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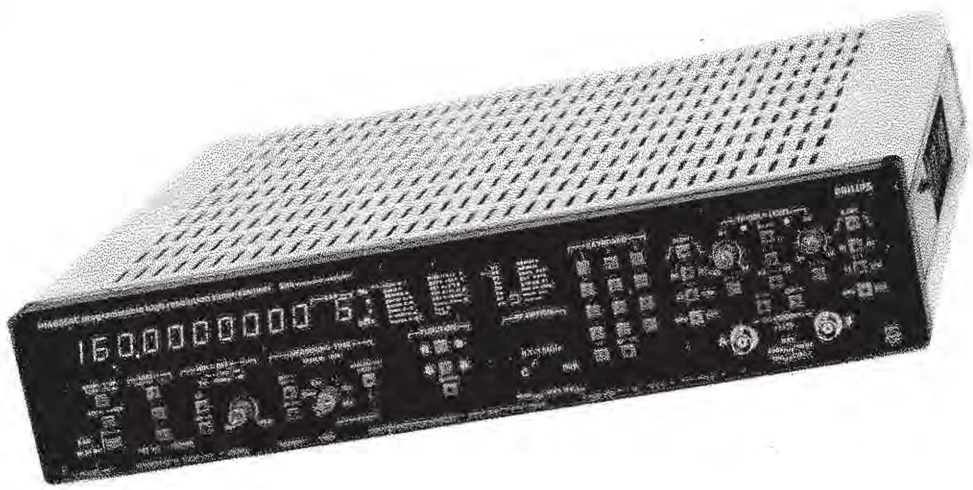
Programmable Timer-Counters PM 6652C...54C

Operators' Manual



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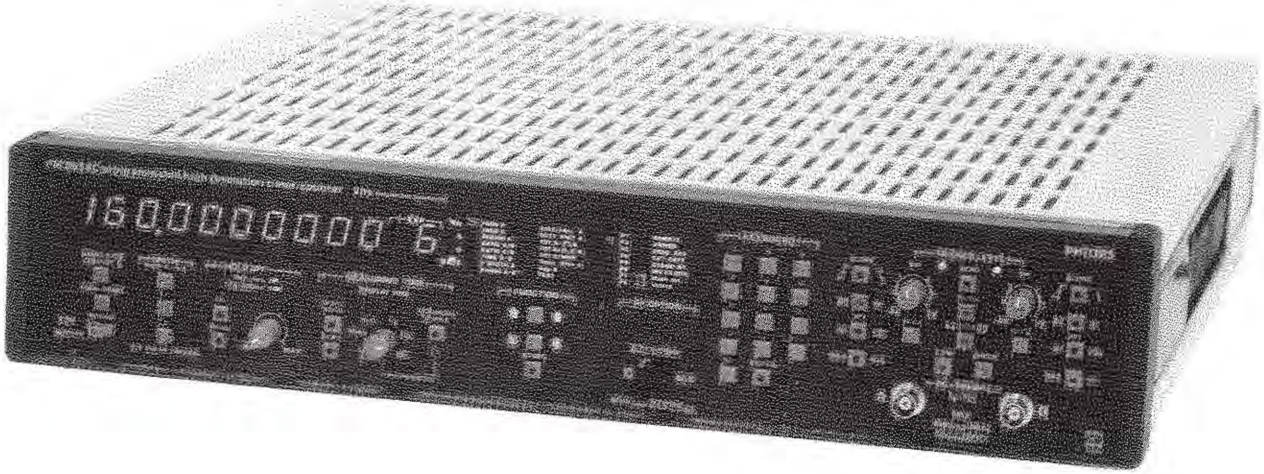
Chapter 1

INTRODUCTION



INTRODUCTION

The Philips high performance timer/counters PM 6652, PM 6654, PM 6652C and PM 6654C are fully programmable and satisfy most frequency and time measurement requirements. The four instruments look the same; the differences being found in resolution, accuracy and measuring speed.

The PM 6652 and PM 6652C have a 10 MHz (100 ns) clock frequency, whereas the extra high resolution PM 6654 and PM 6654C features a 500 MHz (2 ns) real time clock.

Thanks to their short measuring cycle times, the PM 6654 and PM6654C are particularly well suited to high speed automatic test systems.

The 'C'-version, introduced in 1986, have new features added to those of the original PM 6652 and PM 6654. A note is made if a function described in this manual is not applicable to the original PM 6652,-54.

All units are also available in blind panel versions.

Choice of crystal oscillators

The choice of crystal oscillators ranges from a standard oscillator to the 5 x 10^{-10}/24 h oven stabilized oscillator PM 9691. The high stability crystal oscillators are available as options for later upgrading of the counters.

High measuring power

The two timer/counters feature 14 different measuring modes: everything found in conventional counters, plus extra functions such as: PHASE, (directly in degrees), RISE/FALL TIME, DUTY FACTOR and VOLT.

FREQUENCY and PERIOD measurements are made very rapidly. The PM 6654 needs only one second for a 9 digit resolution while the PM 6652, in the same time, gives 7 digits. Both models perform measurements such as burst frequency, multiple burst frequency average and externally gated frequency measurements.

Trigger HOLD-OFF can be activated in frequency and period modes. It inhibits stop triggering during an adjustable hold-off time after start of the measurement, to avoid false triggering due to noise or interference (e.g. relay bounce).

Mathematics

The mathematic facilities of scaling and/or off-setting the measuring result extends the application possibilities. Some examples:

- V_{pp} measurements can be converted to V_{RMS}.
- Frequency readings from a transducer can be calibrated as RPM.
- Liters/s, gallons/min or m/s.
- Phase measurements can be converted from degrees to dians.

Time interval measuring accuracy

The PM 6654 with 2ns single shot resolution allows time interval measurements with a very high accuracy and resolution. Averaging a large number of measuring results in time interval, pulse width or rise or fall time modes gives a resolution of less than one picosecond with the PM 6654 and down to 10ps with the PM 6652.

Trigger accuracy

The PM 6652/54 inputs feature 1ns rise times and 20mV sensitivity over a -5V...+5V range. The counter can simultaneously display the set trigger levels of both the A and B channels. What appears on the display are the real trigger points. Automatic hysteresis compensation enables triggering at the set trigger level. Systematic trigger errors are thus kept to an extremely low level.

The PM 6652/54 gives full control over defining start and stop triggering. Arming and trigger hold-off enable rejection of unwanted signals which would otherwise trigger the counter.

Simple programming of IEEE-488 bus performance

The PM 6652/6654 are fully programmable, including all trigger controls. The optional interface card PM 9696 allows bus operations at a low additional cost. The resolution and measuring speed of the PM 6652/54 can be fully exploited by using the high speed dump mode, allowing up to 400...500 measurements per second. The IEEE 728/IEC-625-2 code and format norms are fully implemented in these counters.

The PM 6652/6654 can write their own program messages. First one finds the best control settings for a measurement. Thereafter activate the BUS LEARN mode, and the counter sends the status of all manually set controls to the controller. This eliminates the risk of programming errors and the need for debugging.

The eight "stored panel programs" P1...P8 can also be selected and created via the bus. This requires only one message and greatly reduces the bus communication load.

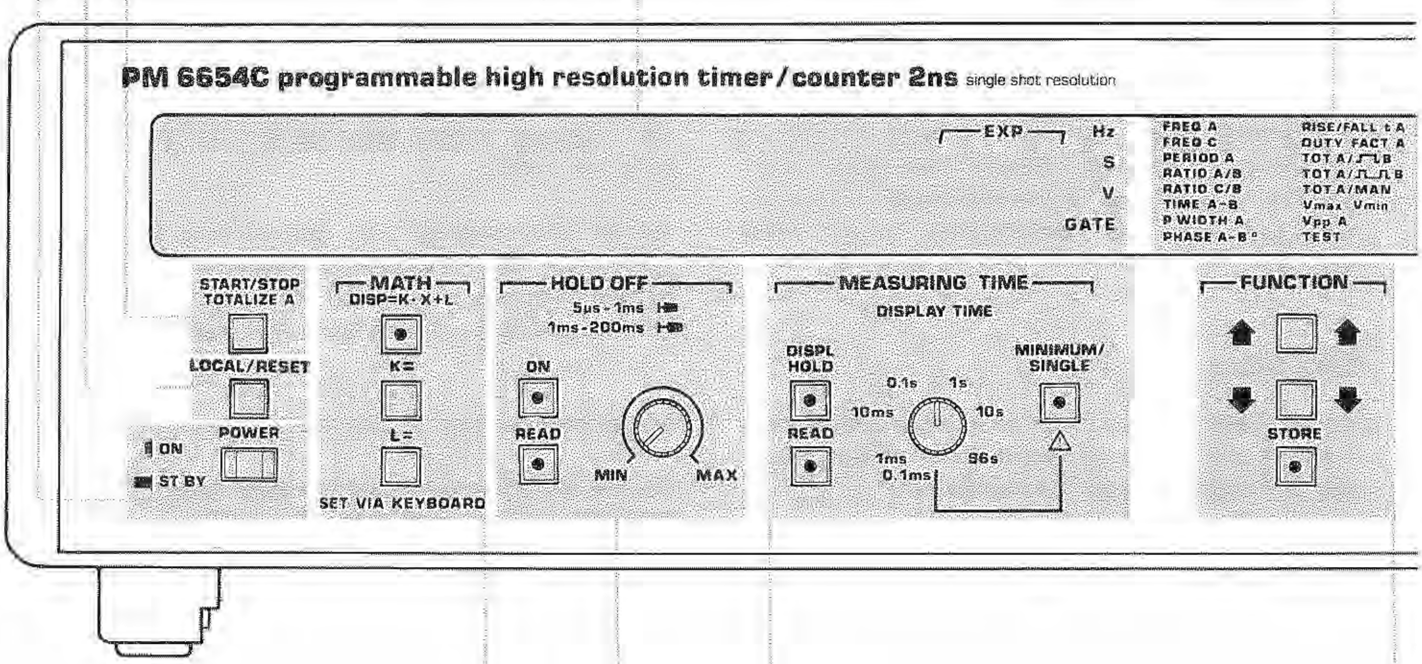
In "ST BY", power is available for an oven stabilized oscillator.

Reset the display and initiate new measurement.

Totalize events by manual Start/Stop (TOT A MAN).

A 10 digit DISPLAY for the measuring result and for digital readout of: measuring time, hold off time, trigger levels and mathematical constants K/L. Exponential notation and unit indicators.

Cursor indication of set function, or set "STORED PANEL PROGRAM" P1...P8, even when operated via the IEEE-488 BUS.



Set mathematical constants K and L for conversion of the displayed results.

Prevents false stop triggering due to spurious signals.

Acts also as a variable low pass filter in the range 5 Hz...150 kHz.

Set the MEASURING TIME between 0.1 ms and 96 s.
Select MINIMUM/SINGLE for shortest measuring time or a single measurement.
READ the set time on the display.
DISPLAY HOLD freezes the display and inhibits new measurements unless reset.

Move the Function Cursor up or down to select the function to be used. Also select stored panel programs P1...P8.

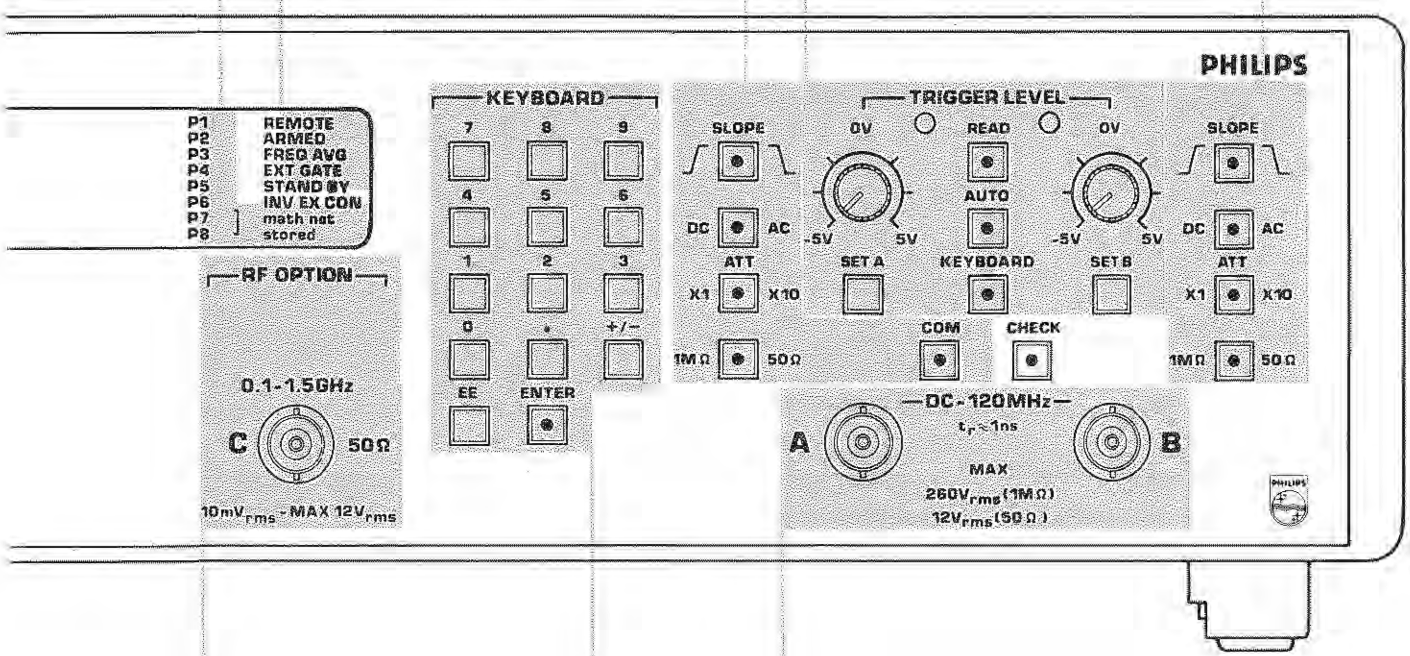
Store the current control panel settings in a "STORED PANEL PROGRAM" P1...P8.

Indication of selected "STORED PANEL PROGRAM".

Input controls: slope, AC/DC coupling, attenuator, impedance, and separate/common.

Indication of rear panel settings, remote operation and stand by.

Set trigger levels via keyboard or automatic or potentiometers.



A and B input channels.

Enter trigger levels and K/L constant values.

INPUT C optional
0.1...1.5 GHz RF signal input with automatic attenuator.

REAR PANEL
AC or DC Power Inputs.
10 MHz reference input/output.
Arming, Frequency Average, Ext Gate, Remote cursor control, Ext Reset inputs.
Gate Open and Trigger Level outputs.
OPTIONAL: Auxiliary Inputs.
OPTIONAL INTERFACES: IEEE-488 BUS or Analog output.

Chapter 2

INSTALLATION

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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. This manual contains information and warnings that should be followed by the user to ensure safe operation and to keep 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 sealed 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 must be disconnected from all voltage sources before it is opened. If adjustment or maintenance of the counter with the covers removed is inevitable, such maintenance must be carried out only by a qualified person. 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 230V, as indicated on the line voltage selector on the rear panel (note that the selector shows 220V). If the voltage setting is incorrect, set the line voltage selector in accordance with the local voltage before connecting the counter to the line.

WARNING: If the counter has accidently been connected to a 230V supply when set to 115V, an internal safety circuit and the line (mains) fuse will blow. These components have to be replaced afterwards. See service manual.

External battery operation

For field applications, the PM 6652 and PM 6654 can be modified for 24V DC on request. Use cable connector 4822 266 20014.

Note: Center pin in the connector should have + polarity.

Fuses

The counter is protected by two fuses. The primary fuse has to be changed when the mains voltage setting is changed. For 230V use a 0.4A delayed action fuse and for 110V use 0.8A delayed action. The secondary fuse on the PC-board unit 2 shall be a 4A fast action. Remove the line plug before fitting a fuse. Ensure that only fuses of the specified type are used.

Type	Service code
0.4A delayed action for 230V	4822 253 30016
0.8A delayed action for 115V	4822 253 30019
4A fast action secondary	4822 253 20026

Operating position

The counter can be operated in any desired position. A fold-down tilting support is available underneath the counter. For use in 19" rack: unscrew the top and bottom covers, remove the two side pieces and fit two rack mount adapters, replace the covers. See fig 2.1.

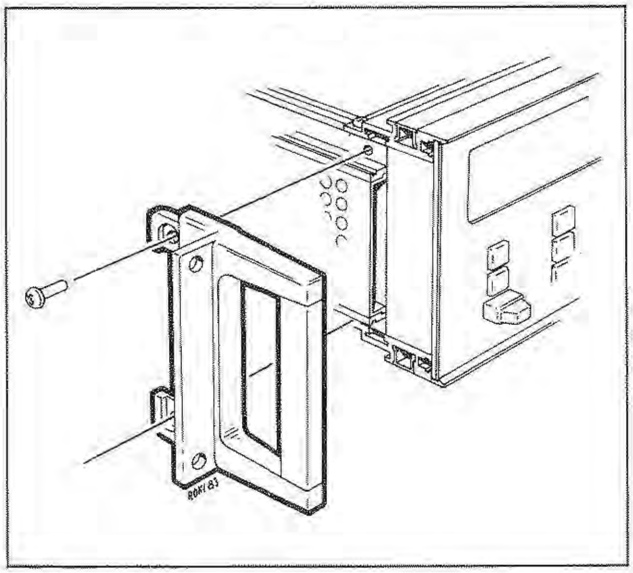

Fig. 2.1 Illustrates how the 19" side pieces are mounted.

Power switch

In position ST BY is only the supply voltages switched off. But the supply to the oven oscillator is still connected.

Warning! This is a secondary power switch. Also in position ST BY there will be live parts inside the counter. To separate the counter completely from the mains, the mains cable must be disconnected.

The POWER ON test

When the inspections and adjustment for local line voltage have been made, switch the power on. Now a practical test of the correct operation of the PM 6652/54 is run automatically. This self-check program starts every time power is switched from STAND BY to ON.

As soon as power is applied, the display shows:

8.8.8.8.8.8.8.8.8.8. EXP-8

and the following indicators appear:

FREQ A (or the function contained in a stored panel program if a program was active last time the instrument was switched to ST BY)

All the "unit" indicators

All the P1..P8 indicators

All the "extra" indicators (i.e., REMOTE, ARMED, FREQ AVG, EXT GATE and STAND BY)

All LEDS on the front panel (except the trigger indicators).

The program runs for about three seconds, and can be stopped by pressing RESET. When finished successfully, the display panel will show:

0 0 0 0 0 0 0 0 0 0 EXP 0

with only the FREQ A or other stored program function cursor from the recalled program displayed (one of the indicators P1...P8 are lit). Any "extra" conditions will also appear.

For all cases, unless a stored program dictates otherwise, the AC COUPLING and AUTO LEDs will be lit, indicating that these controls have been selected automatically.

If an error is detected, it is indicated by an "E" followed by the test number that failed.

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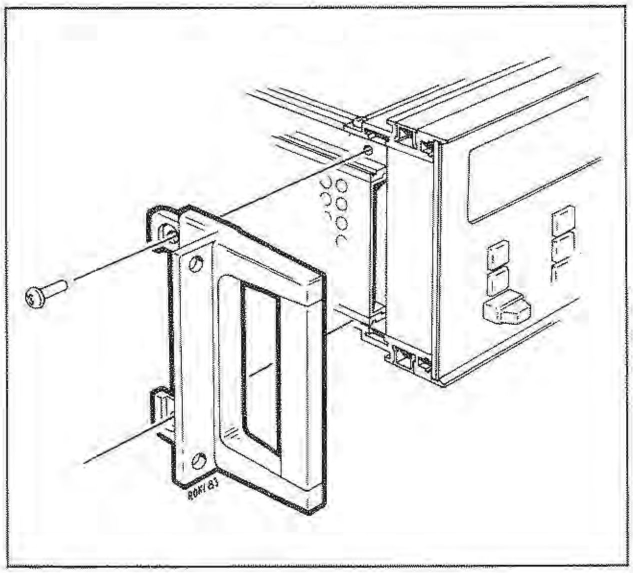

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For all cases, unless a stored program dictates otherwise, the AC COUPLING and AUTO LEDs will be lit, indicating that these controls have been selected automatically.

If an error is detected, it is indicated by an "E" followed by the test number that failed.

Chapter 3

CONTROL PANELS

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AN INTRODUCTION TO OPERATING THE PM 6652/54

This brief introductory guide has been created to avoid the use of lengthy texts to describe the various operating characteristics of the PM 6652/54 Timer/Counters. In it, the first time user is taken on a step by step exercise, using most of the controls and indicators, and having any doubtful points explained.

Note: Before applying power, ensure that the installation checks have been carried out (chapter 2).

1 Before switching on, look at the STAND BY indicator at the far right of the display panel. It is lit, indicating that instruments fitted with an oven stabilised oscillator have power supplied to the oscillator.

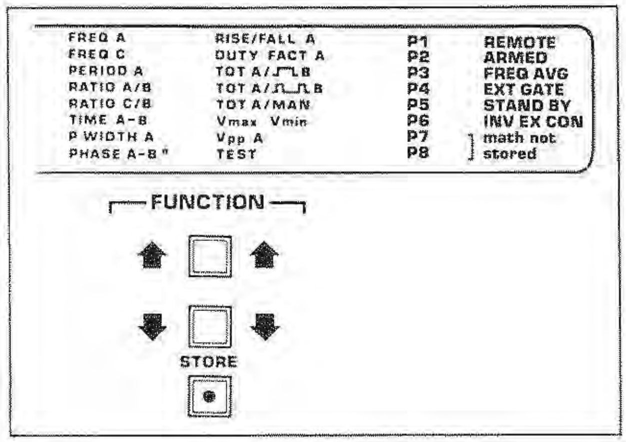
2 Switch on, and watch the self-test program run (see "Installation").

3 Switch off again, then find the rear panel switch marked "INT". Put this switch into the EXT (down) position.

4 Switch on again. The self-test program will end with E4 - a measuring logic circuit error. Put the INT/EXT switch back to INT, then press RESET. Alternatively, put the switch back to INT, then switch the power off and on again. The effect is the same.

5 Make sure that there are no input signals connected.

6 Find the function display above the three pushbuttons marked FUNCTION. The arrow cursor should be pointing to FREQ A. It doesn't matter if it isn't, but if the "function" cursor is pointing to some other function, then there will also be another cursor on the P1...P8 indicator column. This shows that a "stored panel program" is active.



7 Push the FUNCTION buttons (marked with arrows), and see how the function cursor "steps through" the list of functions. (It won't stop at the channel C functions unless the channel C option is fitted). Note how, when the function cursor passes FREQ A (going up) or TEST (going down), the P8 or P1 cursor lights.
Also note that when a P is indicated, the "program" cursor is the one that steps up and down in response to the FUNCTION buttons, while the "function" cursor moves in accordance with the function that was set in the program. Don't touch STORE yet.

8 Press the UP or DOWN buttons continuously, and note how the cursor(s) "scroll", with the "function" cursor hesitating at FREQ A and TEST (to give the operator time to release the button).

9 Set the function cursor to FREQ A, with no program active (no P indicated). Then turn the power off and on.

10 Look across at the input signal and TRIGGER LEVEL control groups (to the right). Channel A AC coupling and AUTO triggering should be selected (LEDs lit). The instrument will always select these two controls for any "manual" measurement (i.e., no stored panel program P1...P8).

11 Press READ. The values on the display are the trigger levels for AUTO mode. There is no input signal, so they will both be 0.01V (or, possibly, varying between 0.01 and 0.02).

12 Press AUTO (LED goes off). The trigger levels shown now are those set on the two variable potentiometers. Turn them.

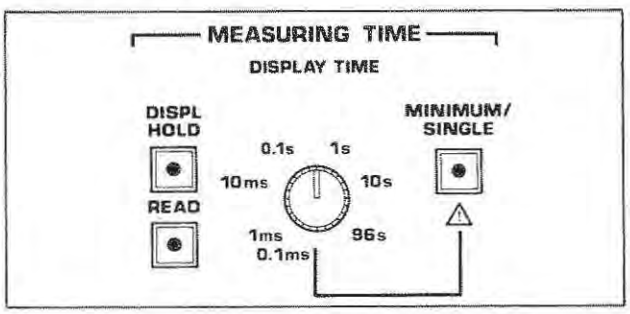
13 Press KEYBOARD. The values on the display are the "keyboard" trigger level values (they should be zero). Enter two new values.

14 Press SET A. The ENTER light on the keyboard will glow steadily. Make an entry, noting that the enter LED begins flashing as soon as the first digit is entered. When complete, press ENTER (RESET clears ENTER at any time up to that last press). Now set B.

15 The values entered on the keyboard will be used whenever KEYBOARD is selected.

16 Turn the power off, then on again.

17 Select KEYBOARD and READ. The "keyboard" trigger levels have been lost (they were never put into a program - that comes later).



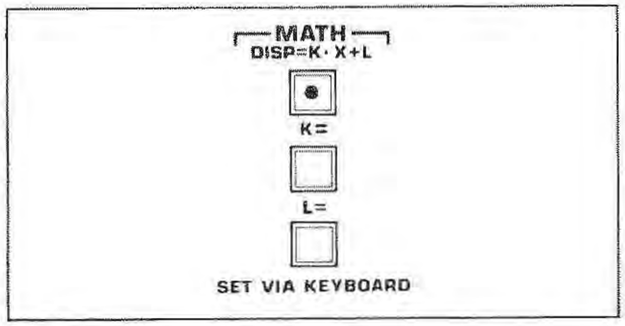
18 Move to the MEASURING TIME group of controls. Press READ, then rotate the variable potentiometer.

19 Press CHECK. This applies the internal reference signal (10MHz) to the logic circuits.

20 This display shows the 10MHz signal with a resolution that varies as the measuring time is changed with the potentiometer.

21 Set the potentiometer to the lowest possible measuring time and observe the display.

22 Press MINIMUM/SINGLE the resolution becomes worse, because the measuring time is now only 1µs (6652) or 2µs (6654). Note that the MINIMUM/SINGLE measuring time cannot be shown on the display (the time that appears when READ is pressed with MINIMUM/SINGLE on is the display time from the potentiometer).



23 Set MINIMUM/SINGLE off, and move to the MATH controls. Press DISP= K x X + L. The display should be exactly as before (no change in value).

24 Make the function FREQ A.

25 Press K=, then enter some value on the key panel. When ENTER is pressed, the displayed result will be changed by the K multiplier. Set an L (addition) value, and change K to an exponential value.

26 Setting an exponent is the same as on a calculator: enter the base value, press EE, then enter the exponent. Press ENTER to finish the entry.

27 Note that whenever the power was switched off and on again, any values entered are lost, and any controls, other than AC coupling and AUTO go out. If the operator has set up a complicated panel configuration and there is a line failure, all those controls and values will have to be set up again. This is one good reason for the use of the function "Stored Panel Programs".

28 Set up a control panel configuration. Enter some keyboard trigger levels with AUTO on - it isn't necessary to have KEYBOARD on to do this, but the effect is slightly different, as will be seen.

29 Decide if this is a set-up that is to be kept more or less permanently, then press STORE.

30 The program cursor is indicating P1. As a sort of "common sense" operating procedure, it is best to reserve P1 as "work area", in which "temporary" panel layouts are stored so that a line failure doesn't lose a complicated layout. Press STORE to store the configuration in P1, or, before pressing STORE:

31 Select some other P number with the DOWN control, then press STORE. The stored panel program for this panel configuration is now Pn, where "n" is the program number chosen.

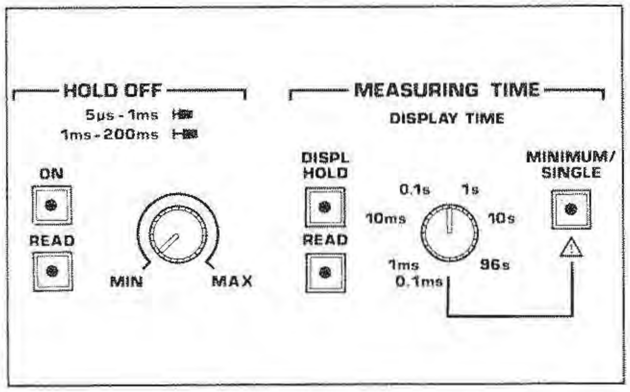
32 Switch off then on, and find the program. It isn't necessary to find it if it was still active at power off - it comes back automatically. Check the controls and values stored.

33 Note that the trigger levels set in the program via the key panel have not been selected - AUTO has (check the trigger levels in use with READ. To use the keyboard trigger levels, KEYBOARD must be pressed to override the AUTO levels. If KEYBOARD was wanted in the program as the primary option, then the KEYBOARD button should have been selected when the program was created.

34 Note that though a HOLD OFF "ON" state can be selected and stored, the HOLD OFF time cannot be stored. Nor can the potentiometer trigger level values. Also note that MATH constants cannot be stored in P7 and P8. Try it.

35 Now move the cursor out of the program indicators and select FREQ A with no program indicator. Note that the controls and values of the controls remain as they were set in the last program selected. That is, the last P-number at which the cursor was stationary. If the cursor "scrolls" continuously through P1...P8, no program is selected. To get back to the "initial" state, switch the power off, then on.

36 Because the potentiometer settings for trigger level and HOLD OFF cannot be stored, and if these are the controls selected in a program (AUTO and KEYBOARD off, HOLD OFF on), then the microcomputer will accept the values currently set on the potentiometers.



37 Select the program created earlier and then note the measuring time. Switch the power off, rotate the measuring time potentiometer as far as it will go in one direction, then switch on again. Check the measuring time with READ. It is that stored in the program, not that on the potentiometer. So if a new program is created, that measuring time on the display will be put into the new program.

38 Rotate the measuring time potentiometer. The program measuring time is overridden, and any new program created now will accept the new measuring time. The old measuring time is, of course, still in the "old" program. Try this.

39 Make a program with the rear panel switch ARMING/AVG/EXT GATE in any position but OFF. The state of the switch will show on the display panel. Turn the power off and set the rear panel switch to OFF. Power on and try to store the program without the switch function.

40 No matter how many times STORE is pressed, the ARMED or AVG or EXT GATE function persists in remaining in the program. To get rid of it, move the switch up and down, and then leave it OFF. This time, the indicator has gone.

41 Now connect an input signal and start measuring.

CONTROL PANEL LOGIC

The front panels of the PM 6652 and 6654 are arranged with a certain common logic to the way in which the keys and indicators operate. These common factors are:

Colour Coding

The descriptive text around the front panel keys is colour coded. The meaning of the colours is:

ORANGE - The control is one used to set or store a numerical value (i.e., trigger level or mathematical constant).

GREEN - The control is in the state expressed by the green script when the LED is alight. When the LED is not lit, the control is in the state indicated by the white script.

WHITE - White text is used to show the function of a group of controls, and to indicate the function of a control which has only one operational state (e.g., the READ controls).

LED Indicators

The LED indicators are colour coded to show:

GREEN - The green script state applies.

STEADY RED - The control is active (e.g., READ). No measurement is pos sible.

BLINKING RED - Applies to the ENTER key when it is expected that either the ENTER key or RESET (to cancel the condition) should be pressed next.

Using LOCAL/RESET*

A short depression of the LOCAL/RESET button makes the counter switch from remote to local mode.

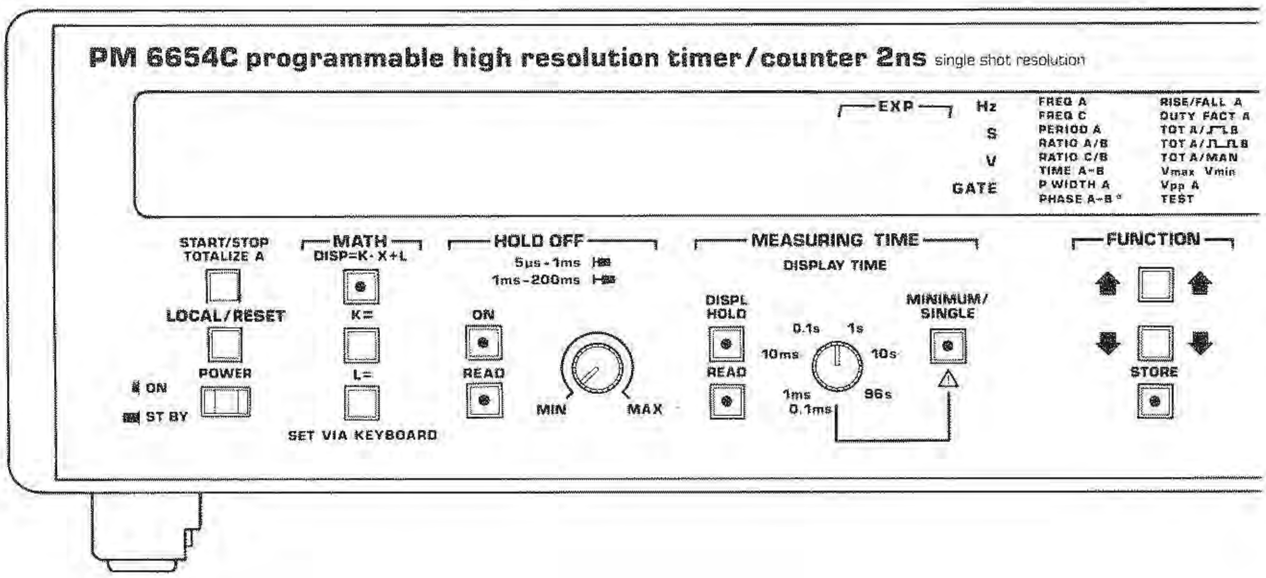
If the button is depressed longer than 400 ms, it also activates the RESET function.

RESET stops the measurement and resets the display to zero when depressed. It also cancells READ, ENTER and STORE. When released a new measurement is started. Although certain other controls will also do this, it is good practice to use RESET.

RESET interrupts measurement for as long as the RESET control is kept pressed. It will not destroy values entered as trigger levels via the KEYBOARD function, or MATH constants.

* The button is only a RESET button on the PM 6652, 54. Switching to local can only be performed from the IEEE-488 bus.

DESCRIPTION OF CONTROLS



The following is a brief description of the various controls and "control groups" on the PM 6652-54 front and rear panels. Information on the way in which the controls are applied to measurement is given in the chapter "Practical Measurement".

POWER ON/ST BY

Note: this is a secondary power switch, in the out (ST BY) position, power is supplied only to the oven stabilising circuit (when an oven stabilised oscillator is fitted). See "Installation" for a description of the power on self test.

LOCAL/RESET*

A short depression of the LOCAL/RESET button makes the counter switch from remote to local mode. If the button is depressed longer than 400 ms, it also activates the RESET function.

RESET interrupts measurement, clears the display and certain control states. Will not cancel preset trigger or mathematical values.

* The button is only a RESET button on the PM 6652, 54. Switching to local can only be performed from the IEEE-488 bus.

START/STOP TOTALIZE A

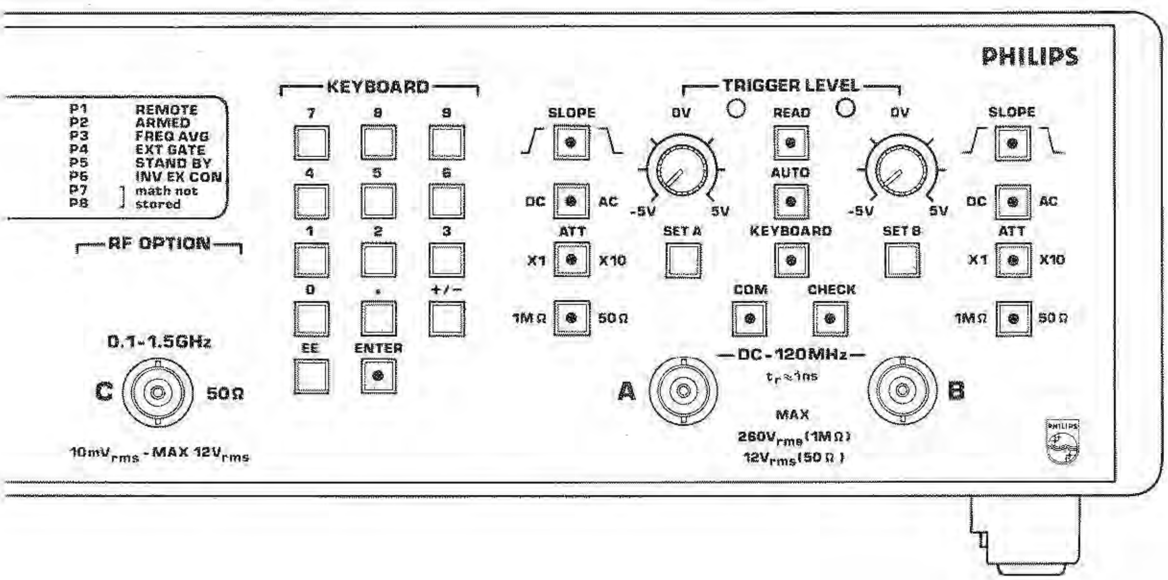
Used when the function is TOT A/MAN, this control starts and stops the "event counting".

MATHematical constants

K and L are mathematical constants supplied by the user, and used in the formula DISP=KxX+L when the DISP=KxX+L key is selected (LED on).

The measured result will be modified by K and L before displayed. K and L are set by pressing K= and/or L=, entering the value on the key panel, then pressing ENTER. Any further depression of K= or L= will show the last values entered, and will set the ENTER light on. RESET will cancel the ENTER, but will not change the previous values of K and L.

Unless stored in a stored panel program, any values set for K and L will reverty to 1 and 0 respectively when power is switched to ST BY.



HOLD OFF

HOLD OFF is a feature which gives the user the opportunity of delaying the retriggering to avoid false counts (as from relay bounce). The hold off time is set when HOLD OFF is on (the ON LED is alight) and by adjusting the potentiometer. With the potentiometer pushed, the adjustment range is 5µs to 1ms; pulled out from 1ms to 200ms. The value of HOLD OFF is displayed by pressing READ. NOTE that HOLD OFF value cannot be stored. A similar bus programmable function, the Time Interval Delay, is available on the PM 6654C, see Chapter 5.

MEASURING TIME/DISPLAY TIME

The measuring time for continuous measurement is set on the variable potentiometer, which has a range of 0.1ms to 96s. To make measurements on signals having a short duration; MINIMUM/SINGLE is used, giving a measuring time of one cycle or 1 microsecond (PM 6652) or 2 microseconds (PM 6654), whichever is the longer. With MINIMUM/SINGLE selected, the potentiometer becomes a display time control. In this case the display will show a measured result for the time set on the potentiometer. It changes to the latest measured result only after the set measuring (i.e. display) time has expired.

When DISPL HOLD is switched on, the counter completes the measurement in process, "freezes" the result on the display and stops measuring. Single measurements can thereafter be made by pressing the RESET button. The counter will not start continous measurements again until DISPL HOLD is switched off.

If DISPL HOLD is pressed when TOT A/MAN is selected, the counter will freeze the result on the display immediately without stopping the measurement.

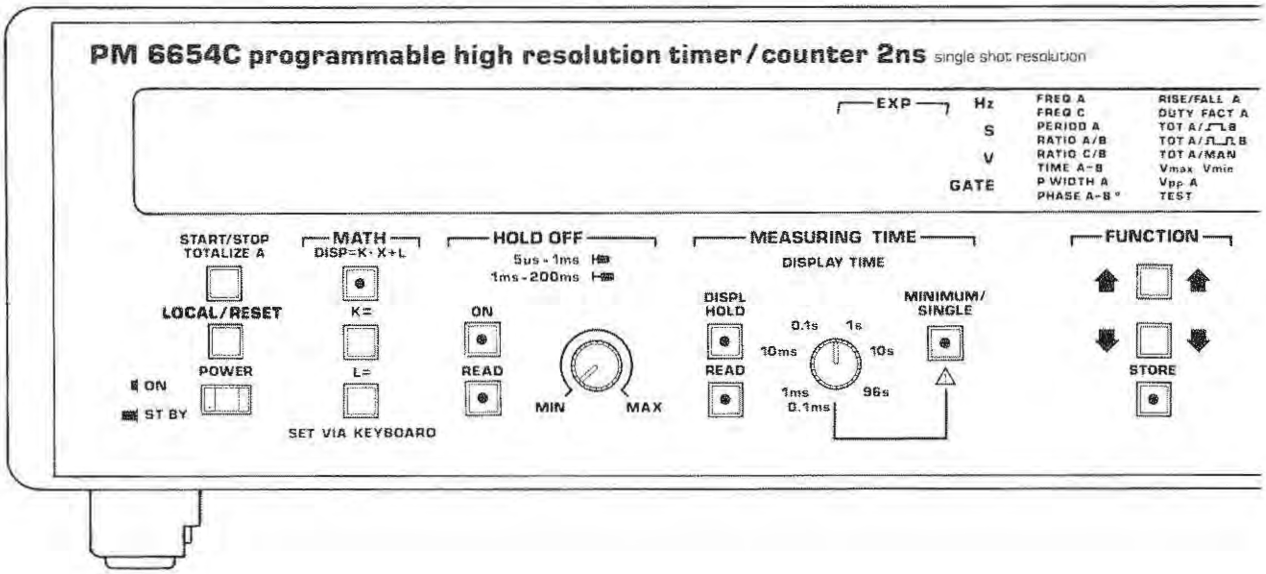
The currently set measuring time is displayed with READ.

Note that after a power down the counter will use the measuring time set by the potentiometer unless a stored panel program P1...P8 is selected.

Measuring time can be stored in a stored panel program.

FUNCTION

The "UP" and "DOWN" push buttons control the movement of the function and program cursors on the display panel. Continuous pressure causes the cursor to "scroll", though the function cursor will hesitate at FREQ A and TEST. Once past FREQ A (going up), or TEST (going down), the program cursor appears. When any stored panel program cursor is lit and the push button released,



the function cursor takes the position of the function specified in the program. Further depressions of the UP and DOWN controls will now move the program (P1...P8) cursor, with the function cursor respond to successive programs.

If the "INPUT C" option is not installed in the instrument, the function cursor skips over any function containing C reference. STORE is described in "Stored Panel Programs", and the individual functions are covered in "Practical Measurements".

RF OPTION input C

This is an optional input, allowing signals of up to 1.5GHz to be measured.

KEYBOARD

The keyboard is used to enter numerical values (K and L constants and KEYBOARD trigger levels). Exponential values can be entered. The ENTER LED lights automatically after K=, L=, SET A or SET B has been pressed. The LED begins blinking as soon as any keyboard entry has been made. If the ENTER LED is not either steady or blinking, no keyboard entry can be made. The ENTER "ON" state can be cancelled by pressing RESET.

SLOPE

Selects the triggering slope.

DC/AC

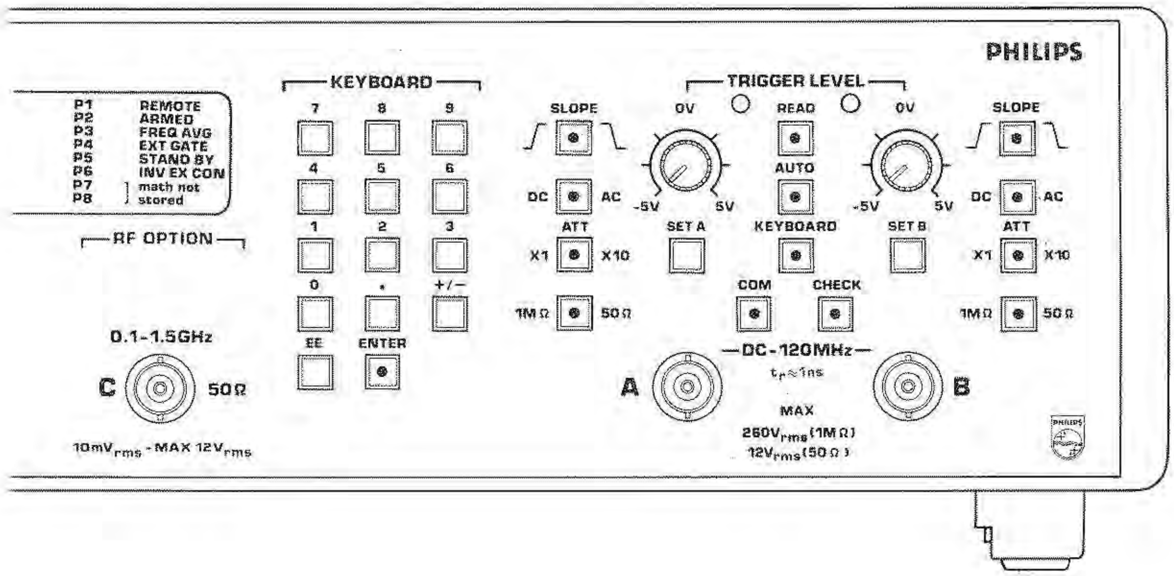
Selection of DC or AC coupling of the signal applied to input A and B respectively. Unless a stored panel program has determined otherwise, AC coupling is automatically selected by the microprocessor at switch on.

ATT x1/x10

When the LED is alight, the input signal is attenuated by a factor of ten, and the trigger levels are multiplied by ten.

1MOhm/50 Ohm

Determines the input impedance of input A and B.When the LED is lit, input impedance is 50 Ohm.



TRIGGER LEVEL

The trigger level is set in one of three ways:

- In AUTO mode the counter automatically calculates the 50% level of the input signal, or sets trigger levels at 10% and 90% of the signal's amplitude. AUTO is automatically selected immediately after power on unless a program dictates otherwise.
- Via KEYBOARD the trigger levels may be set either from a stored panel program or manually from the keybord.
- Via the potentiometers (both AUTO and KEYBOARD are off). Potentiometer values cannot be stored in a stored panel program.

Trigger LEDs

The trigger level is adjustable between +5V and -5V, or between +50V and -50V (ATT x10). The LEDs show the state of triggering:

- ON - the signal is above the trigger level.
- OFF - the signal is below the trigger level.
- BLINKING - the signal is crossing the hysteresis band.

READ

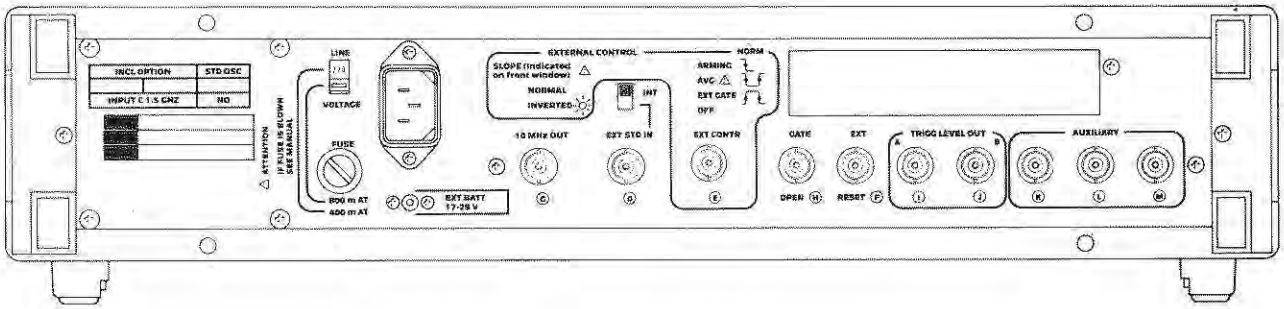
Shows the current trigger levels. Channel A on the left hand side and channel B on the right hand side of the display.

COMmon

Connects channels A and B internally and disables the channel B connector and impedance (1 MOhm/50 Ohm) control. The coupling, attenuation, slope and trigger level controls for channel B remain active.

CHECK

When active, the internal 10MHz reference signal is connected to the logic circuits. CHECK allows a self test of all functions except phase, duty factor, Vmax, Vmin and Vpp.



REAR PANEL CONTROLS and CONNECTORS

LINE VOLTAGE SELECTOR

Sets the line voltage for 230VAC (down) or 115VAC (up). SEE FUSE !

FUSE

Ratings: 0.4A for 230VAC; 0.8A for 115VAC. If the fuse blows, check that the fault has been cleared before replacing the fuse. Ensure that the correct rating of fuse is used.

Cursor Control

Allows an electrical remote input to perform the cursor control function.

10MHz OUT - Output G

An output for the 10MHz reference signal.

EXT STD IN - Input D

Allows the use of an external reference signal. Set the switch to the EXT STD IN position.

ARMING/FREQ AVG/EXT GATE/OFF - Input E

Allows the measuring of the input signal to be controlled by an external source. See "Practical Measurements" for the applications. Any switch position but off is indicated on the display.

SLOPE*

The setting makes Input E is active high (NORMAL) or active low (INVERTED). The setting is indicated on the front panel display.

* This function is not available on PM 6652,-54.

GATE OPEN - Output H

A monitor output to allow observation of the measured time interval and the trigger hold off time.

EXT RESET - Input F

An external electrical reset, equivalent to the front panel RESET control.

TRIGG LEVEL OUT (A, B) - OUTPUTS I, J

Allows the trigger levels on channels A and B to be observed on an oscilloscope. Note that input attenuation of the signals is disregarded, and that the output trigger level range is limited to +5V...-5V.

AUXILIARY Inputs K, L, M (Optional)

These optional inputs replace the corresponding front panel inputs A, B and C. They are factory mounted on request (option PM 9611).

Chapter 4

PRACTICAL MEASUREMENTS

CONTENTS Page

INTRODUCTION

This chapter describes the operation of the PM 6652 and PM 6654 from the viewpoint of its application, and gives practical advice to this end. The principle functions are described, as are the use of stored panel programs and the anciliary facilities. In addition, a few hints and tips and a short "what went wrong" guide are included. A chart, showing recommended control settings for various types of measurements, appears also in this chapter.

Knowledge of the controls, indicators and connectors is assumed (see chapter 3). The use of the IEEE 488 bus is not described (see chapter 5), nor are the operation and results of test programs and other functional checks (see chapter 8).

MEASURING FUNCTIONS

The measuring mode function is selected by using the function control buttons. See chapter 3 and "Stored Panel Programs" in this chapter. For theoretical considerations, see chapter 6.

FREQ A

Sets the instrument to measure the frequency of the signal connected to input A.

FREQ C

Sets the instrument to measure the frequency of the signal at input C. FREQ C cannot be selected if the channel C option, PM 9610 is not fitted.

PERIOD A

Sets the counter to measure the period duration of the signal connected to input A.

RATIO A/B

Sets the instrument to measure the frequency ratio between the signals connected to inputs A and B, with B as the reference signal.

RATIO C/B

Sets the instrument to measure the frequency ratio between the signals connected to channels C and B, with channel B as the reference. Ratio C/B cannot be selected if the channel C option PM 9610 is not fitted.

TIME A - B

Sets the instrument to measure the time interval between events on channels A and B.

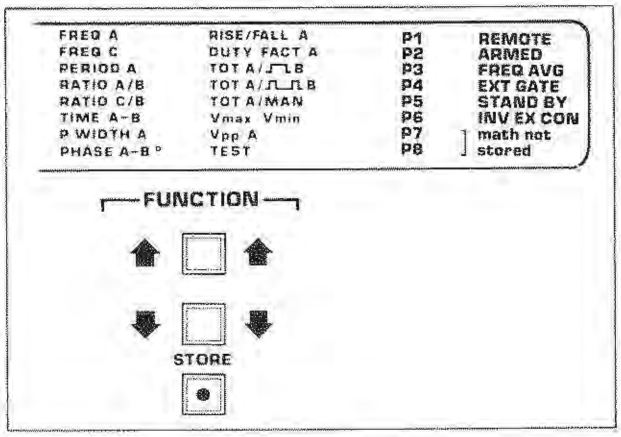


Fig. 4.1 Measuring functions.

P WIDTH A

Sets the counter to measure the pulse width of the signal connected to input A.

PHASE A - B

Sets the counter to measure the phase (in degrees) between the signals connected to inputs A and B.

RISE/FALL A

Sets the instrument to measure the rise or fall time of the signal connected to input A. It is recommended to use auto triggering to get the trigger levels correctly set at 10 and 90%.

DUTY FACTOR A

Sets the counter to measure the duty factor of the signal connected to input A.

TOT A/⎍ B

The counter will totalize events (pulses or cycles) on input A between the leading and trailing edges of the input B signal.

TOT A/⎍⎍ B

Sets the counter to totalize events on input A between start and stop events on input B.

TOT A/MAN

Sets the instrument to measure events on input A between depressions of the START/STOP TOTALIZE A button.

V_{max} V_{min}

Sets the counter to measure the positive peak level and the negative peak level of the input voltage on input A.

V_{pp} A

Sets the counter to measure the peak to peak voltage of the signal on input A.

TEST

See "Performance Check", chapter 8.

P1...P8

See "An Introduction To Operating the PM 6652 and PM 6654" in chapter 3 and "Stored Panel Programs", in this chapter.

STORED PANEL PROGRAMS

Introduction

Stored panel programs are of great assistance to those users who have repetitive tasks to perform, and/or if the measurements require complicated control configurations.

A stored panel program is stored in a non-volatile memory with a retention life of at least ten years. Eight programs can be stored, and they are identified by the titles P1...P8. Each of them can contain a full panel set-up and set values, with the following exceptions:

- READ, ENTER, and STORE cannot be set "ON".
- The potentiometer trigger level values cannot be stored but potentiometer triggering can be selected by specifying AUTO and KEYBOARD "OFF".
- No HOLD OFF value can be stored. But HOLD OFF "ON" can be specified.
- No external reference signal can be specified.
- In P7 and P8 only, neither MATH on nor mathematical constants can be stored.

Stored panel programs can be initiated and created over the IEEE 488 bus.

Creating stored panel programs

To create a stored panel program first set all the controls and values (KEYBOARD trigger levels, measuring time and the K and L MATH constants as required). Select the function, then press STORE once. The P1 indicator will be lit. Step the cursor down to the desired program number, then press STORE again. Any program that previously existed in that area will be overwritten completely.

NOTE: It is recommended that P1 is used as a "work area", rather than as a permanently stored program. This means that when there is a complex, temporary set up in use, it can be stored in P1. Any accidental power off or line failure will not, then, destroy the set up.

Overriding stored panel programs

When a stored panel program is recalled, all the controls, indicators and values will be set exactly as they where when the program was created (except as specified in the introduction). The program controls and values can be overridden temporarily by setting other controls and values. This "real time" selection will last as long as the power remains on, or until the program is reselected. Exceptions to this rule are:

- ARMING/AVG/EXT GATE/OFF and SLOPE. If any of these facilities was chosen when the program was created, that facility will appear as the default when the program is reselected whatever the current position of the switch. Moving the switch while the program is active will give the ARMING/AVG/EXT GATE facility which is displayed on the front panel.
- Measuring time. The measuring time set by the program when the program is reselected is that which was set when the program was created, whatever the current position of the measuring time potentiometer. An override measuring time can be set by rotating the potentiometer. Note that to guard against inadvertant movement of the potentiometer, a movement of 1 decade of the potentiometer is required. Once these limits are exceeded, the potentiometer assumes its full analogue range.

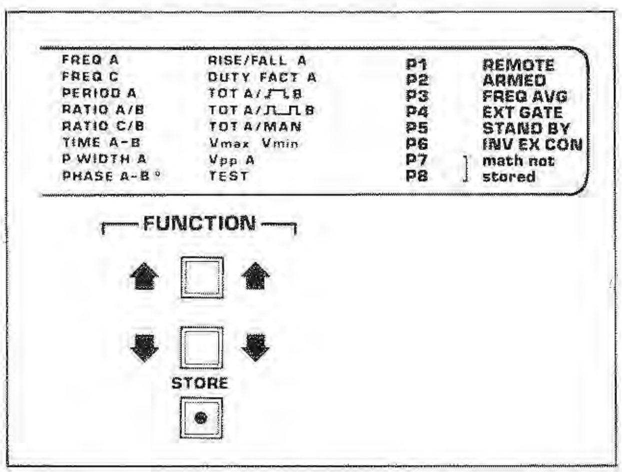


Fig. 4.2 Stored panel programs.

TRIGGER SETTINGS

The PM 6652/54 offers a variaty of trigger possibilities, such as trigger slope, input impedance, AC/DC coupling and two trigger level ranges -5...+5V and -50...+50V.

As further described in the chapter "Measurement Theory", always try to set the controls to AC coupling and x10 attenuation for frequency measurements and DC coupling with no attenuation for time measurements.

For many measurements it is vital to have a good impedance matching to avoid reflections which might make the trigger level setting very difficult. Always use the 50 Ohm termination in 50 Ohm systems.

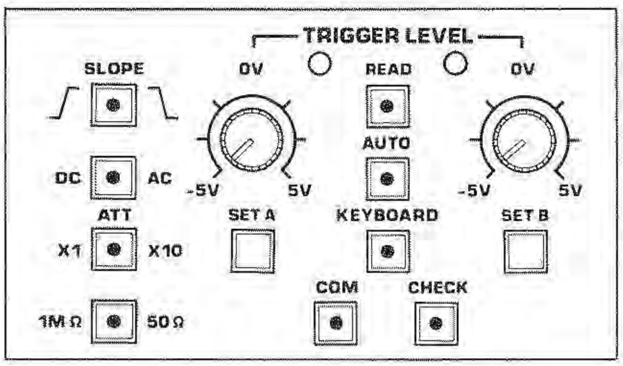


Fig 4.3 Trigger controls.

Trigger level setting

The trigger level can be set in one of three ways: Auto, keyboard or potentiometers.

- In AUTO mode the counter automatically calculates and sets the triggering to the 50% level of the input signal, or for rise/fall time measurements at 10% and 90% of the signal's amplitude. AUTO is automatically selected immediately after power on unless a program dictates otherwise.

- When KEYBOARD is selected, the trigger levels could be entered automatically from a stored panel program, or manually via the keyboard. When the trigger levels are set via keyboard it is good practise to store the values in one of the program positions.

- Potentiometers are selected when neither AUTO nor KEYBOARD pushbuttons are depressed. Note that potentiometer values cannot be stored in a stored panel program.

When the trigger controls have been set, the functioning of the trigger circuits can easily be checked on the trigger indicators, one for each channel. The LED:s show the state of the triggering:

ON the signal is above the trigger level.

OFF the signal is below the trigger level.

BLINKING the signal is crossing the hysteresis band (correct triggering).

MATHEMATICS

On many occasions it is convenient to modify the measured result before presentation in order to make it easier understood. Some examples: An odd result from a transducer can be changed to rpm, or a frequency that has to be monitored may be subtracted before displayed, and the display will only show the deviation.

The formula: Display = K x measured value + L is used when the DISP=KxX+L is selected (LED on). In the formula K and L are set by the user.

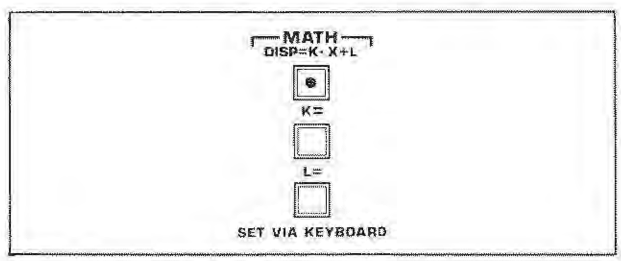


Fig. 4.4 Mathematical controls.

K and L are set by pressing K= and/or L=, entering the value on the key panel, then pressing ENTER. Any further depression of K= or L= will show the last values entered, and will set the ENTER light on. RESET will cancel the ENTER, but will not change the previous values of K and L.

Unless stored in a stored panel program, any values set for K and L will reverty to 1 and 0 respectively when power is switched to ST BY.

Repetitive events

	Input signal characteristics/application	Minimum/single	Triggering: Auto	Triggering: Keyboard	Triggering: Potentiometer	Input control: Coupling	Input control: Slope	Input control: Attenuation	Input control: Impedance	Hold off	External control: Arming	External control: Frequency average	External control: External gate	Notes
Frequency measurements	Normal setting		●			AC	+	x1	1MΩ		○		○	
Frequency measurements	Noisy signal, 100 Hz to 150 kHz		●			AC				●				PM 6654 performance becomes the same as PM 6652
Frequency measurements	Noisy signal, ≤120 MHz			●	○	AC		x10						Only if input signal $\geq 200\,mV_{RMS}$
Frequency measurements	Noisy leading edge, ≤200 kHz				○	DC		x1 or x10		●				PM 6654 performance becomes the same as PM 6652
Frequency measurements	Multiple burst frequencies	○		●	○	DC		x1 or x10				●		Must be gated by an external signal
Frequency measurements	Pulse signal, duty factor <0.25 >0.75		●			DC				○				
Frequency measurements	Frequency <100 Hz			●	○	DC								
Frequency measurements	Fast measurement	●		●	○									Set minimum display time
	Period averaging (A)		●			AC				○	○		○	
	Ratio A/B averaging		●			AC								
	Ratio C/B averaging					AC								
	Time A - B averaging			●		DC	+ or −	x1 or x10		○	○	○		
	Time A - B, pulse width A; Start/stop with contact bounces			●	○	DC	+ or −	x1 or x10		●				
	Pulse width averaging (A)		●			DC	+ or −			○	○	○		Set pos. slope for pulse width and neg. slope for pulse spacing
	Phase A - B			●		AC	+	x1 or x10						Trig. level = 0.00 V. Attenuate <u>if needed</u> to get equal amplitudes for A, B
	Rise/fall time averaging (A)		●			DC	+ or −				○	○		Pos. slope for rise and neg. slope for fall time
	Duty factor (A)		●			DC	+							
	Total A/⎍ B and total A/⎍⎍ B				○	DC	+(B)	x1 or x10			○			Pos. slope in channel B
	Totalize A, manually controlled				○	DC		x1 or x10						

Single events

Input signal characteristics/ application	Minimum/single	Triggering: Auto	Triggering: Keyboard	Triggering: Potentiometer	Input control: Coupling	Input control: Slope	Input control: Attenuation	Input control: Impedance	Hold off	External control: Arming	External control: Frequency average	External control: External gate	Notes
Single burst frequencies			●	○	DC		x1 or x10			○		○	Must be gated by an external signal
Single period (A)	●		●	○	DC		x1 or x10						
Single ratio A/B	●		●	○	DC		x1 or x10						
Single ratio C/B	●		●	○	DC		x1 or x10						
Single time A-B	●		●	○	DC	+ or −	x1 or x10			○			
Single pulse width (A)	●		●	○	DC	+ or −	x1 or x10			○			Pos. slope for pulse width neg. slope for pulse spacing
Time A-B, pulse width A; Start/stop with contact bounces			●	○	DC	+ or −	x1 or x10		●				
Single rise/ fall time (A)	●		●	○	DC	+ or −	x1 or x10			○			Pos. slope for rise time and neg. slope for fall time
V_{max} V_{min} A and V_{pp} A					DC								

Please note that these are recommended control settings for a limited variety of applications. For other tasks (or even those described), the user may find a combination of controls which suits him better. The symbols mean:

● This control setting is recommended for the application.

○ This control may be used as an alternative to another control in the same group, or a control may be used if the operator wishes.

RECOMMENDED CONTROL SETTINGS

HINTS AND TIPS

This section gives a few hints and tips about practical procedures in operating the counter/timers.

Measuring Time

- Low frequency signals (below 100Hz) will tend to give unexpectedly long measuring times.
- The measuring time control for channel C measurements works in exactly the same way as it does for channel A.
- The measuring time potentiometer becomes a display time control in MINIMUM/SINGLE.
- For FREQ A, FREQ C, PHASE A-B and DUTY FACTOR A, MINIMUM/SINGLE forces the counter to make 1μs (PM 6652) or 2μs (PM 6654) measurements of the repetitive signal.
- For PERIOD A, RATIO A/B, RATIO C/B, TIME A-B, P WIDTH A and RISE/FALL TIME A, MINIMUM/SINGLE forces the counter to measure a single complete cycle of the input signal (on B, in the case of RATIO A/B and RATIO C/B, but see below).
- For RATIO A/B and RATIO C/B, the use of MINIMUM/SINGLE in conjunction with a start/stop signal on B changes the functions to:

  TOT A _|‾|_|‾|_ B and TOT C _|‾|_|‾|_ B
  respectively.
- MINIMUM/SINGLE has no effect in the functions: TOT A/MAN, Vmax, Vmin and Vpp.

Triggering

- The AUTO trigger function will always try to find the 50% level on signals, and will attempt to offset for any DC component. If the counter fails to trigger, because the AUTO triggering feature cannot set trigger levels, the Vmax Vmin function can be used to find the signal's peak values. New trigger levels can then be set via the keyboard, or established on the potentiometers. Similarly, values found by using the potentiometers can be examined and set as KEYBOARD levels.
- A low frequency signal (below 100Hz) will cause problems for the AUTO feature. The trigger levels can be set as described above.
- If a signal contains heavy "spikes", the AUTO feature will calculate a false Vpp. The trigger levels should be set manually.
- KEYBOARD or potentiometer trigger levelsetting is generally recommended for:

  Noisy signals < 120MHz
  Burst frequencies
  TIME A-B averaging
  PHASE A-B
  Single RISE/FALL TIME A
  Single RATIO A/B
  Single RATIO C/B
  Single TIME A-B
  Single P WIDTH A

Coupling

DC coupling is recommended for:

- Burst frequencies
- Single RATIO A/B
- Single RATIO C/B
- Single TIME A-B
- Single RISE/FALL TIME A
- ATE

Attenuation

The ATT x1 x10 control is disabled when AUTO is in use, since AUTO selects the attenuation itself. The LED on the ATT control does not necessarily show the attenuation in use.

In voltage measurements (Vmax Vmin and Vpp), the setting of the attenuator is ignored, giving the true voltage at the input.

Use of x10 attenuation is recommended for noisy signals, if possible.

Impedance

- When performing RISE/FALL TIME measurements, it is important that the waveforms are as clean as possible. Input impedances must, therefore, be matched closely.

- The setting of the impedance control will, of course, affect voltage measurements.

The MATHematics Function

The MATH function can be used to store constants and offset factors which will modify the displayed result. The example used so far has been the case in which a voltage signal (V_{pp}) from a transducer could be converted to a value of volume or other units. Another case in which MATH could be used is to store a factor which compensated for differing delays between channels.

The HOLD OFF Function

The HOLD OFF function is used to avoid superimposed or leading edge noise on input signals. When used, however, the PM 6654's performance becomes identical with that of the PM 6652 (see chapter 9). Applications for HOLD OFF are:

- Superimposed noise on carrier frequencies in the range 5 Hz...150 kHz can be suppressed.
- Leading edge noise can be suppressed on signals in the frequency range 5 Hz to 150 kHz.

HOLD OFF is disabled in the functions PHASE A-B and DUTY FACTOR A. It should not be used in the function RISE/FALL TIME A.

HOLD OFF cannot be applied to any function involving Channel C.

PHASE Measurements

The limiting voltages for PHASE measurements are:

- 100 mV_{RMS} to 3.5 V_{RMS} or
- 1 V_{RMS} to 35 V_{RMS} (x10 attenuation)

A higher input voltage will cause waveform distortion, while lower voltages will result in inaccuracy. Maximum frequency is 2 MHz.

DUTY FACTOR Measurements

The highest frequency at which DUTY FACTOR can be used is 2 MHz.

Voltage Measurements

Accurate voltage measurement is possible up to 20 MHz. Frequencies between 20 and 80 MHz can also be measured but with reduced accuracy.

External Control - INT/EXT STD IN

When the INT/EXT STD IN switch is in the down position, the counter will expect an external standard reference signal. Rules applicable to the use of such a signal are:

- If there is no external signal, the counter will display error E4 after the power on sequence (see chapter 8 "Performance Check"). If the E4 error is RESET and there is still no signal, either:

- The PM 6652 will not measure.

- The PM 6654 will attempt to measure frequencies and single time intervals, but the results will be inaccurate.

When using an external signal for time interval averaging measurements, the standard reference signal should not be synchronised with the input signal.

The INT/EXT STD IN control cannot be stored as a stored panel program parameter.

ARMING/FREQ AVG/EXT GATE/OFF

When this control is in the EXT GATE position, the counter will expect an external control signal, and will not measure until such a signal is supplied. If it is set to ARMING or FREQ AVG, the counter will measure when the control signal is absent, or TTL-low.

When stored in a stored panel program, the external control state can be overridden by switching to a new position. For normal operation, the switch should be set to OFF. The functions are applicable as follows:

ARMING — To all but PHASE, DUTY FACTOR and TOT A/MAN measurements.

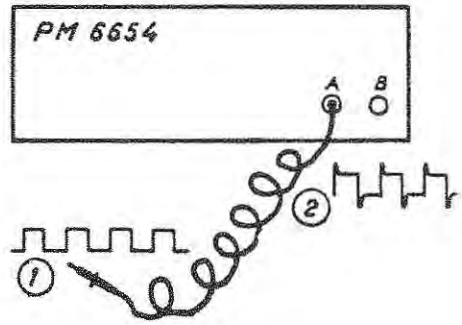
AVG — To FREQ A, FREQ C and PERIOD A and TIME A-B measurements.

EXT GATE — To FREQ A, FREQ C and Period A measurements. Example applications are multiple burst frequencies and masked time intervals. Note that if RF burst are to be measured using FREQ C, the burst should contain at least 32 CW cycles.

SLOPE*

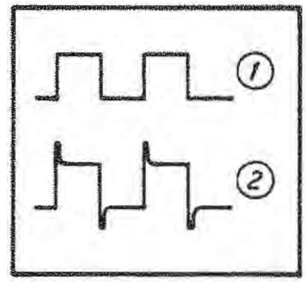
This button inverts the EXT CONTR input making the function selected with the ARMING/AVG/EXT GATE/OFF-switch active on the opposite slope. The selection is indicated on the front panel.

* Not available on the PM 6652,-54.



Channel Considerations

Input B is limited to 10MHz in the RATIO modes. Input C may accept frequencies as low as (approximately) 80MHz.



TIME MEASUREMENTS USING PROBES

Introduction

It is possible to calibrate the probes for Time/Phase measurements directly with a PM 6652 or PM 6654 Timer/Counter. The compensation procedure requires, besides the counter, a generator capable of delivering a 500 Hz square-wave signal with 20 V_{pp} amplitude.

Why are probes used at all?

a) Probes are used to reduce the influence of the measuring instrument on the device under test. When measuring in high-impedance systems, an 1 Mohm load (normal counter input) might be too low and a 10 Mohm load (probe) is required.

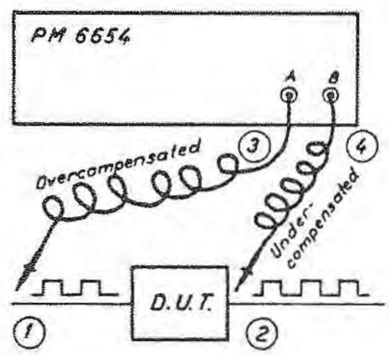
b) Probes are sometimes used to reduce high voltage levels. The measured level is divided by 10 using a 10 Mohm/1 Mohm probe.

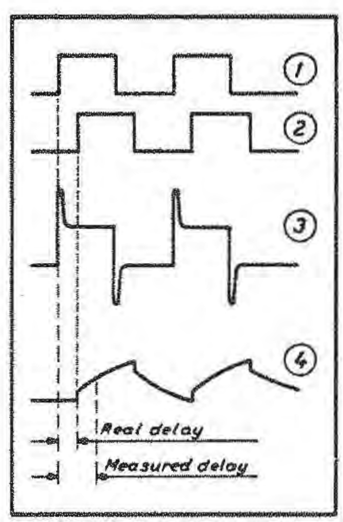
c) A probe is easy to hook on to different measuring points in a test object. For this purpose however it is not necessary to use a 10:1 probe. A single wire with a test hook might do as well ("simple 1:1 probe").

Measurement problems

a) When an over-compensated probe is used in pulse measurements, an "overshoot" is generated in the counters input. This makes the V_{pp} measurement go wrong. The display shows a too high value.

b) Very short Time Interval measurements might go wrong when two **differently compensated** probes are used. An example is given below:





Look-out for the impedance of the counter!

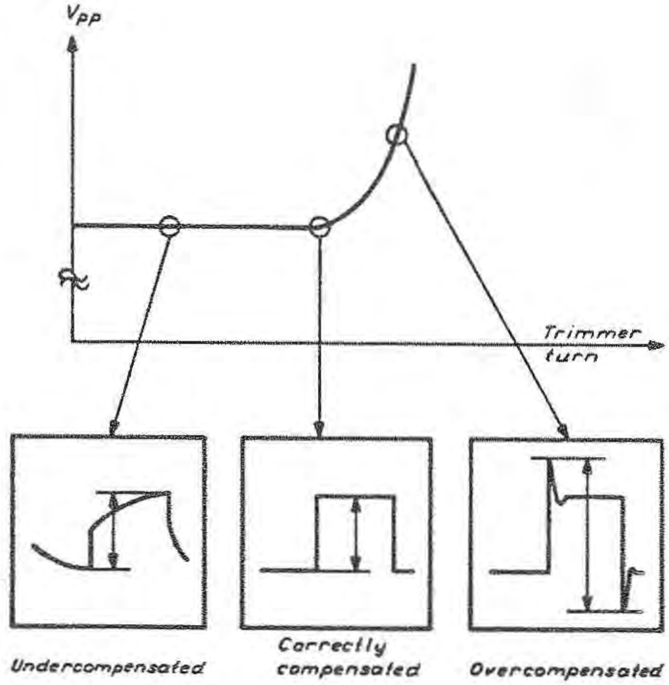
The input impedance of the counter is reduced to from 1 Mohm to 500 kohm when:

a) COMMON inputs have been selected.
b) P-WIDTH, RISE/FALL TIME or DUTY FACTOR measurements are selected.

> This means that a probe compensated with a 1 Mohm load from the counter is un-compensated in the above cases (500 kohm).

In conclusion, a calibrated probe should **only** be used when separate A and B inputs have been selected otherwise the probe will no longer be compensated.

EXAMPLE: When e.g. rise time should be measured using probes, a Time Interval measurement with separate inputs must be selected. The input signal must **externally** be fed to both inputs via two separate (calibrated) probes. Thus the 'COM'-function should **NOT** be used. The levels must be set manually to 10% (A-channel) and 90% (B-channel) resp.



Probe compensation in PM 6652 and PM 6654

1) Set counter inputs to ATTx1, 1 Mohm termination and SEPARATE inputs (NOT 'COM').
2) Select V_{pp}-function.
3) Connect probe to input A.
4) Connect a generator, via the probe, and set square wave signal, 500 Hz and 20 V_{pp}.
5) Turn Probe trimmer until a stable **minimum** voltage reading is obtained.
6) Turn probe trimmer slowly until the voltage reading increases sharply.
7) Turn probe trimmer backwards (very slowly) until minimum voltage plus 10 mV is obtained.
8) The probe should now be correctly compensated, see the "knee" in the trimmer curve below.

WHAT WENT WRONG?

The PM 6652 and PM 6654 feature a high MTBF figure (more than 20000h) thus ensuring reliable operation. If a measurement failure occures, the problem will most certainly be one associated with the operation of the instrument. Below is listed some of the possible failure symptoms, assuming that the input signals to be measured are present and connected.

The instrument fails to measure

Symptom: The disply shows all zeroes

- First press RESET and try again.
- The counter is not triggering. Check the trigger levels, AC/DC coupling, impedance and attenuation, if necessary, go to KEYBOARD or potentiometer control.
- The input frequency is too high, or the pulses present at the input are too short.
- A very long measuring time has been selected. Adjust the measuring time - or wait.
- The STORE button is lit (i.e., the counter is waiting for a program to be stored). Press STORE or RESET.
- External control is being used, and there is an incorrect signal present on input E.

Symptom: The display is "frozen"

- First activate RESET and try again.
- A long measuring or display time has been selected. Adjust the measuring/display time, or wait.
- DISP HOLD is on.
- EXT GATE is in operation, and the gating signal has become disconnected.

Symptom: The display shows an owerflow

- The MATH control is active, with a large exponent value set as K. Disable the MATH feature, or change the K value.
- In PM 6652 frequency measurements, the INT/EXT STD IN has been switched to EXT, and there is no Input D signal.

The measurement is incorrect

Symptom: The measurement is slightly incorrect

- An ERROR E4 has been reset with the INT/EXT STD IN switch in the EXT position. Either switch to INT, or supply an external reference signal. (PM 6654 only, in TIME INTERVAL single mode).
- MATH is on, and there are values other than 1 and 0 in K and L, respectively. Either switch off MATH, or set correct values in K and L.

Symptom: The display showing a more or less constant value

- Either CHECK or COM are on; the latter in cases when a signal on channel B is required for the measurement. Switch (them) off.
- MATH is ON, and there are invalid values (for this measurement) in K and/or L.

Symptom: The measurement varies widely

- HOLD OFF is on, and the time is set to an incorrect value for the measurement. Either switch HOLD OFF off, or adjust its value.
- The signal is very noisy. See the reference chart.

Chapter 5

IEEE-488 BUS INTERFACE

CONTENTS Page

INTRODUCTION

The PM 6652,-54 timer/counters have been designed for use in automatic test system applications, featuring e.g. 19" cabinet, provision for rear panel inputs and optional fan cooling.

All software needed for the bus operations are included as standard, whereas the optional PM 9696 interface board is the hardware required for connection to the IEEE-488 bus.

PM 6652,-54 timer/counters equipped with a PM 9696 IEEE-488 Bus Interface meet the requirements of IEC-625-1 and IEEE-488 as far as hardware is concerned. They also satisfy the requirements concerning codes and formats according to IEC-625-2 and IEEE-728.

When ordered simultaneously with a counter, the interface is supplied factory installed, but is available as a separate option for field installation. When installed, all front and rear panel functions are remotely accessible via the IEEE-488 bus.

The BUS performance features include:

- Full programmability of all front and rear panel controls (except power on/off Hold Off* time and int/ext reference selector).
- Monitoring of HIGH/LOW limits with SRQ alarm.
- High measuring speed. In normal bus data transfer mode the number of readings is approx 30-50/sec. depending on measuring function (measuring time is Min. or single).
- Computer dump output mode (output of "raw" register data) yields approx. 400...500 readings/sec.
- BUS LEARN mode for quick and easy programming of the counters.
- 8 preprogrammed front-panel menus can be recalled via the IEEE-488 Bus with a single instruction.

The PM 6652,-54 can be programmed in 3 different ways: P1...P8 programming, bus learn mode and normal programming.

*) The PM 6654C has a function called Time Interval Delay, which is similar to the Hold-Off but fully bus programmable. See page 5-10.

P1...P8 programming

The simplest and easiest way is to specify up to eight different mesurements and manually set all corresponding controls and store them in locations P1...P8 in the counters.

After that, bus programming is only a matter of selecting one of of the 8 possible menus (P1...P8). This is done simply by sending programming code "LP1...LP8" to the counter.

This ultra-simple programming method is suitable for lab cluster applications where different temporary measurements are carried out and where is no time or no need for sophisticated BASIC programming techniques.

A sample program for HP 85 is shown below, where the purpose is to print-out frequency measurements (stored in P3). The controller's address to the counter is 710 (the counter's address selection switch is factory preset at 10).

```
10  OUTPUT 710; "LP3"
20  ENTER 710; A$
30  PRINT A$
40  END
```

With this ultra-simple programming method it is neccessary to remember only one single mnemonic (LP).

Bus Learn mode or P9... P∞

"Bus learn" means that the controller copies all manual counter settings and stores the setting in the controller's own memory. The settings are stored as a "counter programming status string" and this string can later be sent to the counter for reprogramming.

The bus learn mode extends the memory locations P1...P8 (in the counter) to P9... P∞ (in the controller).

The procedure for storing e.g. "P9" is:

1. Manually set all counter controls for the desired measurement.

NOTE: The Time Interval Delay* and Voltage measurement on the B input must be selected from the bus, if to be used.

2. Send programming code "P1" (Program data out) to the counter.
3. Enter the programming string (43 ASCII characters) and store in the controllers memory.

The bus programming efforts thereafter are reduced to just recalling the stored string.

A sample program for HP85 is shown below. Ten pulse width measurements should be printed out. The pulse width measurement menu is to be stored in memory location "P9".

```
10  REM STORE MANUAL SETTINGS IN P9
20  DIM P9$[43]
30  OUTPUT 710; "P1"
40  ENTER 710; P9$
.
.
.
200  REM RECALL P9 AND MEASURE
210  OUTPUT 710; P9$
220  FOR N = 1 TO 10
230  ENTER 710; A$
240  PRINT A$
250  NEXT N
.
.
.
```

This programming method is also simple to use. Only one programming code must be remembered (P1)

Normal programming

"Normal" means that the counter settings are specified remotely, not manually as in the previous examples.

The advantage with "P1...P8" or "Bus learn" programming is that it requires a knowledge of very few programming codes (just "LP1...LP8" or "P1"). Thus preparation and programming time is reduced to a minimum. The advantage with "normal" programming is that one can make use of the full programming power and flexibility inherent in the counter's smart software. With "normal" programming service request interrupts, limit monitoring alarms, high speed dump mode, leading zero suppression and much more can be executed.

The normal programming procedure is:

1. Set counter to default position (FREQ A, AUTO trigger, AC-coupling (A), Meas. time = 0.1s etc.). The code used is "D".
2. Program the changes from the default settings (e.g. SM2 for 2 seconds measuring time).

A sample program for HP85 is shown below. Ten PHASE A-B measurements (code "F8") with 10ms measuring time (code SM1ØE-3) should be printed out.

```
10  OUTPUT 710;"DF8SM1ØE-3"
20  FOR N = 1 TO 10
30  ENTER 710; A$
40  PRINT A$
50  NEXT N
60  END
```

Normal programming should be made when the software must be optimized for its purpose, e.g. in ATE systems.

Note: When the counter has been switched to stand by in programmed mode, it returns when switched on again into local mode after the self test sequence.

Mode	Bus communication time	Setting time	Comments
P1...P8	Short 3 ASCII characters	Long (EAROM involved)	Very simple and fast programming. Limited to 8 measuring tasks.
Bus learn (P9...P∞)	Long 43 ASCII characters	Normal	Easy programming. Number of measuring tasks is limited only by the controller's memory
Normal programming of changes	Short to normal	Short to normal	Flexible and powerful programming

TABLE 5.1 The different programming methods are summarized in the table.

INTERFACE SPECIFICATIONS

For a complete description of the IEEE-488 interface functions, see the Philips instrumentation systems reference manual. As supplied with either a PM 6652 or PM 6654, the PM 9696 has bus capabilities according to table 5.2.

Description	Code	Capability
Source handshake	SH1	Complete
Acceptor handshake	AH1	Complete
Control function	CØ	No controller
Talker function	T5	Complete
Listener function	L4	Complete (except listen only)
Service request	SR1	Complete
Remote/local function	RL1	Complete
Parallel poll	PPØ	No parallel poll
Device clear function	DC1	Complete
Device trig. function	DT1	Complete

Table 5.2 Summary of interface functions.

Interface characteristics

Under the standards established for interface function subsets in IEC 625, many of the functions can have only two states: present or absent. A function which is present is indicated by a "one", and one which is absent by a "zero" after the function code. Examples are SH, AH, SR, DT, (see table 5.2).

Other interface functions can be implemented in different ways. For instance, there are 9 different "talker" functions (T0...T8), and 5 "listener" (L0...L4) possible. In the PM 9696, the talker function T5 and listener function L4 are included.

- The talker function T5:
  - Basic talker.
  - Talk only mode.
  - Serial poll.
  - Automatic unadressing when addressed as listener.
- The listener function L4:
  - Basic listener.
  - Automatic unadressing when addressed as a talker.

Source and Acceptor Handshake (SH1, AH1)

SH1 and AH1 simply means that the counters are capable of exchanging data with other instruments or a controller, using the bus handshake lines (DAV, NRFD, NDAC).

Talker Function (T5)

The counter can send its measuring results to other devices or to a controller ("it talks"). T5 also means that the counter can send out a status byte as a response to a serial poll, initiated by the controller.

Listener Function (L4)

The counter is capable of receiving programming instructions from a controller ("it listens").

Service Request (SR1)

The counter can interrupt the controller, e.g. after completion of each measurement, to advise that it has data to send.

Remote/Local (RL1)

The counter can be controlled manually (locally) or remotely, via the bus.

Device clear (DC1)

The counter can be reset remotely and forced to default settings.

Device Trigger (DT1)

Enables remote starting (triggering) of a new measurement via the bus.

Address selection

All devices on an IEEE-488 bus must be assigned a bus device address. The counter address is selectable by the five right-most switches at the rear panel address selector. All addresses except 31 (=11111_{BINARY}) are allowed. At delivery the selected address is 10 (01010_{BINARY}).

Talk only

By setting the leftmost address selector (TALK ONLY) in position 1, the counter will not be addressable. TALK ONLY mode is used when measuring data is to be transmitted directly to a listener without any controller involved. A counter (Talk only) can for example be directly connected to a printer (Listen only) for continuous printing of counter data.

Talk only mode must never be used in bus configurations including a controller. Talk-only mode implies that the counter will no longer "listen" to the controller. If the counter is accidentally switched to Talk-only mode, the bus will be blocked, and no other instrument will be able to "talk" on the bus.

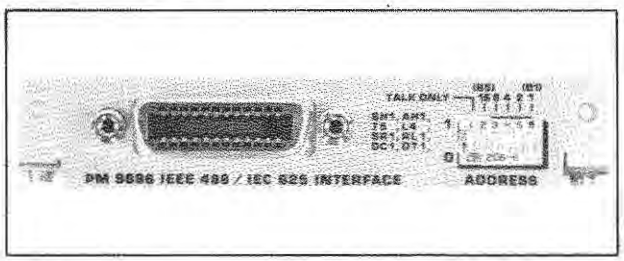


Fig. 5.1 Bus Interface panel.

Timing specifications

Max data output rate

Normal mode:	30...50 readings/sec.
High speed dump mode:	Approx. 420 readings/sec.
V_{max}, V_{min} or V_{pp}:	3...4 readings/sec.
With AUTO-trigger:	3...4 readings/sec.
With mathematics:	Approx. 20...25 read./sec.

NOTE: The highest output rate is obtained at minimum measuring time, with MATH and AUTO trigger disabled, no parameters changed between readings, free-run mode and a controller that does not limit the counter output rate.

Output time for measuring data

Normal mode:	Approx 5 ms (18 bytes)
High speed dump mode:	Approx. 2 ms (24 bytes)
Response time for addressing:	Approx 5 µs
Response time for trigger command (GET);	
- Normal mode:	500 µs
- High speed dump mode:	200 µs

NOTE: The counter must be programmed for triggered mode and ready for measurement.

Nominal read time for programming data

NOTE: "Read time" = "Bus occupation time"

Single command: 0.5 ms/byte (average)

Multiple commands;

Last command in string:	0.5 ms/byte (average)
Previous commands:	
- Measuring modes:	2 ms/byte (average)
- Other input and measuring functions:	0.5 ms/byte (average), except the non-measuring functions, possibly used during system initiation.
- READ Hold-off/Meas. time/trigger levels:	2 ms/byte (average)
- Test 1...6:	8 ms/byte (average)
- Store P1...P8:	240 ms/byte (average)
- Load P1...P8:	20 ms/byte (average)

NOTE: Always use the most time consuming command last.

Electrical specifications

Output connector:	IEEE recommended type Amphenol 57 series "Micro ribbon".
Output:	E1 (open collector).
Output voltage; High:	Above 2.5 V
Low:	Below 0.4 V at 48 mA
Input; Hysteresis typ:	0.8 V
High:	Above 2.0 V
Low:	Below 0.6 V
Termination; (Resistance config.:)	3.3 kOhm ±5%, to +5 V 6.2 kOhm ±5%, to ground
Capacitance:	Below 100 pF

PROGRAMMING INSTRUCTIONS

The counter is instructed to perform various measurements when it receives appropriate programming codes (the counter is "listening" to the controller).

The programming code is a string of one or several ASCII characters. The first character is always alphabetic, and the string is terminated by a delimiter sent out from the controller.

Input delimiters

The PM 6652,-54 can accept six different input string delimiters, and will thus recognize programming messages sent from any controller.

LF	(Line feed)
CR	(Carrige return)
ETX	(End of text)
ETB	(End of text block)
,	(Comma)
;	(Semicolon)

Programming code format

The numerical values for measuring time, trigger levels and math constants K and L can be represented in accordance to all three standardized (IEC-625-2) formats NR1, NR2 or NR3.

NR1: Integer value (without decimal point).
NR2: Scaled (with floating decimal point).
NR3: Exponential notation with floating decimal point and exponent. Preferred exponent values are multiples of ±3. However, the counter also accepts exponent values other than multiples of ±3.

Example: A measuring time of 1.5 s can be represented as SM1.5, SM15 E-1 or SM0.015 E2.

If a programming string contains several functions, for example: Period measurement (code F3), hold-off active (code HE1), measuring time 2 s (code SM2), the different programming codes can be separated by commas (F3,HE1,SM2), by spaces (F3 HE1 SM2) or not separated at all (F3HE1SM2). Spaces can be inserted anywhere in the programming string, e.g. (F 3 HE 1 SM 2).

Programming codes

The programming codes are shown on the next page. Note that frequency A measurements for the PM 6652 can be performed in two different ways:

- Automatic choice of reciprocal mode (below 10 MHz) or conventional mode (above 10 MHz), code F1.
- Always reciprocal mode, code F1G3.

The PM 6654 always uses reciprocal frequency mode.

MEASURING FUNCTION	PROGRAMMING CODE
Frequency A	F1
Frequency C	F2
Period A	F3
Ratio A/B	F4
Ratio C/B	F5
Time interval A-B	F6
Pulse width A	F7
Phase A-B	F8
Rise/Fall time A	F9
Duty factor A	F1Ø
Tot A gated by B	F11
Tot A start/stop by B	F12
Tot A Manual start/stop	F13
V_{max}, V_{min} A	F14
V_{pp} A	F15
V_{max}, V_{min} B (on)	F14QB1 1)
V_{pp} B (on)	F15QB1 1)
V_{max}, V_{min}, V_{pp} B (off)	QBØ

MEASURING/DISPLAY TIME	PROGRAMMING CODE
Set measuring time (100 μs...99 s)	SM...2)
Single/min. meas.time (on, off)	SS1, SSØ
Read meas.time (on, off)	RM1, RMØ
Display-hold (triggered mode)	TE1
Display-hold off ("free run")	TEØ
"RESET" (start new measurement)	X or RE

TRIGGER LEVELS	PROGRAMMING CODE
Trigger level-auto	TL2
Trigger level-keyboard	TL1
Trigger level-potentiometer	TLØ
Set trigger level (channel A, B)	AL...2)
	BL...2)
Read A and B levels (on, off)	RL1, RLØ

INPUT SETTING	PROGRAMMING CODE
Positive slope (A, B)	ASØ, BSØ
Negative slope (A, B)	AS1, BS1
Attenuator: x1 (A, B)	AAØ, BAØ
Attenuator: x10 (A, B)	AA1, BA1
Coupling: DC (A, B)	ACØ, BCØ
Coupling: AC (A, B)	AC1, BC1
Termination 1MOhm (A, B)	ATØ, BTØ
Termination 50 Ohm (A, B)	AT1, BT1
Common via A (on, off)	CE1, CEØ

1) QB1 and HE2 can only be activated from the bus.

EXTERNAL CONTROLS	PROGRAMMING CODE
No external control	GØ
Arming	G1
External gate	G2
Frequency average	G3
Arming inverted	G4
External gate inverted	G5
Frequency average inverted	G6

MISCELLANEOUS SETTINGS	PROGRAMMING CODE
Test mode (Test 1...6)	TS1..TS6
Check (on, off)	CH1, CHØ
Set math constants K, L	SK...2)
	SL...2)
Math function (on, off)	ME1, MEØ
Hold Off (on, off)	HE1, HEØ
Time Interval Delay (on, off)	HE2, HEØ 1)
Read Hold Off time (on, off)	RH1, RHØ
Tot A manual start	TO1
Tot A manual stop	TOØ
Store front panel menu in P1...P8	SP1...SP8
Load front panel menu from P1...P8	LP1...LP8 or MR1...MR8

SERVICE REQUEST	PROGRAMMING CODE
Service request disable	SQØ
Service request enable	SQ1
SRQ when outside limits or neg.	SQ2
SRQ when inside limits or pos.	SQ3

OUTPUT DELIMITERS	PROGRAMMING CODE
Message separator EOI (on, off)	MS1, MSØ
Set output delimiter ETB (ETX)	SDØ
– " – CR	SD1
– " – LF	SD2
– " – CR + LF	SD3

OTHER BUS COMMANDS	PROGRAMMING CODE
Triggered mode (on, off)	TE1, TEØ
Trigger (start new measurement)	X or RE
High speed dump mode (on, off)	HS1, HSØ
Program data out-readable	PØ
Program data out-compressed	P1
Device clear (default)	D or IN
Leading zero suppression (on, off)	LE1, LEØ

2) Numerical value according to NR1, NR2 or NR3 formats.

Table 5.3 Programming codes.

Measuring V_{max}, V_{min}, V_{pp} on channel B

Channel B voltage measurements are only accessible via the bus, and not via the front panel in local (manual) mode.

The used mnemonics are:

F14QB1 for turning on V_{max}, V_{min} B.
F15QB1 for turning on V_{pp} B.
QBØ for turning off V_{max}, V_{min} or V_{pp} B.

The voltage B - function is an odd feature with some exceptions to "normal " condition.

- QB1/QBØ are never shown in the program data out string. I.e. the controller will never know if channel A or B is selected in volt measurements.
- QB1/QBØ cannot be stored in the front panel menus P1...P8.
- QB1 should be sent after the specified function (F14 or F15). I.e. F14QB1 is ok, but QB1F14 is not.
- Always turn off the selection of volt B by QBØ when the measurement is finished.

Device clear

Sending the string "D" will program the counter to default settings which are:

Frequency A, No external control, Min/single off, Measuring time = 100 ms, Math off, Trigger level Auto, Set keyboard trigger levels A = B = 0 V, Coupling A = AC, Coupling B = DC, Attenuation (A and B) = x1, Trigger slope (A and B) = positive, Termination (A and B) = 1 Mohm, COM via A off, Stop manual gating (TOT A only), Dump mode off, service request disable, hold-off off, check off, triggered mode off and default delimiter setting. See "Delimiter settings".

Sending a single: "D" will thus result in the same counter performance as:

"F1GØSSØSM1E-1SK1SLØMEØTL2ALØBLØAC1BCØ
AAØBAØASØBSØATØBTØCEØTOØHSØSQØHEØCHØTEØ"

Sending a "D" is the same as sending bus commands DCL (device clear) or SDC (selective device clear).

Program data out

When PØ or P1 (program data out) is sent, the next output from the counter will not be measuring data but 8 strings (PØ) or 1 string (P1) containing the settings of the counter. The string(s) can be sent back to the counter for later programming. In this way it is possible to perform remote programming of the counter by copying the local settings (BUS LEARN). The procedure is:

a) Set the counter as desired in local mode.
b) Output a "PØ" or "P1" to the counter.
c) Enter the string from the counter (for later use).

Sending a "P1" results in an unreadable 43 character string which should only be used for reprogramming the counter.

Sending a "PØ" returns the programming data of the counter in a readable form, suitable for display on a controller screen or for direct printout. The data is sent as 8 strings each terminated by the selected delimiter.

The format is shown in the table below. The following abbreviations are used:

± means + or - sign
v means either Ø or 1.
w means digit Ø...2
x means digit Ø...3
y means digit Ø...6
z means digit Ø...9

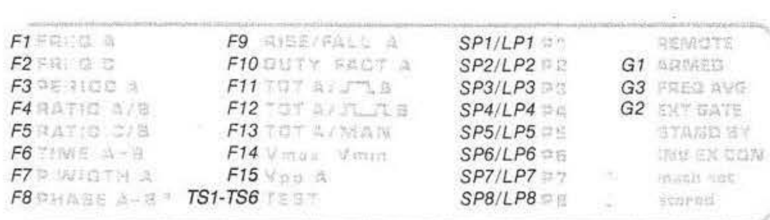
```
FzzSMzz.E±zSSv
ACvASvAAvATvAL±z.zz
BCvBSvBAvBTvBL±z.zz
TLwTOvCEvCHvTEv
SQxHSvLEvMSvSDx
GyHEwMEvRMvRHvRLv
SK+zzzzzzzzz.E±zz
SL+zzzzzzzzz.E±zz
```

NOTE: The decimal point, where present, is fixed. A K value of 60 will be sent as: "SK+000000060.E+00", whereas a L-value of 3750.65 is sent as:"SL+000375065.E-02".

PANEL MNEMONICS
FOR BUS-INTERFACE OPERATION

When a single function pushbutton has two mnemonics, the one ending with Ø means the inactive state.

Three dots (...) after a mnemonic means the numerical value.

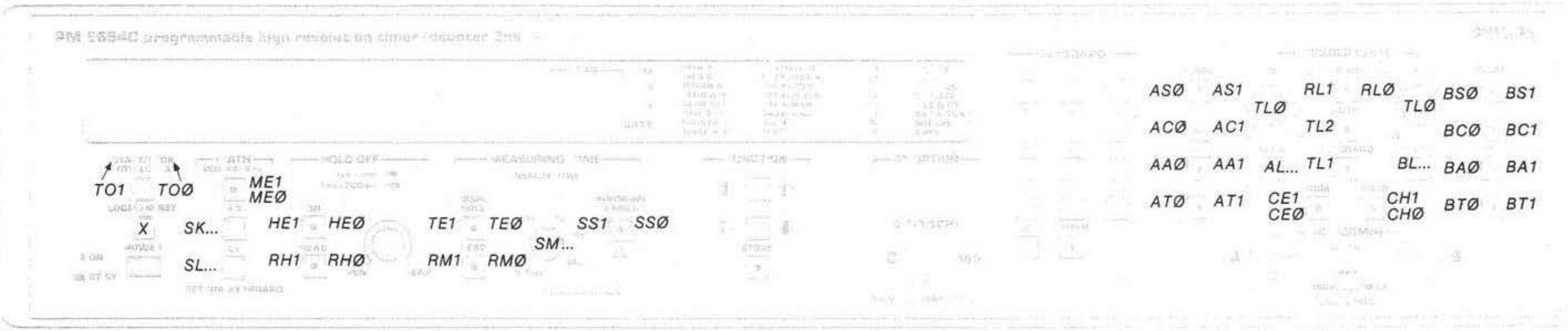


SP. = Store Program
LP. = Load Program

Fig. 5.2 Front panel mnemonics for bus interface operation.

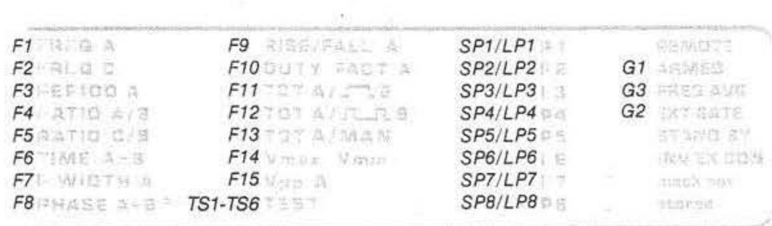
(This picture page is also found on reverse side)

PANEL MNEMONICS FOR BUS-INTERFACE OPERATION



When a single function pushbutton has two mnemonics, the one ending with ∅ means the inactive state.

Three dots (...) after a mnemonic means the numerical value.



SP. = Store Program
LP. = Load Program

Fig. 5.2 Front panel mnemonics for bus interface operation.

(This picture page is also found on reverse side)

Tests numbers 1...6

6 independent hardware tests (TS1...TS6) can be performed according to the table below.

Test 1	ROM test.	4	Measuring logic test.
2	RAM test.	5	Display test.
3	EAROM test.	6	Tests 1-5 in sequence.

To perform any test, the normal procedure is as follows:

- Enable Service Request (code "SQ1").
- Call e.g. test No. 1 (code "TS1").
- When SRQ is recognized by the controller a serial poll is performed and the status byte is checked to see if the test was satisfactory. The status byte is described in section "Status Byte".

Performing the first step above is optional. To speed up the test procedure, skip the first step and go directly to the second step.

Any running test will be stopped when the controller either reprograms the counter or requests measuring data. In this case the test will have to be restarted if it is to be completed.

Trigger mode

When trigged mode is enabled by sending a "TE1", the counter will perform only one measurement at a time. Every individual measurement must be trigged by either the GET (Group Execute Trigger) bus command or by sending "X" (execute). This allows accurate control of the start of the measurement. When "TEØ" is chosen (the default value), the counter is free running, (i.e. as soon as one measurement is finished, the next will start).

NOTE: The counter may perform only one measurement at a time even in the free-running mode. This is the case when the counter is an active talker (e.g. caused by an ENTER-command from HP 85).

Let us consider the following HP 85 program example:

```
10 OUTPUT 710; "D"
20 ENTER 710; A$
30 PRINT A$
40 END
```

In line 10 the counter is set to frequency A measurements (Default) and the measurement is started (TEØ is default).

In line 20 the counter is made an active talker and instructed to handshake the result over to the HP 85. Since the counter is free-running the next measurement starts directly.

In line 30 the first result is printed. By now the second measuring result is ready and displayed, but since the counter is still an active talker it will stop and wait for a handshake procedure to take place.

In line 40 the program ends so this handshake will never take place, and the counter will have to wait for ever.

Now we might find different values on the counter's display and on the HP 85 printer. This is obvious since the printed result is the first measurement and the displayed result is the second.

Time-Interval Delay (Programmable Hold Off)

The PM 6654C (not the PM 6652,-54 nor PM 6652C) is capable of measuring single shot time-intervals using the Time-Interval Delay function, where the delay time can be programmed via the IEEE-488 bus. This function is thus equvivalent to the front panel function Hold-Off.

When programming command "HE2" is sent to the counter, the counter rejects stop-pulses for a time equal to the set **Measuring time.** HEØ switches off the function.

The Time-Interval Delay range is 100 μs...99 s. The accuracy is ±25 μs ±1 % of set value.

Applicable functions are:

Time interval A-B, single	("F6SS1")
Single pulse width A	("F7SS1")
Single rise/fall time A	("F9SS1")

Example: Time-Interval Delay programmed for 1.5 ms in a single pulse width measurement: "F7SS1SM1.5E-3HE2"

NOTE: Time-Interval Delay cannot be selected together with Hold Off.
HE2 is accessible via the IEEE-488 bus only and cannot be stored in the front panel menus P1...P8. It is however stored in the bus learn string.

SERVICE REQUEST

A Service Request (SRQ) is sent from the counter to the controller in the following cases:

When service request is disabled (SQ0)

- On programming errors, such as false codes, measuring time out of range, trigger levels out of range etc.
- After the execution of any of the tests TS1... TS6 and a test error is found.

When service request is enabled (SQ1)

- When a measuring result is ready for output.
- Any of the tests TS1...TS6 is finished.

When limit monitoring is enabled (SQ2, SQ3)

- When the measuring result is outside (inside) the set limits.

Monitoring of alarm limits

The limit monitoring in a PM6652/54 may be performed in four different ways. An SRQ-alarm is given in the following cases:

- If the value(X) is outside the range a...b ($X < a$, $X > b$). "SQ2" must be programmed.
- If the value (X) is inside the range a...b ($a < X < b$). "SQ3" must be programmed.
- If the value (X) is below the limit c ($X < c$) "SQ2" and "SK1" must be programmed.
- If the value (X) is above the limit c ($X > c$) "SQ3" and "SK1" must be programmed.

In all the above cases a prerequisit is that the MATH function is enabled ("ME1"). The range a...b is set by using the MATH. constants K and L to appropriate values. If an SRQ-alarm is to be given for measuring values (X) outside the range a...b, then K and L should be selected:

$$K = \frac{1}{b - a} \qquad L = -\frac{a}{b - a}$$

For example: The counter must monitor a frequency with a nominal value of 455kHz. The counter should not send anything on the bus as long as the frequency falls inside the range 450...460kHz. When the measured frequency falls outside that range, a SRQ is sent to the controller.

$a = 450 \times 10^3 \qquad b = 460 \times 10^3$

The constants K and L should be selected as:

$$K = \frac{1}{b-a} = \frac{1}{10x10^3} = 10^{-4} \qquad L = -\frac{450x10^3}{10x10^3} = -45$$

The counter should be programmed as follows:

1. Set $K = 10^{-4}$ ("SK1E-4")
2. Set L = -45 ("SL-45")
3. Enable Math ("ME1")
4. Activate alarm Monitoring ("SQ2")

There is a special case: When K is set to 1, the counter monitors whether the measured value (X) is above or below a limit value (c). To get a SRQ-alarm if $X > c$ then K and L have to be selected as:

$K = 1 \qquad L = - C$

Example: An SRQ should be sent when a time interval measurement results in a value higher than 400ms. In this case K = 1 and L = - 0.4. The counter should be programmed as follows:

1. Set K = 1 ("SK1")
2. Set L = -0.4 ("SL-0.4")
3. Enable Math ("ME1")
4. Activate Alarm monitoring ("SQ3")

Limit monitoring is illustrated below:

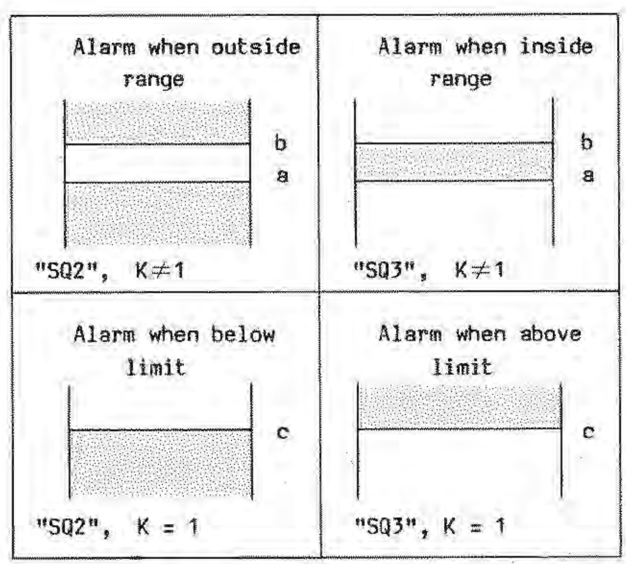


Fig. 5.3 Limit monitoring.

OUTPUT DATA

When the counter is an active "talker", the result of a measurement is transmitted to the controller over the IEEE-488 Bus. The output data from the counter can be of three different kinds.

- Programming status
- Status byte
- Normal measurement values.

Programming status strings

Programming status strings are of two kinds and consist either of a sequence of 8 strings with a total of 133 ASCII characters plus delimiters or an unreadable string of 43 ASCII-characters, defining the present programming status of the counter. They are sent out instead of a measurement value when instructed to do so by programming code "PØ" or "P1" (Program data out). See section "Programming Codes" for details.

Status byte

A status byte is a one byte message sent by the PM 9696 interface logic as a response to a serial poll. The status byte contains information such as:

- Service requested by the counter? Yes/No
- Error condition? Yes/No
- Counter is busy or ready for new measurement

See also section "Status Byte".

Normal measurement values

A normal measurement result is sent from the counter as a string of ASCII characters, in accordance with the following format:

F	F	0 SP	X	X	X	X	X	X	X	X	X	X	X	E	±	X	D	(D)

Bytes 1,2 FF = Function code (see table 5.4).

Byte 3 Normally a space character. On overflow, 0 is sent.

Bytes 4..14 XXXXXXXXXXX means 11 characters containing the measurement value. 10 characters are digits and one is a floating decimal point.

Byte 15 E is an exponent pointer.

Byte 16 Exponent sign is + or -.

Byte 17 Exponent value X is either Ø or multiples of ±3.

Byte 18 Delimiter CR, LF, ETX or ETB

Byte 19 Second delimiter LF (only if delimiter combination CR+LF has been selected).

Note: With negative values of math constants K and/or L the result might be negative. In this case a minus sign ("-") is sent instead of the last of the leading zeros. Example: "FA ØØØ-1234.56E+3"

Leading zero suppression

When leading zero suppression is enabled (LE1), all leading zeros are removed from the output string. The object is to increase the output data transfer rate on the bus. The format is then no longer fixed. The following output data (without leading zero suppression):

F	A		0	0	0	0	0	0	1	2	.	3	4	E	+	3	LF

will be reduced to:

F	A		1	2	.	3	4	E	+	3	LF

with leading zero suppression.

Output of voltages and trigger levels

There are two exceptions to the normal output format. When trigger levels (code TL) or V_{max}, V_{min} (code VM) are sent, the output format will be:

F	F		±	X	X	X	X	,	±	X	X	X	X	D	(D)

Byte 1,2 Function code VM or TL
Byte 3 Space character.
Byte 4 Sign + or - for channel A (TL) or for V_{max} (VM).
Byte 5...8 XXXX indicates the level for channel A (TL) or V_{max} (VM) in Volts. 3 characters are digits and one is a floating decimal point.
Byte.9 Separating comma (,).
Byte 10 Sign + or - for channel B (TL) or for V_{min} (VM).
Byte 11...14 XXXX indicates the level for channel B (TL) or V_{min} (VM) in Volts. 3 characters are digits and one is a floating decimal point.
Byte 15 Delimiter CR, LF, ETX or ETB
Byte 16 Second delimiter LF (only if delimiter combination CR+LF has been selected).

Function codes

Codes	Functions
DF	Duty Factor A
FA	Frequency A
FC	Frequency C
HT	Hold-off Time
MT	Measuring Time
PA	Period A
PH	Phase A-B
PW	Pulse Width A
RA	Ratio A/B
RC	Ratio C/B
RT	Rise/Fall Time A
TG	Tot A gated by B
TI	Time Interval A-B
TL	Trigger Levels A, B
TM	Tot A, Manual
TS	Tot A, Start/Stop by B
VM	V_{max}, V_{min} A
VP	V_{pp} A

Table 5.4 Output function codes.

Output delimiter

The default delimiter can be set by jumpers on the PM 9696 circuit-board to be either CR, LF or CR+LF. If neither is selected ETX will be sent for single measurements (TE1) and ETB will be sent for repetitive measurements (TEØ). The delimiter is factory preset at LF.

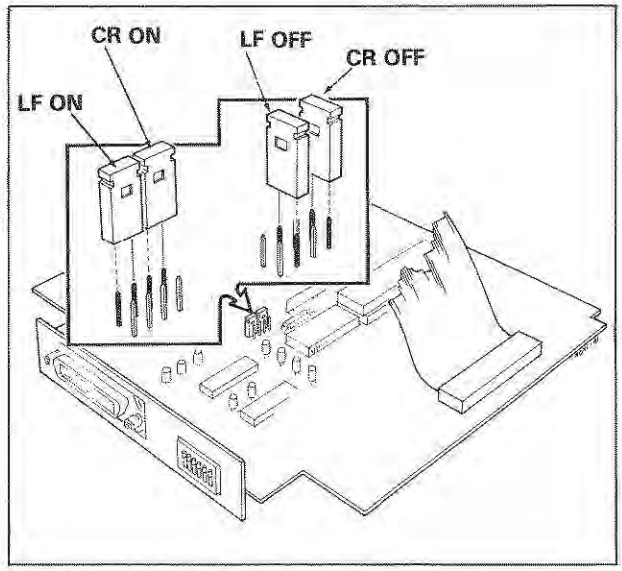


Fig. 5.4 Delimiter settings.

Choice of output string delimiters

The default value of the output delimiter is set by hardware jumpers on the PM 9696 circuit board (factory preset at LF).

The delimiter can be changed by the controller by sending "SDØ", "SD1", "SD2" or "SD3".

Note: When SDØ is selected, the delimiter will be ETB in free running mode (TEØ) and ETX in trigged mode (TE1).

The EOI-line in the IEEE-488 bus will be active together with the last output byte sent when "MS1" has been programmed.

STATUS BYTE

The status byte is a one byte status message that is sent from the counter to the controller as a response to a serial poll. The following format is used:

Bit 8: Always Ø.
Bit 7: Service request has been sent (1) or not (Ø).
Bit 6: Alarm condition (1) or not (Ø).
Bit 5: Counter is busy (1) or ready (Ø).
Bit 1-4: Counter status specification.

Service request (bit 7)

Is sent on the following conditions:
- If there is a programming error.
- After each measurement or test if "SQ1" is programmed.
- When set alarm limits are passed if "SQ2" or "SQ3" is programmed.
- After self-test errors.

Alarm (bit 6)

Alarm status occurs if:
- The counter is wrongly programmed.
- Set alarm limits are passed.
- Self-test errors.

Busy/ready (bit 5)

The counter is busy during the actual measurement and also during the preparation for the measurement. The counter is ready when the result is ready for output on the bus.

Normal measuring cycle

A normal measurement cycle consists of the following phases:
- Preparation for measurement.
- Waiting for a trigger command via the bus if "TE1" is programmed.
- Waiting for input signal synchronization to start.
- Measuring.
- Waiting for input signal synchronization to stop.
- Processing the counting register data.
- Output of the result.

The normal measuring cycle is illustrated below, fig. 5.5.

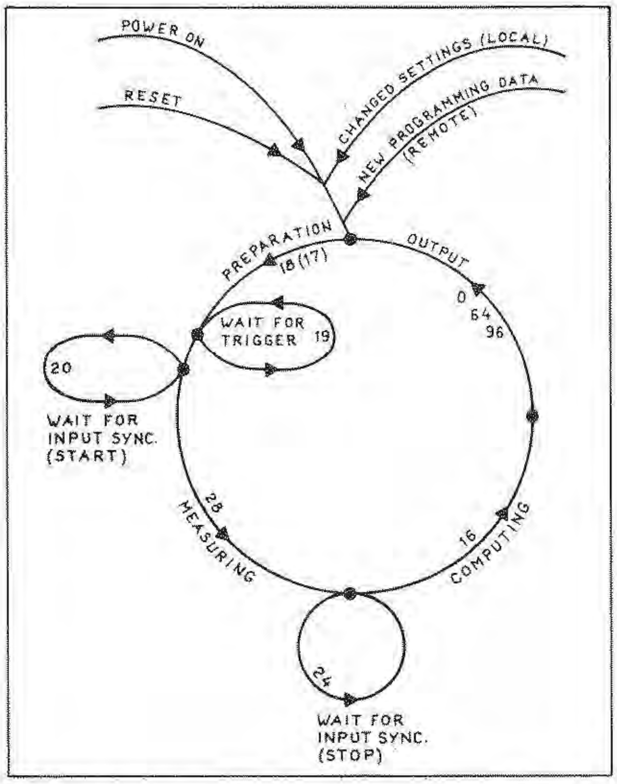


Fig. 5.5 Normal measuring cycle. (The numbers refer to status byte contents).

The status byte codes for the above phases are shown in Table 5.5. Note that the preparation phase can have two different codes depending on whether repetitive measurements (code TEØ), or single measurements (trigged mode TE1) have been selected.

Status message	Binary	Decimal	
Preparation (TEØ)	00010010	18	
Preparation (TE1)	00010001	17	
Waiting for trigger TE1	00010011	19	
Waiting for start sync.	00010100	20	Busy
Measuring	00011100	28	
Waiting for stop sync.	00011000	24	
Computing	00010000	16	
Ready for output	00000000	0	
Ready, with service req	01000000	64	Ready
Limit alarm - " -	01100000	96	

Table 5.5

When triggered mode (TE1) has been selected, the counter makes all necessary preparations for a measurement (status 17) and then waits (status 19) for either a group execute trigger (GET) command via the bus or code "X" (execute).

If a GET command is received the counter will after a short delay synchronize with the input signal and start the measurement. If, however, an "X" is received, the counter will go through the preparation for measurement once again and then start the measurement.

Sending an "X" will result in a small delay (approx. 5ms) compared to the GET command.

The output phase (status 0, 64 or 96) terminates the measuring cycle. "Output" means output to both the display and to the IEEE-488 bus, if requested by the controller.

There are 3 different output states:
- Status Ø indicates a normal output without service request ("SQØ").
- Status 64 indicates a normal output with service request ("SQ1").
- Status 96 indicates limit alarm together with service request ("SQ2" or "SQ3").

Deviations from the normal measuring cycle are found when performing:
- Hold-off, measuring time and trigger level readings.
- Tests 1 through 6.
- Totalize A, Manual gating.
- High Speed Dump mode output.

Hold-off, Measuring time, Trigger levels

The reading of hold-off, measuring time or trigger levels results in the measuring cycle shown in fig. 5.6.
The normal output phase has status 8 and when SRQ is sent ("SQ1" is programmed), the status is 72. Limit monitoring, when selected ("SQ2" or "SQ3") is ignored in these measurements.

Status message	Binary	Decimal	
Measuring and computing	00011010	26	busy
Ready for output	00001000	8	ready
Ready with service req.	01001000	72	ready

Table 5.6

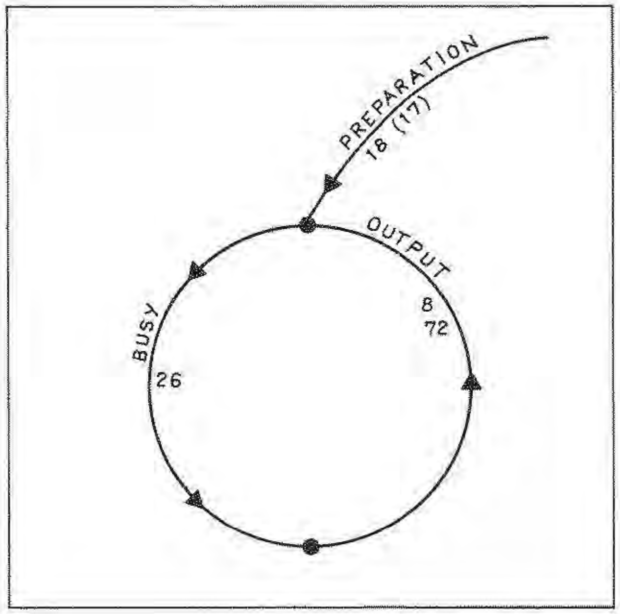


Fig. 5.6 Measuring cycle: HOLD-OFF, MEASURING TIME or TRIGGER LEVELS.

Tests 1...6

The measuring cycle when performing self-tests 1...6 (TS1...TS6) is illustrated in fig. 5.7.

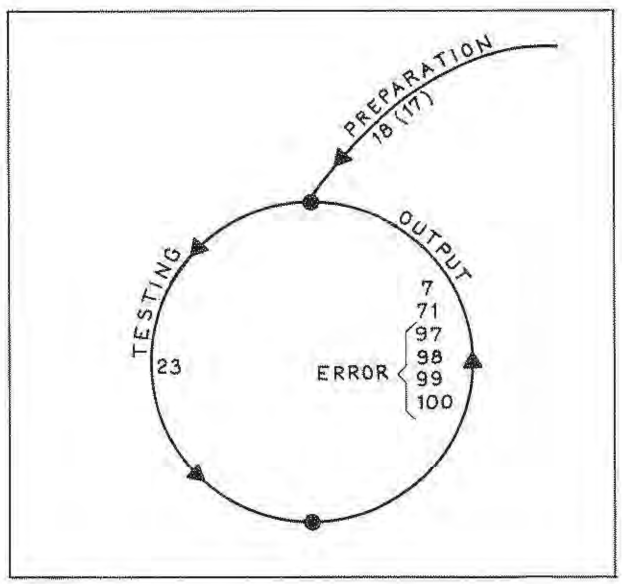


Fig. 5.7 Measuring cycle: TEST.

When the test is finished, the status byte contains 7 (without SRQ), 71 (with SRQ) or error codes 97...100 (with SRQ). If an error occurs, a mandatory SRQ is sent to the controller, even if the service request is disabled ("SQØ").

It is good practice to enable service request before performing a test. The completion of the test is then indicated by an active SRQ line. The alternative (if SQ0 is programmed) would be successive serial-polls until status byte 7 is recognized.

When test No. 6 is executed, a sequence of tests 1...5 is performed. When "SQ1" is programmed, the SRQ line will be active after the last test (No. 5).

The measuring cycle is summarised in table 5.7.

Status message	Binary	Decimal	
Testing	00010111	23	busy
Ready without service req	00000111	7	ready
Ready with service req.	01000111	71	ready
Error in test 1, with SRQ	01100001	97	ready
- " - test 2, - " -	01100010	98	ready
- " - test 3, - " -	01100011	99	ready
- " - test 4, - " -	01100100	100	ready

Table 5.7

Totalize A manual gating

The Totalize A manual gating mode, has a different measuring cycle. Unlike other measuring modes, the counter has no idea if or when the measurement is terminated and when the final result is ready. The only way to terminate a Totalize A manual measurement is to select another measuring function. Closing the manual gate will not terminate the measurement. The gate might, later, be opened for the totalizing to continue.

The contents of the counting registers are sensed approximately 50 times/second during the totalizing process. It is thus possible to follow the totalizing "continuously" (50 readings/sec.) via the bus.

The measuring cycle is illustrated in fig. 5.8. There are in principal only two phases: the registers and output of the result.These phases may have different status values, depending on whether the gate is open or closed.

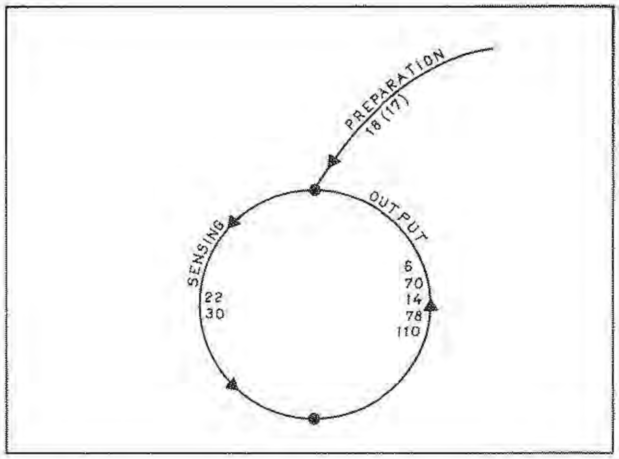


Fig. 5.8 Measuring cycle: TOTALIZE A.

Status message	Binary	Decimal	
Gate open			
Sensing	00011110	30	busy
Output	00001110	14	ready
Output with service req.	01001110	78	ready
Output with limit alarm	01101110	110	ready
Gate closed			
Sensing	00010110	22	busy
Output	00000110	6	ready
Output with service req.	01000110	70	ready

Table 5.8 Summarizes the measuring cycle.

High-speed dump mode

The measuring cycle for the high speed dump output is shown in fig. 5.9. The status byte has the binary value 00001100 (decimal 12) during dump mode.

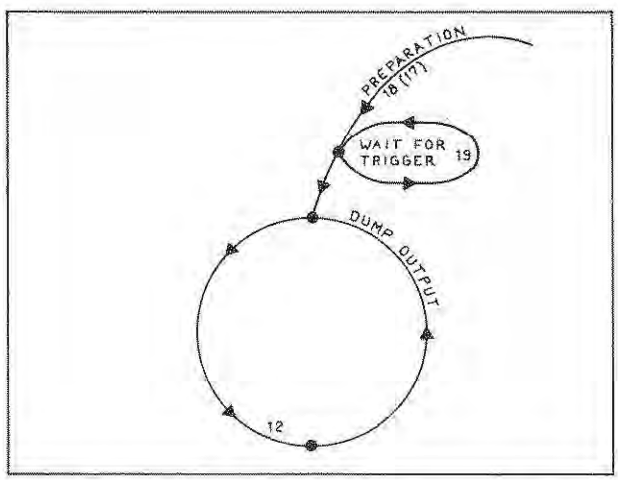


Fig. 5.9 Measuring cycle: HIGH SPEED DUMP MODE.

Miscellaneous

Programming errors will result in a mandatory SRQ and will also block any further operation of the counter. The counter will ignore the faulty programming codes (e.g. "F53") or the faulty range (e.g. "AL-300"). There are 4 ways to release the counter:

a) Local mode.
b) Read the status byte (serial Poll).
c) Device clear.
d) Program data out ("PØ" or "P1").

After release of the counter the measuring cycle starts from the beginning with a new preparation phase. The status byte for programming errors is binary 01101111, decimal 111.

The counter can be busy performing tasks that are not found in the previous examples. This "undefined busy" status is binary 00010101, decimal 21. This status is, for example, temporarily present during the power up phase.

The SRQ-line in the IEEE-488 interface as well as bit No. 7 in the status byte are set to 1 in the following situations, at output (when requested by "SQ1"), when limits are exceeded (when requested by "SQ2" or "SQ3") or upon errors.

The SRQ-line and status bit No. 7 are reset in the following cases:

- Directly after a serial poll.
- When the counter receives new programming data.
- When the counter sends measuring data on the bus.

That means that in case of a SRQ, the controller should first of all make a serial poll to examine the status byte before any other bus actions are performed with the counter. Otherwise the information of a possible counter-SRQ is lost.

It is possible to find temporary status byte values that are not shown in table 5.9. If an alarm condition occurs (status 96, 97, 98, 99, 100, 110, 111) and the SRQ-bit is reset after a serial poll, an additional serial poll will result in status byte showing alarm without SRQ (status 32, 33, 34, 35, 36, 46, 47).

Summary

All possible status bytes, in ascending order, are summarized in table 5.9.

Status value		Status message
0	00000000	Normal output
6	00000110	Output T.M., gate closed
7	00000111	Test ready
8	00001000	Output H.O., M.T., T.L.
12	00001100	Dump mode
14	00001110	Output T.M., gate open
16	00010000	Computing
17	00010001	Preparation ("TE1")
18	00010010	Preparation ("TEØ")
19	00010011	Waiting for trigger
20	00010100	Waiting for input sync.to start
21	00010101	Busy, undefined task
22	00010110	Sensing T.M., gate closed
23	00010111	Performing Test
24	00011000	Waiting for input sync.to stop
26	00011010	Reading H.O., M.T., T.L.
28	00011100	Measuring
30	00011110	Sensing T.M., gate open
64	01000000	Normal output with SRQ
70	01000110	Output T.M. with SRQ,gate closed
71	01000111	Test ready with SRQ
72	01001000	Output H.O., M.T., T.L. with SRQ
78	01001110	Output T.M. with SRQ, gate open
96	01100000	Ready with limit alarm
97	01100001	Error in test No. 1
98	01100010	Error in test No. 2
99	01100011	Error in test No. 3
100	01100100	Error in test No. 4
110	01101110	Limit alarm, T.M., gate open
111	01101111	Programming error

H.O. = Hold-Off
M.T. = Measuring time
T.L. = Trigger levels
T.M. = Tot. A Manual gating.

Table 5.9

HIGH-SPEED DUMP MODE

Every normal measuring cycle include computation of the result (e.g. to get frequency). A calculation of the resolution (number of displayed digits) as well as display formatting is also performed. The duration of this computation phase is some 10 milliseconds.

This will limit the measuring speed to 20...50 readings/sec, even when a minimum measuring time (1...2μs) has been selected.

The use of high speed dump mode is a way to increase measuring speed to 400...500 readings/sec. (typical when minimum measuring time is selected). In this mode the microcomputer skips the computation phase and will just output the contents of decade count registers. The computation of the result as well as calculation of resolution must then be made by the controller.
The dump mode is entered by programming "HS1".
When High Speed Dump mode has started the display will indicate "HS" instead of measuring values. There are four different ways to terminate the dump mode:

- Sending programming string "HSØ".
- Sending programming string "D".
- Sending bus commands SDC or DCL (device clear).
- Go to local mode.

The dump mode output string contains 24 or 25 ASCII characters, with the following format:

Code	X	X	....	X	X	D	(D)

byte 1 = Alphabetic code A...U specifying what calculation should be made.
byte 2...23 = Register contents (numeric).
byte 24 = Selected delimiter.
byte 25 = Delimiter LF (only if delimiter CR + LF has been selected).

The 22 numeric characters normally represents the contents of the event count register and the time count register respectively.

In totalizing mode only event counts are represented in the numeric string. In single time measurements only time counts are represented. The following abbreviations are used:
T = Time count register contents.
E = Event count register contents.
X = Don't care byte.
D = Delimiter.

Individual bytes in the time count and event count registers are numbered e.g. T9, T5, E11, E1 etc. Least significant byte is called T1 and E1 resp. There are 6 different formats depending on the measuring function selected. There are as many as 21 possible ways of calculating the final result. The calculation algorithm to be used is indicated by the code (A...U) in byte No. 1.

Format No. 1

Functions:
PM 6652/54: Period, Phase, Duty Factor, Freq A, Ratio A/B, Time Average, Freq. C.

Output format:

	Code	E10	E9	..	E1	X	T9	T8	..	T1	X	X	D	(D)
Byte	1	2	3	..	11	12	13	14	..	21	22	23	24	(25)

Calculation algorithms:

Code	Calculation
C	$(T/E)x10^{-7}$
G	(T/E)x360
H	T/E
K	$(E/T)x10^{8}$
L	$(E/T)x10^{7}$
O	E/(T+1)
P	$(E/(T+1))x10^{-7}$
T	$(E/T)x16x10^{8}$

Format No. 2

Functions:

PM 6654: Freq A, Freq C, Period A, Time Average
PM 6652: -

Output format:

	Code	E11	E10	...	E1	T11	T10	...	T1	D	(D)
Byte	1	2	3	...	12	13	14	...	23	24	(25)

Calculation algorithms:

Code	Calculation
J	$(E/T)x5x10^{8}$
M	$(E/T)x8x10^{9}$
N	$(T/E)x2x10^{-9}$
R	$(T/E)x10^{-8}$