WAVETEK

MAINTENANCE MANUAL

Model 39A

40MHz Arbitrary Waveform Generator

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Specifications

Note: This specification covers the whole series which includes 2- and 4- channel instruments; the interchannel specifications only apply to the multi-channel instruments.

Specifications apply at 18–28ºC after 30 minutes warm–up, at maximum output into 50Ω

WAVEFORMS

Standard Waveforms

Sine, square, triangle, DC, positive ramp, negative ramp, sin(x)/x, pulse, pulse train, cosine, haversine and havercosine.

Sine, Cosine, Haversine, Havercosine

Range:	0.1mHz to 16 MHz
Resolution:	0.1mHz or 7 digits
Accuracy:	10 ppm for 1 year
Temperature Stability:	Typically <1 ppm/ºC.
Output Level:	2.5mV to 10Vp–p into 50Ω
Harmonic Distortion:	<0.1% THD to 100kHz; <–65dBc to 20kHz
	<–50dBc to 1MHz,
	<–35dBc to 10MHz
	<–30dBc to 16MHz
Non–harmonic Spurii:	<–65dBc to 1MHz, <–65dBc + 6dB/octave 1MHz to 16MHz

Square

Range:	1mHz to 16MHz
Resolution:	1mHz (4 digits)
Accuracy:	± 1 digit of setting
Output Level:	2.5mV to 10Vp–p into 50Ω
Rise and Fall Times:	<25ns

Triangle

Range:	0.1mHz to 100kHz
Resolution:	0.1mHz or 7 digits
Accuracy:	10 ppm for 1 year
Output Level:	2.5mV to 10Vp–p into 50Ω
Linearity Error:	<0.1% to 30 kHz

Ramps and Sin(x)/x

Range:	0.1mHz to 100kHz
Resolution:	0.1mHz (7 digits)
Accuracy:	10 ppm for 1 year
Output Level:	2.5mV to 10Vp–p into 50Ω
Linearity Error:	<0.1% to 30 kHz

Pulse and Pulse Train

Output Level:	2.5mV to 10Vp–p into 50Ω
Rise and Fall Times:	<25ns
Period:	
Range:	100ns to 100s
Resolution:	4-digit
Accuracy:	±1 digit of setting
Delay:	
Range:	–99.99s to +99.99s
Resolution:	0.002% of period or 25ns, whichever is greater
Width:	
Range:	25ns to 99.99s
Resolution:	0.002% of period or 25ns, whichever is greater

Note that the pulse width and absolute value of the delay may not exceed the pulse period at any time.

Pulse trains of up to 10 pulses may be specified, each pulse having independently defined width, delay and level. The baseline voltage is separately defined and the sequence repetition rate is set by the pulse train period.

Arbitrary

Up to 100 user defined waveforms may be stored in the 256K point non–volatile RAM. Waveforms can be defined by front panel editing controls or by downloading of waveform data via RS232 or GPIB.

Waveform Memory Size:	64k points per channel. Maximum waveform size is 64k points, minimum waveform size is 4 points
Vertical Resolution:	12 bits
Sample Clock Range:	100mHz to 40MHz
Resolution:	4 digits
Accuracy:	± 1 digit of setting

Sequence

Up to 16 waveforms may be linked. Each waveform can have a loop count of up to 32,768.

A sequence of waveforms can be looped up to 1,048,575 times or run continuously.

Output Filter

Selectable between 16MHz Elliptic, 10MHz Elliptic, 10MHz Bessel or none.

OPERATING MODES

Triggered Burst

Each active edge of the trigger signal will produce one burst of the waveform.

Carrier Waveforms:	All standard and arbitrary
Maximum Carrier Frequency:	The smaller of 1MHz or the maximum for the selected waveform. 40Msamples/s for ARB and Sequence.
Number of Cycles:	1 to 1,048,575
Trigger Repetition Rate:	0.005Hz to 100kHz internal dc to 1MHz external.
Trigger Signal Source:	Internal from keyboard, previous channel, next channel or trigger generator.
	External from TRIG IN or remote interface.
Trigger Start/Stop Phase:	± 360° settable with 0.1° resolution, subject to waveform frequency and type.

Gated

Waveform will run while the Gate signal is true and stop while false.

Carrier Waveforms:	All standard and arbitrary.
Maximum Carrier Frequency:	The smaller of 1MHz or the maximum for the selected waveform. 40Msamples/s for ARB and Sequence.
Trigger Repetition Rate:	0.005Hz to 100kHz internal dc to 1MHz external.
Gate Signal Source:	Internal from keyboard, previous channel, next channel or trigger generator.
	External from TRIG IN or remote interface.
Gate Start/Stop Phase:	± 360° settable with 0.1° resolution, subject to waveform frequency and type.

Sweep

Frequency sweep capability is provided for both standard and arbitrary waveforms. Arbitrary waveforms are expanded or condensed to exactly 4096 points and DDS techniques are used to perform the sweep.

Carrier Waveforms:	All standard and arbitrary except pulse, pulse train and sequence.
Sweep Mode:	Linear or logarithmic, triggered or continuous.
Sweep Direction:	Up, down, up/down or down/up.
Sweep Range:	From 1mHz to 16 MHz in one range. Phase continuous. Independent setting of the start and stop frequency.
Sweep Time:	30ms to 999s (3 digit resolution).
Marker:	Variable during sweep.
Sweep Trigger Source:	The sweep may be free run or triggered from the following sources: Manually from keyboard. Externally from TRIG IN input or remote interface.
Sweep Hold:	Sweep can be held and restarted by the HOLD key.
Multi channel sweep:	Any number of channels may be swept simultaneously but the sweep parameters will be the same for all channels. Amplitude, Offset and Waveform can be set independently for each channel.

Tone Switching

Capability provided for both standard and arbitrary waveforms. Arbitrary waveforms are expanded or condensed to exactly 4096 points and DDS techniques are used to allow instantaneous frequency switching.

Carrier Waveforms:	All waveforms except pulse, pulse train and sequence.
Frequency List:	Up to 16 frequencies from 1mHz to 10MHz.
Trigger Repetition Rate:	0.005Hz to 100kHz internal dc to 1MHz external.
	Usable repetition rate and waveform frequency depend on the tone switching mode.
Source:	Internal from keyboard, previous channel, next channel or trigger generator.
	External from TRIG IN or remote interface.
Tone Switching Modes:	
Gated:	
	The tone is output while the trigger signal is true and stopped, at the end of the current waveform cycle, while the trigger signal is false. The next tone is output when the trigger signal is true again.
Triggered:	
	The tone is output when the trigger signal goes true and the next tone is output, at the end of the current waveform cycle, when the trigger signal goes true again.
FSK:	The tone is output when the trigger signal goes true and the next tone is output, immediately, when the trigger signal goes true again.

Using 2 channels with their outputs summed together it is possible to generate DTMF test signals.

Trigger Generator

Internal source 0.005 Hz to 100kHz square wave adjustable in 10us steps. 3 digit resolution. Available for external use from any SYNC OUT socket.

OUTPUTS

Main Output - One for each channel

Output Impedance:	50Ω
Amplitude:	5mV to 20Vp–p open circuit (2.5mV to 10Vp–p into 50Ω). Amplitude can be specified open circuit (hi Z) or into an assumed load of 50Ω or 600Ω in Vpk–pk, Vrms or dBm.
Amplitude Accuracy:	2% ±1mV at 1kHz into 50Ω.
Amplitude Flatness:	±0.2dB to 200 kHz; ±1dB to 10 MHz; ±2.5dB to 16 MHz.
DC Offset Range:	±10V.DC offset plus signal peak limited to ±10V from 50Ω.
DC Offset Accuracy:	Typically 3% ±10mV, unattenuated.
Resolution:	3 digits or 1mV for both Amplitude and DC Offset.

Sync Out - One for each channel

Multifunction output user definable or automatically selected to be any of the following:

Waveform Sync:	
(all waveforms)	A square wave with 50% duty cycle at the main waveform frequency, or a pulse coincident with the first few points of an arbitrary waveform.
Position Markers:	
(Arbitrary only)	Any point(s) on the waveform may have associated marker bit(s) set high or low.
Burst Done:	Produces a pulse coincident with the last cycle of a burst.
Sequence Sync:	Produces a pulse coincident with the end of a waveform sequence.
Trigger:	Selects the current trigger signal. Useful for synchronizing burst or gated signals.
Sweep Sync:	Outputs a pulse at the start of sweep to synchronize an oscilloscope or recorder.
Phase Lock Out:	Used to phase lock two generators. Produces a positive edge at the 0° phase point.
Output Signal Level:	TTL/CMOS logic levels from typically 50Ω.

Cursor/Marker Out

Adjustable output pulse for use as a marker in sweep mode or as a cursor in arbitrary waveform editing mode. Can be used to modulate the Z–axis of an oscilloscope or be displayed on a second ‘scope channel.

Output Signal Level:	Adjustable from nominally 2V to 14V, normal or inverted; adjustable width as a cursor.
Output Impedance:	600Ω typical

INPUTS

Trig In

Frequency Range:	DC – 1MHz.
Signal Range:	Threshold nominally TTL level; maximum input ±10V.
Minimum Pulse Width:	50ns, for Trigger and Gate modes; 50us for Sweep mode.
Polarity:	Selectable as high/rising edge or low/falling edge.
Input Impedance:	10kΩ

Modulation In

Frequency Range:	DC – 100kHz.
Signal Range:	VCA: Approximately 1V pk–pk for 100% level change at maximum output. SCM: Approximately ± 1Vpk for maximum output.
Input Impedance:	Typically 1 kΩ.

Sum In

Frequency Range:	DC – 8 MHz.
Signal Range:	Approximately 2 Vpk–pk input for 20Vpk–pk output.
Input Impedance:	Typically 1kΩ.

Hold

Holds an arbitrary waveform at its current position. A TTL low level or switch closure causes the waveform to stop at the current position and wait until a TTL high level or switch opening which allows the waveform to continue. The front panel MAN HOLD key or remote command may also be used to control the Hold function. While held the front panel MAN TRIG key or remote command may be used to return the waveform to the start. The Hold input may be enabled independently for each channel.

Input Impedance:	10kΩ

Ref Clock In/Out

Set to Input:	Input for an external 10MHz reference clock. TTL/CMOS threshold level.
Set to Output:	Buffered version of the internal 10MHz clock. Output levels nominally 1V and 4V from 50Ω.
Set to Phase Lock:	Used together with SYNC OUT on a master and TRIG IN on a slave to synchronise (phase lock) two separate generators.

INTER-CHANNEL OPERATION

Inter-channel Modulation:

The waveform from any channel may be used to Amplitude Modulate (AM) or Suppressed Carrier Modulate (SCM) the next channel. Alternatively any number of channels may be Modulated (AM or SCM) with the signal at the MODULATION input socket.

Carrier frequency:	Entire range for selected waveform.
Carrier waveforms:	All standard and arbitrary waveforms.
Modulation Types:	
AM:	Double sideband with carrier.
SCM:	Double sideband suppressed carrier.
Modulation source:	Internal from the previous channel.
	External from Modulation input socket.
	The external modulation signal may be applied to any number of channels simultaneously.
Frequency Range:	DC to >100 kHz.
Internal AM:	
Depth:	0% to 105%
Resolution:	1%.
Carrier Suppression (SCM):	> –40dB.
External Modulation Signal Range:	VCA: Approximately 1V pk–pk for 100% level change at maximum output.
SCM:	Approximately ± 1Vpk for maximum output.

Inter-channel Analog Summing:

Waveform Summing sums the waveform from any channel into the next channel.

Alternatively any number of channels may be summed with the signal at the SUM input socket.

Carrier frequency:	Entire range for selected waveform.
Carrier waveforms:	All standard and arbitrary waveforms.
Sum source:	Internal from the previous channel. External from SUM IN socket.
Frequency Range:	DC to >8MHz.
External Signal Range:	Approximately 5Vpk–pk input for 20Vpk–pk output.

Inter-channel Phase locking:

Two or more channels may be phase locked together. Each locked channel may be assigned a phase angle relative to the other locked channels. Arbitrary waveforms and waveform sequences may be phase locked but certain constraints apply to waveform lengths and clock frequency ratios. With one channel assigned as the Master and other channels as Slaves a frequency change on the master will be repeated on each slave thus allowing multi–phase waveforms at the same frequency to be easily generated.

DDS waveforms are those with 7 digits of frequency setting resolution, while Non–DDS waveforms have 4 digits

Phase Resolution:

DDS waveforms:	0.1 degree
Non–DDS waveforms:	0.1 degree or 360 degrees/number of points whichever is the greater.

Phase Error:

All waveforms:	<±10ns

The signals from the REF IN/OUT socket and the SYNC OUT socket can be used to phase lock two instruments where more than 4 channels are required.

Inter-channel Triggering:

Any channel can be triggered by the previous or next channel.

The previous/next connections can be used to ’daisy chain’ a trigger signal from a ‘start’ channel, through a number of channels in the ‘chain’ to an ‘end’ channel. Each channel receives the trigger out signal from the previous (or next) channel, and drives its selected trigger out to the next (or previous) channel. The ‘end’ channel trigger out can be set up to drive the ‘start’ channel, closing the loop.

In this way, complex and versatile inter–channel trigger schemes may be set up. Each channel can have its trigger out and its output waveform set up independently. Trigger out may be selected from Waveform End, Position Markers, Sequence Sync or Burst Done.

Using the scheme above it is possible to create a sequence of up to 64 waveform segments, each channel producing up to 16 segments and all channels being summed to produce the complete waveform at the output of channel 4.

INTERFACES

Full remote control facilities are available through the RS232 or GPIB interfaces.

RS232:	Variable Baud rate, 9600 Baud maximum. 9–pin D–connector.
IEEE–488:	Conforms with IEEE488.1 and IEEE488.2

GENERAL

Display:	20 character x 4 row alphanumeric LCD.
Data Entry:	Keyboard selection of mode, waveform etc.; value entry direct by numeric keys or by rotary control.
Stored Settings:	Up to 9 complete instrument set–ups may be stored and recalled from battery–backed memory. Up to 100 arbitrary waveforms can also be stored independent of the instrument settings.
Size:	3U (130mm) height; 350mm width (2 and 4 channels), 212mm (½–rack) single channel; 335mm long.
Weight:	7.2 kg. (16 lb), 2 and 4 channels; 4.1kg (9lb) 1 channel.
Power:	230V, 115V or 100V nominal 50/60Hz, adjustable internally; operating range ±14% of nominal; 100VA max. for 4 channels, 75VA max. for 2 channel, 40VA max. for 1 channel. Installation Category II.
Operating Range:	+5°C to 40°C, 20–80% RH.
Storage Range:	–20°C to + 60°C.
Environmental:	Indoor use at altitudes up to 2000m, Pollution Degree 2.
Options:	19 inch rack mounting kit.
Safety:	Complies with EN61010–1.
EMC:	Complies with EN50081–1 and EN50082–1.

Safety

This generator is a Safety Class I instrument according to IEC classification and has been designed to meet the requirements of EN61010–1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use). It is an Installation Category II instrument intended for operation from a normal single phase supply.

This instrument has been tested in accordance with EN61010–1 and has been supplied in a safe condition. This instruction manual contains some information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in a safe condition.

This instrument has been designed for indoor use in a Pollution Degree 2 environment in the temperature range 5°C to 40°C, 20% – 80% RH (non–condensing). It may occasionally be subjected to temperatures between +5° and –10°C without degradation of its safety. Do not operate while condensation is present.

Use of this instrument in a manner not specified by these instructions may impair the safety protection provided. Do not operate the instrument outside its rated supply voltages or environmental range.

WARNING! THIS INSTRUMENT MUST BE EARTHED

Any interruption of the mains earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited. The protective action must not be negated by the use of an extension cord without a protective conductor.

When the instrument is connected to its supply, terminals may be live and opening the covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts. The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair.

Any adjustment, maintenance and repair of the opened instrument under voltage shall be avoided as far as possible and, if inevitable, shall be carried out only by a skilled person who is aware of the hazard involved.

If the instrument is clearly defective, has been subject to mechanical damage, excessive moisture or chemical corrosion the safety protection may be impaired and the apparatus should be withdrawn from use and returned for checking and repair.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short–circuiting of fuse holders is prohibited.

This instrument uses a Lithium button cell for non–volatile memory battery back–up; typical life is 5 years. In the event of replacement becoming necessary, replace only with a cell of the correct type, i.e. 3V Li/$Mn0_2$ 20mm button cell type 2032. Exhausted cells must be disposed of carefully in accordance with local regulations; do not cut open, incinerate, expose to temperatures above 60°C or attempt to recharge.

Do not wet the instrument when cleaning it and in particular use only a soft dry cloth to clean the LCD window. The following symbols are used on the instrument and in this manual:–

Caution –refer to the accompanying documentation, incorrect operation may damage the instrument.

terminal connected to chassis ground.

mains supply OFF.

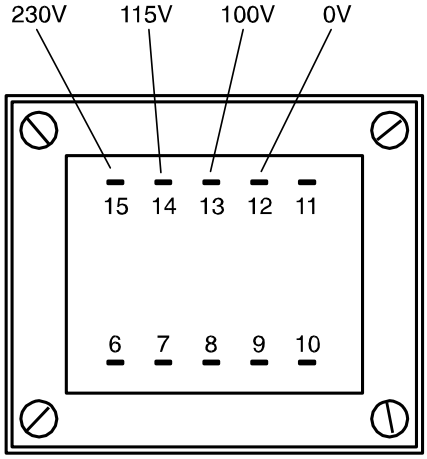
mains supply ON.

alternating current.

Mains Operating Voltage

Check that the instrument operating voltage marked on the rear panel is suitable for the local supply. Should it be necessary to change the operating voltage, proceed as follows:

1) Disconnect the instrument from all voltage sources.
2) Remove the screws which retain the top cover and lift off the cover.
3) Change the transformer connections following the diagram below.
4) Refit the cover and the secure with the same screws.
5) To comply with safety standard requirements the operating voltage marked on the rear panel must be changed to clearly show the new voltage setting.
6) Change the fuse to one of the correct rating, see below.



for 230V operation connect the live (brown) wire to pin 15
for 115V operation connect the live (brown) wire to pin 14
for 100V operation connect the live (brown) wire to pin 13

Fuse

Ensure that the correct mains fuse is fitted for the set operating voltage. The correct mains fuse types are:

for 230V operation:	250 mA (T) 250V HRC
for 100V or 115V operation:	500 mA (T) 250V HRC

To replace the fuse, disconnect the mains lead from the inlet socket and withdraw the fuse drawer below the socket pins. Change the fuse and replace the drawer.

The use of makeshift fuses or the short–circuiting of the fuse holder is prohibited.

Mains Lead

When a three core mains lead with bare ends is provided it should be connected as follows:–

Brown	–	**Mains Live**
Blue	–	**Mains Neutral**
Green / Yellow	–	**Mains Earth**

WARNING! THIS INSTRUMENT MUST BE EARTHED

Any interruption of the mains earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited. The protective action must not be negated by the use of an extension cord without a protective conductor.

Mounting

This instrument is suitable both for bench use and rack mounting. It is delivered with feet for bench mounting. The front feet include a tilt mechanism for optimal panel angle.

A rack kit for mounting in a 19” rack is available from the Manufacturers or their overseas agents.

Service Handling Precautions

Service work or calibration should only be carried out by skilled engineers. Please note the following points before commencing work.

Most of the integrated circuits are CMOS devices and care should be taken when handling to avoid damage by static discharge. Also most devices are surface mounted miniature components with very fine leads on small pitches. These components must be removed and replaced with great care to avoid damage to the PCB. It is essential that only the proper tools and soldering equipment as recommended for surface mount components are used.

The decoupling capacitors associated with the integrated circuits are surface mounted on the solder side of the PCB.

Dismantling the Instrument

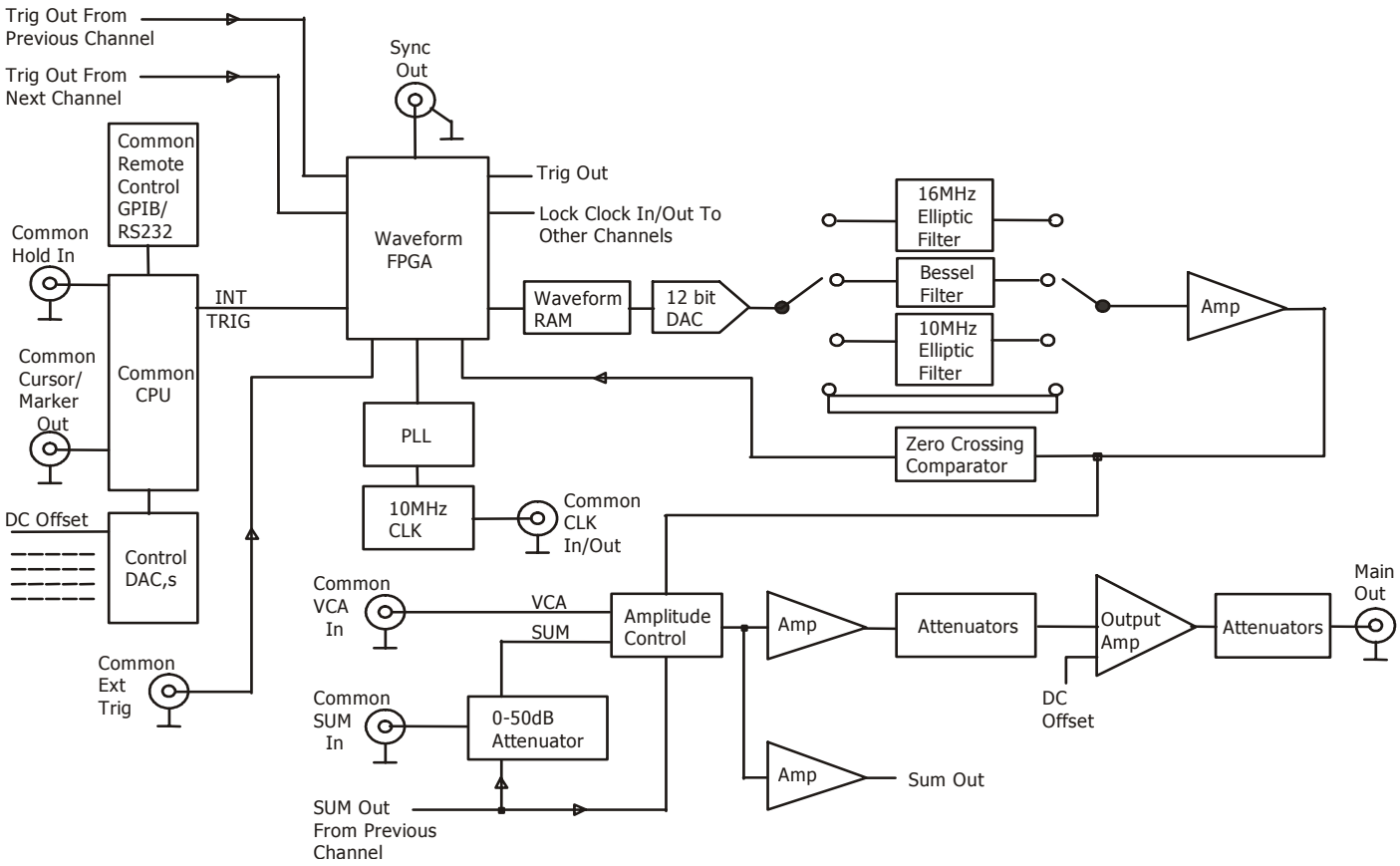
WARNING!

Disconnect the instrument from all voltage sources before it is opened for adjustment or repair. If any adjustment or repair of the opened instrument is inevitable it shall be carried out only by a skilled person who is aware of the hazards involved.

1. Remove the six screws retaining the top cover.
2. The rear panel may be removed as follows. Disconnect the grey ribbon cable from PJ6 on the GPIB PCB. Invert the instrument and remove the three screws securing the rear panel and the nuts securing the 9-way RS232 connector to the rear panel. The panel may now be tilted back to allow access. If the panel is to be completely removed the connectors must be removed from PJ3, PJ7, PJ8 and PJ11, the blue and brown wires disconnected from the mains inlet filter and the blue and brown wires unsoldered from the mains transformer. Cut the ties holding the cable assembly to the side instrument chassis. The panel is then completely free of the instrument.
3. The front panel assembly may be removed as follows. Remove the connectors from PJ2, PJ4, PJ12, PJ13 and PJ200 and desolder the screened cable from PJ202. Remove the two nuts and bolts in the sides and two screws in the bottom of the instrument securing the front panel assembly. The panel may now be drawn clear of the instrument.
4. Main pcb removal. Remove all connectors from the pcb and desolder the screened cable from PJ10. Tilt the rear panel away as in 2 above. Remove six screws and lift away the main pcb. When re-assembling the instrument ensure that all fixings use the correct fastenings.

General

The following sections should be read with reference to the block diagram and the circuit diagrams.

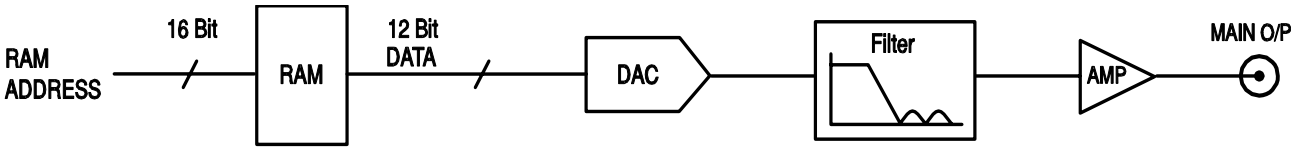


Simplified Block Diagram

Principles of Operation

The instrument operates in one of two different modes depending on the waveform selected. DDS mode is used for sine, cosine, haversine, triangle, sinx/x and ramp waveforms. Clock Synthesis mode is used for square, pulse, pulse train, arbitrary and sequence.

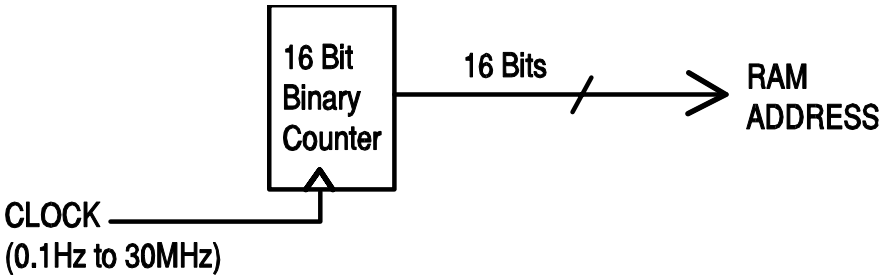
In both modes the waveform data is stored in RAM. As the RAM address is incremented the values are output sequentially to a Digital-to-Analogue Converter (DAC) which reconstructs the waveform as a series of voltages steps which are subsequently filtered before being passed to the main output connector.



The main difference between DDS and Clock Synthesis modes is the way in which the addresses are generated for the RAM and the length of the waveform data.

Clock Synthesis Mode

In Clock Synthesis mode the addresses are always sequential (an increment of one) and the clock rate is adjusted by the user in the range 40MHz to 0.1Hz. The frequency of the waveform is clock frequency ÷ waveform length, thus allowing short waveforms to be played out at higher repetition rates than long waveforms, e.g. the maximum frequency of a 4 point waveform is 40e6÷4 or 10MHz but a 1000 point waveform has a maximum frequency of40e6÷1000 or 40kHz.

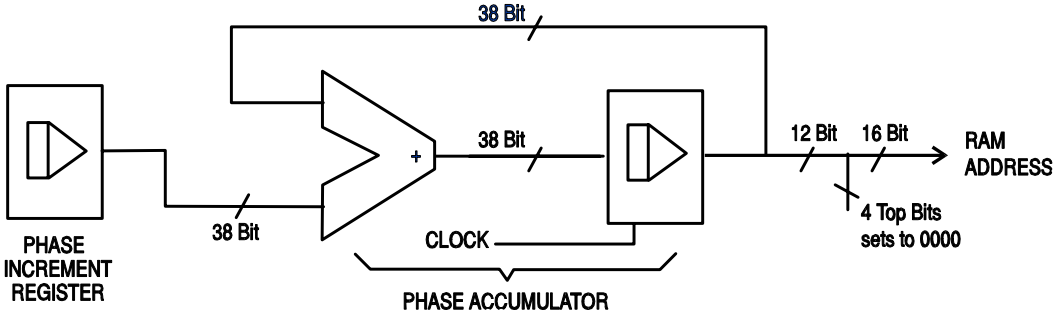


Arbitrary waveforms have a user defined length of 4 to 65536 points. Squarewaves use a fixed length of 2 points and pulse and pulse train have their length defined by the user selected period value.

DDS Mode

In DDS mode (Direct Digital Synthesis) all waveforms are stored in RAM as 4096 points. The frequency of the output waveform is determined by the rate at which the RAM addresses are changed. The address changes are generated as follows:

The RAM contains the amplitude values of all the individual points of one cycle (360º) of the waveform; each sequential address change corresponds to a phase increment of the waveform of 360º/4096. Instead of using a counter to generate sequential RAM addresses, a phase accumulator is used to increment the phase.



On each clock cycle the phase increment, which has been loaded into the phase increment register by the CPU, is added to the current result in the phase accumulator; the 12 most significant bits of the phase accumulator drive the lower 12 RAM address lines, the upper 4 RAM address lines are held low. The output waveform frequency is now determined by the size of the phase increment at each clock. If each increment is the same size then the output frequency is constant; if it changes, the output frequency changes as in sweep mode.

The generator uses a 38 bit accumulator and a clock frequency which is $2^{38} \times 10^{-4}$(~27.4878 MHz); this yields a frequency resolution of 0.1 mHz.

Only the 12 most significant bits of the phase accumulator are used to address the RAM. At a waveform frequency of $F_{CLK}/4096$ (~6.7MHz), the natural frequency, the RAM address increments at every clock. At all frequencies below this (i.e. at smaller phase increments) one or more addresses are output for more than one clock period because the phase increment is not big enough to step the address at every clock. Similarly at frequencies above the natural frequency the larger phase increment causes some addresses to be skipped, giving the effect of the stored waveform being sampled; different points will be sampled on successive cycles of the waveform.

MPU and Memory

The majority of the digital hardware in the instrument is contained in 3 LSI devices, these being a MicroProcessor Unit, IC3, and 2 Field Programmable Gate Arrays, IC10 and IC221.

The Z80180 MPU contains an 8 bit Z80 core, 2x16 bit counter-timers, 2x8 bit serial interfaces and a memory management unit. The MPU is clocked at 12MHz by XTL1.

The MPU provides 20 memory address lines which are used to provide access to a total of 1M bytes of memory, this comprising a 512k byte EPROM (IC4) and 5 128k byte rams IC5 – 9. The EPROM is located at address 00000h and extends to 07FFFFh. The top 128k bytes are shared by IC5 and the selection of ram or EPROM is controlled by the FPGA, IC10. The other 4 rams are located at addresses 080000h to 0FFFFFh. IC9 is the system ram which contains all the essential variables and work areas including the software stack. IC5 -8 is the non volatile store for all the arbitrary waveforms and is not used for any other purpose. The MPU selects between the memory devices via address decoders located in the FPGA at IC10.

The RS232 interface is provided directly by the MPU and is buffered to the rear panel connector (PJ1) by IC1 and IC2.

One of the counter-timers provides a constant 0.5ms 'tick' to the MPU which is used to time all the housekeeping functions, e.g. keyboard scan, knob control, as well as some generator functions, e.g. frequency sweep. The second counter-timer is not used.

The FPGA, IC10, provides the port select signals to the GPIB board.

Keyboard, LCD and LEDs

The keyboard is interrogated every 10ms. This is done by reading the registers in IC12 and IC13. If a key is down then one of the transistors Q6-Q13 will be on and the corresponding bits read from IC12/IC13 will be high. The MPU decodes this to produce a key code which is passed to the software. Multiple keys down are ignored. IC10 provides the port decode signals for access to IC12 and IC13.

The knob is connected directly to the FPGA, IC10. This decodes the 4 states of the switches and increments/decrements a counter. The counter is read and cleared every 10ms and the value and sign passed to the software.

The 6 LEDs are driven directly from the outputs of IC18 and IC19 which are shift registers loaded under CPU control by IC10.

The LCD is accessed via a bi-directional 4 bit port in IC10.

FPGA Waveform Generation

The FPGA, IC221, provides the complete waveform generation system including a 38-bit phase accumulator (for DDS operation), a programmable divide-by-n register (for arbitrary waveform playback), a 16-segment waveform sequencer, trigger/gate control logic, 20 bit re-loadable burst counter, multi-instrument phase synchronisation logic and an 8-bit 16 port bi-directional MPU interface.

Access is provided to the waveform RAM to allow the patterns to be written and the Sync and Cursor/Marker output signals are generated.

All internal operations of the FPGA are clocked by the signal ARBCLK. Note that if this signal is interrupted it is possible for the FPGA to become non-functional requiring the FPGA be completely reset. The clock could be interrupted by a fault condition or by setting the CLOCK BNC to INPUT and then providing an unacceptable clock. An unacceptable clock is any signal which overrides the internal clock but produces a replacement which is less than 9MHz or greater than 10.5MHz. This would happen if, for example, a DC voltage >2V was connected to the clock input.

Trigger Generator

This is created by a counter-timer in IC10. The counter-timer produces a squarewave in the range 100kHz to 0.005Hz. The FPGA, IC221, may be set to use this as the internal trigger.

Power Supply

The transformer has two separate secondaries; one provides ± 15V by IC30 and IC31, the other provides +5V by low drop-out regulator IC32 and −5V by IC33. The display backlight is driven by a current source made up of Q22 and associated components and is approximately 150mA. IC34 provides local regulation for the +5V analogue. IC204 provides local regulation for the VCO. IC226 provides local regulation for the PLL. PJ5 is a test point for the supply rails. Four PCB mounted fuses protect the transformer secondaries under fault conditions.

Required values measured at PJ5:

pin 1: +5VCPU ± 0.2V
pin 2: 0V
pin 3: −5V ± 0.2V
pin 4: −15V ± 0.6V
pin 5: +5VA ± 0.2V
pin 6: +15V ± 0.6V

Waveform DAC and Filters

IC210 is a high speed 12-bit DAC whose data is latched on the rising edge of DACCLK. The output current is 20mA fullscale giving 1Vp-p into 50Ω, from 0V to −1V. The DAC has an internal −1.23V (−1.27V to −1.17V) reference. R218 sets the full-scale output current. An internal control amplifier mirrors this with respect to the −5V rail.

L201,L202,L203 and associated components form the 16MHz 7-stage elliptic filter. The inductors are factory set before board assembly and must not be adjusted. L204 provides sinx/x correction and is adjusted at initial calibration.

L205,L206,L207 and associated components form the 10MHz 7-stage elliptic filter. The inductors are factory set before board assembly and must not be adjusted. L208 provides sinx/x correction and is adjusted at initial calibration.

L209, C252 and C253 form a Bessel filter. L209 is also factory preset.

Amplitude Control, Sum and Modulation

IC215 is a 4-quadrant multiplier driven differentially via IC211. The main signal is at M and is 0V to −1V; a dc reference, M1, of half this is generated by IC200-A. Amplitude is controlled by IC218-A; with the output set to maximum the voltage at its output is approximately 1V.

External AM is selected by IC214-A and is summed with the amplitude control voltage at the input of IC218-A.

Sum is selected by IC214-C and the external signal is summed at the multiplier output via its Z input.

IC212 and IC213 form the sum input attenuator.

Amplifiers and Attenuators

With the amplitude at maximum the signal at the output of the multiplier is approximately 1Vp-p. IC219 gives a gain of 5.5 to give 5.5Vp-p and IC220 gives a gain of 3.8 to give 20Vp-p.

IC218-B provides DC offset for the main output; when set to maximum, i.e. +10V, IC218-B's output will be approximately −10V and its input approximately –3.6V.

Relays RL201 and RL202 select 20dB output attenuators and IC217 selects an intermediate −10dB attenuator.

Zero Crossing Detector

IC201 is a comparator with positive feedback via R203. M is the signal selected by IC211 and M2 is the signals dc mid-point which is buffered by IC200-B. This circuit is used to detect zero crossing of high frequency DDS waveforms of sine, ramp or triangle and sent to the FPGA.

Control DACs

IC27 is a 12-bit voltage output DAC with internal 2V reference. IC115 provides a bi-polar output of ± 3.3V. IC28 multiplexes the DAC output voltage onto the appropriate hold capacitor. FET input amplifiers IC29 buffer the voltages on the hold capacitors.

IC208 is a quad 8-bit DAC. IC209D provides a 3.3V reference to give 0 to 3.3V DAC output. IC209-A, -B and -C give gain and/or offset. VR200 gives coarse adjustment of the multiplier offset and is only adjusted at initial calibration with the default calibration values present.

The voltage at each DAC output is controlled by the MPU which calculates each value from a combination of the instrument set up and the calibration constants stored in EEPROM.

Reference Clock

IC105 is an integrated 10MHz voltage controlled crystal oscillator. If an external clock is applied, C48 is charged up via D5 blocking the internal clock.

Phase-Locked-Loop and VCO

IC203 is a VCO tuned by varicap diodes D209-212. The range is 20MHz to 40MHz for square and arbitrary waveforms and fixed at 27.48779MHz in the DDS mode. Comparator IC205 gives TTL output levels.

IC206 is a PLL IC and has internal dividers for both inputs which are set by the MPU. Phase comparison is done at 3kHz in PLL mode and slightly higher in DDS mode. IC15 is the loop filter which drives the VCO. LED2 is out when the loop is in lock.

Inputs and Outputs

IC21 is a hex Schmitt; -A, -B, -D and -E are used for the Trig In and Hold In inputs. The Sync output has four gates in parallel, IC202.

IC23 is an octal 3-state buffer. When Clock In/Out is an output the top four buffers are enabled and the bottom four disabled. When Clock In/Out is an input the top four buffers are disabled and the bottom four enabled.

The Zmod output high is set by the three digital signals at the input of IC16-A. IC16-A provides gain to give a maximum output high of 14V. When Q14 is on, the output is low; when turned off the output goes high until D2 conducts, clamping output high to the required level.

All parameters can be calibrated without opening the case, i.e. the generator offers 'closed–box' calibration. All adjustments are made digitally with calibration constants stored in EEPROM. The calibration routine requires only a DVM and a frequency counter and takes no more than a few minutes.

The crystal in the timebase is pre–aged but a further ageing of up to ±5ppm can occur in the first year. Since the ageing rate decreases exponentially with time it is an advantage to recalibrate after the first 6 month's use. Apart from this it is unlikely that any other parameters will need adjustment.

Calibration should be carried out only after the generator has been operating for at least 30 minutes in normal ambient conditions.

Equipment Required

- 3½ digit DVM with 0.25% DC accuracy and 0.5% AC accuracy at 1kHz.
- Frequency counter capable of measuring 10.00000MHz.

The DVM is connected to the MAIN OUT of each channel in turn and the counter to any SYNC OUT.

Frequency meter accuracy will determine the accuracy of the generator's clock setting and should ideally be ±1ppm.

Calibration Procedure

The calibration procedure is accessed by pressing the **calibration…** soft–key on the **UTILITY** screen.

```
CALIBRATION SELECTED
 Are you sure ?
◊password… tests…◊
◊exit continue◊
```

The software provides for a 4–digit password in the range 0000 to 9999 to be used to access the calibration procedure. If the password is left at the factory default of 0000 no messages are shown and calibration can proceed as described in the Calibration Routine section; only if a non–zero password has been set will the user be prompted to enter the password.

Setting the Password

On opening the Calibration screen press the **password…** soft–key to show the password screen:

```
ENTER NEW PASSWORD
____
```

Enter a 4–digit password from the keyboard; the display will show the message **NEW PASSWORD STORED!** for two seconds and then revert to the **UTILITY** menu. If any keys other than 0–9 are pressed while entering the password the message **ILLEGAL PASSWORD!** will be shown.

Using the Password to Access Calibration or Change the Password

With the password set, pressing **calibration…** on the **UTILITY** screen will now show:

```
ENTER PASSWORD
----
```

When the correct password has been entered from the keyboard the display changes to the opening screen of the calibration routine and calibration can proceed as described in the Calibration Routine section. If an incorrect password is entered the message **INCORRECT PASSWORD!** is shown for two seconds before the display reverts to the **UTILITY** menu.

With the opening screen of the calibration routine displayed after correctly entering the password, the password can be changed by pressing **password...** soft–key and following the procedure described in Setting the Password. If the password is set to 0000 again, password protection is removed.

The password is held in EEPROM and will not be lost when the memory battery back–up is lost. In the event of the password being forgotten, contact the manufacturer for help in resetting the instrument.

Calibration Routine

The calibration procedure proper is entered by pressing **continue** on the opening Calibration screen; pressing **exit** returns the display to the **UTILITY** menu. Pressing **tests**... calls a menu of basic hardware checks used at production test which are self-explanatory. At each step the display changes to prompt the user to adjust the rotary control or cursor keys, until the reading on the specified instrument is at the value given. The cursor keys provide coarse adjustment, and the rotary control fine adjustment. Pressing **next** increments the procedure to the next step; pressing CE decrements back to the previous step. Alternatively, pressing **exit** returns the display to the last CAL screen at which the user can choose to either **save new values, recall old values** or **calibrate again.**

The first two displays (CAL 00 and CAL 01) specify the connections and adjustment method. The next display (CAL 02) allows the starting channel to be chosen in multi-channel instruments; ignore CAL02 in this instrument and step on to CAL03. The subsequent displays, CAL 03 to CAL 55, permit all adjustable parameters to be calibrated.

The full procedure is as follows:

CAL 03	CH1. DC offset zero.	Adjust for 0V ± 5mV.
CAL 04	CH1. DC offset at + full scale.	Adjust for + 10V ± 10mV.
CAL 05	CH1. DC offset at – full scale.	Check for –10V ± 3%
CAL 06	CH1. Multiplier zero.	Adjust for minimum Volts AC
CAL 07	CH1. Multiplier offset.	Adjust for 0V ± 5mV.
CAL 08	CH1. Waveform offset.	Adjust for 0V ± 5mV.
CAL 09	CH1. Output level at full–scale	Adjust for 10V ± 10mV.
CAL 10	CH1. 20dB attenuator	Adjust for 1V ± 1mV.
CAL 11	CH1. 40dB attenuator	Adjust for 0.1V ± .1mV.
CAL 12	CH1. 10dB attenuator	Adjust for 2.236V AC ± 10mV.
CAL 13	CH1. Not used.	
CAL 14	CH1. Not used.	
CAL 15	CH1. Not used.	
CAL 55	Clock calibrate	Adjust for 10.00000 MHz at SYNC OUT.

Service Adjustments

The following 3 sections contain information about adjustments which are normally done once only at the factory. These may need to be repeated if a component in the relevant area is changed.

VCO Adjustment

This should not normally be necessary and L6 is sealed at the factory. However if a problem is suspected or components in this circuit have been changed carry out the following test first.

Set the output to 10MHz squarewave and check that the voltage at TP200.3 is −9.5V to −10.5V. Check LED 200 is off.

Only if the voltage is outside these limits should L200 be adjusted to −10V ±0.2V. L6 core must then be resealed again to reduce phase noise caused by mechanical vibration. Use only non-corrosive silicon rubber.

VR200 Adjustment

Not normally necessary. Must only be adjusted with the default calibration values loaded or CAL07 set to 0128. At CAL07 adjust VR200 for 0Vdc ± 5mV.

Amplitude Flatness

This should not normally be necessary. Set to 20Vpk-pk and use a 50Ohm terminator, frequency to 100kHz sinewave. Adjust oscilloscope to show exactly 6 divisions. Frequency to 10.00000MHz and adjust L208 for exactly 6 divisions. Frequency to 10.1MHz and adjust L204 for exactly 6 divisions. These two adjustments should only be done using a high quality oscilloscope with a bandwidth of at least 100MHz.

Remote Calibration

Calibration of the instrument may be performed over the RS232 or GPIB interface. To completely automate the process the multimeter and frequency meter will also need to be remote controlled and the controller will need to run a calibration program unique to this instrument.

The remote calibration commands allow a simplified version of manual calibration to be performed by issuing commands from the controller. The controller must send the CALADJ command repeatedly and read the dmm or frequency meter until the required result for the selected calibration step is achieved. The CALSTEP command is then issued to accept the new value and move to the next step.

While in remote calibration mode very little error checking is performed and it is the controllers responsibility to ensure that everything progresses in an orderly way. Only the following commands should be used during calibration.

WARNING: Using any other commands while in calibration mode may give unpredictable results and could cause the instrument to lock up, requiring the power to be cycled to regain control.

CALIBRATION <cpd> [,nrf]	The calibration control command. <cpd> can be one of three sub−commands:−
START	Enter calibration mode; this command must be issued before any other calibration commands will be recognised.
SAVE	Finish calibration, save the new values and exit calibration mode.
ABORT	Finish calibration, do not save the new values and exit calibration mode.
	<nrf> represents the calibration password. The password is only required with CALIBRATION START and then only if a non−zero password has been set from the instrument's keyboard. The password will be ignored, and will give no errors, at all other times.
	It is not possible to set or change the password using remote commands.
CALADJ <nrf>	Adjust the selected calibration value by <nrf>. The value must be in the range −100 to +100. Once an adjustment has been completed and the new value is as required the CALSTEP command must be issued for the new value to be accepted.
CALSTEP	Step to the next calibration point.

For general information on remote operation and remote command formats, refer to the Instrument instruction manual remote operation sections.

PCB ASSY - KEYBOARD (44912-0710)

Part Number	Description	Position
22224-0010	ENCODER ROT 36 POS W/O DETENT	SW1
22226-0101	KEYSWITCH - ALPS SKHHBW	K5-12, 20, 21, 30, 31, 48
22226-0150	KEYSWITCH LIGHT GREY	K1, 2, 4, 13-19, 22-29, 32-47, 49
23202-1680	RES 680RF W25 MF 50PPM	R1-3,5,11,12
23382-2470	RES PS/H 5K0 CERMET MIN	VR3
25061-0200	LED - T1 ROUND (3mm) - RED	LD1-5,11
35555-3010	PCB - KEYBOARD	
43171-2230	CONN ASSY KB/MAIN 34W	

PCB ASSY – MAIN (44912-0720)

Part Number	Description	Position
10366-9701	ADHESIVE MTG PADS 25 x 12MM	FOR BATTERY
20613-0006	WASHER (SIL-PAD) TO220	FOR SK200
20613-0007	WASHER (SIL-PAD) TO220 PLAIN	FOR SK2
20670-0135	CLIP GP02 FOR PCB MTG H/SINKS	FOR SK2-5,200
20670-0310	HEATSINK PCB MTG 38MM PLAIN	SK200 FOR IC220
20670-0320	HEATSINK PCB MTG 50MM PLAIN	SK2,3,4,5
20670-0340	HEATSINK TO220 CLIP-ON 29DEG/W	SK8
22010-0610	BATTERY 3V LITH 20MM BUTTON	BATT
22040-0920	BEAD FERRITE – LEADED	FB1,200-206
22042-0260	INDUCTOR 2.7UH	L208
22042-0261	INDUCTOR 2.07UH BLK	L205
22042-0262	INDUCTOR 2.0UH WHT	L206
22042-0263	INDUCTOR 1.78UH GRN	L207
22042-0271	INDUCTOR 1.545UH RED	L209
22042-0290	INDUCTOR 1.2UH	L204
22042-0291	INDUCTOR 1.322UH YEL	L201
22042-0292	INDUCTOR 1.157UH RED	L202
22042-0293	INDUCTOR 1.06UH BLUE	L203
22042-0300	INDUCTOR 0.47UH	L200
22240-0020	RELAY TYPE 53/5 (24V)	RL201,202
22240-0050	RELAY TYPE 47 (24VDC)	RL200,203,204,205
22315-0450	FUSE 500mAT SUBMIN PCB MNT	FS3,4
22315-0453	FUSE 1.5AT SUBMIN PCB MTG	FS1, 2
22573-0041	HEADER 2WAY STR SIL STD/GOLD	LK1, 2, TP1, TP201/202
22573-0048	HEADER 3WAY STR SIL STD/GOLD	PJ202 (CENTRE PIN REMOVED)

PCB ASSY – MAIN (44912-0720) continued/...

Part Number	Description	Position
22573-0070	HEADER 4WAY STR SIL STD	TP200
22573-0202	HEADER 2 WAY STRAIGHT .156P	PJ3, 7, 200
22573-0204	HEADER 4 WAY STRAIGHT .156P	PJ11/12, PJ13
22573-0206	HEADER 6 WAY STRAIGHT .156P	PJ8
22574-0450	SKT 9W R/A D-TYPE (CLIP IN)	PJ1
22575-0038	HEADER 6WAY STR SIL STD	PJ5
22575-0065	HEADER 20 WAY(2X10) STR SKEL	PJ6
22575-0100	HEADER 34 WAY(2X17) STR SKEL	PJ2, 4
23105-0010	RES SM0805 1R00F W1	R276
23105-0022	RES SM0805 2R20F W1	R275
23105-0068	RES SM0805 6R80F W1	R274
23105-0100	RES SM0805 10R0F W1	R25
23105-0215	RES SM0805 21R5F W1	R204, 273
23105-0510	RES SM0805 51R0F W1	R200, 237, 238, 239, 244, 253, 278, 300
23105-0620	RES SM0805 62R0F W1	R219
23105-0680	RES SM0805 68R0F W1	R247, 250, 272, 277
23105-0820	RES SM0805 82R0F W1	R269
23105-1100	RES SM0805 100RF W1	R7, 225, 227, 229, 230, 249
23105-1110	RES SM0805 110RF W1	R48-51, 251, 266
23105-1130	RES SM0805 130RF W1	R58, 62
23105-1150	RES SM0805 150RF W1	R201, 213-216
23105-1180	RES SM0805 180RF W1	R220, 294, 309
23105-1215	RES SM0805 215RF W1	R248, 271
23105-1220	RES SM0805 220RF W1	R3, 59, 223, 312
23105-1470	RES SM0805 470RF W1	R36, 37, 252, 281, 293
23105-1510	RES SM0805 510RF W1	R226, 297
23105-1620	RES SM0805 620RF W1	R24, 307
23105-1680	RES SM0805 680RF W1	R311
23105-2100	RES SM0805 1K00F W1	R5,10,27,33,34,56,57,60,61,202,218,228,304-305
23105-2130	RES SM0805 1K30F W1	R268
23105-2150	RES SM0805 1K50F W1	R292
23105-2180	RES SM0805 1K80F W1	R267, 291
23105-2200	RES SM0805 2K00F W1	R222, 231, 287
23105-2220	RES SM0805 2K20F W1	R280
23105-2240	RES SM0805 2K40F W1	R19, 28, 243
23105-2270	RES SM0805 2K70F W1	R18, 22, 26, 232, 299

PCB ASSY – MAIN (44912-0720) continued/...

Part Number	Description	Position
23105-2300	RES SM0805 3K00F W1	R30, 310
23105-2470	RES SM0805 4K70F W1	R23, 282, 288, 289, 290, 295, 296, 298
23105-2510	RES SM0805 5K10F W1	R233, 242, 306
23105-2560	RES SM0805 5K60F W1	R240, 270
23105-3100	RES SM0805 10K0F W1	R1, 2,4,6,11-14,32, 35 55,205,207,209-211,235
23105-3120	RES SM0805 12K0F W1	R217
23105-3150	RES SM0805 15K0F W1	R221, 236, 241, 279
23105-3200	RES SM0805 20K0F W1	R53, 54, 154
23105-3270	RES SM0805 27K0F W1	R206, 212
23105-3330	RES SM0805 33K0F W1	R155
23105-3470	RES SM0805 47K0F W1	R29, 203, 208, 234, 301, 302, 303
23105-3510	RES SM0805 51K0F W1	R17
23105-4100	RES SM0805 100KF W1	R8, 16, 20, 21, 38
23105-4200	RES SM0805 200KF W1	R15
23105-5100	RES SM0805 1M00F W1	R9
23105-6100	RES SM0805 10M0F W1	R45, 52, 224
23202-0039	RES 3R90F W25 MF 50PPM	R72
23202-0100	RES 10R0F W25 MF 50PPM	R70
23202-0102	RES 10R2F W25 MF 50PPM	R262, 265
23202-1240	RES 240RF W25 MF 50PPM	R40
23202-1750	RES 750RF W25 MF 50PPM	R39
23202-2220	RES 2K20F W25 MF 50PPM	R71
23206-0412	RES 41R2F W60 MF 50PPM	R260, 261, 263, 264
23206-1200	RES 200RF W60 MF 50PPM	R256-259
23222-0047	RES 4R70J W33 MF FUSIBLE	R254, 255
23301-0443	RES NETWK SIL 22K X 8	RP1-3
23377-2220	RES PS/H 2K2 CF 10MM	VR200
23424-0443	CAP10NZ 1KV CER D10 P5	C70, 71
23427-0268	CAP22PJ 100V CER NPO P2.5	C1, 4, 50, 51, 206, 207
23427-0331	CAP1N0K 63V CER HI K P5	C311
23427-0593	CAP82PG 100V CER NPO P2.5	C233
23427-9205	CAP47PJ 100V CER NPO P2.5	C245, 276, 293, 318
23427-9209	CAP33PJ 100V CER NPO P2.5	C8, 246, 248, 250, 251
23427-9218	CAP 330PK 100V CER MED K P2.5	C253
23428-0082	CAP8P2C 100V CER NPO P2.5	C232, 234, 270, 319
23428-0390	CAP39PG 100V CER N150 P2.5	C240, 242, 244, 252, 254

PCB ASSY – MAIN (44912-0720) continued/...

Part Number	Description	Position
23428-0560	CAP56PG 100V CER N150 P2.5	C239, 247
23428-1100	CAP 100PG 100V CER NPO P2.5	C12, 235, 241, 249
23428-1150	CAP 150PG 100V CER N150 P2.5	C236
23428-1180	CAP 180PG 100V CER N750 P2.5	C238, 243
23461-0015	CAP SM0805 10NK 50V CER X7R	C48, 210, 213, 216, 218, 219, 221, 224, 225, 271, 288, 289, 290, 292, 320, 322
23461-0020	CAP SM0805 100NZ 50V CER Y5V	C3, 6, 9-11,16-41,52-57,60-63,66,67, 81, 141, 155, 200, 201,203, 204, 205,208, 209,211, 214, 215, 217, 220, 229, 230, 255, 256, 257, 261, 262, 263, 265, 267-269, 272-275, 277-279, 281, 283, 291, 294, 295,300-310, 312-317, 321
23557-0612	CAP 1U0 100V ELEC RE2 P2	C15
23557-0647	CAP 10U 35V ELEC RE2 P2	C2, 5, 13, 14, 42, 43, 76, 77, 79, 212, 264, 266, 280, 282, 285, 286
23557-0658	CAP 100U 25V ELEC RE2 P2.5	C78, 80
23557-0660	CAP 2200U 16V ELEC RE2 P5	C75
23557-0664	CAP 1000U 35V ELEC RE2 P5	C72, 73
23557-0673	CAP 22U 35V ELEC RE2 P2	C7, 202, 231
23557-9122	CAP 4700U 16V ELEC RE2 P7.5	C74
23620-0242	CAP 22NJ 100V P/E P5	C227
23620-0246	CAP 100NK 63V P/E P5	C228
23620-0249	CAP 330NK 63V P/E P5	C64, 65
23620-0252	CAP 2N2K 63V P/E P5	C226
25021-0901	DIO 1N4148 B/R	D1-3, 5-9, 200-207, 213, 214
25061-0200	LED - T1 ROUND (3mm) - RED	LED1, LD200
25115-0907	DIO 1N4002 B/R	D10-13
25130-9201	DIO ZEN 6V2 W5	D208
25131-0224	DIO ZEN 18V 1W3	D14, 15
25131-0227	DIO ZEN 6V8 5W	D16-18
25174-0224	DIO SM VARICAP BB148	D209-212
25211-9302	RECTIFIER BRIDGE W02G	BR1
25334-0011	TRAN PNP TIP30	Q22
25336-5590	TRAN PNP BC559C	Q1, 3, 6-13
25377-5490	TRAN NPN BC549C	Q2, 4, 5, 14, 15, 20, 21, 200-205
27103-0041	IC NE527N	IC201
27103-1020	IC SM AD8561AR	IC205
27106-0517	IC NE5532N	IC218

PCB ASSY – MAIN (44912-0720) continued/...

Part Number	Description	Position
27106-0633	IC EL2099CT	IC220
27106-1110	IC SM LM358M DUAL OP AMP	IC16, 200
27106-1160	IC SM LM324M OP AMP	IC209
27106-1170	IC SM AD8055AR OP AMP	IC219
27106-1180	IC SM AD8056AR OP AMP	IC25, 216
27106-1210	IC SM LMC662CM	IC29, 115
27107-0071	IC SM TL071 BIFET OP AMP	IC207
27151-1010	IC AD835AN	IC215
27153-1050	IC SM LTC1257CS8	IC27
27153-1060	IC SM TLC5620CD DAC	IC208
27153-1070	IC SM HI5735KCB DAC	IC210
27158-0020	IC SM MC145170D	IC206
27158-0030	IC SM MC12148D	IC203
27160-0011	IC V/REG 78L05 TO92	IC108, 204, 226
27160-0013	IC V/REG 7815 TO220	IC30
27160-0020	IC V/REG 7915 T0220	IC31
27160-0210	IC V/REG LM337 TO220	IC33
27160-0460	IC V/REG L4941BV	IC32, 34
27227-0510	IC SM 4051	IC28
27227-0940	IC SM 4094	IC18, 19
27236-0520	IC SM 74HC4052	IC211, 212, 217
27236-0530	IC SM 74HC4053	IC213, 214
27238-0000	IC SM 74HCT00	IC202
27238-0140	IC SM 74HCT14	IC11, 21
27239-0000	IC SM 74HC00	IC22
27239-0320	IC SM 74HC32	IC14, 15, 20
27239-2400	IC SM 74HC240	IC23
27239-3730	IC SM 74HC373	IC12, 13
27253-0020	IC SM 64180	IC3
27253-0050	IC SM 14C88	IC1
27253-0060	IC SM 14C89	IC2
27400-0140	IC 27C4001 512Kx8 EPROM	IC4
27403-0010	IC SM 93C46 1K(64x16) EEPR	IC17
27410-0460	IC SM 32KX8 RAM 15ns	IC222-225
27412-0080	IC SM XCS10-4TQ144C	IC221
27412-0090	IC SM XCS05-3VQ100C	IC10
27413-0430	IC SM 128Kx8 RAM 70ns	IC5-9

PCB ASSY – MAIN (44912-0720) continued/...

Part Number	Description	Position
28151-0010	BUZZER	BUZZ
28502-0020	RESONATOR CERAMIC 12MHZ	XTL1
28515-0070	OSC MODULE 10MHz VCXO	IC105
31331-9030	SCREEN PCB MOUNT	S205, 206
35555-3210	PCB - MAIN	

FRONT PANEL ASSY

Part Number	Description	Position
20030-0263	WASHER M3 ZPST	BEZEL
20030-9201	WASHER 6BA x 1/32in. FIBRE	LCD FIXING
20030-9202	WASHER 6BA x 1/16in. FIBRE	LCD FIXING
20038-9501	WASHER M3 SPRING	KEYBOARD PCB/FRONT PANEL
20065-0090	SCREW K22 X 5 PT LN1442 PNHDZ	BEZEL FIXING
20210-0104	NUT M2.5 ZPST	LCD FIXING
20234-0027	SCREW M3 X 6 PNHDPZ ZPST	KEYBOARD PCB/FRONT PANEL, BEZEL
20234-0040	SCREW M2.5 X 12MML PNHDPZ ZPST	LCD FIXING
20612-0011	WASHER FIBRE M3	KEYBOARD PCB/FRONT PANEL
20620-0010	CLIP - ENCODER KNOB	
22219-0090	SWITCH ROCKER DPST GREY	
22573-0056	HEADER 16WAY STR SIL STD	FOR DISPLAY
22575-0202	SKT 2W .156 20AWG (YELLOW) IDT	MAIN PCB PJ200A & PJ200B, PJ7
22575-0204	SKT 4W .156 20AWG (YELLOW) IDT	INTERFACE 1 PJ6
22588-0004	BNC SKT BKHD 50R STANDARD	
26100-0160	LCD 20 X 4 BACK LIT	
31711-0180	BEZEL	
33331-7210	FRONT PANEL	
33331-7290	OVERLAY FRONT PANEL	
37113-2030	KEYCAP 8X3MM LIGHT GREY	
37151-0430	KNOB ENCODER LIGHT GREY	
43171-1400	CONN ASSY 2 WAY 285MM	PJ12, 200 (MAIN)
43171-1401	CONN ASSY 2 WAY 195MM	PJ13 (MAIN)
43171-2210	CONN ASSY CRIMPED	

REAR PANEL ASSY

Part Number	Description	Position
20037-0401	SOLDER TAG SHAKEPROOF - 4BA	EARTH
20038-9502	WASHER M4 SPRING EARTH	
20063-0010	SCREW NO6 X 3/8 NIB HDPZ ST/AB	TRANSFORMER
20210-0102	NUT M4 ZPST EARTH	
20213-0040	CAPTIVE NUT SPIRE NO.6	
20223-9001	SCREW M3 X 8 RAISED CKHDPZ	MAINS INLET
20236-0010	SCREW M4 X 12 TAMPERPROOF	EARTH
22115-0340	TRANSFORMER	
22520-0170	FILTER - IEC INLET + FUSE - 1A	
20037-0401	SOLDER TAG SHAKEPROOF - 4BA	EARTH
20038-9502	WASHER M4 SPRING	EARTH
20063-0010	SCREW No 6 x 3/8 NIB HDPZ ST/AB	TRANSFORMER
22588-0004	BNC SKT BKHD 50R STANDARD	
33331-7430	REAR PANEL PRINTED	
43171-1401	CONN ASSY 2 WAY 195MM	PJ1, 3, 11 MAIN

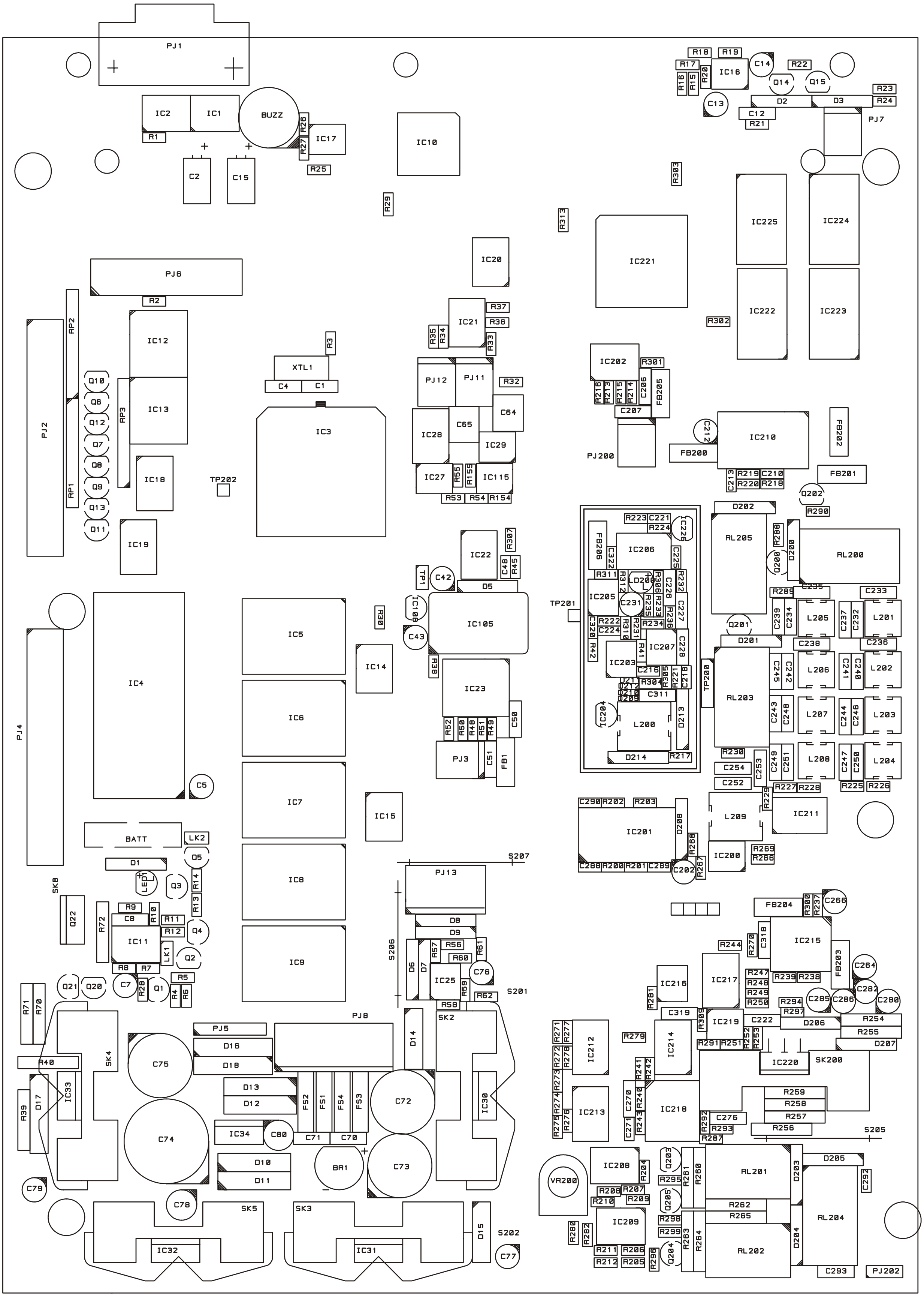
CASING AND OTHER ITEMS

Part Number	Description	Position
10144-0007	CABLE COAX 50Ω 2.6MM RG316/U	BNC TO PCB MAIN (PJ202)
20030-0266	WASHER M4 ZPST	RUBBER FEET
20037-0301	WASHER M3 SHK/PROOF I/T ZPST	CHASSIS/F. PANEL
20038-9501	WASHER M3 SPRING	CHASSIS/SPACERS, PCB/SPACERS, FRONT PANEL
20062-0700	SCREW NO 6 X 3/8 RFLNGPZ ST/AB	CHASSIS/REAR PANEL
20063-0010	SCREW NO6 X 3/8 NIB HDPZ ST/AB	CASE UPPER
20210-0101	NUT M3 ZPST	FRONT PANEL
20213-0040	CAPTIVE NUT SPIRE NO.6	CHASSIS
20234-0012	SCREW M3 X 8 PNHDPZ ZPST	CHASSIS
20234-0027	SCREW M3 X 6 PNHDPZ ZPST	CHASSIS/SPACERS, PCB/SPACERS
20234-0029	SCREW M4 X 12 PNHDPZ ZPST	FEET
20612-0011	WASHER FIBRE M3	PCB/SPACERS
20661-0219	SPACER HEX M3 x 15 NPBR	
20662-0201	BRACKET PLAS FOOT 3786-7001	
20662-0520	FOOT PVC PV2629 BLACK	
22315-0232	FUSE 250MA TL HRC S/F	230V VERSIONS
22315-0233	FUSE 500MA TL HRC S/F	115V VERSIONS

CASING AND OTHER ITEMS continued/...

Part Number	Description	Position
22491-0120	MAINS LD 2M ST IEC/UK PLUG 5A	UK VERSIONS
22491-0270	MAINS LD 2M ST IEC/EURO PLUG	EURO VERSIONS
22491-0040	MAINS LD 2M ST IEC/USA PL	USA VERSIONS
22469-0203	SOLDER TERMINAL PIN (18-0223K)	DISPLAY CABLE
22575-0202	SKT2W .156 20AWG (YELLOW)IDT	PJ3, 7,11,12,200 ON MAIN
22575-0204	SKT4W .156 20AWG (YELLOW) IDT	PJ13 ON MAIN
22575-0206	SKT6W .156 20AWG (YELLOW) IDT	PJ8 ON MAIN
33171-0130	SPRING FOOT	
33537-0900	CASE UPPER	
33537-0910	CASE LOWER	
43171-1430	CONN ASSY GPIB/MAIN 20W	
43171-2250	CONN ASSY DIS/MAIN 34W	
48584-0221	CONN ASSY RS232/PC SCRND 2M	

Main Pcb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IC2
IC1
BUZZ
IC17
IC10
C2
C15
R1
R25
R26
R27
R29
PJ6
R2
IC12
IC13
IC18
IC19
RP1
RP2
RP3
PJ2
Q10
Q6
Q12
Q7
Q8
Q9
Q13
Q11
TP202
XTL1
C4
C1
IC3
R3
IC20
IC21
R37
R36
R35
R34
R33
PJ12
PJ11
R32
C64
C65
IC28
IC29
IC27
IC115
R55
R155
R53
R54
R154
IC22
R307
C48
R45
TP1
C42
D5
IC108
IC105
C43
R30
R38
IC14
IC23
C50
R52
R50
R48
R51
R49
PJ3
C51
FB1
IC4
PJ4
IC5
IC6
IC7
IC8
IC9
IC15
C5
BATT
LK2
D1
Q5
LED1
Q3
R14
R13
SK8
Q22
R72
R9
C8
R10
R11
IC11
R12
Q4
LK1
Q2
R8
R7
R5
C7
R28
Q1
R4
R6
Q21
Q20
R71
R70
R40
IC33
D17
R39
SK4
C75
C74
C79
C78
PJ5
D16
D18
D13
D12
IC34
C80
D10
D11
SK5
IC32
PJ8
FS2
FS1
FS4
FS3
C71
C70
C72
C73
BR1
SK3
IC31
D14
IC30
D15
S202
C77
PJ13
S207
S206
D8
D9
D6
D7
R57
R56
R61
R60
IC25
C76
R59
R58
R62
S201
SK2
R18
R19
R17
R16
R15
R20
IC16
C14
R22
Q14
Q15
R23
R24
C13
D2
D3
C12
R21
PJ7
R303
R313
IC221
IC225
IC224
IC222
IC223
R302
IC202
R301
R216
R213
R215
R214
C206
FB205
C207
C212
IC210
FB202
PJ200
FB200
C213
R219
C210
R220
R218
FB201
Q202
R290
D202
R223
C221
R224
C226
FB206
IC206
C322
C225
R311
R312
D200
R306
R233
C226
R232
IC205
C231
R235
C227
R222
C224
R310
R231
R234
R236
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R260
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D203
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R207
R210
R209
Q205
R295
R262
R265
RL204
IC209
R298
R299
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Q204
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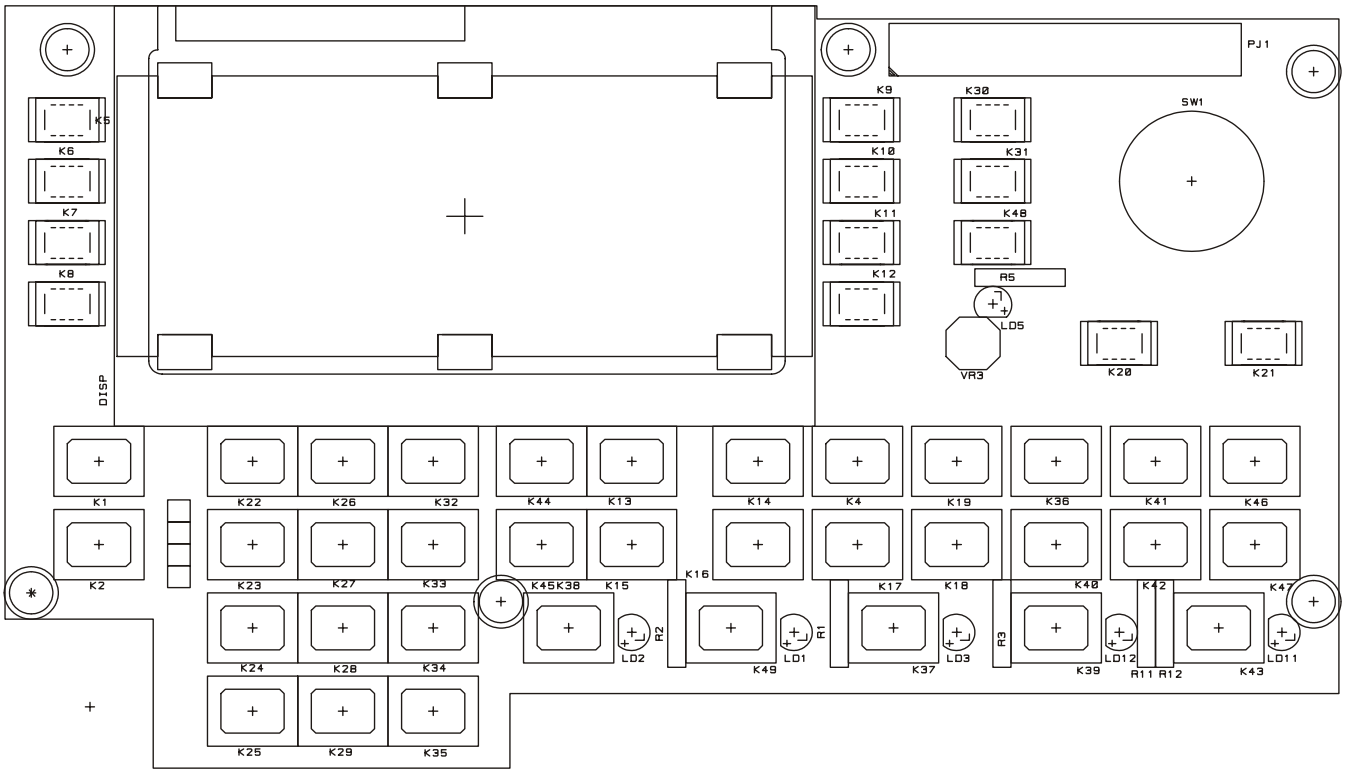
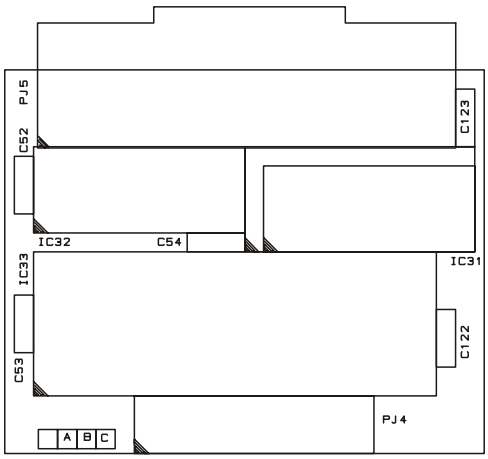
R264
RL202
D204
C293
PJ202

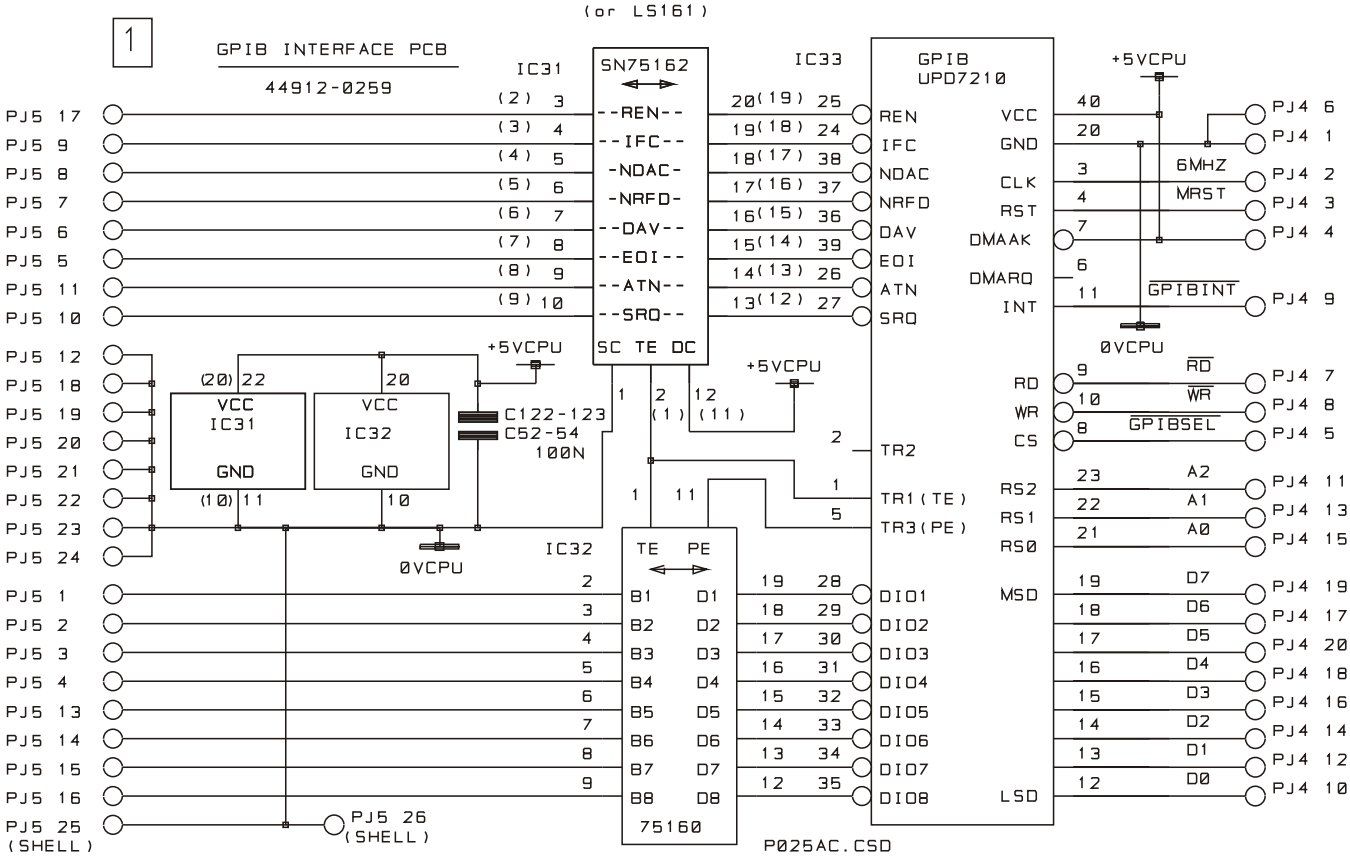
Keyboard Pcb



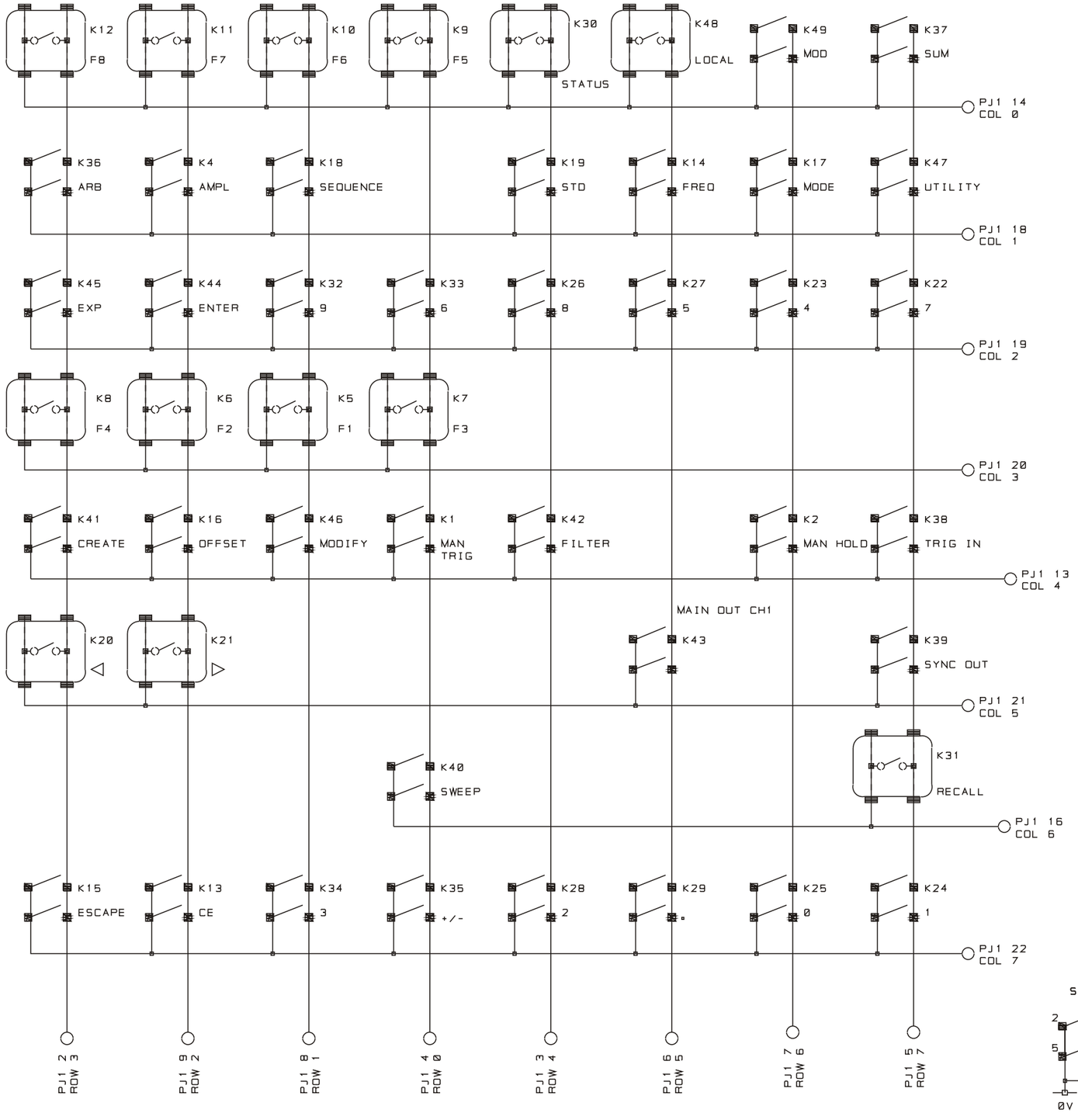
GPIB Pcb



Circuit Diagrams



Gpib Interface Pcb



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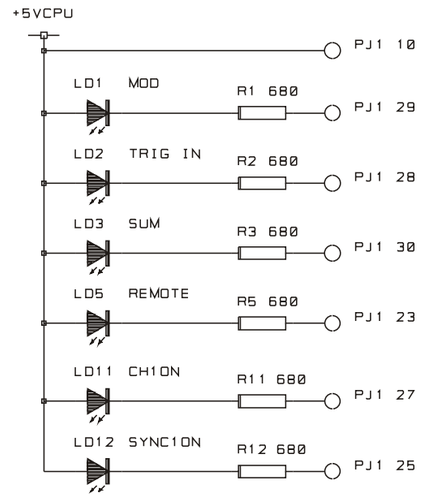
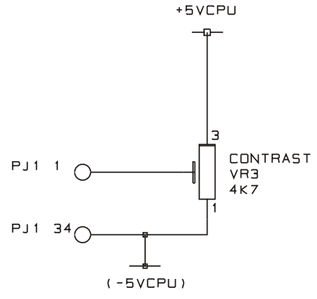
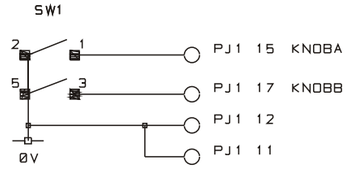






Keyboard Pcb

ARC/RS232 INTERFACE

CPU AND MEMORY

POWER FAIL, RESET AND BATTERY CONTROL LOGIC

GPIB INTERFACE

DISPLAY INTERFACE

KEYBOARD INTERFACE

Main Pcb Sheet 1 of 4

MPU and Interfaces

4

SYNC

ZEROX

REF3.3V

-REF

SUMOFST

MULTOFSET

WAVOFST

CLKCAL

PJ200 1

PJ200 2

TP200

PLLCTL

REFCLK

ARBCLK

LD200

RL200-A

RL205-A

RL203-A

* NOT FITTED

AMPL

AMEXT

AMON

SUM

M

M1

M2

WAVOFST

FILT1

FILT0

SUMAT1

SUMAT2

SUMAT3

SUMAT4

SUMAT5

SUMOFF

DCOFFSET

EXTSUM

UNREG

OPON

AT1

AT2

AT3

SK200
SW25-4
HSK FOR
IC220

S205-A S205-B

PJ202 1
MAIN
OP

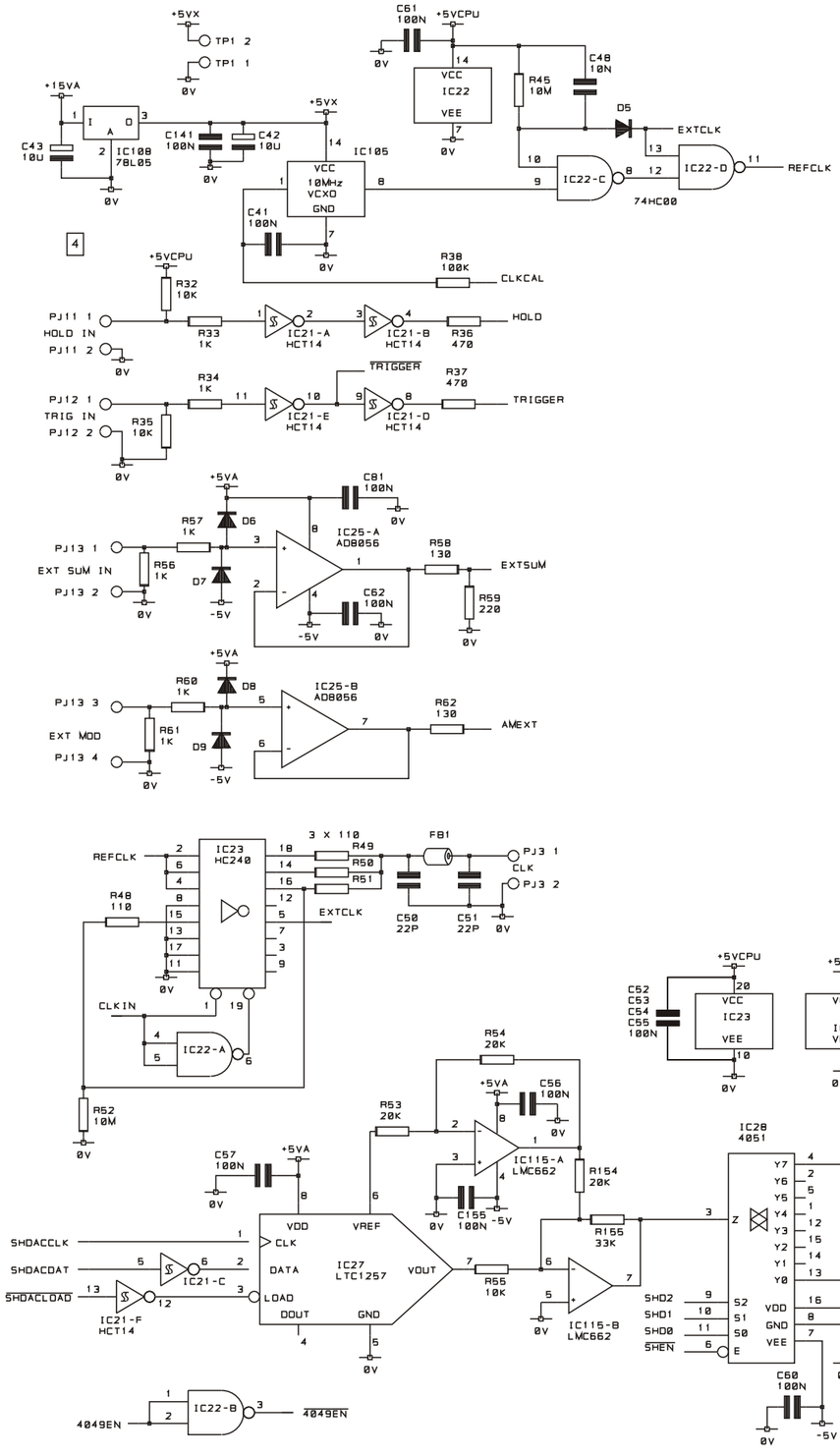
PJ202 2

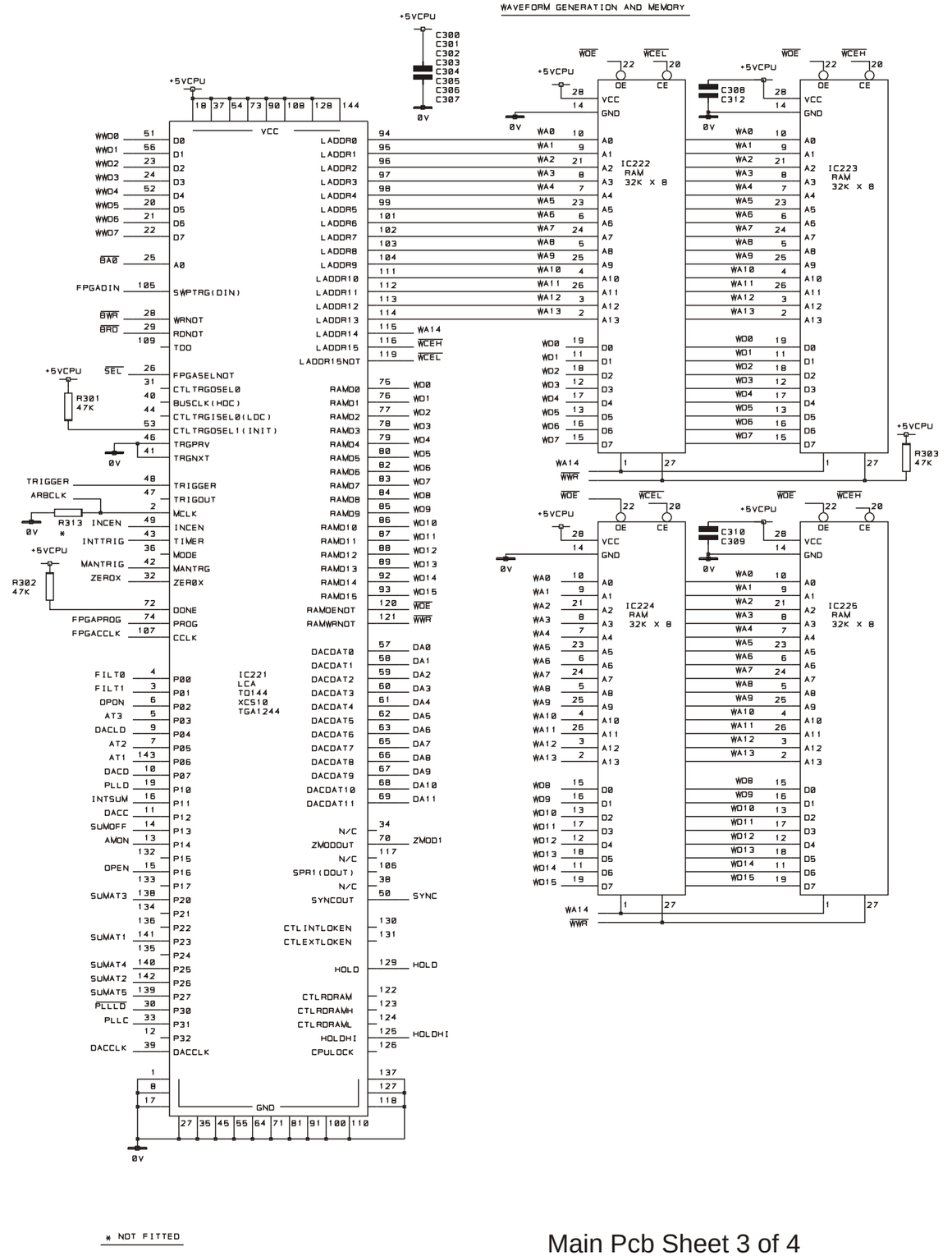
O/P
ON/OFF

4 x
BB
148

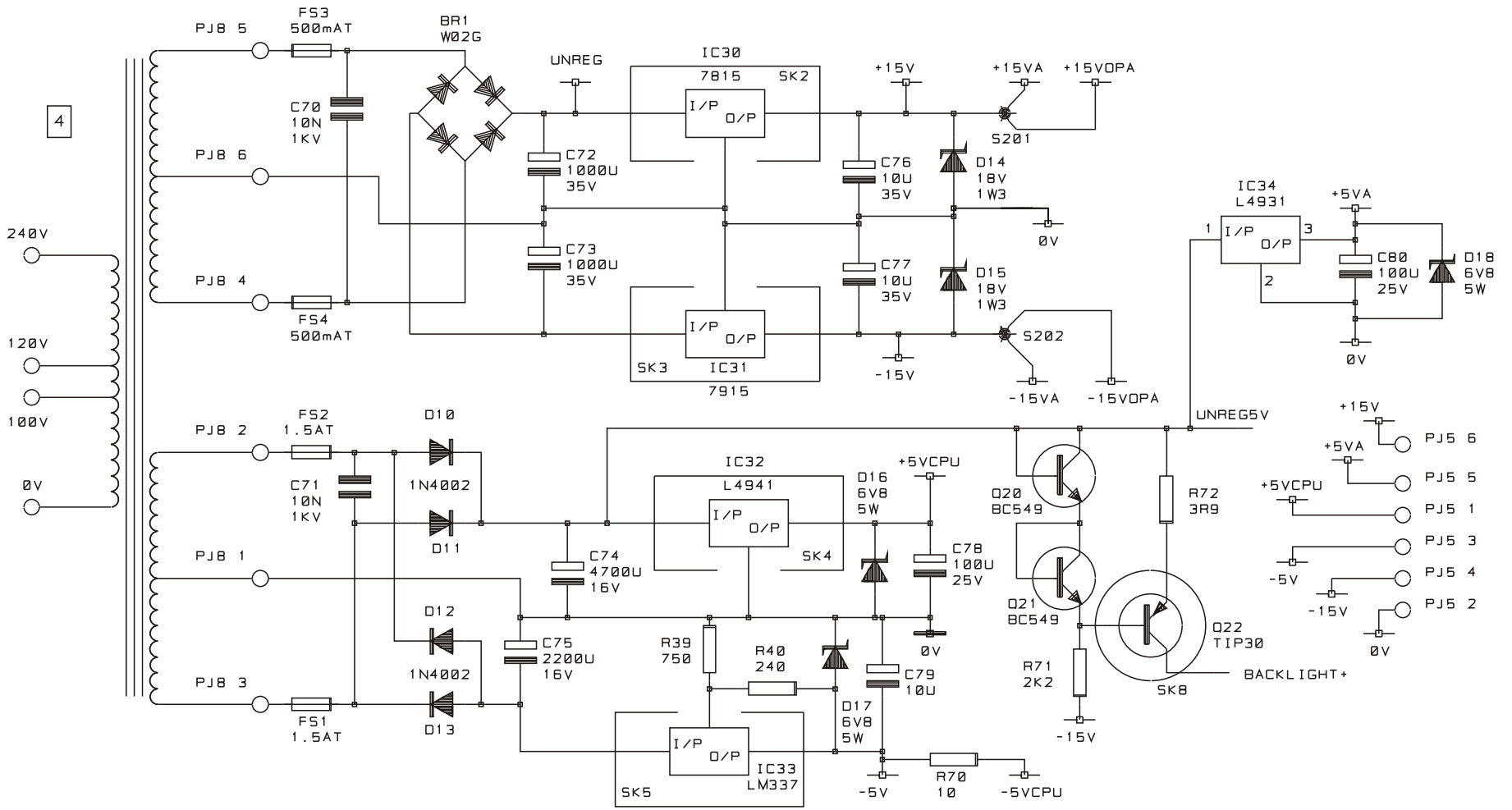
4X200 0W6

Main Pcb Sheet 2 of 4
Analogue Section





Main Pcb Sheet 3 of 4
Waveform FPGA and Memory



Main Pcb Sheet 4 of 4

Power Supplies