MultiFunction Counter software for Windows®
Documenting:	Transfers waveforms and measurement data from MultiFunction Counter to a PC with the optional optical-to-RS232 adapter PM9080/001. Print out complete screens directly or store graphical data in a popular file format to import into word processor or spreadsheet programs.
Archiving:	Waveform storage and retrieval with text annotations like measurement conditions and instrument set up.
Analysis:	Log and graph readings to monitor and analyze signal variations and related events, reveal relationships and conditions that could otherwise remain hidden.

Auxiliary Functions

Statistics (163)

Statistical functions:	Maximum-, Minimum- Mean- values, plus Standard Deviation and Peak-peak Deviation (= Max-Min). Not available in Totalize functions.
Error reduction:	Random uncertainties for instance from noise and jitter can normally be reduced by $\sqrt{N}$, by averaging a number of measurement readings.
N (Sample Size):	2 to 1 000 000

Mathematics (163)

Mathematics:	Displayed value = K x measurement + L, where K and L are selectable constants
Constants K and L range:	0 and ±(10^{-20} to 10^{20}), 12 digits resolution

INFO

A built in context sensitive help function gives guidance for all manual settings.

Safety

Safe Operation:	100 Vrms to 10 kHz (models 163/164 only), 30 Vrms (models 164H/164T).
Floating voltage:	All inputs: 300 Vrms to ground, (model 163/164 only), 30 Vrms (models 164H/164T).
Compliance:	EN 61010-1:1993, Cat. II CE
	CSA CAN / CSA - C22.2 No.1010.1 - 92
AC/DC adapter:	UL: UL1310 Class 2
	C22.2 No. 223

Power Supply

Line voltage:	Via PM 9651 AC/DC adapter: 90 to 130 Vrms or 190 to 255 Vrms, 45 Hz to 440 Hz, 18 VA
Internal Ni-Cd Battery:	Type PM 9086, 4.8 V
Battery Operating Time:	Pulse output and external reference input switched off, lowest backlight brightness level and full battery capacity
Model 163, 164:	typical 2¼ hours
Model 164T:	typical 1¾ hours
Model 164H:	typical 1½ hours
Battery Charging Time:	3 h typical (instrument switched OFF) 30 h typical (instrument switched ON)
Alternate Battery:	4 alkaline C cells (not included)
External DC Supply:	10 V to 20 V DC, 10 W typical
Current at 12 Vdc:	0.8 A (operating) 0.5 A (non operating, charging only)
Input Connector:	5 mm power jack, DIN 45323

Mechanical Data

Height x Width x Length:	60 x 130 x 260 mm / 2.4 x 5.1 x 10.2 in., excl. holster 65 x 140 x 275 mm / 2.5 x 5.5 x 10.8 in., incl. holster
Weight:	1.5 kg /3.3 lb., excl. holster, 1.8 kg/4.0 lb., incl.holster
Transport weight:	3.4 kg / 7.5 lb.

Frequency measurements on PULSE signals

Table 2 shows the uncertainty for measurements on undistorted 1Vp-p pulse signals with 10 ns rise/fall times (except where otherwise noted for rise/fall-time measurements), with instrument settings obtained through AUTO-SET and making use of the internal time-base at room temperature.

Table 2 Uncertainty for measurements pulse input signals

Model	163, 164	164T	164H
Mode and input signal	Absolute uncertainty	Absolute uncertainty	Absolute uncertainty
Frequency & Period Average: (Period =1 ÷ Frequency) 20 Hz to 1.3 GHz	$5x10^{-6}$ x Frequency	$1x10^{-6}$ x Frequency	$1x10^{-7}$ x Frequency
Period Single: ≤ 1 µs	1 ns	1 ns	1 ns
1 ms	5 ns	1.5 ns	1 ns
1 s	5 µs	1 µs	100 ns
Time Interval, Pulse width: ≤ 1 µs	1.5 ns	1.5 ns	1.5 ns
1 ms	5 ns	2 ns	1.5 ns
1 s	5 µs	1 µs	100 ns
Rise/Fall time (@ 100 kHz): ≤ 10 ns	2 ns	2 ns	2 ns
100 ns	5 ns	5 ns	5 ns
1 µs	50 ns	50 ns	50 ns
Duty Cycle: ≤ 100 Hz	0.0001 %	0.0001 %	0.0001 %
10 kHz	0.0015 %	0.0015 %	0.0015 %
1 MHz	0.15 %	0.15 %	0.15 %

Conditions that lead to a better accuracy (reduced uncertainty) are: steeper trigger transitions (for instance through shorter rise-/fall time and higher input amplitude), use of STATISTICS to average the result of a number of readings (not model 163), the use of a more accurate external time-base reference and a shorter calibration interval than 12 months. For short duration Time measurements, the 1ns resolution is the dominating error-contributor, whereas for long duration Time measurements, the internal time-base uncertainty dominates.

Phase(degrees)

Uncertainty due to Random Effects (rms or standard deviation)

$$\sqrt{(1\,ns^2 + Start\ Trigger\ Error^2 + Stop\ Trigger\ Error^2)} \times Frequency \times 360°$$

Uncertainty due to Systematic Effects (maximum values)

$$\pm(Trigger\ Level\ Timing\ Error \times Freq. \times 360°) \pm (1\,ns \times Frequency \times 360°)$$

LSD Displayed

0.01°

Duty Cycle (%)

Uncertainty due to Random Effects (rms or standard deviation)

$$\sqrt{(1\,ns^2 + Start\ Trigger\ Error^2 + Stop\ Trigger\ Error^2)} \times Frequency \times 100\ \%$$

Uncertainty due to Systematic Effects (maximum values)

$$\pm(Trigger\ Level\ Timing\ Error \times Freq. \times 100\%) \pm (1\,ns \times Frequency \times 100\%)$$

LSD Displayed

0.0001%

$$\text{Input Amplifier Hysteresis Error} = \frac{0.01}{\text{Slew rate } (V/s) \text{ at start trigger point}} - \frac{0.01}{\text{Slew rate } (V/s) \text{ at stop trigger point}}$$

Calculation of Measurement Uncertainty (2 σ)

The total uncertainty of a measurement is calculated as twice the combined standard uncertainty (two standard deviations or 2 σ) using the following formula:

$$\text{Total Combined Standard Uncertainty} = 2x\sqrt{s^2 + \frac{S a_i^2}{3}}$$

where:

s = uncertainty due to random effects, calculated from the formula, specified for each measuring function.

a_i = uncertainty due to systematic effects, calculated for each contributing error, specified for each measuring function.

Ordering Information

Selection guide

Table 4 Features.

Models	163	164	164T	164H
160 MHz Frequency Counter 50 MHz Time and Vp-p meter 100 MHz PulseTotalizer V dc and 10 MHz true-RMS V ac meter	•	•	•	•
50 MHz Waveform presentation mode	•	•	•	•
Frequency in Burst and Burst Repetition Rate		•	•	•
1.3 GHz Frequency- and Period			•	•
Timebase stability / Accuracy	5×10^{-6}	5×10^{-6}	1×10^{-6}	5×10^{-7}
Statistics, including Jitter measurements		•	•	•
Mathematics,		•	•	•
Trigger Hold-Off, Arming and Arming Delay		•	•	•
Optional PC-support: RS232 adapter Optional FlukeView® for Windows®		•	•	•

Fluke 163 — 50MHz / 160 MHz MultiFunction Counter with Standard Time Base

Fluke 164 — 50MHz / 160 MHz MultiFunction Counter with Standard Time Base

Fluke 164T — 50 MHz / 1.3 GHz MultiFunction Counter with TCXO Time Base

Fluke 164H — 50 MHz / 1.3 GHz MultiFunction Counter with High Stability Oven Time Base

Included Accessories

Operators Manual

Chapter 3
Circuit Descriptions

Title	Page

Introduction

A basic MultiFunction Counter (Fluke 163 and Fluke 164) consists of three main units:

- Input PCA
- Display PCA
- Keyboard

"T"-models

In Fluke 164**T**, the following boards are added:

- A 1.3 GHz HF input
- A Temperature Compensated X-tal Oscillator (TCXO)

"H"-models

In Fluke 164**H**, the following boards are added:

- A 1.3 GHz HF input
- An Oven Controlled X-tal Oscillator (OCXO)

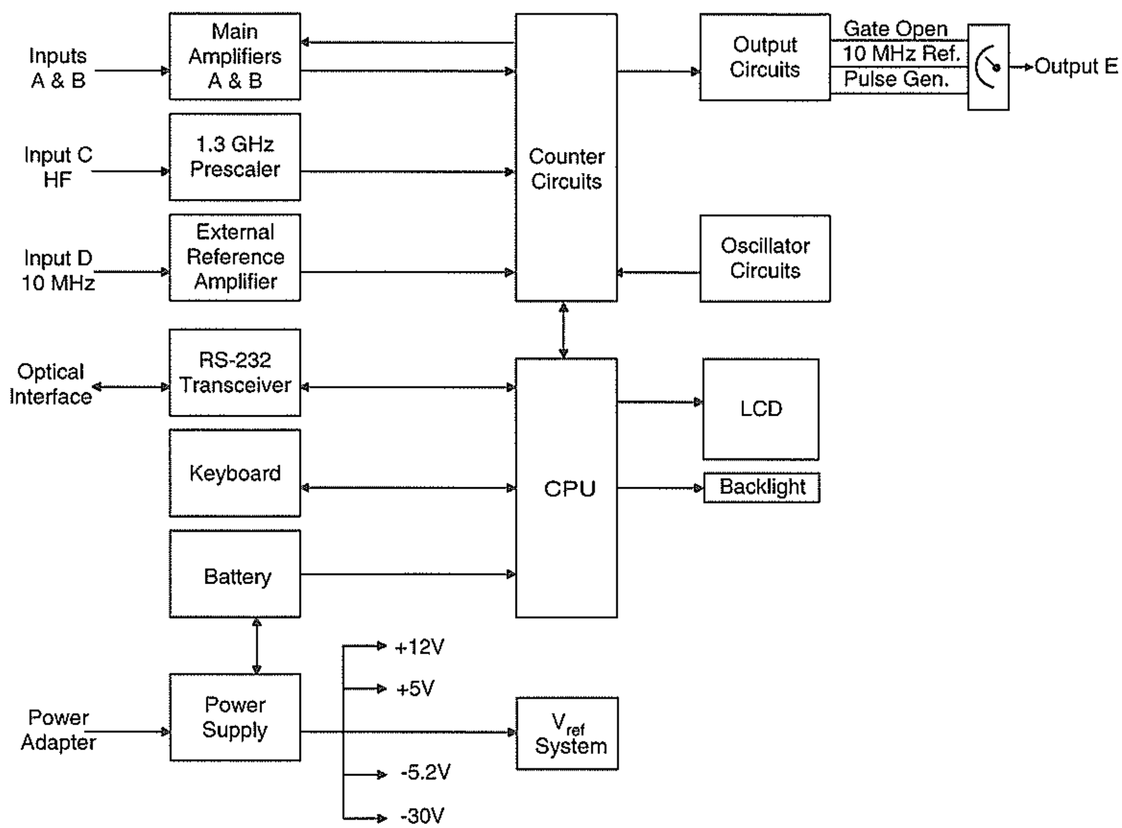


Figure 3-1. Block Diagram, Fluke 160 series

The following functions are placed on the input PCA:

- Input amplifiers and part of trigger level circuitry

Input PCA

Input amplifier

Channel A and Channel B are formed by two identical, matched 200 MHz amplifiers.

The following description refers to channel A but is also valid for channel B. See Figure 3-2

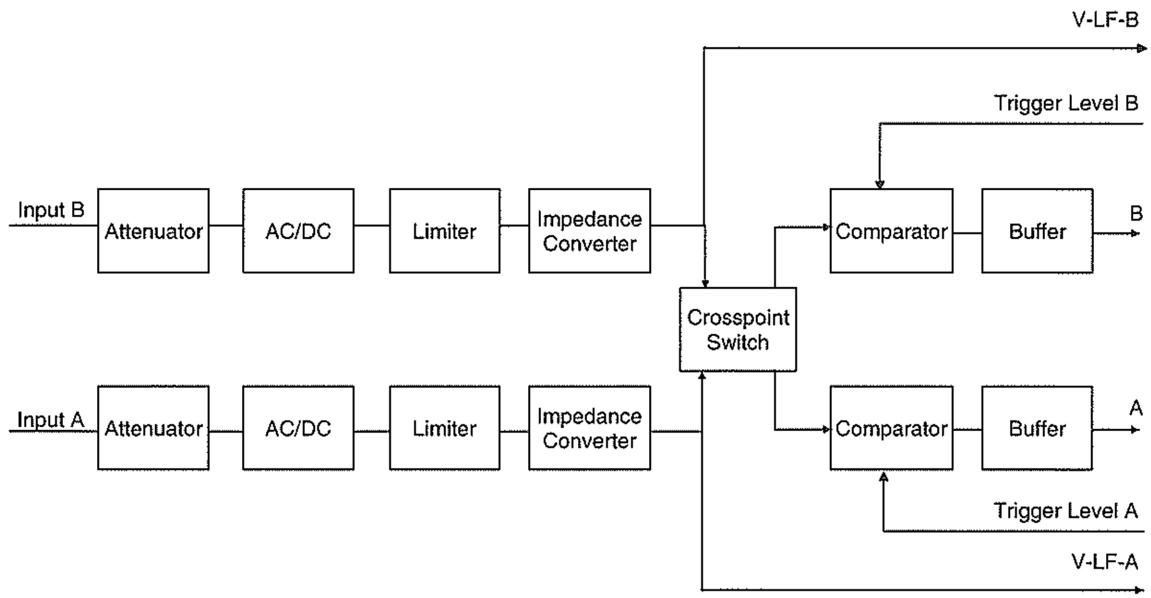


Figure 3-2. Input Amplifier Block Diagram

Four main stages make up the input amplifier: Attenuator and protection circuitry, impedance converter, comparator and buffer.

Attenuator and Protection Circuitry

The attenuator and protection circuitry contains:

- 1X/10X attenuator
- AC/DC coupling
- Voltage limiter

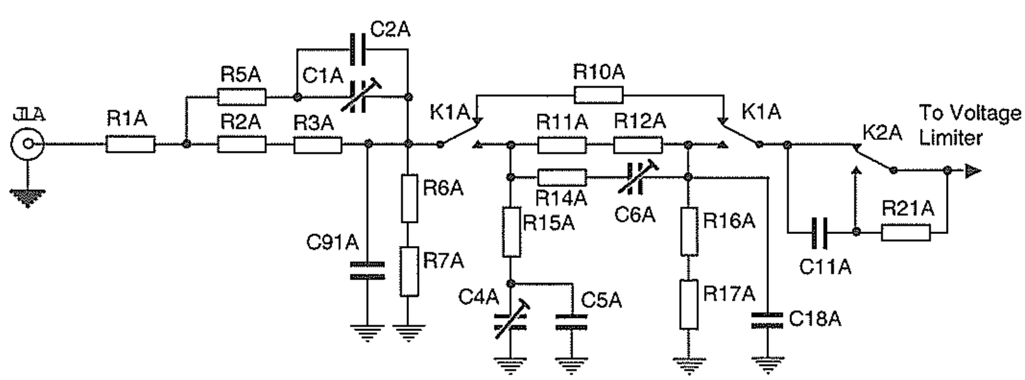


Figure 3-3. x1/x10 Attenuator and AC/DC Coupling

Impedance Converter Stage

The analog signal from the input stage is fed to an amplifier stage where split-band technique is used to get a good response over a wide frequency range. See Figure 3-5.

This means that the high frequency contents of the signal are fed to a high input impedance AC-coupled dual gate MOSFET transistor stage. The low frequency contents from DC to about 5 kHz are handled in parallel by a high input impedance operational amplifier stage.

Both the FET (V1A) and the op amps (U1A) are used to convert high input impedance to low output impedance. The two signal paths are summed at the source of V1A by letting the LF signal control the current source V2A serving as part of the V1A source load impedance.

The FET drain is supplied with +12 V instead of +5 V via resistors R35A and 36A in order to optimize the HF characteristics within the whole input voltage dynamic range.

The resistor R20A sets the 1 MΩ input impedance and limits the low frequency signal before it is coupled to the inverting input of the op amp U1A:1. The resistors R30A and R31A at the output of U1A:2 center the output swing.

A driver stage (V4A and V7A) and an output stage (V5A and V6A) form an amplifier with high output drive capability. This amplifier is used to get a linear output swing of ±2 V with high slew rate.

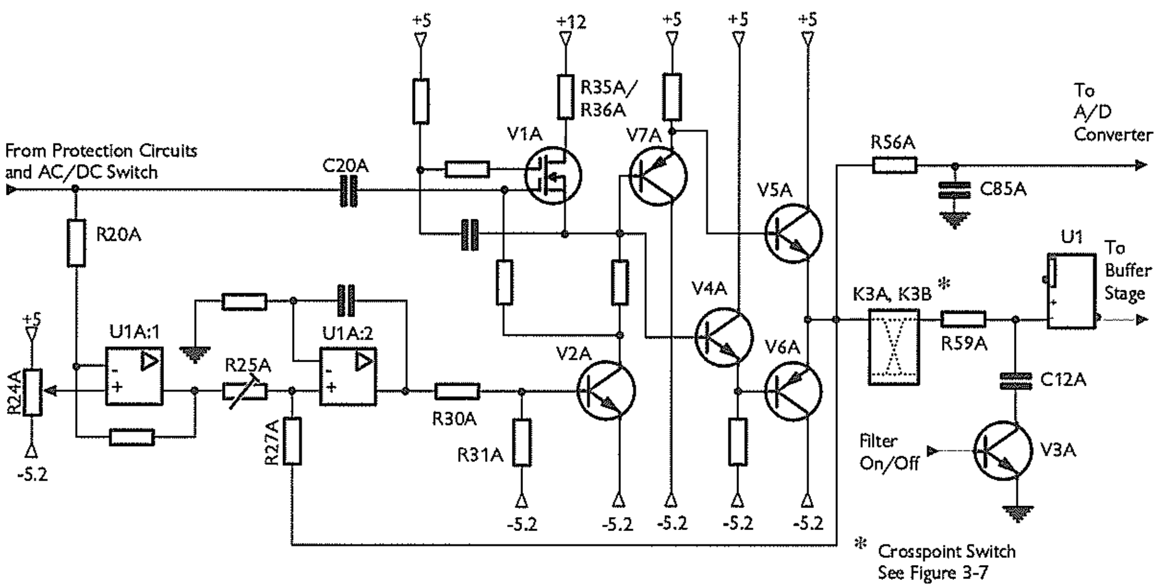


Figure 3-5. Impedance Converter

From the output of this second amplifier stage there is a feedback path to the non-inverting input of U1A:2 via R27A. Trimmer R25A sets the gain of the low frequency path equal to the gain of the high frequency path (about 0.9). Trimmer R24A is used to adjust the offset voltage of the complete input amplifier.

An A/D converter in the microcontroller is fed from the amplifier output via a lowpass filter consisting of R56A and C85A. This signal is used to measure the input voltage.

Another lowpass filter is connected to the amplifier output. It is a 100 kHz RC filter consisting of R59A and C12A. The microcontroller switches this filter on or off via

Crosspoint Switch

The normal signal flow from amplifier A to comparator A (and from amplifier B to comparator B) can be altered by means of the crosspoint switch. See Figure 3-7. Full control is possible so the input channels can be swapped or one of the input channels can be fed to both comparators. Unused contacts are connected to ground to minimize crosstalk. The relays are controlled by the microcomputer.

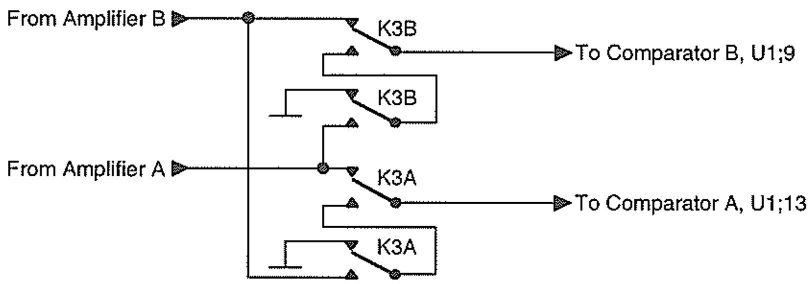


Figure 3-7. Crosspoint Switch

Trigger Level Circuits

See Figure 3-8. The description below refers to channel A but is equally valid for channel B provided the part numbers are substituted accordingly.

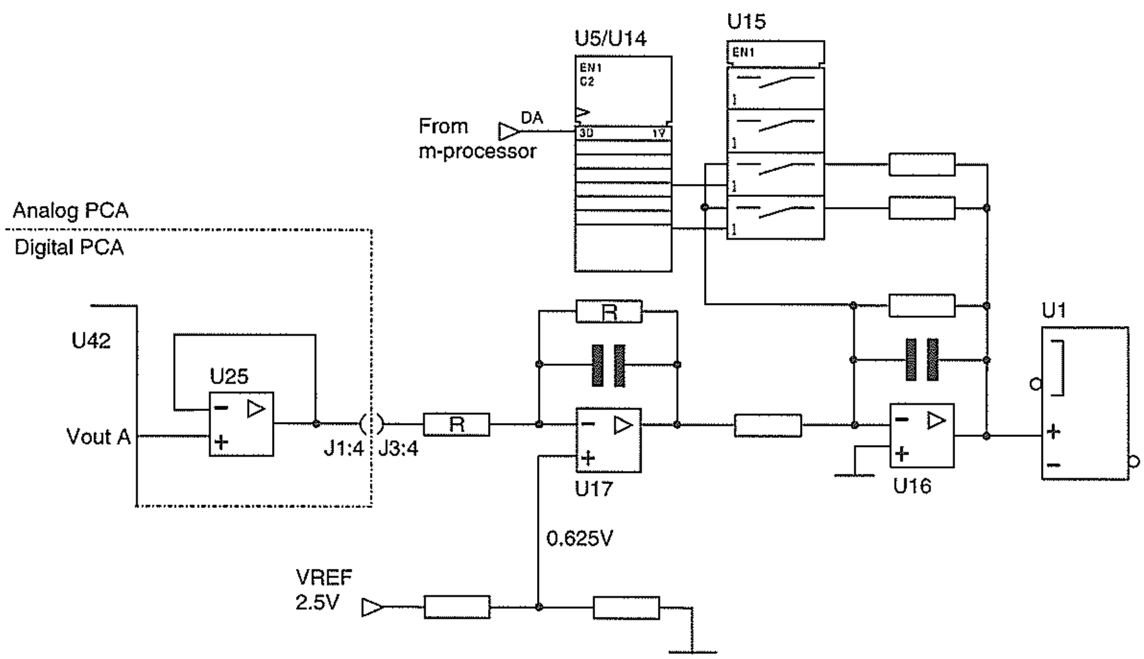


Figure 3-8. Trigger Level Circuits

The ASIC U42 has a built-in 10-bit DAC leaving an output voltage VoutA in the range 0 V<= VoutA <= +2.5 V and a resolution of 2.44 mV. The output impedance of the DAC is high and must be buffered by the op amp U25. Then the voltage is inverted and level shifted in U17 according to the formula VoutA" = -VoutA' + 1.25 resulting in a voltage range of ±1.25 V. This voltage is inverted and amplified in U16. The amplification factor can be set to three different values (-1.86, -0.73 or -0.186) by means of the analog

Power Supply

Note

See also chapter 9, Circuit Diagrams, Power supply for detailed information.

See Figure 3-10.

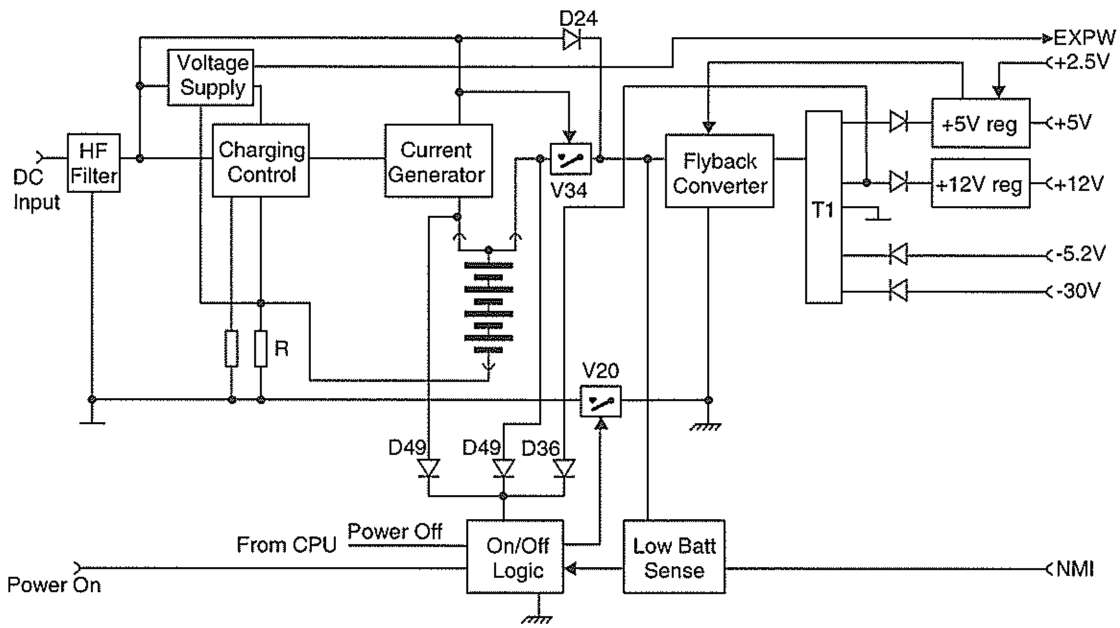


Figure 3-10. Power Supply Block Diagram

The power supply is designed to meet several requirements that are often interacting and sometimes counteracting. The main functions are:

- To supply the instrument with multiple voltages generated from either a single, normally rechargeable battery package or an external DC source, normally the AC/DC power adapter that was delivered with the instrument. However, alkaline cells shall also be accommodated.
- To charge the battery package if it is rechargeable. An intelligent control procedure insures that the battery is recharged as fast as possible without impairing its expected lifetime. In case the instrument is operating it has first priority and the battery will only be trickle charged.
- To warn the user when the battery has to be recharged.
- To switch off the power before the battery voltage is so low that measuring results may be affected by malfunction. Permanent damage to the battery package is also liable to occur if the discharge is too deep.

The power supply consists of the following blocks:

HF Filter

This filter prevents high frequency signals generated inside the instrument from reaching the power lines.

Flyback Converter

To generate voltages with reverse polarity or voltages higher than the battery voltage, it is necessary to use a converter. The flyback converter is simple and reliable and fulfills the basic requirements: DC/AC conversion, transformation, rectification and regulation. The circuit chosen for this instrument is self-oscillating and generates a sawtooth current in the transformer T1.

When the MFC is switched on current will flow from V+BATT via the transformer T1, transistor V19, and the resistors R80/R81/R214/R215 to V-BATT. The voltage drop over the resistors will increase linearly due to the inductance in T1 and C58 is charged. The unijunction transistor V21 will start to conduct when its trigger level is reached and V19 will be switched off due to the low gate voltage. When C58 has been discharged V21 will be switched off again and one cycle has been completed.

The oscillation is maintained by positive feedback to the V19 gate from the secondary side of T1 via capacitor C75.

Switch Transformer T1

The transformer generates four voltages which are +14V, +5V, -5.2V and -30V after rectification and filtering.

+5V Regulation

The amplitude of the sawtooth current in T1 is set by the +5V control stage which has a very stable +2.5 V reference voltage generated by U46 on the display PCA. A higher current consumption will cause the DC level from the regulating circuit (V15 and V16) to decrease. This voltage change is fed to the gate of V21 via diode D19. The recharging of C58 will be delayed, indirectly increasing the current level in the transformer where V19 will switch off.

+12V Regulation

The +14V from T1 is regulated by the linear voltage regulator U3 and V14 to +12V.

External / Internal Power Sources

With an external DC source connected to the MFC the converter is supplied via diode D24. The battery is always trickle charged if the MFC is switched on in this state. If the MFC is switched off the battery will be charged normally.

When the internal battery is used as the sole power source the current to the converter goes via V34, a power MOSFET working as a diode with very low forward voltage. It is of paramount importance to keep voltage drops and power losses at a minimum in this operating state. The signal EXPW will be high informing the microcontroller that the MFC is supplied by the internal battery.

Display PCA

Reference Voltage System

Stable reference voltages are required in different places, both on the display PCA and the input PCA. See Figure 3-12. The main reference circuit is U46.

Its output is buffered/multiplied by a system of op amps arranged to avoid undesirable signal interaction and noise distribution.

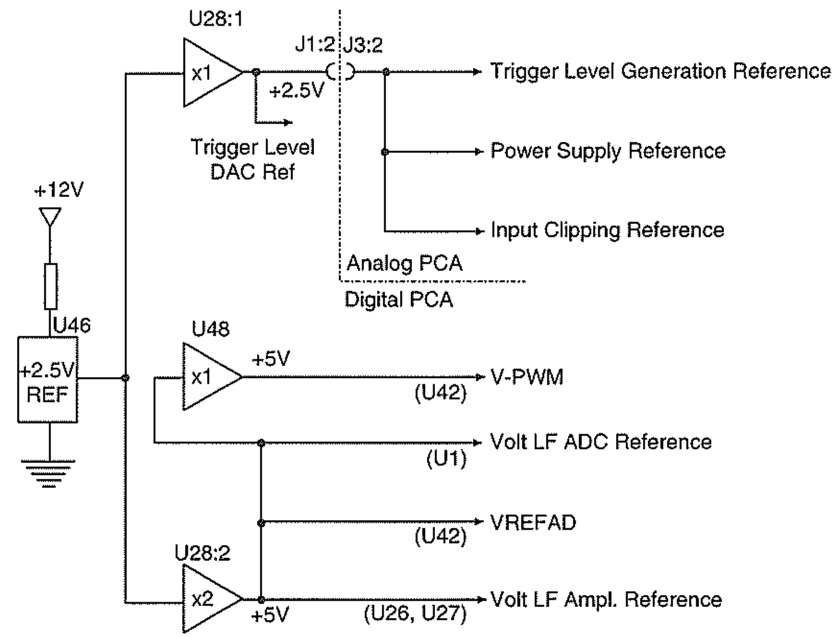


Figure 3-12. Reference Voltage System

Microcomputer Circuitry

Microcontroller

The microcomputer circuitry consists mainly of the microcontroller U1, an Intel 16-bit CHMOS 80C196NT, RAM's (U2, U3, U6, U7), and FLASH EPROM's (U4, U8). The microcontroller has built-in AD converters and works at 16MHz. The data and address lines AD0 to AD15 are shared by means of multiplexing. Therefore the addresses are stored in the latches U11 and U12. The ALE signal (Address Latch Enable) enables the latches.

power supply. However, if the MFC is already on, the Power-On/Off key is scanned in the normal way and will give an interrupt to the microcontroller that sends the Power-Off signal to the On/Off logic.

Oscillator Circuits

CPU Oscillator

The microcontroller U1 is clocked at 16 MHz. The crystal B1 is connected to the XTAL inputs of the microcontroller.

Reference Oscillators

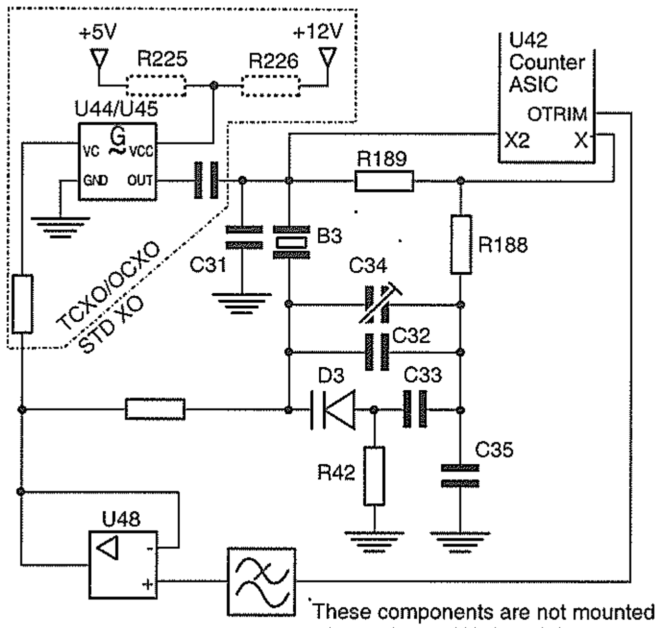


Figure 3-14. Oscillator Circuits

A 10 MHz crystal oscillator is used as the reference for the measuring logic. See Figure 3-14. If a stable external 10 MHz reference is available it can be connected to the REF INPUT and selected via the USER OPTIONS menu.

There are several optional oscillators to choose from. The uncompensated standard oscillator is mounted in the 163 model and the 164 model without 1.3 GHz HF input. A TCXO or OCXO is mounted in the more advanced models.

The standard oscillator consists of the crystal B3, C31 -C35, R42, R188, and R189. C34 is used for manual coarse adjustment of the frequency and is only intended for compensation of manufacturing tolerances. Drift due to aging is taken care of by a software routine allowing 'closed case' calibration and adjustment.

If a TCXO or OCXO is mounted, the crystal B3 and the capacitors C31 and C34 are not mounted. The supply voltage for the TCXO is +5 V and for the OCXO +12 V, so only one of the jumper resistors R225 or R226 is mounted.

Fine tuning of all oscillators is made by means of the signal OTRIM from the ASIC U42. It is a pulse width modulated signal generated by a D/A converter block. The DC content

PG

A built-in pulse generator having the 10 MHz clock as a reference can generate pulses with controllable duration and repetition rate at the OUTPUT connector. The level is fixed TTL.

RTC

A real time clock not used at present.

TLDAC

This block contains two 10-bit DAC's generating the trigger levels for the input comparators, VOUTA for channel A and VOUTB for channel B. An external reference voltage is connected to V+REFA and V+REFB.

HO

The Hold Off block can manipulate the internal measuring signal X in several ways. One operating mode simulates a low pass filter (normal hold off), another mode is used in burst measurements.

The following blocks (SYNC, STST, CNTS and MCTRL) form the actual measuring logic in the ASIC. Three types of measurements can be made in this MEAS block:

- Continuous measurements (frequency, ratio and period average). Not used at present.
- Controlled measurements (time interval, period single, pulse width, frequency, totalize gated, totalize start-stop, and ratio).
- Totalize manual

SYNC

The SYNC block synchronizes the actual measurement with certain internal or external events like measuring time and arming signals.

STST

The start and/or the stop of the measurements are controlled by this block. External events can be used to define the exact moments.

CNTS

Two 32-bit binary counters count external events or keep track of the time.

Interpolator

This block is not used at present.

MCTRL

The different events in the measurement cycle of the ASIC are timed by this block.

Display Controller and LCD Driver Circuits

Display Controller

The display controller U13 reads screen data from the external RAM U15 and sends it to the LCD. It also sends line pulses, LINECL (17 kHz) and frame pulses, FRAME (70 Hz).

The screen data, for example cursor and grid information, is stored in the external RAM as bitmap data.

The trace data is stored as a value for every vertical line on the LCD. This data is converted to bitmap form and added to the cursor and grid information.

The display controller module also has the facilities to change the dot size of the trace displayed and to use dot joining.

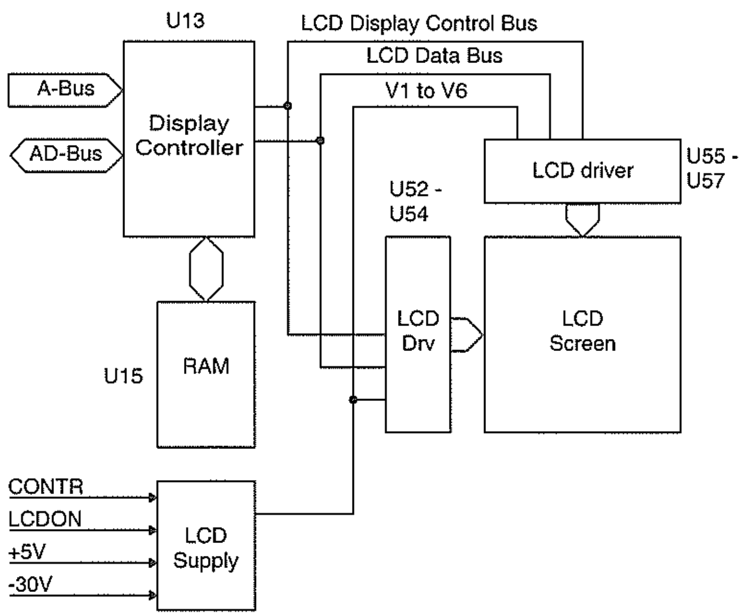


Figure 3-16. Display Controller and LCD Driver Circuits

LCD Screen

The LCD used in the MultiFunction Counter is controlled by six LCD driver IC's. These drivers get their data and control signals directly from the display controller U13.

The MFC uses a Super Twisted Nematic Liquid Crystal Display with a resolution of 240x240 pixels. The display is of the transmissive type and requires backlight, in this case a CCFL unit.

The picture on the LCD screen is written columnwise. It is divided horizontally in three row sections, each 80 pixels high, and vertically in three column sections, each 80 pixels wide.

LCD Drivers

The LCD is controlled by the display controller, U13 via six LCD drivers, the three row drivers U52 to U54, and the three column drivers U55 to U57.

The transistors V53 and V56 form an overvoltage protection circuit that trips if, for instance, the CCFL tube gets disconnected. Then the high voltage converter will be transferred from current mode to voltage mode preventing damage due to flashovers or overstress.

The average voltage between the primary of the transformer T1 and the emitters of the switch transistors V54, V55 is monitored by the zener diode D42 and the base-emitter junction of V56. When the trip point is exceeded V56 starts to conduct and V53 saturates pulling the input CCFL on U5 low. The regulator loop switches from current to voltage control until the cause for mode change is removed.

RS232 Optical Interface

The asynchronous serial communication facilities in the microcontroller U1 are employed to operate the infrared receiver V19 and transmitter D28 of the MFC. For this purpose a stripped version of the RS232C protocol is used.

Only the TXD (transmit data) and RXD (receive data) lines from the RS232C standard are implemented. The IR transmitter D28 is driven directly from the TXD pin of the microcontroller.

The operational amplifier U32 powers the collector of the photo transistor V19. On receiving IR light V19 will drive V3 into saturation pulling the RXD line low. A low level is interpreted as a logic 1 by the microprocessor.

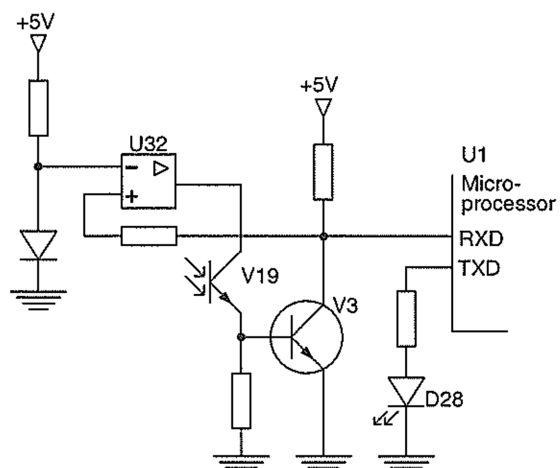


Figure 3-17. RS232 Optical Interface

Amplifier

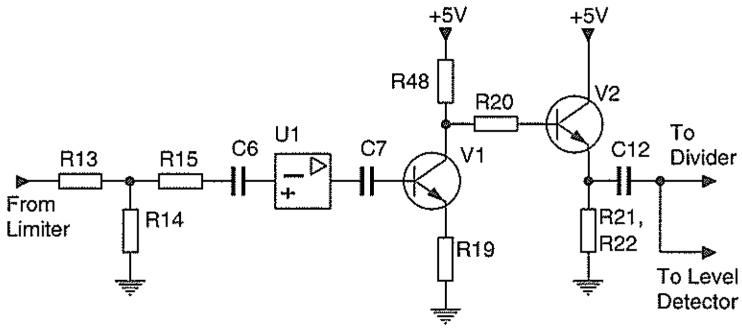


Figure 3-20. Amplifier Circuits

R13, R14, and R15 attenuate the HF signal 3 dB to prevent overloading of the amplifier circuit U1that amplifies the HF signal approximately 15 dB. V1 raises the amplitude in the frequency range 0.9 GHz to 1.4 GHz by 8 dB to compensate for the falling frequency response of U2. V2 is an impedance converter, (see Figure 3-20).

Divider

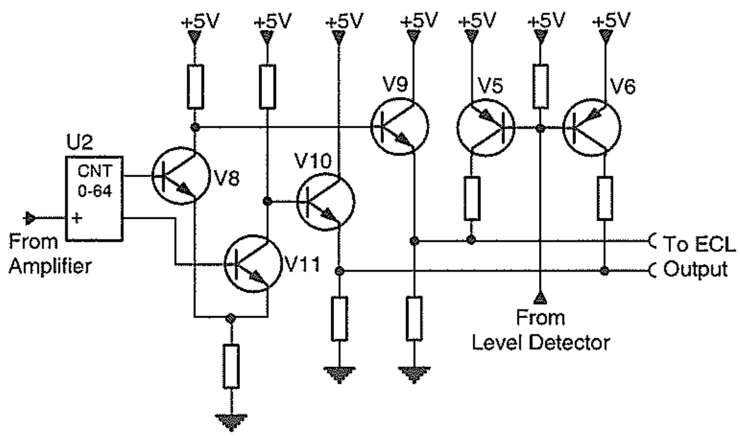


Figure 3-21. Divider and ECL-converter Circuits

The divider U2 divides the input frequency by 64. The output frequency is maximum 21 MHz. See Figure 3-21.

ECL output

See Figure 3-22. The transistors V8 and V11 form a differential amplifier that reduces the transition times of the differential signal at the outputs of U2. V9 and V10 convert the signal to positive ECL levels. The transistors V5 and V6 can disable the ECL output by setting the normally differential output levels high. This is done by means of the control signal from the level detector. Base currents applied to V5 and V6 make them conduct, lifting the emitters of V9 and V10 to a logic high level. The base-emitter junctions of these transistors will be reverse biased and the output signal will be blocked.

Chapter 4
Performance Verification

Title	Page

Introduction

The MultiFunction Counter should be calibrated and in operating condition when you receive it.

The following performance verification tests are provided to ensure that the MultiFunction Counter is in proper operating condition. If the instrument fails any of the tests, calibration adjustments (see chapter 5) and/or repair (see chapter 7) is necessary.

The Performance Verification Procedure consists of two parts

Operational Verification Procedure useful for:

- Incoming inspection
- Routine maintenance
- Check after instrument repair

Complete Performance Verification Procedure to verify the specifications listed in chapter 2.

If the instrument passes the Operational Verification and the Complete Performance Verification it is considered to be calibrated and can carry a calibration sticker.

All tests can be performed without opening the cover of the instrument.

Warning

Before turning on the instrument, ensure that it has been installed in accordance with the installation instructions outlined in Chapter 1 of the operators manual.

Operational Verification

The operational verification is a quick way to check that the instrument operates properly without performing the complete performance verification. Because of the highly integrated design of the MultiFunction Counter, it is not always necessary to check all features separately.

Note

Power up the MultiFunction Counter and the test equipment at least 30 minutes before testing to let them reach normal operating temperature. Failure to do so may result in certain test steps not meeting the specifications.

Test 1, Self Test

Procedure

1. Press (power key) to turn on the MultiFunction Counter.
2. Select Default Settings by: Pressing [SAVE RECALL] and choosing [Recall Default Setup] and then pressing [SELECT].
3. Press [USER OPTIONS].
4. Position the black cursor on [Test&Adjust] and press [SELECT].
5. Check that **Select Self Test: All Self Tests** are displayed.
6. Position the black cursor on [Run Self Tests] and press [SELECT].
7. Check that all tests are passed. If the test is not applicable, dashes (----) will show in stead of "Passed".
8. End the self test by pressing any key.

Test 4, STATISTICS Test Procedure (163)

1. Press [MAX MIN].
2. Verify the following measured approximate values:
   Mean: 1.000 MHz
   Standard Deviation: <5 mHz
   Maximum: 1.000 MHz
   Minimum: 1.000 MHz
   Max-Min: < 30 mHz

Test 5/6/7, Measure Function

These tests verify the operation of the MEASURE FUNCTION setup menu.

Test setup

As test setup in Figure 4-1. Test setup.

Test 5, Time Interval A to B Test Procedure

1. Select Default Settings by: Pressing [SAVE RECALL] and choosing [Recall Default Setup] and then pressing [SELECT].
2. Press [USER OPTIONS]; then choose Output; then press [SELECT].
3. Set Output as follows:
   Output: On
   Output Signal: 1 kHz, Square
4. Press [MEASURE FUNCTION]; then choose [Period&Time]; then press [SELECT].
5. Choose [Time Interval]; then press [SELECT].
6. Press [INPUT TRIGGER]; choose [Input A]; then press [SELECT].
7. Set Input A conditions to:
   Trigger Slope: Positive
   Auto Trigger: On
   Voltage Range: ±5.0V
   Coupling: DC
   100 kHz LP Filter: Off
8. Press [EXIT] to exit Input A settings.
9. Choose Input B; then press [SELECT].
10. Set input B conditions to:
    Trigger Slope: Negative
    Auto Trigger: On
    Voltage Range: ±5.0V
    Coupling: DC
    100 kHz LP Filter: Off
11. Press [EXIT] to exit input B settings.
12. Choose [Arming&Hold Off]; then press [SELECT].
13. Set Hold Off conditions to
    Trigger Hold Off: On
    Hold Off Time: 2.00 ms

Test 8, 10 MHz Reference Input

This test verifies the operation of the External Timebase Reference Input.

Test setup

As test setup in Figure 4-1. Test setup. Also connect an external 10 MHz, 0.5 Vrms signal to the MultiFunction Counter's REF INPUT.

Test Procedure

1. Select Default Settings by: Pressing [SAVE RECALL] and choosing [Recall Default Setup] and then pressing [SELECT].
2. Press [USER OPTIONS]; then choose **Timebase Reference: External.**
3. Choose [Output]; then press [SELECT].
4. Set OUTPUT as follows:
   Output: On
   Output Signal: 10 MHz, Reference.
5. Press [1234];

Verify that the display reads approximately 10.000 000 XX MHz and the Ext Ref on the INFORMATION MENU is lit.

Test 10. Time Interval Uncertainty

These tests check the resolution and channel mismatch errors in Time Interval measurements:

Test Equipment

Pulse Generator.

Test Setup

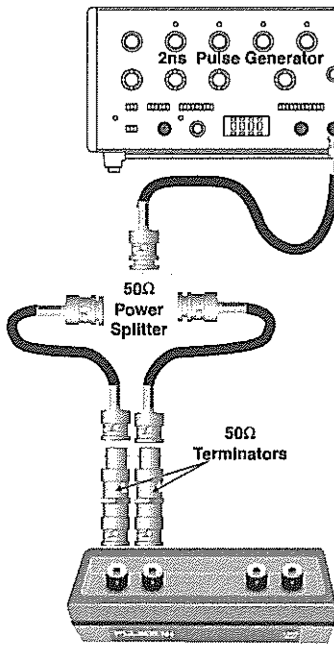


Figure 4-2. Test Setup for Time Interval Uncertainty

Set the Pulse Generator to the following:

- Period: 100 µs
- Width: Square wave signal
- Amplitude Levels: +2V and -2V
- Rise Time: 2 ns

Procedure

1. Cycle ⏻ to preset MultiFunction Counter.
2. Select Default Settings by: Pressing [SAVE RECALL] and choosing [Recall Default Setup] and then pressing [SELECT].
3. Press [MEASURE FUNCTION]; then choose Period & Time; then press [SELECT].
4. Choose Time Interval; then press [SELECT].
5. Press [INPUT TRIGGER]; then choose Input A; then press [SELECT].
6. Set input A conditions to:
   Trigger Slope: Positive

Set the MultiFunction Counter to the following:

1. Cycle ⏻ to preset MultiFunction Counter.
2. Select Default Settings by: Pressing [SAVE RECALL] and choosing [Recall Default Setup] and then pressing [SELECT].
3. Press [USER OPTIONS]; then choose Output; then press [SELECT].
4. Set OUTPUT as follows:
5. Output: On
6. Output Signal: 10 MHz, Reference
7. Press [EXIT] twice to exit OUTPUT settings.

11-1. Procedure for Input A tests

1. Set the Signal Generator to output 1 MHz, -30 dBm sine wave signal.
2. Press [1234]: then press [AUTO SET] to measure frequency A.
3. In 1 dB steps, increase the power level until the MultiFunction Counter displays a stable reading of 1 MHz.
4. Record the power level in the appropriate place in the Test 11, Frequency Sensitivity Test Record.
5. Repeat steps 1, 3, and 4 for 50 MHz and 160 MHz.

11-2. Procedure for Input B tests

1. Connect the Signal Generator to Input B, via the 50Ω feedthrough termination, and set the Generator to output 1 MHz, -30 dBm sine wave signal.
2. Press [INPUT TRIGGER] select 'Measure Channel(s)' and press [SELECT] then choose Channel B and press [SELECT].
3. In 1 dB steps, increase the power level until the MultiFunction Counter displays a stable reading of 1 MHz.
4. Record the power level in the appropriate place in the Test 11, Frequency Sensitivity Test Record.
5. Repeat steps 1, 3, and 4 for 50 MHz and 160 MHz.

11-3 Procedure for Input C tests (163)

1. Connect the Signal Generator to Input C, without the 50Ω feedthrough termination, and set the Generator to output 70 MHz, -35 dBm sine wave signal.
2. Press [INPUT TRIGGER] select 'Measure Channel(s)' and press [SELECT] then choose Channel C and press [SELECT].
3. In 1 dB steps, increase the power level until the MultiFunction Counter displays a stable reading of 70 MHz.
4. Record the power level in the appropriate place in the Test 11, Frequency Sensitivity Test Record.
5. Repeat steps 1, 3, and 4 for 900 MHz, 1100 MHz, and 1300 MHz.

12-2. Procedure for Input B tests

1. Connect the Signal Generator to Input B.
2. Press [INPUT TRIGGER] select 'Measure Channel(s)' and press [SELECT] then choose Channel B and press [SELECT].
3. Record the Mean value and Standard Deviation in the appropriate place in the Test 12, Frequency Uncertainty Test Record.

12-3. Procedure for Input C tests (163)

1. Connect the Signal Generator to Input C without the 50Ω feedthrough termination.
2. Press [INPUT TRIGGER] select 'Measure Channel(s)' and press [SELECT] then choose Channel C and press [SELECT].
3 Record the Mean value and Standard Deviation in the appropriate place in the Test 12, Frequency Uncertainty Test Record.

Test 13/14/15. Voltage Uncertainty

These tests check the voltage uncertainty specifications of INPUTS A and B.

Test Equipment

Fluke 5500A Multi-Product Calibrator.

Test Setup

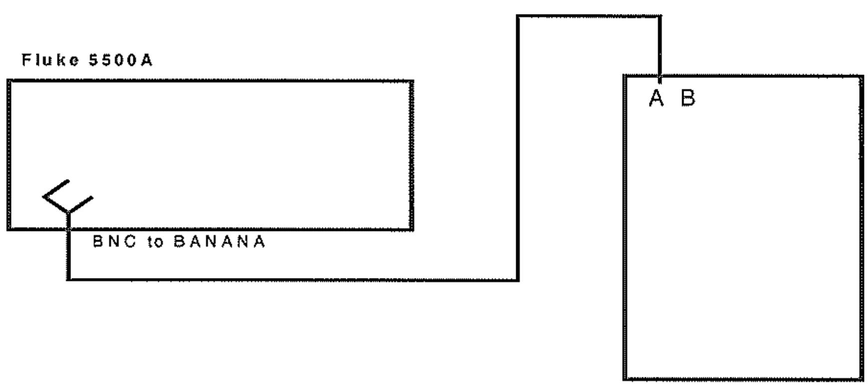


Figure 4-5. Test Setup for Voltage Uncertainty

14.Press [AUTO SET].

15.Record the voltage reading in the appropriate place in the Test 14, AC Voltage Uncertainty Test Record.

16.Repeat steps 13 through 15 to complete the AC Voltage Uncertainty Test Record for INPUT A.

17.Connect the Signal Generator to INPUT B and choose Channel B via [INPUT TRIGGER] key and repeat steps 13 through 15 for INPUT B tests.

18.Disconnect the Signal Generator.

Test 15. Peak Voltage Uncertainty

Procedure

1. Cycle ⏻ to preset MultiFunction Counter.
2. Select Default Settings by: Pressing [SAVE RECALL] and choosing [Recall Default Setup] and then pressing [SELECT].
3. Press [MEASURE FUNCTION]; then choose Voltage; then press [SELECT].
4. Choose Vp-p; then press [SELECT].
5. Choose 'VALUES' mode by pressing [1234].
6. Connect the Calibrator to INPUT A and set it to output 1.00 Vrms, 2 kHz.
7. Press [AUTO SET].
8. Record the voltage reading in the appropriate place in the Test 15, Peak Voltage Uncertainty Test Record.
9. Connect the Calibrator to INPUT B and choose Channel B via [INPUT TRIGGER] key.
10. Record the voltage reading in the appropriate place in the Test 15, Peak Voltage Uncertainty Test Record.
11. Disconnect the Calibrator and connect the Signal Generator via a 50Ω feedthrough termination to INPUT A.
12. Choose Channel A via [INPUT TRIGGER] key.
13. Set the Signal Generator to output 1.00 Vrms, 5 MHz.
14. Record the voltage reading in the appropriate place in the Test 15, AC Voltage Uncertainty Test Record.
15. Repeat steps 13 and 14 to complete the Test 15, Peak Voltage Uncertainty Test Record for INPUT A.
16. Connect the Signal Generator to INPUT B and choose Channel B via [INPUT TRIGGER] key.
17. Repeat steps 13 and 14 to complete the Test 15, Peak Voltage Uncertainty Test Record for INPUT B.

Test 11. Frequency Sensitivity Test Record

(page 4-12)

Primary Channel	Frequency	Reading	Specification	Test Result	
				Pass	Fail
A	1 MHz		≤-21 dBm (20 mV rms)		
A	50 MHz		≤-21 dBm (20 mV rms)		
A	160 MHz		≤-15 dBm (40 mV rms)		
B	1 MHz		≤-21 dBm (20 mV rms)		
B	50 MHz		≤-21 dBm (20 mV rms)		
B	160 MHz		≤-15 dBm (40 mV rms)		
C	70 MHz		≤-27 dBm (10 mV rms)		
C	900 MHz		≤-27 dBm (10 mV rms)		
C	1100 MHz		≤-23.5 dBm (15 mV rms)		
C	1300 MHz		≤-15 dBm (40 mV rms)		

Test 12. Frequency Uncertainty Test Record

(page 4-14)

Primary Channel	Mean			Standard Deviation		Test Result	
	Min.	Reading	Max.	Spec.	Reading	Pass	Fail
A	99.999 900 MHz		100.000 100 MHz	≤ 100 Hz			
B	99.999 900 MHz		100.000 100 MHz	≤ 100 Hz			
C	99.999 900 MHz		100.000 100 MHz	≤ 100 Hz			

Test 13. DC Voltage Uncertainty Test Record

(page 4-16)

Primary Channel	Range	Input Signal	Min.	Reading	Max.	Test Result	
						Pass	Fail
A	±0.5V	400 mV DC	391 mV DC		409 mV DC		
A	±0.5V	-400 mV DC	-409 mV DC		-391 mV DC		
A	±5V	4.00V DC	3.91V DC		4.09V DC		
A	±5V	-4.00V DC	-4.09V DC		-3.91V DC		
A	±50V	40.0V DC	39.1V DC		40.9V DC		
A	±50V	-40.0V DC	-40.9V DC		-39.1V DC		
B	±0.5V	400 mV DC	391 mV DC		409 mV DC		
B	±0.5V	-400 mV DC	-409 mV DC		-391mV DC		
B	±5V	4.00V DC	3.91V DC		4.09V DC		
B	±5V	-4.00V DC	-4.09V DC		-3.91V DC		
B	±50V	40.0V DC	39.1V DC		40.9V DC		
B	±50V	-40.0V DC	-40.9V DC		-39.1V DC		

Chapter 5
Calibration Adjustment

Title	Page

Introduction

Calibration adjustment is made in two steps, Closed Case Calibration and Hardware Adjustment. The Closed Case Calibration procedure is the normal calibration to be performed when you want to verify the calibration status of the instrument and compensate for aging. Hardware adjustment should only be made after repair and replacement of components, and when Closed Case Calibration fails.

Fluke 163 &164 Closed Case Calibration Procedures

These procedures allow you to perform closed case calibration and adjustment of the Timebase and Voltmeter functions of the MultiFunction Counter. The following procedures are available

- Make Timebase Adjustment
- Make Voltage Adjustment
- Undo Timebase Adjustment
- Undo Voltage Adjustment

Press [USER OPTIONS] and select [About] to check calibration adjustment date at any time.

Before beginning the calibration adjustments, connect the power adapter and power up the instrument. Leave it on for approximately 60 minutes to reach normal operating temperature.

Pressing [i] when calibrating will give additional information about the current step of the calibration and adjustment procedure.

Timebase Calibration and Adjustments

Calibration equipment

10 MHz reference frequency with at least a 4:1 test uncertainty ratio, e. g. Fluke PM 6685R, PM 6681R or 'house standards' with similar specifications.

Calibration setup

Connect the 10 MHz reference frequency to the input of the MultiFunction Counter as described on the display while running the procedure.

Procedure

The Adjustment Access Code printed on the next page must be entered before you get access to the "Make Adjustment" buttons.

1. Press [USER OPTIONS] to enter the USER OPTIONS menu.
2. Press appropriate [▲][▼][◀][▶] key to position the cursor on the [Test & Adjust] button, then press [SELECT].
3. Press appropriate [▲][▼] key to position the cursor on [Adjust Access Code], then press [SELECT]. A keypad will appear where you can enter the code.

5. Position the cursor on [Make Voltage Adjustment], then press [SELECT]. Follow the instructions that appear on the display of the MultiFunction Counter (e.g. connect 0.000V DC to input A). A few adjustment cycles will be performed.
6. Enter date of adjustment, then press [EXIT] to finish this procedure.

If you want to cancel the calibration you just finished, then perform steps 7 and 8.

7. Position the cursor on [Undo Voltage Adjustment], then press [SELECT].
8. Press [▲][▼] to select the previous adjustment or the factory adjustment, then press [SELECT]. Follow the instructions that appear on the display of the MultiFunction Counter.

Note

The following procedure refers to test points that are marked on the digital PCA and on the corresponding layout drawing. See page 9-8.

Note

Use Analog Ground (test point X50) as the reference point for the voltage measurements below. It is not possible to adjust these voltages. Values outside the tolerance range depend on faulty parts and must be corrected before further adjustments.

Reference Voltages

Checks

1. Connect the DMM to test point X48. Check that the voltage is +2.500 ± 0.010 V.
2. Check that the voltage at test point X49 is +5.00 ± 0.05 V.
3. Check that the voltage at test point X51 is +2.50 ± 0.15 V.
4. Check that the voltage at test point X52 is +2.500 ± 0.015 V.
5. Check that the voltage at test point X53 is +2.50 ± 0.15 V.
6. Check that the voltage at test point X54 is +2.500 ± 0.015 V.

Power Supply Voltages

Checks

1. Connect the DMM to test point X22. Check that the voltage is +5.00 ± 0.05 V.
2. Check that the voltage at test point X23 is 12.25 ± 0.25 V.
3. Check that the voltage at test point X24 is –5.5 ± 0.5 V.
4. Check that the voltage at test point X25 is –30.5 ± 1.5 V.

Input Amplifiers

Step Response

Setup

Table 5-2. Step Response Setup

Fluke 16X MultiFunction Counter	
Function	Time Interval A to B
Input A + B	50 Ω / DC / Manual trigger levels
Voltage Range	5 V
Pulse Generator	
Amplitude	10 V
Pulse Period	1 ms / T/2 (Square Pulse)
Oscilloscope	
Time	0.1 ms/div
Vertical Setting: A	1 V/div DC
Vertical Setting: B	50 mV/div, passive probe 10:1 <1.5 pF, DC

Adjustment

Note

The adjustments should preferably be made at an ambient temperature of +25°C.

Note

It is most important that the output pulses from the pulse generator do not tilt more than 0.1% of the pulse amplitude.

1. Connect the Pulse Generator to input A of the MFC and to Input A of the oscilloscope via the power splitter. Use 50 Ω terminations at the inputs. As regards the oscilloscope it is in general preferred to use the built-in termination if available.
2. Set the attenuator to X1. Connect Input B of the oscilloscope via a probe to test point J2A. Make sure that the probe is correctly compensated.
3. Adjust C1A (with the special screwdriver) and R25A until the shape of the signal traces equal each other without overshoot or undershoot.
4. Change the attenuator setting to X10 and the oscilloscope vertical setting for Input B to 5 mV/div .
5. Adjust C4A and C6A in the same way as under point 3 above.
6. Repeat steps 1 - 5 for Input B of the MFC. Replace index A by B in the part numbers, e. g. J2A by J2B.

Voltage Calibration

Procedure

Hardware adjustments made during the procedures described above affect the voltage calibration. It is therefore absolutely necessary to perform a new software calibration according to the method given earlier in this chapter.

Verification

Perform the relevant voltage uncertainty tests in chapter 4 (tests 13, 14 and 15).

Chapter 6
Disassembling

Title	Page

Introduction

The Fluke 160 series is available in different versions. These are:

Fluke 163	MultiFunction Counter with basic functions and standard XO
Fluke 164	MultiFunction Counter with standard XO
Fluke 164T	Fluke 164 + 1.3 GHz HF input TCXO in place of std. XO
Fluke 164H	Fluke 164 + 1.3 GHz HF input OCXO in place of std. XO

Most screws used to assemble the MFC are of type M3 Torx 10.

Removing the Battery Pack

Note

The MFC will lose all settings within 50 seconds after the battery pack is removed if there is no lithium battery mounted in the instrument. To avoid this keep it connected to the line power via the power adapter, but in power off mode.

1. Turn the MFC upside down.
2. Loosen the two screws “A” holding the battery cover and remove it from the MFC. See Figure 6-1.
3. Use the black pull-strip gently to remove the battery pack.

Note

When reinstalling the rechargeable battery pack be sure that the contact tongue on the battery and the contact strip at the bottom of the battery container mate.

Note

This instrument contains a Nickel-Cadnium battery. Do not dispose of this battery with other solid waste. Used batteries should be disposed of by a qualified recycler or hazardous materials handler. Contact your authorized Fluke Service Center for recycling information.

Opening the MultiFunction Counter

Warning

Do not perform any internal service or adjustment of this instrument unless you are qualified to do so.

Warning

When you remove the covers you will expose live parts and accessible terminals which can cause death.

Warning

To avoid electric shock, disconnect test leads, probes, and power supply from any live source and from the instrument itself.

Removing the Input PCA

1. Open the MFC.
2. Loosen the three screws and spring washers "E" holding the top screening and the Input PCA to the bottom cover. See Figure 6-2.
3. Lift the metal top screening while pulling it backwards.
4. Disconnect the battery wiring plug from the battery connector of the Input PCA.
5. Lift both sides of the upper part of the flat cable connector J3.
6. Pull the flat cable out of the connector.

Note

Do not touch the flat cable ends to avoid that dirt or grease from your hands may cause contact problems!

7. Loosen the two screws "F" holding the input assembly to the bottom cover.
8. Lift the Input PCA out of the bottom cover.

Note

Be sure to put the flat cable in exactly the same position as before when reassembling the MultiFunction Counter.

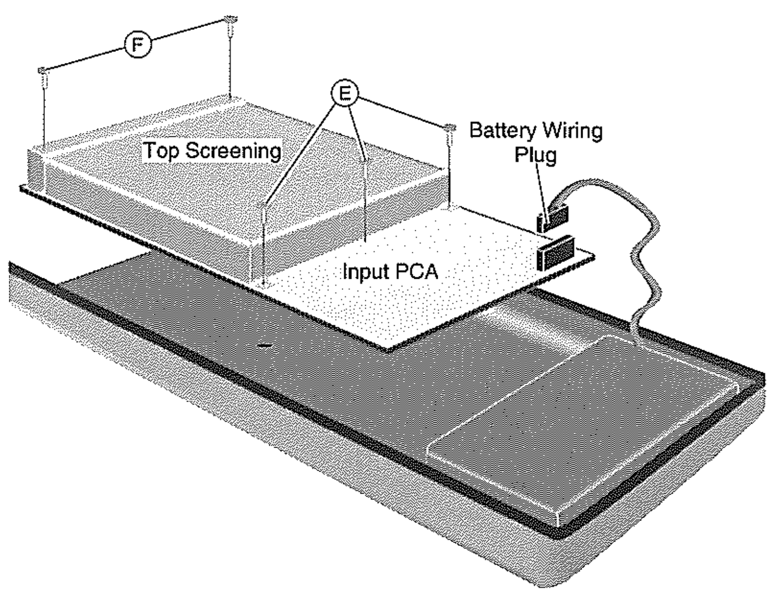


Figure 6-2. Removing the Input PCA

1. The following description is only meant to be elementary.
2. Open the MultiFunction Counter.
3. Remove the Display PCA.
4. Pull the three metal clamps from the display. Not shown in Figure 6-4.
5. The rest of the parts are disassembled in alphabetical order

Note

Do not damage the zebra strips when removing them from the display. Do not touch the contact surface of the display or the zebra strips to avoid that dirt or grease from your hands may cause contact problems.

A. LCD Frame	5322 256 10192
B. Si Rubber Connector	5322 460 11046
C. Si Rubber Connector	5322 460 11045
D. LCD	5322 135 00027
E. Dust Filter	5322 480 10121
F. Bracket	5322 402 10618
G. Backlight Assembly CCFL	5322 466 11306

Reassemble the parts in reverse alphabetical order after having prepared parts G and E in the following way:

A. Fold the reflecting foil over the CCFL and fasten it with double-coated adhesive tape to the surface of the diffuser.

E. Make sure the dust filter has the adhesive side down.

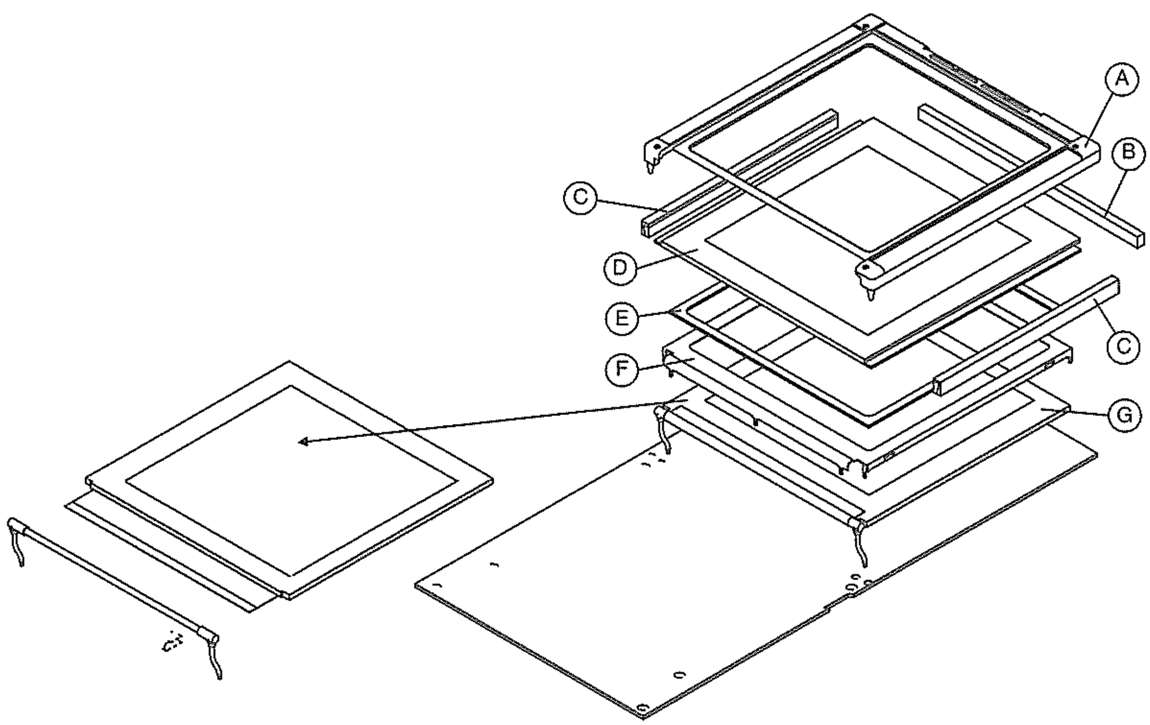


Figure 6-4. Removing the LCD

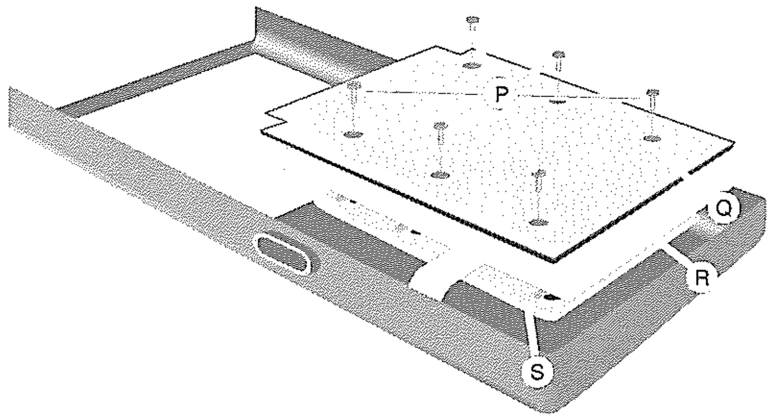


Figure 6-6. Removing the Keyboard

Replacing the BNC connectors

Note

The BNC connectors can not be removed from the Input Unit without jeopardizing the Front Frame. It is rccommended to replace the Input Unit altogether. A kit containing four BNC connectors, four gaskets, four toroid ferrite cores, one Front Frame and one Front Shield is available. See Chapter 8, Replaceable Parts.

1. Open the MultiFunction Counter.
2. Remove the Input PCA according to Fig. 6-2.
3. Lift the metal top screening while pulling it backwards.
4. Remove the HF input if it is fitted. See Fig. 6-5.
5. Unsolder the BNC connectors from the PCA.
6. Remove the old Input Unit.
7. Open the new Input Unit Kit.
8. Fit the gaskets on to the BNC connectors.
9. Press the BNC connectors into the holes in the Front Frame. See Figure 6-7.
10. Fit the Front Shield to the Front Frame.
11. Fit the toroid cores on to the back of the BNC connectors and fix each of them to the front shield with a small amount of fast-hardening glue.
12. Bend the BNC leads in right angle to fit the mounting holes in the Input PCA.
13. Mount the new assembled Input Unit on the Input PCA and solder the BNC leads to the board.
14. Assemble the MFC

Chapter 7
Corrective Maintenance

Introduction

This chapter contains information about faultfinding and repair. It only deals with what is not covered by traditional faultfinding/repair using diagrams and function descriptions.

Flash PROM

The firmware in the MultiFunction Counter is stored in Flash PROMs.

Checking the Flash PROM

1. Power ON the MultiFunction Counter.
2. Is the screen blank? No startup screen, nothing?
   If so, make sure the rest of the hardware is OK, then try loading the firmware. It is most likely that you must first replace the Flash PROM circuits.
3. Is the screen checkered (filled with black and white squares)?
   Load new firmware from diskette (see below).
4. Does the MultiFunction Counter start up normally?
   If so, press [USER OPTIONS] and select [Test & Adjust]

   - **Select Self Test: ROM**
   - Press [Run Self Test]

   If the test fails, load new firmware from disk.
   If the test is passed, the Flash PROM is OK.

Loading new Firmware

The disk contain both Fluke 163 and Fluke 164 firmware.

Note:

You cannot make a Fluke 163 into a Fluke 164 by loading the Fluke 164 firmware. (New firmware will be loaded, but functionality remains as Fluke 163.)

Caution:

Loading the Fluke 163 firmware into a Fluke 164 will permanently convert the instrument into a Fluke 163. You cannot reverse the process by loading the Fluke 164 firmware again, bust must replace the Flash PROM circuits, or return the unit to the factory for repair.

Caution:

NEVER EVER INTERRUPT LOADING IN PROGRESS.

If loading fails, rerun loading without interrupting the power to the MultiFunction Counter.

If you disregard these warnings, the FLASH-PROM may have to be replaced!

Chapter 8
List of Replaceable Parts

Title **Page**

Introduction

Standard Parts

Electrical and mechanical replacement parts can be obtained through your local Fluke organization or representative. However, many of the standard components can be obtained from other local suppliers. Before purchasing or ordering replacements parts, check the parts list for value, tolerance, rating, and description.

If the value of the physical component differs from what is described in the parts list, you should always replace the part with the same value as originally mounted.

Note

Physical size and shape of a component may affect the performance of the instrument, particularly at high frequencies. Always use direct replacements unless it is known that a substitute will not degrade the performance of the instrument.

Special Parts

In addition to standard electronic components, the following special components are used:

- Components that are manufactured or selected by Fluke to meet specific performance requirements.
- Components that are important for the safety of the instrument.

Both type of components may be replaced only by components obtained through your local Fluke organization.

The above mentioned parts are ‘Recommended Replacement Parts’ and are marked with an ‘R’ in the ✰ column of the parts list.

Components marked with a ‘P’ in the ✰ column are ‘Production items’ not kept in replacement parts stock. These items can be ordered, but the delivery time is longer than for normal replacement parts.

Mechanical parts, all versions[2]

Item	Description	Part Number	☆
1	Top Cover Unit	5322 442 00551	R
2	Bottom Cover	5322 447 70113	
3	Front Rim Fluke 160-ser	5322 447 92377	R
4	Text Plate Kit Fluke 163	5322 455 90489	R
4	Text Plate Kit Fluke 164	5322 455 90488	R
5	Battery Cover	5322 447 70116	
6	Stand Up Assy	5322 456 90416	
7	Foot TM	5322 462 41825	
8	Rubber Keypad Fluke 164	5322 414 20547	R
9	Input Unit	5322 693 92121	R
10	Front Shield Fluke 160-ser	5322 466 30468	P
11	Gasket	5322 530 51238	R
12	Strip Anti Slip	5322 466 62045	
13	Screw MFT 3x16 St FZB TX	5322 502 21643	P
14	Screw MRT 3x12 St FZB TX	5322 502 21642	P
15	Spring Washer KBA 3.2 ST FZ DIN137	4822 530 80173	P

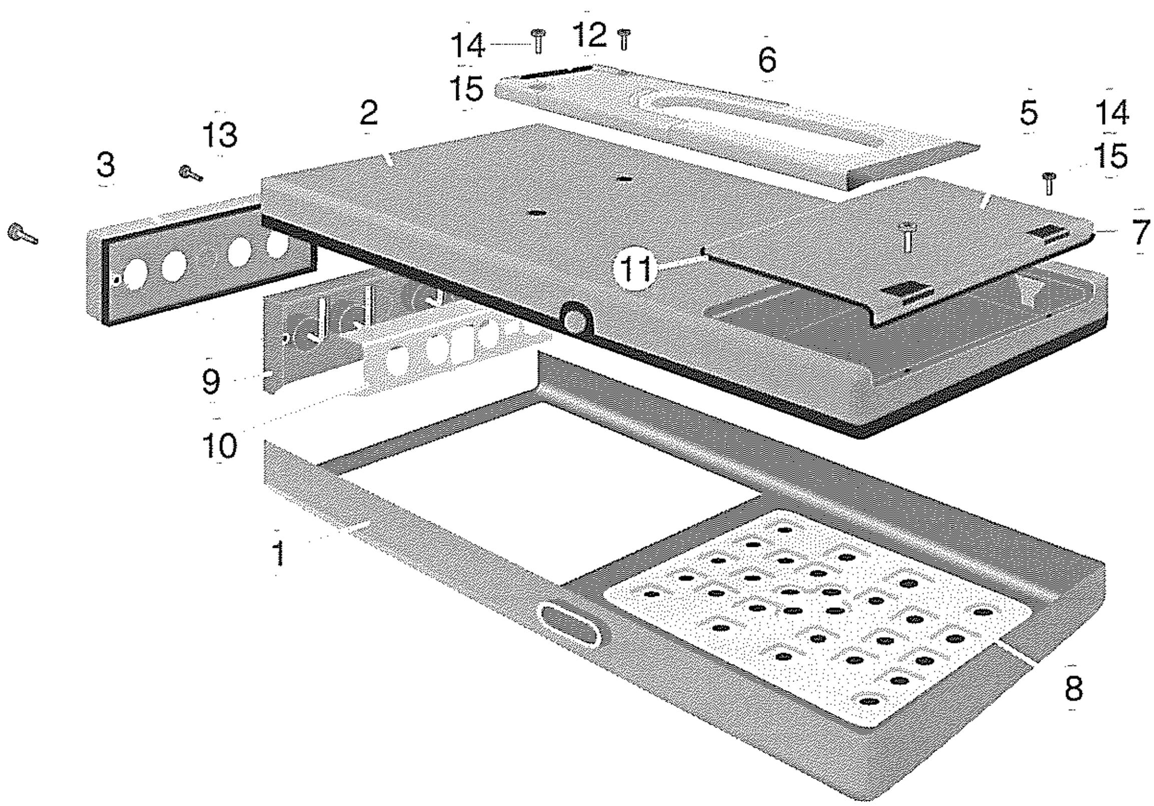


Figure 8-2. Box

19	Keyboard Plate Fluke 163, 164	5322 466 70792	
20	Keyboard Foil Fluke 163, 164	5322 466 10694	R

[2] See page 6-9 for replacing the BNC connectors.

Item	Description	Part Number	☆
36	LCD Frame TM	5322 256 10192	P
37	Clamp TM	5322 401 11411	P
38	LCD Display 240x240	5322 135 00027	P
39	Dust Filter LCD	5322 480 10121	P
40	Si-rubber Connector Type: I P=0.1	5322 460 11045	R
41	Si-rubber Connector Type: sec P=0.05	5322 460 11046	R
42	Backlight Assy CCFL	5322 466 11306	R
43	Bracket	5322 402 10618	P

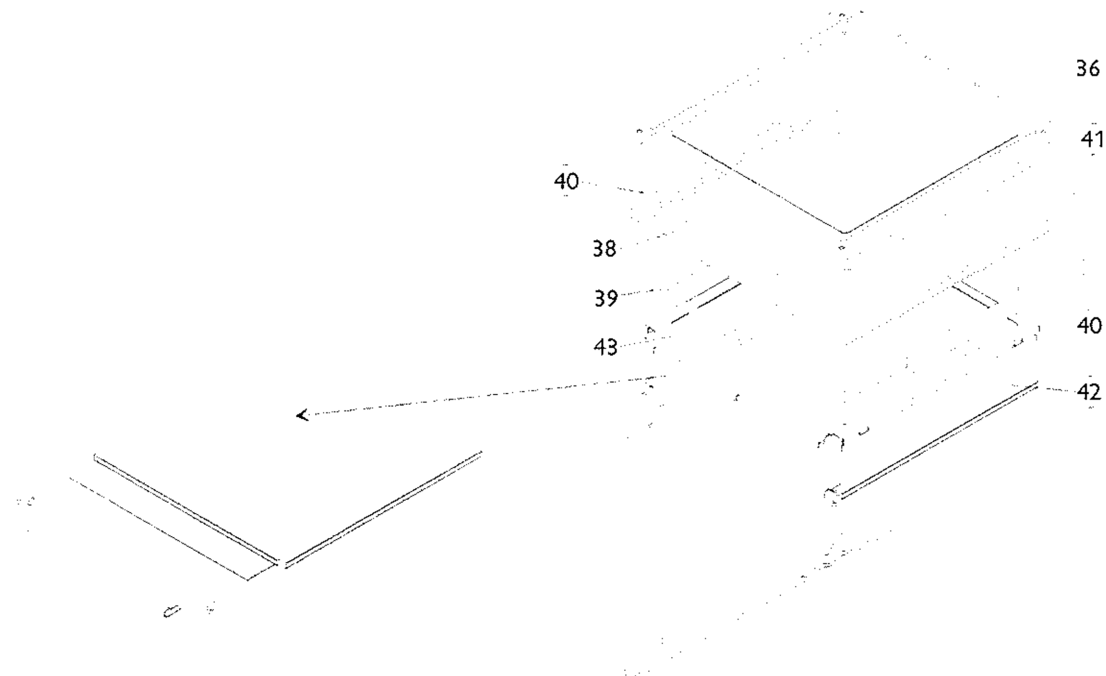


Figure 8-5. Parts for assembling the display

Item	Description	Part Number	☆
44	Sealing Ring 9x7x1 Si	5322 466 62647	R
45	Guide Piece, Optical Interface	5322 405 91772	
46	Guide Piece, Power inlet	5322 405 91784	

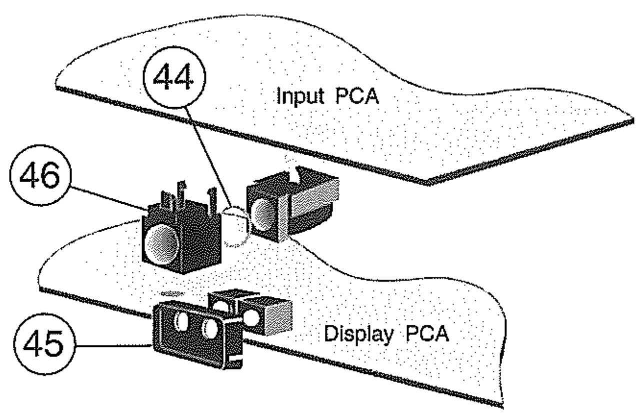


Figure 8-6. Seals for optical interface and power inlet

Display PCA, Fluke 163, 164

Item	Description	Ordering code	☆
0	PC-Board Assy Interpolator Fluke 160	5322 216 04224	P
0	Status Label 25.4x12.7 Polyimide	5322 454 13144	P
2	Status Label 25.4x12.7 Polyimide	5322 454 13144	P
3	Led Holder 3mm(2x) AST 0035.9611	5322 255 41213	
B1	Crystal 16.000MHz SMD SCM-309	5322 242 82111	R
B3	Crystal 10MHz HC-49U/13 (not fitted on 164T and H)	5322 242 82118	R
C1	Capacitor 22pF 5% 50V NP00805	5322 122 32658	
C2	Capacitor 22pF 5% 50V NP00805	5322 122 32658	
C3	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C4	Capacitor 2.20 µF 20%6.3V 3.2x1.6	5322 124 10685	
C5	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C6	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C7	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C8	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C10	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C11	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C12	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C13	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C14	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C15	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C16	Capacitor 2.20 µF 20%6.3V 3.2x1.6	5322 124 10685	
C17	Capacitor 82pF 5% 50V NP00805	4822 122 33515	
C18	Capacitor 2.20 µF 20%6.3V 3.2x1.6	5322 124 10685	
C27	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C31	Capacitor 82pF 5% 50V NP00805	4822 122 33515	
C32	Capacitor 15pF 5% 50V NP00805	5322 122 33869	
C33	Capacitor 10pF 5% 50V NP00805	5322 122 32448	
C34	Capacitor-Trim 3-10pF (not fitted on 164T and H)	5322 125 50306	R
C35	Capacitor 82pF 5% 50V NP00805	4822 122 33515	
C42	Capacitor 220pF 5% 50V NP00805	4822 122 33575	
C43	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C44	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C47	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C48	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C49	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C50	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C51	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C52	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C53	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C54	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C55	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C56	Capacitor 6.80 µF 20% 16v 6.0x3.2	5322 124 10687	R
C57	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	

Item	Description	Ordering code	☆
C109	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C112	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C113	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C114	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C115	Capacitor 82pF 5% 50V NP00805	4822 122 33515	
C116	Capacitor 82pF 5% 50V NP00805	4822 122 33515	
C117	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C118	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C119	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C120	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C121	Capacitor 100nF 20% 25V X7R 0805	5322 126 13638	
C122	Capacitor 6.80 µF 20% 16v 6.0x3.2	5322 124 10687	R
C123	Capacitor 2.20 µF 20%6.3V 3.2x1.6	5322 124 10685	
C124	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C125	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C126	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C127	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C128	Capacitor 2.20 µF 20%6.3V 3.2x1.6	5322 124 10685	
C132	Capacitor 2.20 µF 20% 35V 6.0x3.2	5322 124 11465	
C133	Capacitor 5.6pF "0.5pF 63V NP0 0805	5322 122 32967	
C135	Capacitor 5.6pF "0.5pF 63V NP00805	5322 122 32967	
C137	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C138	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C139	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C140	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C141	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C142	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C143	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C144	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C145	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C146	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C147	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C148	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C149	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C150	Capacitor 2.20 µF 20%6.3V 3.2x1.6	5322 124 10685	
C151	Capacitor 1nF 5% 50V NP00805	5322 126 10511	
C152	Capacitor 1nF 5% 50V NP00805	5322 126 10511	
C153	Capacitor 1nF 5% 50V NP00805	5322 126 10511	
C154	Capacitor 1nF 5% 50V NP00805	5322 126 10511	
C157	Capacitor 2.20 µF 20%6.3V 3.2x1.6	5322 124 10685	
C158	Capacitor 100nF 20% 25V X7R0805	5322 126 13638	
C163	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C164	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C165	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C166	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	

Item	Description	Ordering code	☆
R15	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R16	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R17	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R18	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R21	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R22	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R24	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R25	Resistor 5.60kΩ 1% 1/8W 100ppm	4822 051 10562	
R34	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R35	Resistor 100kΩ1% 1/8W 100ppm	4822 051 51004	
R36	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R38	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R39	Resistor 470 Ω 1% 1/8W 100ppm	4822 051 54701	
R42	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R45	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R47	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R53	Resistor 470 kΩ 1% 1/8W 100ppm	5322 116 80447	
R54	Resistor 470 kΩ 1% 1/8W 100ppm	5322 116 80447	
R55	Resistor 470 kΩ 1% 1/8W 100ppm	5322 116 80447	
R56	Resistor 470 kΩ 1% 1/8W 100ppm	5322 116 80447	
R57	Resistor 5.60kΩ 1% 1/8W 100ppm	4822 051 10562	
R58	Resistor 390 Ω 1% 0.1W 100ppm	5322 117 12508	
R59	Resistor 4.70kΩ 1% 1/8W 100ppm	4822 051 54702	
R60	Resistor 27.0kΩ 1% 1/8W 100ppm	4822 051 52703	
R61	Resistor 15.0kΩ 1% 1/8W 100ppm	5322 116 82261	
R62	Resistor 33.0kΩ 1% 1/8W 100ppm	4822 051 53303	
R63	Resistor 470 kΩ 1% 1/8W 100ppm	5322 116 80447	
R64	Resistor 470 kΩ 1% 1/8W 100ppm	5322 116 80447	
R65	Resistor 2.70kΩ 1% 1/8W 100ppm	4822 051 52702	
R66	Resistor 3.90kΩ 1% 1/8W 100ppm	4822 051 53902	
R67	Resistor 680 kΩ 1% 1/8W 100ppm	5322 117 11787	
R68	Resistor 15.0kΩ 1% 1/8W 100ppm	5322 116 82261	
R69	Resistor 220.0Ω 1% 1/8W 100ppm	4822 051 52201	
R70	Resistor 180 kΩ 1% 1/8W 100ppm	4822 051 51804	
R71	Resistor 27.0kΩ 1% 1/8W 100ppm	4822 051 52703	
R72	Resistor 5.60kΩ 1% 1/8W 100ppm	4822 051 10562	
R73	Resistor 4.70kΩ 1% 1/8W 100ppm	4822 051 54702	
R74	Resistor 390 Ω 1% 0.1W 100ppm	5322 117 12508	
R75	Resistor 33.0kΩ 1% 1/8W 100ppm	4822 051 53303	
R76	Resistor 15.0kΩ 1% 1/8W 100ppm	5322 116 82261	
R77	Resistor 470 kΩ 1% 1/8W 100ppm	5322 116 80447	
R78	Resistor 470 kΩ 1% 1/8W 100ppm	5322 116 80447	
R79	Resistor 2.70kΩ 1% 1/8W 100ppm	4822 051 52702	
R80	Resistor 3.90kΩ 1% 1/8W 100ppm	4822 051 53902	
R81	Resistor 680 kΩ 1% 1/8W 100ppm	5322 117 11787	

Item	Description	Ordering code	☆
R138	Resistor 22 Ω 1% 0.1W 100ppm	5322 117 12507	
R139	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R140	Resistor 33.0kΩ 1% 1/8W 100ppm	4822 051 53303	
R141	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R142	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R143	Resistor 220.0Ω 1% 1/8W 100ppm	4822 051 52201	
R144	Resistor 220.0Ω 1% 1/8W 100ppm	4822 051 52201	
R145	Resistor 47 Ω 1% 0.1W 100ppm	5322 117 12505	
R146	Resistor 120 Ω 1% 0.1W 100ppm	5322 117 12506	
R147	Resistor 390 Ω 1% 0.1W 100ppm	5322 117 12508	
R148	Resistor 390 Ω 1% 0.1W 100ppm	5322 117 12508	
R149	Resistor 47 Ω 1% 0.1W 100ppm	5322 117 12505	
R150	Resistor 47 Ω 1% 0.1W 100ppm	5322 117 12505	
R151	Resistor 22 Ω 1% 0.1W 100ppm	5322 117 12507	
R152	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R153	Resistor 33.0kΩ 1% 1/8W 100ppm	4822 051 53303	
R154	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R155	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R156	Resistor 220.0Ω 1% 1/8W 100ppm	4822 051 52201	
R157	Resistor 220.0Ω 1% 1/8W 100ppm	4822 051 52201	
R160	Resistor 390 Ω 1% 0.1W 100ppm	5322 117 12508	
R161	Resistor 390 Ω 1% 0.1W 100ppm	5322 117 12508	
R162	Resistor 120 Ω 1% 0.1W 100ppm	5322 117 12506	
R163	Resistor 47 Ω 1% 0.1W 100ppm	5322 117 12505	
R164	Resistor 47 Ω 1% 0.1W 100ppm	5322 117 12505	
R165	Resistor 680 Ω 1% 0.1W 100ppm	5322 117 12509	
R166	Resistor 680 Ω 1% 0.1W 100ppm	5322 117 12509	
R167	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R168	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R169	Resistor 220.0Ω 1% 1/8W 100ppm	4822 051 52201	
R178	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R179	Resistor 680 Ω 1% 0.1W 100ppm	5322 117 12509	
R180	Resistor 33.0kΩ 1% 1/8W 100ppm	4822 051 53303	
R182	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R184	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R186	Resistor 1.00kΩ 1% 1/8W 100ppm	4822 051 51002	
R187	Resistor 15.0kΩ 1% 1/8W 100ppm	5322 116 82261	
R188	Resistor 1.00kΩ 1% 1/8W 100ppm	4822 051 51002	
R189	Resistor 1.00mΩ 1% 1/8W 100ppm	4822 051 10105	
R190	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R191	Resistor 10.0kΩ 1% 1/8W 100ppm (not on 164H)	4822 051 51003	
R192	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R193	Resistor 680 Ω 1% 0.1W 100ppm	5322 117 12509	
R194	Resistor 33.0kΩ 1% 1/8W 100ppm	4822 051 53303	
R195	Resistor 39 Ω 1% 1/8W 100ppm	5322 116 82263	

Item	Description	Ordering code	☆
R267	Resistor 1.00k Ω 1% 1/8W 100ppm (only 164H)	4822 051 51002	
R268	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R269	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R271	Res. Network 100kΩx 4 1% 664A1003F	5322 117 12496	
R277	Resistor 39 Ω 1% 1/8W 100ppm	5322 116 82263	
R280	Resistor 33.0kΩ 1% 1/8W 100ppm	4822 051 53303	
R281	Resistor 33.0kΩ 1% 1/8W 100ppm	4822 051 53303	
R285	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R286	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R289	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R303	Resistor 22.0kΩ 1% 1/8W 100ppm	4822 051 52203	
R304	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R306	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R307	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R308	Resistor 39 Ω 1% 1/8W 100ppm	5322 116 82263	
R309	Resistor 39 Ω 1% 1/8W 100ppm	5322 116 82263	
R310	Resistor 39 Ω 1% 1/8W 100ppm	5322 116 82263	
R317	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R320	Resistor 2.70kΩ 1% 1/8W 100ppm	4822 051 52702	
R321	Resistor 2.20kΩ 1% 1/8W 100ppm	4822 051 52202	
R323	Resistor 820 Ω 1% 1/8W 100ppm	5322 116 82264	
R324	Resistor 2.70kΩ 1% 1/8W 100ppm	4822 051 52702	
R325	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R326	Resistor 68.0kΩ 1% 1/8W 100ppm	4822 051 56803	
R327	Resistor 68.0kΩ 1% 1/8W 100ppm	4822 051 56803	
T1	Transformer-CCFL CTX210657	5322 146 10405	R
U1	IC-CPU N80C196NT16 SMD PLCC68	5322 209 52775	R
U2	IC-SRAM HM628128ALFP-7 128KX8	5322 209 52773	
U4	IC-prom Fluke 160-ser Bas Sw U4	5322 209 15028	R
U5	IC-Reg LT1184CS	5322 209 12971	R
U6	IC-SRAM HM628128ALFP-7 128KX8	5322 209 52773	
U10	IC-CMOS MC74AC138D SO14 SMD	5322 209 90428	
U11	IC-CMOS MC74AC573DW 8 Latch	5322 209 90435	
U12	IC-CMOS MC74AC573DW 8 Latch	5322 209 90435	
U13	IC-LCD MSM6355GS-K	5322 209 52774	R
U14	IC-CMOS PC74HC163T SMD SO16	5322 209 30675	
U15	IC 256 Kbit UPD43256GU-12LSO28	5322 209 62421	
U17	IC-Ana TL7705BCD SMD Low V Detect	5322 209 90426	R
U18	IC-CMOS PC74HC00TSO14	5322 209 71802	
U19	IC-CMOS 74AC32D 4X0R2 SO14	5322 209 33104	
U22	IC-CMOS74AC20SC SMD SO14	5322 209 90427	
U23	IC-CMOS MC74AC573DW 8 Latch	5322 209 90435	
U25	IC-Op Amp LF453CM SMD SO8 JFET	4822 209 63757	
U26	IC-Op Amp LF453CM SMD SO8 JFET	4822 209 63757	
U27	IC-Op Amp LM358 X2 SMDSo8	4822 209 60175	R

Item	Description	Ordering code	☆
V19	Transistor, Photo 3mm SFH309F-4 IR900nm	5322 130 62923	
V20	Transistor BC857B .1A45V SOT23	5322 130 60508	
V21	Transistor BSR12 0.1A 15V SOT23	5322 130 44743	
V22	Transistor BSR12 0.1A 15V SOT23	5322 130 44743	
V23	Transistor BC857B .1A45V SOT23	5322 130 60508	
V31	Transistor BC857B .1A45V SOT23	5322 130 60508	
V47	Transistor BC847B .1A45V SOT23	4822 130 60511	
V48	Transistor BC857B .1A45V SOT23	5322 130 60508	
V49	Transistor BC847B .1A45V SOT23	4822 130 60511	
V51	Transistor BC857B .1A45V SOT23	5322 130 60508	
V52	Transistor BC847B .1A45V SOT23	4822 130 60511	
V53	Transistor BC847B .1A45V SOT23	4822 130 60511	
V54	Transistor-Sw N FZT849 SOT223 SMD	5322 130 10191	R
V55	Transistor-Sw N FZT849 SOT223 SMD	5322 130 10191	R
V56	Transistor BC857B .1A45V SOT23	5322 130 60508	

Item	Description	Ordering code	☆
C23b	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C24a	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C24b	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C25a	Capacitor33pF 5% 63V NP0	4822 126 10324	
C25b	Capacitor33pF 5% 63V NP0	4822 126 10324	
C26a	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C26b	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C27a	Capacitor 1nF 5% 63V NP0	4822 122 31746	
C27b	Capacitor 1nF 5% 63V NP0	4822 122 31746	
C28a	Capacitor 10nF 10% 63V X7R	4822 122 32442	
C28b	Capacitor 10nF 10% 63V X7R	4822 122 32442	
C29b	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C31a	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C31b	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C32a	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C32b	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C34a	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C34b	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C36a	Capacitor 10nF 10% 63V X7R	4822 122 32442	
C36b	Capacitor 10nF 10% 63V X7R	4822 122 32442	
C37a	Capacitor 10nF 20% 50V X7R0805	5322 122 34098	
C37b	Capacitor 10nF 10% 63V X7R	4822 122 32442	
C38a	Capacitor 100pF 5% 63V NP0	4822 122 31765	
C38b	Capacitor 100pF 5% 63V NP0	4822 122 31765	
C41a	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C41b	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C42a	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C42b	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C43b	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C45	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C46	Capacitor 1nF 5% 63V NP0	4822 122 31746	
C47	Capacitor 68µF "20% 16v 5x11	5322 124 41384	
C49	Capacitor 82pF 5% 63V NP0	4822 122 31839	
C50	Capacitor 22nF 20% 200V 2F4	5322 126 10527	
C51	Capacitor 1000µF 20% 25V	5322 124 81189	R
C52	Capacitor 100µF "20%40V10x12	5322 124 81194	
C58	Capacitor 2.20nF 10% 63V X7R	4822 122 31644	
C59	Capacitor 68µF "20% 16v 5x11	5322 124 41384	
C060	Capacitor 220nF 10% 63V X7R	5322 126 13642	
C61	Capacitor 22nF 20% 200V 2F4	5322 126 10527	
C62	Capacitor 68µF "20% 16v 5x11	5322 124 41384	
C63	Capacitor 22nF 20% 200V 2F4	5322 126 10527	
C064	Capacitor 470nF 10% 25V X7R1210	4822 126 12549	
C65	Capacitor 1000µF "20% 6.3V 10x20	5322 124 81192	
C66	Capacitor 100µF "20%40V10x12	5322 124 81194	

Item	Description	Ordering code	☆
C120	Capacitor 470nF 10% 25V X7R1210	4822 126 12549	
C123	Capacitor 220pF 5% 63V NP0	4822 122 31965	
C126	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C127	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C128	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C129	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C130	Capacitor 100nF 10% 63V X7R	4822 122 33496	
C131	Capacitor 10nF 10% 63V X7R	4822 122 32442	
C132	Capacitor 10nF 10% 63V X7R	4822 122 32442	
C133	Capacitor 10nF 10% 63V X7R	4822 122 32442	
C134	Capacitor 10nF 10% 63V X7R	4822 122 32442	
D1	Diode 0.10A BAV99SOT23	5322 130 34337	
D2	Diode-Sch MBRD630CT SMD 369-04	5322 130 62922	R
D3	Diode 0.10A BAV99SOT23	5322 130 34337	
D3a	Diode 0.10A BAT18 35V 1pFSOT23	5322 130 32076	
D3b	Diode 0.10A BAT18 35V 1pFSOT23	5322 130 32076	
D4	Diode 0.10A BAV99SOT23	5322 130 34337	
D4a	Diode 0.10A BAT18 35V 1pFSOT23	5322 130 32076	
D4b	Diode 0.10A BAT18 35V 1pFSOT23	5322 130 32076	
D5	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D6	Diode-Sch MBRD630CT SMD 369-04	5322 130 62922	R
D9	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D12	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D13	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D14	Diode 0.10A BAV99SOT23	5322 130 34337	
D15	Diode 0.10A BAV99SOT23	5322 130 34337	
D19	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D22	Diode-Sch MBRD630CT SMD 369-04	5322 130 62922	R
D24	Diode-Sch MBRD630CT SMD 369-04	5322 130 62922	R
D25	Diode-Sch MBRD630CT SMD 369-04	5322 130 62922	R
D27	Diode 0.10A BAV99SOT23	5322 130 34337	
D29	Diode 0.35 Ω BZX84-C6V8 SOT23	5322 130 80406	
D30	Diode 0.10A BAV99SOT23	5322 130 34337	
D33	Diode 0.10A BAV99SOT23	5322 130 34337	
D36	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D37	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D46	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D49	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D52	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D55	Diode 0.35 Ω BZX84-C6V8 SOT23	5322 130 80406	
D56	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D58	Led 3mm HLMP-1503-101 Green	5322 130 83933	
D59	Diode 0.25A BAS2875VSOT143	5322 130 80214	
D62	Diode 0.35w Bzx84-b5v6 2%SOT23	4822 130 33004	
J3	Connector Socket 30 Pole 52030-3010	4822 267 51143	

Item	Description	Ordering code	☆
R10b	Resistor 1.0 Ω 1% 1/8W 100ppm	5322 117 10967	
R11	Resistor 47 kΩ 1% 1/8W 100ppm	5322 116 80446	
R11a	Resistor 680 kΩ 1% 1/8W 100ppm	5322 117 11787	
R11b	Resistor 680 kΩ 1% 1/8W 100ppm	5322 117 11787	
R12a	Resistor 220 kΩ 1% 1/8W 100ppm	4822 051 52204	
R12b	Resistor 220 kΩ 1% 1/8W 100ppm	4822 051 52204	
R13a	Resistor 470 kΩ 1% 1/8W 100ppm	5322 116 80447	
R13b	Resistor 470 kΩ 1% 1/8W 100ppm	5322 116 80447	
R14a	Resistor 10.0 Ω 1% 1/8W 100ppm	4822 051 10109	
R14b	Resistor 10.0 Ω 1% 1/8W 100ppm	4822 051 10109	
R15a	Resistor 10.0 Ω 1% 1/8W 100ppm	4822 051 10109	
R15b	Resistor 10.0 Ω 1% 1/8W 100ppm	4822 051 10109	
R16a	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R16b	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R17a	Resistor 12.0kΩ 1% 1/8W 100ppm	5322 117 10968	
R17b	Resistor 12.0kΩ 1% 1/8W 100ppm	5322 117 10968	
R18a	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R18b	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R19a	Resistor 470 Ω 1% 1/8W 100ppm	4822 051 54701	
R19b	Resistor 470 Ω 1% 1/8W 100ppm	4822 051 54701	
R20a	Resistor 1.00mΩ 1% 1/8W 100ppm	4822 051 10105	
R20b	Resistor 1.00mΩ 1% 1/8W 100ppm	4822 051 10105	
R21a	Resistor 100kΩ 1% 0.1W 100ppm 0805	5322 117 12501	
R21b	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R22	Resistor 220 kΩ 1% 1/8W 100ppm	4822 051 52204	
R22a	Resistor 1.00mΩ 1% 1/8W100ppm	4822 051 10105	
R22b	Resistor 1.00mΩ 1% 1/8W 100ppm	4822 051 10105	
R23	Resistor 120 Ω 1% 1/8W 100ppm	4822 051 10121	
R23a	Resistor 1.00kΩ 1% 1/8W 100ppm	4822 051 51002	
R23b	Resistor 1.00kΩ 1% 1/8W 100ppm	4822 051 51002	
R24	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R24a	Potentiometer 100 kΩ 3304X-1-104	5322 101 10841	
R24b	Potentiometer 100 kΩ 3304X-1-104	5322 101 10841	
R25	Resistor 4.70kΩ 1% 1/8W 100ppm	4822 051 54702	
R25a	Potentiometer 100 kΩ 3304X-1-104	5322 101 10841	
R25b	Potentiometer 100 kΩ 3304X-1-104	5322 101 10841	
R26a	Resistor 180 kΩ 1% 1/8W 100ppm	4822 051 51804	
R26b	Resistor 180 kΩ 1% 1/8W 100ppm	4822 051 51804	
R27a	Resistor 220 kΩ 1% 1/8W 100ppm	4822 051 52204	
R27b	Resistor 220 kΩ 1% 1/8W 100ppm	4822 051 52204	
R28a	Resistor 6.80kΩ 1% 1/8W 100ppm	4822 051 10682	
R28b	Resistor 6.80kΩ 1% 1/8W 100ppm	4822 051 10682	
R29a	Resistor 10 MΩ 10% ¼W RC01	4822 051 10106	
R29b	Resistor 10 MΩ 10% ¼W RC01	4822 051 10106	
R30a	Resistor 10.0kΩ 1% 1/8W 100ppm 1206	4822 051 51003	

Item	Description	Ordering code	☆
R49b	Resistor 1.00kΩ 1% 1/8W 100ppm	4822 051 51002	
R50	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R50a	Resistor 0 Ω Jumper RC-01	4822 051 10008	
R50b	Resistor 0 Ω Jumper RC-01	4822 051 10008	
R51	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R51a	Resistor 0 Ω Jumper RC-01	4822 051 10008	
R51b	Resistor 0 Ω Jumper RC-01	4822 051 10008	
R52	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R52a	Resistor 390 Ω 1% 1/8W 100ppm	4822 051 53901	
R52b	Resistor 390 Ω 1% 1/8W 100ppm	4822 051 53901	
R53	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R53a	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R53b	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R54	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R54a	Resistor 68 Ω 1% 1/8W 100ppm	4822 051 10689	
R54b	Resistor 68 Ω 1% 1/8W 100ppm	4822 051 10689	
R55	Resistor 47 kΩ 1% 1/8W 100ppm	5322 116 80446	
R55a	Resistor 68 Ω 1% 1/8W 100ppm	4822 051 10689	
R55b	Resistor 68 Ω 1% 1/8W 100ppm	4822 051 10689	
R56	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R56a	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R56b	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R57	Resistor 15.0kΩ 1% 1/8W 100ppm	5322 116 82261	
R57a	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R57b	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R58	Resistor 33.0kΩ 1% 1/8W 100ppm	4822 051 53303	
R58a	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R58b	Resistor 100 Ω 1% 0.1W 100ppm 0805	5322 117 12497	
R59	Resistor 470 kΩ 1% 1/8W 100ppm	5322 116 80447	
R59a	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R59b	Resistor 100 Ω 1% 0.1W 100ppm 0805	5322 117 12497	
R60	Resistor 680 kΩ 1% 1/8W 100ppm	5322 117 11787	
R60a	Resistor 150 Ω 1% 1/8W 100ppm	4822 051 51501	
R60b	Resistor 150 Ω 1% 1/8W 100ppm	4822 051 51501	
R61	Resistor 47 Ω 1% 1/8W 100ppm	5322 116 80448	
R62	Resistor 56 Ω 1% 1/8W 100ppm	4822 051 10569	
R62a	Resistor 33 Ω 1% 0.1W 100ppm 0805	5322 117 12504	
R62b	Resistor 33 Ω 1% 0.1W 100ppm 0805	5322 117 12504	
R63	Resistor 10.0 Ω 1% 1/8W 100ppm	4822 051 10109	
R63a	Resistor 33 Ω 1% 0.1W 100ppm 0805	5322 117 12504	
R63b	Resistor 33 Ω 1% 0.1W 100ppm 0805	5322 117 12504	
R64	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R65	Resistor 270 Ω 1% 1/8W 100ppm	4822 051 10271	
R66	Resistor 33.0kΩ 1% 1/8W 100ppm	4822 051 53303	
R67	Resistor 33.0 Ω 1% 1/8W 100ppm	4822 051 10339	

Item	Description	Ordering code	☆
R120	Resistor 180 kΩ 1% 1/8W 100ppm	4822 051 51804	
R121	Resistor 6.80kΩ 1% 1/8W 100ppm	4822 051 10682	
R122	Resistor 6.80kΩ 1% 1/8W 100ppm	4822 051 10682	
R123	Resistor 10.0 Ω 1% 1/8W 100ppm	4822 051 10109	
R124	Resistor 10.0 Ω 1% 1/8W 100ppm	4822 051 10109	
R125	Resistor 5.60kΩ 1% 1/8W 100ppm	4822 051 10562	
R126	Resistor 5.60kΩ 1% 1/8W 100ppm	4822 051 10562	
R127	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R128	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R136	Resistor 120 kΩ 1% 1/8W 100ppm	4822 051 51204	
R140	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R141	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R143	Resistor 0 Ω Jumper RC-01	4822 051 10008	
R144	Resistor 0 Ω Jumper RC-01	4822 051 10008	
R145	Resistor 0 Ω Jumper RC-01	4822 051 10008	
R146	Resistor 56.0kΩ 1% 1/8W 100ppm	5322 117 10971	
R147	Resistor 2.20kΩ 1% 1/8W 100ppm	4822 051 52202	
R148	Resistor 680 kΩ 1% 1/8W 100ppm	5322 117 11787	
R149	Resistor 0.22Ω 5% 1/8W LRC01 3.2x1.6	5322 117 11786	R
R150	Resistor 0.22Ω 5% 1/8W LRC01 3.2x1.6	5322 117 11786	R
R151	Resistor 2.20kΩ 1% 1/8W 100ppm	4822 051 52202	
R152	Resistor 56.0kΩ 1% 1/8W 100ppm	5322 117 10971	
R153	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R154	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R155	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R156	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R157	Resistor 1.00mΩ 1% 1/8W 100ppm	4822 051 10105	
R160	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R162	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R164	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R165	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R166	Resistor 100 Ω 1% 1/8W 100ppm	4822 051 51001	
R170	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R171	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R172	Resistor 150 kΩ 1% 1/8W 100ppm	4822 051 51504	
R181	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R186	Resistor 10.0kΩ 1% 1/8W 100ppm	4822 051 51003	
R191	Resistor 680 kΩ 1% 1/8W 100ppm	5322 117 11787	
R192	Resistor 1.00kΩ 1% 1/8W 100ppm	4822 051 51002	
R194	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R195	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R196	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R197	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R198	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	
R199	Resistor 100kΩ 1% 1/8W 100ppm	4822 051 51004	

Item	Description	Ordering code	☆
V5b	Transistor BFR93 35mA12V SOT23	5322 130 44801	
V6a	Transistor BFT93 35mA12V SOT23	5322 130 44824	
V6b	Transistor BFT93 35mA12V SOT23	5322 130 44824	
V7	Transistor 0.5A BC807-25 45V SOT23	5322 130 60845	
V7a	Transistor-Sw P PMBTH81 SOT23	5322 130 63822	
V7b	Transistor-Sw P PMBTH81 SOT23	5322 130 63822	
V8a	Transistor BFR31 .01A 25V SOT23	5322 130 44787	
V8b	Transistor BFR31 .01A 25V SOT23	5322 130 44787	
V9	Transistor 0.5A BC807-25 45V SOT23	5322 130 60845	
V10	Transistor 0.5A BC807-25 45V SOT23	5322 130 60845	
V11	Transistor 0.5A BC807-25 45V SOT23	5322 130 60845	
V12	Transistor 0.5A BC817-25 45V SOT23	4822 130 42804	
V13	Transistor 0.5A BC817-25 45V SOT23	4822 130 42804	
V14	Transistor 0.5A BC817-25 45V SOT23	4822 130 42804	
V15	Transistor 0.5A BC817-25 45V SOT23	4822 130 42804	
V16	Transistor 0.5A BC807-25 45V SOT23	5322 130 60845	
V18	Transistor-Pow N MOSFET BUZ11A SMD	5322 130 62654	R
V19	Transistor-Pow N MOSFET BUZ11A SMD	5322 130 62654	R
V20	Transistor-Pow N MOSFET BUZ11A SMD	5322 130 62654	R
V21	Thyristor BRY62 SMD SOT143	5322 130 62661	R
V24	Transistor BC857B .1A45V SOT23	5322 130 60508	
V25	Transistor BC857B .1A45V SOT23	5322 130 60508	
V27	Transistor BC857B .1A45V SOT23	5322 130 60508	
V28	Transistor 0.5A BC817-25 45V SOT23	4822 130 42804	
V30	Transistor BC847B .1A45V SOT23	4822 130 60511	
V33	Transistor 0.5A BC807-25 45V SOT23	5322 130 60845	
V34	Transistor-FET SMD MOS SI4435DY SO8	5322 130 10679	

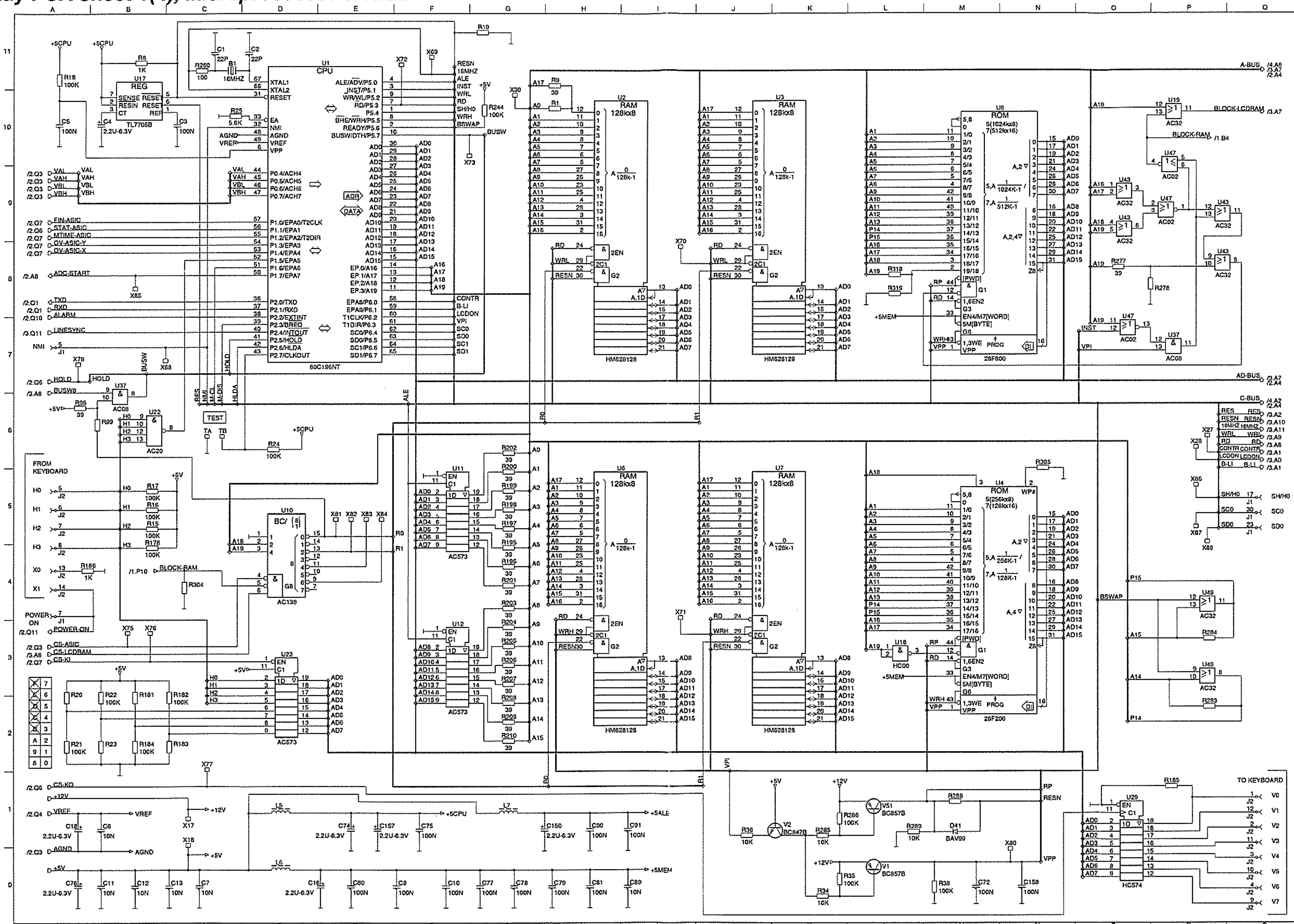
Item	Description	Part Number	☆
5	IC-ADC 8bit SO20 ADC0820CNED	5322 209 14861	R
6	IC-CMOS PC74HC541T SMD SO20	4822 209 63763	
V1	Transistor BFT92 25mA15V SOT23	5322 130 44711	
V2	Transistor BFS17 0.05A 15V SOT23	5322 130 40781	
V3	Transistor BFT92 25mA15V SOT23	5322 130 44711	
V4	Transistor BFS17 0.05A 15V SOT23	5322 130 40781	
Z1	IC PC74HC00T SO14	5322 209 71802	
Z5	IC PC74HC00T SO14	5322 209 71802	

Item	Description	Ordering code	☆
C31	Capacitor 1pF 5% 50V NP0	5322 122 32447	
C32	Capacitor 3.3pF 5% 50V NP0	5322 122 32286	
C34	Capacitor 3.3pF 5% 50V NP0	5322 122 32286	
C35	Capacitor 22pF 5% 50V NP0	5322 122 32658	
C36	Capacitor 10nF 20% 50V X7R	5322 122 34098	
C38	Capacitor 10nF 20% 50V X7R	5322 122 34098	
C39	Capacitor 1nF 20% 50V X7R	5322 122 34123	
C40	Capacitor 1nF 20% 50V X7R	5322 122 34123	
C42	Capacitor 10nF 20% 50V X7R	5322 122 34098	
C43	Capacitor 10nF 20% 50V X7R	5322 122 34098	
C46	Capacitor 10nF 20% 50V X7R	5322 122 34098	
C47	Capacitor 10nF 20% 50V X7R	5322 122 34098	
C49	Capacitor 10nF 20% 50V X7R	5322 122 34098	
C50	Capacitor 10nF 20% 50V X7R	5322 122 34098	
C51	Capacitor 2.2pF 5% 50V NP0	5322 122 33063	
D1	Diode 0.03A BAT17SOT23	5322 130 31544	
D2	Diode 0.03A BAT17SOT23	5322 130 31544	
D3	Diode BAR16-1 SOT23	5322 130 80246	
D5	Diode 0.03A BAT17SOT23	5322 130 31544	
D6	Diode 0.03A BAT17SOT23	5322 130 31544	
D7	Diode 0.03A BAT17SOT23	5322 130 31544	
D8	Diode 0.10A BAV99SOT23	5322 130 34337	
D9	Diode 0.03A BAT17SOT23	5322 130 31544	
D10	Diode 0.03A BAT17SOT23	5322 130 31544	
D11	Diode 0.10A BAV99SOT23	5322 130 34337	
D12	Diode 0.10A BAV99SOT23	5322 130 34337	
D13	Diode 0.10A BAV99SOT23	5322 130 34337	
J1	Connector-Coax 31-5329-52RFX	5322 265 10297	
J2	Connector Socket 16 Pole 70182 1 5-44-3716	5322 267 70355	
L1	Choke 0.10 µH 10% MLF3216DR10K	5322 157 52986	
L7	Choke 0.10 µH 10% MLF3216DR10K	5322 157 52986	
L8	Choke 0.10 µH 10% MLF3216DR10K	5322 157 52986	
L9	Choke 0.10 µH 10% MLF3216DR10K	5322 157 52986	
L10	Choke 31 Ω CB50-321611T	5322 157 61919	
L12	Choke 31 Ω CB50-321611T	5322 157 61919	
R1	Resistor 470 Ω 1% 1/8W 100ppm	4822 051 54701	
R2	Resistor 470 Ω 1% 1/8W 100ppm	4822 051 54701	
R3	Resistor 470 Ω 1% 1/8W 100ppm	4822 051 54701	
R4	Resistor 22 Ω 1%1/8W 100ppm	4822 051 10229	
R5	Resistor 22 Ω 1% 1/8W 100ppm	4822 051 10229	
R6	Resistor 22 Ω 1% 1/8W 100ppm	4822 051 10229	
R7	Resistor 22 Ω 1% 1/8W 100ppm	4822 051 10229	
R8	Resistor 22 Ω 1% 1/8W 100ppm	4822 051 10229	
R9	Resistor 22 Ω 1% 1/8W 100ppm	4822 051 10229	
R10	Resistor 270 Ω 1% 1/8W 100ppm	4822 051 10271	

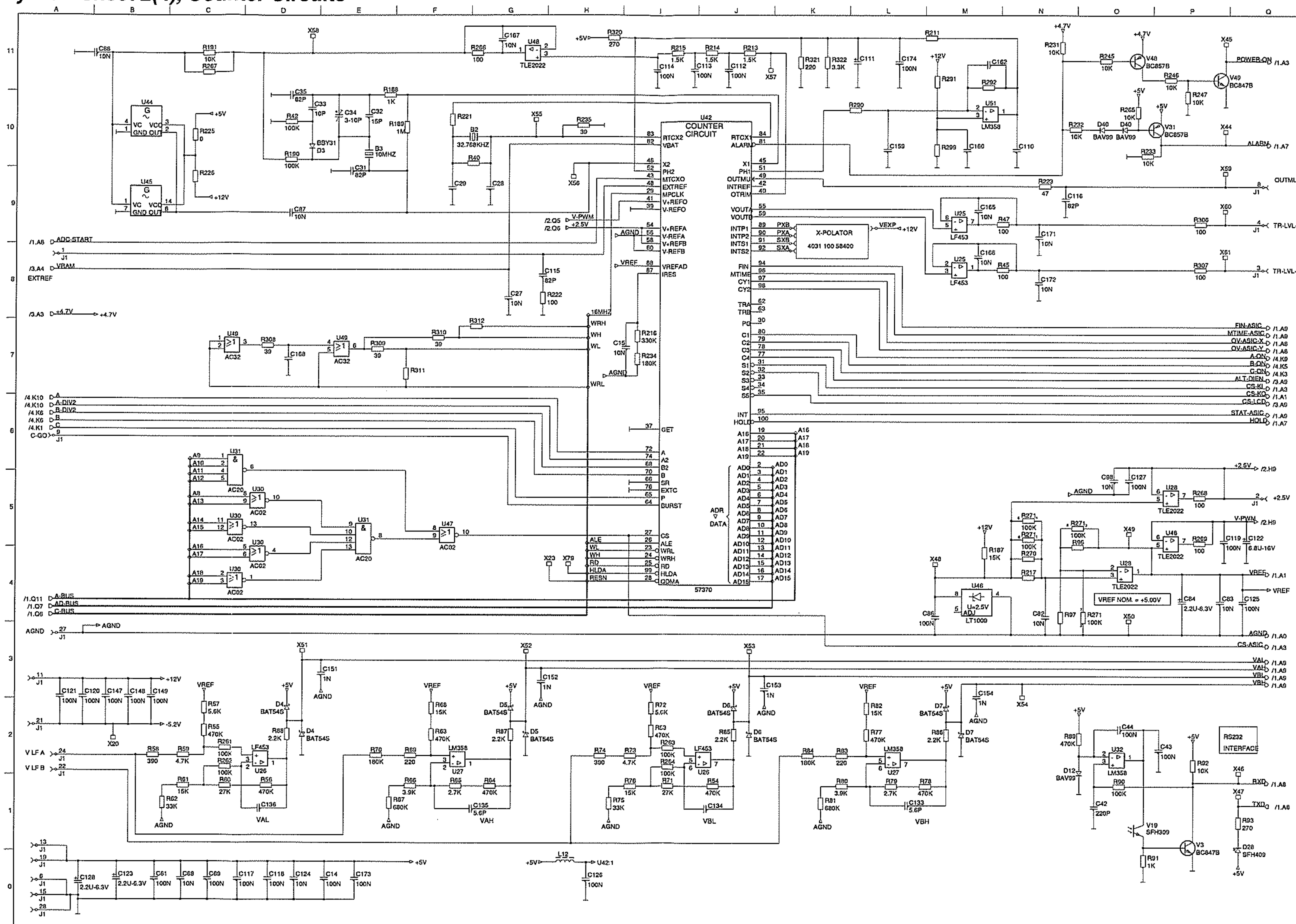
Item	Description	Ordering code	☆
U3	IC NE532D Dual OP-AMP SO-8	5322 209 71553	
V1	Transistor BFQ67SOT23	5322 130 42567	
V2	Transistor BFQ67SOT23	5322 130 42567	
V3	Transistor BC847B .1A45V SOT23	4822 130 60511	
V4	Transistor BC847B .1A45V SOT23	4822 130 60511	
V5	Transistor BFT92 25mA15V SOT23	5322 130 44711	
V6	Transistor BFT92 25mA15V SOT23	5322 130 44711	
V7	Transistor 0.5A BC807-25 45VSOT23	5322 130 60845	
V8	Transistor BFS17 0.05A 15V SOT23	5322 130 40781	
V9	Transistor BFS17 0.05A 15V SOT23	5322 130 40781	
V10	Transistor BFS17 0.05A 15V SOT23	5322 130 40781	
V11	Transistor BFS17 0.05A 15V SOT23	5322 130 40781	

Chapter 9
Circuit Diagrams

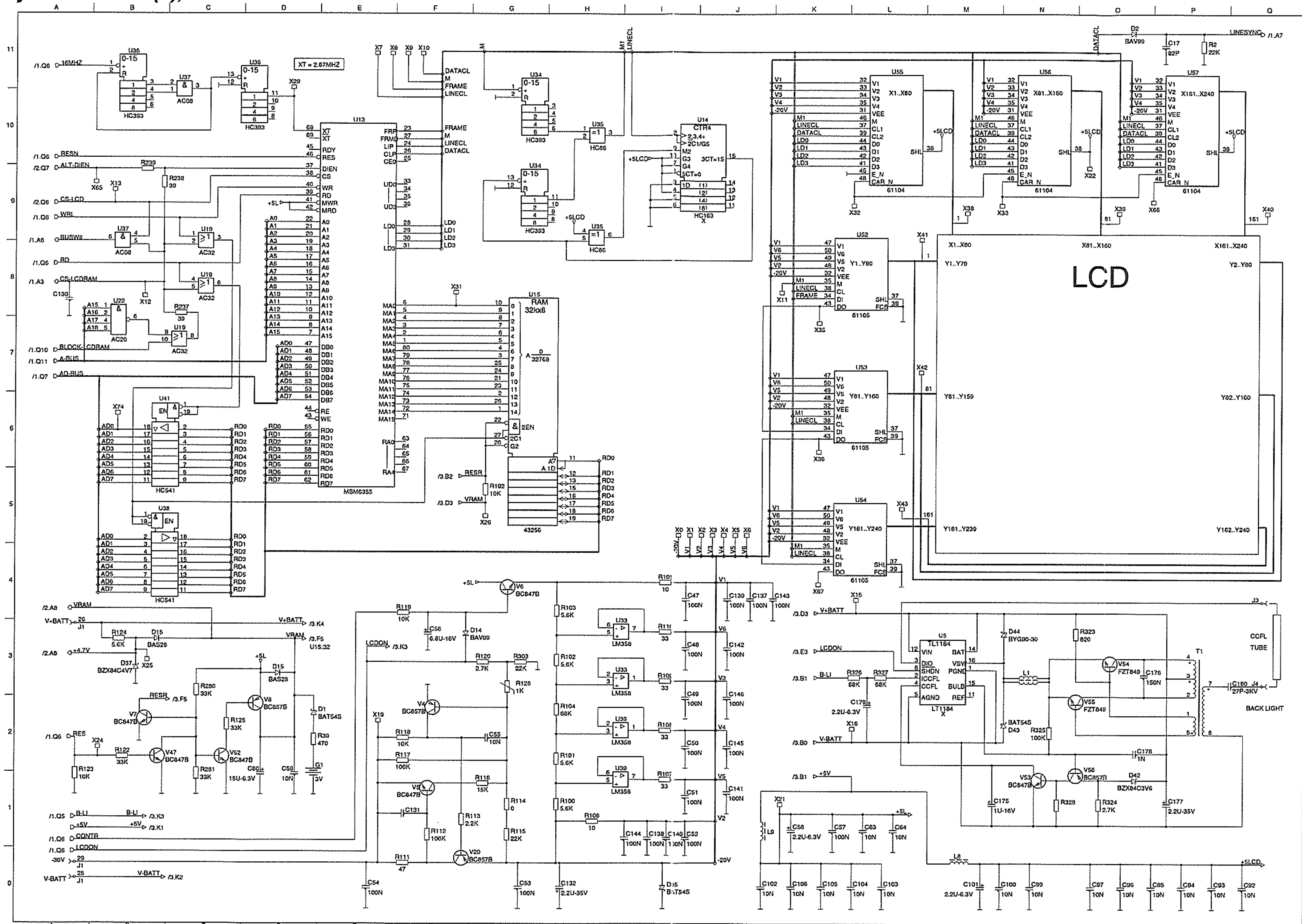
Display PCA sheet 1(4), Microprocessor & RAM



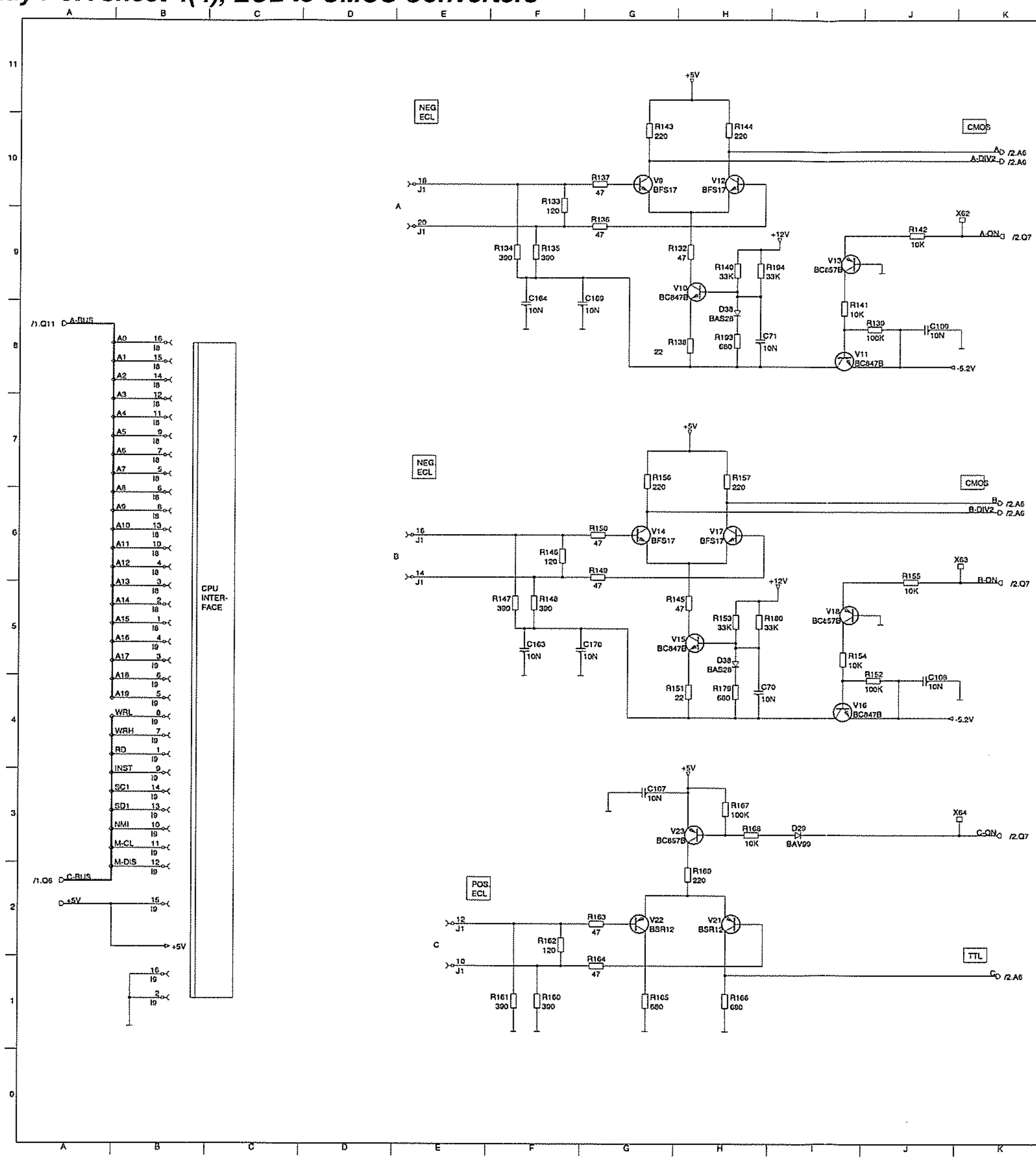
Display PCA sheet 2(4), Counter Circuits



Display PCA sheet 3(4), LCD Circuits



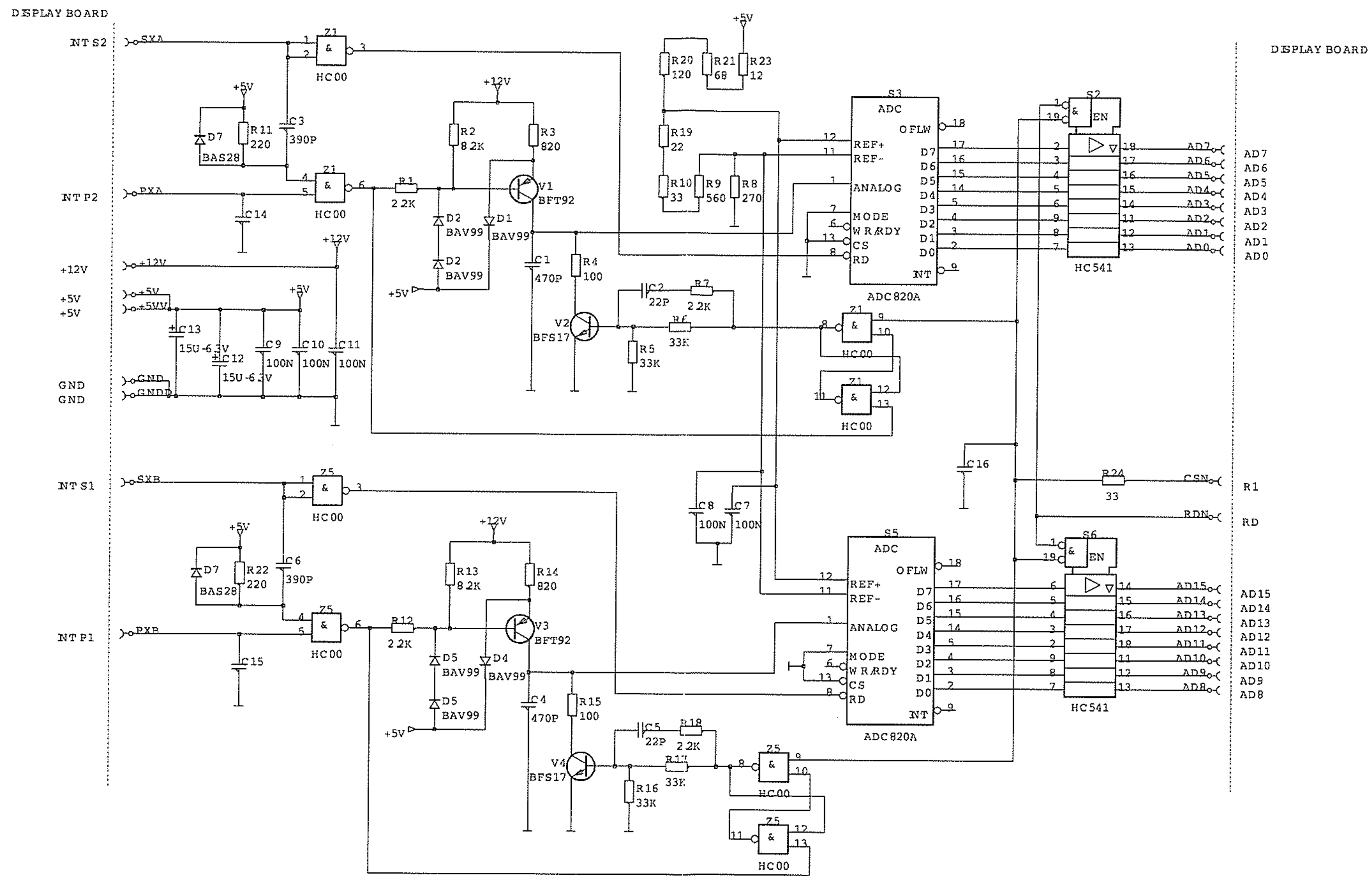
Display PCA sheet 4(4), ECL to CMOS Converters



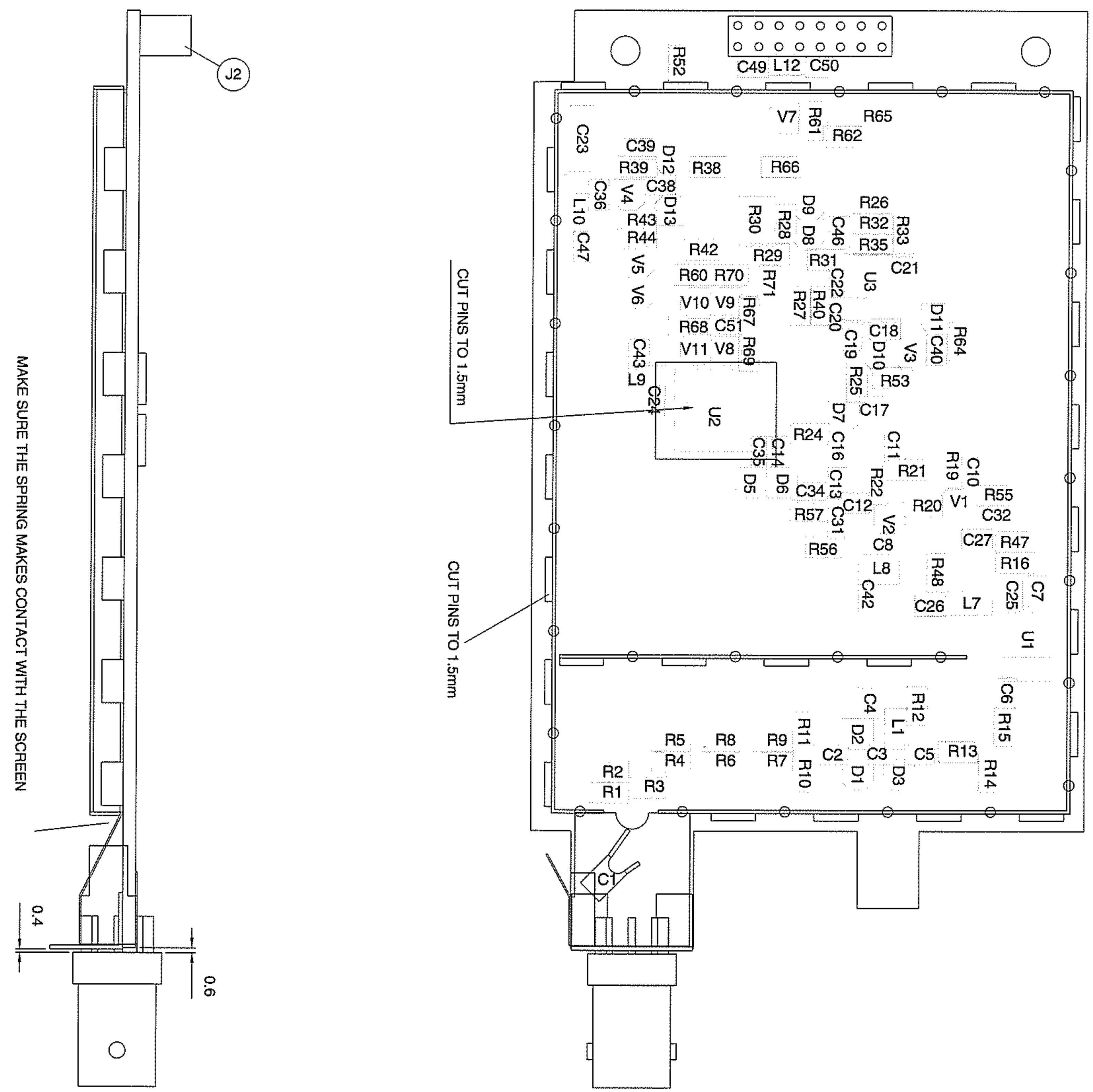
VOLTAGE DISTRIBUTION						
IC	TYPE	+12V	+5..	GND	-5.2V	SPECIAL
U1	80C196NT		35	5,34,68		
U2,U3	HM628128		32	16		
U4	28F200		23	13,32		
U6,U7	HM628128		32	16		
U8	28F800		23	13, 32		
U10	AC138		16	8		
U11,U12	AC573		20	10		
U13	MSM6355		32	70		
U14	HC163		16	8		
U15	43256			14		VRAM P 28
U17	TL7705B		8	4		
U18	HC00		14	7		
U19	AC32		14	7		
U22	AC20		14	7		
U23	AC573		20	10		
U25	LF453	8			4	
U26	LF453	8			4	
U27	LM358	8			4	
U28	TLE2022	8			4	
U29	HC574		20	10		
U30	AC02		14	7		
U31	AC20		14	4		
U32	LM358		8	4		
U33	LM358		8			-20V P 4
U34	HC393		14	7		
U35	HC86		14	7		
U36	HC393		14	7		
U37	AC08		14	7		
U38	HC541		20	10		
U39	LM358		8			-20V P 4
U41	HC541		20	10		
U42	57370(ASIC)		36,47,50 57,71,85,93	18,38,44 53,61,67 69,73,75,86		U42:1 P 1
U43	AC32		14	7		
U47	AC02		14	7		
U48	TLE2022	8			4	
U49	AC32		14	7		
U51	LM358(DUMMY)	8			4	
U52,U53	61105		44	41		
U54	61105		44	41		
U55,U56	61104		49	36		
U57	61104		49	36		

Interpolator PCA

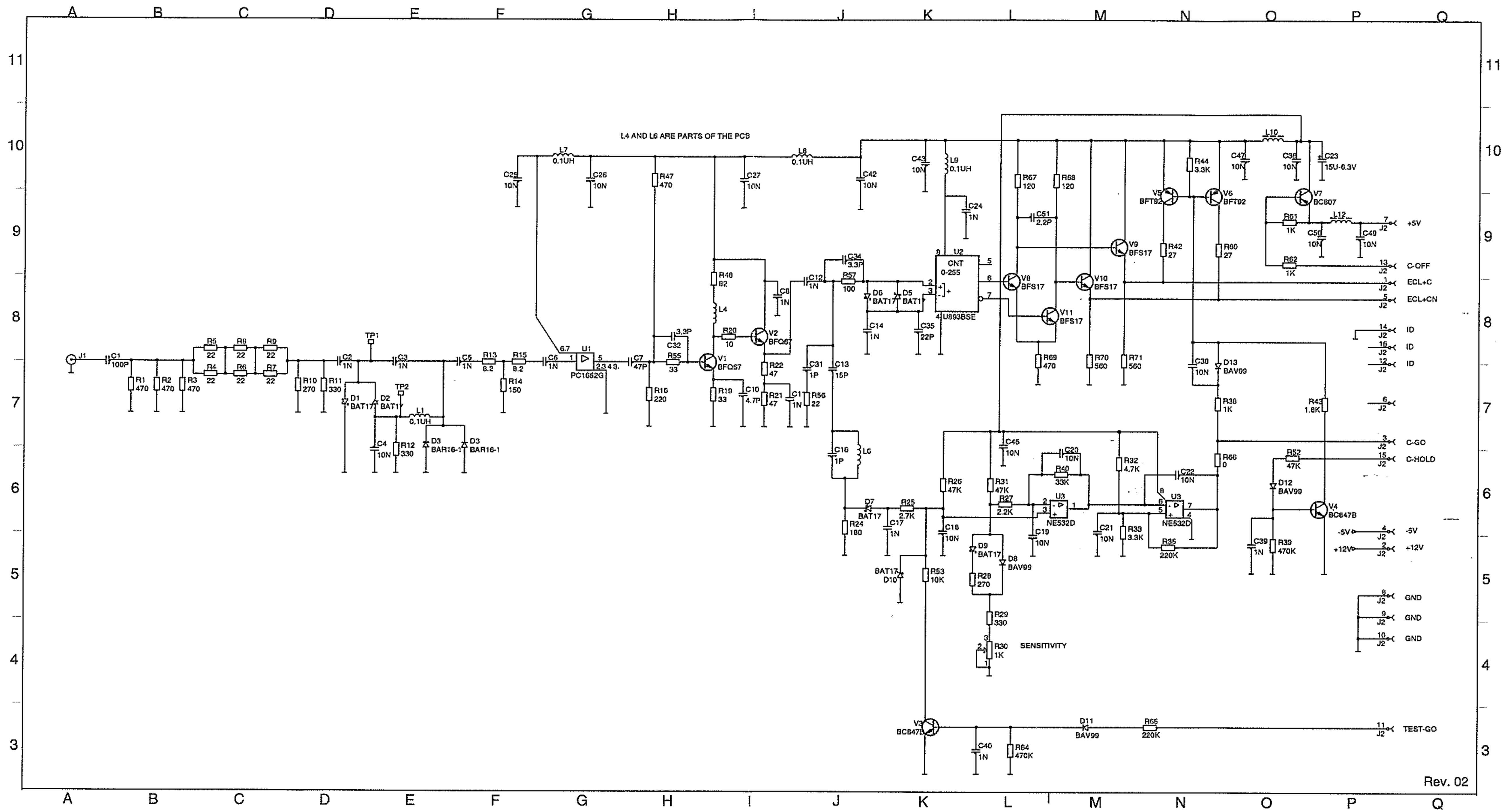
See Component layout on page 9-8



Prescaler PCA (Fitted in 164T and 164H) , Component Layout



Prescaler PCA (Only 164T and 164H)



Introduction

This chapter contains circuit diagrams and component layout information.

Each diagram contains a list of the ICs used. These lists shows connections that are not shown in the diagram, such as GND and supply voltages.

Signals

The signals in the counter are named after what they do, e.g. LEAD-EDGE is used as control current to the leading edge circuits.

Two different types of arrows are used to mark references for continued connection somewhere else in the diagram.

This arrow is used if the reference is directed to a point located on the same page.

This arrow is used if the reference is directed to a point located on another page. The example means that the point is on sheet 1, coordinate A1.

Circuit Symbols

The diagrams are computer drawn. The symbols conform to IEC standards. These symbols are designed to be logical and easy to read.

The component number is written above the symbol.

Inside the symbol at the top is an abbreviated description of the circuit's function.

Pin numbers are written outside the symbol and, if the circuit is complex, the pin functions are written inside.

A small circle on a pin indicates that the input/output inverts the signal.

The component name is written below the symbol.

The signal flow through the circuit is always from left to right.

Resistors, Capacitors, Diodes, Transistors and Other Components.

These components are similar to the old-fashioned, hand-drawn symbols. They have their component number above and their value or component name below.

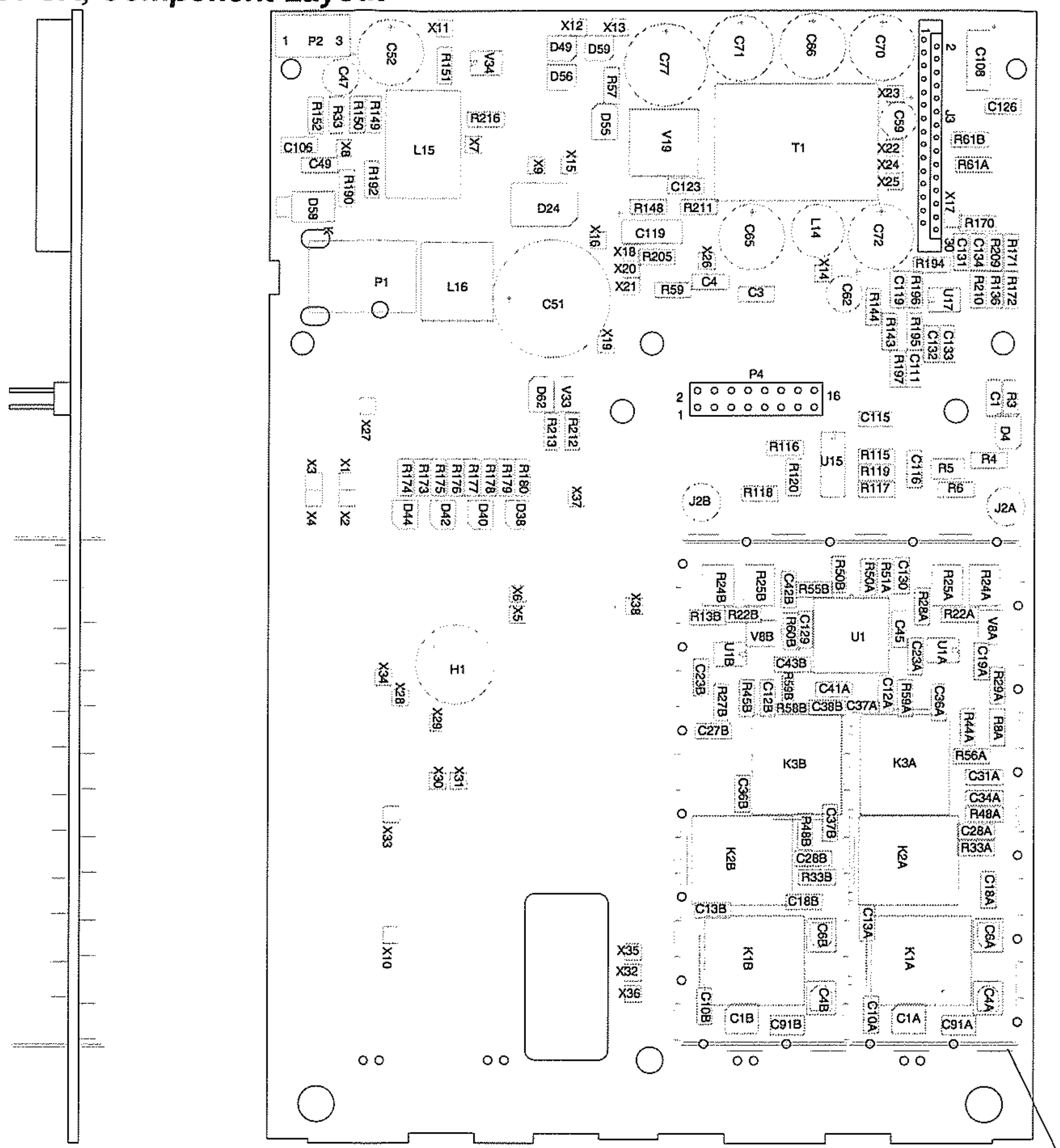
A resistor contained in a resistor network has a frame drawn around it and one of the pin numbers is written to the left or below it.

Component Numbers

Table 9-1. Components are identified by a letter and a sequential number

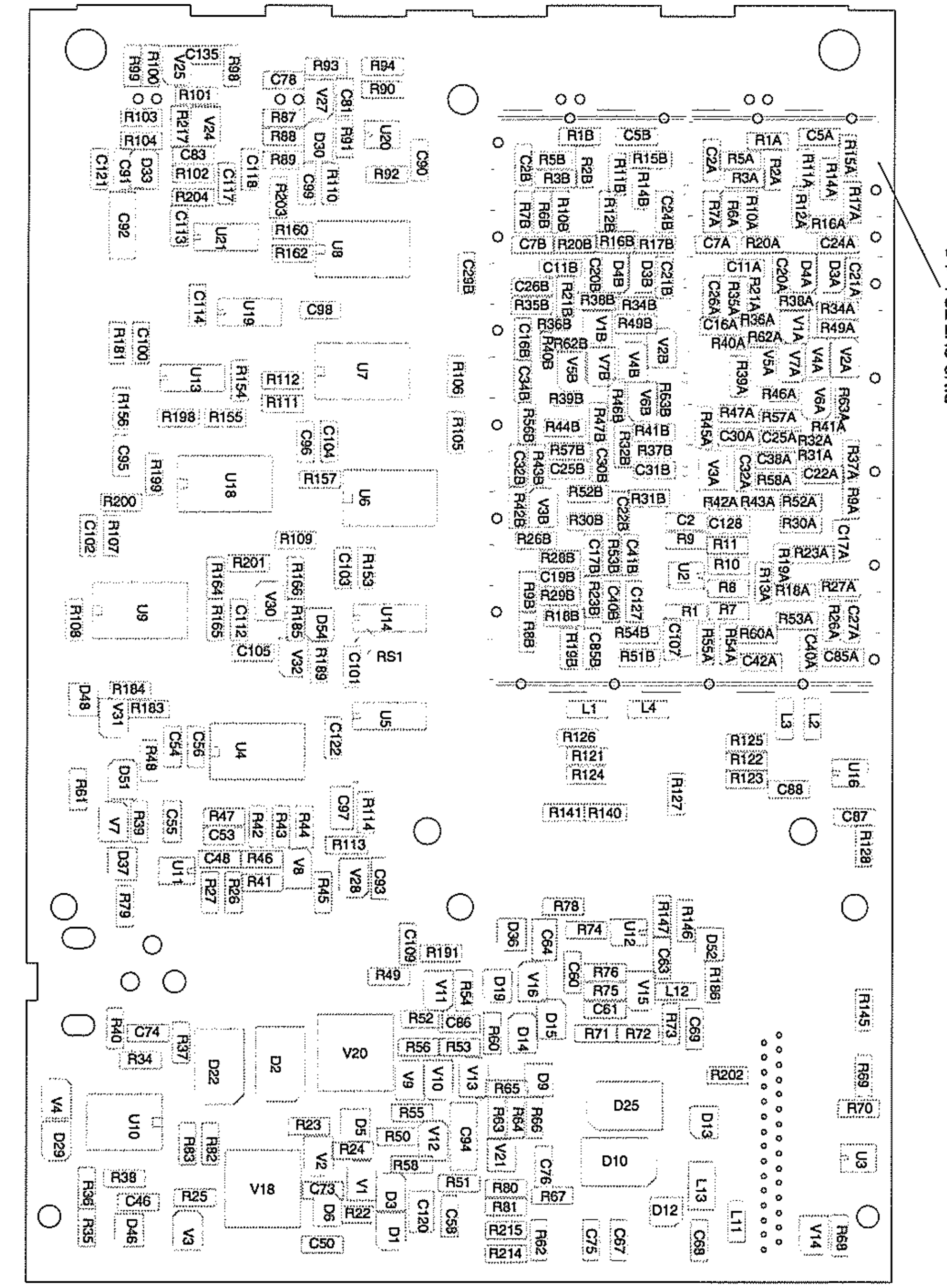
Letters	Components	Letters	Components
B	Crystals and crystal filters	L	Coils
C	Capacitors	P	Connectors
D	Diodes	R	Resistors
F	Fuses	U	IC;s
G	Batteries	V	Transistors
J	Jumpers and connectors	X	Test points
K	Relays		

Input PCA, Component Layout



COMPONENT LAYOUT TOP SIDE, INPUT BOARD

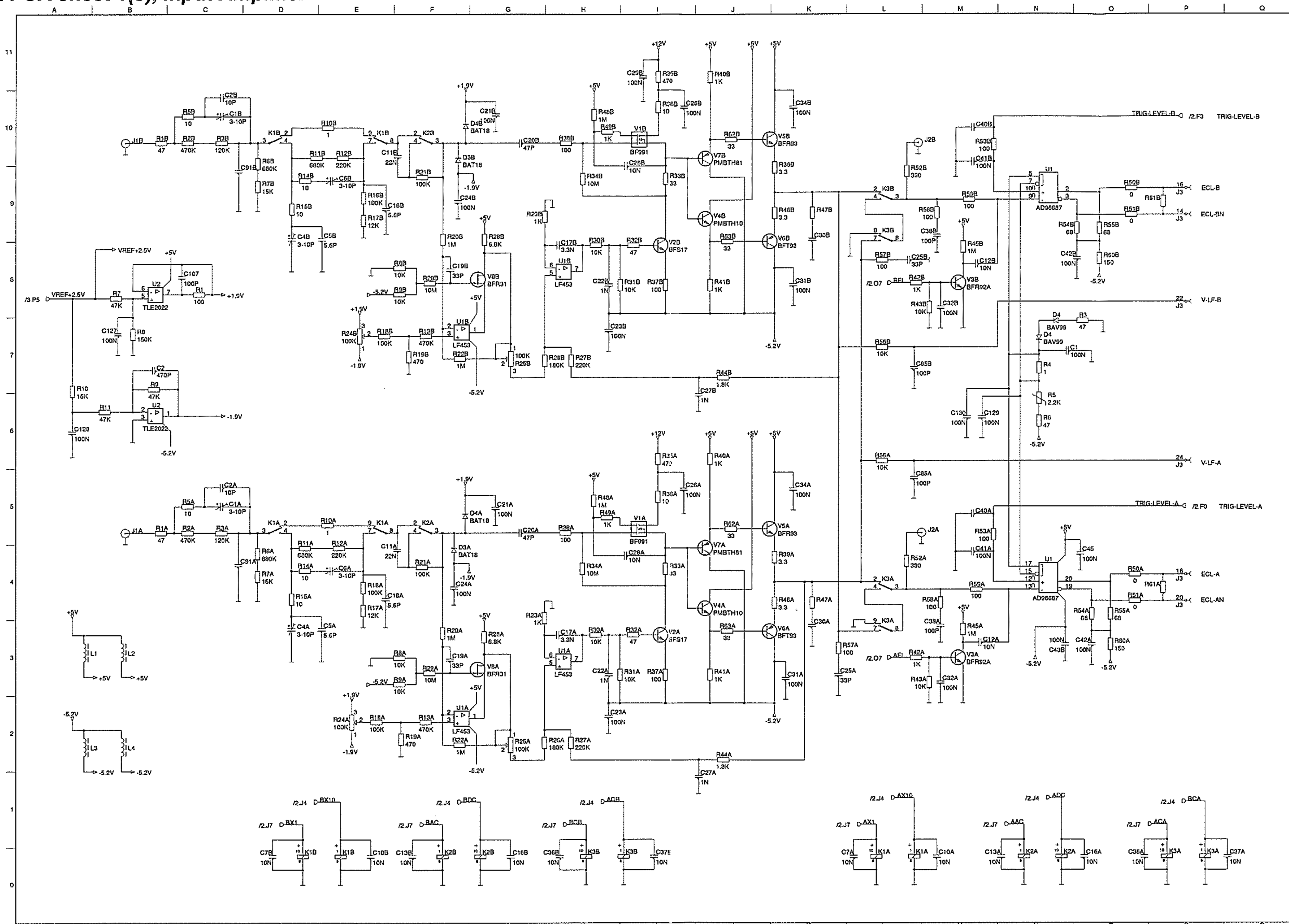
PINS CUT TO L=1.5mm



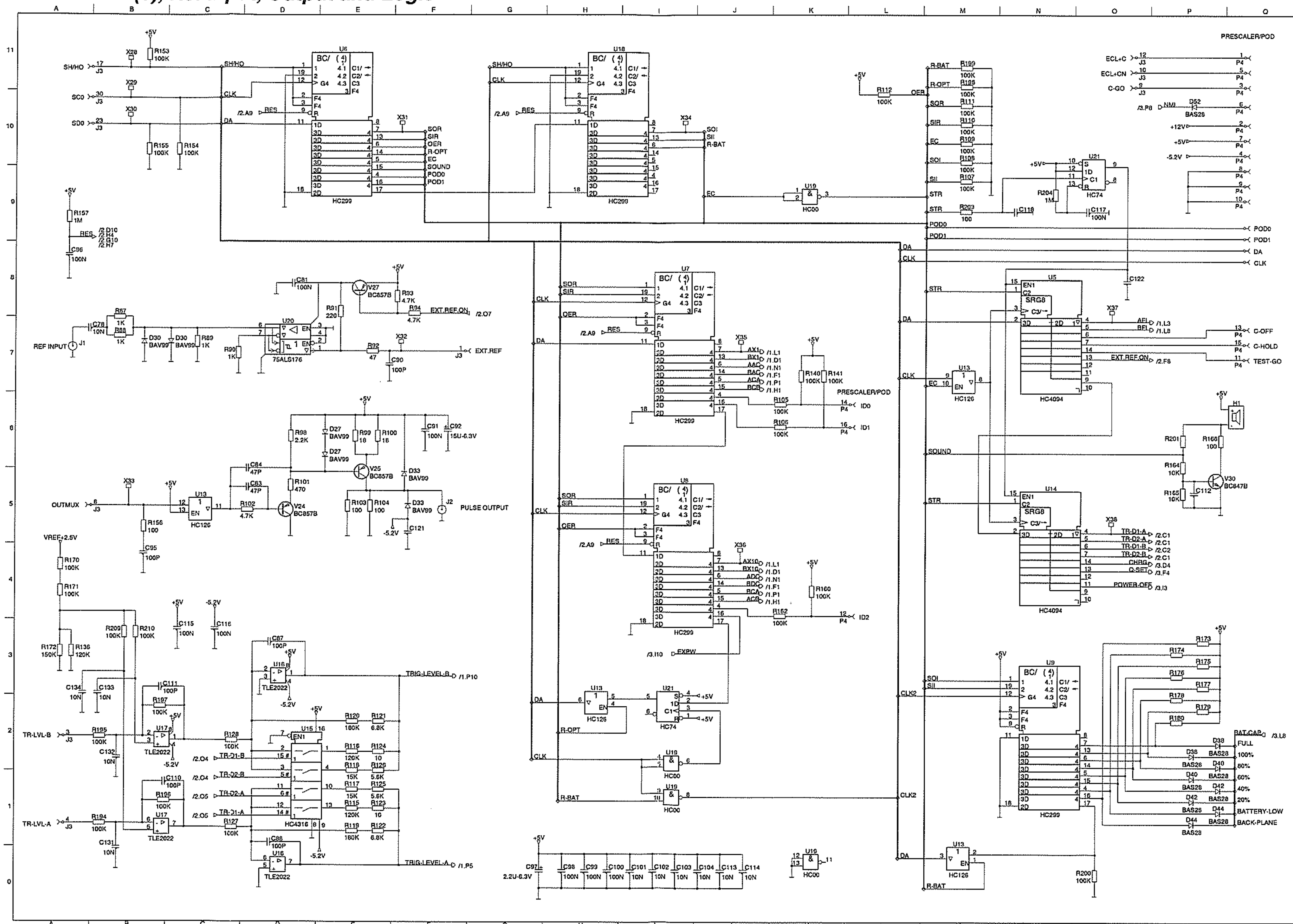
COMPONENT LAYOUT BOTTOM-SIDE, INPUT BOARD

D6 IS SOLDERED BETWEEN R22 AND THE CATHODE (WIDER PIN) OF C73

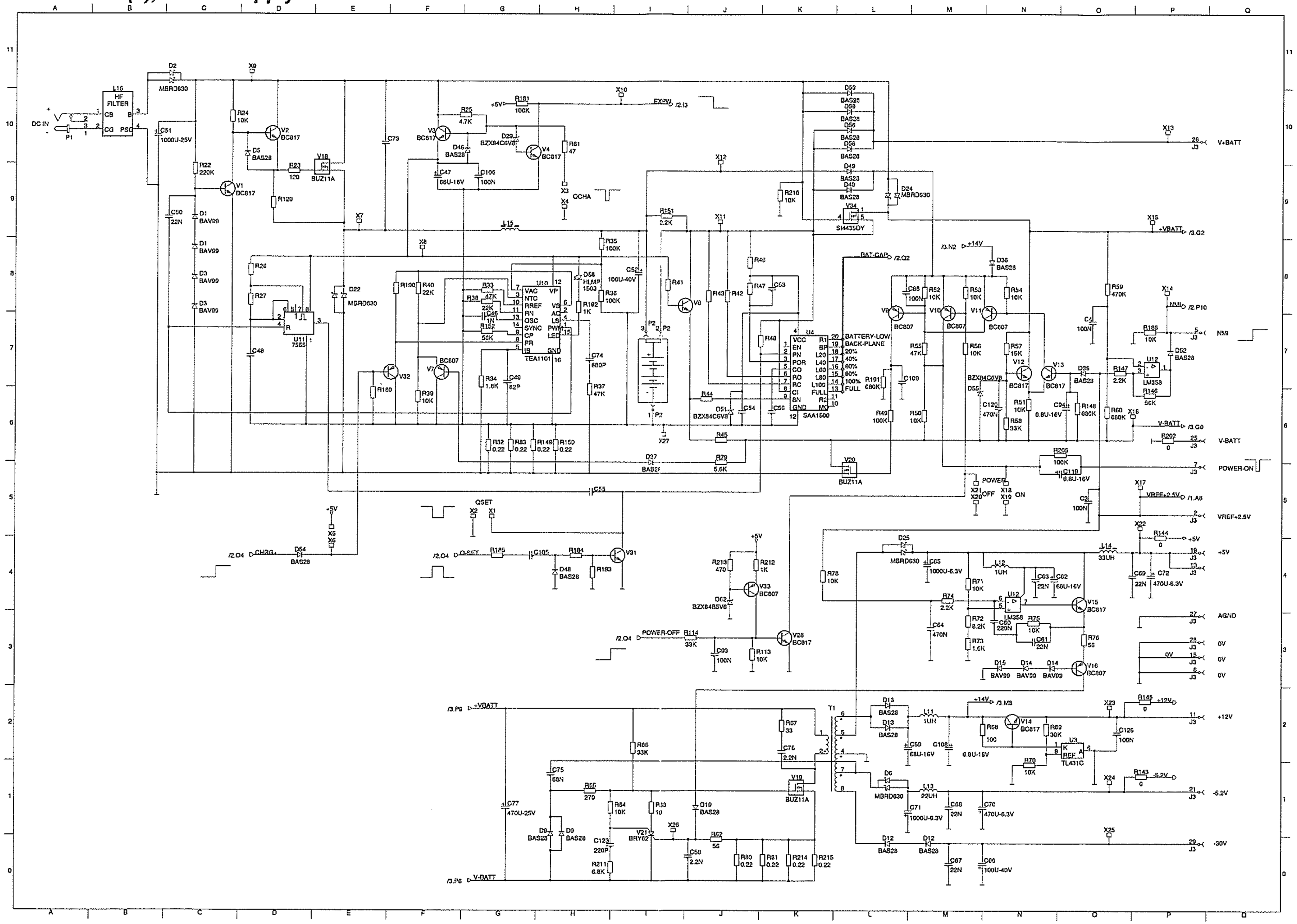
Input PCA sheet 1(3), Input Amplifier



Input PCA sheet 2(3), Ref Input, Output and Logic



Input PCA sheet 3(3), Power Supply



Display PCA, Component Layout