Frequency counters
PM 6667 and PM 6668

Instruction manual

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I&E
Industrial & Electro-acoustic Systems Division

PHILIPS
Industrial &
Electro-acoustic Systems

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Important

As the instrument is an electrical apparatus, it may be operated only by trained personnel. Maintenance and repairs may also be carried out only by qualified personnel.

Please note

In correspondence concerning this instrument, please quote the type number and serial number as given on the type plate.

Printed in Sweden

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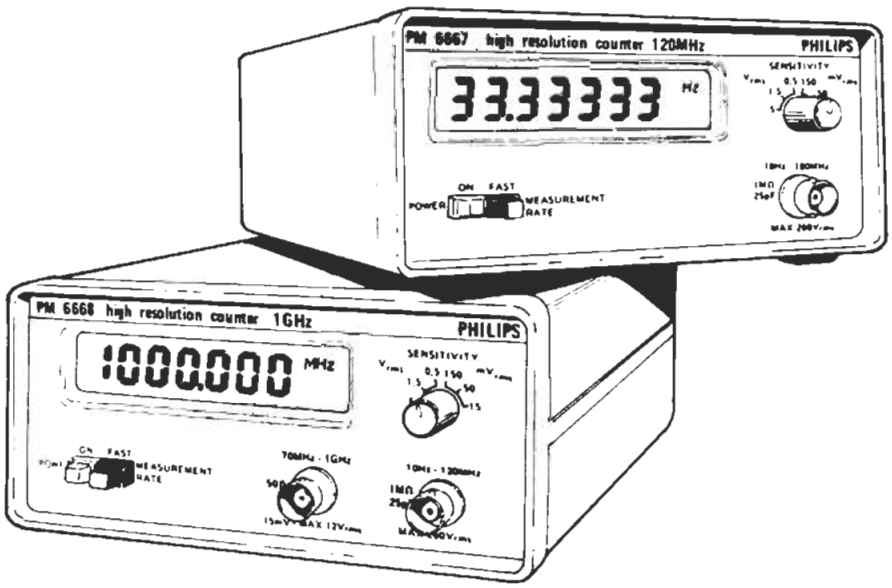
Instruction manual



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1. Introduction

The PM 6667 and PM 6668 are microcomputer based frequency counters, spanning a frequency range of 10 Hz ... 120 MHz (PM 6667) and 10 Hz ... 1 GHz (PM 6668).

The use of the microcomputer allows a new approach in frequency measurements, that eliminates the traditional ±1 cycle error. By making a multiple period measurement and computing the reciprocal value, these counters perform high resolution frequency measurements on low frequency signals.

Another microcomputer feature in these counters is the automatic range selection. The measuring result is always displayed with maximum resolution without overflow and with proper indication of Hz, kHz, MHz and decimal point.

There is choice between two measurement rates; NORMAL with 7-digits resolution every second or FAST with 6 or 7-digits resolution every 200 ms. The fast mode is used for measuring changing frequencies as with tuning.

The following options are available: a more stable time base version with TCXO (/02 version), a rechargeable battery unit PM 9601 that can be mounted inside the counter, an impact resistant (ABS) protective carrying case PM 9602 and a 19" rack/panel mount adapter PM 9603.

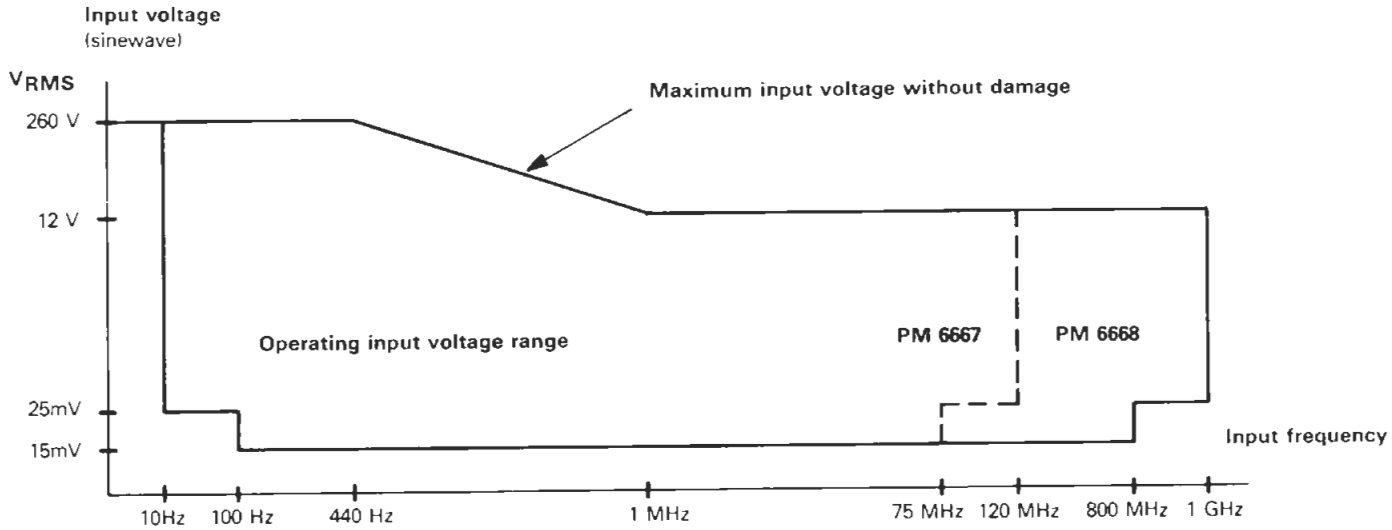
The 7-digit liquid crystal (LCD) display contains also the unit and decimal-point indicators.

After you switch on the counter, a self test is executed. Should an error be detected, it is shown on the display by a diagnostic code.

WARNING

Before connecting the instrument to the line voltage, read the safety regulations on page 5.

2. Technical specification



Frequency range

PM 6667: 10Hz .. . 120MHz
PM 6668: 10Hz ... 1GHz

Input sensitivity

(in $15mV_{RMS}$ position)

LF-input: $15mV_{RMS}$ sinewave; 100Hz ... 75MHz

$25mV_{RMS}$ sinewave; 10Hz ... 120MHz

$45mV_{p-p}$ for pulses with a pulse duration of ⩾ 7ns

RF-input: *(PM 6668 only)*

$15mV_{RMS}$ sinewave; 70MHz ... 800MHz

$25mV_{RMS}$ sinewave; 800MHz ... 1GHz

(see input voltage characteristics)

Input attenuation

LF-input: x 1 to x 300 in 6 positions
RF-input: automatic attenuation

Trigger level

A fixed (+, 0 or −) voltage is automatically applied to ensure proper triggering on any waveform and duty cycle.

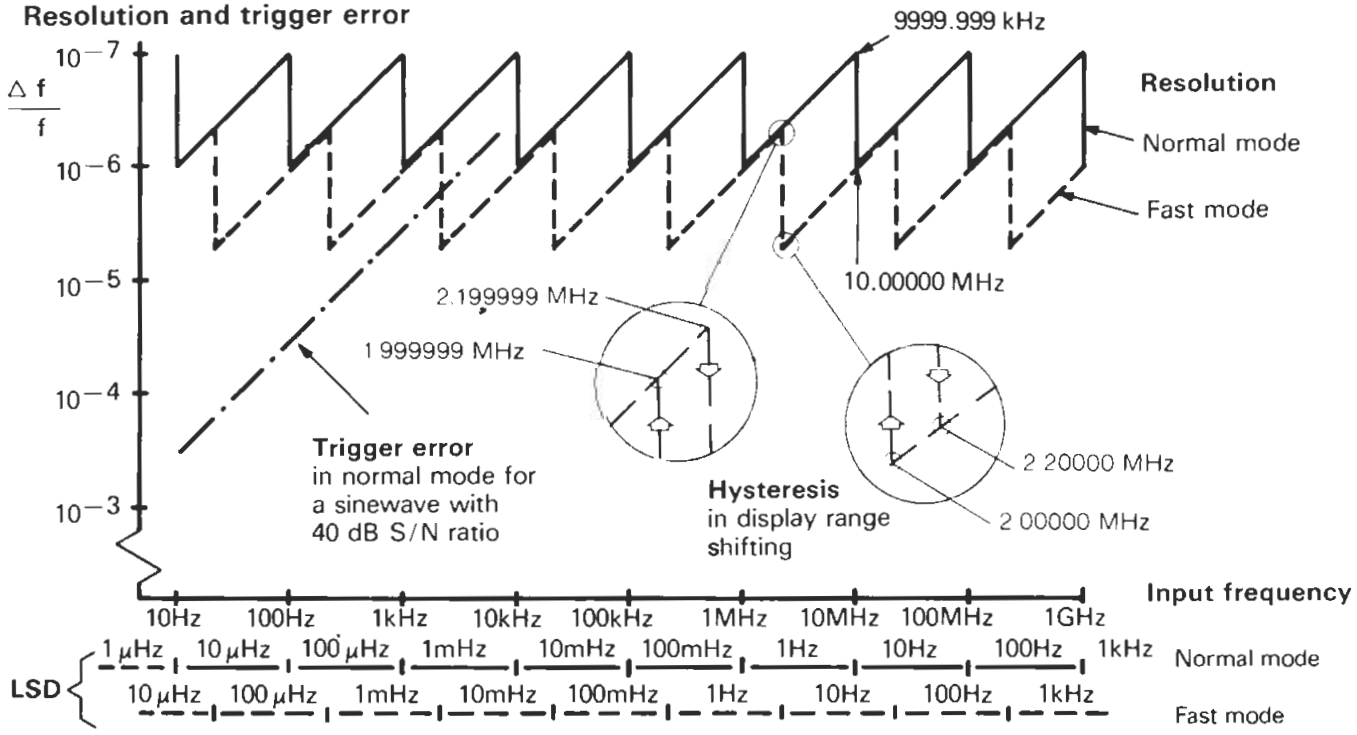
Coupling: AC

Input impedance

LF-input: 1MΩ// ≈ 25pF
RF-input: 50Ω nominal with VSWR < 2 (PM 6668 only)

Max. input voltage without damage

DC: 300V
AC: $260V_{RMS}$ at ⩽ 440Hz, falling to $12V_{RMS}$ at 1 MHz (see input voltage characteristics above)



Measurement rate

Normal, (out): approx 1 measurement/s
Fast, (in): approx 5 measurements/s; at frequencies below 100Hz, the measurement rate gradually slows down to one measurement per second to reduce the trigger error influence.

Display

7 digits, 11.5 mm, liquid crystal display with unit indication of Hz, kHz, MHz and LO BAT.

Inaccuracy (relative frequency error)

$$\pm \frac{\text{LSD}}{\text{input frequency}} \pm \text{rel. trigger error} \pm \text{time base error}$$

Rel. trigger error:

For any waveshape:

$$\frac{\text{Measurement rate}}{\text{Signal slope (V/s)}} \times \text{peak-to-peak noise voltage}$$

For sinewaves:

$$\frac{\text{Measurement rate}}{\text{Input frequency} \times \pi \times \text{S/N ratio}}$$

Example: for S/N ratio of 100 (40dB) and sample rate of 1 measurement/s, the trigger error is

$$\frac{3 \times 10^{-3}}{\text{input frequency}}$$

Resolution

For the least significant digit (LSD) and relative resolution see graph above

Ext. reference input

Frequency: 10MHz
Input voltage range: $0.5V_{RMS}$...$12V_{RMS}$
Input impedance: approx. 2kΩ

Power requirements

115/230V, ±15%, 50 ... 60Hz; 15VA or by built-in optional battery pack PM 9601 or by external 12V battery.

Time base characteristics

Time base version	/01 (standard)	/02 (TCXO)
X-tal frequency	10MHz	10MHz
Ageing	$\leq 5 \times 10^{-7}$/month	$\leq 1 \times 10^{-7}$/month
Temperature stability		
0 ... 50°C, ref. to +25°C	$\leq 1 \times 10^{-5}$	$\leq 1 \times 10^{-6}$
20 ... 30°C, ref. to +25°C	$\leq 3 \times 10^{-6}$ (typical)	$\leq 3 \times 10^{-7}$ (typical)

Safety

According to IEC 348 and CSA 556 B.

Line interference

Below class II CENELEC/CISPR

Dimensions and weight

Width: 160 mm (6,3 in)
Height: 77 mm (3 in)
Depth: 180 mm (7,1 in)
Weight: 1,2 kg (2,6 lb)

Environmental conditions

Temperature:

Storage:	−40°C ... +70°C
Operating:	0°C ... +45°C

Altitude/barometer pressure:

Storage: 15000 m (50000ft) /15.2kN/m²
Operating: 5000 m (15000 ft) /53.3kN/m²

Humidity:

10% ... 90% RH, (26°C dew point)

Vibration test: according IEC 68 Fc
Bump test: according IEC 68 Eb
Handling test: according IEC 68 Ec
Transport test: according NLN - L88

3. Accessories

3.1. Standard accessories
(Supplied with the instrument)

- Line power cord.
- Instruction manual.

3.2. Optional accessories
(To be ordered separately)

- PM 9601 Battery unit.
- PM 9602 Carrying case.
- PM 9603 19" rack/panel mount adapter.
- PM 9665 B 50kHz low pass filter, BNC–BNC.
- PM 9236 15 MHz, 10 M ohm attenuator probe set.
- PM 8935 250MHz, 10 M ohm attenuator probe set.
- Battery jack (see section 5 and 7.5 in this manual).

4. Battery unit PM 9601

4.1. General information

The PM 9601 is a rechargeable battery unit for inside mounting in the counters PM 6667 and PM 6668.

The unit contains a standard 6V, sealed battery of solid gel lead acid type. It further contains the charging and overcharge protection circuitry.

The battery unit is fixed with four screws in the metal innerframe of the cabinet (see the installation instructions).

The battery is of a standard type and is available from variety of battery manufacturers. To obtain spare batteries, contact directly your battery supplier who stores fresh and fully charged batteries:

Manufacturer	Country of origin	Type	Capacity
Sonnenschein*	W-Germany	3GX3S	3 Ah
Varta*	W-Germany	Accu Pb30704063	3 Ah
Gold Gelyte	USA	Pb 626-1	2.6 Ah
Elpower	USA	Ep 626A-6	2.6 Ah
SAFT*	France	PA 601	4 Ah
Kono	Japan	6-26k	2.6 Ah

* recommended brand

WARNING

The capacity of rechargeable batteries degrades when the batteries are not used or recharged frequently. Read therefore carefully the instructions for storage!

4.2. Recharging

The battery is automatically recharged when the counter is connected to the line voltage and the power switch is in OFF position.

When "LO BAT" is indicated on the display, about 15 minutes of operation remain before recharging is needed.

The counter automatically switches over to internal battery supply if line voltage fails.

To prevent unwanted discharging of the batteries when the counter is not used, always use the power switch to turn off the counter, not the line power cord.

Recharging time (typical at 20°C) 10h to 90% of full capacity, 5h to 70% of full capacity.

4.3. Storing

Avoid storage of completely discharged batteries.

When the instrument is not in use, set power switch in OFF position but keep the instrument connected to the line voltage. The battery will then be kept fully charged and always ready for use. If the instrument can not be connected to the line voltage or when the battery pack is stored outside the instrument, recharging during 5 to 10h every 3 months is recommended.

If longer storage periods are needed, remove the fuse in the battery unit and store the battery cool and dry.

WARNING

Permanent use and storage at high temperatures adversely affects the life of the battery.

Prolonged storage and operation above +40°C and charging above +35°C should be avoided.

For storage at –40°C, the battery must be charged to at least 75% of its full capacity.

Other environmental conditions are the same as for the main instrument.

Additional weight for battery pack: 0.75 kg.

Fuse: 1.6A fast action.

5. External battery

An external 12V battery can be used to power the counter. Replace rear BNC connector by a battery jack as described in section 7.5. of this manual.

NOTE

The battery jack including the plug can be obtained free of charge from:

Philips Elektronikindustrier AB
Div. I
Supply Center
S-175 88 JÄRFÄLLA
Sweden

Please indicate the type number and the serial number of your instrument.

6. Safety regulations

(in accordance with IEC 348)

Before connecting the instrument to the line voltage, visually check the cabinet, controls and connectors etc. to ascertain that no damage has occured in transit.

If any defects are apparent, do not connect instrument to the mains (line). The instrument must be disconnected from all voltage sources, and any high voltage points discharged before any maintenance or repair work is carried out.

If adjustments or maintenance of the operating instrument with covers removed is inevitable, it must be carried out only by a skilled person who is aware of the hazard involved.

NOTE

All parts on the primary side of the transformer are CSA approved and should be replaced only by original parts.

7. Installation

7.1. Line connection

Before connecting the instrument to the line, make sure it is set to the local line voltage. On delivery, the instrument is set to 115V or 230V ±15%, which is indicated on the rear of the instrument. If the instrument has to be set to another voltage than indicated, contact your local service organization.
The service manual contains setting instructions.

7.2. Grounding

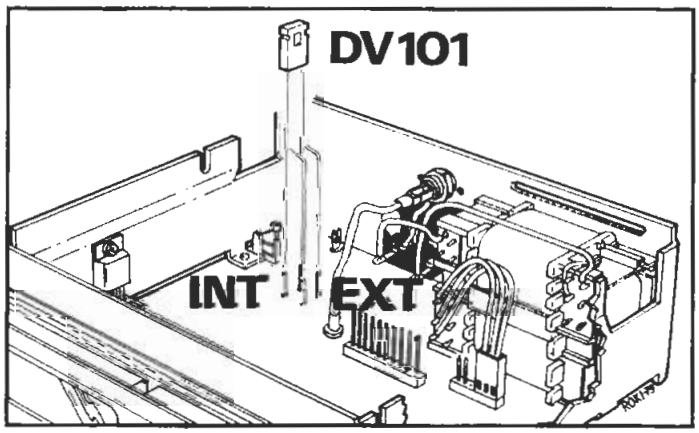
The instrument is grounded via the three-core line power cord plugged into an outlet with protective ground contact.

No other way of safety grounding is allowed.

7.3. Internal and external standard

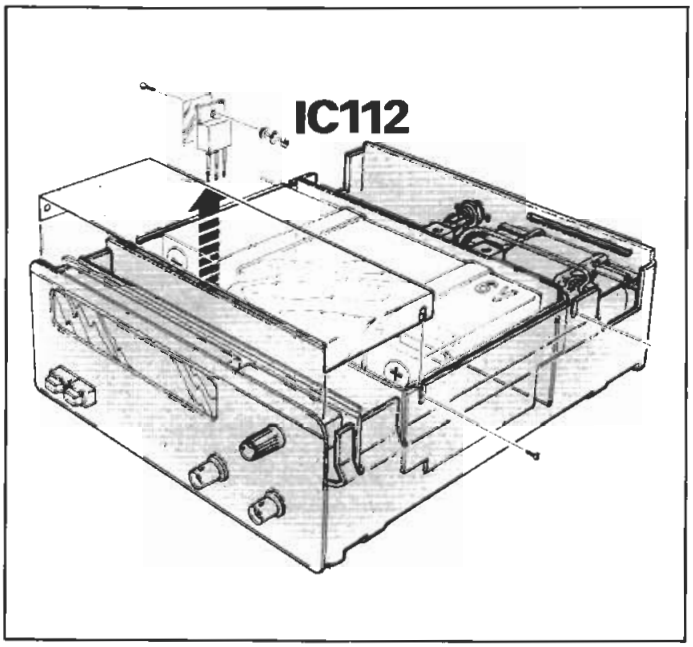
The counter can be set to external or internal standard by setting the jumper connector DV 101 as shown in the figure below.

At delivery the counter is set to internal standard.



7.4. Internal battery unit PM 9601

- Remove housing of counter.
- Remove the upper screening plate.
- Remove +5V regulator IC 112 (see figure below).
- Place battery unit as shown in figure below. Keep wires from battery to p.c. board along the edges of the battery.
- Mount the new screening plate as shown in figure below and secure it to the sidewalls of the counter with 2 screws.
- Secure unit with screws to sidewalls of counter.



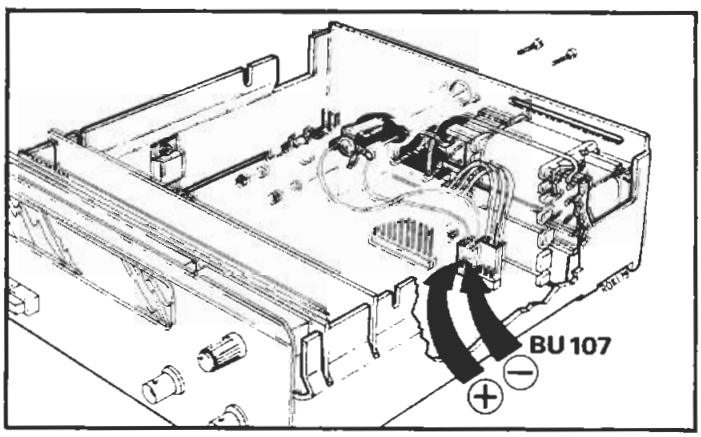
7.5. External Battery Jack

The rear BNC connector for External Standard can be replaced by a battery jack for External Battery supply. The jack fits to DIN 45323.

Proceed as follows to change from BNC connector to battery jack:

- Loosen coaxial cable from p.c. board and unsolder central lead from BNC connector.
- Replace BNC connector with battery jack and connect the two-pole connector so it fits the polarity of your battery plug. See figure below.

The two pins connector (p/o BU 107) is diode-protected to prevent damage if the input polarity is shifted.



8. Controls & connectors

POWER ON

Turns counter on/off. CAUTION: This is a secondary power switch. Even in the POWER OFF position, the counter contains live conductors and parts. The line cord has to be removed to fully unpower the counter.

In case of line power failure the counter automatically switches over to battery supply.

MEASUREMENT RATE

Sets measurement rate to one of two speeds. NORMAL (released) or FAST (depressed).

NORMAL rate means about 1 measurement/s and FAST rate about 5 measurements/s. The measurement rate in the FAST position will be reduced at lower frequencies down to about 1 measurement/s at 10Hz.

SENSITIVITY

Sets input sensitivity in 6 steps from 15mV$_{RMS}$ to 5 V$_{RMS}$.

NOTE: to reduce the influence from noise and interference, never set to higher sensitivity than necessary.

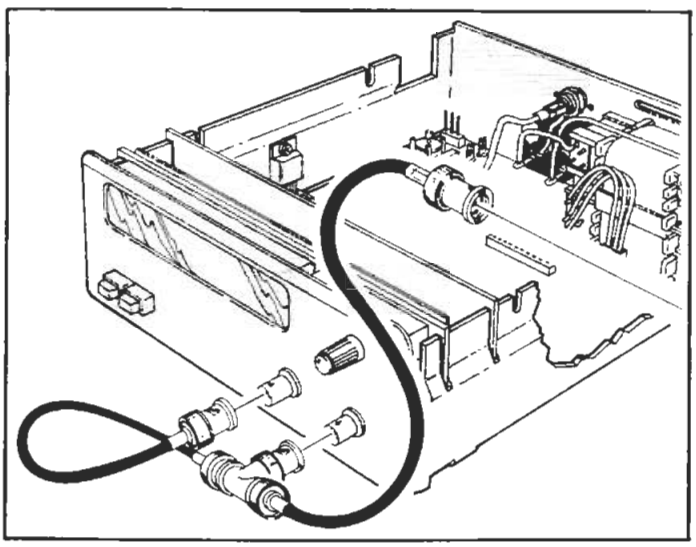
LF input

A high-ohmic (1Mohm), AC-coupled input for signals with frequencies from 10Hz to 120MHz. An **auto-trigger** circuit ensures correct triggering on both sinewaves and pulses with any duty factor.

RF input (PM 6668 only)

A low-ohmic (50 ohm), AC-coupled input for sinewave signals with frequencies from 70MHz to 1GHz.

The microcomputer of the counter detects the presence of an RF signal and selects this input automatically when the input frequency is high enough for counting. This makes it possible to connect the same signal to both inputs via a T-piece. See figure below.



The counter will then switch automatically between the two inputs when the signal frequency is changing, e.g. when measuring a frequency sweep.

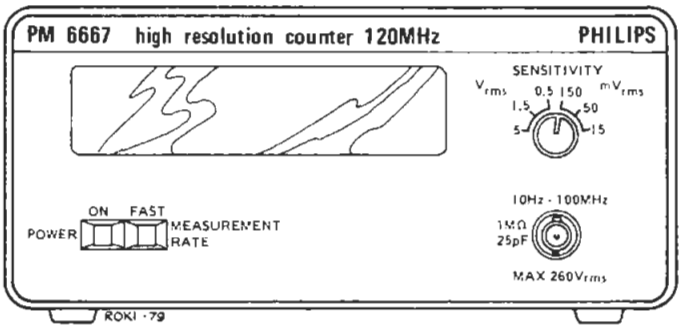
More information on the input signal is given in the Technical Specifications.

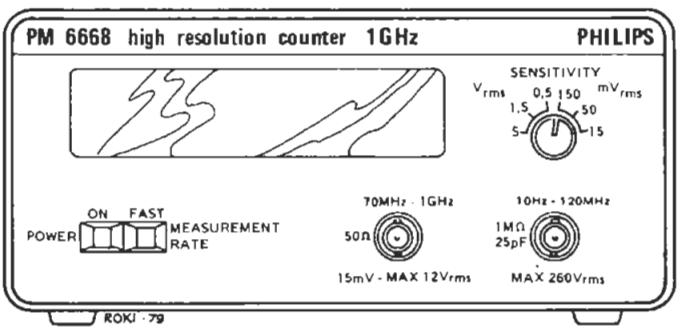
EXTERNAL STANDARD or BATTERY

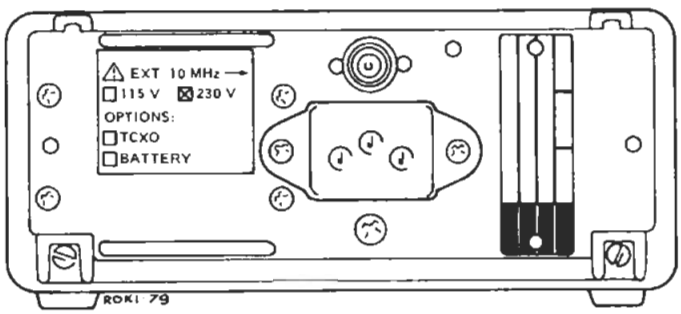
BNC input for external time base standard or, as optional extra, battery jack for external battery.

Line voltage receptacle

Input for line voltage. Always use the three-core line power cord supplied with the counter.







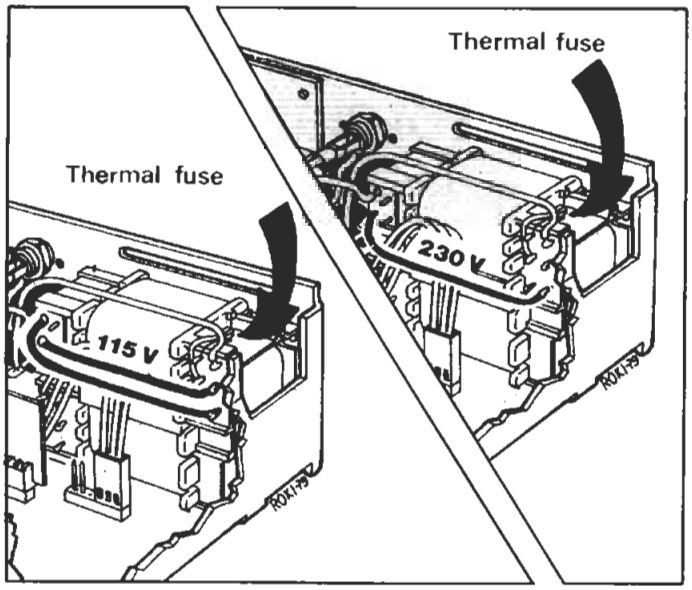
Service part

Service part

9. Line voltage setting

The instrument can be set to 115 V or 230 V. On delivery, the instrument is set to the line voltage as indicated at the rear of the instrument.

The instrument is protected by a thermal fuse located in the line transformer.



10. Technical description

10.1. Principles of the computing reciprocal counter

Fig 10.1 and 10.2 illustrate the difference between a conventional counter and a computing reciprocal counter.

In the conventional counter the input cycles are totalized in the decimal counting unit during a well defined time, the gate time e.g. 1 s or 0.1 s.

With a high frequency at input, more counts are accumulated than with a low frequency and hence the realtive resolution will increase with increased frequency.

The computing reciprocal counter, however, has two counting registers, one totalizing the number of input cycles (Event counter) and the other one (Time counter) totalizes, during the same time, the number of 10 MHz cycles from the reference oscillator.

The correct frequency is then computed by the microcomputer (μC) as $f_{displayed} = \frac{\text{Event counts}}{\text{Time counts} \times 10^{-7}}$

The resolution is depending on the 10 MHz clock frequency together with the measuring time, and in PM 6667 and PM 6668 this means a resolution of ±1 Hz in 10 MHz (i.e. a relative resolution of 10^{-7}) with measurement rate in normal mode (1 s measuring time).

Conventional frequency counter

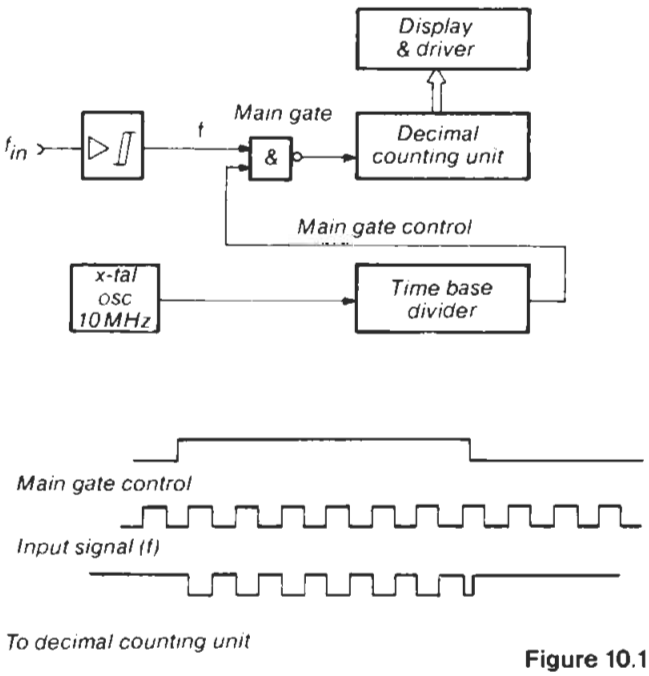


Figure 10.1.

Computing reciprocal counter

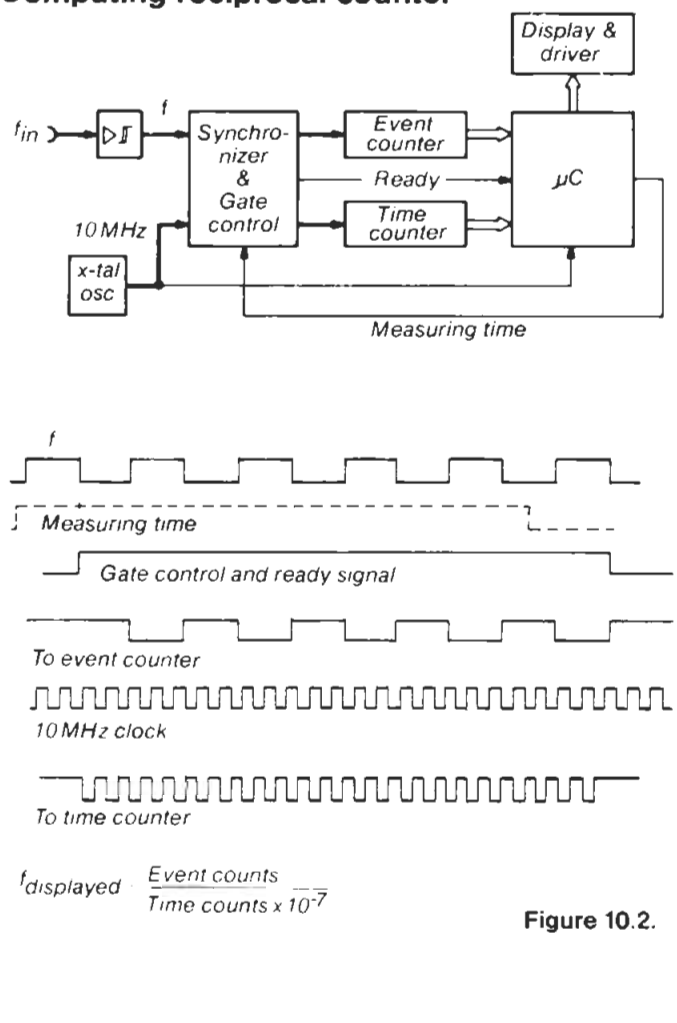


Figure 10.2.

The resolution is hence not affected by the fact that the input signal is prescaled before being gated in the main gate.

The traditional ± one count error will be only one cycle of the 10 MHz reference frequency since the signal to be measured is controlling the main gate (just like in a conventional period measurement).

10.2. Block diagram description

See figure 10.3.

In PM 6667 and PM 6668 the LF input frequency is first divided by 10 before the gating takes place. In the RF input (PM 6668 only) the division factor is 256.

This, however, does not influence the measurement resolution of $\frac{10^{-7}}{\text{measuring time (s)}}$

These dividers are actually parts of the period averaging and are compensated for by the µC.

The LF input circuit contains a traditional FET input circuit and a 6-position step attenuator. Next, a special patented AUTO TRIGGER circuit takes care of all possible duty factors and polarities. The AUTO TRIGGER circuit automatically offsets the trigger circuit to compensate for the DC offset caused by variations in the duty factor of the input signal. The principle of function of the AUTO TRIGGER circuit is illustrated in figures 10.4.

Two Schmitt triggers "A" and "B" (fig. 10.4) are used in the trigger circuit. "A" has a zero-offset hysteresis band. "B" has two locations of the hysteresis band, B_{HI} and B_{LO}. The offset of the hysteresis band (B_{HI} or B_{LO}) is controlled by the output state of Schmitt trigger A.

Assuming that the hystereses offset is B_{LO} and the input signal intersects point (1), the output of trigger "A" goes high. This makes that the hysteresis band will be offset to position B_{HI}. The subsequent pulses will then trigger the Schmitt trigger B correctly at points (2), (3) and (4) etc.

The first pulse in the pulse train is, as we see, used to correct the offset of Schmitt trigger B if that is necessary due to a wrong position of the offset in the initial state.

At negative polarity of the input signal the triggering sequence is the same but hysteresis band B_{LO} is now used. At cross-over point (7), trigger "B" will switch over to B_{LO}. The Schmitt trigger B will then trigger at points (8), (9) and (10) etc.

At symmetrical input waveforms the Schmitt triggers will operate as shown in fig. 10.4.

The central part of the counter is the microcomputer (µC). It controls the SYNCHRONIZER & GATE CONTROL by the "measuring time"-signal. When this signal goes high the next input cycle opens the input gates (synchronous with the input signal). After elapsed measuring time the next input cycle will close the input gates (again synchronous with the input signal).

The counting registers incorporated in the µC are used for the main part of the TIME COUNTER. However, the 8-bit counter outside the µC forms the fastest part.

The EVENT COUNTER consists of a 2-bit binary counter followed by two quad decades forming an 8-decade counter.

The driving circuitry for the liquid crystal display (LCD) is based upon a special driving circuit. Three such circuits are used as serial to parallel converters. The display information is transmitted on one line and is then stored in the shift registers of the LCD driver. The driver also contains the necessary oscillator and driver systems to drive the LCD in a proper AC mode.

The LCD contains 7 digits, 11.5 mm high, decimal point and unit indications.

The HF input of the PM 6668 has a PIN diode arrangement to attenuate high amplitudes and to provide also an overload protection. The integrated amplifier (similar to the amplifier at the LF-input) is followed by a detector and the divide-by-256 circuit. The DC output from the detector is fed to a comparator, which generates an output signal "HF disable" to the µC. The µC generates a return signal "LF enable" which is high if no HF signal is present. When the frequency of the HF signal is high enough, the "LF enable" signal goes low, enabling the HF channel. Hence, the HF signal will be counted automatically if it is availavle simultaneously with an LF signal.

Both counter models operate from a single 5 V power supply. An optional built-in battery supply is available.

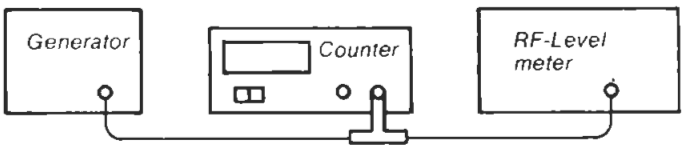
11. Performance check

11.1. Test equipment

- 1 RF-millivoltmeter or a 50 ohm input oscilloscope or any other level meter ranging up to 120 MHz for PM 6667 and to 1 GHz for PM 6668.
- Sinewave generator with a 50 ohm output 10 Hz . . . 120 MHz (PM 6667), 10 Hz . . . 1 GHz (PM 6668).
- 1 BNC T-piece.
- 3 Coaxial cables with 50 ohm impedance.

11.2. Low frequency input

(1 M ohm)

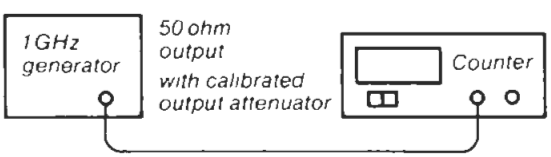


Use as short cables as possible!

- Set the sinewave generator to a voltage of 15 mV_{RMS} and with a sensitivity setting on the counter of 15 mV_{RMS}. Check that counter correctly displays any value in the range 100 Hz . . . 75 MHz.
- Adjust sinewave generator output to 25 mV and check that counter displays correct values at 10 Hz and at 120 MHz.

11.3. High frequency input

(50 ohm, PM 6668 only)



- Set signal generator to a voltage of 15 mV_{RMS} (-24 dB) and check that counter correctly displays any value in the range 70 MHz . . . 800 MHz.
- Set the generator output to 25 mV_{RMS} (-19 dB) and check that counter displays correct value at 1 GHz.

Block diagram PM 6667 and PM 6668

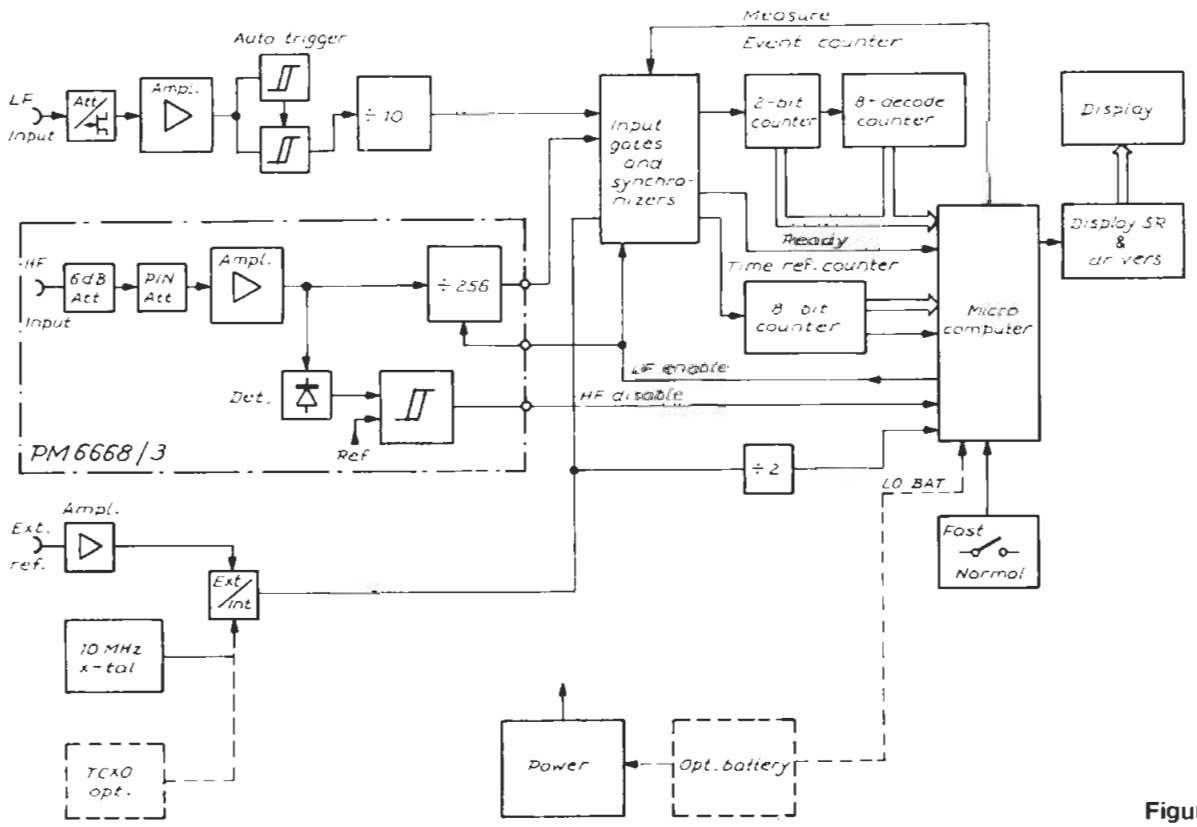


Figure 10.3.

Auto trigger operation

(patented)

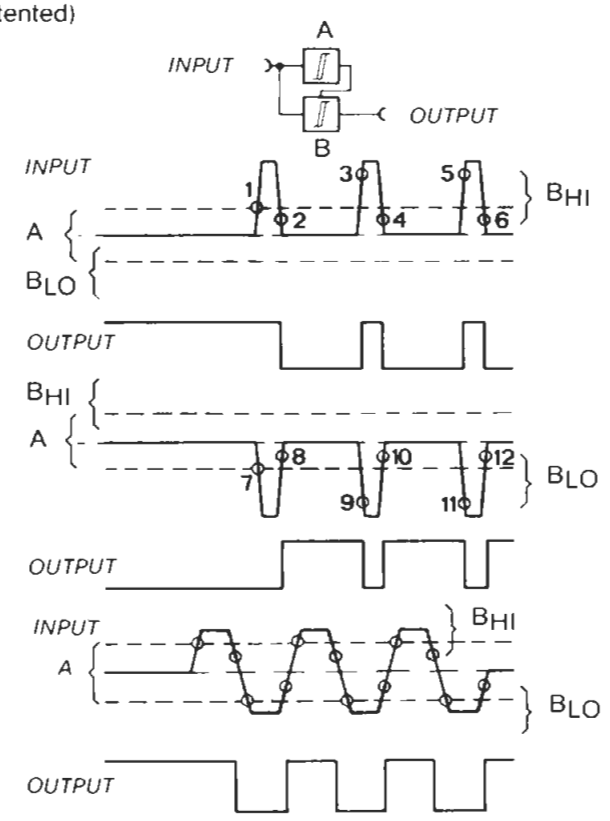


Figure 10.4.

Traditional trigger operation

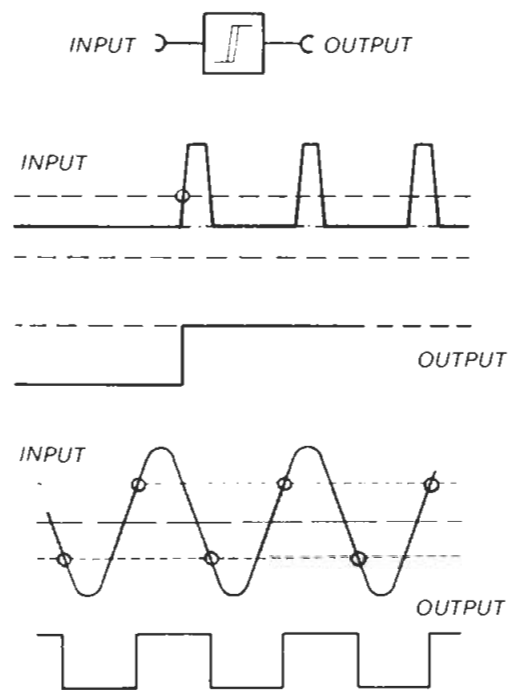


Figure 10.5.

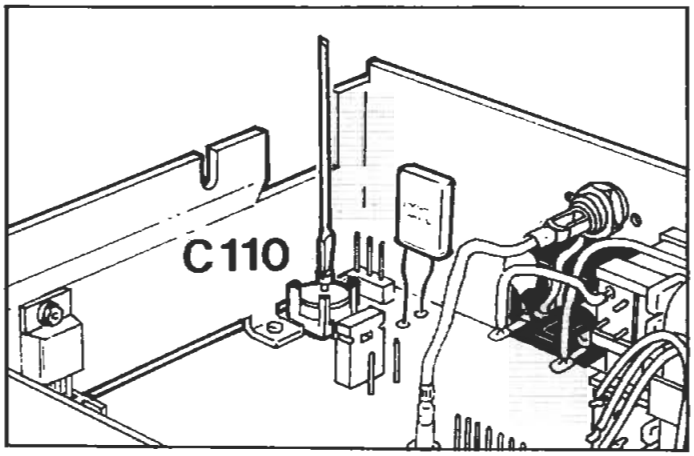
12. Adjustments

12.1. Frequency adjustment of standard oscillator (Models PM 6667/01, PM 6668/01)

Equipment required:
10MHz reference signal, inaccuracy $\leq 1 \times 10^{-6}$

Note: adjustment should preferably be made at an ambient temperature of +25°C (+77°F) after 1h warm up.

- Remove housing.
- Connect reference signal to LF input.
- Adjust C110 to read 10MHz ±10Hz on display.

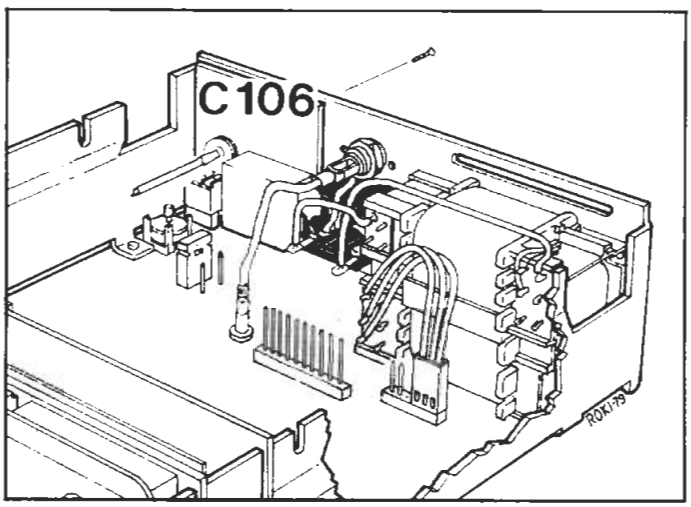


12.2. Frequency adjustment of TCXO
(Models PM 6667/02, PM 6668/02)

Equipment required:
10MHz reference signal, inaccuracy $\leq 1 \times 10^{-7}$.

Note: adjustment should preferably be made at an ambient temperature of +25°C (+77°F) after 1h warm up.

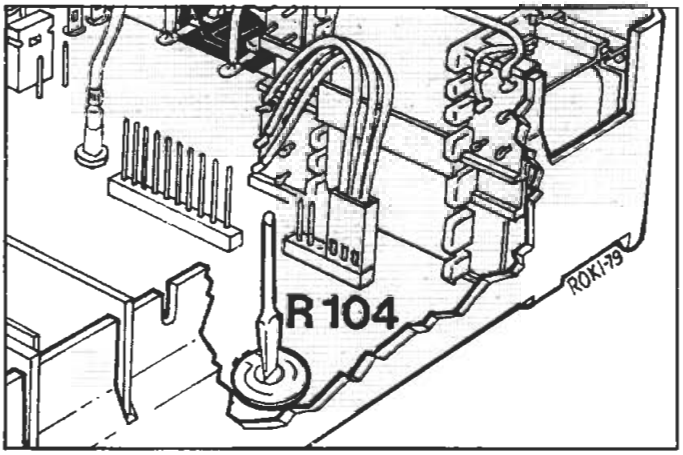
- Remove housing.
- Connect reference signal to LF input.
- Adjust C106 to read 9999.999kHz on display.



12.3. DC balance adjustment

Equipment required:
LF sinewave generator and LF oscilloscope.

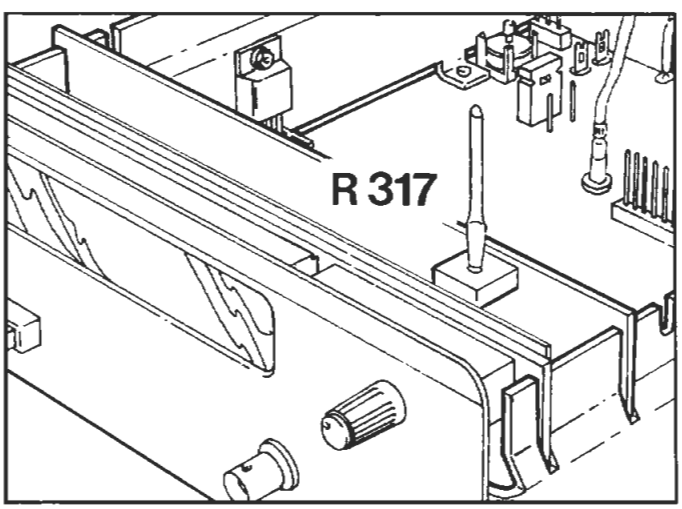
- Connect sinewave generator (set to approx. 1kHz and 30mV$_{RMS}$) to LF input of counter.
- Connect oscilloscope between pin 7 of IC103 and ground.
- Adjust R104 until displayed square-wave has a duty-factor of 0.5.
- Decrease input amplitude to 15mV$_{RMS}$ and fine-adjust R104 for a dutyfactor of 0.5 on oscilloscope display.



12.4. RF enable adjustment (PM 6668 only)

Equipment required: 1GHz signal generator

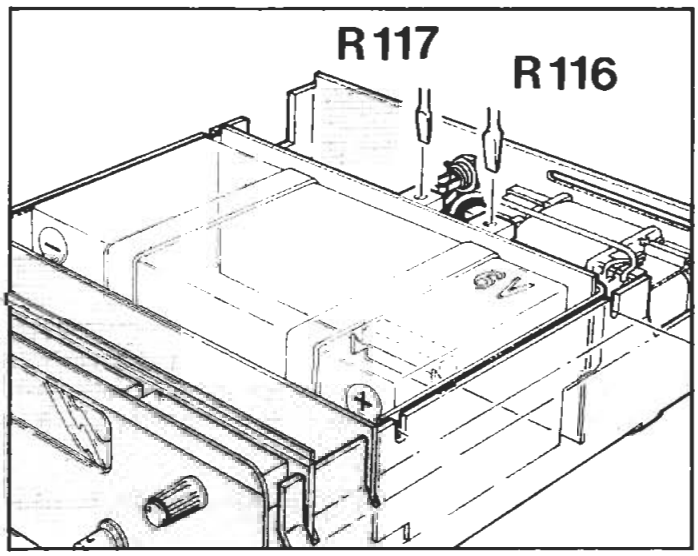
- Connect signal generator to RF input of counter.
- Set signal generator to 70MHz and 15mV$_{RMS}$.
- Check that counter displays a stable 70MHz read-out.
- If there is no read-out, adjust R317.
- Set signal generator to 500MHz and 800MHz. Check read-out at each frequency and adjust R317 if required.
- Set signal generator to 1000MHz, 25mV$_{RMS}$ and check read-out.
- Repeat the procedure and readjust if required.



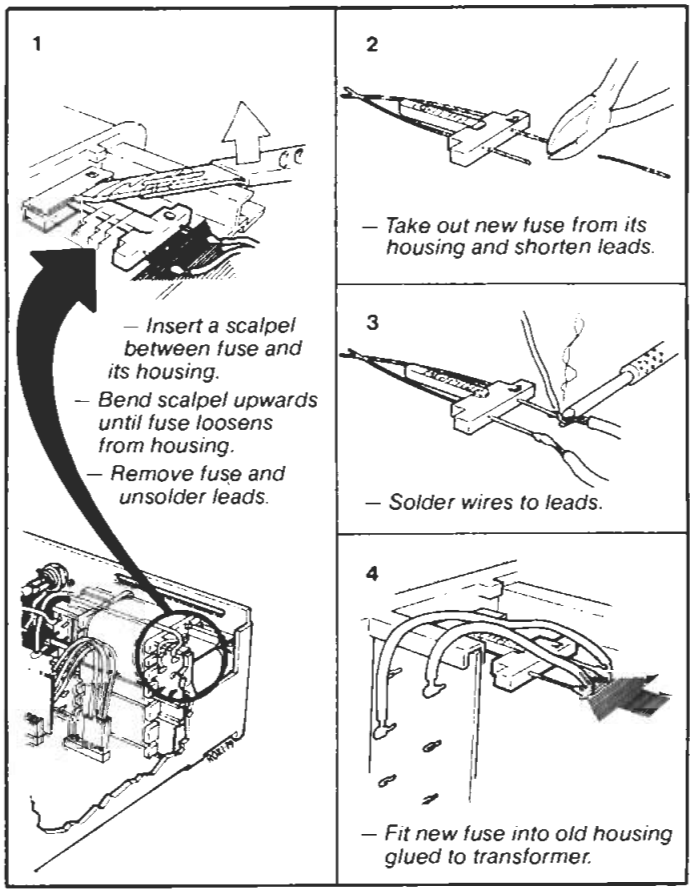
12.5. Battery unit adjustment

Equipment required:
Digital voltmeter

– Connect voltmeter between pin 2 of IC103 and ground.
– Adjust R117 until voltage is +2V ±50mV.
– Remove fuse VL101.
– Connect voltmeter to plus pole of battery and ground and adjust R116 until voltage is +6.9V ±50mV. (at +20 . . . +25°C)
– Reinstall fuse.



13.2. Fuse replacement



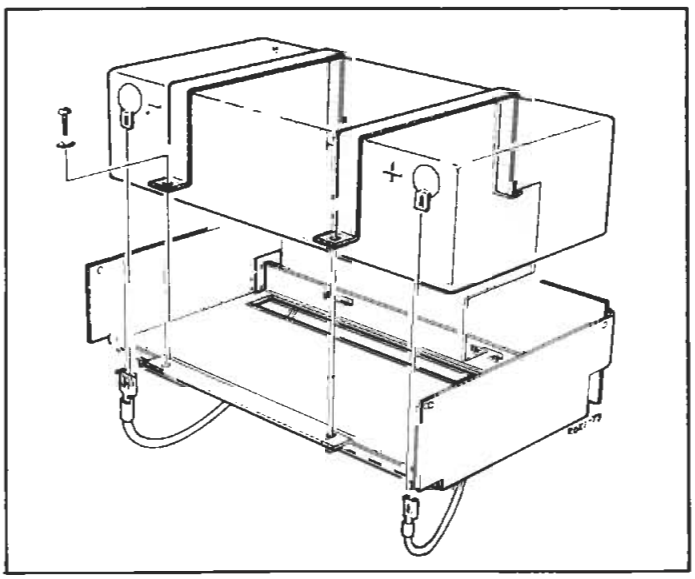
13. Replacing parts

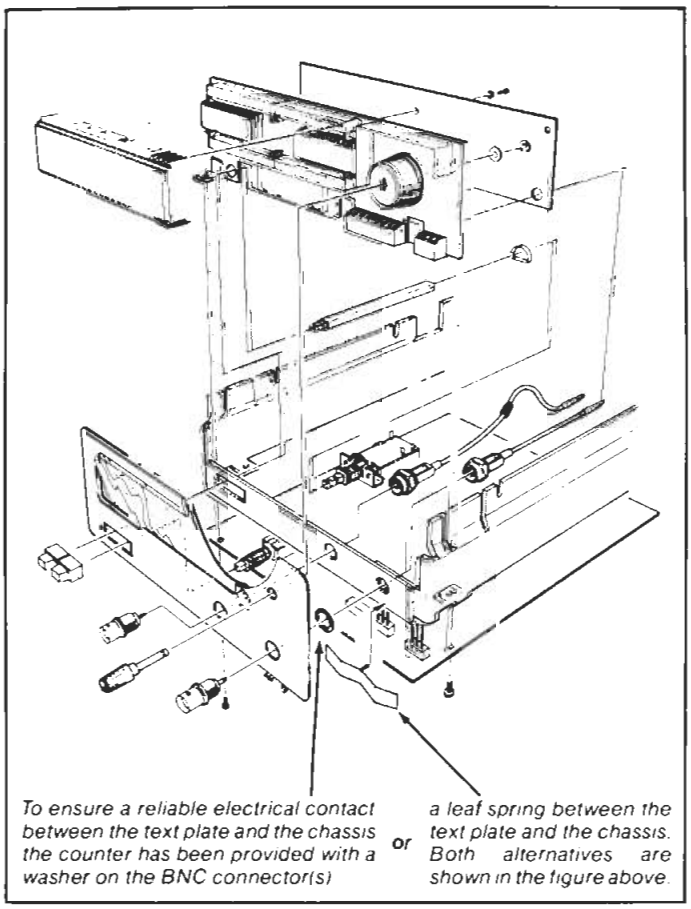
13.1. Battery replacement

– Loosen the four side-wall screws and remove battery unit.
– Remove screws at holding brackets.
– Detach fast-on connectors.
– Pull up battery.

Note: Check that the plus pole of the new battery is at the right-hand side (viewed from battery connector side).

See figure below.





14. Trouble-shooting circuit diagrams and spare parts

General

The PM 6667 and PM 6668 are provided with a built-in self-diagnosis routine that is performed when the counter is switched on. If certain faults are present, this is shown on the display as one of six error codes, i.e. "Error 1" through "Error 6".

The fault-finding diagrams Error 1 . . . 6 make it possible to isolate the fault to the microprocessor, certain IC's or other sources.

"Conventional" faults occurring in, e.g., the power supply or the input circuitry are normally not generating an "Error" indication.

If the counter does not operate properly, switch off the power and then switch on again. Check whether an error code is displayed. If not, trouble-shoot in the conventional way (measure DC voltages, check waveforms etc.). If an error code is displayed, check the relevant diagram.

The "Error" indication can be removed as follows:

- Ensure that an input signal is connected.
- Press or release the MEASUREMENT RATE button once or a couple of times.

Unless the fault has been remedied, the "Error" code is displayed again as soon as the counter has been switched off and then on again.

Self-check at Power On

Once Power On has been switched on, the µC performs a self-check including a diagnosis routine. The self-check consists of three parts:

1 Test of program memory by means of software signature analysis of the µC.

2 Test of data memory.

3 A test that the µC can set the external logic to zero.

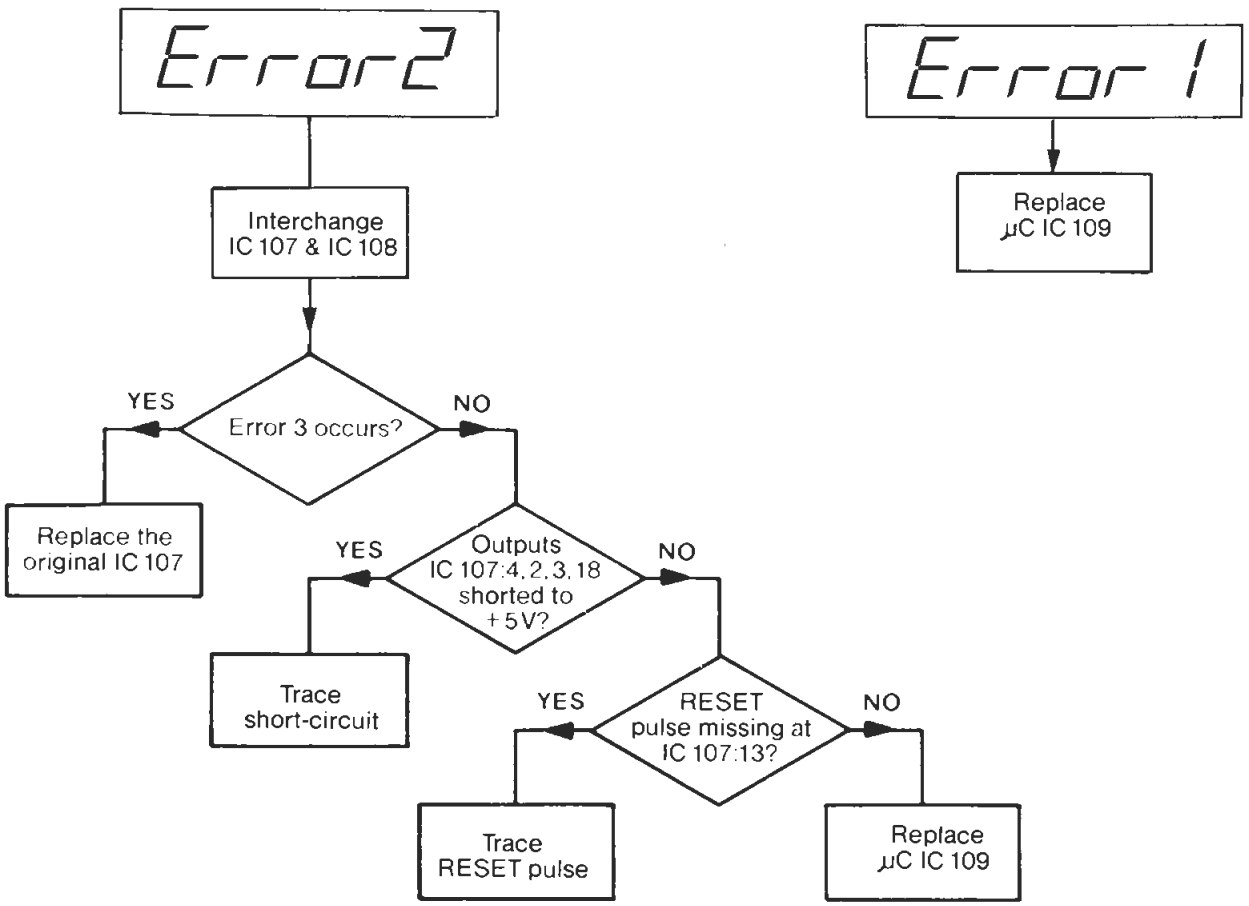
All segments, decimal points and units are visible on the display during the test. This makes it possible for the operator of the counter to check the function of the display.

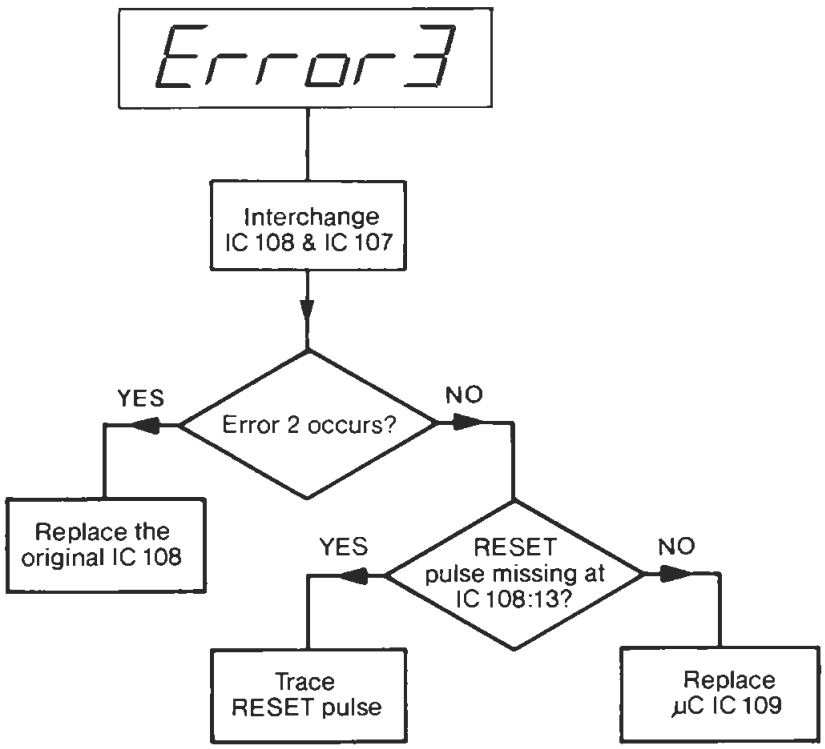
If the test fails during the test of program memory or data memory, the code Error 1 will be displayed.

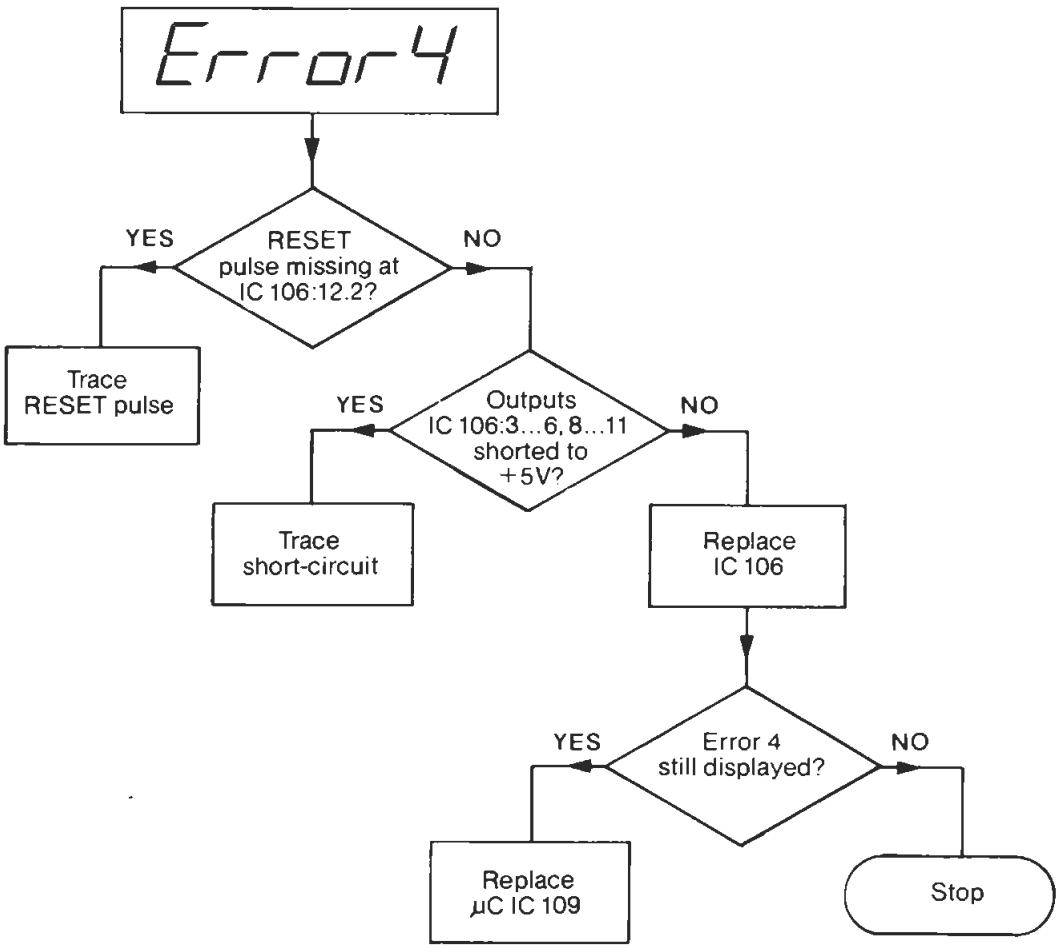
If, however, the test that the µC can set the external logic to zero fails, there will be an Error code between 2 and 6 depending on where the faulty part is.

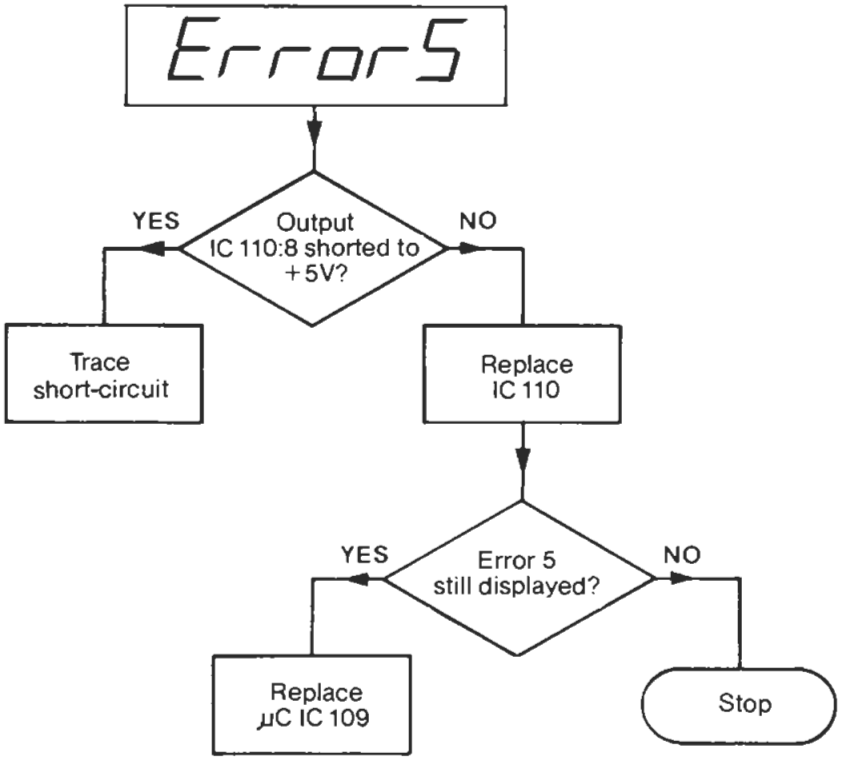
NOTE: The diagrams illustrate the faults that are most likely to occur in the microcomputer circuitry. Other fault combinations may be possible which also generate an "Error" code or a nonsense display read-out.

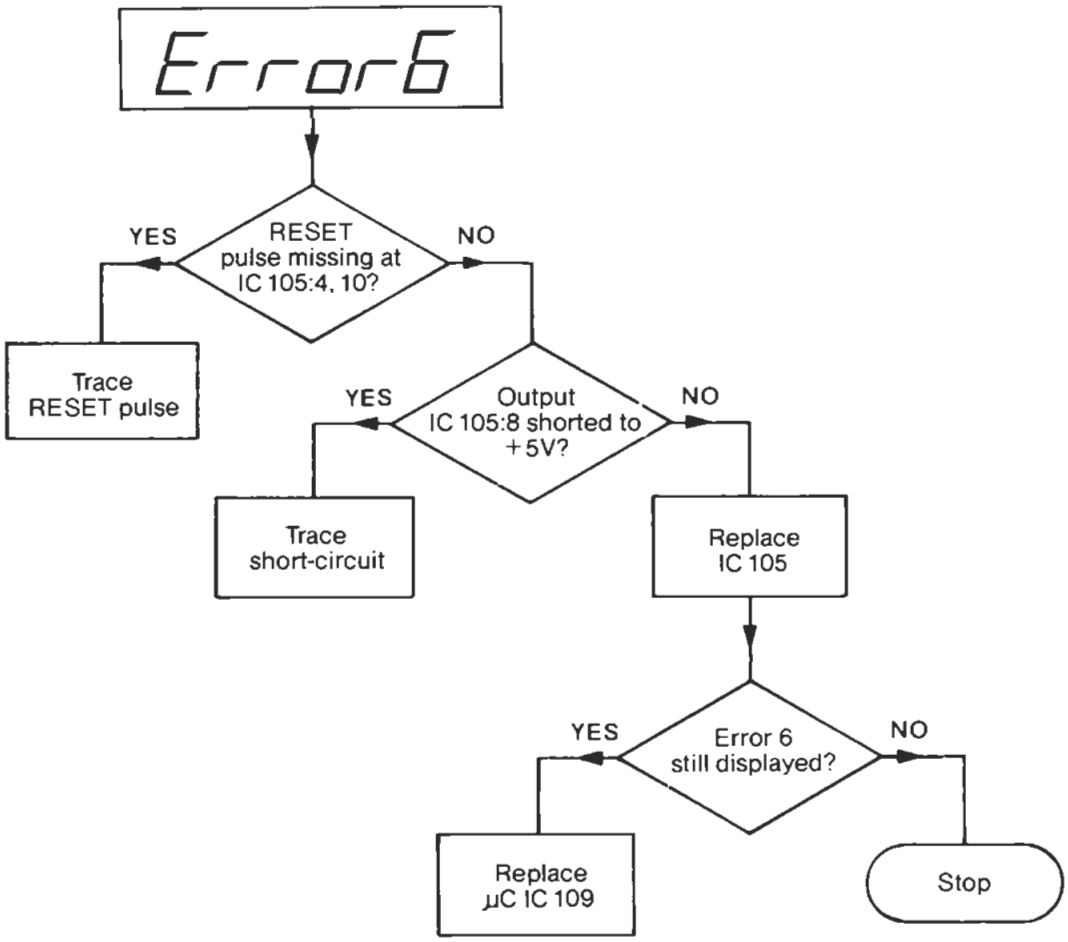
Always check the DC supply voltage before any replacements are made!



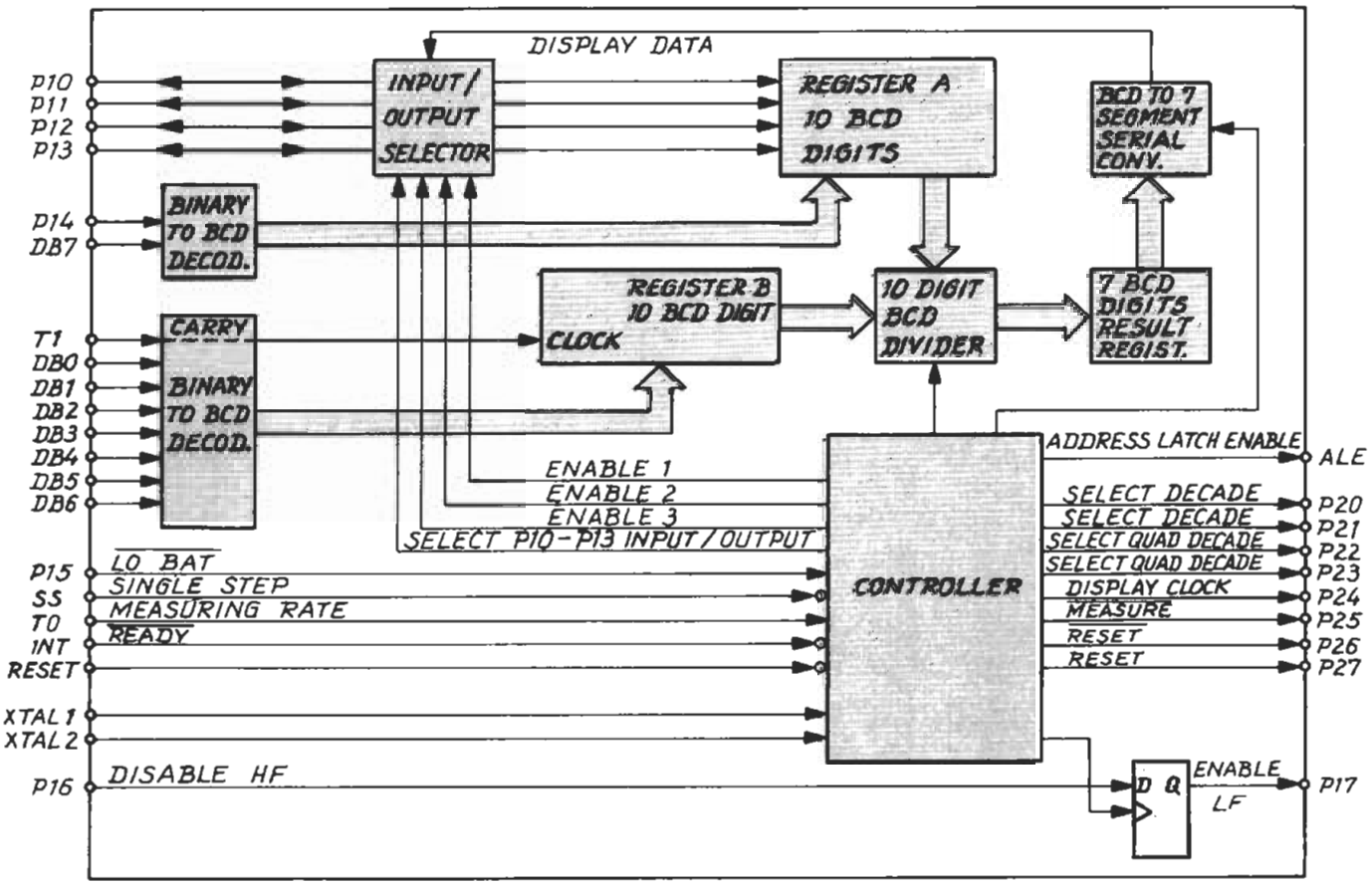

Error 3
Interchange IC 108 & IC 107
Error 2 occurs?
YES
NO
Replace the original IC 108
RESET pulse missing at IC 108:13?
YES
NO
Trace RESET pulse
Replace µC IC 109


Error 4
RESET pulse missing at IC 106:12.2?
YES
NO
Trace RESET pulse
Outputs IC 106:3...6, 8...11 shorted to +5V?
YES
NO
Trace short-circuit
Replace IC 106
Error 4 still displayed?
YES
NO
Replace µC IC 109
Stop


Error 5
Output IC 110:8 shorted to +5V?
YES
NO
Trace short-circuit
Replace IC 110
Error 5 still displayed?
YES
NO
Replace µC IC 109
Stop


Error 6
RESET pulse missing at IC 105:4, 10?
YES
NO
Trace RESET pulse
Output IC 105:8 shorted to +5V?
YES
NO
Trace short-circuit
Replace IC 105
Error 6 still displayed?
YES
NO
Replace µC IC 109
Stop

The Microcomputer



Application block diagram.

How the result is calculated and the presentation is done

By programming the µC with a program that controls measurements, performs calculations and presents the result on the display, the µC has got an application with well specified functions. This application of the 8048 µC is illustrated in the "Application block diagram of the µC". This description is based upon this illustration, the "Functional diagram" and the "Signal path diagram".

The Controller performs all communication of control signals, internally in the µC as well as externally with the rest of the logics in the counter.

The pins P10—P13 can be used both as inputs as well as outputs. The mode in which they shall work is decided by the controller and executed by the "Input/output selector".

After elapsed measuring time the result of the event signal is kept in the Event counter, IC 105, 107, 108 and 110.

The result in the two divide-by-2 counters IC105 and IC110 are transferred to P14 and DB7. It is converted from binary notation to BCD code and stored in "Register A".

The result in the two Quad decades IC107 and IC108 are transferred to the pins P10—P13. The controller sets them to be inputs. The controller also sets the pins P20—P23 so that the uC can read the content in every single decade within each Quad decade. The result is stored in Register A together with the result from the two divide-by-2 counters.

The Timer Counter has two registers. One register with 256 bits, ≈ 2.5 digits, in IC 106 to take care of the 10 MHz signals. The other one in the "10 BCD digit Register B". The carry signal from IC106:8 has a frequency of 10 MHz divided by 256. The carry signal is connected to T1 and is counted and registered in Register B. After elapsed measuring time the result in IC106 is transferred via T1 and DB0—DB6 to the Register B after it has been decoded from binary notation to BCD code in the "Binary to BCD decoder".

The results in Register A and Register B are divided in the "10 digit BCD divider". After this calculation only the 7 most significant digits are stored in the "7 digit result register".

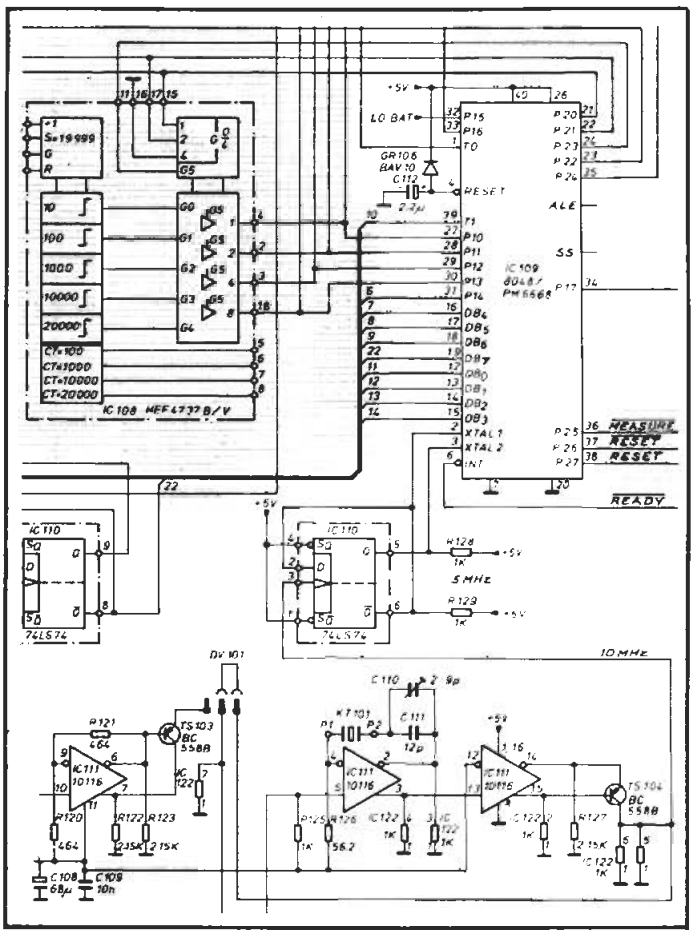
In the "BCD to 7 segment serial converter" the 7 BCD digits are transferred into 7 segment information in serial form. In this block the decimal point, units and LO BAT are added.

Via the "Input/output selector" the pins P10—P13, are set in output mode, the 64 bits display Data signal, the Enable1, 2 and 3 signals are transferred to the display driver circuits IC 201, 202 and 203. To complete the necessary information to the display the controller sends out the "Display clock" signal on port P24.

The µC needs a clock signal

The external clock signal needed for the µC is a 5 MHz signal taken from the 10 MHz reference signal and divided by two in IC 110.

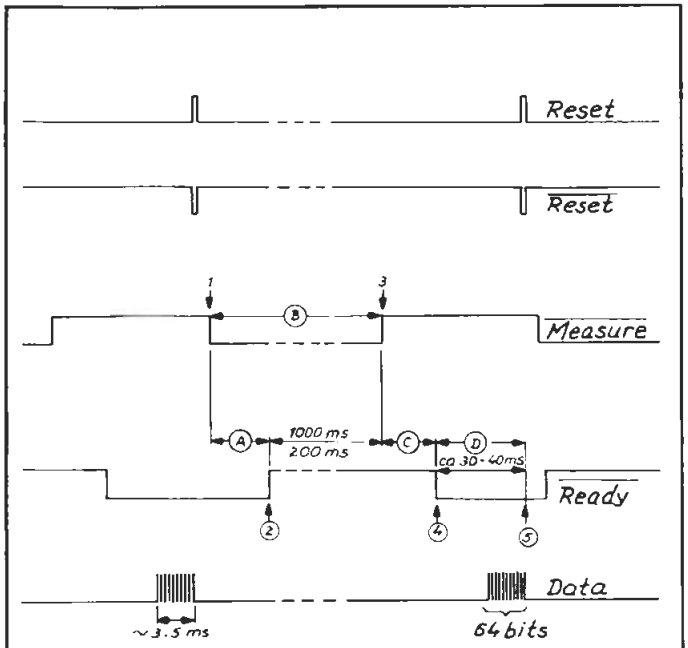
This 5 MHz clock signal has nothing to do with the resolution and accuracy specification but it must always be present to get the µC running. It is important that the internal oscillator is operating since it can not be replaced with an external reference signal. The internal reference oscillator is either a standard crystal oscillator or an optional TCXO.



Five important pins on the µC IC 109

- Check that there is a 5 MHz signal on pin 2 and 3.
- If there is a 5 MHz signal on pin 2 and 3, there should be a 333.3 kHz pulse train on pin 11 having TTL levels.
- If there is no signal on pin 11, check that pin 4 is high.
  After POWER ON has been switched on and the + 5 V supply voltage has reached the + 4.75 V level, the capacitor C 112 will keep pin 4 low (< + 0.8 V) during at least 50 ms.
- If there is no signal on pin 11 and pin 4 is high, check that pin 5 is high.
  This is a single step input that makes the program stop when level is low.

Timing Diagram



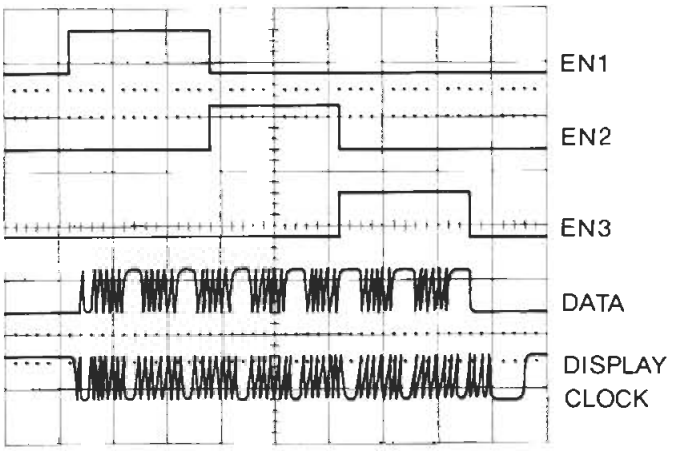
(A) *The time interval between MEASURE goes low and READY goes high is depending on the input frequency. The lower limit is 1 to 2 periods of the input signal. The upper limit is 270 ms.*

(B) *If there is no input signal or the frequency is too low, MEASURE will be low for 270 ms.*

(C) *The time interval between MEASURE goes high and READY goes low is depending on the frequency of the input signal. Maximum is 1.2 s.*

A new measurement cycle starts when $\overline{\text{MEASURE}}$ goes low ①, waiting for an event signal to occur. If no event signal occurs within 270 ms Ⓐ the $\overline{\text{MEASURE}}$ goes high again. During the time $\overline{\text{MEASURE}}$ is low the µC is ready to start a new measurement cycle. If, however, an event signal occurs during the 256 ms waiting time, this will clock $\overline{\text{MEASURE}}$ to be a high $\overline{\text{READY}}$ signal ② at IC 105:2, 3, 6. The time when $\overline{\text{READY}}$ is high is the actual measuring time. During this time event signals are counted in the Event counter and the 10 MHz reference signal is counted by the Time counter. Depending on whether FAST or NORMAL MEASUREMENT RATE is chosen, the µC sets the time for $\overline{\text{MEASURE}}$ to go high ③. The Synchronizer and Gate control ensure that only whole periods of the event signals are counted in the Event counter. The time interval Ⓒ between $\overline{\text{MEASURE}}$ going high ③ and $\overline{\text{READY}}$ going low ④ is therefore depending on the input frequency. The time interval Ⓒ is maximum 1.2 s. The time interval Ⓓ between $\overline{\text{READY}}$ going low ④ and the 64 bits data are transferred to the display ⑤ is the computing time of 30–40 ms. During the computing time the result is calculated and transferred in serial form to the display.

Wrong display read-out



TTL levels 500 µs/div.

Presentation of the zeros on the display.

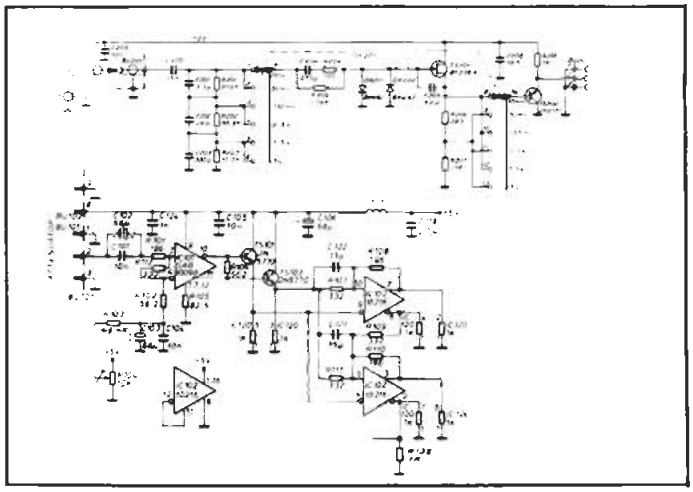
Step 1. Check the Data, Clock and Enable Signals to the Display PCB, according to the photo.

Step 2. If step 1 is correct but there is still no read-out, check the Display PCB.

Step 3. If step 1 is false, check the "Five important pins on the µC".

Step 4. If step 1 and the Display PCB is correct and there is still no significant read-out, the trouble is most likly found in the logic circuits on PCB 1.

Input Amplifier



The input amplifier is divided into two parts on different PCB:s. The input network, the six-step sensitivity control and the impedance converter are located on U2. The amplifier and the auto-trigger are located on U1.

The sensitivity control consists of two parts. One three-step attenuator in the high impedance part and a two-step gain control of the impedance converter TS 201.

IC 101 is an integrated amplifier with fixed gain. The amplification is controlled by means of R 106 and R 112. R 112 is factory selected. To obtain higher amplification equal to more sensitivity, R 106 can be increased. The recommended minimum value of R 106 is 562 Ohms.

TS 101 and TS 102 acts as interface between IC 101 and the auto-trigger.

A description of the Auto Trigger is found in chapter 10.2. Block diagram description.

How to measure on the Liquid Crystal Display

An LCD is working in an AC mode. IC 201, containing the Backplane oscillator, works in a master mode. IC 202 and IC 203 are slaves. The frequency of the Backplane oscillator is set to approximately 60 Hz by C 207.

As long as the segments are not visible the segment input and the back-plane are oscillating in the same phase and with the same frequency. When, however, the segments are visual (black) the segment input is oscillating 180° out of phase to the back-plane. This requires a two channel oscilloscope when trouble shooting the LCD. One channel is applied to the back-plane BU 204:1 *or* 10 and is used as the trigger channel. The other channel is then used for fault finding the information flow from the display drivers to the LCD.

If the Backplane oscillator stops oscillating or a DC voltage is applied across the Backplane (BPD) and one or more segments for a longer time the LCD might be damaged.

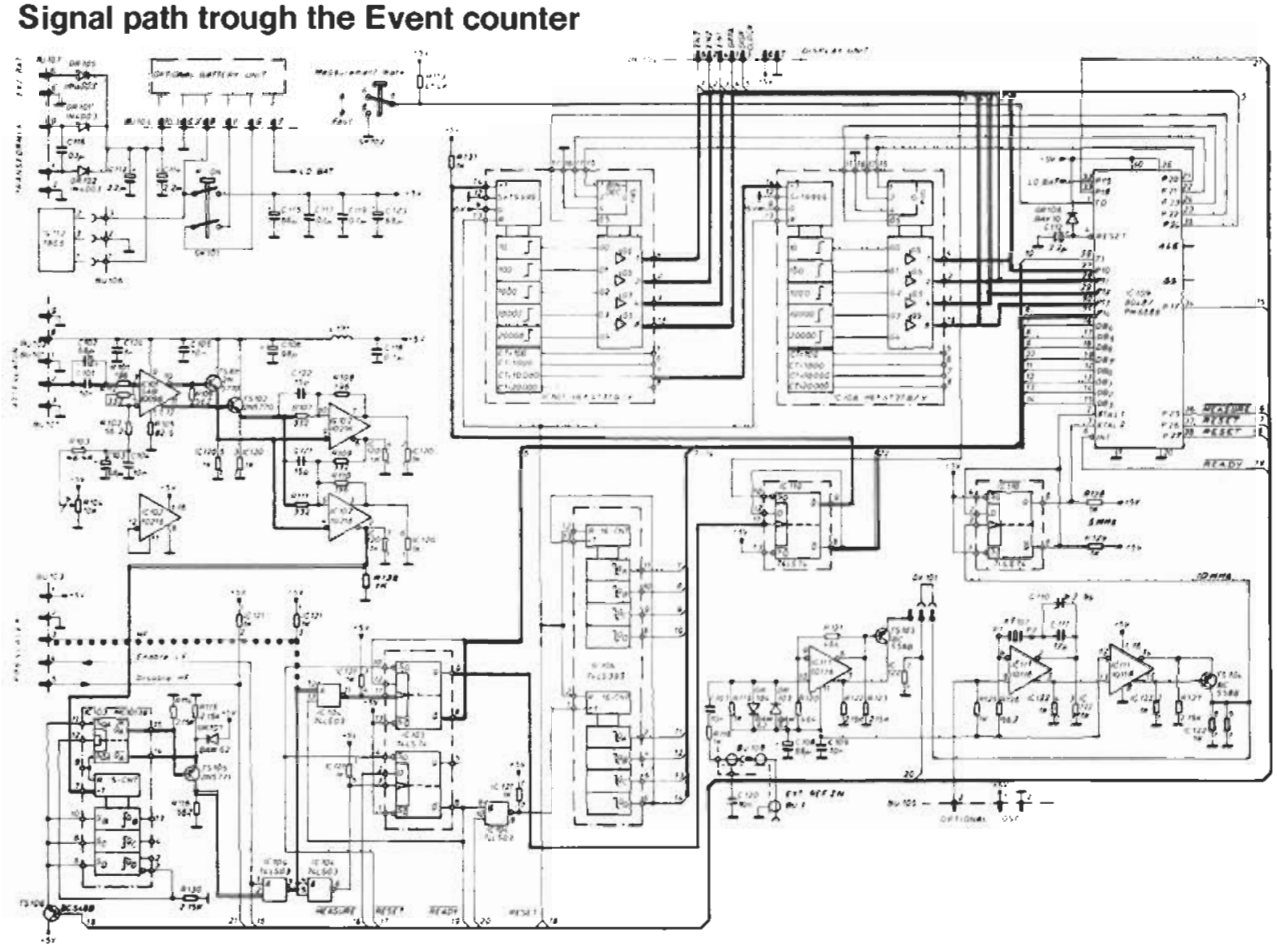
Synchronizer and Gate control

The µC controls the timing of every measurement cycle via the Synchronizer and Gate control. This circuit synchronize the start and stop of the event and time reference signals so that only whole periods of the event signal are counted. (See fig. 10.2).

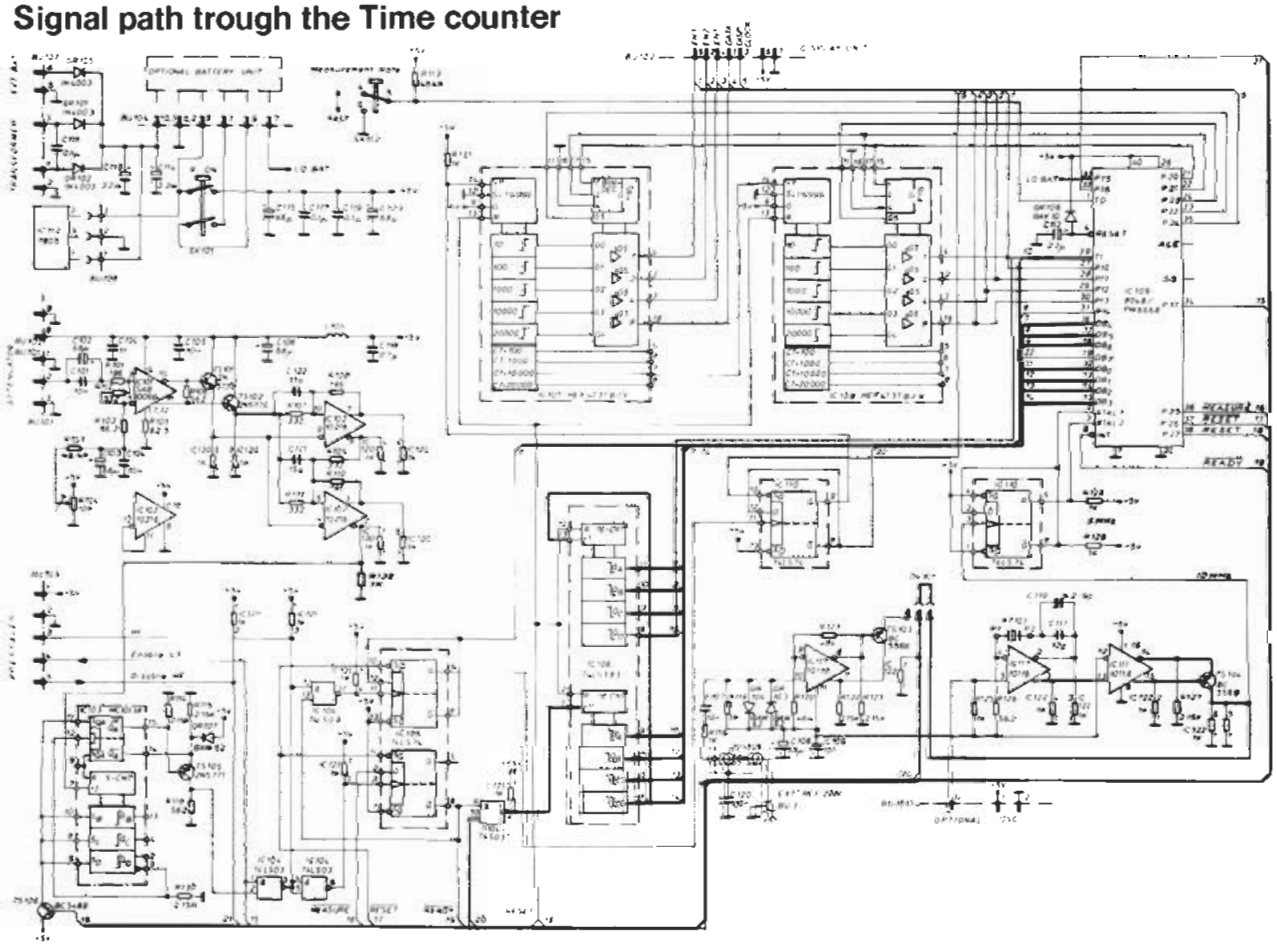
The signal path through the Event and Time counters are indicated with blue in the signal path diagram.

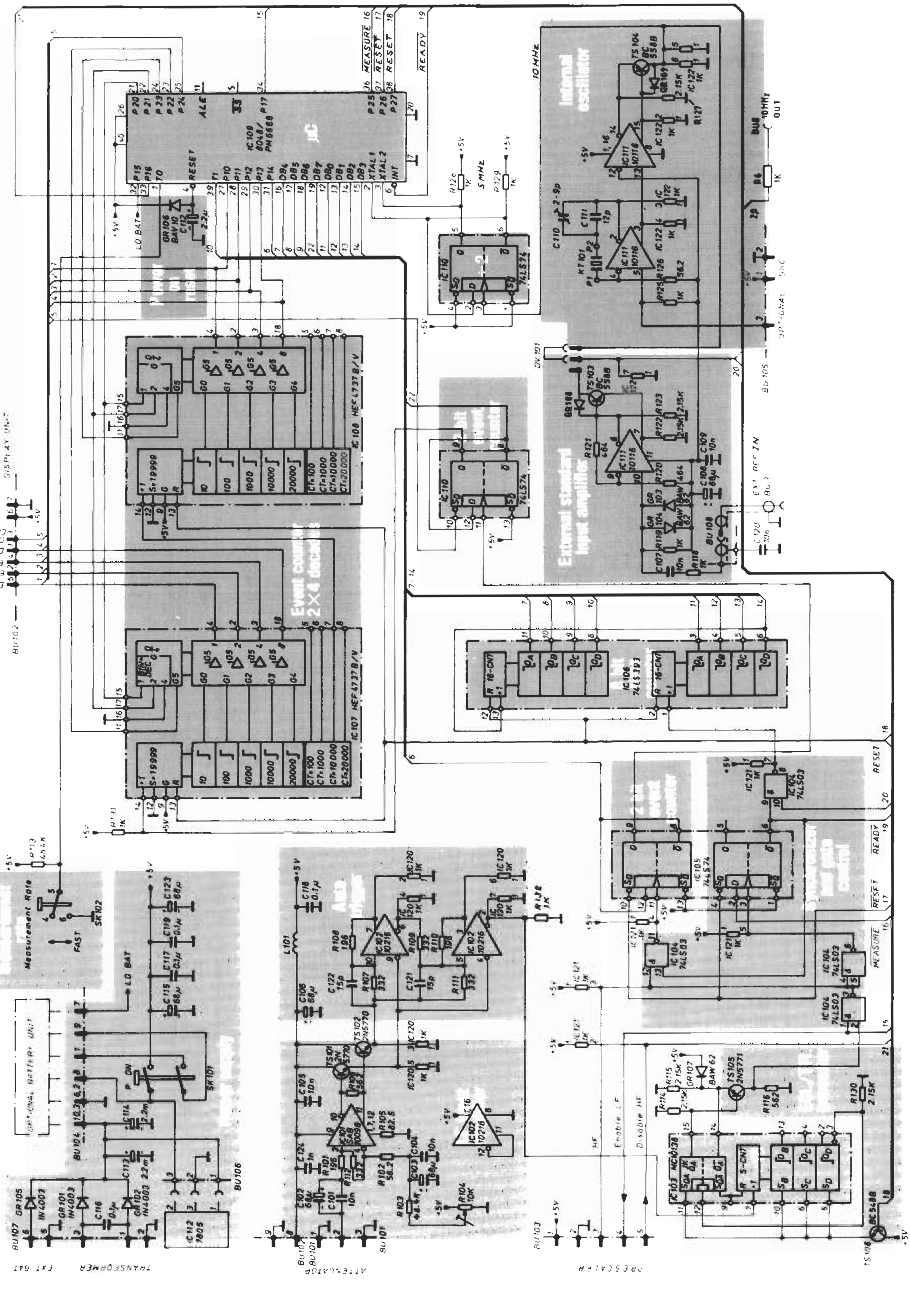
The µC reads the content in the Event counter and the Time counter after the measuring time has elapsed. This is indicated by the red signals in the signal path diagram. It calculates the result and converts it to a 64 bit serial information including clock and enable signals needed for correct presentation on the 7 digit LCD.

Signal path trough the Event counter

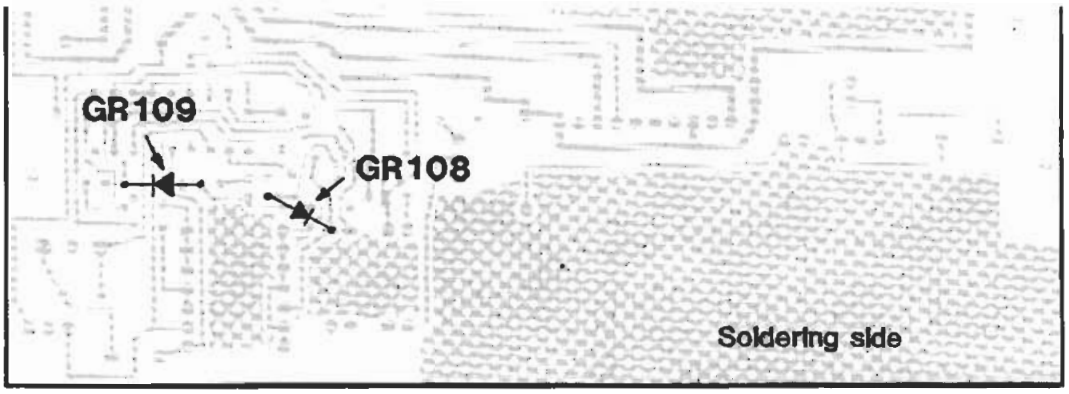


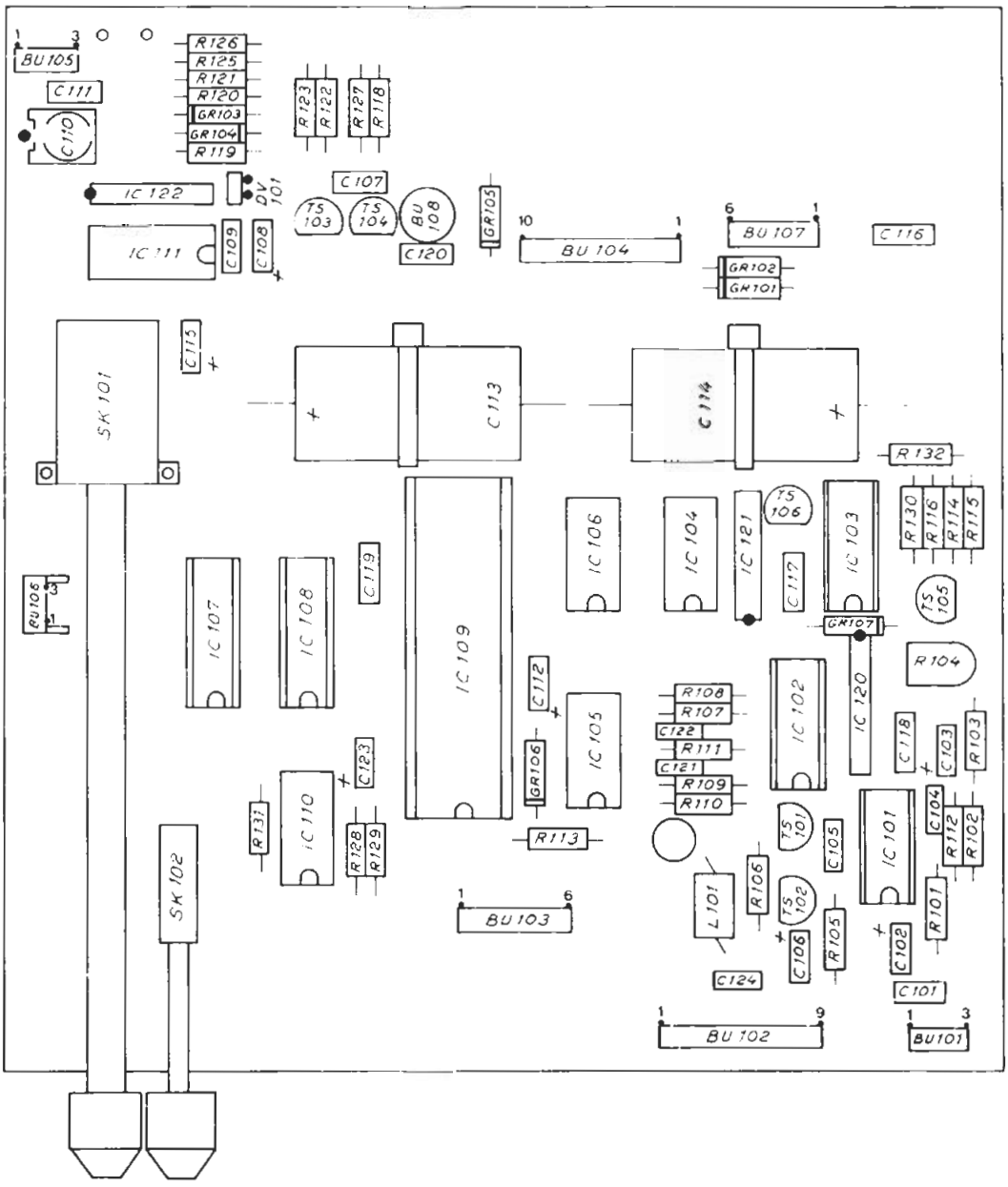
Signal path trough the Time counter

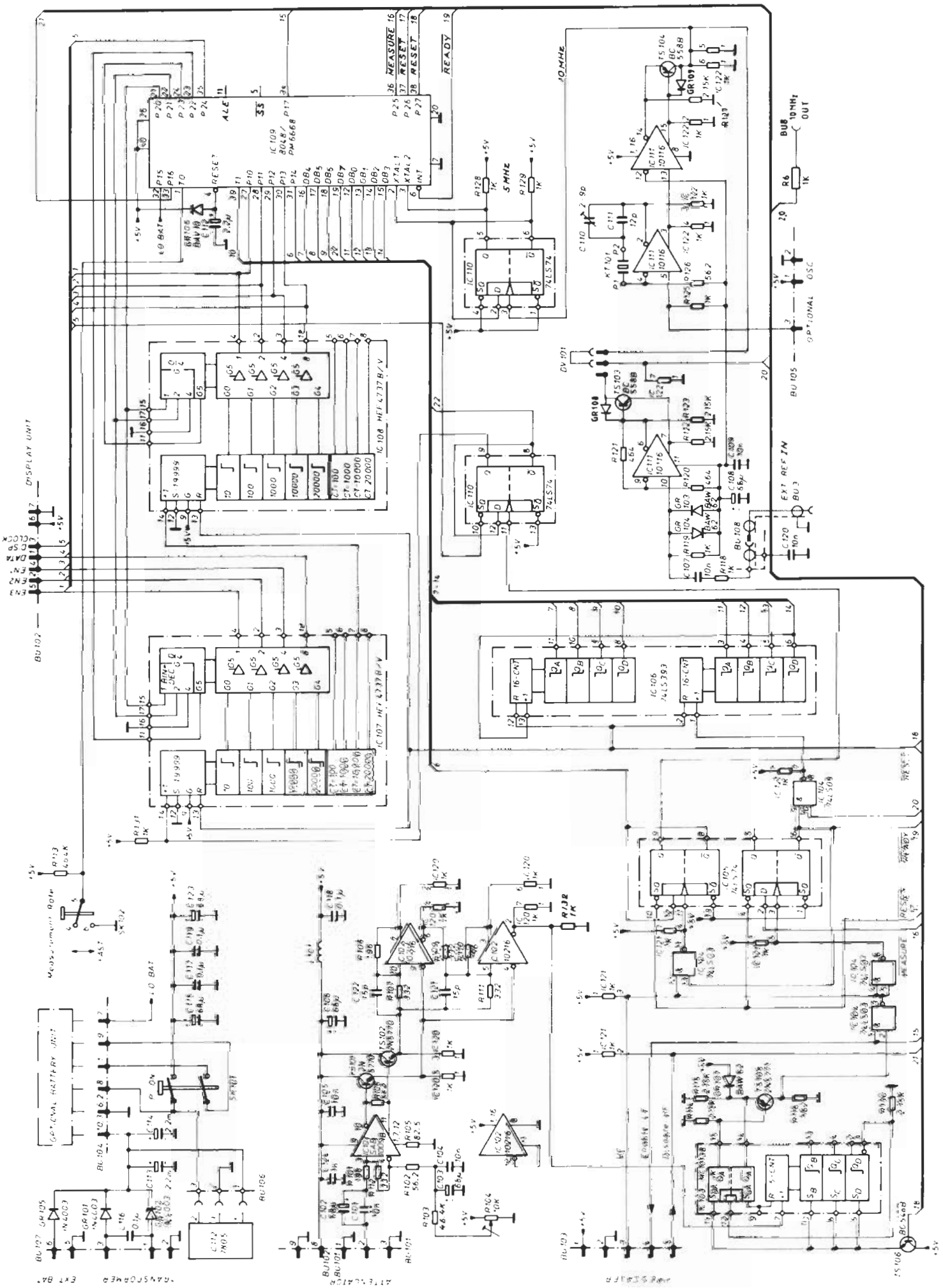



MEASURE
RESET
READY
IC 109 8048/ PM 6668
µC
10 MHz
Internal oscillator
IC 110 74LS74
5 MHz
External standard input amplifier
EXT REF IN
DISPLAY UNIT
CLOCK
DISP
DATA
EN1
EN2
EN3
BU102
IC 108 HEF 4737 B/V
IC 107 HEF 4737 B/V
Event counter 2×4 decades
IC 106 74LS393
IC 105 74LS74
IC 104 74LS03
Measurement Rate
FAST
SK102
LO BAT
OPTIONAL BATTERY UNIT
SK101
BU104
BU106
BU107
IC112 7805
EXT BAT
TRANSFORMER
ATTENUATOR
BU101
BU103
HF
Enable LF
Disable HF
PRESCALER
IC 103 MC10138
TS106 BC548B
10 MHz OUT
OPTIONAL OSC
BU105

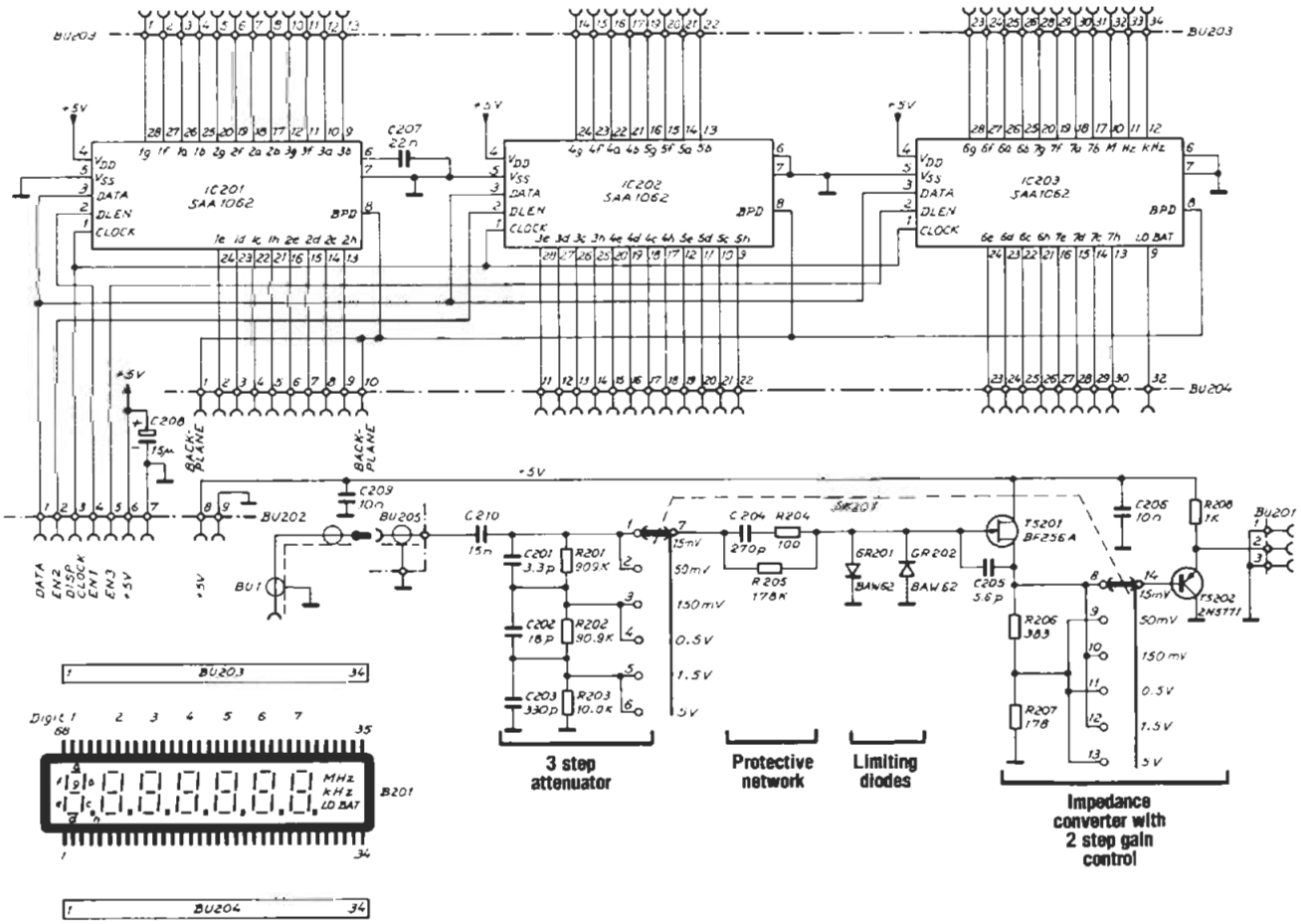
Basic board Unit 1

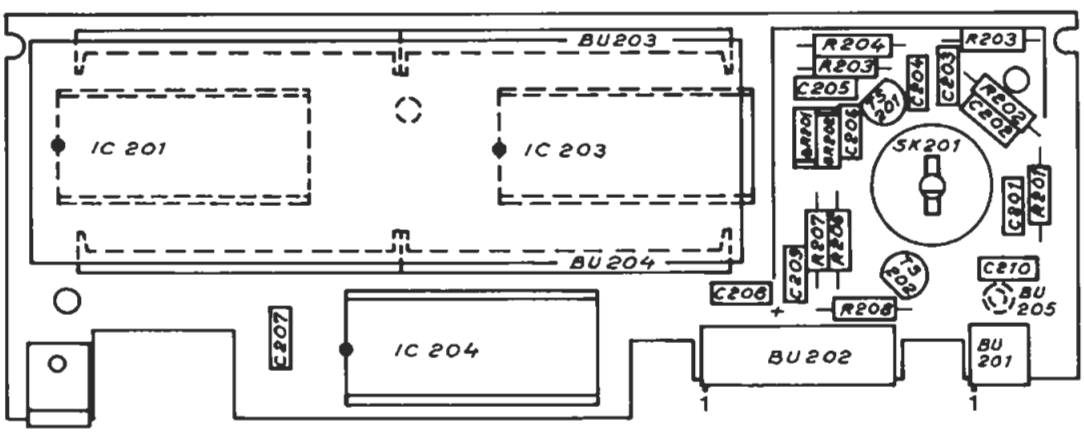




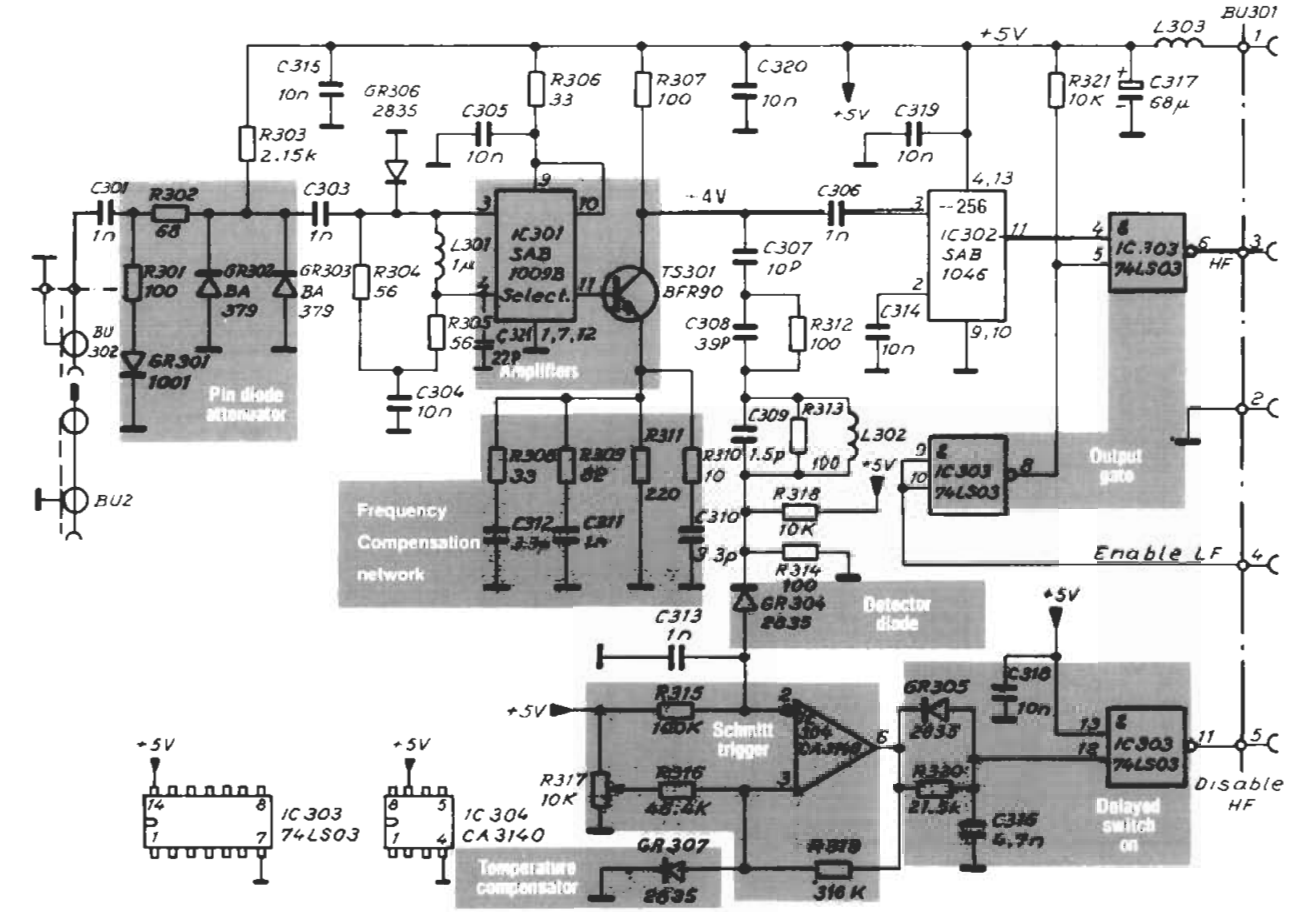


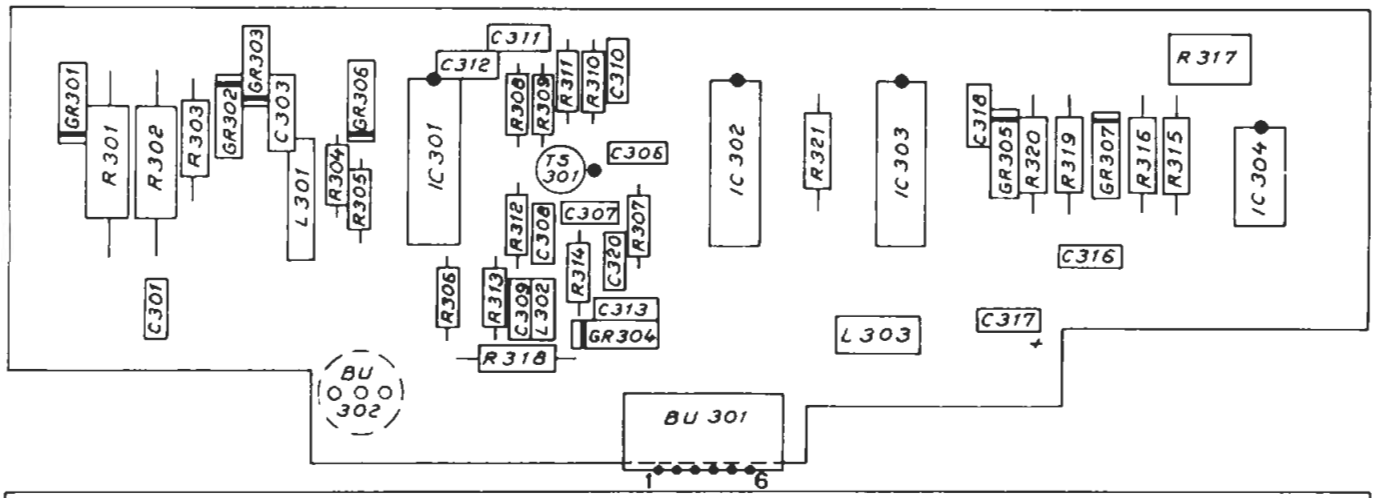
Input amplifier and display drivers Unit 2

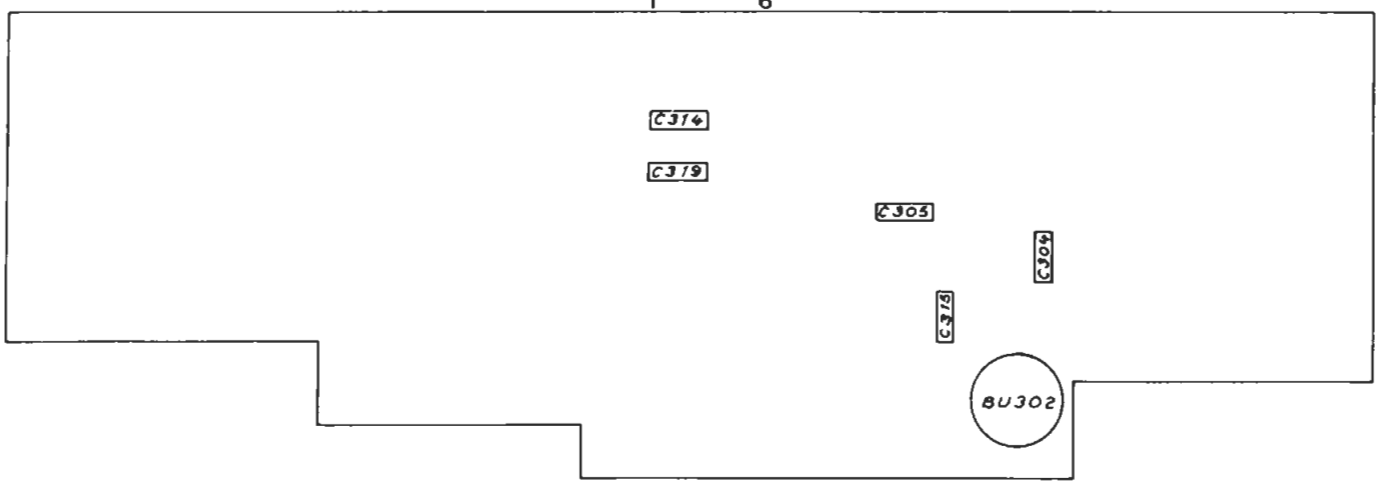




Prescaler Unit 3

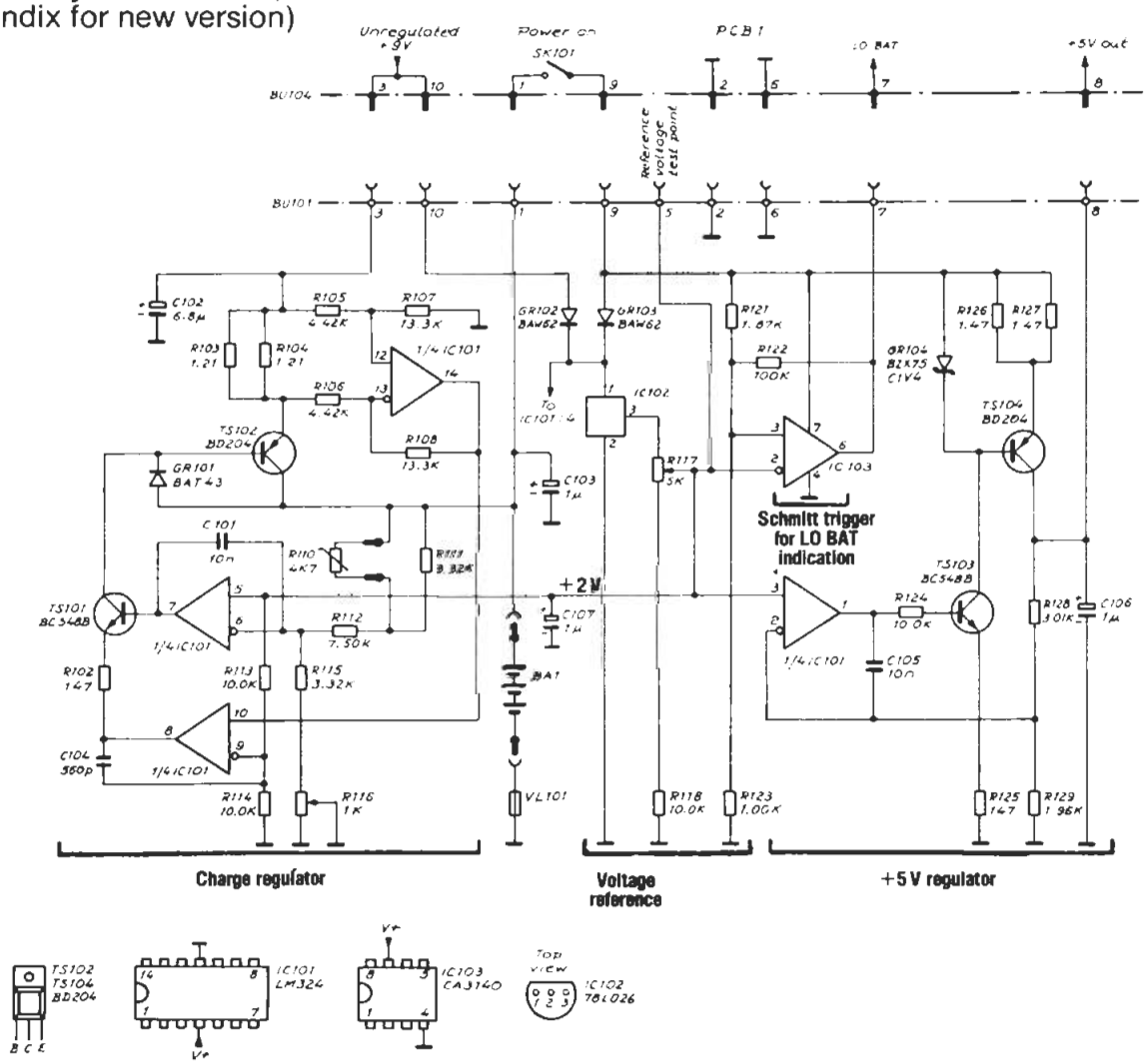


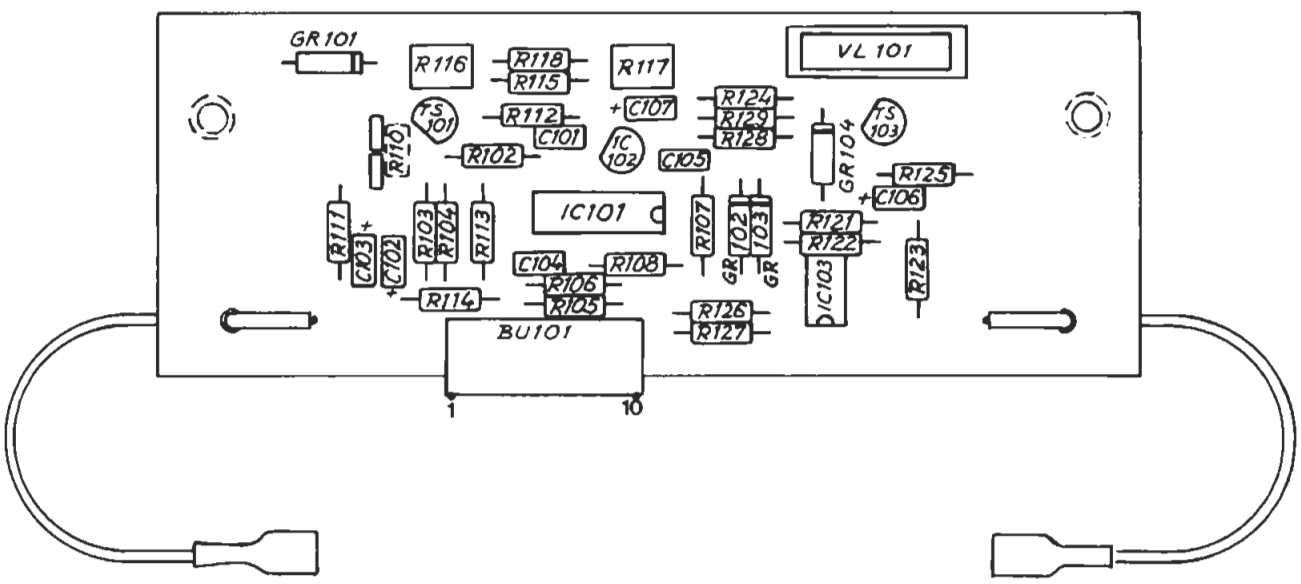




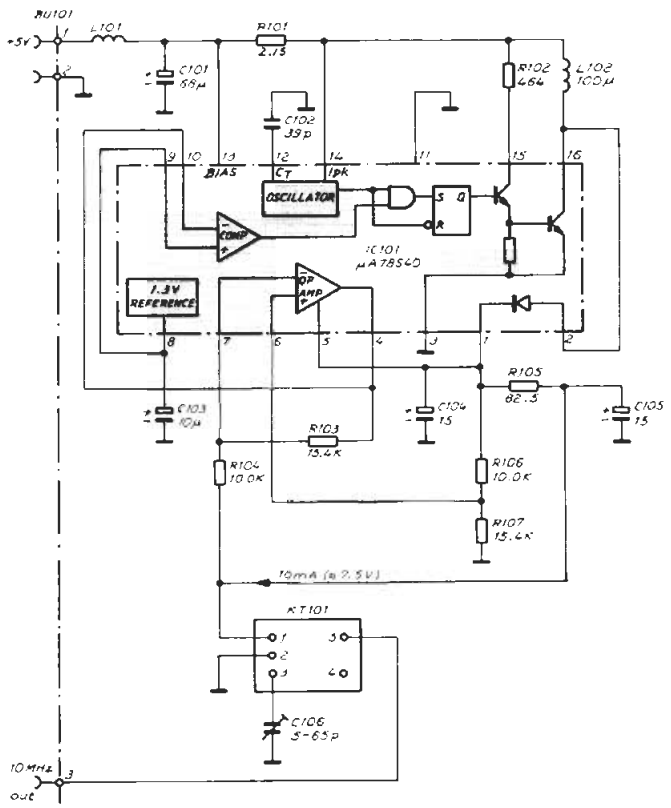
Optional battery unit PM 9601, old version

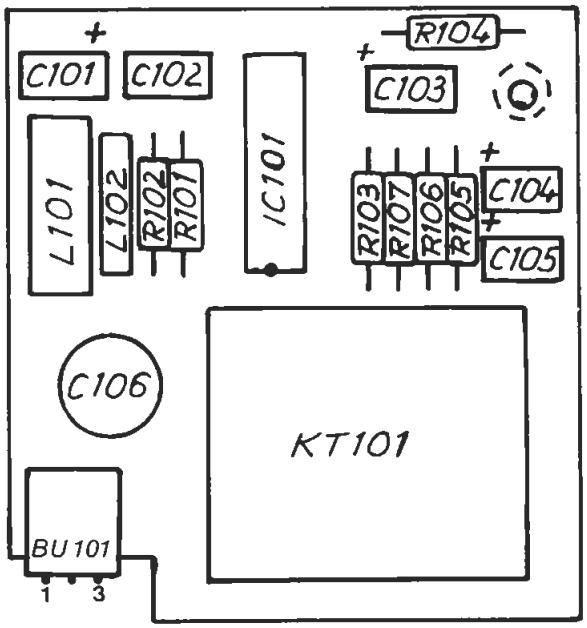
(See appendix for new version)



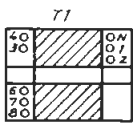


TCXO / 02

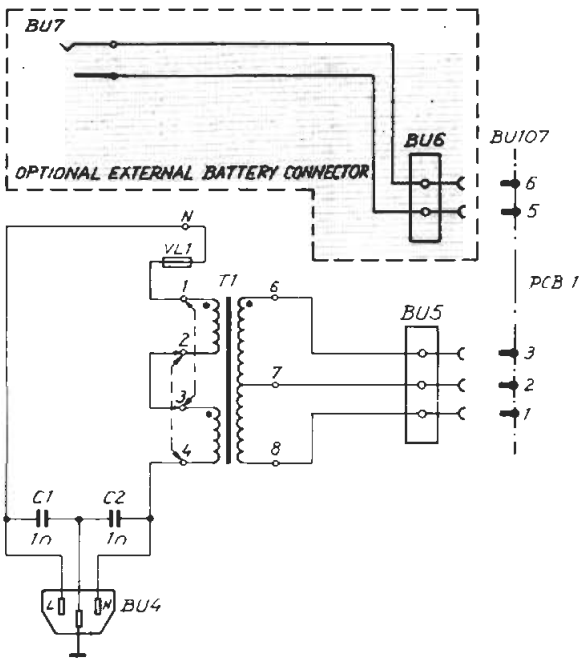




External battery jack and mains transformer

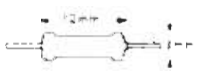


Mains voltage	Interconnect.
230V	2-3
115V	1-3 , 2-4



Lacquered Metal Film
Manufacturer: Philips
Type: MR30

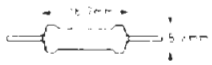
P at 70°C: 0.5 W
Tolerance: 1 %



Ω	Ordering Number
909k	5322 116 54408

Power Metal Film
Manufacturer: Philips
Type: PR52

P at 70°C: 2.5 W
Tolerance: 5 %



Ω	Ordering Number
68	5322 116 54396
100	5322 116 54392

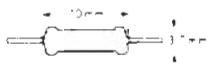
Carbon Film
Manufacturer: Philips
Type: CR25

P at 70°C: 0.33 W
Tolerance up to 1 M: 5 %
Tolerance from 1.2 M: 10 %

Ω	Ordering Number
1M	4822 110 63187
10M	4822 110 63214

Power Metal Film
Manufacturer: Philips
Type: PR37

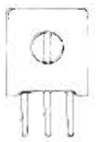
P at 70°C: 1.6 W
Tolerance: 5 %



Ω	Ordering Number
100	4822 116 51098

Ceramic Potentiometers
Manufacturer: Beckman
Type: Cermet 72X

P at 70°C: 0.5 W
Tolerance: 10%



Ω	Ordering number
1 k	5322 101 14299
5 k	5322 101 14301
10 k	5322 101 14254

Ceramic Potentiometers
Manufacturer: Philips
Type: Cermet Preset

Lin/Log: Lin
P at 70°C: 0.5 W
Tolerance: 20 %

Ω	Ordering Number
10k	5322 100 10113

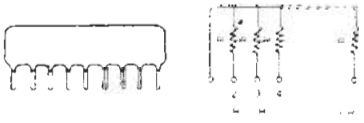
NTC Thermistor
Manufacturer: Elcoma
Type: 2322 642 1

P at 55°C: 0.5 W
Tolerance: 5 %

Ω at 25°C	Ω at 0°C	Ω at 50°C	Ordering Number
4.7 k	15 k	1.5 k	4822 116 30114

Standard Networks
Manufacturer: Koa Denko
Type: RK 1/8 B

P at 70°C: Rn × 125 mW
Tolerance: 10 %
Max voltage: 200 V



Ω	Length	Ordering Number
1k×6	19.5	5322 111 94015

Carbon Film
Manufacturer: Philips
Type: CR16

P at 70°C: 0.2 W
Tolerance up to 220 k: 5 %
Tolerance from 270 k: 10 %

Ω	Ordering Number
10	4822 111 30349
22	5322 111 30396
33	4822 111 30067
56	5322 111 30074
82	4822 111 30352
100	4822 111 30324
220	4822 111 30327
330	4822 111 30328

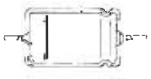
Lacquered Metal Film
Manufacturer: Philips
Type: MR25

P at 70°C: 0.4 W
Tolerance: 1 %

Ω	Ordering Number
1.21	5322 116 55603
1.47	5322 116 55604
2.15	5322 116 55415
56.2	5322 116 54446
82.5	5322 116 54462
147	5322 116 50766
178	5322 116 54492
196	5322 116 50676
332	5322 116 54513
383	5322 116 54518
464	5322 116 50536
562	5322 116 54009
1 k	5322 116 54549
1.87 k	5322 116 50728
1.96 k	5322 116 55605
2.15 k	5322 116 50767
3.01 k	5322 116 50524
3.32 k	5322 116 54005
4.42 k	5322 116 50556
6.81 k	5322 116 54012
7.5 k	5322 116 54608
10 k	5322 116 54619
13.3 k	5322 116 55276
15.4 k	5322 116 50479
21.5 k	5322 116 50451
46.4 k	5322 116 50557
90.9 k	5322 116 54694
100 k	5322 116 54696
332 k	5322 116 54731

Aluminium Electrolytic
Manufacturer: Philips
Type 2222 030...033

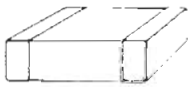
Tolerance: —10+50 %



Capacitance, μF	Voltage, V	Ordering Number
2200	25	4822 124 20788

Ceramic Chip
Manufacturer: Philips
Type 2222 852

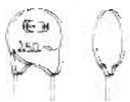
Voltage: 50 V



Capacitance, pF	Tolerance, %	Ordering Number
10000	20	5322 122 34098

Ceramic Disc
Manufacturer: Philips
Type: 2212 660

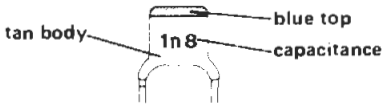
Rated ac voltage: 250 V
Tolerance: 20 %



Capacitance, pF	Ordering Number
1000	4822 122 44019

Miniature Ceramic Plate
Manufacturer: Philips
Type: 2222 640

Voltage: 100 V
Tolerance: —20+50 %



Capacitance, pF	Ordering Number
10000	5322 122 34041

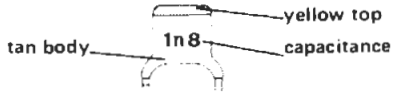
Miniature Ceramic Plate
Manufacturer: Philips
Type: 2222 655

Voltage: 500 V
Tolerance: 10%

Capacitance, pF	Ordering Number
1000	4822 122 31175

Miniature Ceramic Plate
Manufacturer: Philips
Type: 2222 630

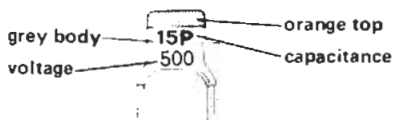
Voltage: 100 V
Tolerance: 10 %



Capacitance, pF	Ordering Number
330	4822 122 31165
560	4822 122 30126
1000	4822 122 31175

Miniature Ceramic Plate
Manufacturer: Philips
Type: 2222 650

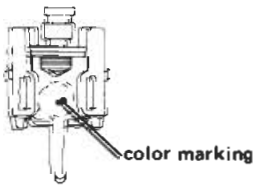
Voltage: 500 V
Tolerance: 2 %



Capacitance, pF	Ordering Number
3 3	4822 122 31217

Film Dielectric Trimmers
Manufacturer: Philips
Type: 2222 809 090

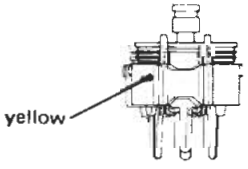
Voltage: 300 V



Capacitance, pF	Ordering Number	Colour Marking
2–9	5322 125 54024	White dot

Film Dielectric Trimmers
Manufacturer: Elcoma
Type: 2222 808

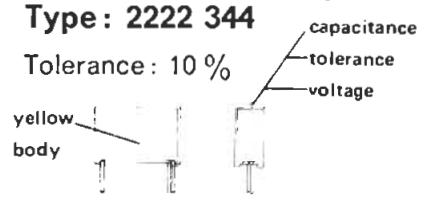
Voltage: 250 V



Capacitance, pF	Ordering Number	Colour Marking
5.5–65	4822 125 50017	Yellow

Metallized Polyester and
Polycarbonate Film
Manufacturer: Philips
Type: 2222 344

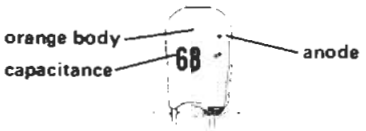
Tolerance: 10 %



Capacitance, nF	Voltage, V	Ordering Number
4.7	630	5322 121 44225
10	400	5322 121 44291
22	250	5322 121 40308
100	100	5322 121 40323

Solid Aluminium
Electrolytic
Manufacturer: Philips
Type: 2222 122

Tolerance: —10+50 %



Capacitance, μF	Voltage, V	Ordering Number
1	25	5322 124 14075
2.2	16	4822 124 10204
6.8	25	5322 124 14081
10	6.3	5322 124 14066
15	6.3	4822 124 20941
15	16	5322 124 14036
68	6.3	5322 124 14079

Miniature Ceramic Plate
Manufacturer: Philips
Type: 2222 638

Voltage: 100 V
Tolerance: 0.25 pF or 2 %

Capacitance, pF	Ordering Number
1.5	4822 122 30105
3.3	4822 122 31041
5.6	4822 122 31047
6.8	4822 122 31049
10	4822 122 31054
12	4822 122 31056
15	4822 122 31058
18	4822 122 31061
22	4822 122 31063
33	4822 122 31067
39	4822 122 31049

Transistors

Type	Ordering number
BD 204	4822 130 41043
BRF 90	5322 130 44179
BF 256A	5322 130 44418
BC 458B	4822 130 40937
BC 558B	5322 130 44197
2N 5770	5322 130 44435
2N 5771	5322 130 44845

Diodes

Type	Ordering number
BAT 43	4822 130 31353
BAV 10	5322 130 30594
BAW 62	5322 130 30613
BA 379	5322 130 34364
HSCH 1001	5322 130 34877
1N 4003	5322 130 30208
BZX 75C1V4	5322 130 34047
HP 5082–2835	5322 130 34283

Integrated circuits

Type	Ordering number
SAB 1009BP	5322 209 86202
SAB 1046P	5322 209 86199
SAA 1062	5322 209 86204
GZF 1201P	5322 209 84722
HEF 4737VP	5322 209 14511
CA 3140E	5322 209 86201
MC 7805CT	5322 209 84454
µA 78S40	5322 209 86513
µA 78L26AC	5322 209 86515
µC 8048	5322 209 14702
µC 10116P	5322 209 85798
LM 324	5322 209 86514
MC 10138P	5322 209 86203
MC 74LS03N	5322 209 85265
MC 74LS74N	5322 209 84986
MC 74LS393	4822 209 80447

IC holders

Description	Ordering number
3 pins	5322 265 64028
14 pins	5322 255 44082
16 pins	5322 255 44111
18 pins	5322 255 44133
28 pins	5322 255 44047
40 pins	5322 255 44217

Sockets and connectors

Item	Description	Ordering number
BU 1	BNC for LF input	5322 267 10004
BU 2	BNC for RF input	5322 267 10004
BU 3	BNC for Ext. std input	5322 267 10004
BU 4	Line voltage input	5322 265 30066
BU 6	2 pole for external battery jack	see section 5 in this manual
BU 7	Battery jack for external battery	see section 5 in this manual
BU 8	10 MHz out for rear panel	5322 290 30236
BU 101	3 pole for display board	5322 265 34105
BU 101	10 pole for PM 9601	5322 267 54195
BU 101	3 pole for TCXO	5322 267 44111
BU 102	9 pole for display board	5322 265 64028
BU 103	5 pole for prescaler board	5322 265 44057
BU 104	10 pole for internal battery	5322 265 64028
BU 105	3 pole for TCXO	5322 265 34105
BU 106	3 pole for IC 112	5322 265 64028
BU 107	5 pole for mains trafo and external battery	5322 265 44057
BU 108	Miniature BNC for Ext. Std.	5322 267 34043
BU 201	3 pole for basic board	5322 267 44111
BU 202	9 pole for basic board	5322 267 54194
BU 203	2 x 17 pole for LCD	5322 267 54193
BU 204	2 x 17 pole for LCD	5322 267 54193
BU 205	Miniature BNC for LF input	5322 267 34043
BU 301	5 pole for basic board	5322 267 44112
BU 302	Miniature BNC for HF input	5322 267 34043

Switches

Item	Description	Ordering number
SK 101	Line	5322 276 14358
SK 102	Measurement time	5322 276 14388
SK 201	Sensitivity	5322 273 44017
DV 101	Jumper for Ext /Int. Std.	5322 263 64007

Inductances

Item	Ordering number
L 101	5322 158 10052
L 102	5322 158 10243
L 301	5322 158 10311
L 302	5322 157 34019
L 303	5322 158 10052

Cabinet

Item	Ordering number
Handle	5322 498 54101
Spring for handle	5322 492 64745
Housing, grey	5322 447 94581
Housing, brown	5322 447 90547

Textplates

Instrument	Ordering number
PM 6667, brown	5322 456 90113
PM 6668, brown	5322 456 90114

Knobs and cover for knobs

Item	Ordering number
Line knob, grey	5322 414 26019
Measurement knob, grey	5322 414 14011
Sensitivity knob, grey	5322 414 34091
Cover, sens knob, grey	5322 414 74015
Line knob, brown	5322 414 20035
Measurement knob, brown	5322 414 20033
Sensitivity knob, brown	5322 414 30044
Cover, sens knob, brown	5322 414 70015

Feet

Item	Ordering number
Rear	5322 462 44434
Front	5322 462 44435

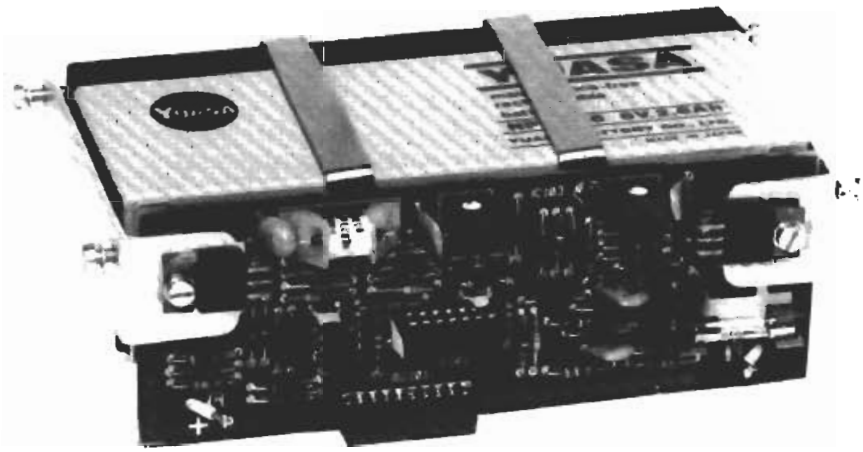
Miscellaneous

Item	Ordering number
Window	5322 459 44002
Display	5322 130 94021
Extension bar	5322 535 94648
Mains transformer	5322 146 14188
Crystal 10 MHz	5322 242 74372
Thermal fuse	4822 252 20007
1.6A fuse	4822 253 20022
Fuse holder	5322 256 34104
TCXO	5322 216 94047

Battery Unit
PM 9601

Instruction Manual

9499 463 01211
850415 First edition



Contents

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Operating part

1. Introduction

The PM 9601 is an optional rechargeable battery unit for inside mounting in counters PM 6667 and PM 6668. The unit contains a standard 6 V sealed battery of lead-acid type. This battery can be positioned in any direction and do not need any other maintenance than charging. The unit also contains a charging circuit and a low-battery indication circuit.

There are two versions of the battery unit. The newer one described here has an additional deep-discharge protection circuit that disconnects the battery from the load before the battery is fully discharged. The life-time of the battery is thereby increased. The new version can be identified by the number on the PC board 4031 100 38370.

2. Characteristics

Performance characteristics

Properties expressed in numerical values with stated tolerances are guaranteed by the Philips organisation in your country. Specified nontolerance numerical values indicate those that could be expected from the mean of a range of identical units.

Electrical characteristics

Input voltage:	7.3...15 VDC at full load.
Battery voltage:	6 V nominal.
Fuse:	1.6 A fast action.
Charge current:	Limited at 560 ± 30 mA.
Charging time: (in ST BY)	5 h from min. level to appr. 70 % capacity, 10 h from min. level to 90 % of full capacity.
Battery low indication	A TTL-low signal, when the battery voltage drops below 5.7 V, the display indicates "LO BAT" and 10...15 min of operation is left before recharging.
Deep discharge protection:	When the battery voltage drops below 5.5 V the battery is disconnected from the load.
Capacity:	6 hours operation in PM 6667 and 4 hours in PM 6668.
Output voltage:	5.0 ± 0.2 V.
Over voltage protection:	6.9 V.
Over current protection:	0.8 ± 0.2 A at short circuit

Enviromental characteristics

Temperature:	Operating 0 °C...+45 °C.
Barometric pressure:	Storage 15.2 kN/m^2 (15000 m)
	Operating 53.3 kN/m^2 (5000 m)
Humidity:	10...90 %RH (26 °C dew point)
Mechanical:	Vibration test acc. to IEC68Fc
	Bump test acc. to IEC68Eb
	Handling test acc. to IEC68Ec
	Transport test acc. to NLN-L88
	Dimensions: 140x95x50 mm
	Weight approx: 0.75 kg

Accessory

- One screening plate.

3. Installation

The battery unit includes screws to secure the unit inside the counter. See figures 3.1 and 3.2 and proceed as follows:

- Disconnect the counter from the line.
- Set the mains switch to STBY
- Remove the cover of the counter.
- Remove the +5 V regulator IC112, see fig 3.1.
- Unscrew the four fixing screws on PM 9601 sufficient to allow the mounting.

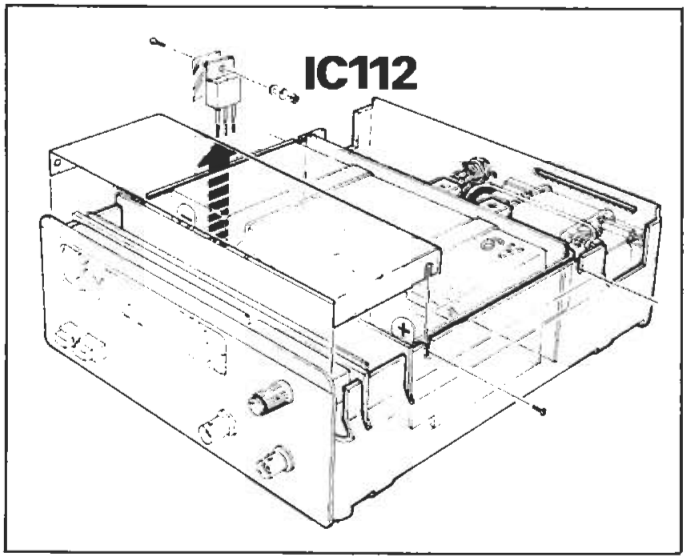


Fig 3.1 Mounting the battery unit.

- Place the battery unit inside the counter with the PC board facing the rear panel. Make sure that the counter pin connector fits properly into the battery unit's socket connector. Be careful, to avoid damaging the PCBpattern. In the same time, the four fixing screws must fit into their slots in the side pieces of the counter.

- Fasten the battery unit to side pieces of the counter with the two rear screws.
- Set the mains switch to position ON but do not connect the power cord.
- Check that all segments, decimal points and sorts are displayed for a short moment, after that only zeros shall be displayed when no signal source is connected.
- Check that the display do not indicate "LO BAT"

"LO BAT" indicates a too low battery voltage. See chapter Operating.

- Release the power switch.
- Fasten the new screening plate with the two front screws on the battery unit, see also fig. 3.1. The old screening plate shall not be used.

- Refit the cover on the counter.
- Mark the square "BATTERY" on the label on the counter's rear panel to indicate that this option is installed.
- When the installation is completed, connect the counter to the mains and allow it to charge the battery for at least 10 hours.

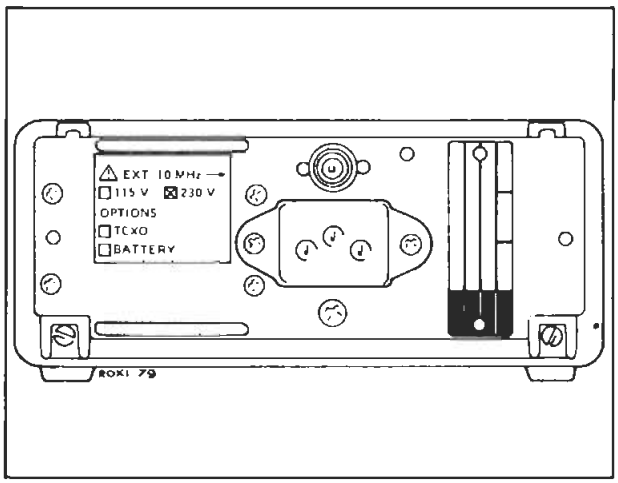


Fig. 2 Marking the square "BATTERY" on the label.

4. Operating

NOTE: When the counter has not been used for some time, always start the operation by charging the battery. The battery will automatically be charged if power is connected to the counter.

Line operation

When the counter has got a battery unit, operating is the same as normal in most aspects. Charging the battery is done automaticly as long as the mains voltage is connected to the counter. The battery is charged no matter how the power switch of the counter is set.

External DC operation

The counter can after modification also be supplied from an external DC-system. A 12 V battery is recommended as external DC source but as long as the DC-level is above 9 V a built in optional battery will be charged. Note that the highest allowed DC input voltage is 15 V.

Internal battery operation

For internal battery operation the power switch shall be set to ON and no mains voltage connected. Switching from external to internal supply mode and vice versa, is done without interruption.

Fuse

The battery unit is provided with a 1.6 A fast action fuse, located on the printed-circuit board.

Capacity

Capacity is the total energy available from a fully charged battery, normaly expressed in ampere-hours. At normal room temperature, the counter can work on the battery for a minimum of 4 hours. When low-battery voltage is indicated, the counter can operate for another 10 to 15 minutes before charging is necessary.

The capacity of rechargable batteries degrades when the batteries are not used frequently. The degraded capacity of batteries after having been inoperative, can be upgraded again by cycling the batteries some times, i.e. fully charging and discharging the batteries.

Charging

When the counter display indicates low battery voltage, or when the battery unit has been stored for more than three months, the battery should be charged as follows:

- Connect the counter to the line voltage.
- Set the counter power switch to STBY.
- Charge for a minimum of 8 hours. The battery is protected against overcharge, so an extended charging time will cause no damage.

Storing

Do not store discharged batteries!

When the counter is out of use, set the power switch to position STBY. Keep the counter connected to the line voltage. In this way the batteries will be kept fully charged and ready for use.

If the counter cannot be left connected to the line voltage, or when the battery unit is stored outside the counter, recharging for 5 to 10 hours every 3 months is recommended. If longer storage periods cannot be avoided, store the unit in a cool, dry place.

Note: 1. Permanent use and storage at high temperatures shortens the life of the battery.

2. +40 °C as well as charging above +35 °C should be avoided.

3. be charged to at least 75 % of its full capacity.

Service part

These service instructions are for use by qualified personnel only. To reduce the risk of electrical shock do not perform any service other than that specified in the operating instructions unless you are fully qualified to do so.

5. Functional description

General

The circuit diagram consist of:
- The prestabilizer and charging circuit IC102, TS101 and IC101:7 with their associated components.
- The low-voltage warning circuit, IC101:8.
- The deep discharge protection circuit IC101:14 TS103 and RE101.
- The +5 V output voltage stabilizer with over current protection IC101:1 and TS102.

When the counter is connected to the line voltage, a 7.3...15 V unregulated DC voltage is fed to BU101:3,10. When the switch SK101 is set to position ON, the +5 V output voltage of PM 9601 feeds the counter. The battery is continuously charged. The control circuit gives warning for low battery voltage and disconnects the load to avoid a too deep discharge of the battery.

Charging circuit

The voltage on BU101:3,10 is applied to the charge regulator IC101:5,6,7 and TS101. IC102 senses the input current via the resistive network R102, R103 and R105...R108. IC102 controls the charge current by changing the sense-voltage to IC101. The charge voltage is sensed by R104, R109...R111 and R114. R109 and R104 are used for temperature compensation, and the potentiometer R114 sets the charge voltage. Diode GR105 prevents reverse leakage current from discharging the battery.

When the power switch on the counter is set to STBY the charging current is about 0.5 A.

Low voltage warning circuit

The low voltage warning circuit includes IC101:8, which works as a comparator. A stabilized 2 V reference voltage is supplied from IC103 via R117 to IC101:9. This voltage is compared with the battery voltage via R123 and R124. The output of IC101:8 is fed via BU101:7 to the "LO BAT" input of the counter.

Deep discharge protection circuit

The voltage divider R123, R124,127 and the voltage reference IC103 determines the cut off level for the battery. When the battery voltage drops to 5.5 V, IC101:14 disconnects the battery from the load by switching off RE101 via TS103.

Battery mode ON/OFF

From the battery, 6V is connected via BU101:1, SK101 in the counter to BU101:9 and via R131 to C108. This turns TS103 and RE101 on which gives supply to the IC:s and the voltage divider R123, 124, 127.

When SK101 is switched off, TS104 starts conducting due to R133, R130 will reduce the level on IC101:12, turning RE101 off.

6. Adjustment

The parameters that might need adjustment, e.g. after replacement of components are the internal reference voltage and the charging voltage.

The reference voltage available on BU101:5 shall be adjusted to 2.000 ± 0.005 V with R117.

The voltage limit of the prestabilizer is temperature compensated via R104. Before an adjustment is made the ambient temperature has to be measured and no soldering is allowed close to the NTC resistor.

For adjustment, proceed as follows:

- Remove the battery unit's fuse.
- Connect the counter to the line voltage.
- Set the mains switch to STBY.
- Connect a digital voltmeter to the plus pole of the battery and the earth terminal of the fuse holder.
- Adjust R114 to 6.90 ± 0.002 V at a room temperature of 19...22 °C or 6.82 ± 0.002 V at a room temperature of 23...26 °C.

The current limit of the prestabilizer / charging circuit shall be 560 ± 30 mA. The limit is set with R115. If R115 has been changed the reference voltage must be readjusted.

When replacing components on the circuit board, always disconnect the counter from the line voltage and remove the battery unit fuse.

7. Replacement of batteries

If the battery unit is mounted in the counter, it must be removed for replacement of batteries. Proceed as follows:

- Remove the fuse.
- Remove the two screws on the battery holders.
- Detach the two cables with fast-on connectors and remove the battery.
- Observe the correct polarity when fitting the new battery.
- Fix the new battery with the holders, connect it and replace the fuse.

The battery, which are of standard type is available from a number of manufacturers. The following list includes some of the battery types that can be used.

Manufacturer	Made in	Type	Capacity
Sonnenschein*	W-Germany	3GX3S	3.0 Ah
Varta*	W-Germany	AccuPb30704063	3.0 Ah
Yuasa*	Japan	NP2.6-6	2.6 Ah
Kono	Japan	6-26K	2.6 Ah
Gold Gelyte	USA	Pb 626-1	2.6 Ah
Elpower	USA	Ep 626-1	2.6 Ah

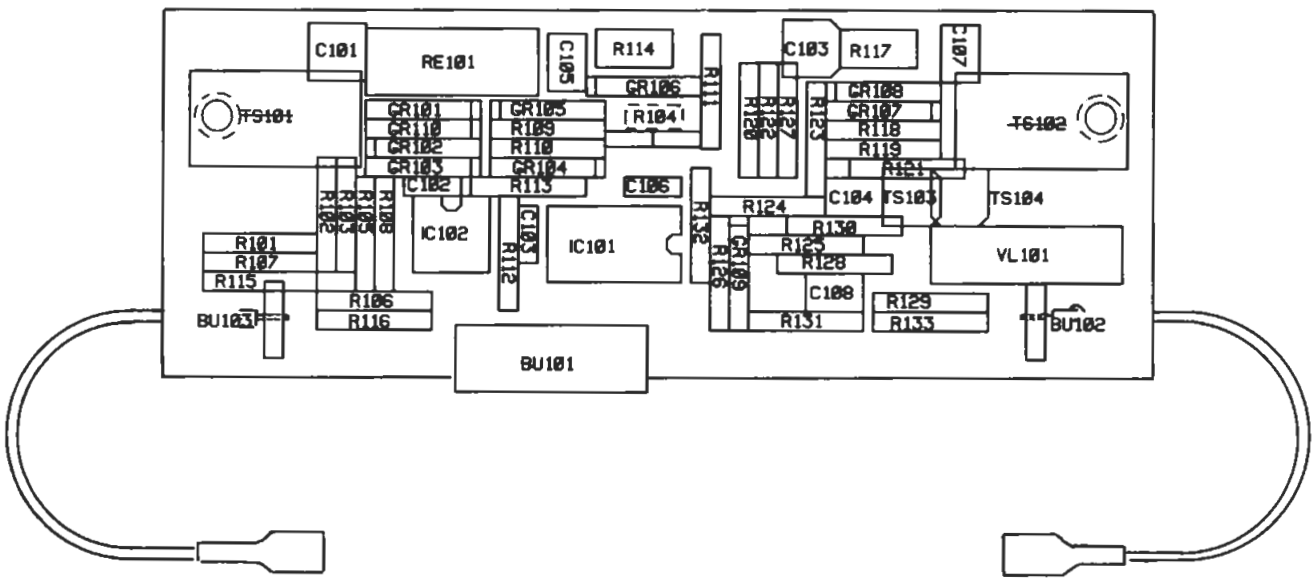
* Recommended

8. Spare part list

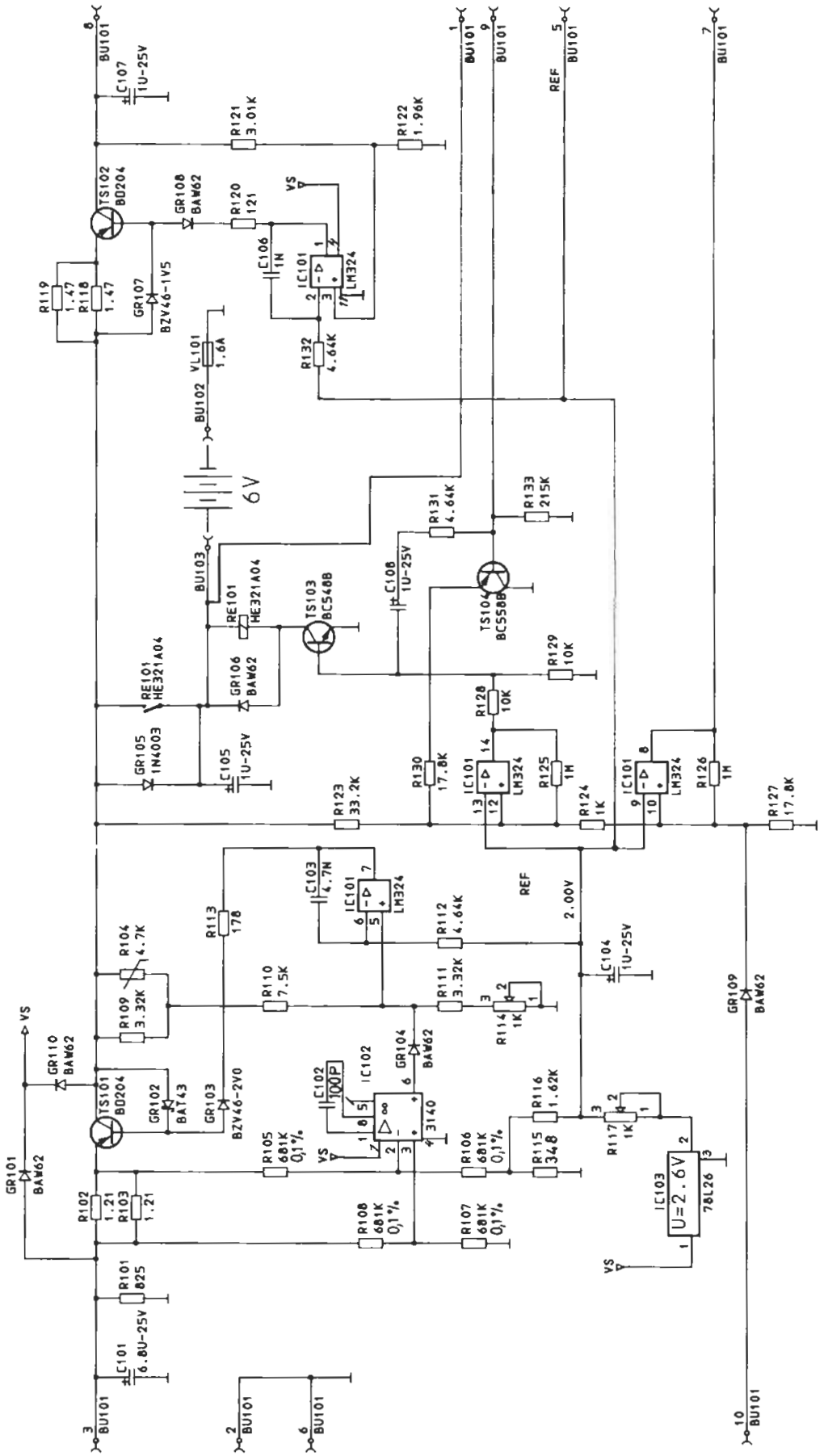
Item	Order number	Description	Specification		
BU101	5322 267 54195	Connetor			
C101	5322 124 14081	Capacitor solid alu	6.8µF	20%	25V
C102	4822 122 31316	Capacitor ceramic	100pF	2%	100V
C103	4822 122 31125	Capacitor ceramic	4,7nF	80%	63V
C104...105	4822 124 21457	Capacitor solid alu	1µF	10%	25V
C106	4822 122 30027	Capacitor ceramic	1nF	10%	100V
C107...108	4822 124 21457	Capacitor solid alu	1µF	10%	25V
GR101	4822 130 30613	Diode,	BAW62/75		
GR102	4822 130 31353	Diode,	BAT43/30		
GR103	4822 130 31248	Diode, reference	BZV46/2V0		
GR104	4822 130 30613	Diode,	BAW62/75		
GR105	4822 130 31174	Diode,	1N4003/200		
GR106	4822 130 30613	Diode,	BAW62/75		
GR107	4822 130 34865	Diode, reference	BZV46/1V5		
GR108...110	4822 130 30613	Diode,	BAW62/75		
IC101	5322 209 86514	Integrated circuit	LM324		
IC102	5322 209 86201	Integrated circuit	CA3140		
IC103	5322 209 86515	Integrated circuit	UA78L26AWC		
RE101	5322 280 20144	Relay, reed	HE321A0400		
R101	5322 116 54541	Resistor metal film	825ohm	1%	0.4W
R102, 103	5322 116 55603	Resistor metal film	1.21ohm	1%	0.4W
R104	not used				
R105...108	5322 116 53066	Resistor metal film	681k	0.1%	1/8W
R109	4822 116 51247	Resistor metal film	3.32k	0.5%	0.5W
R110	5322 116 54608	Resistor metal film	7.5k	1%	0.4W
R110-2	5322 116 30239	Resistor NTC	4.7k	5%	0.5W
R111	4822 116 51247	Resistor metal film	3.32k	0.5%	0.4W
R112	5322 116 50484	Resistor metal film	4.64k	1%	0.4W
R113	5322 116 54492	Resistor metal film	178ohm	1%	0.4W
R114	5322 101 14299	Potentiometer trim	1k	10%	
R115	5322 116 54515	Resistor metal film	348ohm	1%	0.4W
R116	5322 116 55359	Resistor metal film	1.62k	0.5%	0.4W
R117	5322 101 14299	Potentiometer trim	1k	10%	
R118, 119	5322 116 55604	Resistor metal film	1.47ohm	1%	
R120	5322 116 54426	Resistor metal film	121ohm	1%	0.4W
R121	4822 116 51246	Resistor metal film	3.01k	0.5%	0.4W
R122	5322 116 54571	Resistor metal film	1.96k	1%	0.4W
R123	4822 116 51259	Resistor metal film	33.2k	0.5%	0.4W
R124	4822 116 51235	Resistor metal film	1k	0.5%	0.4W
R125...126	5322 116 55535	Resistor metal film	1M	1%	0.4W

Item	Order number	Description	Specification		
R127	5322 116 54637	Resistor metal film	17.8k	1%	0.4W
R128...129	4822 116 51253	Resistor metal film	10k	0.5%	0.4W
R130	5322 116 54637	Resistor metal film	17.8k	1%	0.4W
R131...132	5322 116 50484	Resistor metal film	4.64k	1%	0.4W
R133	5322 116 54728	Resistor metal film	215k	1%	0.4W
TS101..102	5322 130 44324	Transistor	BD204		
TS103	4822 130 40948	Transistor	BC548B		
TS104	4822 130 44197	Transistor	BC558B		
VL101	5322 256 34104	Holder, fuse			
VL101	4822 253 20022	Fuse 1.6A	5 x 20mm		

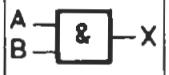
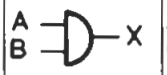
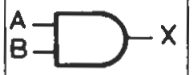
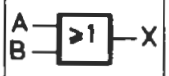
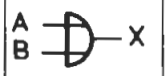
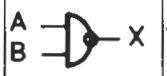
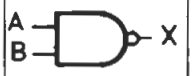
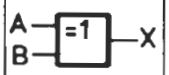
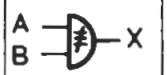
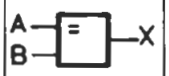
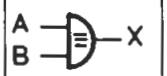
9. Component layout



10. Circuit diagram



Standard symbols for logic elements

Circuit	I.E.C.	DIN norm 40700	American standard	Boolean function
AND				$X = AB$
OR				$X = A + B$
NAND				$X = \overline{AB}$
NOR				$X = \overline{A + B}$
NAND with one inverting input				$X = \overline{\overline{A}B}$
NOR with one inverting input				$X = \overline{\overline{A} + B}$
INHIBIT GATE				$X = (A + B)\overline{C}$
EXCLUSIVE OR				$X = A\overline{B} + \overline{A}B$
COM-PARATOR				$X = AB + \overline{A}\,\overline{B}$
Distributed AND				
Distributed OR				
DELAY				
FLIP-FLOP