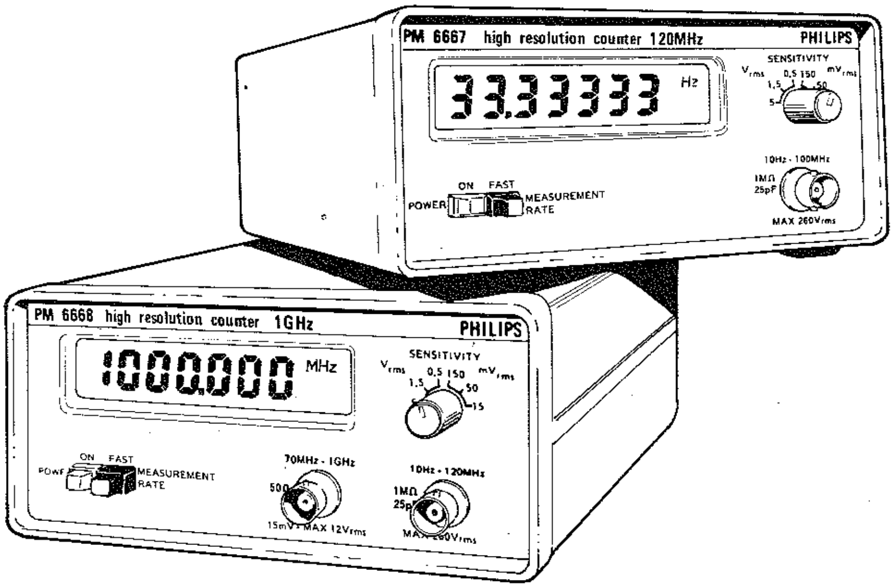
Frequency counters PM 6667 and PM 6668

Instruction manual

9499 463 10399
801115



PHILIPS

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.

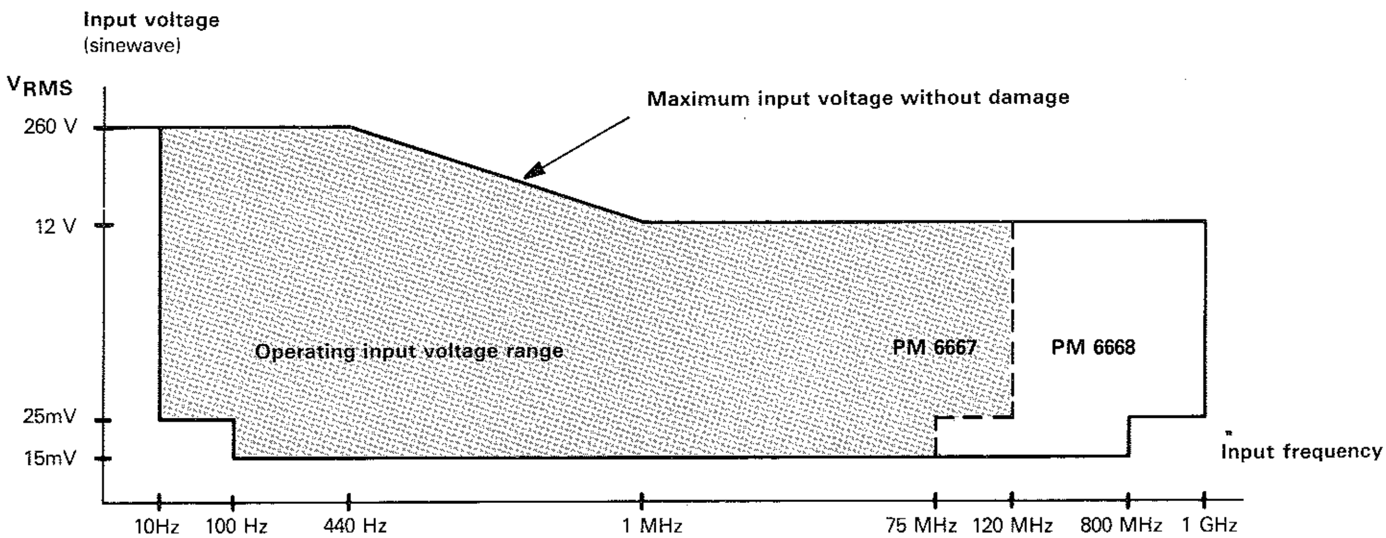
The 7-digit liquid crystal (LCD) display contains also the unit and decimal-point indicators.

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

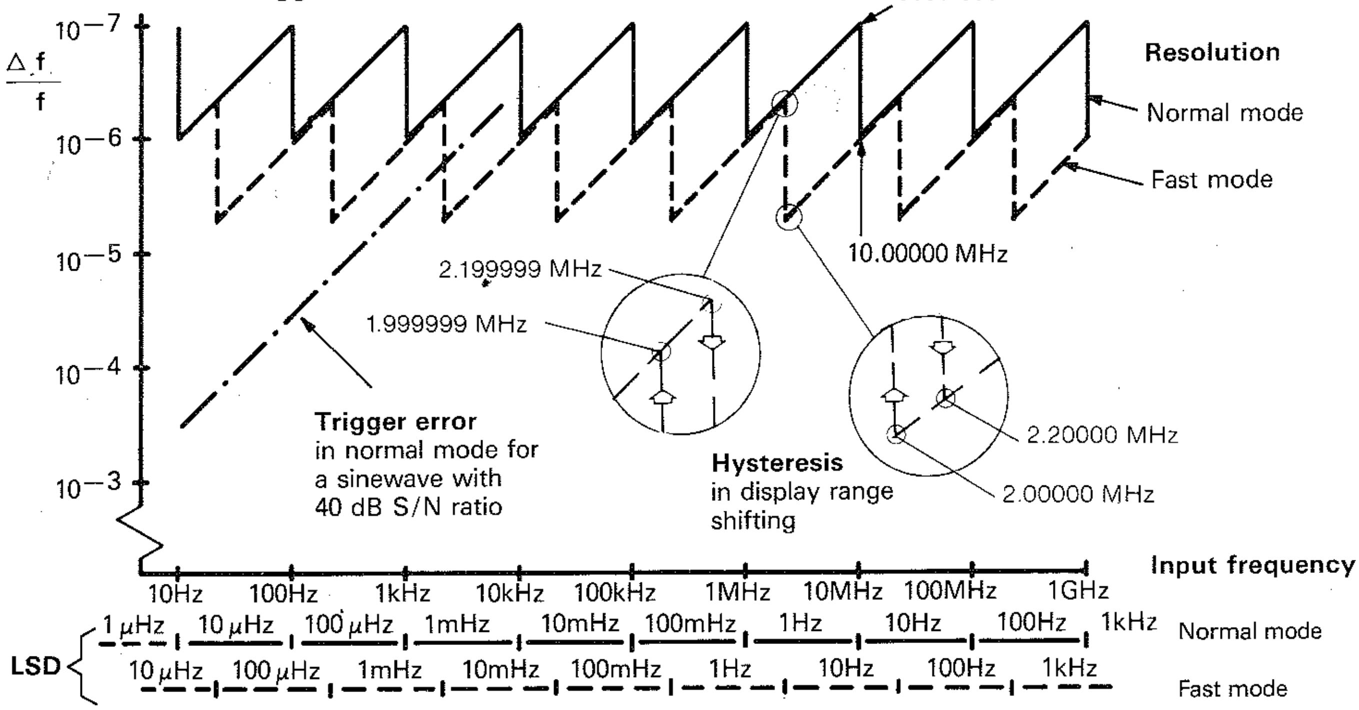
Input impedance

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)

Resolution and trigger error



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)

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

Rel. trigger error:

For any waveshape:

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

For sinewaves:

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

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: $0.5V_{RMS} \ldots 12V_{RMS}$
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	$\leqslant 5 \times 10^{-7}$/month	$\leqslant 1 \times 10^{-7}$/month
Temperature stability		
0 ... 50°C, ref. to +25°C	$\leqslant 1 \times 10^{-5}$	$\leqslant 1 \times 10^{-6}$
20 ... 30°C, ref. to +25°C	$\leqslant 3 \times 10^{-6}$ (typical)	$\leqslant 3 \times 10^{-7}$ (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/m^2
Operating: 5000 m (15000 ft) /53.3kN/m^2

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

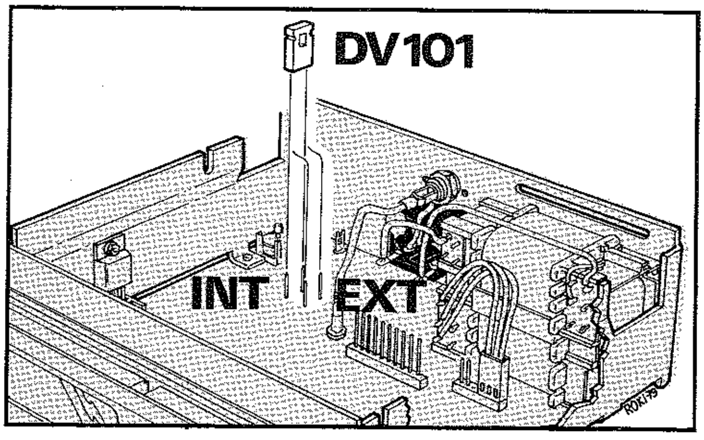
The instrument is grounded via the three-core line power cord plugged into an outlet with protective ground contact.

No other way of safety grounding is allowed.

7.3. Internal and external standard

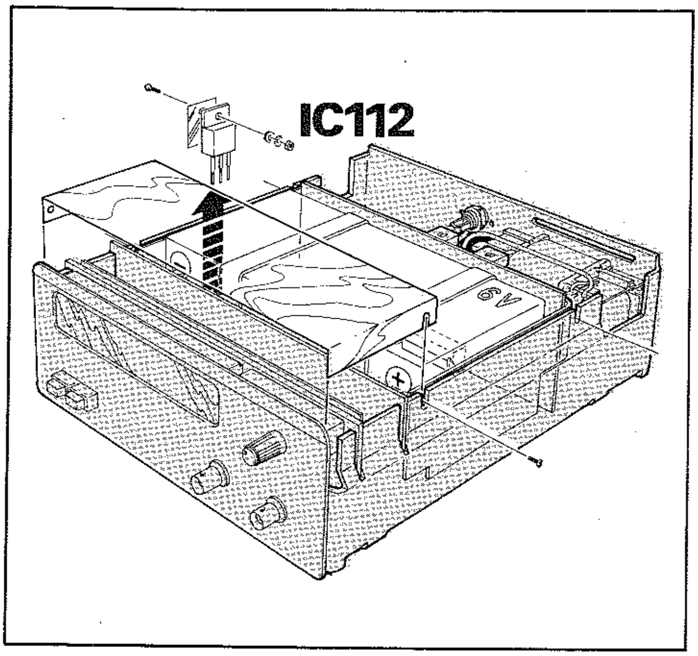
The counter can be set to external or internal standard by setting the jumper connector DV 101 as shown in the figure below.

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.



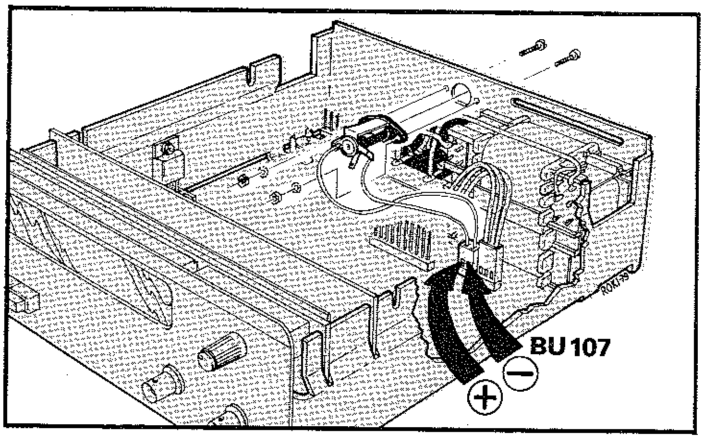
7.5. External Battery Jack

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.

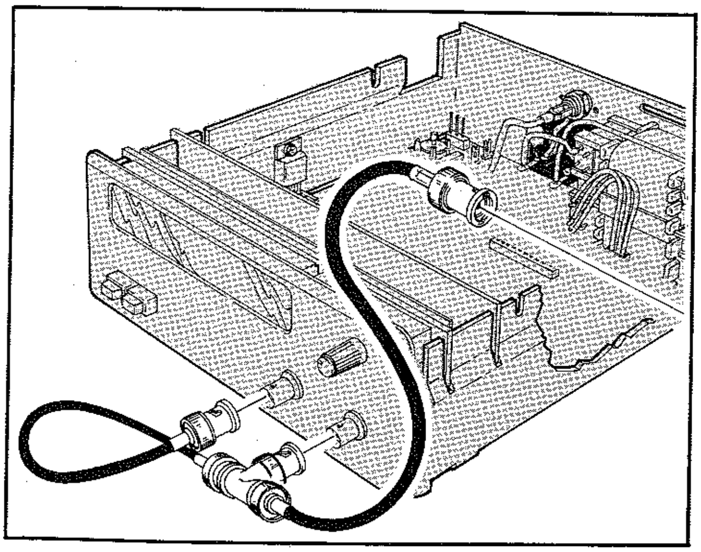
LF input

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.

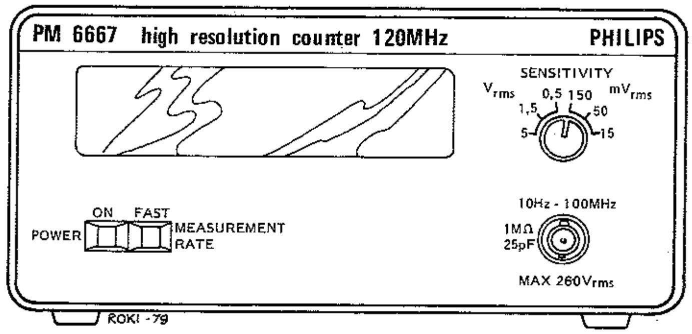
More information on the input signal is given in the Technical Specifications.

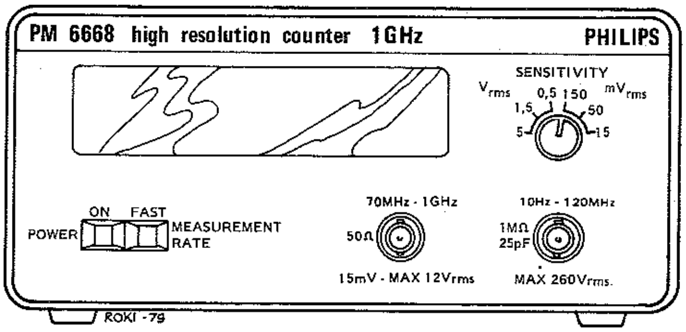
EXTERNAL STANDARD or BATTERY

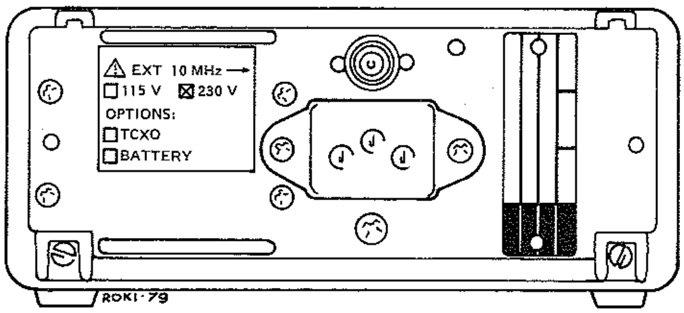
BNC input for external time base standard or, as optional extra, battery jack for external battery.

Line voltage receptacle

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





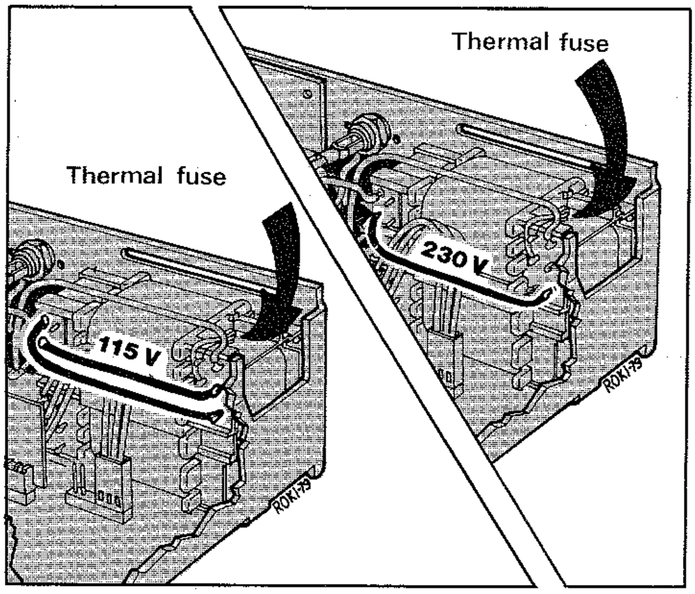


Service part

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 $f_{displayed} = \dfrac{\text{Event counts}}{\text{Time counts} \times 10^{-7}}$

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

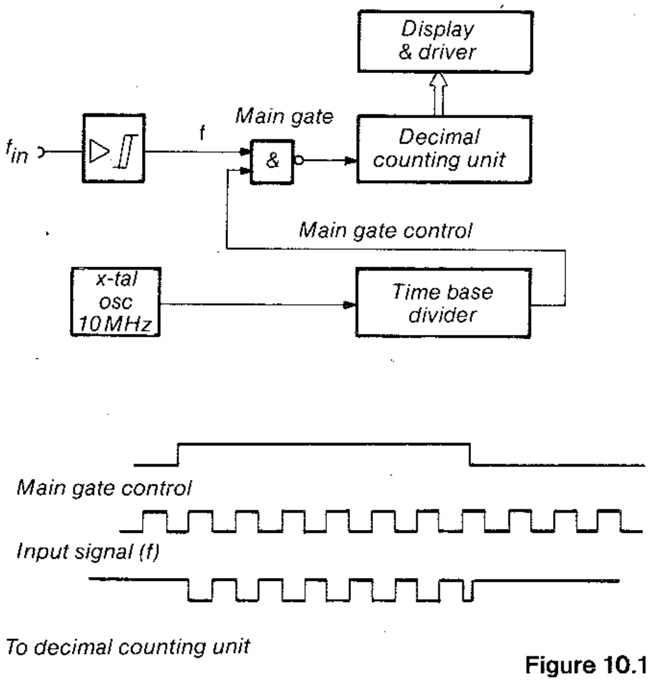


Figure 10.1.

Computing reciprocal counter

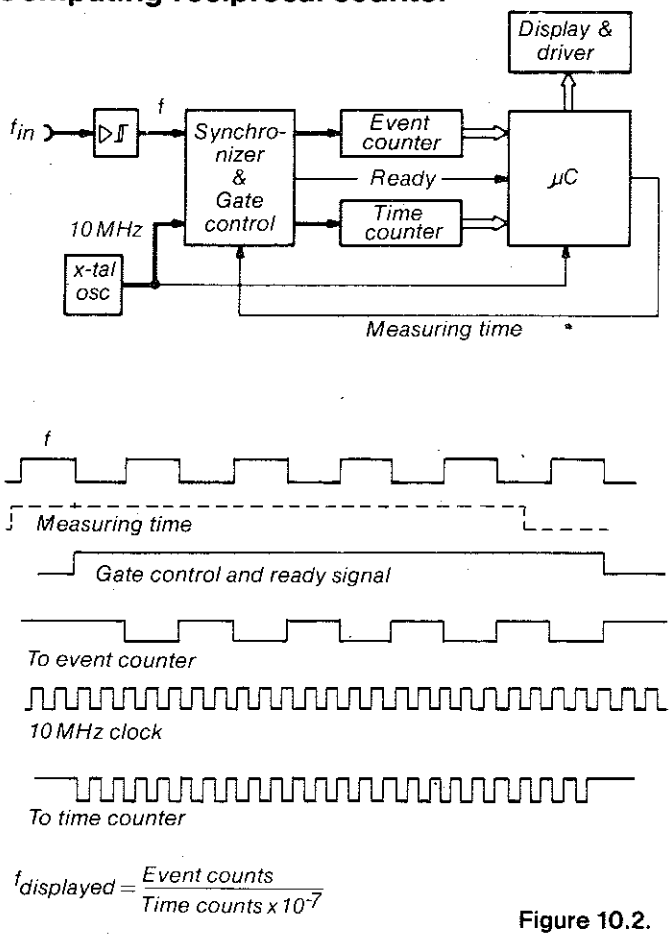


Figure 10.2.

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 crossover 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.

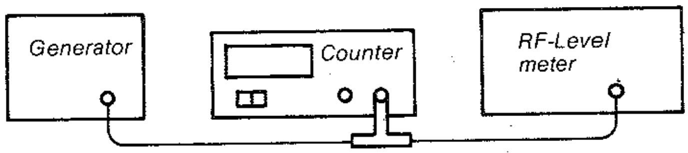
11. Performance check

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)

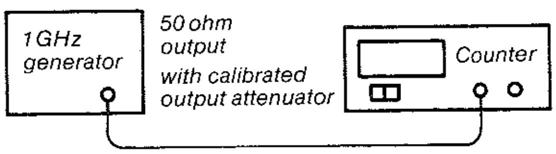


Use as short cables as possible!

- 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

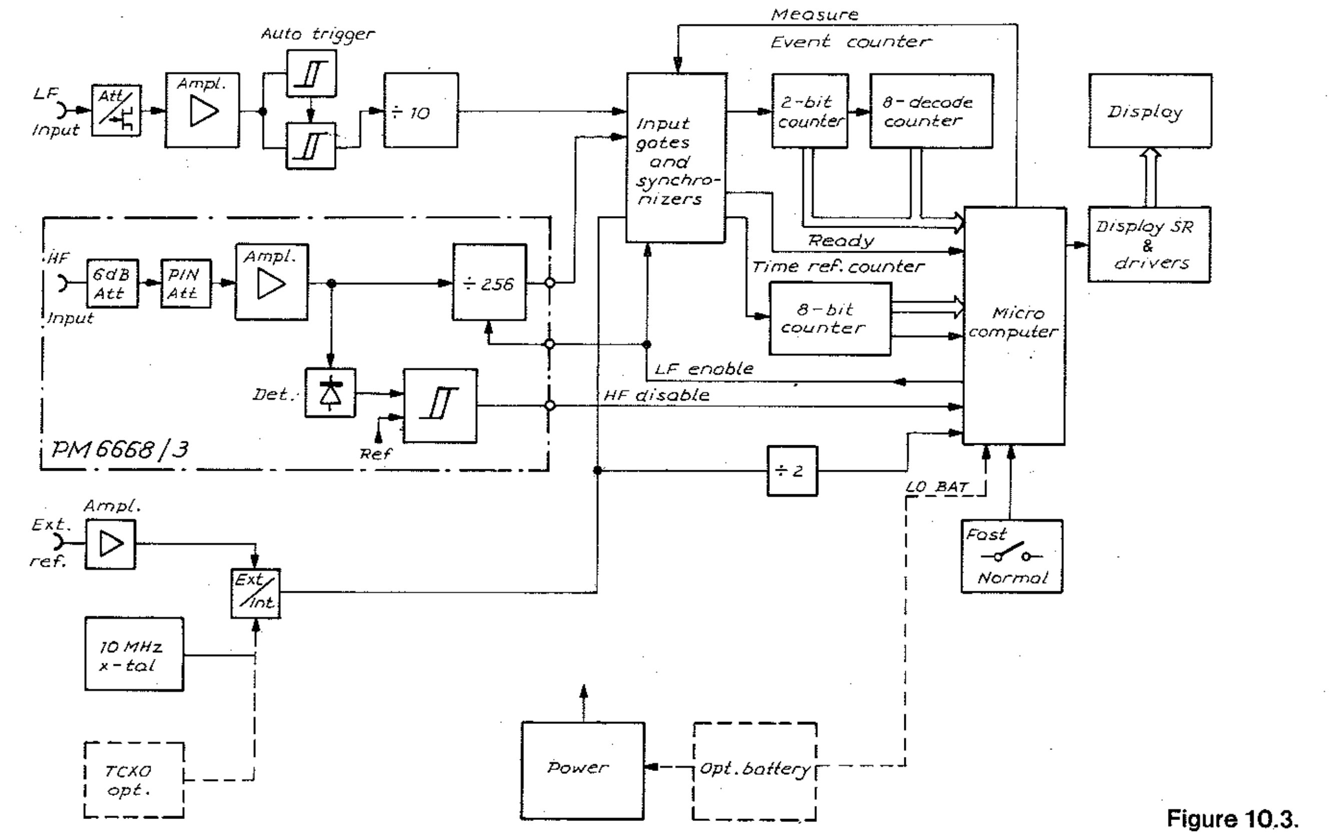


Figure 10.3.

Auto trigger operation

(patented)

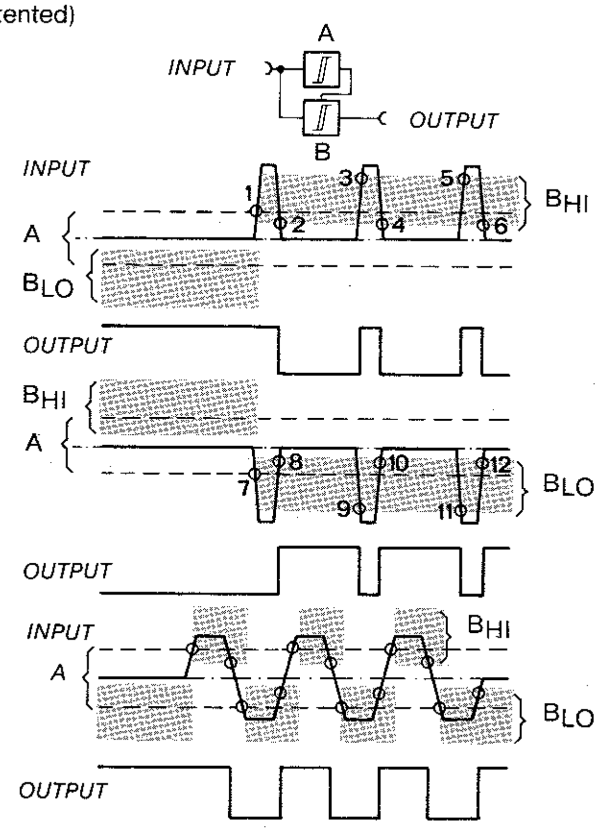


Figure 10.4.

Traditional trigger operation

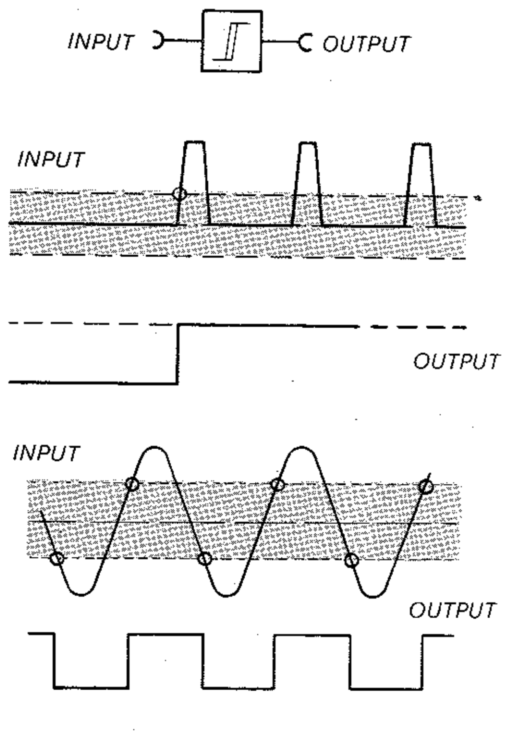


Figure 10.5.

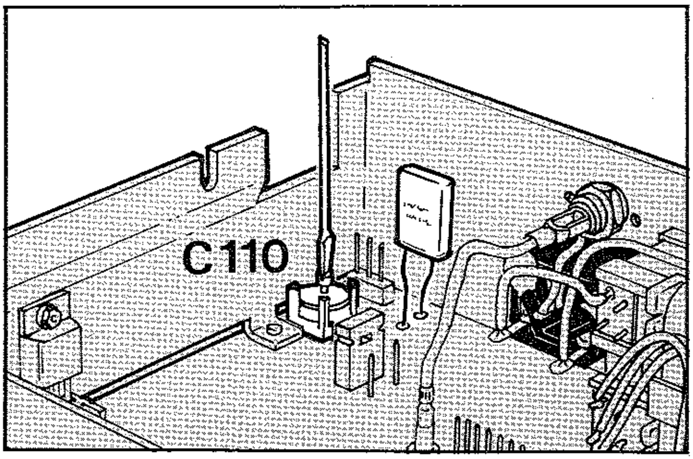
12. Adjustments

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

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

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

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

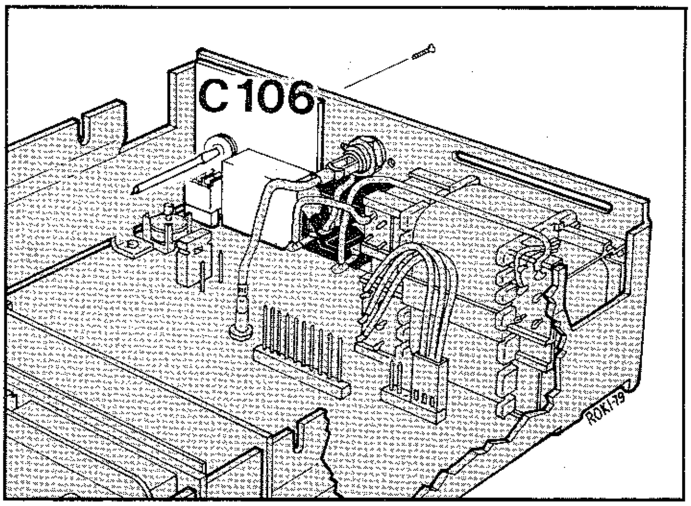


12.2. Frequency adjustment of TCXO
(Models PM 6667/02, PM 6668/02)

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

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

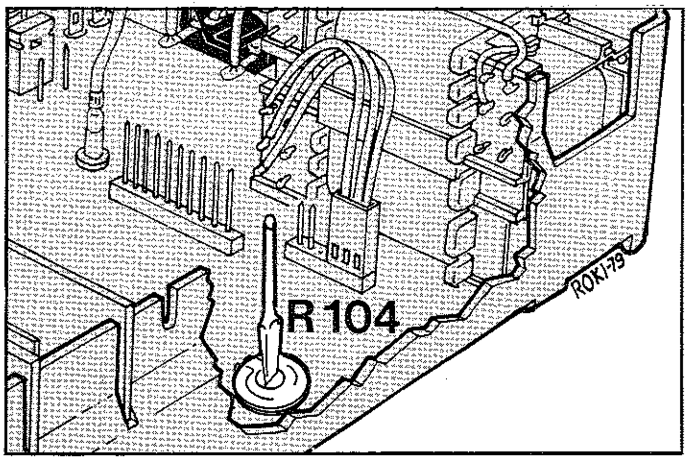
- Remove housing.
- Connect reference signal to LF input.
- Adjust C106 to read 9999.999 kHz on display.



12.3. DC balance adjustment

Equipment required:
LF sinewave generator and LF oscilloscope.

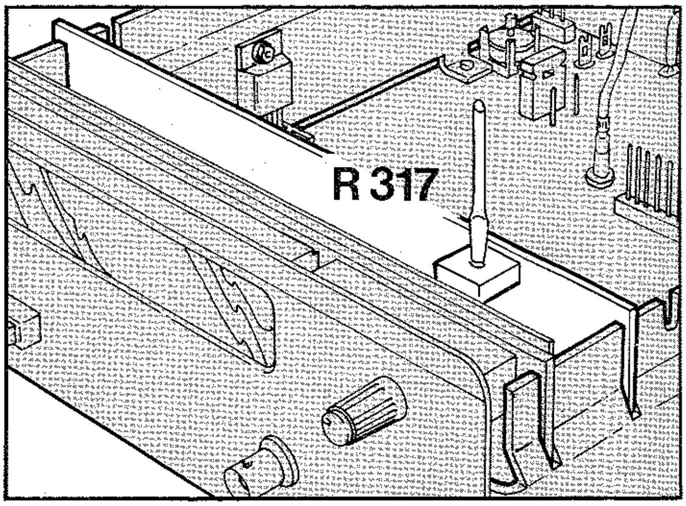
- Connect sinewave generator (set to approx. 1 kHz and 30 mV$_{RMS}$) to LF input of counter.
- Connect oscilloscope between pin 7 of IC103 and ground.
- Adjust R104 until displayed square-wave has a duty-factor of 0.5.
- Decrease input amplitude to 15 mV$_{RMS}$ and fine-adjust R104 for a dutyfactor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



12.4. RF enable adjustment (PM 6668 only)

Equipment required: 1 GHz signal generator

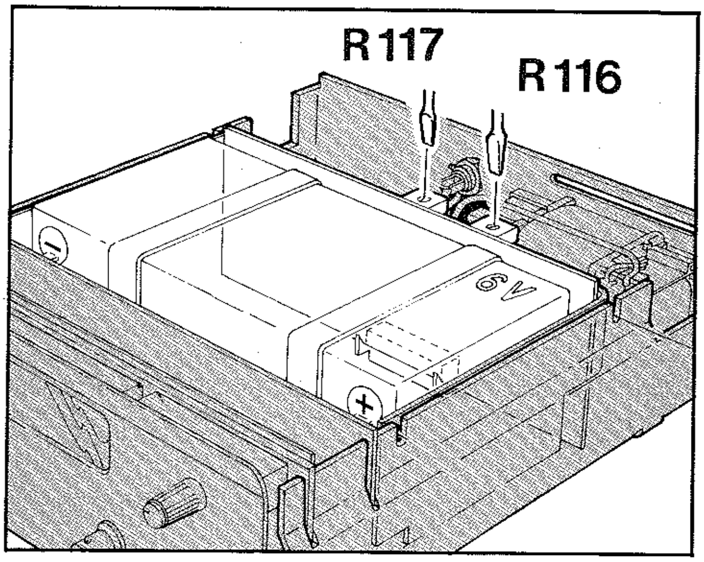
- Connect signal generator to RF input of counter.
- Set signal generator to 70 MHz and 15 mV$_{RMS}$.
- Check that counter displays a stable 70 MHz read-out.
- If there is no read-out, adjust R317.
- Set signal generator to 500 MHz and 800 MHz. Check read-out at each frequency and adjust R317 if required.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

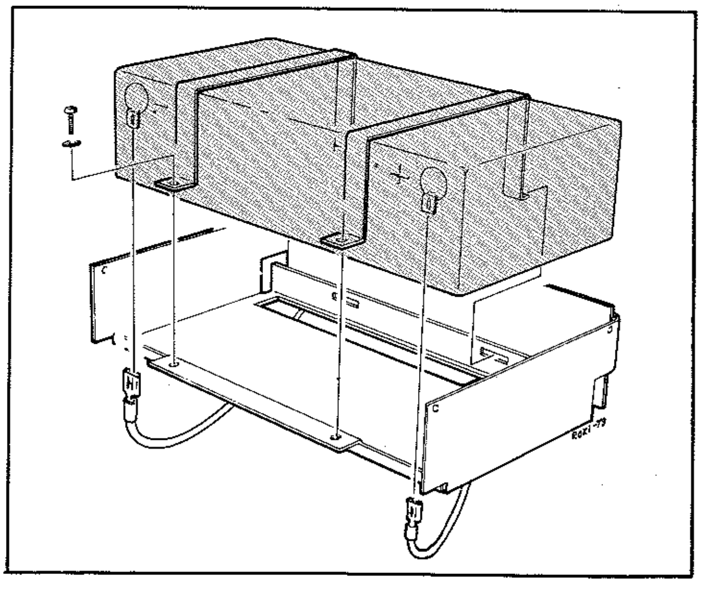


13. Replacing parts

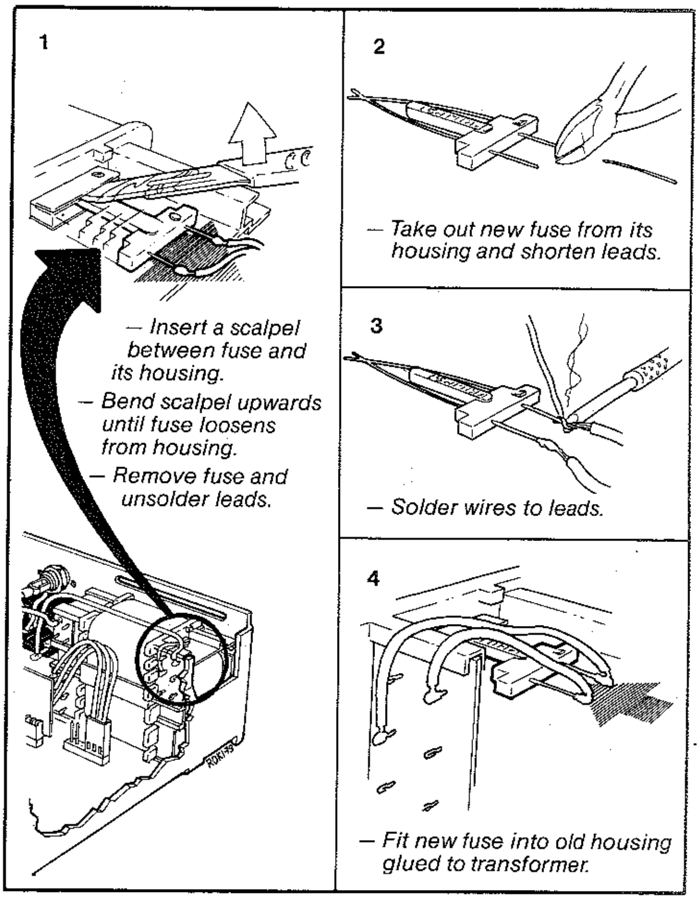
13.1. Battery replacement

- 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.



13.2. Fuse replacement

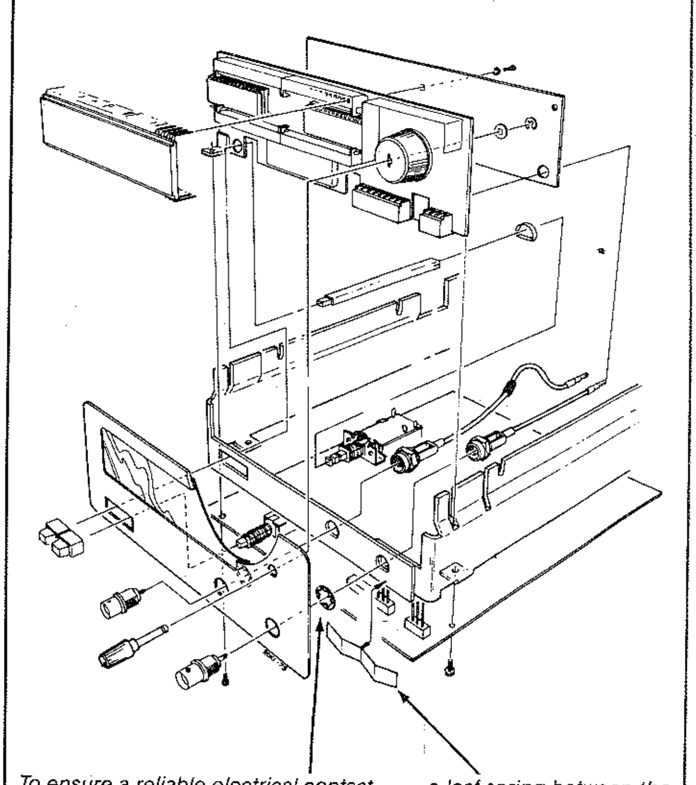


— Insert a scalpel between fuse and its housing.
— Bend scalpel upwards until fuse loosens from housing.
— Remove fuse and unsolder leads.

— Take out new fuse from its housing and shorten leads.

— Solder wires to leads.

— Fit new fuse into old housing glued to transformer.



To ensure a reliable electrical contact between the text plate and the chassis the counter has been provided with a washer on the BNC connector(s) or *a leaf spring between the text plate and the chassis. Both alternatives are shown in the figure above.*

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.

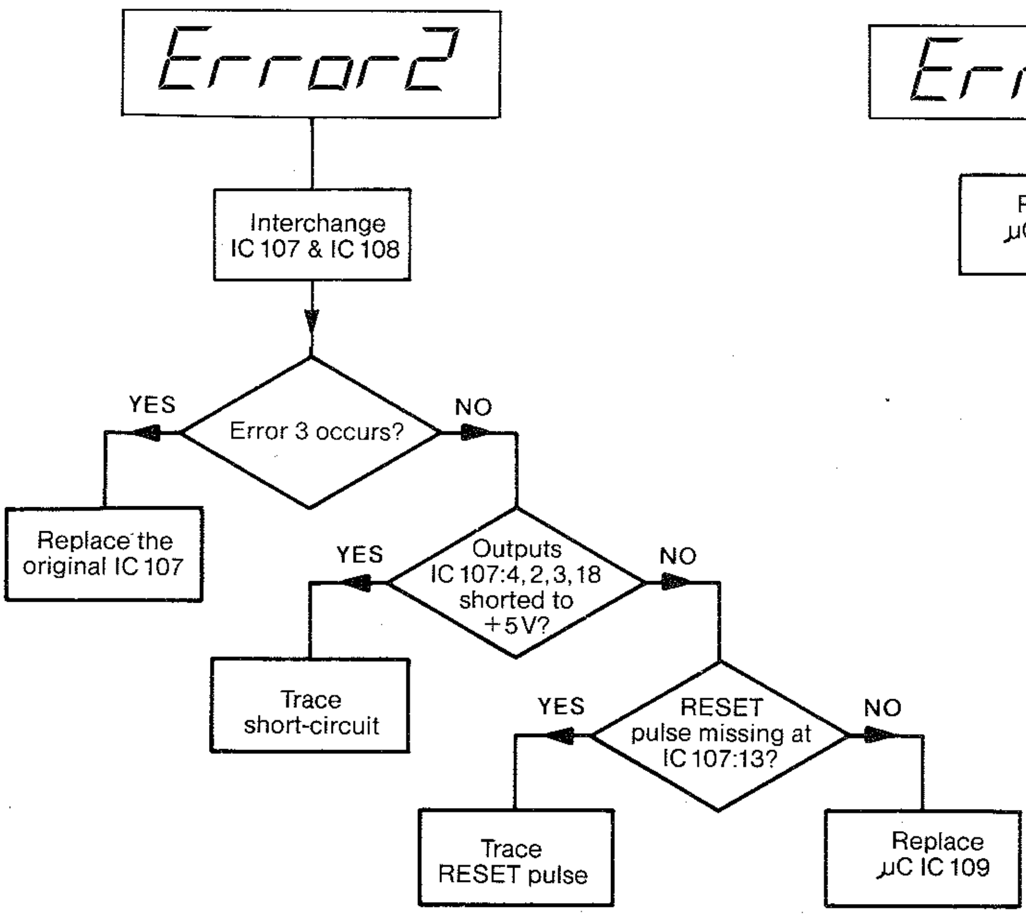
All segments, decimal points and units are visible on the display during the test. This makes it possible for the operator of the counter to check the function of the display.

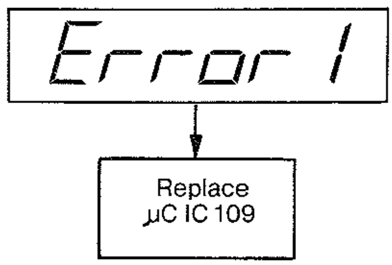
If the test fails during the test of program memory or data memory, the code Error 1 will be displayed.

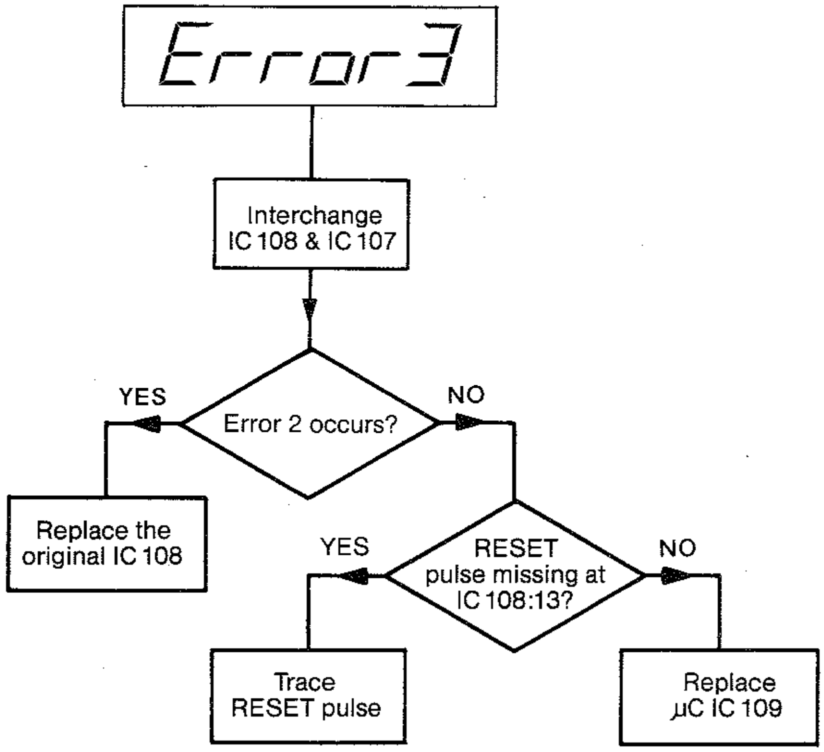
If, however, the test that the µC can set the external logic to zero fails, there will be an Error code between 2 and 6 depending on where the faulty part is.

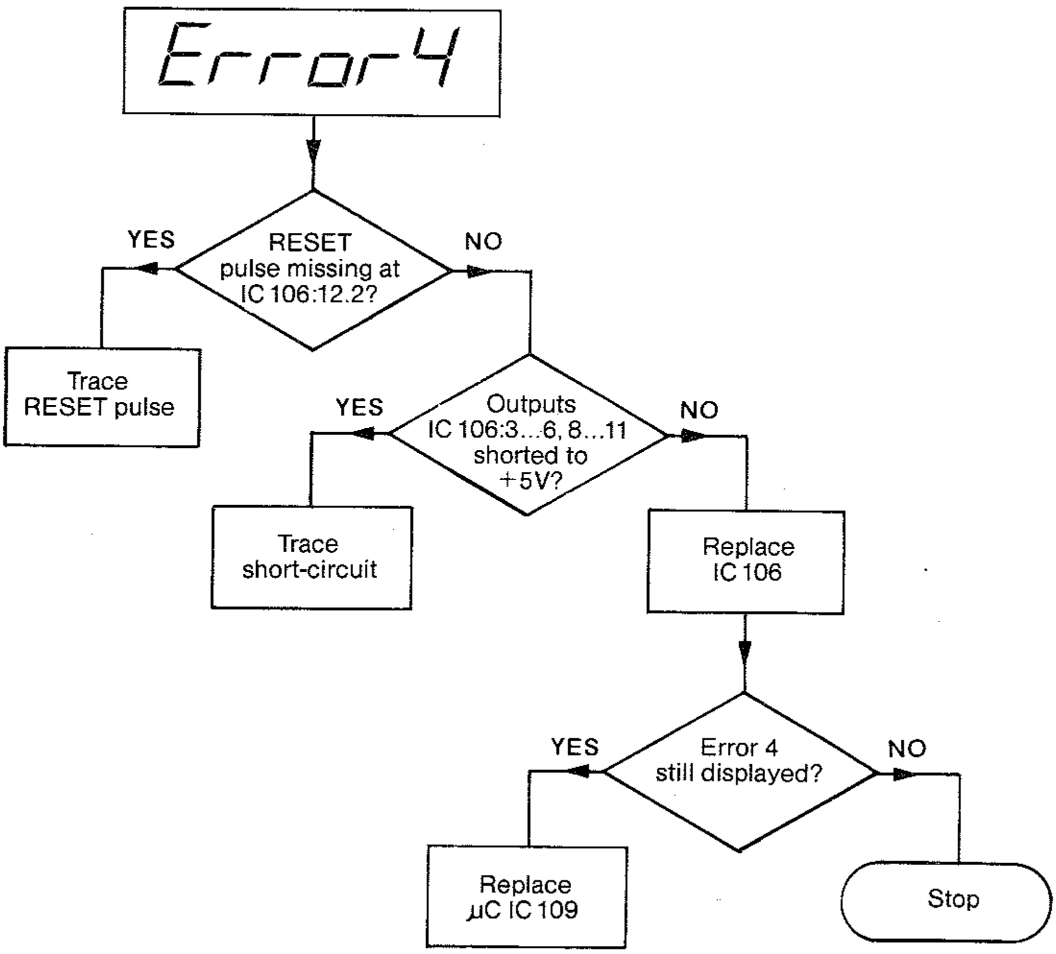
NOTE: The diagrams illustrate the faults that are most likely to occur in the microcomputer circuitry. Other fault combinations may be possible which also generate an "Error" code or a non-sense display read-out.

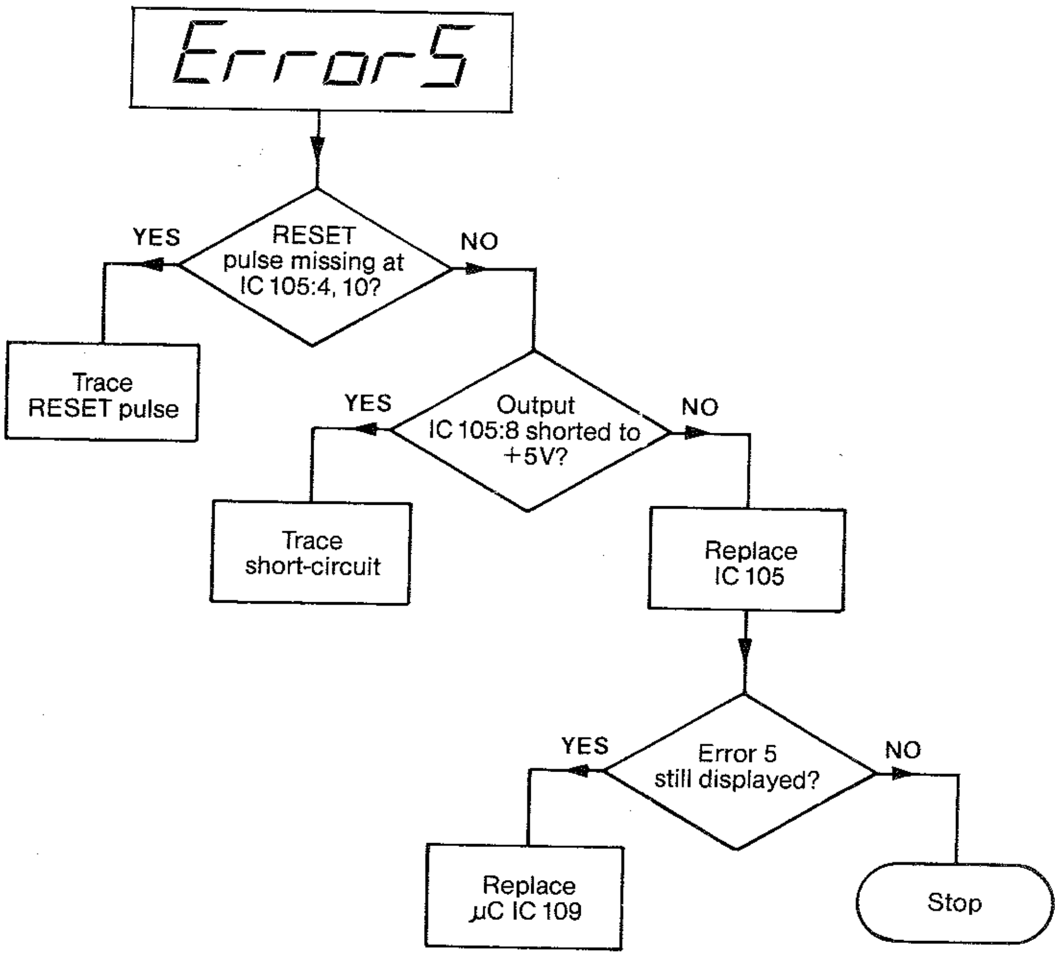
Always check the DC supply voltage before any replacements are made!

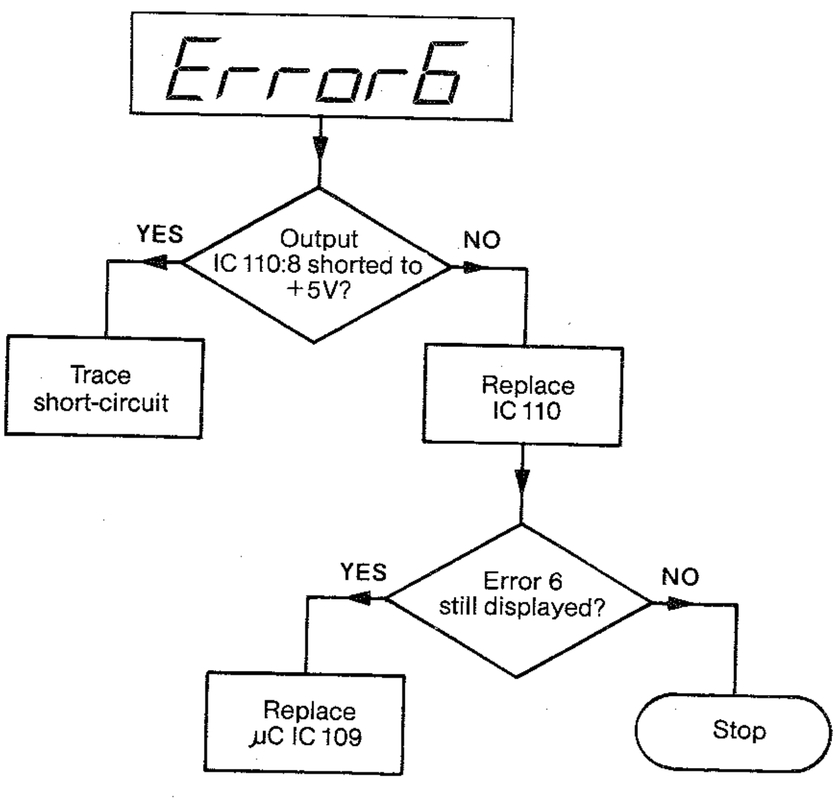




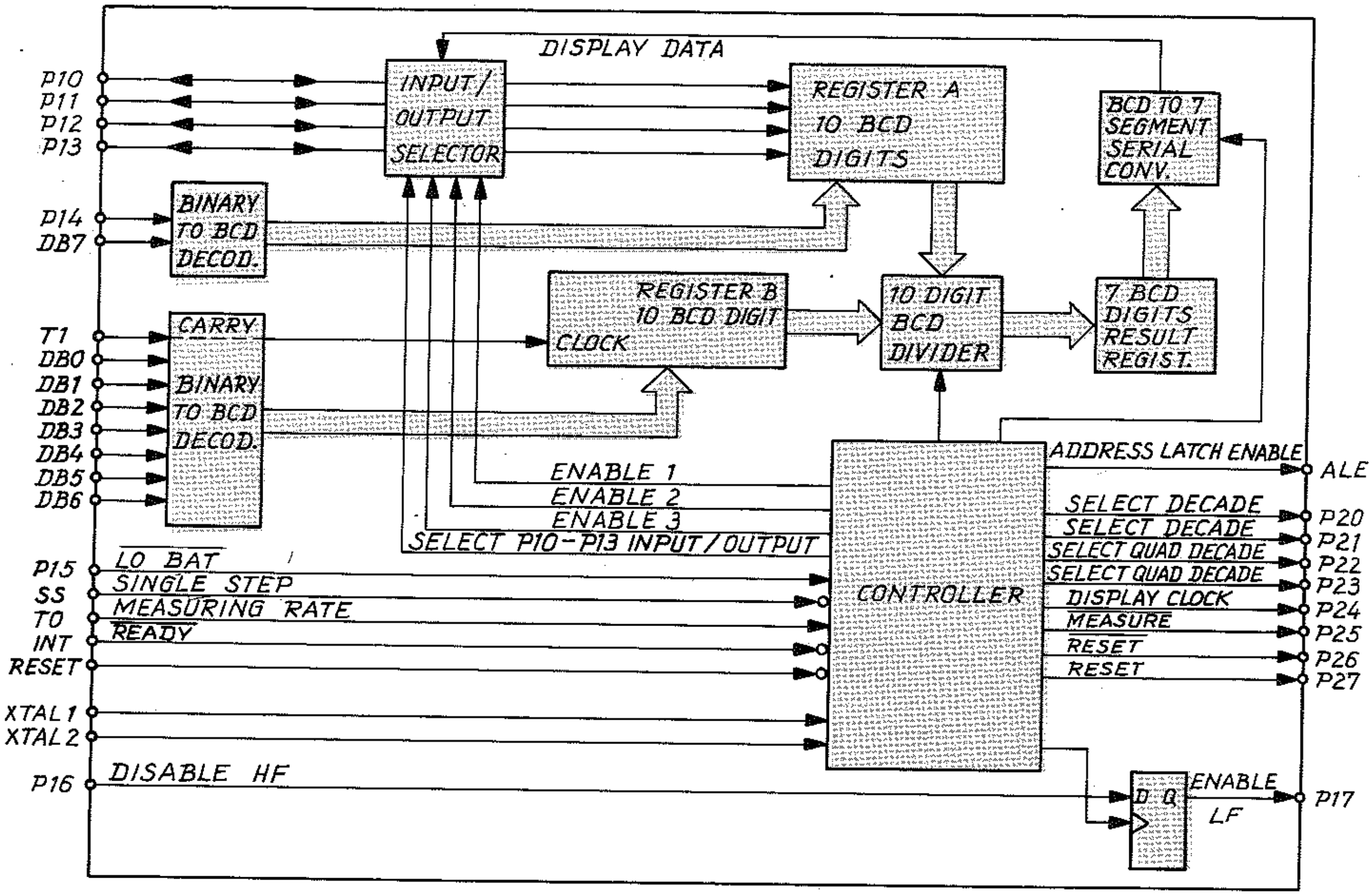

Error 3
Interchange IC 108 & IC 107
Error 2 occurs?
YES
NO
Replace the original IC 108
RESET pulse missing at IC 108:13?
YES
NO
Trace RESET pulse
Replace µC IC 109


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
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 5 still displayed?
YES
NO
Replace µC IC 109
Stop


Error 6
Output IC 110:8 shorted to +5V?
YES
NO
Trace short-circuit
Replace IC 110
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".

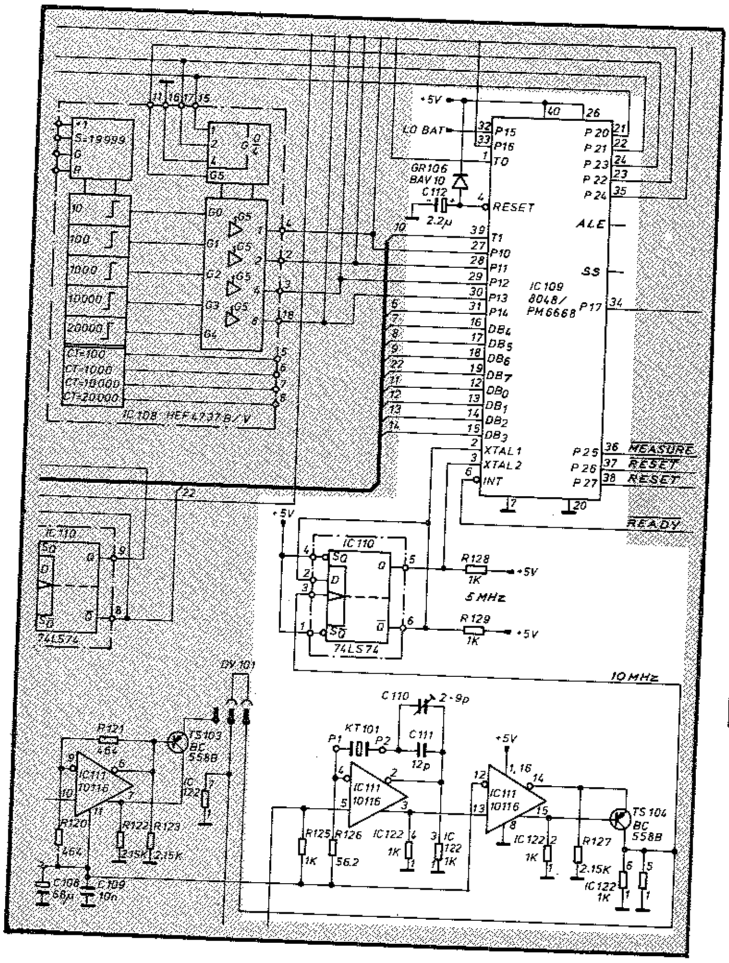
In the "BCD to 7 segment serial converter" the 7 BCD digits are transferred into 7 segment information in serial form. In this block the decimal point, units and LO BAT are added.

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 IC201, 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.

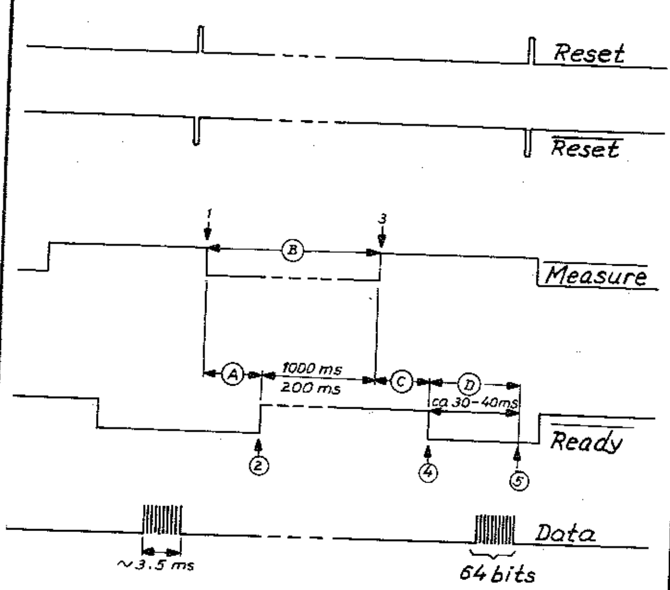
This 5 MHz clock signal has nothing to do with the resolution and accuracy specification but it must always be present to get the µC running. It is important that the internal oscillator is operating since it can not be replaced with an external reference signal. The internal reference oscillator is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



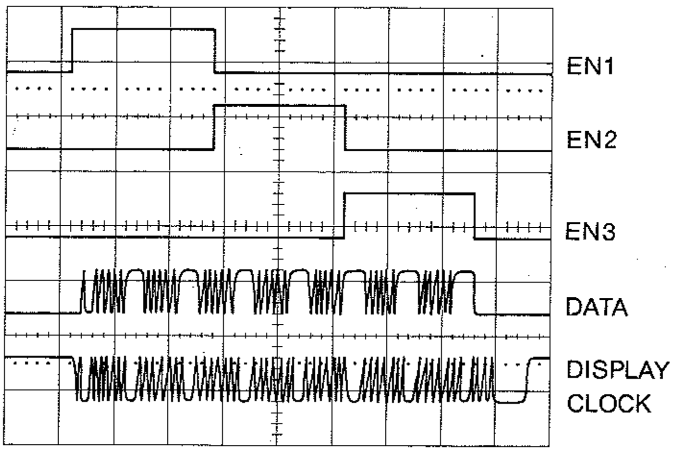
Ⓐ *The time interval between MEASURE goes low and READY goes high is depending on the input frequency. The lower limit is 1 to 2 periods of the input signal. The upper limit is 270 ms.*

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

Ⓒ *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 MEASURE goes low ①, waiting for an event signal to occur. If no event signal occurs within 270 ms Ⓐ the MEASURE goes high again. During the time 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 MEASURE to be a high READY signal ② at IC 105:2, 3, 6. The time when 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 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 MEASURE going high ③ and READY going low ④ is therefore depending on the input frequency. The time interval Ⓒ is maximum 1.2 s. The time interval Ⓓ between 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.

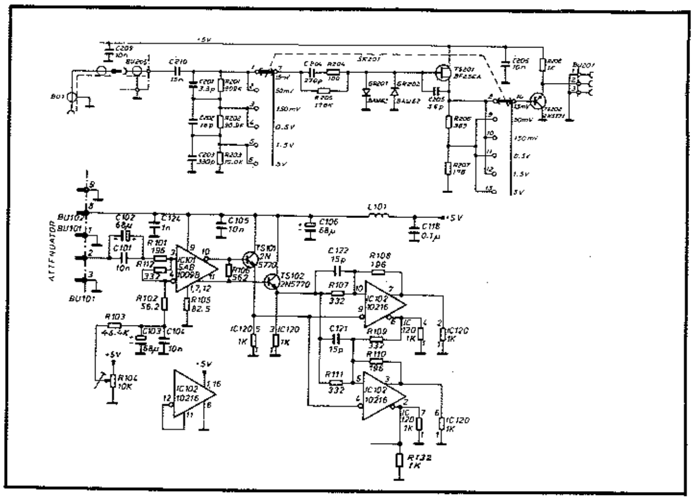
Step 1. Check the Data, Clock and Enable Signals to the Display PCB, according to the photo.

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.

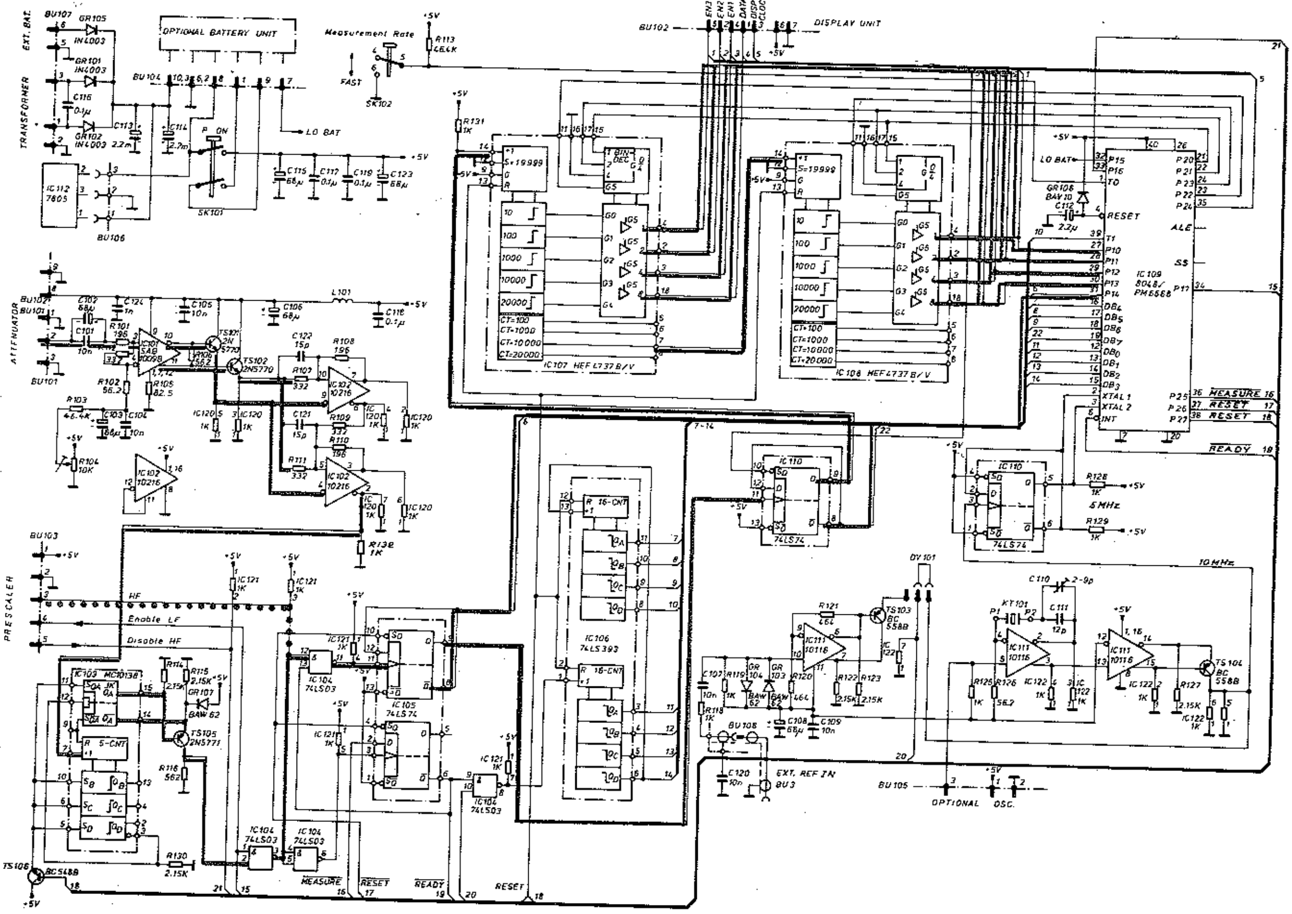
Synchronizer and Gate control

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).

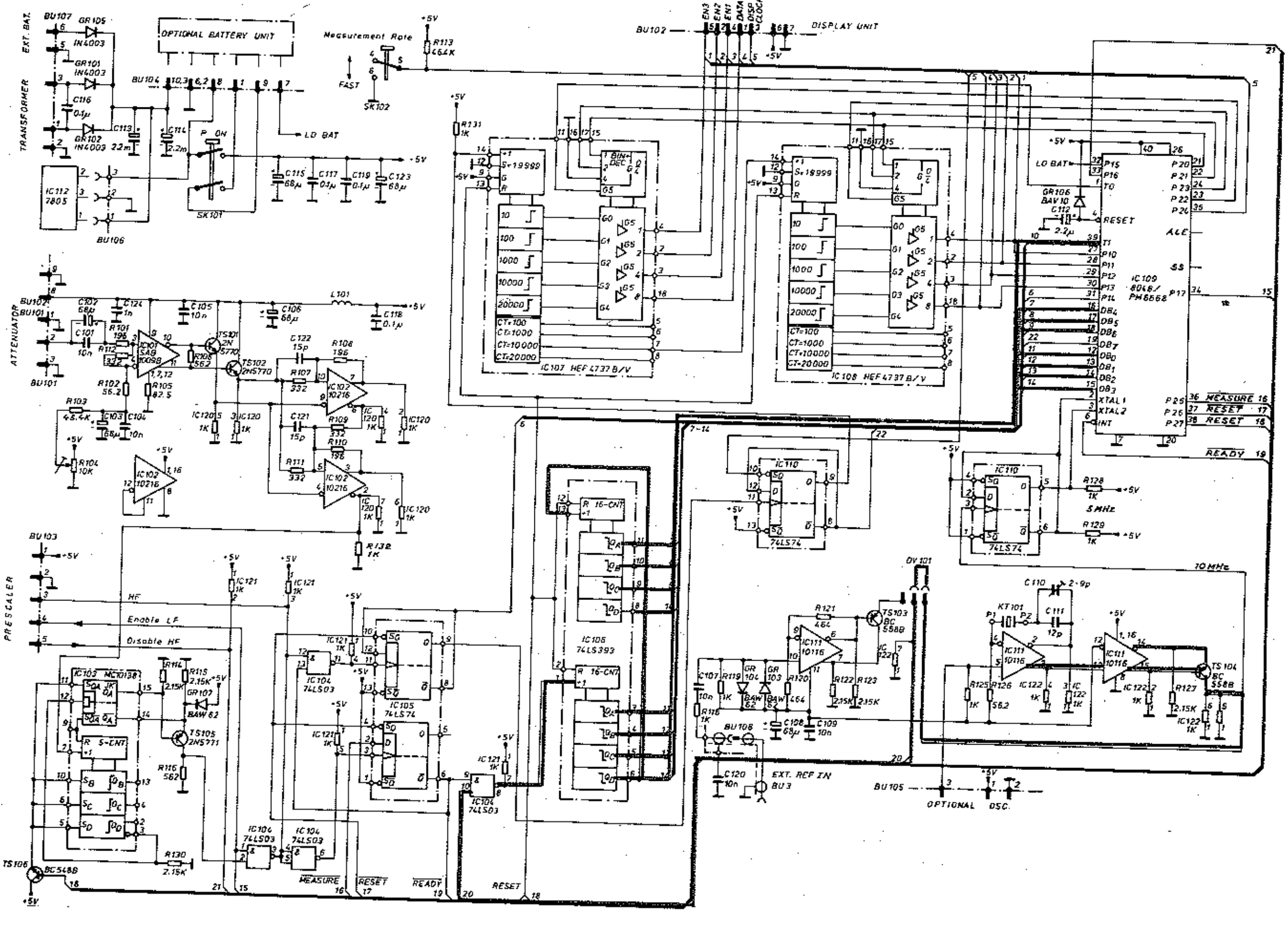
The signal path through the Event and Time counters are indicated with blue in the signal path diagram.

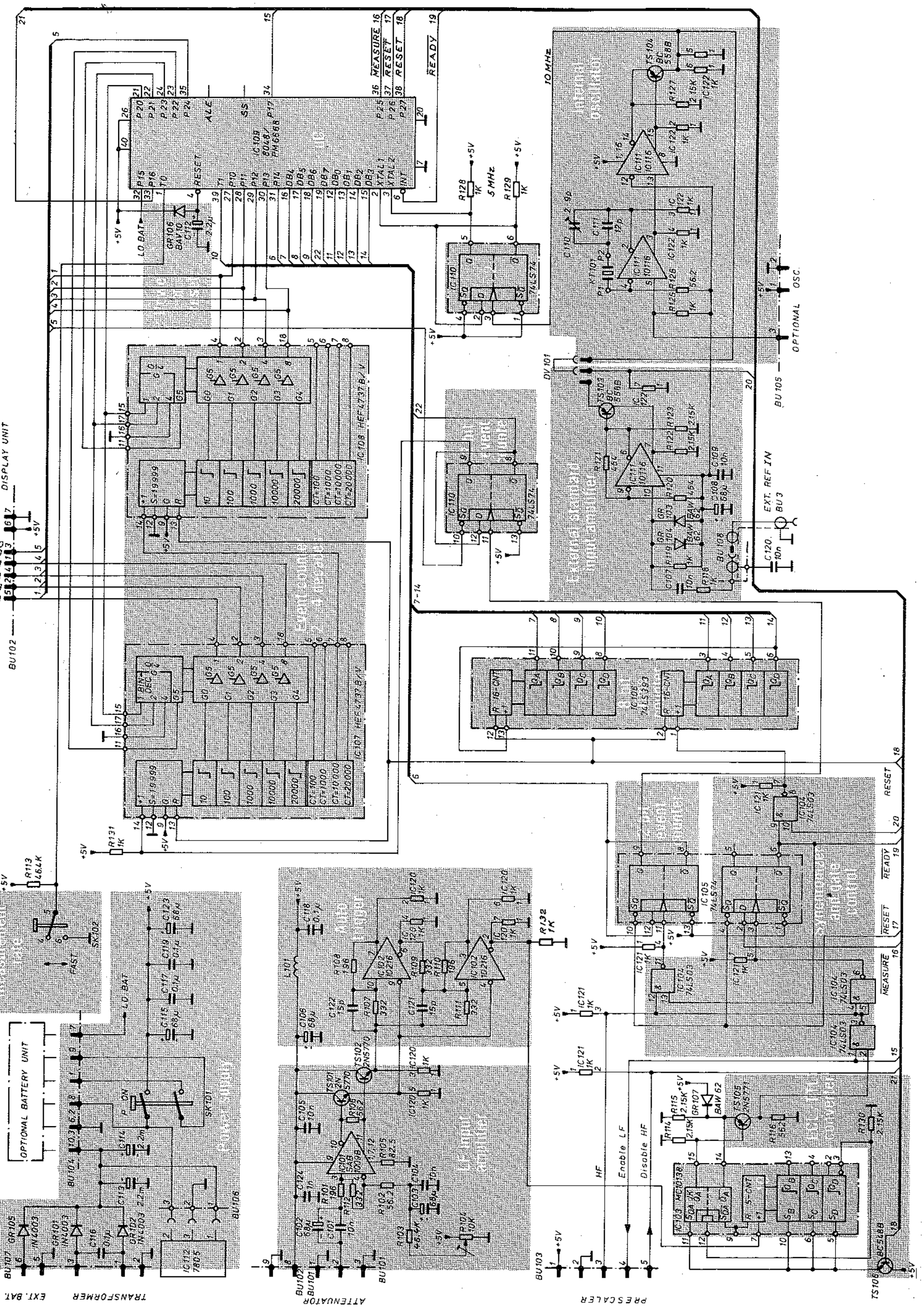
The µC reads the content in the Event counter and the Time counter after the measuring time has elapsed. This is indicated by the red signals in the signal path diagram. It calculates the result and converts it to a 64 bit serial information including clock and enable signals needed for correct presentation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

Signal path trough the Event counter

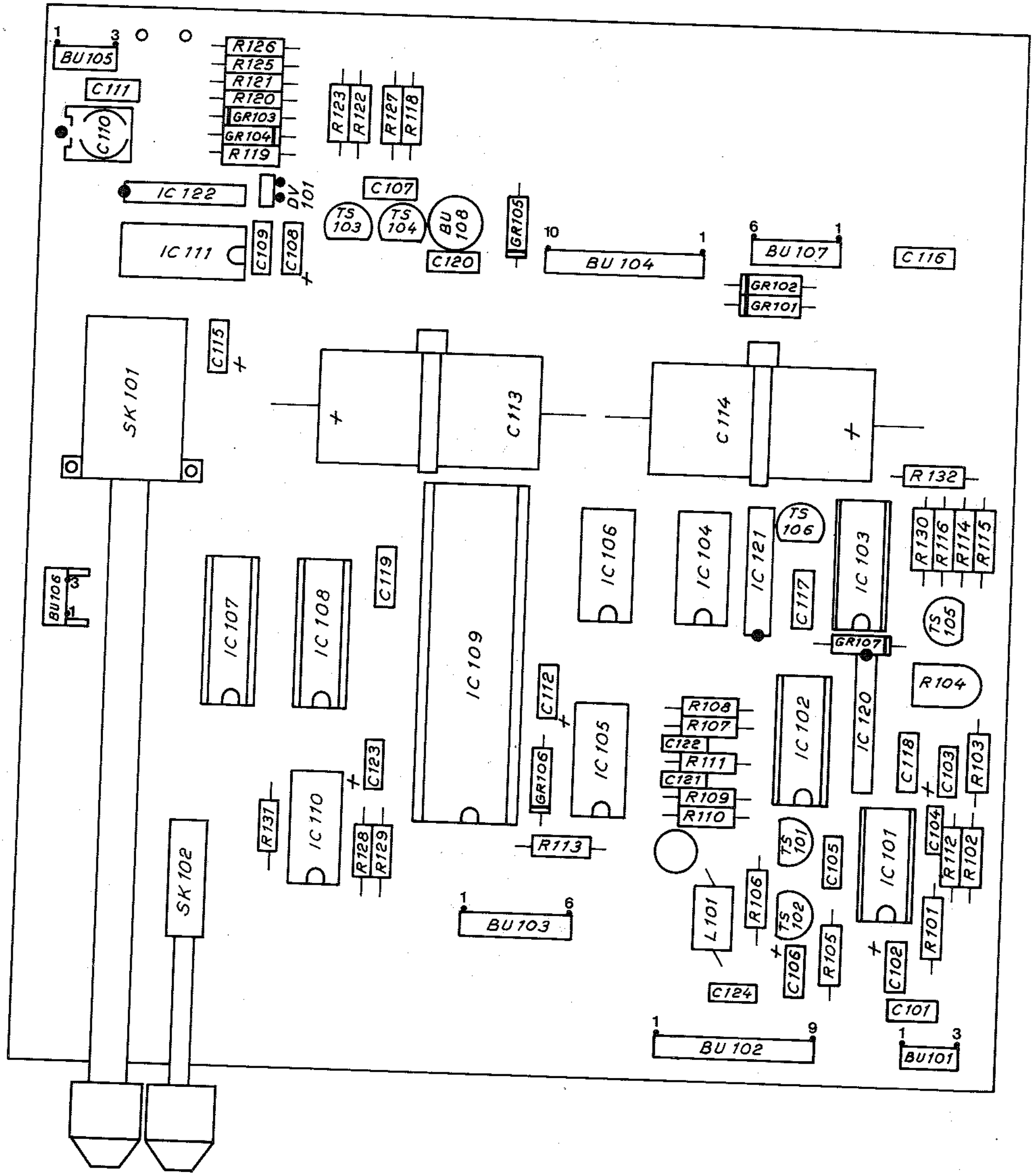


Signal path trough the Time counter

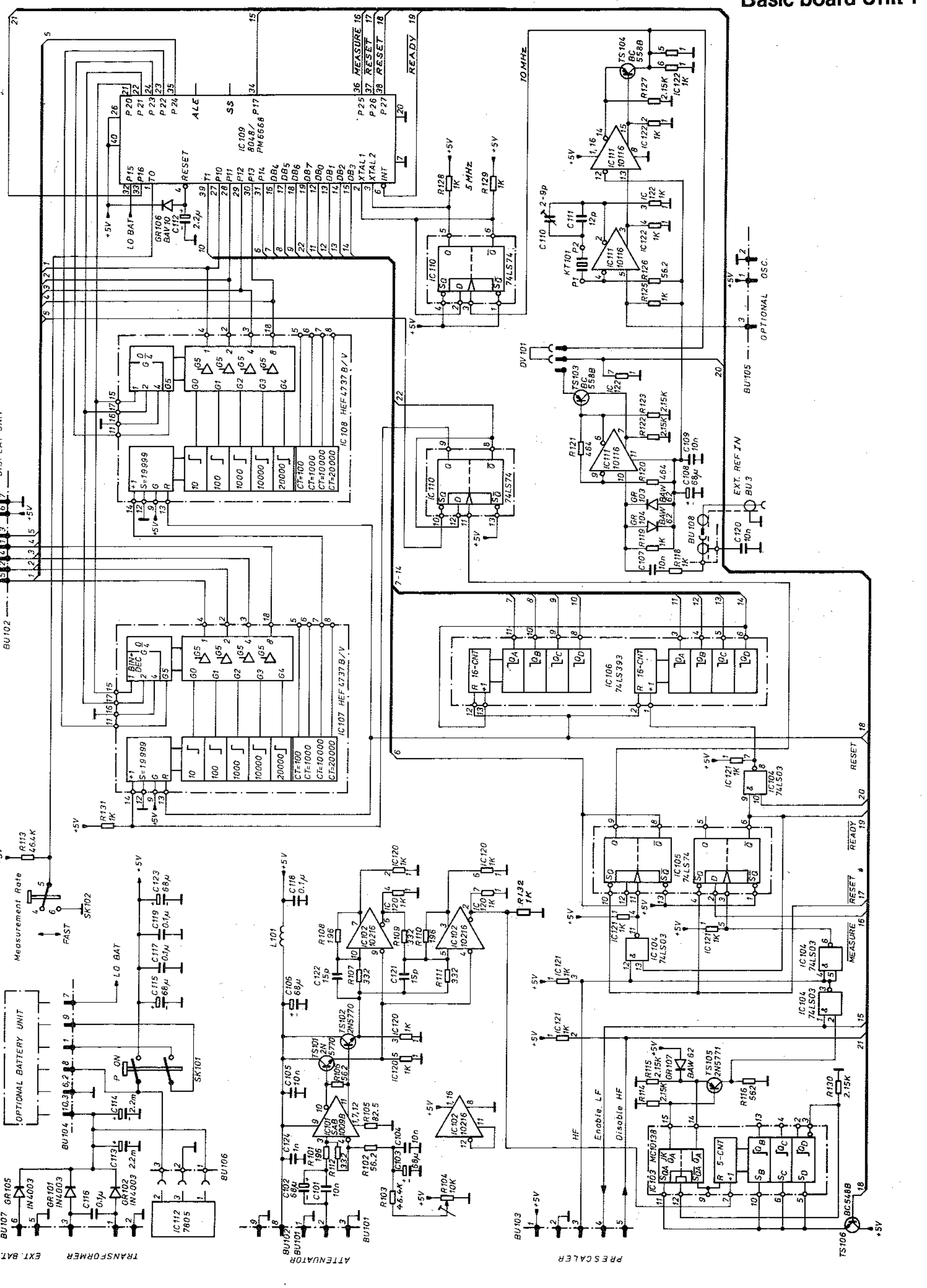



DISPLAY UNIT
OPTIONAL BATTERY UNIT
EXT. REF IN
OPTIONAL OSC.
MEASURE
RESET
READY
10 MHz
5 MHz
TRANSFORMER
EXT. BAT.
ATTENUATOR
PRESCALER

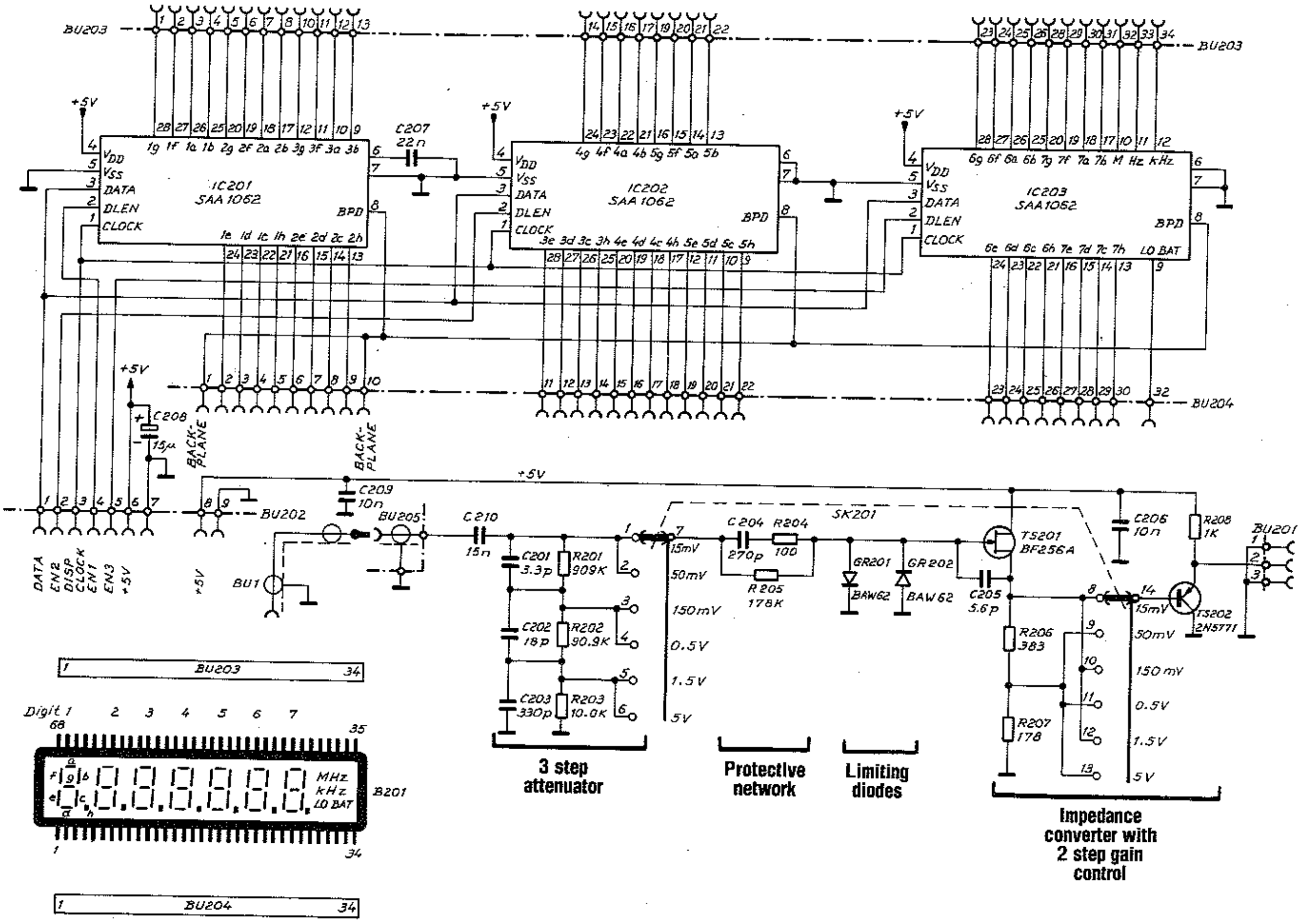
Basic board Unit 1

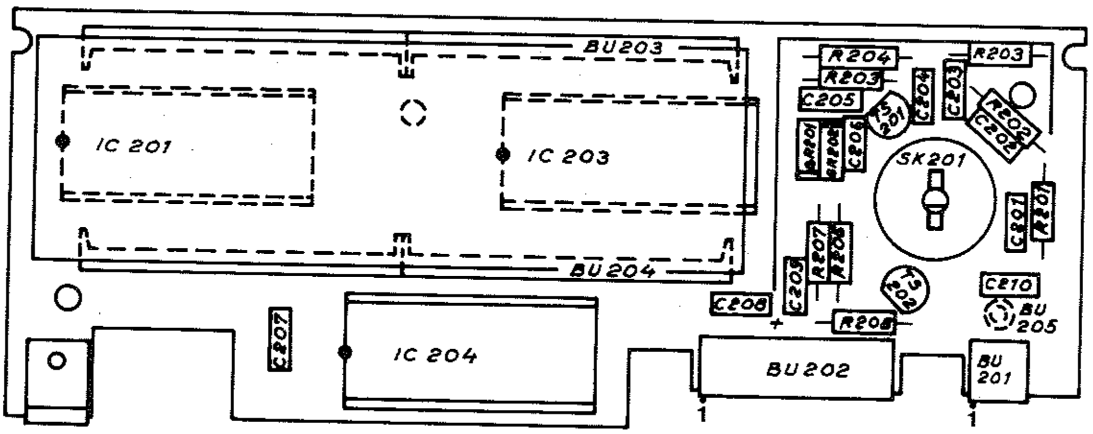


Basic board Unit 1

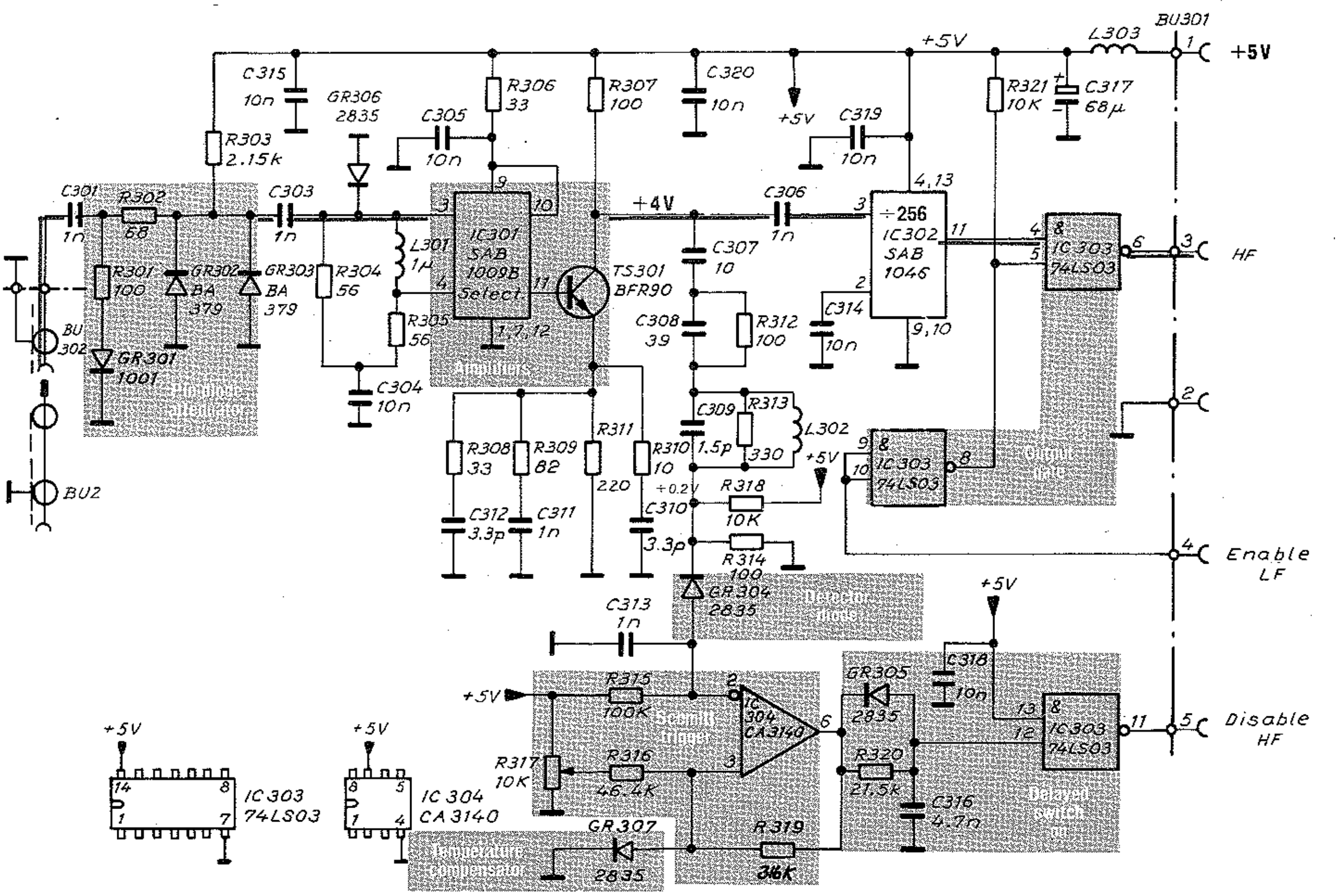


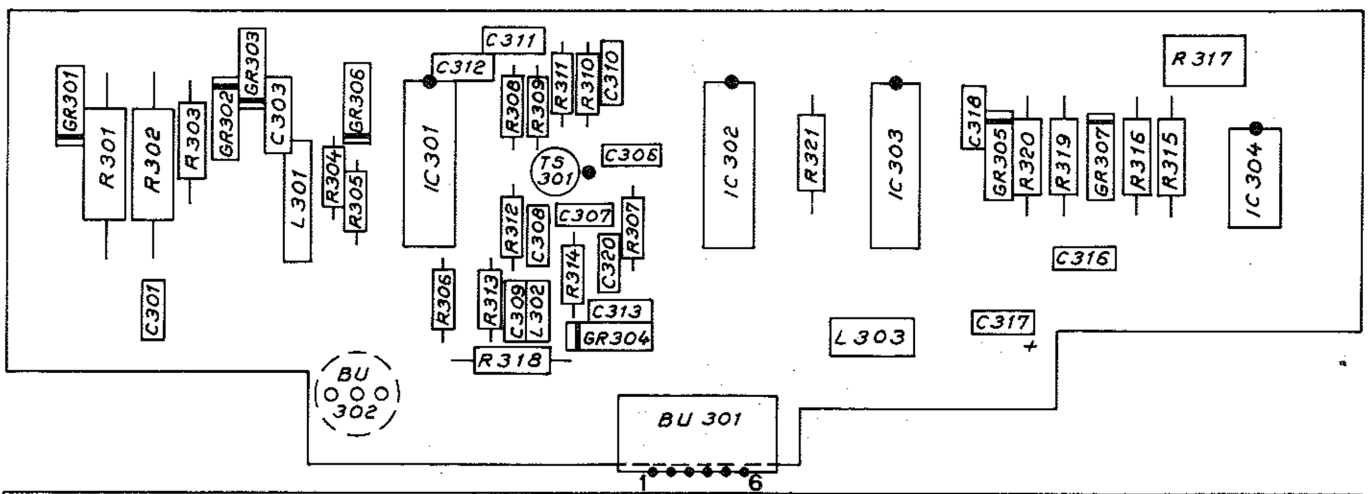
Input amplifier and display drivers Unit 2

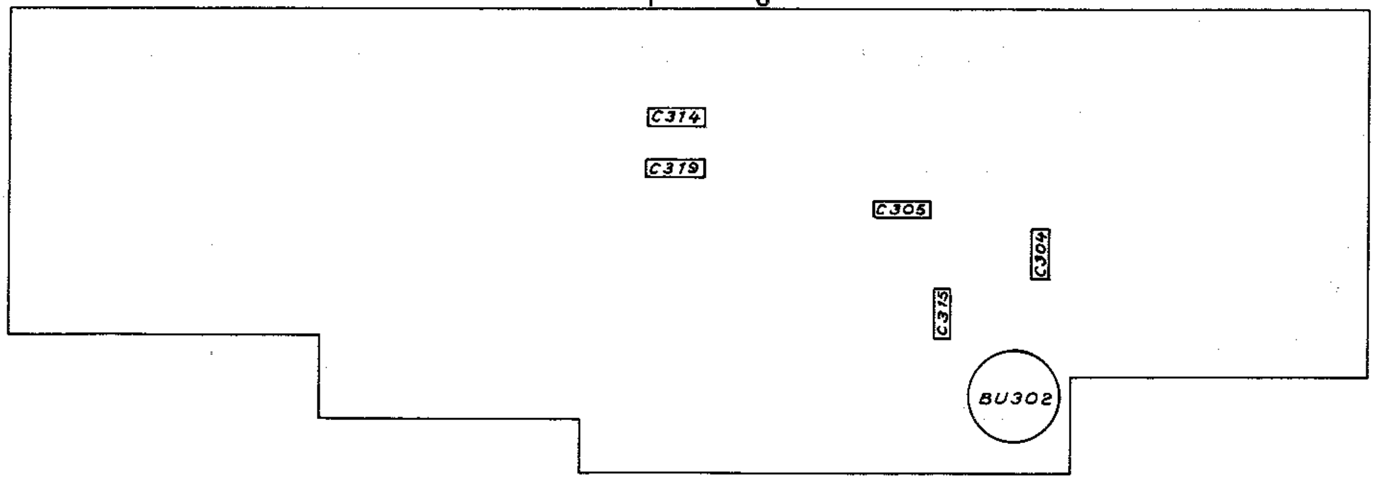




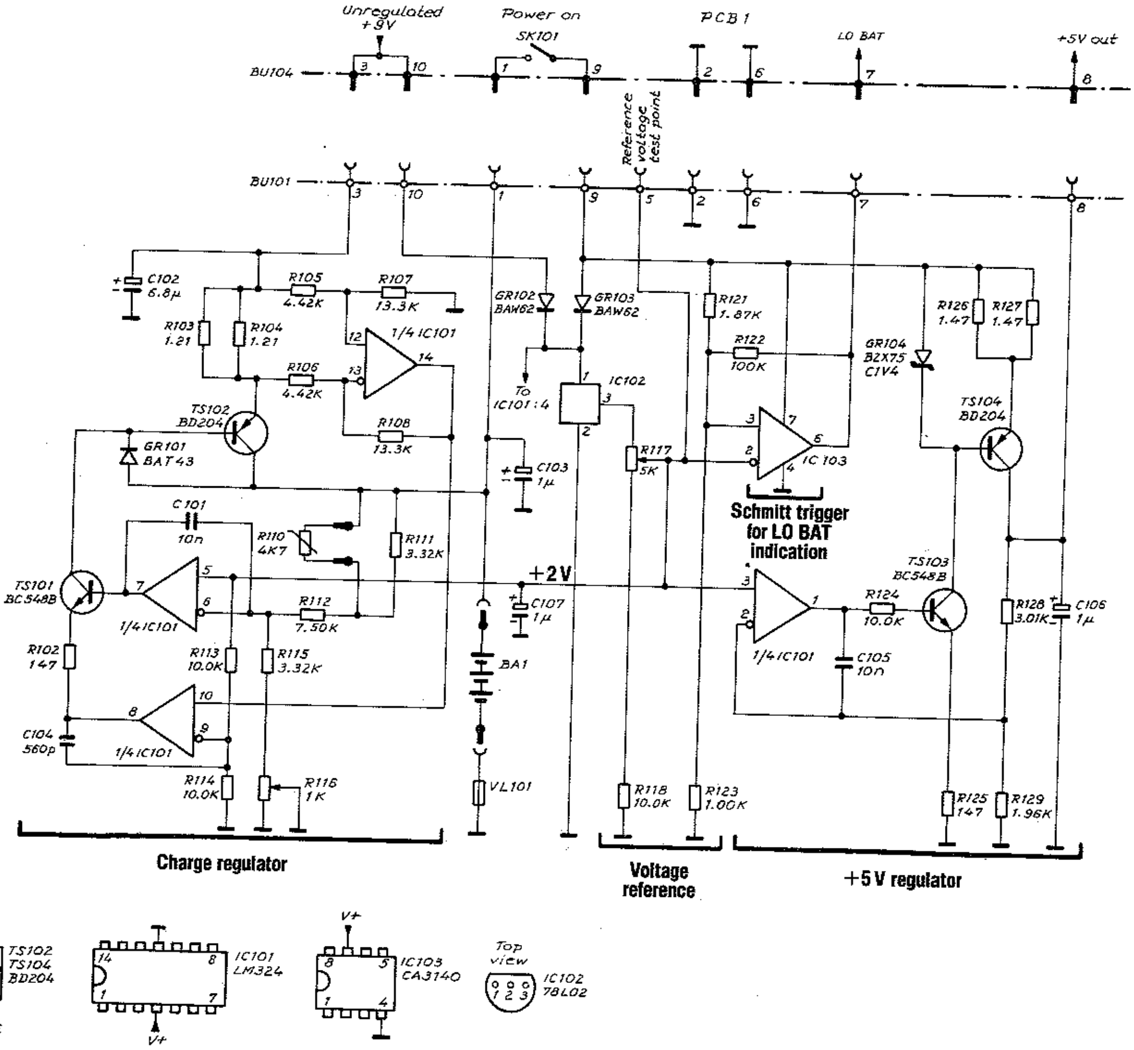
Prescaler Unit 3

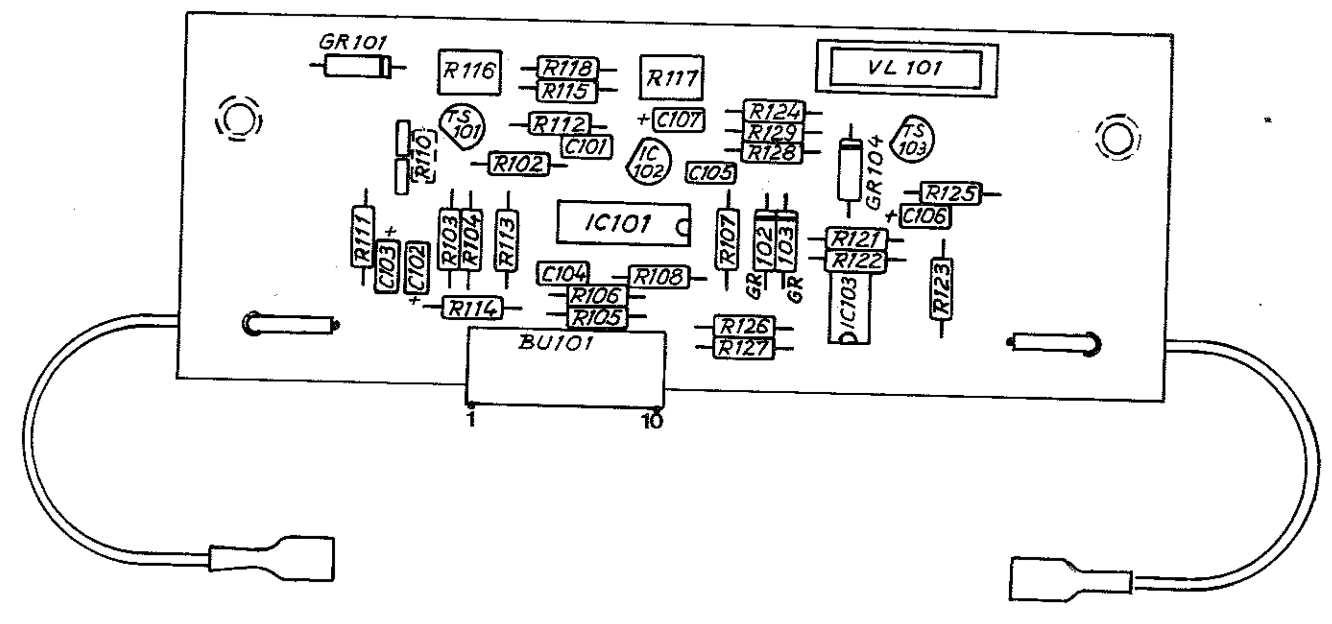




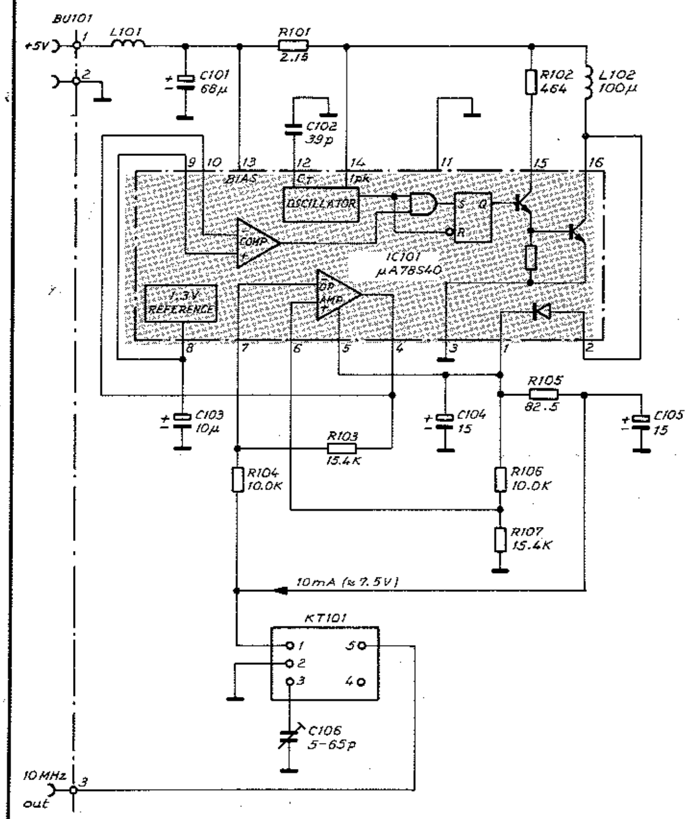


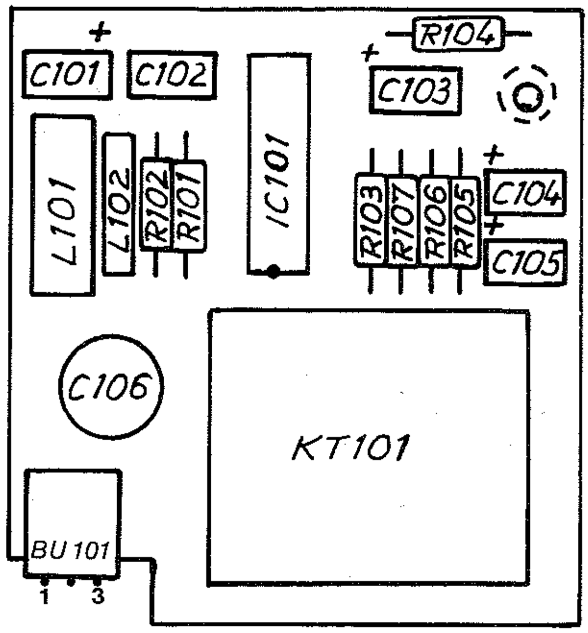
Optional battery unit PM 9601



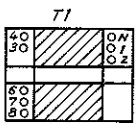


TCXO / 02





External battery jack and mains transformer



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