Universal Frequency Counters
PM 6673...76

Service Manual

9499 465 00111
820615 First edition

S&i
Scientific & Industrial equipment division

PHILIPS

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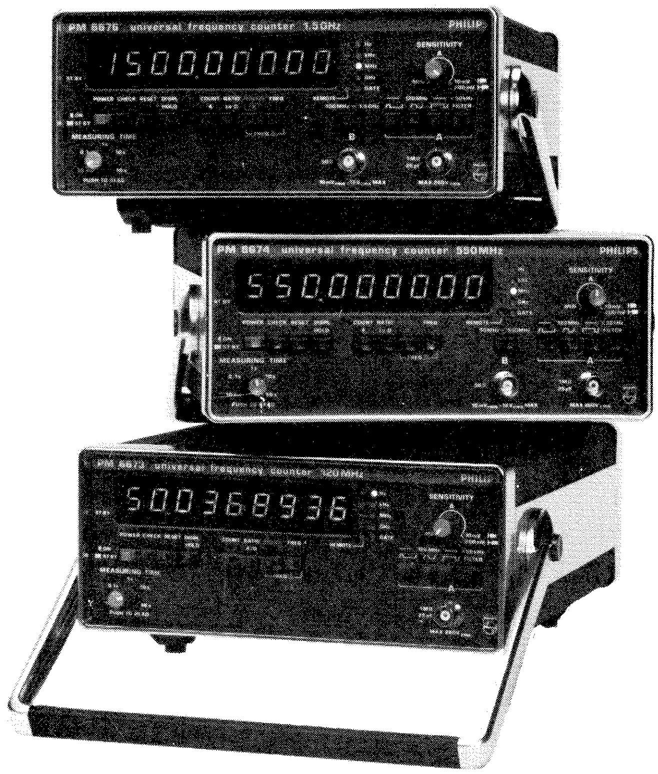

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SAFETY REGULATIONS

General information

This counter has been designed and tested in accordance with IEC Publication 348, Safety Requirements For Electronic Measuring Apparatus For Class 1 Instruments, and has been supplied in a safe condition. The present manual contains information and warnings that shall be followed by the user, to ensure safe operation and to retain the counter in a safe condition.

Before connecting the counter to the line (mains), visually check the cabinet, controls, connectors, etc, to ascertain whether any damage has occurred in transit. If any defects are apparent, do not connect the counter to the line. All components on the primary side of the line transformer are CSA approved and should only be replaced with original parts.

In the event of obvious damage, missing parts or if the safety of the counter is suspected, a claim should be made to the carrier immediately. A PHILIPS Sales or Service organisation should also be notified in order to facilitate the repair of the counter.

Grounding

The counter is connected to ground via a three-core line cable, which must be plugged into a socket outlet with a protective ground contact. No other method of safety grounding is permitted for this counter. When the counter is brought from a cold to a warm environment, condensation may cause a hazardous condition. Therefore, ensure that the grounding requirements are strictly met.

Any interruption of the protective ground, inside or outside the counter is dangerous. Line extension cables must always have a protective ground conductor.

Opening of the cabinet

The counter shall be disconnected from all voltage sources before any adjustment, replacement, maintenance or repair is effected with the covers removed.

If adjustment or maintenance of the counter with the covers removed is inevitable, it shall be carried out only by a skilled person, who is aware of the hazard involved. Bear in mind that capacitors inside the counter may still retain their charge, even if the counter is disconnected from all voltage sources.

Opening of the cabinet or removing of parts, except those to which access can be gained by hand, is likely to expose live parts and accessible terminals that can be dangerous to life.

Line voltage setting

Before connecting the counter to the line, ensure that it is set to the local line voltage. On delivery, the counter is set to either 115V or 220V, as indicated on the line voltage selector on the rear panel. If the voltage setting is incorrect, set the line voltage selector in accordance with the local voltage, before connecting the counter to the line.

Fuses

The counter is protected by a thermal fuse, located in the line transformer, and a secondary fuse (1.6A fast-blow) on PCB U1. Remove the line plug before fitting a fuse. Ensure that only fuses of the specified type are used. If the counter is set for operation on 115V line voltage, but is connected to a 220V supply, the thermal fuse will blow immediately to protect the counter.

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1. CIRCUIT DESCRIPTION

A block diagram, a functional block diagram, circuit diagrams and component layouts can be found in Section 7.

120MHz Input Amplifier

The input amplifier for channel A is identical for all models PM 6673...76.

Due to high accuracy components, the input attenuator (R1001, R1003, C1002 and C1003) does not need to be adjusted. The input signal is AC-coupled by C1001. Input protection is provided by C1001, R1005 and the diodes GR101...104. Transistors TS101 and TS102 function as an impedance converter with very low output impedance. At high frequencies, TS101 is bypassed by C1008 to improve the HF characteristics of this stage. The sensitivity of the input amplifier can be adjusted with potentiometer R1013. The switch SK110 activates the 50kHz Low-Pass Filter R1012, L1001 and C1010. See section Theory of Measurements in the Operating Manual.

IC101 is a wide-band amplifier. The gain is set by R1020 and the HF range is improved by L1003 in series. A chip capacitor, C1015, prevents oscillation. The -5V regulated supply for IC101 is derived from the -8V line, via the voltage regulator IC102. Capacitor C1024 prevents DC variations from IC101 effecting the Schmitt Trigger TS103...105. The Schmitt Trigger is balanced by potentiometer R1025. Temperature stabilisation and level shifting are obtained by the diode GR106.

Switches SK111 and SK113 give an input DC offset (+ or -) to the amplifier IC101 and to the Schmitt Trigger, to provide for input signals with very high or very low duty factors. Refer to section Theory of Measurements in the Operating Manual for more information.

Resistors R1027 and R1028 convert the output from the Schmitt Trigger to positive ECL levels (high 4.2V and low 3.2V).

Input D Amplifier

This Schmitt trigger/amplifier is an AC-coupled input for external standard or ratio measurement. The output is an ECL signal, as shown in Fig. 1.1.

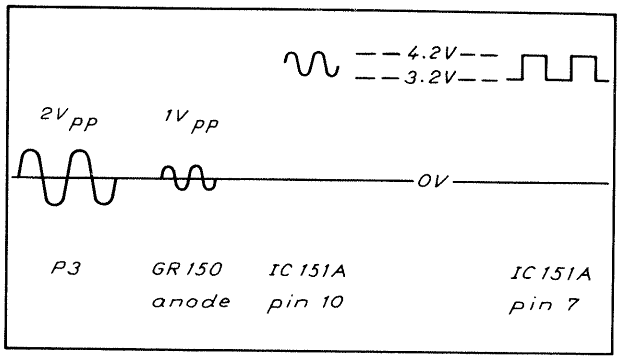


Fig. 1.1 A 100kHz sine-wave with $2V_{pp}$ amplitude, connected to Input D.

Internal or external standard can be selected with switch SK114 on the rear panel. Even if an external standard is used, the internal standard is still used as a clock signal to the microcomputer. When an optional oscillator is installed in the counter, the crystal KT151 must be removed. IC151B will then be used as an amplifier.

IC151C is a buffer amplifier between the oscillator and the logic circuits. Output pins 14 and 15 of IC151C give two complementary ECL signals, which are converted to TTL signals in the differential amplifier TS151 and TS152. The TTL signal is available at INT STD OUT on the rear panel. This output can be used as an external input signal to an other counter.

The 10MHz standard signal is divided by two in IC152A to provide a 5MHz clock signal for the microcomputer. The 5MHz signal is also divided by two in IC152B to provide a 2.5MHz clock signal for the optional Bus Interface PM 9696 via BU101:9.

0Q0040 Counter-on-a-chip

The 0Q0040 (IC161) is an in-house developed LSI counter-on-a-chip. It contains two 9-decade counting registers. One is used for counting 100ns clock pulses from the x-tal oscillator and the other is used for counting pulses from the signal to be measured, see Fig. 1.2. An input synchronizing and timing control block precedes these two counting registers. Its purpose is to:

- connect A (pin 1), B (pin 27), CARRY (pin 28) and CLK (pin 2) to the correct decade counting register.
- synchronize the start and stop of the measurement.
- act as a main gate for functions using the internal main gate in 0Q0040.
- control the external main gate IC140 with the TRIGG signal (pin 4).
- inform the microcomputer (IC162) with the signal READY (pin 24) when a measurement has started and stopped.
- receive a request to terminate a measurement, SCAN CLK/STOP (pin 5).

The microcomputer resets the counting registers in 0Q0040 and makes it ready for a new measurement by sending information to ST/ST/DATA (pin 25), see section Microcomputer - 0Q0040 Communication. When 0Q0040 receives an input signal,a new measurement starts as soon as the synchronization condition is met. With EXT CONTROL it is possible to delay the start until a positive pulse is received at EXT CONTROL.

When the measurement is completed, the microcomputer reads the registers in 0Q0040. The registers are read one by one in a scanned mode. The microcomputer supplies clock pulses to SCAN CLK/STOP for controlling the scanning. DECADE 9 (pin 8) indicates which part of the reading cycle the microcomputer is reading. A more detailed description can be found in section Microcomputer - 0Q0040 Communication. If an external decade counting register is used, the microcomputer reads it via 0Q0040 "Data from external ECL decade" pin 10, 11, 18 and 19 in BCD format.

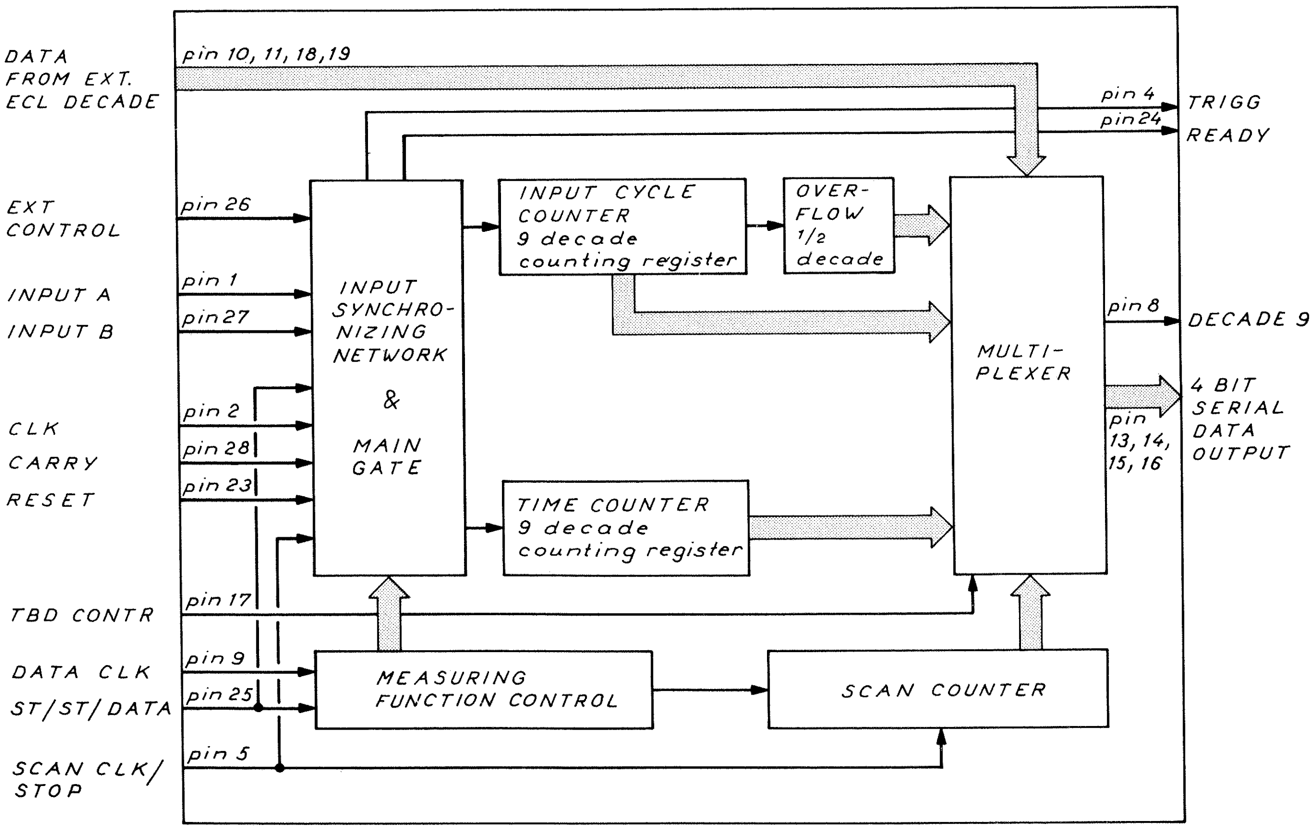


Fig. 1.2 Simplified block diagram of 0Q0040.

The Microcomputer

The microcomputer (IC162) used in PM 6673...76 is an 8049 single-chip microcomputer with an 8-bit bi-directional data bus and 16 static input/output ports. The internal memory consists of 128 byte RAM (read/write memory) and 2K byte ROM (Read-Only-Memory) for the program.

The microcomputer performs the following functions:

- Reads the setting of the function selector pushbuttons and the measuring time control on the front panel.

- Sends control information to OQ0040 and other logic circuits.

- Reads the decade counting registers in OQ0040 and the external decade (IC160) after the measurement.

- Calculates and sends the result to the display with correct resolution.

If the RESET pushbutton is pressed, the microcomputer is forced to start from RESTART in the program and all logic circuits are initialized, see Fig. 1.4.

The 8049 microcomputer has a timer function. Every 0.5ms, the timer function interrupts the microcomputer. In the interrupt routine, a new digit lights, a control setting is read and during a measurement the measuring time is counted down 0.5ms, see Fig. 1.3.

In Count A mode, the register content is read each 25ms and the display is updated each 25ms. In reciprocal frequency mode, 20 input cycles are needed to start and to stop a measurement because the input signal is divided by 10. The total measuring time is shown in Table 1.1 and the program flow-chart is shown in Fig. 1.4. The program memory for the options PM 9694...96 is located on the PCB of the particular option. The microcomputer reads the program instructions via BU101. The 12-bit address is sent via the data bus (8 bits) and via ports 20...23 (4 bits).

This address is used for pointing to a program instruction in the program memory. With the signal PSEN, the microcomputer commands the program memory to send out the instruction on the data bus. After that, the microcomputer fetches the instruction and executes it.

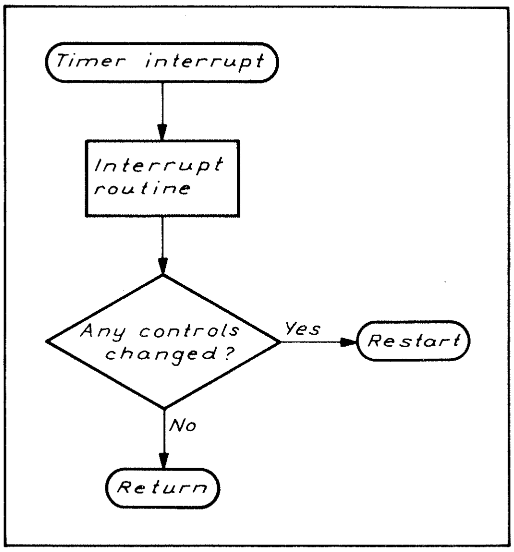


Fig. 1.3 Timer interrupt each 0.5ms.

Function	Total time
Period A	MT + 45 ms
Frequency	
Conventional	MT + 50 ms
Reciprocal	MT + 45 ms
Automatic	MT + 60 ms
Ratio to D	MT + 50 ms

MT = set measuring time + time for synchronizing start and stop of a measurement.

Table 1.1 Measurement initialize, perform and terminate times.

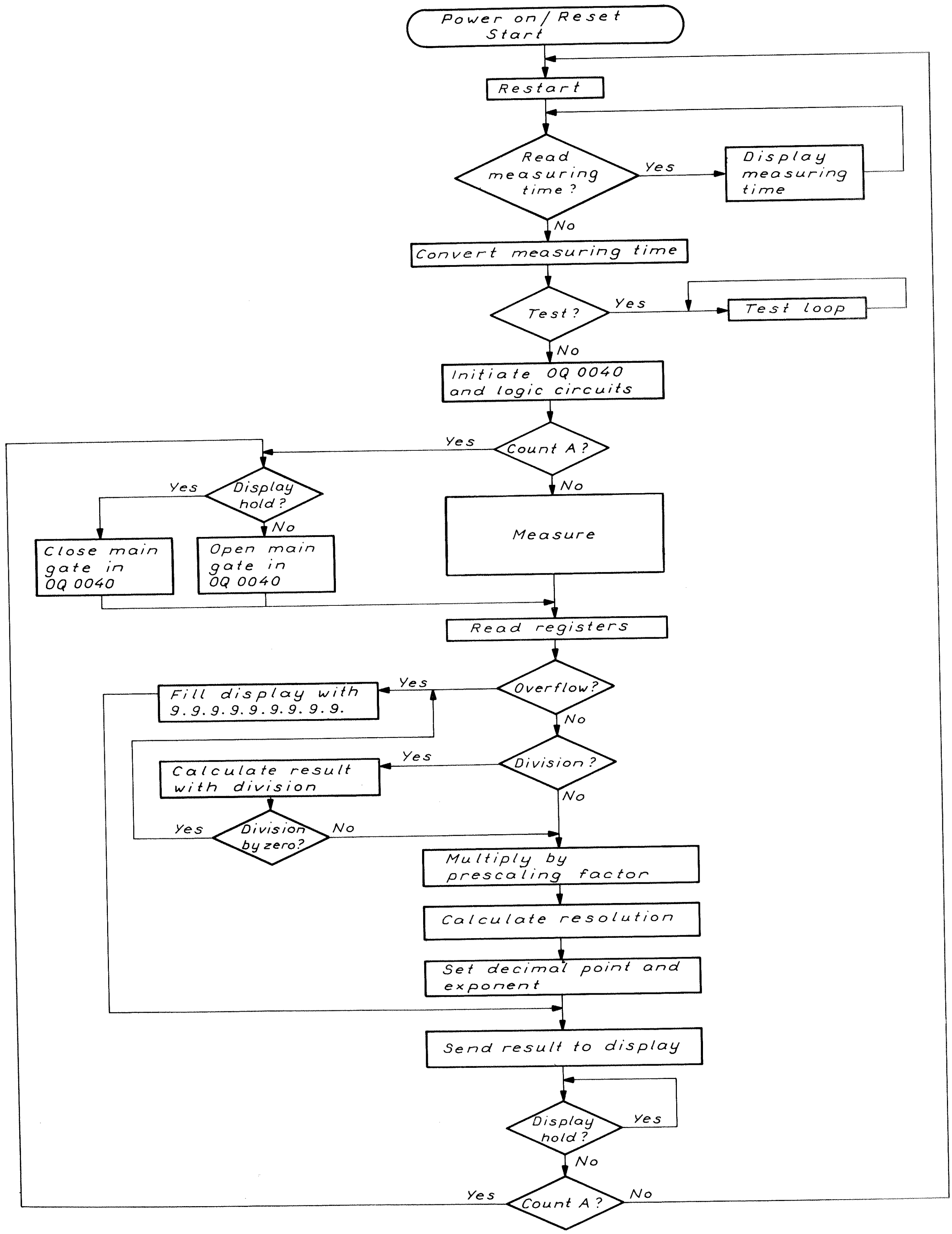
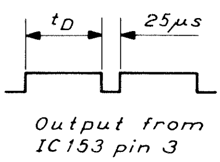


Fig. 1.4 The program flow-chart.

Measuring Time

IC153 is used as an astable multivibrator, with the MEASURING TIME potentiometer controlling the frequency. The output from IC153 pin 3, see Fig. 1.5, is connected to the microcomputer input T1. The pulse duration is measured and converted to a measuring time, which can be varied in 33 steps per decade between 10ms...96s.



t_D	Measuring time
80µs	10ms
1.8ms	96s

Fig. 1.5 The pulse duration is converted to a measuring time in the microcomputer.

The space between pulses is set by R1167 and C1156. The pulse duration is set by R1166, R1167, C1156 and the MEASURING TIME potentiometer R1 on the front panel. Potentiometer R1164 is used for adjusting the max pulse duration to 1.8ms.

If the jumper DV1 (TEST) is removed, the counter is set to the self-test mode.

External Main Gate Network

This network consists of the ECL Main Gate FF (IC140A) and ECL Main Gates & Input Select (IC141 and IC142).

The main gate is used to accurately open and close the signal path to the counting registers, controlled by the set measuring time. In the PM 6673...76 series of counters, there are two different main gates:

- One internal in OQ0040.
- One external for a higher frequency range, IC141.

Table 1.2 shows which main gate is used for different measuring modes.

When the internal main gate in OQ0040 is used, IC141A and B are used for selecting Input A or Input B. IC141C is used for the 10MHz reference signal in the CHECK mode.

When the external main gate IC141 is selected, one of the three gates functions as main gate:

IC141A Main gate for Input A.
IC141B Main gate for Input B.
IC141C Main gate for the 10MHz reference signal in CHECK mode.

To select the external main gate, the microcomputer sets the signal EXT. DECADE low. If the microcomputer sets the signal CH A high (via TS132), IC141A is selected as main gate, i.e. Input A is used. Otherwise, Input B is used.

FUNCTION	MAIN GATE		INPUT (OQ 0040)	SYNC	NOTE
	INT.	EXT.			
PERIOD A	X		Input A CLK	X ---	
COUNT A	X		Input A		The Main Gate is controlled by DISPL HOLD via the µC
FREQ input synchr.	X		Carry CLK	X ---	
FREQ clock synchr.		X	Carry CLK	--- X	External counting decade
RATIO to D		X	Carry Signal via Input D: Input B	--- X	External counting decade

Table 1.2 Main gate and synchronization for different measuring modes.

The measurement starts when the microcomputer sets RESET low and IC140:6 receives a trigger pulse from the TRIGG output of IC161. The pulse sets the output IC140:2 high. This signal is called the Main Gate Signal.

To terminate a measurement, a new pulse is sent from the TRIGG output. The Main Gate Signal goes low and the main gate is closed. The pulse also sets IC140:15 high and by "wired-OR function" closes the clock input IC140:6 (see Fig. 1.6) to prevent further triggering on IC140:2.

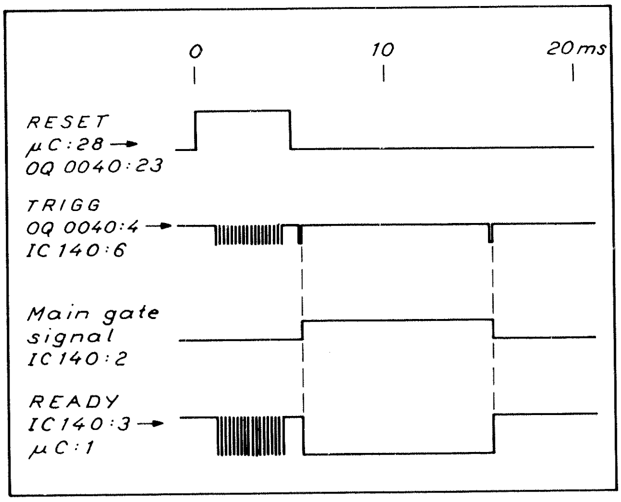


Fig. 1.6 10ms measurement with an external main gate.

The function PERIOD A uses Input A, thus CH A (IC162:30) is high. The external main gate is not used, i.e. EXT DECADE is high, see Fig. 1.7.

NOTE: Fig. 1.7-1.11 can be found in section 7, Circuit Diagrams.

The function COUNT A uses Input A and the internal main gate in OQ0040. The measurement is selected with pushbutton COUNT A, initiated by releasing DISPL HOLD and terminated by pushing DISPL HOLD. The signal ST/ST/DATA is controlled by the pushbutton DISPL HOLD. This signal controls the internal main gate in OQ0040. ST/ST/DATA is low for an open main gate, i.e. pulses are counted (refer to Fig. 1.8). Every 25ms the decade counting registers are read and displayed. However, the measurement is not interrupted.

When the CHECK pushbutton is depressed, IC141C works as main gate for selected measuring functions where an external main gate is used.

If Input A is selected, CH A is high and the prescaler is turned off via BU107:1. If Input B is selected, CH A is low. A jumper between BU107:5 and BU107:6 on the prescaler board, routes the main gate signal from the IC142:3 output to IC141B:13. Refer to Fig. 1.9 for signal path.

An external main gate is used for ratio and clock synchronized frequency measurements. The difference between a ratio and a frequency measurement, is that ratio uses Input D as reference and frequency uses the 10MHz standard, see Fig. 1.10.

For the reciprocal mode, Input A and the internal main gate in OQ0040 are used. The frequency of the input signal is divided by 10 in IC160, ECL 120MHz Decade. This decade counting register is not read. It is only used as a scaler in this mode. IC142D gives the signal a duty factor of approx 0.50. The signal path is shown in Fig. 1.11.

Automatic switch between conventional and reciprocal frequency measurement

Before the actual frequency measurement is made, the counter makes a short measurement over 10us to determine if a conventional or a reciprocal frequency measurement is to be made. If the input frequency is higher than approx 10MHz a conventional, clock synchronized, measurement is made. Refer to Fig. 1.12 and to the section Theory of Measurements in the Operating Manual.

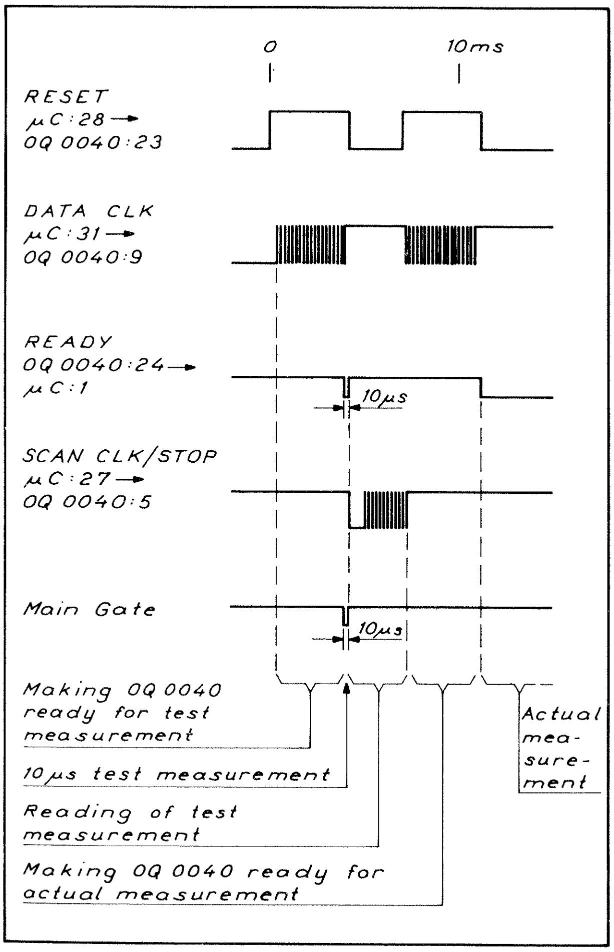


Fig. 1.12 Test for selecting conventional or reciprocal frequency measurement.

Microcomputer - OQ0040 Communication

Before the measurement, the microcomputer sends control information to OQ0040. This information is sent when pin 28 of the microcomputer is high, i.e. OQ0040 is reset. The information bits are sent in serial format to ST/ST/DATA, one bit for each positive-going slope of DATA CLK, see Fig. 1.13. The information consists of 39 bits.

When pin 28 of the microcomputer goes low again, the measurement starts as soon as the synchronization conditions are met. Then OQ0040 pin 24 READY goes low, the microcomputer acknowledges by setting ST/ST/DATA high and starts to count down the selected measuring time.

During the actual measurement the microcomputer and OQ0040 do not communicate. When the selected measuring time has elapsed, the microcomputer sets SCAN CLK/STOP low. OQ0040 then stops the measurement when the synchronization conditions are met and sets READY high.

The content in the 18 decade counting registers in OQ0040, plus the external ECL 120MHz decade (IC160), are sent in BCD format to the microcomputer from $A_{out}...D_{out}$. The microcomputer reads one decade at a time and steps to the next decade by sending clock pulses to SCAN CLK/STOP. To read a digit, TBD CONTR is set high.

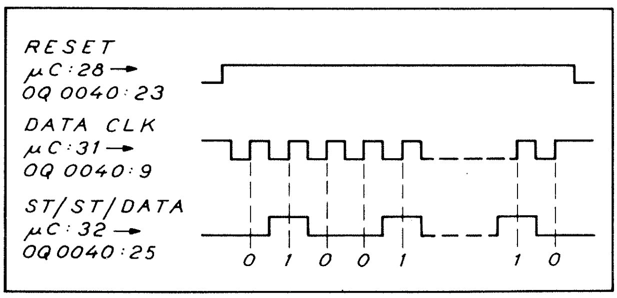


Fig. 1.13 The microcomputer sends information needed to make OQ0040 ready for a measurement.

To find out which decade is read, the microcomputer sends clock pulses to SCAN CLK/STOP until DECADE 9 (pin 8) goes high. This indicates that the position is decade 9. The microcomputer starts reading, see Fig. 1.14. The external ECL decade is read via OQ0040 A_{in}...D_{in}.

When all 19 decade counting registers have been read, the microcomputer calculates the result and sends it to the display. It resets OQ0040 and a new measurement can now start.

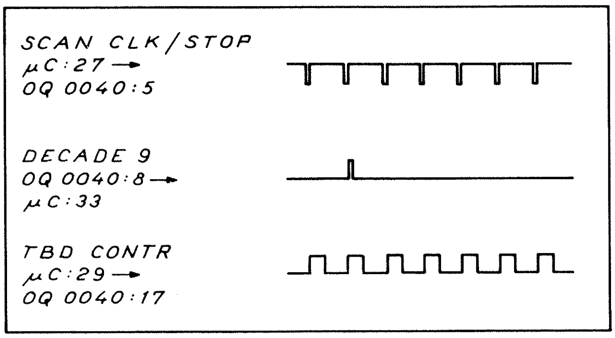


Fig. 1.14 A new digit is read after each pulse to SCAN CLK/STOP when TBD CONTR is high.

Example:

Function selector setting:

- Depress PERIOD A, ⊓⊔ and CHECK
- Set measuring time to 10ms
- Set the Input E switch to EXT RESET

A suitable trigger signal for an oscilloscope is available on OQ0040 pin 23 (RESET).

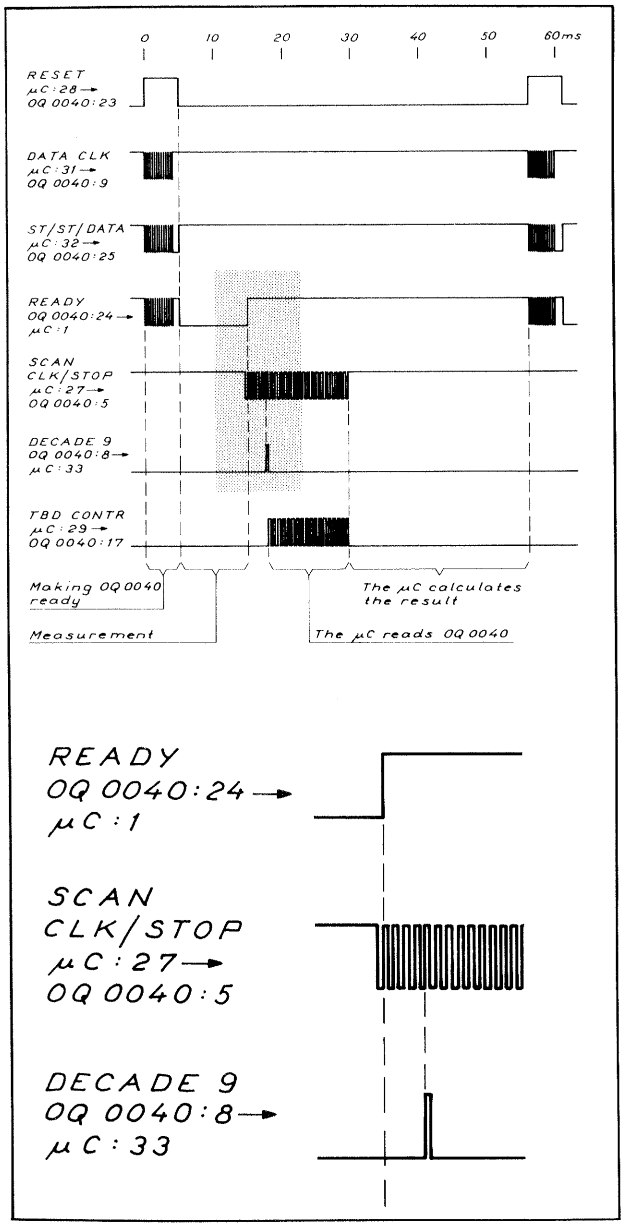


Fig. 1.15 Timing diagrams for microcomputer and OQ0040 communication.

Microcomputer - Display - Function Selector Communication

The Display, Decimal Points, Unit Indicator and Function Selector are scanned by the microcomputer. During each scanning cycle the microcomputer sends out the measured result and reads the setting of the Function Selector. Each digit is sequentially turned on for 0.5ms. The measurement can be sent both to the display and an installed option, e.g. Bus Interface, via connector BU101. The microcomputer pin 38 (P27) controls the information flow.

P27 low: the display and function selector is addressed
P27 high: the installed option is addressed

The bidirectional data bus DB0...DB7 on the microcomputer is used for sending information to the display and receiving information from the function selector. The microcomputer pin 8 (RD) and pin 10 (WR) control this information flow.

WR pos flank: information is sent to the display
RD pos flank: information is received from the function selector

Four bits, DB4...DB7, are used for sending (in BCD format) the digits to be displayed. Each digit in the display shows its specific value for a period of 0.5ms. The digit´s value is latched and decoded to a seven-segment format in the Segment Decoder/Driver (IC201). The remaining four bits, DB0...DB3, are used for addressing the digit to be displayed. Thisaddress is sent in BCD format. The address is latched in the Address Latch (IC164) and decoded in the Digit Decoder (IC165). Only one of the outputs in the Digit Decoder is high at a time. This high signal, opens the corresponding Digit Driver for 0.5ms. At the same time, the digit´s value is sent from the Segment Decoder/Driver. During the following 0.5ms, the next digit is turned on, and so on.

The current flows from the +5V supply through the digit driver transistor, the lighted segments and then to earth via the Segment Decoder Driver. All digits have a decimal point. Digit drivers 1...6 also have a Unit Indicator LED connected. Signal lines P24 (pin 35) and P25 (pin 36) of the microcomputer control them.

P24 low: a decimal point is lit
P25 low: a unit indicator LED is lit

The microcomputer blanks leading zeros by setting P26 (pin 37) low. This blanking signal is also used for the Fail Safe Circuit. If the microcomputer stops, one digit will remain lit and could be degraded after a couple of minutes. If P26 (pin 37) stays high, C1163 will be charged to +5V. This results in a reset signal to the Address Latch. All outputs goes low. The Digit Decoder sets output pin 3 high. Pin 3 is not connected to any digit driver so all digits will be turned off.

The output from the Digit Decoder is also used for reading the setting of the function selector switches DISPL HOLD, COUNT, RATIO to D, PERIOD, FREQ, FREQ A AVERAGE, Input B and PUSH TO READ measuring time. Each output from the digit decoder is connected to one switch. When a digit is lit, the microcomputer reads the setting of the corresponding switch. This is achieved by the RD output going low, which opens the tristate buffer IC163. The switch setting information is now available on the bidirectional data bus, DB0... DB3, to the microcomputer. The prescaler coding diodes (part of Unit 3) are sensed in the same way.

The logic states are as follows:

Closed switch: logic high level
Open switch: logic low level

The function of the diode GR140 is to inform the microcomputer that this is a PM 6673...76 counter. This diode is not installed in PM 6670...72.
The same microcomputer (8049) is used in all counters of the PM 6670 series.

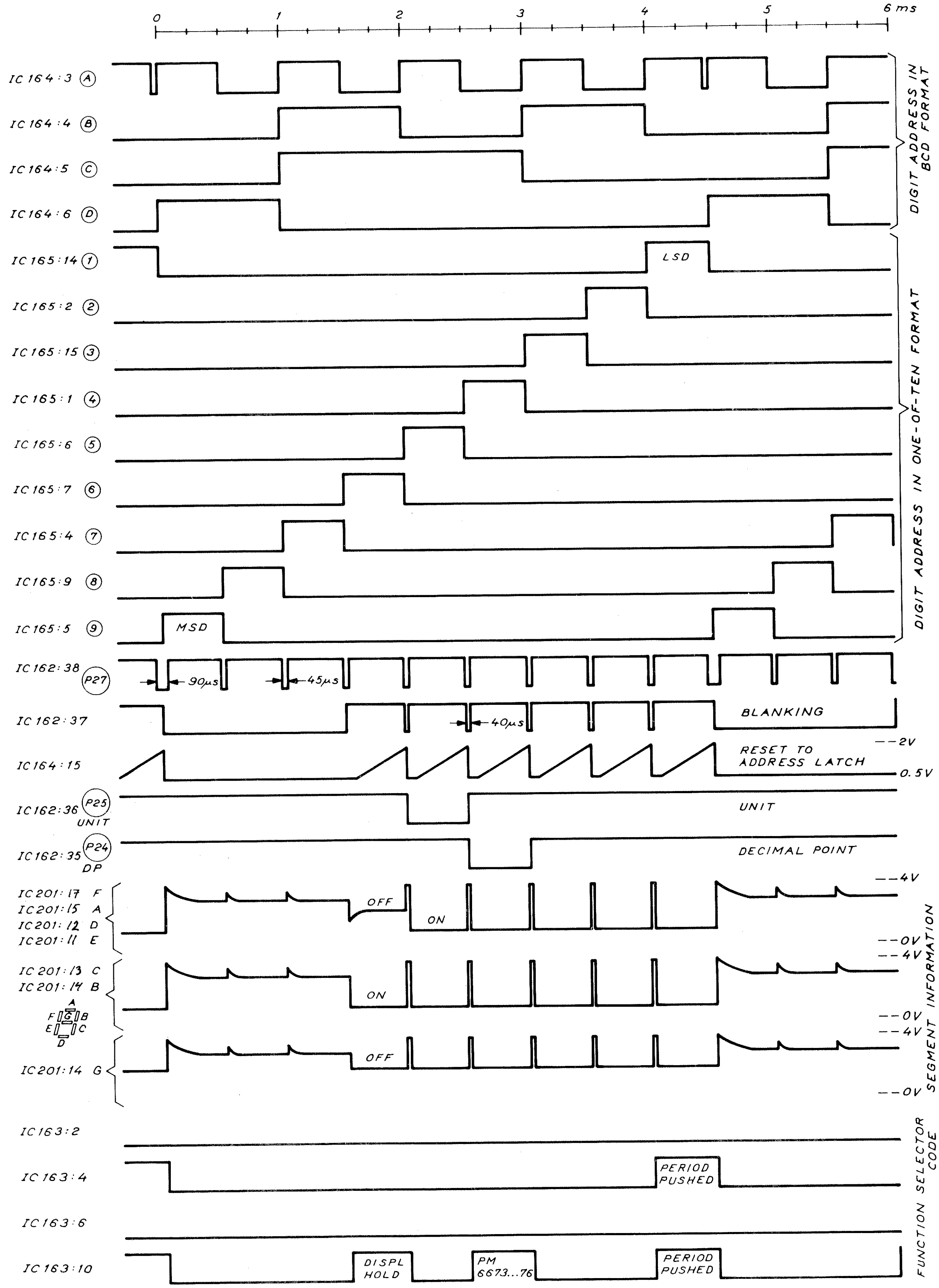


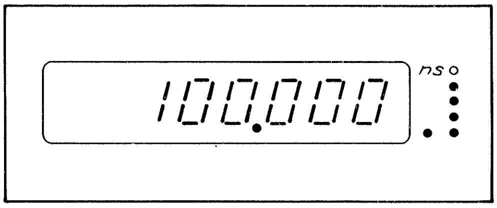
Fig. 1.16A Timing diagrams for Microcomputer - Display - Function Selector communication. Applicable to the example on the following page.

Example:

Function selector setting:

- Depress PERIOD A, ⊓⊔ , CHECK and DISPL HOLD
- Set measuring time to 10ms
- Set Input E switch to EXT RESET

The display will show:



A suitable trigger signal for an oscilloscope is available on IC165 pin 5. Timing diagrams are shown in Fig. 1.16.

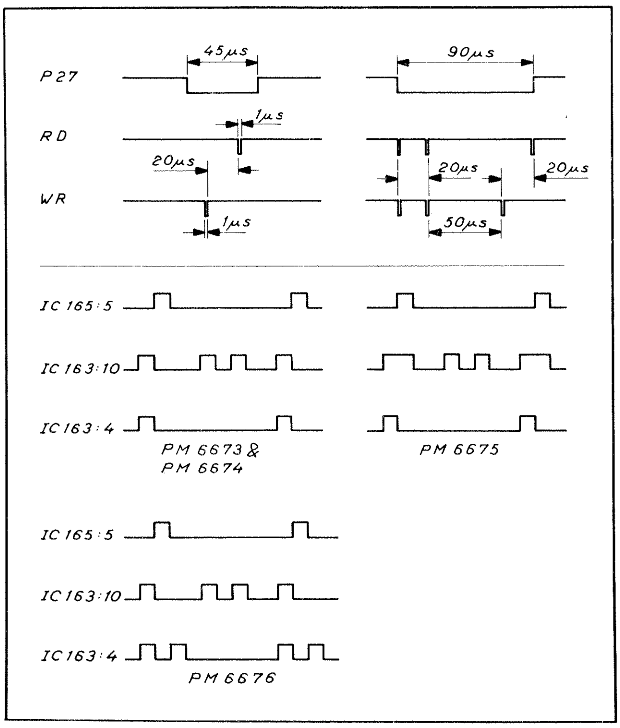


Fig. 1.16B A close-up of some timing diagrams in conjunction to Fig. 1.16A.

The Power Supply

The PM 6673...76 series of counters can be connected to

- 115V_{AC} or 230V_{AC} ±10%, 45...440Hz
- 11.8...28V_{DC}
- The optional battery pack PM 9693 (12V_{DC})

The output from the power supply is

- +5V regulated
- -8V unregulated.

The counter is protected by a thermal fuse VL101 located in the line transformer and a secondary fuse VL102 (1.6A fast-blow) on PCB U1. At VL102 the voltage is approx 25V_{DC} in a PM 6673/01 connected to 220V_{AC}.

When the optional internal battery pack PM 9693 is installed, the voltage on pin BU104:7 is used for charging the battery. BU104:7 is connected to BU104:6 via a jumper when PM 9693 is not installed.

The POWER ON/OFF switch SK101 on the front panel is a secondary switch, which has no effect on the voltage supply to the optional oven stabilized oscillator.

In position POWER ON, the voltage is supplied to IC180 via the transistor TS184 and diode GR186, which form a voltage limiter. The voltage is limited to approx 15V_{DC}.

IC180 is specially designed for applications in switched-mode power supplies. The output control signal (pin 14) is connected to the switch transistor TS182. This pulse train has constant amplitude and frequency, but a pulse duration that is dependent on the load. The frequency (40kHz approx) is set by resistor R1197 and capacitor C1192.

The control loop senses the +5V output via R1187...1189, as shown in Fig. 1.17. The +5V output is adjustable with potentiometer R1188.

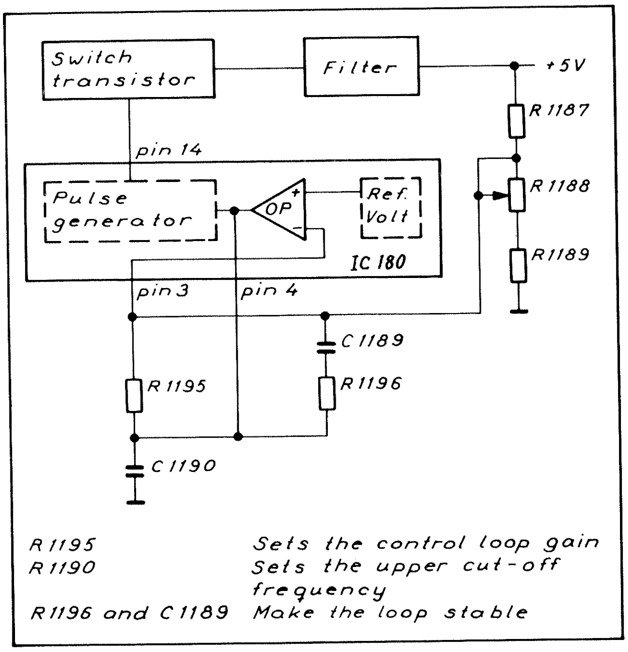


Fig. 1.17 IC180 and the control loop.

The amplifier output (IC180:4) is 4V for 12V input and 2V for 30V input. The output is 8.5V when the power supply is not regulating. This 8.5V is used to reset the microcomputer at POWER ON and at line (mains) failures of short duration.

The output from the OP amplifier controls the pulse duration to the switch transistor TS182. When TS182 is conducting, magnetic energy is stored in the transformer T102. When TS182 stops conducting, the magnetic energy is discharged via the diode GR183. Some of the magnetic energy is discharged via the secondary winding of T102 to obtain the unregulated -8V.

When the current increases, the voltage across resistor R1182 increases, and at a current through R1182 of approx 2A, transistor TS181 starts conducting. When the voltage at IC180:11 exceeds 0.5V, the pulse duration decreases to avoid current surge. The diode GR185 gives over voltage protection.

550MHz Prescaler for PM 6674

The 550 MHz prescaler for PM 6674 is AC-coupled and divides the frequency of the Input B signal by 6.

Capacitor C301 blocks any DC component on the input signal, while the network R301...R303, GR301 and GR302 form a PIN diode attenuator and provide the required input impedance. The PIN diode GR302 and the resistor R302 form a variable attenuator, controlled by the amplitude of the signal to be measured. The current through R301...R303 and the Schottky diode GR301 makes the PIN diode reversed biased with a bias voltage of approx 0.65V.

The PIN diode attenuator is not activated for input signals with low amplitude. If the input amplitude increases to a level that makes GR301 rectify, the DC level of the input signal will decrease, as the positive voltage then is limited. The PIN diode GR302 will start conducting when the DC level has decreased from +0.5V to -0.65V. A PIN diode has a current controlled variable impedance. An increased input amplitude, increases the current through the PIN diode. Thus giving it lower impedance, i.e. higher attenuation in the attenuator R302 and GR302. The result is an almost constant amplitude at IC301:3 when the PIN diode attenuator is activated.

IC301 is a wide-band amplifier. The gain and frequency of the output signal from IC301 are controlled by TS301, R310, C307, C306, R311 and TS302. The network GR305, GR306 and C308 forms a limiter at the input of the divider IC302. Transistors TS301 and TS302 also form a buffer amplifier between IC301 and IC302.

In IC302, the frequency is divided by 6. To prevent errors due to insufficient amplitude, the amplitude of the input signal to IC302 is monitored. The detector diode is GR304 and the bias current through this diode is provided by R318, R323 and R315.

In the Schmitt trigger (IC303 and R324...326) this detector voltage is compared with a reference voltage set by potentiometer R316. If the detector voltage is lower than the reference voltage, IC 302 pin 8 and pin 1 are set to low logic level. This means that the signal passes through IC302. When the input amplitude decreases, the detector voltage increases. If the detector voltage exceeds the reference voltage, IC302 is disabled. The output signal has ECL levels and is connected to the main gate network on Unit 1 via BU307:10.

For test purpose, IC302 could be enabled independently of input amplitude, by connecting +5V to BU307:2 (TEST). When channel B is not used, BU307:1 is set to +5V and IC302 is disabled.

600MHz Direct Gated Input for PM 6675

The difference between Input B of PM 6674 and PM 6675 is that PM 6675 has a readable decade divider (IC301) which gives PM 6675 one more digit of resolution for the same set measuring time.

This AC-coupled input is protected by a PIN-attenuator (GR303, GR304, R302) and two Schottky diodes (GR301, GR302). When the amplitude of the input signal increases, the current through the Schottky diodes increases. This results in an increased current through the PIN diodes and as a result, their impedance decreases. The voltage attenuation between R302 and the PIN diodes changes so that the amplitude on the base of TS301 is constant.

Transistors TS301...305 form a 5-stage DC amplifier with frequency compensation. The DC gain is less than 1 and the AC gain is 40...45dB. To prevent DC shift due to temperature variation, the transistor pairs TS302/303 and TS304/305 are of different types, PNP resp. NPN.

The frequency of the input signal is divided by 10 in the readable decade divider IC301. When IC301 needs to be read, a pulse is sent to the tri-state buffer IC302. Then a BCD-coded digit is sent to the microcomputer (IC162) via the buffer. The read pulse is generated by the signals DEC 9 (high), TBD CONTR (high) and B (low) via IC303.

The main gate signal from the counter, is sent via BU3:5 and the level converter network TS307, TS308, GR311, R341...R343 and R349 to IC301 pin 16. A voltage of -2V at IC301:16 implies open main gate, -0.9V implies closed main gate. When the main gate is closed, IC301 is read.

The CARRY output from IC301:9 is converted to ECL levels by TS309, GR319 and R345... R347. This signal is sent via BU3:10 to the next decade (IC160) on Unit 1.

If the amplitude of the input signal is too low, IC301 is reset to prevent erroneous counting. The detector network consists of L303, C320, L302, C336, R332, GR308, C322, R363 and R364. Higher amplitude results in a higher DC voltage on pin 2 of the Schmitt trigger IC304. The reference voltage is set by potentiometer RV301. When the detector voltage is higher than the reference, the Schmitt trigger output is low and the reset signal to IC301:3 is disabled, i.e. counting is possible. IC301 can also be reset by the microcomputer (IC162:28) via BU3:3. For testing purpose, it is possible to make IC301 count even if the amplitude of the input signal is too low. This is accomplished by connecting +5V to BU3:2 (TEST).

The diode GR315 generates a code, which indicates to the microcomputer that the counter is a PM 6675.

In CHECK mode, the two least significant digits are dependent on set measuring time.

1500MHz Prescaler for PM 6676

This AC-coupled input is protected by a PIN-attenuator (GR303, GR304, R302) and two Schottky diodes (GR301, GR302). When the amplitude of the input signal increases, the current through the Schottky diodes increases. This results in an increased current through the PIN diodes with a corresponding decrease in their impedance. The voltage attenuation between R302 and the PIN diodes changes so that the amplitude on the base of TS301 is constant.

Transistors TS301...306 form a 6-stage DC amplifier with frequency compensation. The high-frequency response can be adjusted with capacitors C308 and C318. The DC gain is less than 1 and the AC gain is 30...35dB. IC301 and IC302 each divide the frequency of the input signal by 4, i.e. the frequency is divided by 16 in total. The output ECL signal from IC302:10 is sent to the main gate in the counter via BU307:10.

The amplitude of the input signal is sensed via the network C323, R329, GR309, C326 and R330. The voltage on IC303:2 decreases when the amplitude of the input signal increases. When the detector voltage is lower than the reference voltage (set by potentiometer R333) the output of the Schmitt trigger IC303:6 is high, i.e. the signal to be counted is able to pass through IC302.

When the amplitude of the input signal is too low, the Schmitt trigger output is low, which results in a current through the diode GR314, i.e. the signal is stopped. This prevents erroneous counting. For testing purpose, it is possible to open IC302 even for small input amplitudes. This is accomplished by connecting +5V to BU307:2 (TEST).

The connection TEST POINT is used when adjusting the frequency response. The diode GR315 generates a code, which indicates to the microcomputer that the counter is a PM 6676.

2. PERFORMANCE CHECK

Required test equipment

- Voltmeter, e.g. Philips PM 2517
- Frequency counter, e.g. Philips PM 6673/02
- 50MHz oscilloscope, e.g. Philips PM 3215
- Sampling oscilloscope, e.g. Philips PM 3400
- Pulse generator, e.g. Philips PM 5771
- Function generator, e.g. Philips PM 5131
- HF signal generator, e.g. Wavetek 2002A
- Probe, 10 Mohm, 120MHz
- T-piece, BNC-type
- Termination, 50 ohm, BNC-type

Initial set-up

All pushbuttons should be in a released position. The slide switches on the rear panel should be set to INT STD and EXT RESET. Set the line voltage slide switch on the rear panel to the local line voltage. Connect the counter to the line and press POWER ON.

Check of the oscillator

The /01 version of PM 6673...76 can be checked by connecting a counter, e.g. a PM 6673 equipped with at least a calibrated TCXO, to INT STD OUT (via a 10Mohm probe) on the rear panel. The frequency should be 10MHz ± 10Hz.

For /02.../05 versions, please refer to section Optional Oscillators.

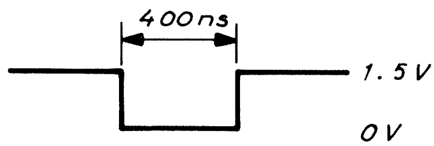
Check of Input D sensitivity

Press RATIO to D and CHECK. Connect a 1kHz sinewave with 1.2V_{pp} amplitude to Input D. Set the slide switch for Input D to EXT STD IN. Set the measuring time to 1.0s and check that the display read-out is 1.000. Set the slide switch for Input D to INT STD.

Check of Input E

Press PERIOD A and CHECK. Set the measuring time to 1.0s. Set the slide switch for Input E to EXT RESET. A DC voltage of +0.5V connected to Input E should not reset the counter, but +1.5V should. A positive pulse with +1.5V amplitude and 180us duration should reset the counter.

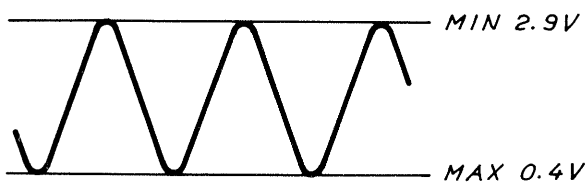
Set the slide switch to position ARMING. The arming function is described in the operating manual. A DC voltage of +0.5V connected to Input E should not arm the counter, but +1.5V should. A pulse, as illustrated below, should release the counter from the arming mode.



Set the slide switch to position EXT RESET.

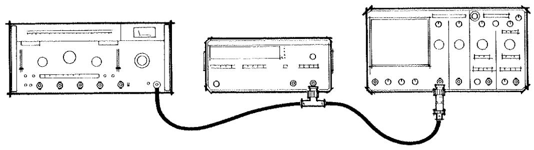
Check of INT STD OUT

Connect an oscilloscope via a 10Mohm probe to the INT STD OUT connector on the rear panel. Voltage levels are illustrated below.



Check of Input A

Press FREQ and ⊓⊔ . Set the measuring time to 10ms and the sensitivity fully clock-wise and depressed. Connect a sine-wave with 20mV_{pp} amplitude to Input A. The amplitude should be checked with an oscilloscope, see below.



Check that the counter display is correct when the frequency is adjusted between 10Hz and 120MHz. Decrease the amplitude to 5mV_{pp}. The display should be zero (no counting) for frequencies between 10Hz and 120MHz.

Check of the attenuator

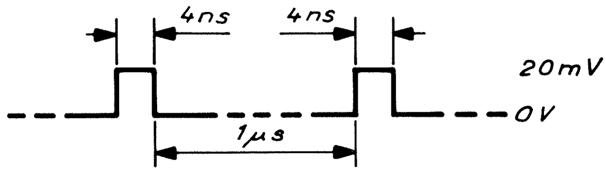
Connect a 10MHz sine-wave to Input A. Set the sensitivity control fully counter clock-wise and depressed. The display should be correct for an input amplitude of 350mV_{pp}. Set the sensitivity control fully clock-wise and pulled. The display should be correct for an amplitude of 600mV_{pp}. Push the sensitivity knob, i.e. max sensitivity, and increase the amplitude as much as possible, but max to 12V_{RMS}. The display should still show a correct value (10MHz).

Check of the low-pass filter

Press the <50kHz FILTER pushbutton. Connect a 500kHz sine wave to Input A. Check that the display is correct for an amplitude 20dBm (10x) higher than the sensitivity without filter.

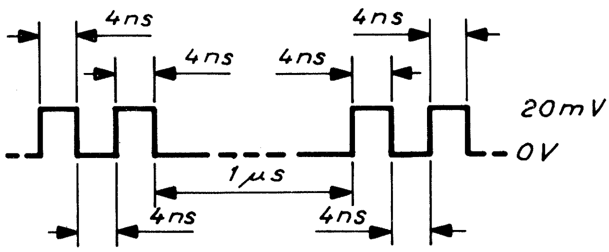
Check of the pulse sensitivity

Press the ⎍⎽⎽⎾ pushbutton. Connect the signal below to Input A.



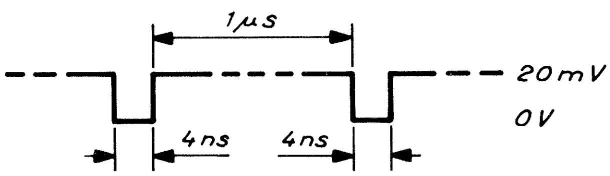
The counter should count correctly.

Connect the signal below to Input A.



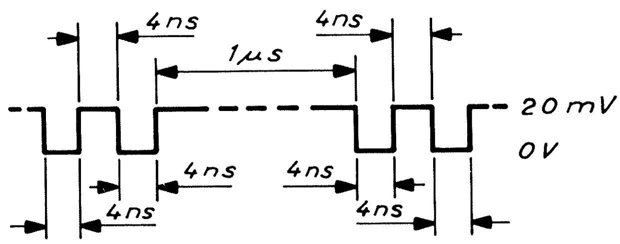
The counter should count correctly, i.e. twice the value of above.

Press the ⎾⎺⎺⎽⎾ pushbutton. Connect the signal below to Input A.



The counter should count correctly.

Connect the signal below to Input A.



The counter should count correctly, i.e. twice the value of above.

Check of the display

Press the FREQ pushbutton. With no signal connected, press RESET. The display should be 000000000. Connect a 10MHz sine-wave with 1V_{pp} amplitude to Input A. Set slide switch D on the rear panel to position EXT STD IN. Press RESET. The display should be 9.9.9.9.9.9.9.9.9. Set slide switch D to position INT STD.

Check of the PERIOD function

Press the ⊓⊔ pushbutton and set the measuring time to 1s. Press PERIOD A and connect a 14MHz sine-wave with 30mV_{pp} amplitude to Input A. Approx 70ns should be displayed.

Check of the FREQUENCY function

Press the FREQ pushbutton and connect a 5Hz sine-wave with 50mV_{pp} amplitude to Input A. Set slide switch E on the rear panel in position ARMING. The display read-out should be:

5.XXXXXX Hz.

Press PERIOD A and FREQ simultaneously. The display read-out should be 0.005kHz.

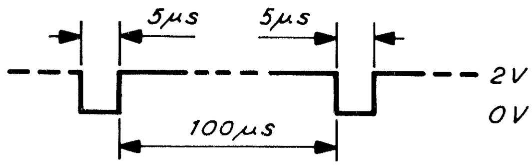
Check of the RATIO function

Press the RATIO to D pushbutton and connect a 120MHz sine-wave with 50mV_{pp} amplitude to Input A. Connect a 1kHz sine-wave with 1.2V_{pp} amplitude to Input D on the rear panel. Approx 120000 should be displayed.

Check of the FREQUENCY AVERAGE function

Press the FREQ pushbutton. Set slide switch E on the rear panel to position FREQ A AVERAGE. Connect a 120MHz sine-wave with 50mV_{pp} amplitude to Input A. Set the measuring time to 1s. The display read-out should be 120.XXXXX MHz.

Connect the signal below to Input E.



The display read-out should be 120.XXX MHz. Note that the result now is approx 0.2% higher.

Refer to the Operating Manual for more information about frequency average measurements.

Check of the COUNT function

Press the COUNT A and ⊓⊔ pushbuttons. Connect a pulse generator with "single shot" pulses with 50ns duration and 20mV_{pp} amplitude to Input A. Check that the counter counts correctly when single pulses are generated. Disconnect the pulse generator.

Press DISPL HOLD, RESET and then CHECK. Release DISPL HOLD. The counter should now start counting. Stop the counting by pressing DISPL HOLD. Press RESET. The display read-out should be 0.

Check of MEASURING TIME

Press the MEASURING TIME knob and rotate the knob. Check that the displayed measuring time corresponds with the scale.

Check of Input B (PM 6674...76)

Press the Input B pushbutton on the front panel. Connect a sine-wave to Input B and check that the counter counts correctly according to the following table.

Model	Frequency	Signal level
PM 6674	50...550MHz	-27dBm
PM 6675	100...500MHz 50...600MHz	-33dBm -27dBm
PM 6676	100...1000MHz 1500MHz	-27dBm -17dBm

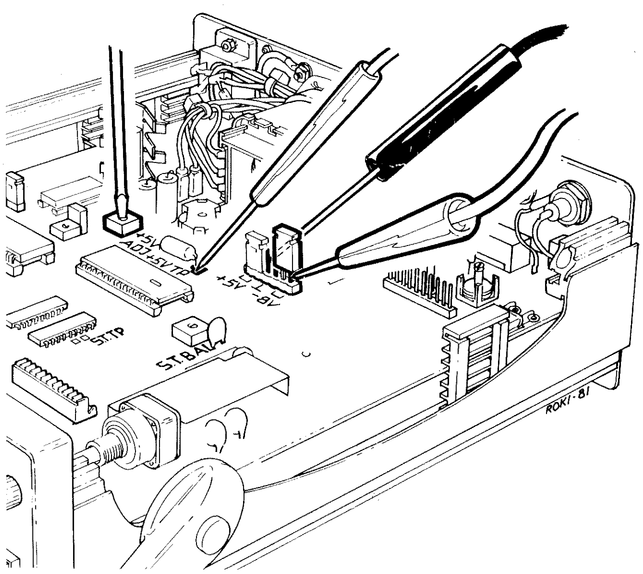
3. ADJUSTMENTS

Required test equipment

- Voltmeter, e.g. Philips PM 2517
- RF Signal Generator, e.g. Wavetek 2002A
- Sampling Oscilloscope, e.g. Philips PM 3400
- Frequency counter, e.g. Philips PM 6667

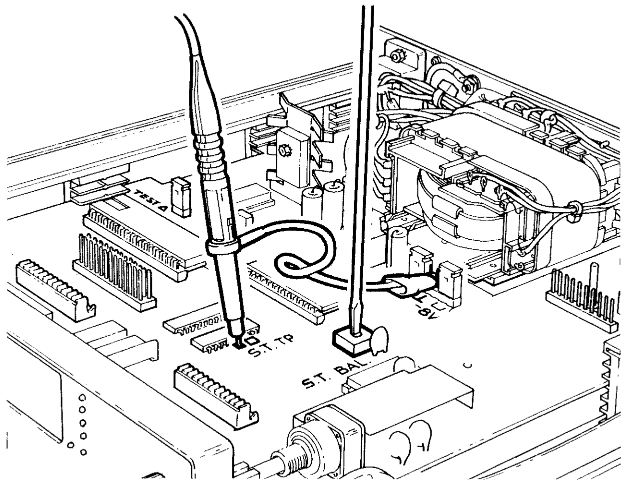
DC Voltage

- Connect a voltmeter between +5V TP and earth.
- Adjust R1188 (+5V ADJ) to 5.0V ± 0.05V.
- Connect the voltmeter to BU110:1 (-8V) without removing the jumper. Check that the voltage is 8.0V ± 0.5V.



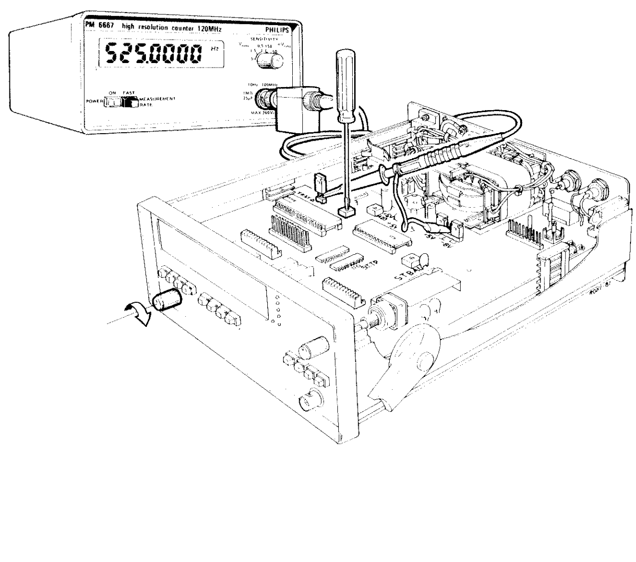
Schmitt Trigger Balance

- Connect a 1kHz sine-wave with 30mV$_{pp}$ amplitude to INPUT A.
- Press the ⊓⊔ pushbutton.
- Set SENSITIVITY to 10mV.
- Connect an oscilloscope to the test point S.T. TP.
- Adjust R1025 (S.T. BAL) until the displayed square-wave has a duty factor of 0.50.



Measuring Time

The measuring time adjustment is performed with an universal counter equipped with a LF probe. Set this testing counter to measure frequency with a sensitivity of approx 1V$_{pp}$ referred to the probe tip.



- Connect the LF probe to the connector labelled TEST without removing the jumper.
- Turn the potentiometer R1164 (MEASURING TIME ADJUST) fully anti-clockwise.
- Turn R1 (MEASURING TIME) fully clockwise.
- Turn the potentiometer R1164 slowly clockwise until the testing counter measures 522 ± 4Hz.

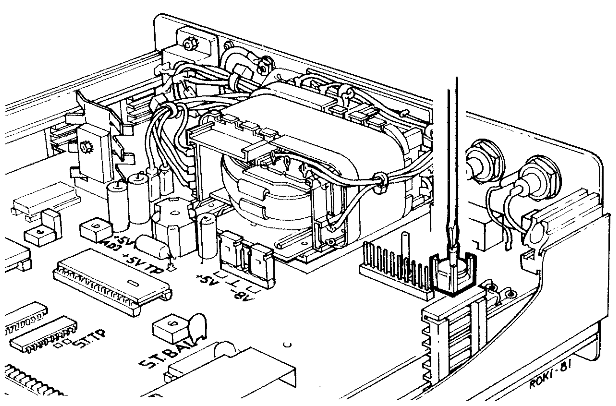
If the MEASURING TIME ADJUST potentiometer is turned too far clockwise, the counter under test will run into the self-test mode. The display read-out is then a test code. To exit the self-test mode, ensure that the MEASURING TIME ADJUST potentiometer is correctly adjusted before pressing RESET.

Frequency Adjustment of the Standard Oscillator (01 version)

This adjustment is performed at an ambient temperature of approx 23°C after a warm-up period of one hour.

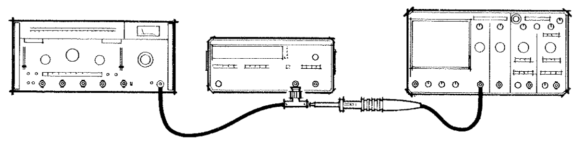
Proceed as follows:

- Connect a 10MHz reference signal with a tolerance of $<1x10^{-6}$ to Input A.
- Press the FREQ and ⊓⊔ pushbutton.
- Select correct SENSITIVITY by increasing the control until a stable read-out is obtained.
- Set the MEASURING TIME to 1s.
- Adjust trimmer C1154 with an isolated trimming screw driver until the read-out on the display is 10000.000kHz ± 10Hz.

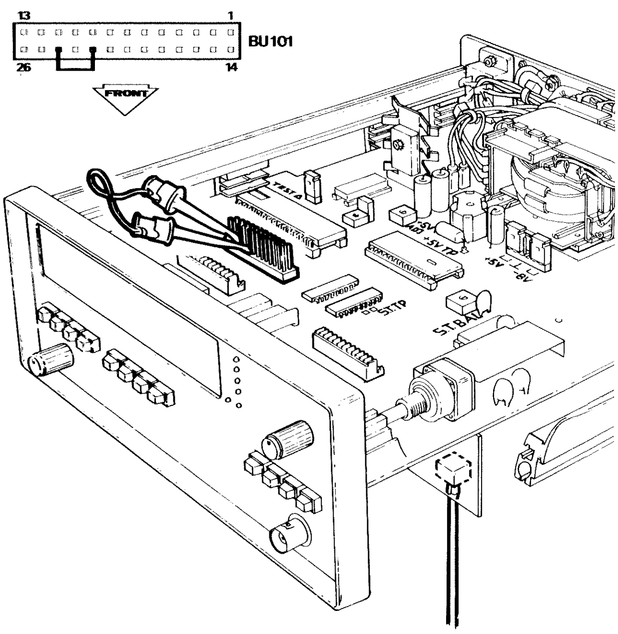


PM 6674 Prescaler

- Connect an RF signal generator with a frequency range of 10...600MHz to Input B, together with a sampling oscilloscope.



- Set the RF generator frequency to 550MHz at -29dBm.
- Adjust the reference voltage potentiometer R316 on Unit 3 so that the counter starts to count the 550MHz signal. The part of the prescaler that makes the counter display only zeros, when the signal amplitude to Input B is below specification, is called the Enable Function. To disable this function, connect BU101:24 (TEST) to BU101:22 (+5V).



- Set TEST high, and check the sensitivity when the display shows a correct, stable result. The difference in sensitivity between TEST high, and TEST low should be greater than 2dB.
- Check the sensitivity at 400MHz and 50MHz in the same manner

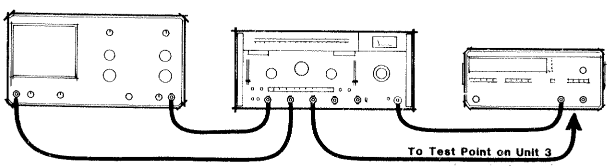
PM 6675 Direct Gated Input

The test procedure is the same as for the prescaler in PM 6674, but with the following changes.

- Set the RF generator frequency to 500MHz at -35dBm output level.
- Adjust the reference voltage with potentiometer RV301.
- The difference in sensitivity between TEST high and TEST low should be greater than 1dB.
- Check that the sensitivity is -33dBm for 100...500MHz and -27dBm for 50...600MHz.

PM 6676 Prescaler

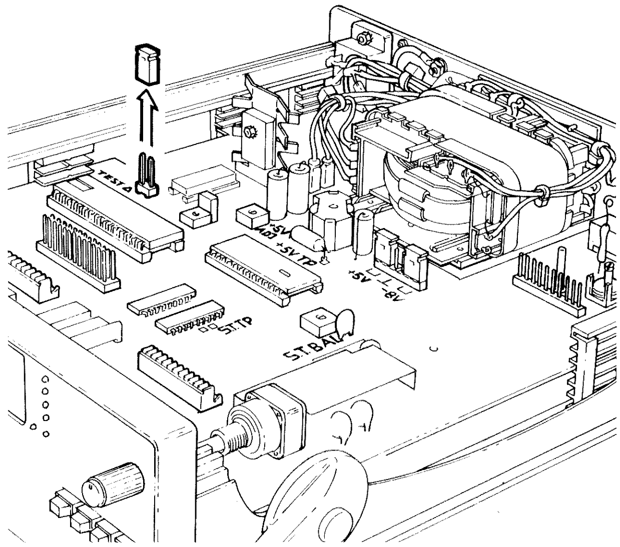
- Connect an RF signal generator with a 1500MHz frequency range to Input B.
- Set the generator output level to -30dBm.
- Connect the vertical output of the generator to channel Y_A and the horisontal output to channel Y_B of the sampling oscilloscope (set to 0.1V/div and X/Y mode).
- Connect a coaxial cable between the test point connector on the prescaler board and DEMOD IN on a Wavetek 2002A.



- Adjust C308 and C318 for max output at 1500MHz. The output level at 1200...1400MHz may not be lower than at 1500MHz.
- Connect BU101:22 to BU101:24.
- Measure at which input level the counter counts correctly at 100, 200, 1000 and 1500MHz.
- Remove the connection between BU101:22 and 24.
- Adjust R333 to -30dBm sensitivity at 1000MHz. The difference in sensitivity between TEST high and TEST low should be greater than 1dB.
- Check the sensitivity at 100, 200, 900 and 1500MHz. The sensitivity should be -27dBm for 100...1000MHz and fall to -17dBm at 1500MHz.
- Connect 50MHz to Input B with as large amplitude as possible, but max $12V_{RMS}$. Check that the counter measures correctly.

4. SELF-TEST

The counters of the PM 6673...76 series, each have a built-in self-test facility, which complements the CHECK function available on the front panel. This facility provides a test of the communication between the microcomputer and the function selector switches on the front and rear panels, and also the communication between the microcomputer and the display.



The test procedure is as follows:

- Remove the jumper labelled TEST.
- Release all pushbuttons.
- Press the POWER pushbutton.
- Press the RESET pushbutton.
- Ensure that FREQ A AVERAGE is not selected on the rear-panel slide switch.

MODEL	SELECT				DISPLAY READ-OUT								
PM 6673... 76	No controls selected. FREQ A AVERAGE not selected on the rear panel.				MSD 0	0	0	0	0	1	0	0	LSD 0
PM 6674	Input A					0							
	Input B					1							
PM 6675	Input A					4							
	Input B					5							
PM 6676	Input A					2							
	Input B					3							
PM 6673... 76	PUSH TO READ								1				
	DISPL HOLD							1					
	FREQ A AVERAGE						1						
	COUNT A	RATIO to D	PERIOD A	FREQ									
	Pushed											0	0
	Pushed	Pushed										4	1
	Pushed	Pushed	Pushed									4	1
	Pushed	Pushed	Pushed	Pushed								4	1
	Pushed		Pushed	Pushed								0	0
	Pushed			Pushed								0	0
	Pushed		Pushed									0	0
		Pushed										0	1
		Pushed	Pushed									0	1
		Pushed	Pushed	Pushed								0	1
		Pushed		Pushed								0	1
			Pushed									2	1
			Pushed	Pushed								5	0
				Pushed								1	0

Table 4.1 Self-test sequence. Only digits of interest (position and value) are indicated.

5. TROUBLE-SHOOTING

The following points will help trouble-shooting the PM 6673...76 series of counters.

- First check that the procedures in the Operating Manual, section Practical Measurements have been followed. Take particulary notice of the slide switch settings on the rear panel.
- Check that +5V is present at the +5V test point and that -8V is present at BU110:1.
- Make the self-test as previously described. If the self-test gives an erroneous result for a particular function, check the corresponding circuit and switch for that function.
- If the self-test functions correct, the fault is probably in the input circuits, in the external main gate network or in 0Q0040. IC140...142, IC160 and 0Q0040 can be tested by the CHECK function. Using the following sequence, circuits are gradually added which makes it easier to find the fault.

  1. Count: IC141C and IC161:1 are used.
  2. Period: IC141C, IC161:1 and the 10MHz standard are used.
  3. Frequency (reciprocal): IC160, IC142D, IC161:28 and the 10MHz standard are used.
  4. Frequency (conventional): more complicated to trouble-shoot, as an external main gate is used. IC140, IC141C, IC142C+D and IC160 are used.
  5. Ratio: as conventional frequency, but use an external signal via Input D.

For trouble-shooting, the ratio mode is sometimes better than the frequency mode because it is possible to use a low frequency signal. This makes it easier to display the signal TRIGG, IC161:4 on an oscilloscope.

IC141A can be tested by connecting a signal to Input A. IC141B is used for Input B signals. Make the tests in the 1...5 sequence above (only 3...5 for Input B).

- If the display makes no sense at all, check the microcomputer signal ALE (IC162:11) with an oscilloscope. The pulse width should be approx 0.7us and the pulse space approx 2.3us.
- If there is no ALE output, check that +5V is present at pin 26 and 40 of IC162. Measure to ground of the microcomputer (pin 20). Check that the oscillator signals at pin 2 and 3 of IC162 are correct, i.e. 5MHz. Replace the microcomputer if the oscillator signals are correct, but the ALE signal is not.
- If a correct ALE signal is present at pin 11 of the microcomputer, check the signals as illustrated in Fig. 5.1. It is difficult to get a steady display on an oscilloscope, so these figures are only a schematic illustration of the display.

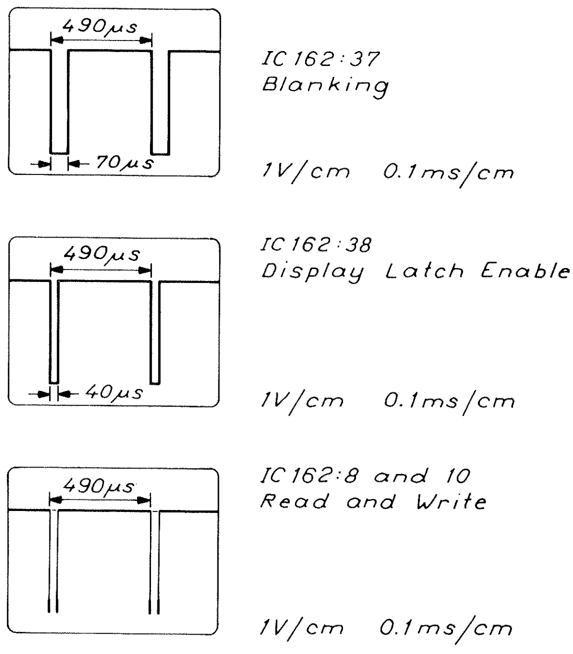


Fig. 5.1 If ALE is correct, check these signals.

Notes to Fig. 5.1:

- Trigg on IC165:1, negative slope, pulse duration = 0.5ms and pulse space = 3.8ms.
- At IC162:37, every 9:th pulse has longer duration.
- At IC162:38, every 9:th pulse has 90us duration.
- At IC162:8 and 10, every 9:th group of pulses consists of 3 pulses. The pulse duration is approx 1us.

If the microcomputer signals are correct as illustrated in Fig 5.1, continue with checking IC164, see Fig. 5.2.

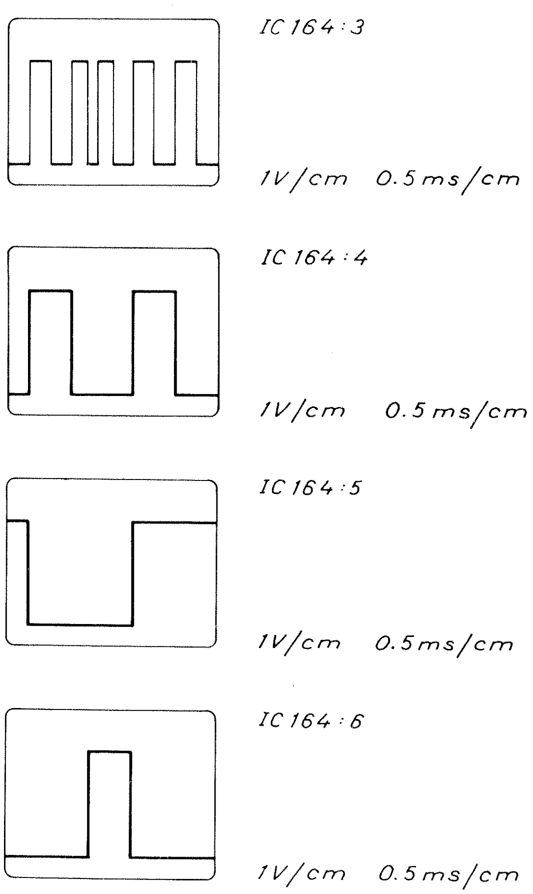


Fig. 5.2 Signals to check on IC164.

The power supply

A fault in the power supply can be isolated easier if the counter circuits are disconnected by removing the two jumpers on BU110. However, to simulate the load, a dummy load has to be used.

- Connect a 5 ohm, $<$ 5W resistor between BU110:1 and BU110:3.
- Connect a 50 ohm, $<$ 1.3W resistor between BU110:4 and BU110:6.
- The dummy load can be assembled by using a female connector, ordering number 5322 267 54102. Cut the connector to a suitable length.

First aid service kit

A kit containing components of interest for service is available. One each of the following components is supplied in the kit.

Component	Item number
LED display 7651, PM7773...76	B201...209
LED display 7651, PM6670...72	B201...208
Microcomputer 8049	IC162
Counter-on-a-chip 0Q0040	IC161
Display drive transistor MPS-A12	TS201...209
Seven segment decoder NE587N	IC201
Timer ICM 7555IPA	IC153
Input amplifier AM687DL, PM6670...72	IC102

The kit can be ordered from:

PHILIPS Elektronikindustrier AB
Industrial Operations
Supply Centre Service Department
S-175 88 JÄRFÄLLA
Sweden

Service Notes

The following hints apply only to counters with these serial numbers:

PM 6673: sn $<$ 1800	PM 6674: sn $<$ 1870
PM 6675: sn $<$ 1800	PM 6676: sn $<$ 1730

If there is no +5V output from the power supply, the following two hints might be of help.

1) The heat sink, on which transistor TS182 and diod GR183 are mounted, might cause a short circuit to ground. If necessary, either isolate the transistor and diod from the heat sink or make sure that the heat sink is not accidently connected to ground due to insufficent space on the foil.

2) If the optional oven enclosed oscillator PM 9679E is installed, check that the height of the pins on BU103 measured to the PCB is less than 11mm. If necessary, replace the connector with the type in the spare parts list.

New Seven Segment Decoder

In the first delivered counters, the Seven Segment Decoder consisted of two 9374PC (IC201 and IC202). These have now been replaced by a single NE587N (IC201) plus a 825 ohm resistor (R202). The new IC has better current capacity and the current through the segments are set by an external resistor (R202). It is not necessary to up-date an older version. However, the PCB is prepaired for the new IC and resistor.

- Remove IC201 and IC202.
- Remove the jumper from the IC socket.
- Install the NE587N in the IC201 socket.
- Mount a 825 ohm, 0.4W, 1% metal film resistor between pin 8 and ground.
- Connect pin 10 to ground.

Order number for the 9374PC: 5322 209 80955.