Format No. 3

Functions:
PM 6654: Ratio A/B, Ratio C/B.
PM 6652: Freq. A, Freq. C, Ratio A/B, Ratio C/B.

Output format:

Code	E11	E10	...	E1	T9	T8	...	T1	X	X	D	(D)
Byte 1	2	3	...	12	13	14	...	21	22	23	24	(25)

Calculation algorithms:

Code	Calculation
A	$(E/(T+1))\times10^7$
B	$(E/(T+1))\times16\times10^7$
D	$E/(T+1)$
E	$16\times E/(T+1)$

Format No. 4

Functions:
PM 6652/54: Single Time, Single period, Tot. A gated by B, Tot A start/stop by B.

Output format:

Code	T19	T18	..	T10	X	T9	..	T1	X	X	D	(D)
Byte 1	2	3	..	11	12	13	..	21	22	23	24	(25)

Calculation algorithms:

Code	Calculation
F	$T\times10^{-7}$
S	T

Format No. 5

Functions:
PM 6654: Single period, single time.
PM 6652: -

Output format:

Code	T21	T20	...	T12	X	T11	...	T1	D	(D)
Byte No: 1	2	3	...	11	12	13	...	23	24	(25)

Calculation algorithm:

Code	Calculation
Q	$T\times2\times10^{-9}$

Format No. 6

Functions:
PM 6652/54: Tot. A gated by B, Tot. A start/stop by B, Single ratio A/B, single ratio C/B.

Output format:

Code	E20	E19	..	E11	E1	E10	..	E2	X	X	D	(D)
Byte 1	2	3	..	11	12	13	..	21	22	23	24	(25)

Calculation algorithms:

Code	Calculation
I	E
U	16xE

PROGRAM EXAMPLES

The following programs will demonstrate how PM 6654 or PM 6652 communicate with an HP 85 controller.

Program No. 1 will make any desirable number of frequency measurements and calculate the mean value, standard deviation and max/min values.

Program No. 2 is simpler and much shorter. Ten period measurements are made and only the mean value is calculated and displayed.

Program No. 3 asks the operator for a programming string which is sent directly to the counter, whereafter the correspondent measuring value is displayed. This program is illustrated with a lot of hard-copy print-outs.

Program No. 4 illustrates the "Program data out" command.

Program No. 5 gives an example how the limit monitoring with service request alarm can be used.

Program No. 6 finally, shows how the HP85 is programmed for High speed dump mode using the so called FHS-teqnique (FHS = Fast Hand Shake). The dump mode output format is also illustrated.

The output delimiter in the PM 9696 interface should be set to LF (Line feed) when a HP 85 controller is used.

If the counter will not communicate with the controller, i.e. the counter cannot be addressed, there will be no input data, or the counter cannot be programmed remotely. Press the RESET pushbutton on the HP 85 and/or press the POWER ON/OFF switch on the counter and try again. If the counter still doesn´t communicate, check:

- All connectors of the IEEE-488 bus.
- The trigger LED indicators. If the input signal is lost, the counter might not terminate the measurement.
- The address switch on the counter rear panel must be set to 10 (binary 01010).
- The output string delimiter in the PM 9696 interface should be set to LF when a HP controller is used.

Program No. 1

The number of samples, which must not exceed 1000, is given by the operator (INPUT statement). The counter is programmed to measure FREQ A (default value) with a 10ms measuring time. The device address of the counter is 10.

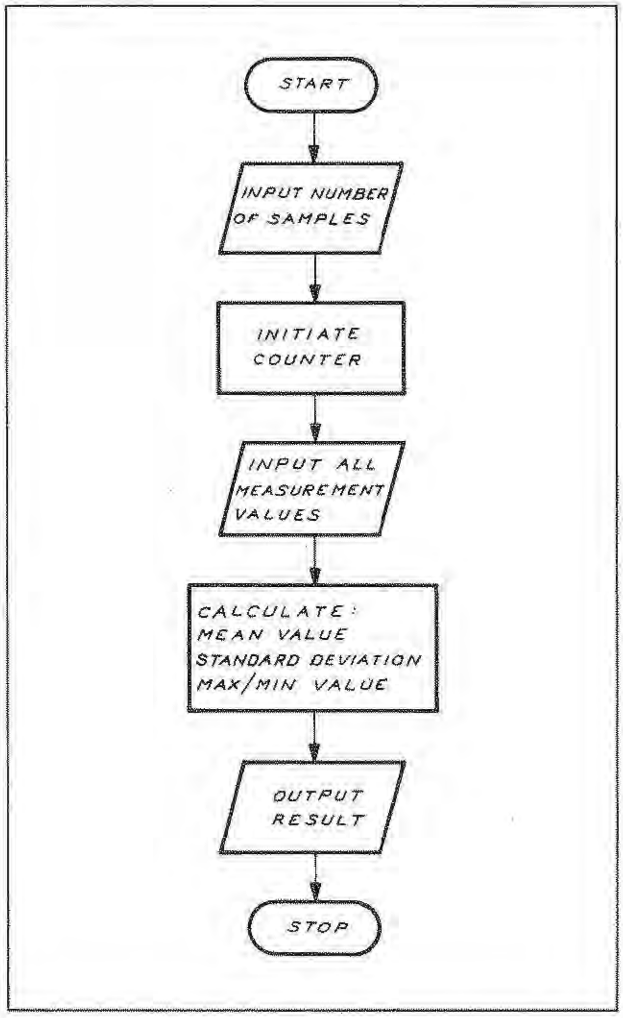


Fig. 5.10 Program No. 1 flow-chart.

```
 10 !   IEC-BUS PROGRAM 1 FOR
 20 !   PM 6652/54 COUNTERS
 30 !   AND HP 85 AS CONTROLLER
 40 !
 50 PRINT
 60 PRINT "FREQUENCY MEASUREMENT
    S"
 70 PRINT
 80 CLEAR ! CLEAR DISPLAY SCREEN
 90 BEEP !  WAKE-UP SIGNAL
100 DISP "HOW MANY SAMPLES?"
110 INPUT Q
120 !   CLEAR AND SET DEFAULT
130 !   VALUES IN PM9696-INTER-
140 !   FACE
150 CLEAR 710
155 WAIT 100
160 !   SET 10 ms MEASURING TIME
170 !   AND TRIGGER (X)
180 OUTPUT 710 ;"SM1E-2,X"
190 DIM A(1000)
200 !   INPUT ALL SAMPLE VALUES
210 FOR N=1 TO Q
220 ENTER 710 ; A$
230 A(N)=VAL(A$[4])
240 NEXT N
250 !   CALCULATE MEAN VALUE
260 M=0
270 FOR N=1 TO Q
280 M=M+A(N)
290 NEXT N
300 M1=M/Q
310 !   CALCULATE ST. DEVIATION
320 S2=0
330 FOR N=1 TO Q
340 S2=S2+(M1-A(N))^2
350 NEXT N
360 !   CALCULATE MAX AND MIN
370 H=A(1)
380 L=A(1)
390 FOR N=2 TO Q
400 IF A(N)>H THEN H=A(N)
410 IF A(N)<L THEN L=A(N)
420 NEXT N
430 !   OUTPUT ALL PARAMETERS
440 PRINT "NUMBER OF SAMPLES=";Q
450 Y=1
460 IF M1<100000 THEN Y=10
470 IF M1<10000 THEN Y=100
480 IF M1<1000 THEN Y=1000
490 IF M1<100 THEN Y=10000
500 IF M1<10 THEN Y=100000
510 IF M1<1 THEN Y=1000000
520 PRINT "AVERAGE=";
530 PRINT INT(M1*Y)/Y;"Hz"
540 PRINT "ST. DEVIATION=";
550 PRINT INT(SQR(S2/Q)*Y)/Y;
560 PRINT "Hz"
570 PRINT "MAX VALUE=";H;"Hz"
580 PRINT "MIN VALUE=";L;"Hz"
```

Program No. 2

The counter is programmed to do 10 PERIOD measurements with 1s measuring time. See flow-chart below.

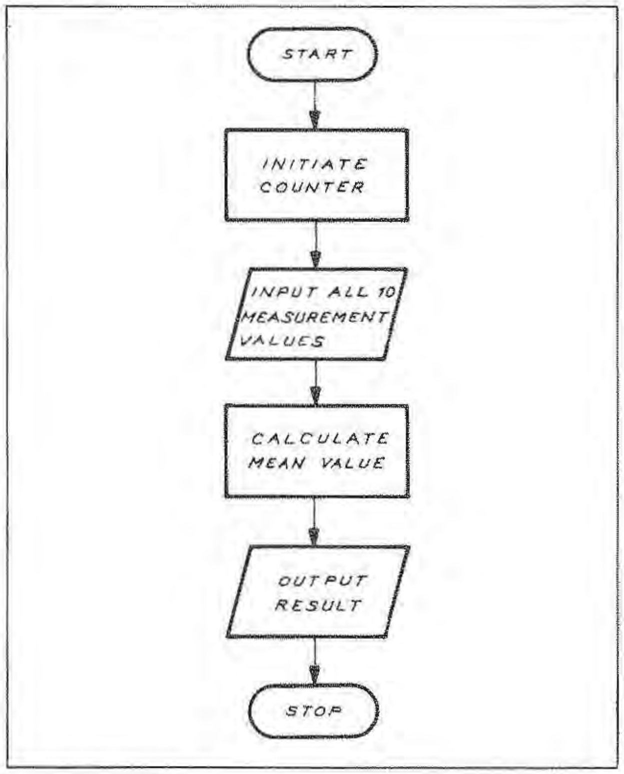


Fig. 5.11 Program No 2 flow chart.

```
 10 !   DEMO PROGRAM NO 2
 20 !   FOR PM 6652/54 AND
 30 !   AND HP 85 AS CONTROLLER
 40 !
 50 CLEAR ! CLEAR DISPLAY
 60 CLEAR 710 ! DEFAULT SETTINGS
 70 !   SELECT PERIOD A (F3)
 80 !   AND 1s MEASURING TIME
 90 OUTPUT 710 ;"F3SM1"
100 !   INPUT ALL SAMPLE VALUES
110 Z=0
120 FOR N=1 TO 10
130 TRIGGER 710
140 ENTER 710 ; A$
150 Z=Z+VAL(A$[4])
160 NEXT N
170 !   GET MEAN VALUE
180 M=Z/10
190 !   DISPLAY MEAN VALUE
200 DISP "AVERAGE=";M;"s"
210 END
```

Program no 3.

This program asks the operator for a programming string to be sent to the counter. After that a measuring value is entered and displayed for 5 seconds. See flow-chart below.

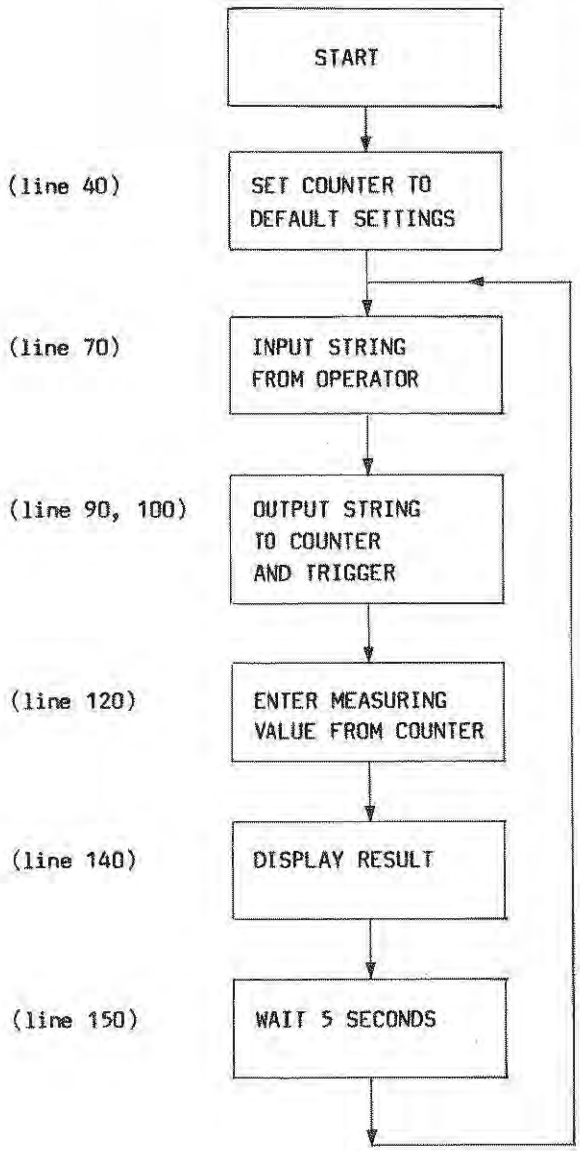


Fig 5.12. Program no 3 Flow chart

The program listing is shown below.

```
 10 ! DEMO PROGRAM NO 3
 20 ! FOR PM6652/54 AND
 30 ! HP85 AS CONTROLLER
 40 CLEAR 710 ! CLEAR COUNTER
 50 CLEAR ! CLEAR DISPLAY
 60 DISP "INPUT YOUR PROGRAMMING
      STRING"
 70 INPUT A$
 80 ! PROGRAM THE COUNTER AND TR
    IGGER
 90 OUTPUT 710 ;A$
100 TRIGGER 710
110 ! GET THE MEASURING RESULT
120 ENTER 710 ; B$
130 DISP
140 DISP "RESULT IS: ";B$
150 WAIT 5000 ! WAIT 5 SECONDS
160 GOTO 50
170 END
```

To illustrate the program running, the measuring results are copied from the HP85 display to the integral thermal printer.

a) To measure Frequency A with 1s measuring time, it is not necessary to program Frequency measurements because that is the default function. The programming string is simply: "SM1" (Set Measuring time = 1s).

```
INPUT YOUR PROGRAMMING  STRING
?
SM1

RESULT IS: FA 084.8633289E+3
```

b) The result was a 9 digit result for 1 second measuring time (correct). In changing measuring time to minimum by means of string "SS1" (set Single/minimum):

```
INPUT YOUR PROGRAMMING  STRING
?
SS1

RESULT IS: FA 00000084.87E+3
```

c) There are now only 4 digits for approx. 2μs measuring time. But the readout is difficult to read with 6 leading zeroes. To remove all leading zeroes by means of string "LE1" (Leading zero suppression Enable):

```
INPUT YOUR PROGRAMMING  STRING
?
LE1
RESULT IS: FA 84.87E+3
```

d) Which gives a much nicer print-out. To measure period A instead, first program "D" (Default setting) followed by F3 (Function 3 = period).

```
INPUT YOUR PROGRAMMING  STRING
?
DF3
RESULT IS: PA 011.7831194E-6
```

e) To measure the duty factor of the signal (code "F10").

```
INPUT YOUR PROGRAMMING  STRING
?
F10
RESULT IS: DF 0000869.649E-3
```

f) To make a fast Duty Factor measurement by programming:
"SS1" for shortest possible Measuring time
"SM1E-4" for shortest possible Display time
"LE1" for leading zero suppression

```
INPUT YOUR PROGRAMMING  STRING
?
SS1SM1E-4LE1
RESULT IS: DF 0.88E+0
```

g) To determine the rise time of the input signal, program:
"F9" for Rise Time function
"SSØ" and "SM1ØE-3" for 10ms meas. time.
"ACØ" for DC-coupled inputs
"AT1" for 50 Ohm termination

```
INPUT YOUR PROGRAMMING  STRING
?
F9SS0SM10E-3AC0AT1
RESULT IS: RT 1.48238E-6
```

h) To discover the trigger levels used for the previous rise time measurement, program: "RL1" (Read trigger Levels).

```
INPUT YOUR PROGRAMMING  STRING
?
RL1
RESULT IS: TL +0.02,+0.68
```

i) To examine the input voltage, V_{max} and V_{min} by using "F14" and "RLØ" (switch off read trigger level mode).

```
INPUT YOUR PROGRAMMING  STRING
?
RL0F14
RESULT IS: VM +0.75,-0.06
```

j) To use the 20% and 80% trigger points instead (20% is +0.10V and 80% is +0.59V), the programming codes used are:
"TL1" for Trigger Level via keyboard
"AL.1Ø" for channel A level = 0.10V
"BL.59" for channel B level = 0.59V
"RL1" for checking our set levels

```
INPUT YOUR PROGRAMMING  STRING
?
TL1AL.1BL.59RL1
RESULT IS: TL +0.10,+0.59
```

Program no. 4

This program displays the current programming status of the counter as a result of a "PØ"-command.

The "PØ"-command will result in an output of 8 consequtive program data strings which are input to the HP85 and displayed.

At the end of the program there is a "LOCAL 710" statement. This enables manual changes of the counter settings before re-running the program with new programming status.

The listing is shown below.

```
 10 ! DEMO PROGRAM NO 4
 20 ! FOR PM6652/54 AND
 30 ! HP85 AS CONTROLLER
 40 CLEAR
 50 DISP
 60 ! ASK FOR PROGRAM DATA OUT
 70 OUTPUT 710 ;"P0"
 80 DIM P$[25]
 90 ! ENTER AND DISPLAY 8 STRING
    S
100 FOR K=1 TO 8
110 ENTER 710 ; P$
120 DISP P$
130 NEXT K
140 ! RETURN TO LOCAL MODE
150 LOCAL 710
160 END
```

A display readout (copied to the integral thermal printer) is shown below.

```
F01SM60.E-3SS0
AC1AS0AA0AT1AL+0.00
BC0BS0BA0BT0BL+0.00
TL2T00CE0CH0TE0
SQ0HS0LE0MS0SD2
G0HE0ME0RM0RH0RL0
SK+000000001.E+00
SL+000000000.E+01
```

After having made some manual changes on the front panel, a new "RUN" resulted in the following print-out. Note the changed settings.

```
F03SM10.E-1SS1
AC1AS0AA0AT1AL+0.12
BC1BS1BA1BT1BL+0.00
TL1T00CE0CH0TE0
SQ0HS0LE0MS0SD2
G0HE0ME1RM0RH0RL0
SK+000000001.E+06
SL-000000011.E+00
```

Program no 5

This program activates an upper and a lower limit for frequency measurements. When the frequency exceeds the set limits, an SRQ is sent to the controller, which will display the erroneous value together with the limits.

To activate the limit alarm the counter must be programmed with the following commands (see line 200):

- "SK..." and "SL..." to set the relevant K and L values

- "ME1" to enable MATH

- "SQ2" to enable limit alarm SRQ

The SRQ interrupt is enabled in line 130. Line 120 instructs the HP85 where to go in case of an interrupt (i.e. line 230). The SRQ-interrupt routine starts with a "STATUS" statement which clears the interrupt cause register (CR1) in the HP85. Furthermore, a serial poll (line 260) is executed to "take away" the active SRQ line in the bus. A test is made (line 270) to see whether the SRQ interrupt was caused by limits exceeded (status 96) or by something else.

At the very end (line 430), there are some necessary statements to enable further monitoring after the first SRQ interrupt.

- "SEND 7; UNT" means that the counter is told to "untalk", otherwise the counter will not measure but wait forever for a handshake procedure with the HP85.

- "TRIGGER 710" is needed to start further measurements.

- "ENABLE INTR 7;8" is needed to re-enable SRQ interrupts.

The listing is shown below:

```
 10 ! DEMO PROGRAM NO 5
 20 ! FOR PM 6652/54 AND
 30 ! HP85 AS CONTROLLER
 40 LOCAL 710
 50 CLEAR ! CLEAR SCREEN
 60 DISP "INPUT LOWER LIMIT:"
 70 INPUT A
 80 DISP "INPUT HIGHER LIMIT:"
 90 INPUT B
110 ! ENABLE SRQ-INTERRUPT
120 ON INTR 7 GOTO 230
130 ENABLE INTR 7;8
140 ! CALCULATE K AND L
150 K=1/(B-A)
160 L=-A/(B-A)
170 K$="SK"&VAL$(K)
180 L$="SL"&VAL$(L)
185 CLEAR 710 ! DEFAULT SETTINGS
190 ! OUTPUT DESIRED K AND L VAL
    UES, ENABLE MATH AND ENABLE
    LIMIT ALARM MONITORING
200 OUTPUT 710 ;K$&L$&"SQ2ME1"
210 GOTO 210
220 ! INTERRUPT ROUTINE
230 STATUS 7,1 ; D
240 BEEP
250 DISP @ DISP
260 S=SPOLL(710)
270 IF S=96 THEN 340
280 DISP "SERVICE REQUESTED FOR"
290 DISP "OTHER REASONS"
300 ENABLE INTR 7;8
310 DISP "PRESS 'END LINE' TO RE
    START"
320 INPUT D$
330 GOTO 440
340 ENTER 710 ; B$
350 DISP "MEASUREMENT RESULT:"
360 DISP "    ";(VAL(B$[4])-L)/K
370 DISP "HAS EXCEEDED LIMITS:"
380 DISP A;" AND ";B;" RESP."
390 DISP
400 DISP "DO YOU WANT TO CONTINU
    E THE"
410 DISP "MEASUREMENT? (Y/N)"
420 INPUT R$
430 IF R$="Y" THEN SEND 7 ; UNT
    @ TRIGGER 710 @ ENABLE INTR
    7;8 @ GOTO 210
440 END
```

The hard-copy output of a test run is shown below:

```
INPUT LOWER LIMIT:
?
70E3
INPUT HIGHER LIMIT:
?
80E3

MEASUREMENT RESULT:
    61153.306
HAS EXCEEDED LIMITS:
 70000  AND  80000  RESP.

DO YOU WANT TO CONTINUE THE
MEASUREMENT? (Y/N)
?
```

Program no 6

This program example demonstrates how 1000 single period measurements can be transferred in a few seconds to HP85 using High speed dump mode.

For this purpose HP85 must be programmed for "Fast Handshake Transfer" (FHS) using a large I/O-Buffer (25000 bytes is used in the program). In High speed dump mode every measuring result contains 24 bytes. This explains line 170 which says:" Transfer data from the counter (address 710) to the 25000 byte I/O-buffer B$ using Fast Hand-Shake (FHS) and do not stop until 1000 measurements (24000 bytes) have been counted!"

The program listing is shown on next page.

```
 10 ! DEMO PROGRAM NO 6
 20 ! FOR PM 6652/54 AND
 30 ! HP85 AS CONTROLLER
 40 CLEAR
 50 DISP
 60 DISP "HIGH SPEED DUMP MODE"
 70 DISP "1000 PERIOD MEASURMENT
    S"
 80 DISP
 90 ! DIMENSION I/O-BUFFER
100 DIM B$[25000]
110 IOBUFFER B$
120 CLEAR 710
130 ! PROGRAM SINGLE PERIOD, KEY
    BOARD SET LEVEL (0V) AND DUM
    P MODE
140 OUTPUT 710 ;"F3SS1TE1HS1TL1"
150 TRIGGER 710
160 ! HIGH SPEED INPUT TRANSFER
170 TRANSFER 710 TO B$ FHS ; COU
    NT 24000
180 OUTPUT 710 ;"HS0"
190 FOR I=0 TO 99
200 FOR K=0 TO 9
210 DISP B$[240*I+24*K+1,240*I+2
    4*K+23]
220 NEXT K
230 DISP "PRESS 'CONT' TO SEE MO
    RE!"
240 DISP "(MEASUREMENTS NO";10*I
    +1;"TO";10*I+10;"ARE NOW SHO
    WN)"
250 PAUSE
260 CLEAR
270 NEXT I
280 DISP "THAT'S ALL"
290 END
```

NOTE: If ENTER is used instead of TRANSFER at line 170, the number of measurements/second will be reduced by approximately 50%.

A hard-copy printout is shown below. The first byte is code "Q" saying that all bytes (except byte No 12) contain time counts and that the data should be multiplied by 2 ns to get the correct result. In this example we see that the periods are 218 or 220 ns.

```
Q00000000004000000000109
Q00000000004000000000109
Q00000000004000000000109
Q00000000004000000000110
Q00000000004000000000109
Q00000000004000000000109
Q00000000004000000000109
Q00000000004000000000109
Q00000000004000000000109
Q00000000004000000000109
PRESS 'CONT' TO SEE MORE!
(MEASUREMENTS NO 231 TO 240
ARE NOW SHOWN)
```

See section "High speed dump mode", page 5.19 ("Format No 5") for a detailed explanation.

Chapter 6

OTHER OPTIONS

CONTENTS Page

INTRODUCTION

This chapter contains the operating manuals for all options for the counters PM 6652,-54 with exception of the IEEE-bus interface (PM 9696), which is included in chapter 5 of this manual. The technical specification for each option is included in chapter 9. Mounting instructions for the options are included in the service manual.

WARNING: Mounting of the different options shall only be carried out by personel qualified to do so. To reduce the risk of electric shock do not perform any form of servicing other than that specified in the operating manual unless you are fully qualified to do so.

Please note that some options e.g. Blind panel, Fan unit and Rear inputs are factory options.

CHANNEL C PM 9610

With the option PM 9610 is the frequency range for PM 6652,-54 extended to 1.5 GHz. This HF-input is on the front panel marked input C.

The C channel option is principally a prescaler which divides the input frequency by 16. For example, an input frequency of 800 MHz will be counted by the counting logic as if it were a 50 MHz signal; see Fig. 6.1.

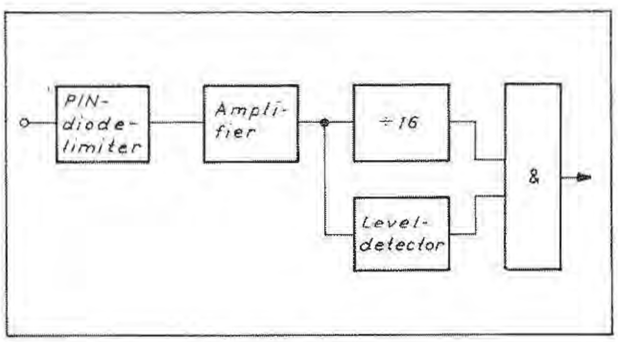


Fig. 6.1 Input C block diagram

A signal level detector enables counting only when the input level is high enough. Below that level no measurement at all is made. A "clean drop-out" is thus provided and no erroneous measurements are made on RF noise. This circuit is automatically disabled* when the C-input is used for FREQ.AVG. measurements to improve the burst capability.

*) Not on the PM 6652,-54.

NOTE: If FREQ. C and AVG. is selected and the C-input left open, the display will show a false readout instead of being blanked out.

The input amplifier is automatically protected against signal levels above +10 dBm. This enables a wide dynamic range of 10 mV_{rms}...12 V_{rms} and excellent overload protection.

Amplitude modulated signals can be measured as long as the minimum amplitude in the modulation envelope is higher than the sensitivity of the C-channel (see fig. 6.2).

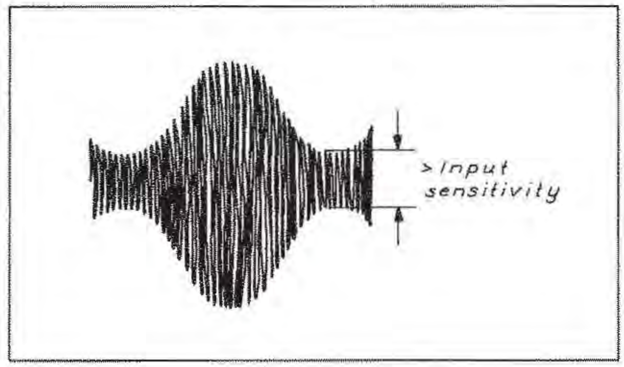


Fig. 6.2 Amplitude modulated signals can be measured down to 10 mV_{RMS}.

REAR INPUTS PM 9611

The rear inputs PM 9611 is a factory mounted option. With this option are the front panel inputs A, B and C substituted by the rear panel inputs K, L and M.

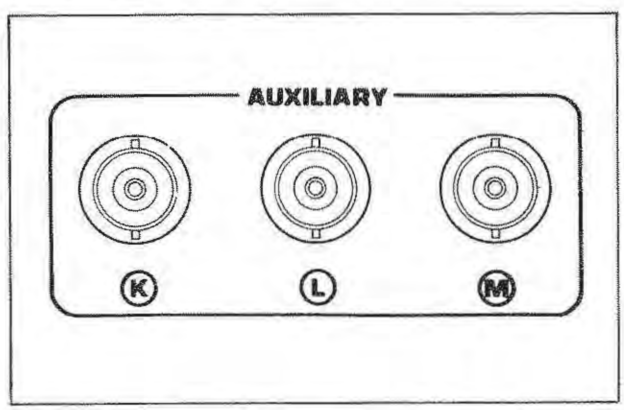


Fig. 6.3 The rear panel inputs K, L and M.

In order to preserve the 50 Ohm input impedance it is necessary to disconnect the front panel inputs when installing the rear panel inputs.

FAN UNIT PM 9612

The fan unit is designed for applications were the environmental temperature increases to over 40 °C and the natural air circulation is prohibited. There must anyhow be sufficient free space available around the counter (at least 20 mm).

In order to make the fan unit efficient there must be sufficient free air available around the counter. The ventilation holes for the fan is located in the side panels at both sides of the counter.

The fan unit is a factory option.

OSCILLATORS PM 9678, -79, -90, -91

The frequency of the reference crystal oscillator is the main accuracy defining parameter in a counter. The frequency is effected by external conditions like the ambient temperature and supply voltage but also by ageing.

When making a recalibration, the reference crystal oscillator is only compensated for deviation in frequency due to ageing.

Some important points:

- The high stability oscillators has been built into an oven in order to keep the oscilator temperature as stable as possible. Continous operation is also important for the stability. After a mains-voltage interruption the oscillator restarts at a slightly different frequency. It will then, as time goes on follow an equal ageing rate.

- The stabilities indicated for the oscillators are valid within a temperature range of 0...-50 °C, with a reference temperature of 23 °C. If the counter is used in a room temperature of 20...30 °C, the temperature stability will be increased with a factor of 3.

- The temerature stability indicated for TCXO and standard oscillators are mainly dependent on the ambient temperature. At power on there is always a temperature increase inside the counter which will influence the oscillator.

Recalibration

The Mean Time Between ReCalibration, MTBRC, is defined as:

$$\text{MTBRC} = \frac{\text{Acceptable error} - \text{Temp. stability}}{\text{Ageing}}$$

It can be calculated when the total acceptable error and the oscillator specifications are known.

The total acceptable error is defined as:

$$\text{Acceptable error:} = \frac{\text{Deviation of ref. frequency}}{\text{Nominal ref. frequency}}$$

Example:
- A user can accept a maximum of ±3 Hz deviation on the 10 MHz frequency of the oscillator, this results in:

- $$\text{Acceptable error:} = \frac{3}{10 \times 10^6 \text{ Hz}} = 3 \times 10^{-7}$$

The Ageing and temperature factors can be selected from the table in Chapter 9.

The value of the Ageing factor is correctly selected from the table when the calculation of MTBRC results in 1...30 days, 1...12 months or over 1 year (not e.g. 43 days or 17 month or 0.8 years).

Example:
- The user has the same requirements as in the example above. The counter has an oscillator PM 9690.
- Look up information about PM 9690 in the Technical Specification, Chapter 9. The results will be the following:

Relative Frequency deviation caused by:

Ambient temperature variation:	Less than 3×10^{-8}
Ageing/year:	Less than 1.5×10^{-7}

- Use the MTBRC formula with the above values. This gives a MTBRC of maximum:

$$\frac{3 \times 10^{-7} - 3 \times 10^{-8}}{1.5 \times 10^{-7}} = 1.8 \text{ year}$$

NOTE: When making a recalibration, the reference crystal oscillator will only be compensated for relative frequency deviation caused by ageing.

ANALOG RECORDER OUTPUT PM 9695

The PM 9695 converts the digital information of the PM 6652/54 counters into an analog signal. One application for the analog output is for recording the stability of oscillators and filters on a strip chart recorder. In frequency control systems with analog feedback, the DAC serves as an accurate frequency to voltage converter.

Output and switches

The analog output signal from the PM 9695 is sent out via a BNC connector on the rear panel. A resolutioin selector and an offset switch are used to select the desired output digits.

Resolution selector

Any 3 consecutive digits can be selected with the 12-position resolution selector. The converter functions as a magnifying glass to focus on the desired part of the read-out. The resolution selector has two scales. One scale (marked s) is for time measurements from 10^{-13}s to 10^{-2}s. The other scale (marked Hz) is used for voltage, degrees, ratio, counts and frequency, from 10^{-4} to 10^{7}. See Fig. 6.4.

The position of the resolution selector corresponds to the least significant of the digits selected.

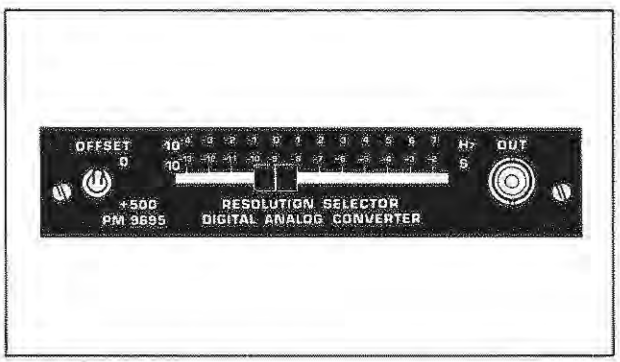


Fig. 6.4 The digital-to-analog converter panel with the resolution selector.

When the resolution selector is set to a position where one or two of the digits to be converted are outside the display of the counter, then these digits will be converted as zeros.

At power on or reset, the output is 0mV. If an overflow occurs on the converter display, the analog output will be 1023mV.

Some examples

If the display shows 1 2 3 4 5 6 7 8 9 kHz and the resolution selector is set to 10^3Hz as indicated in the left-hand column below, then the digits 123 (marked in the middle column, example 1) are converted to an analog output signal. this is shown in Table 6.1, together with some additional examples.

Position of resolution selector, upper scale	Converted digits	Analog output signal
10^3Hz	123.456789	123mV
10^2Hz	123.456789	234mV
10^4Hz	123.456789	012mV
10^{-4}Hz	123.456789	890mV

Table 6.1

Offset switch

In normal operating mode, the offset switch should be set to position 0. The analog output is then directly proportional to the digital input, which means that 000 produces 0.000V and 999 produces 0.999V.

For offset mode operation, the offset switch is set to position +500. this adds 500 to the digital input, and 500 then produces 0.000V, whereas 499 produces 0.999V. Thus, for a display changing between 9.99999999MHz and 10.00000000MHz, the frequency will be recorded at the center of the strip chart, rather than shooting between zero and full scale.

REFERENCE FREQUENCY MULTIPLIER PM 9697

With this option installed, the PM 6652/54 counters can accept external reference frequencies of 1MHz, 5MHz or 10MHz via input D (EXT STD IN) on the rear panel. The multiplier can however only be installed together with the standard oscillator.

Selection of multiplication factor

The selection of multiplication factor has to be reconsidered at installation (see instruction manual PM 9697) or change of external reference.

Note that only trained personel are alowed to work with an opened instrument.

- Disconnect the mains cable.
- Remove the top cover of the counter.
- Find the two jumpers BU103 and BU104 on PM 9697, see Fig. 6.5.

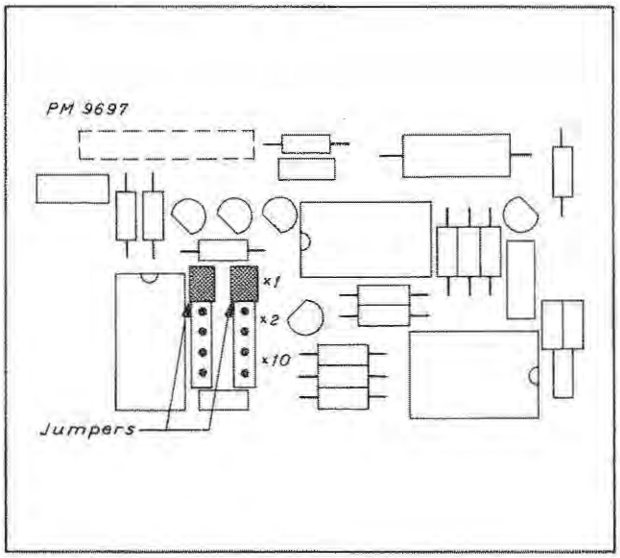


Fig. 6.5 Component layout PM 9697.

- If necessary change the jumpers.
- Refit the cover.

BLIND PANEL

Counters used only in IEEE-BUS applications, may from the factory be equipped with a blind panel. The counter is still electrically identical to the "normal" version.

The blind panel includes:

- Three input connectors A, B and C. These inputs can be substituted by the rear panel inputs K, L and M (PM 9611).
- One potentiometer, protected by a screw-fastened cover, for setting the HOLD OFF time, which cannot be set via the IEEE-BUS.
- The secondary power switch.
- Three LED:s on the left hand side of the panel, indicating: POWER ON, REMOTE and STAND BY.

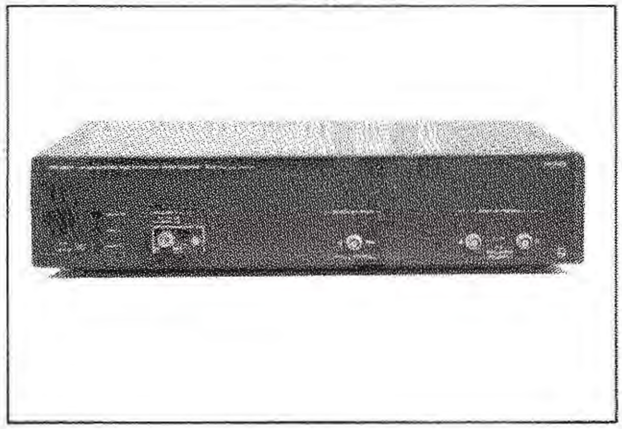


Fig. 6.6 Blind panel for counters PM 6652/54.

Chapter 7

MEASUREMENT THEORY

CONTENTS

INTRODUCTION

The microcomputer-based PM 6652 and PM 6654 timer/counters provide a wide range of frequency and time measuring functions, including time interval, rise or fall time, phase, duty factor, etc. The counters also offer voltage measurements such as V_{max}, V_{min} and V_{pp} of the input signal. A summary of all possible measuring functions is given below:

Frequency related measuring functions:	Time related measuring functions:
Frequency A	Time interval
Frequency C	Pulse width
Ratio A/B	Rise or fall time
Ratio C/B	Phase
Period A	Duty factor
Totalize (3 modes)	

Voltage measuring functions:

V_{max}, V_{min}, V_{pp}

Block diagram

The counters contain two microprocessors and a "counter-on-a-chip" LSI. The LSI, together with the input circuit, performs all counting functions; whereas the master microprocessor controls the logic functions of the counter and does all calculations on the counting result. The slave microprocessor performs the communication between control panel (controls, indicators and the display) and the master processor.

The microprocessors computing power allows mathematical manipulations of the result (offset and/or scaling). The PM 6652/54 also features automatic truncation of digits so that only significant digits are displayed. Thus, no overflow can occur. A block diagram is shown in Fig. 7.1. Two identical input channels are used for accurate time interval measurements.

The PM 6652 and PM 6654 have identical measuring functions. The difference is found in the input synchronization and in the internal clock pulse frequency. The PM 6652 operates with a clock frequency of 10MHz, whereas the PM 6654 operates with a clock frequency of 500MHz in most measuring functions.

The PM 6654 has a synchronization network that operates at 500MHz, 100MHz or 10MHz depending on the measuring function.

- 500MHz operation is found in Frequency A or C, Period and Single Time measurements.
- 100MHz operation is found in average time measurements (time interval, pulse width, rise and fall time) totalize modes and time.
- 10MHz operation is found in phase, duty factor and ratio.

In any measuring function, the use of hold off or external gate will automatically convert the PM 6654 to 10MHz clock frequency operation. The use of AVG (average) in time measurements will automatically result in 10MHz operation, whereas the AVG function in frequency or period measurements will not affect the resolution.

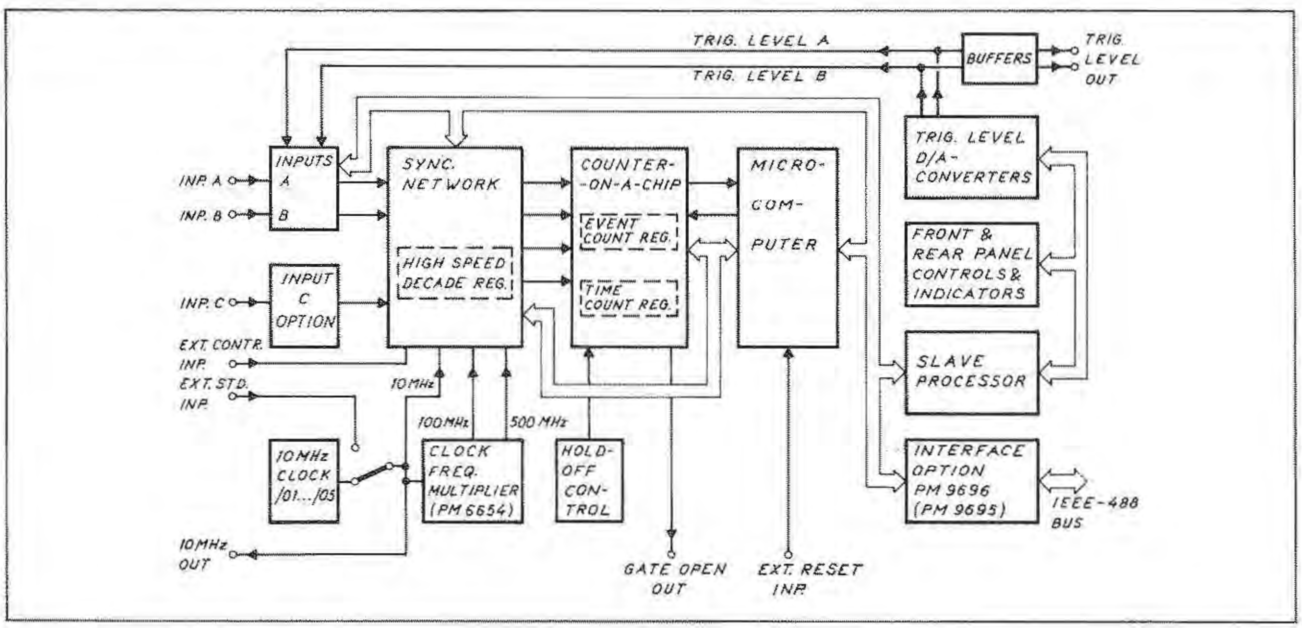


Fig. 7.1 Block diagram PM 6652/54

Clock frequency: Resolution:	500MHz 2ns	100MHz 10ns	10MHz 100ns
Frequency A or C, Period	X		
Single Time Interval	X		
Multiple Time Interval AVG		X	
Totalize		X	
Phase, Duty factor, Ratio,			X
External gate, Hold-off			X
AVG and Frequency A or C	X		
AVG and Time average			X

Table 7.1 Resolution vs function in PM 6654

INPUT TRIGGERING

Functions - Channel A and B

As the input signal can have very different wave forms, it is necessary to shape the signals so that the counting circuits can handle the signals. The input circuits must be able to trigger on narrow pulses, signals superimposed on DC levels, noisy signals and low level signals as well as on high level signals. The input must also have selectable impedance (1MOhm/50 Ohm) to fit various system configurations. The input circuits consist of:

- A 1MOhm/50 Ohm input termination selector;
- AC/DC-coupling selector;
- An input attenuator (x10), to attenuate excessive input signals to fit the ±5V trigger level off-set range;
- A differential amplifier for trigger level setting;
- Schmitt trigger circuit with fixed hysteresis band (trigger window) for pulse shaping.

Schmitt-trigger function

The Schmitt-trigger function is illustrated in Fig. 7.3.

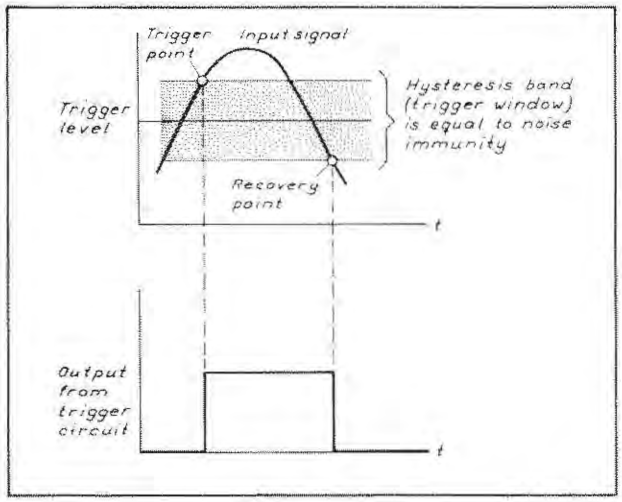


Fig. 7.3 Illustration of the trigger function.

The hysteresis band (trigger window) is centered around the trigger level and the width of the hysteresis band at the input is the same as the effective input sensitivity in Vpp.

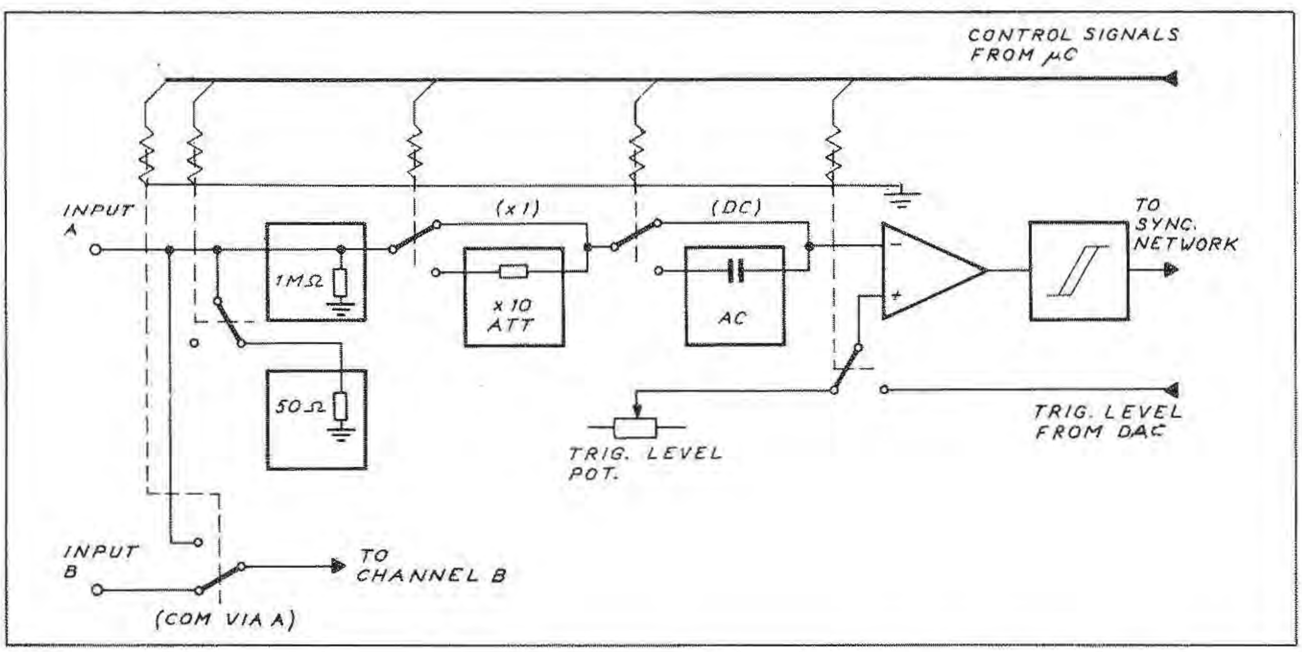


Fig. 7.2 Block diagram of the input circuits.

Trigger level settings

When the trigger level setting is changed, the hysteresis band is shifted with respect to the input signal; see fig 7.4

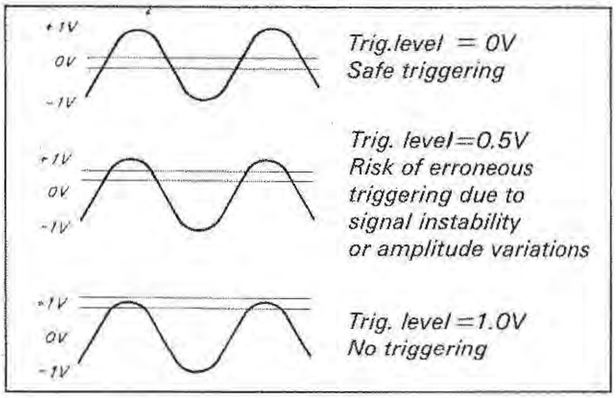


Fig. 7.4 Trigger level offset.

For reliable triggering the trigger level should, in almost all cases, be positioned at 50 % of the signal's peak-to-peak voltage. This is assured by the counter's AUTO trigger function.

When AUTO is selected, the microcomputer, not the operator, is doing the trigger level setting. The microcomputer will automatically measure max and min values of the input voltage, calculate the mid-value and position the trigger level accordingly. For rise or fall time measurements, the microcomputer will calculate trigger levels as the 10% and 90% values of the input voltage. If nesseccary, the microcomputer will automatically change the attenuator setting (x1 or x10). AUTO requires a repetitive input signal > 100Hz.

Trigger level can also be set manually via the keyboard or with the potentiometers. The range is -5V...+5V. The trigger level is set in 10mV steps via the keyboard. The real trigger level with respect to the input signal is then:

(Attenuator setting) x (Keyboard setting)

The set trigger level can also be read on the display with 10mV resolution for all three trigger level modes (AUTO, KEYBOARD, Potentiometers)

Frequency measurements

Timer/counters are used for both frequency and time interval measurements. However, frequency and time interval measurements have contradictory requirements in respect of correct triggering. For frequency measurements, too narrow a hysteresis band (i.e. too high a sensitivity) means that the counter is too sensitive to noise; see Fig. 7.5. The hysteresis band is the noise immunity band.

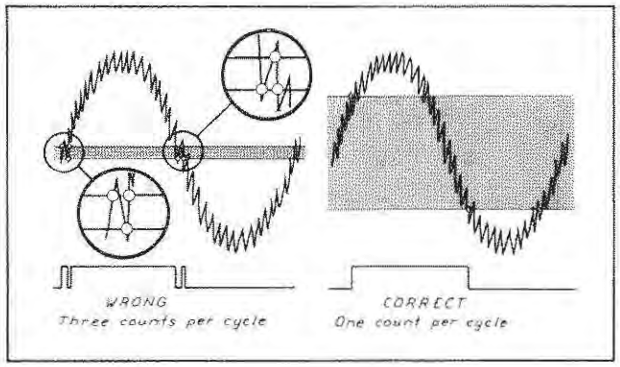


Fig. 7.5 Do not use a higher sensitivity than needed for correct triggering.

Signals which are superimposed on a DC voltage, must be separated via a capacitor (i.e. AC-coupling). The advantages of AC coupling are:
- No DC drift.
- Good protection against DC overload.

AC coupling, however, gives a drop in sensitivity for very low frequencies.

When measuring low frequency signals with superimposed high-frequency noise, one can use the HOLD-OFF as a low-pass filter with a variable cut-off frequency for input signals between 5Hz and 150kHz. For optimal noise rejection, set HOLD-OFF time to approx. 3/4 of the input signal's period duration. The function of HOLD-OFF is illustrated in Fig. 7.6.

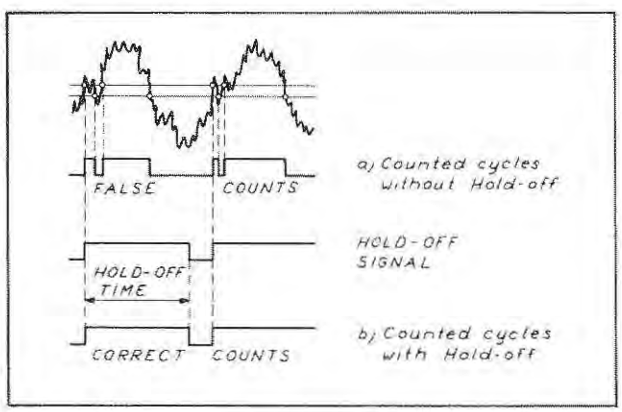


Fig. 7.6 HOLD-OFF acts as a noise rejection filter.

After the first triggering the HOLD-OFF period starts; during which time the counter is unable to perform any further input triggering. The selected Hold-Off time should expire when the signal is at maximum amplitude, to enable recovery and the start of a new Hold-Off at the beginning of the next pulse.

Time interval measurements

For time interval measurements, too wide a hysteresis band (i.e. too low a sensitivity), means that different signal slopes at the start and stop trigger point cause different delays between the trigger level crossing and the trigger point; see Fig. 7.7.

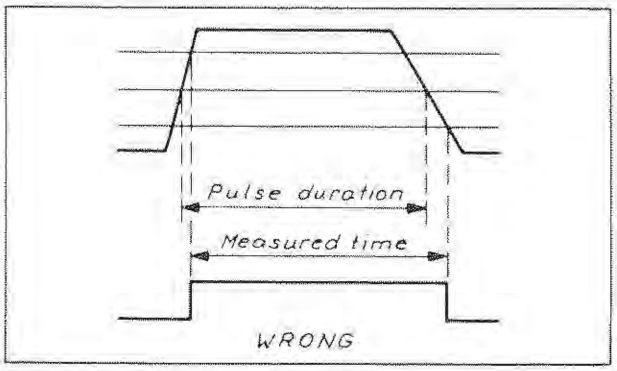


Fig. 7.7 Too wide a hysteresis might cause incorrect time interval measurements.

Systematic trigger errors are kept at a very low level thanks to the narrow hysteresis band (40 mV_{pp}) and the microcomputer controlled automatic hysteresis compensation. The resultant maximum trigger level error is only 5 mV_{pp}; see Fig. 7.8.

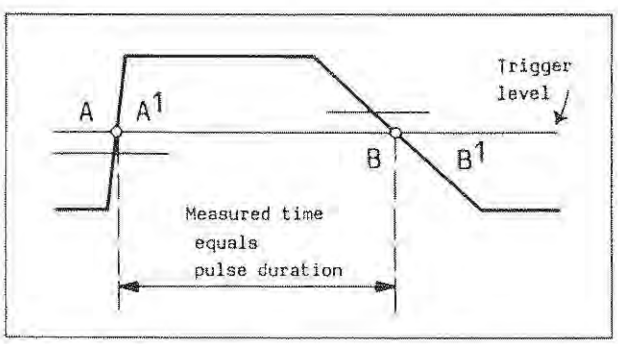


Fig. 7.8 Systematic trigger level errors are reduced with hysteresis compensation.

By lowering the trigger level on positive trigger slopes and raising it on negative slopes, one can compensate for the error due to hysteresis.

However, a calibrated input attenuator is necessary to enlarge the trigger level setting range. A separate x10 attenuator, which expands the trigger level range to -50 V...+50 V is available on the PM 6652,-54.

DC-coupling, trigger slope selection and a continuously variable setting of the trigger level is necessary for setting the trigger level at any required point of the input signal, independent of waveform or duty factor. Two identical inputs are also necessary to minimize the systematic channel mismatch error.

Input C

The counters have an optional RF input (input C) which extends the frequency measuring range up to 1.5 GHz.

The C channel option is principally a prescaler which divides the input frequency by 16. For example, an input frequency of 800 MHz will be counted by the counting logic as if it were a 50 MHz signal; see Fig. 7.9.

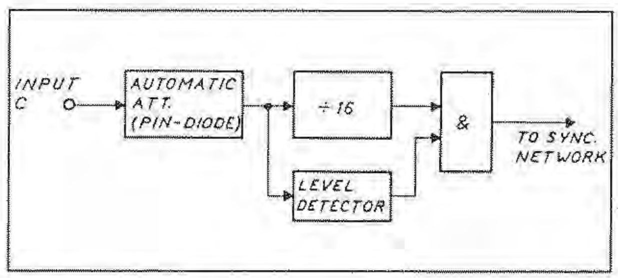


Fig. 7.9 Input C block diagram

The input signal is automatically attenuated over a wide range by means of a PIN-diode attenuator. This enables a wide dynamic range of 10 mV_{RMS}...12 V_{RMS} and excellent overload protection.

A signal level detector enables counting only when the input level is high enough. Below that level no measurement at all is made. A "clean drop-out" is thus provided and no erroneous measurements are made on RF noise.

To improve the burst-measuring capability, the level detector is automatically disabled* when the input C is used for FREQ.AVG.

NOTE: If the input C is left open in FREQ.AVG. mode, the display will show a false readout.

*) Not on PM 6652,-54, only on PM 6652C,-54C

MEASURING TIME AND RESOLUTION

The measuring time can be varied in 33 steps per decade between 0.1ms and 96s. Using the MINIMUM/SINGLE measuring time push button gives a minimum gate time of 1...2µs for (e.g.) frequency measurements. Minimum/single gives a single period measurement when (e.g.) PERIOD A is selected. The set measuring time can be displayed by pushing the READ measuring time push button. This resets the counter and a new measurement will start. In the reciprocal mode, the counter totalizes input cycles until the set measuring time has elapsed and the synchronization conditions are met. Hence, the effective measuring time (also called gate time) is longer than the set measuring time.

The number of cycles (N) is:

$$N = \frac{\text{Effective measuring time}}{\text{Period duration}}$$

NOTE: When measuring frequency with PM 6652, "N" is always rounded to the nearest higher multiple of 10.

When the measuring time has elapsed, the microcomputer reads the count registers and computes the measuring result with an 11-digit resolution. The number of digits displayed, however, is limited only to the significant digits, depending on the measuring resolution. This measuring resolution is defined by the input frequency and the measuring time.

The number of digits is selected in such a way that the measuring resolution is equal to 0.2...2 units of the least-significant digit (LSD), where:

$$\text{LSD} = \frac{5 \times \text{Frequency}}{\text{Meas.time} \times 10^9 \text{Hz}} \quad \text{or} \quad \frac{5 \times \text{Period} \times 10^{-9}\text{s}}{\text{Meas. time}}$$

for the PM 6654 and:

$$\text{LSD} = \frac{2.5 \times \text{Frequency}}{\text{Meas.time} \times 10^7 \text{Hz}} \quad \text{or} \quad \frac{2.5 \times \text{Period} \times 10^{-7}\text{s}}{\text{Meas. time}}$$

for the PM 6652.

MEASURING MODES

Frequency A or C, Period A

The PM 6652/54 perform frequency and period measurements as given in the definitions:

$$\text{Frequency} = \frac{\text{Number of cycles}}{\text{Time}}$$

$$\text{Period} = \frac{\text{Time}}{\text{Number of cycles}}$$

The counter:

- Measures the effective measuring time.
- Counts the number of input cycles during the measuring time.
- Computes the number of cycles per second (frequency) or time units per cycle (period).

The measurement in the PM 6654 is always synchronized with the input signal. This is called the input synchronized or reciprocal method.

In the input synchronized mode, both the opening and closing of the main gate are synchronized with the input signal, so that only completed input cycles are counted. This means that a ±1 input cycle error is avoided. During the gate time, the counter also totalizes the number of clock cycles; see Fig. 7.10.

The resolution in the input synchronized mode is caused by truncation of the clock pulses, which results in a ±1 clock pulse error (2ns or 100ns). The resolution of the measurement thus only depends on the measuring time. For example, the resolution for 1s measuring time is 10^{-7} (100ns/1s) for the PM 6652 and 2×10^{-9} (2ns/1s) for the PM 6654, independent of input frequency.

In conventional counters, the gate time is synchronized with the clock signal. The first and last input cycle can therefore be truncated, causing a ±1 cycle error. This results in a good resolution for high frequency measurements, but a poor resolution for low frequency measurements (±1/frequency for 1s measuring time).

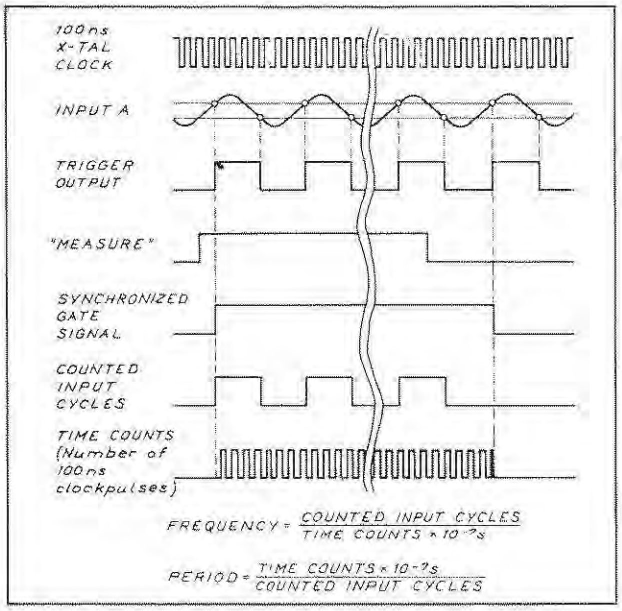


Fig. 7.10 Input synchronized mode.

For this reason, the PM 6652 uses input synchronized mode (reciprocal) for frequencies up to 10MHz and clock synchronized mode (conventional) above 10MHz. This ensures optimal resolution for all frequencies.

The PM 6654 with its very fast internal clock, uses the reciprocal mode for all frequencies.

Fig 7.11 and 7.12 shows the relative resolution of PM 6652 and PM 6654 for 1s measuring time.

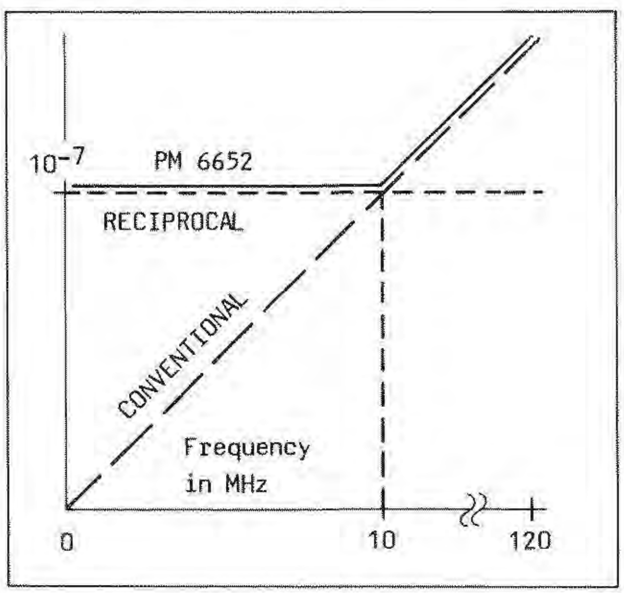


Fig 7.11 The resolution of PM 6652

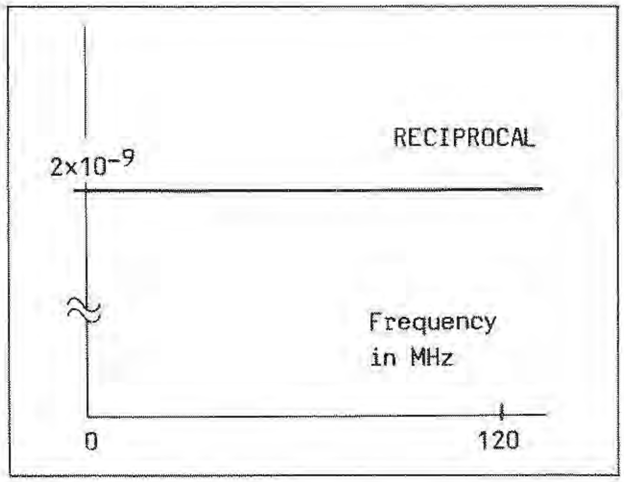


Fig. 7.12 The resolution of PM 6654

Frequency measurements on channel C (FREQ C) are made in the conventional mode in the PM 6652 and in the reciprocal mode in the PM 6654. The resolution in the PM 6654 remains the same as for FREQ A, i.e. $2x10^{-9}$ for a measuring time of 1s.

Depending on the conventional mode in the PM 6652 and on the 'divide by 16' prescaler, the resolution is 16 times the resolution of a FREQ A measurement, i.e:

$$\text{Rel. resolution} = \frac{16}{\text{FREQUENCY C}} \quad \text{(for 1s)}$$

The resolution for 1s measuring time varies over the FREQ C range from $1.6x10^{-7}$ (at 100MHz) to $1.1x10^{-8}$ (at 1.5GHz).

Ratio measurements

The counters measure the frequency ratio between signals connected to input A and input B or between the input signals on channel C and channel B.

A ratio measurement is useful, for instance, when calibrating oscillators with an odd frequency. For example, say that the frequency should be 4.3625872MHz. This is difficult to recognize on the display. By connecting such a reference signal to input B and measuring the ratio instead, the oscillator is correctly calibrated when the display shows 1.0000000, which is much easier to read.

When MINIMUM/SINGLE measuring time is selected, the counters perform a single ratio measurement: that is, the counter will count the number of input cycles on channel A or C during one single period on channel B.

Totalizing of events

There are three different modes of totalizing.

Manual:
the counter totalizes events at input A, during the time interval between releasing and depressing the START/STOP TOTALIZE A push button. An event is defined as a positive-going transition.

Gated by B:
the counter totalizes events at input A, between the leading and trailing edge of the input B signal.

Start/Stop by B:
the counter totalizes events at input A, between the start and stop event at input B.

Time interval single measurements

Time interval measurements are made in modes TIME A-B, RISE/FALL TIME A and PULSE WIDTH A. Single time intervals are measured when MINIMUM/SINGLE measuring time is selected. Otherwise, an average measurement is made.

In TIME A-B single mode, the time (i.e. number of 100ns or 2ns clock pulses) is measured between a start event at channel A and a stop event at channel B. The start and stop triggering can be set individually with respect to: coupling, trigger level, slope and attenuation (x1 or x10).

In single source TIME measurements (RISE/FALL TIME and PULSE WIDTH) only input A is connected. The input B connector is disconnected. However, channel B is internally connected to input A. Channel B will automatically get the same attenuation, coupling and input termination as channel A.

Single channel time intervals can also be measured in the TIME A-B mode by pushing the COM pushbutton. In this case, the input impedance setting of channel B is disconnected (identical to that of channel A). The coupling, attenuation, trigger level and slope in channel B can still be set independently of the channel A setting. The resolution of the single measurement is 1 clock pulse (2 or 100ns).

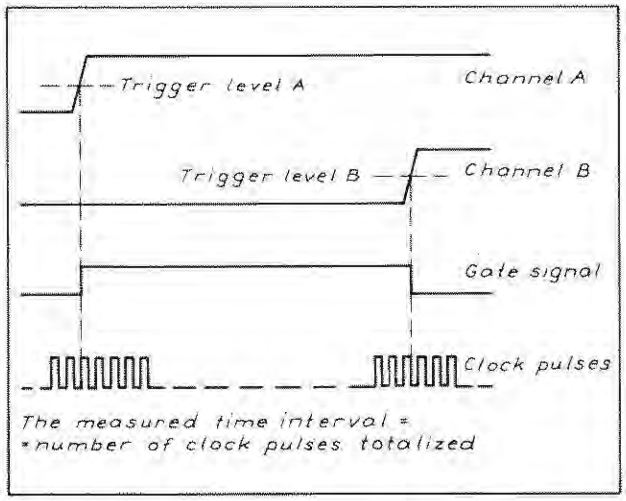


Fig. 7.13 Time interval single mode.

Pulse width measurements

These measurements are similar to single time interval measurements. When PULSE WIDTH A is selected, the counter automatically:

- Activates COM via A;
- Sets trigger level B = trigger level A;
- Sets coupling B = coupling A;
- Sets attenuation B = attenuation A;
- Sets slope B = inverse slope A.

When AUTO triggering is selected, the counter automatically sets the trigger level to 50% of the pulse amplitude in channel A. Note that AUTO requires a repetitive input signal > 100Hz.

Rise/fall time measurements

Rise or fall time measurements (RISE/FALL time) are very similar to TIME A-B measurements. When RISE/FALL time is selected, the counter automatically:

- Activates COM via A function;
- Sets coupling B = coupling A;
- Sets attenuator B = attenuator A;
- Sets slope B = slope A.

A rise time measurement is selected by choosing positive trigger slope A; fall time by choosing negative slope. When AUTO triggering is selected (in a rise time measurement), the counter also sets trigger level A to 10% and trigger level B to 90% of the Vpp value. For fall time measurements (negative slope on input A), the trigger levels are automatically set to 90% in channel A and 10% in channel B.

Time interval average measurements

By using the time interval average technique, which means multiple measurements of a repetitive signal, the measuring accuracy and resolution are greatly improved. Compared to single time interval measurements, the basic 2ns or 100ns resolution is improved by a factor of $1/\sqrt{N}$, where N is the number of time intervals being averaged.

$$N = \frac{\text{Measuring time}}{\text{Pulse repetition time}}$$

Averaging of TIME A-B, RISE/FALL time A and PULSE WIDTH A measurements are normally performed as long as MINIMUM/SINGLE measuring time is not selected. When using time interval average, the number of leading edges of the clock pulses occurring in each individual "time window" are totalized. Fig. 7.14 illustrates a rise-time measurement.

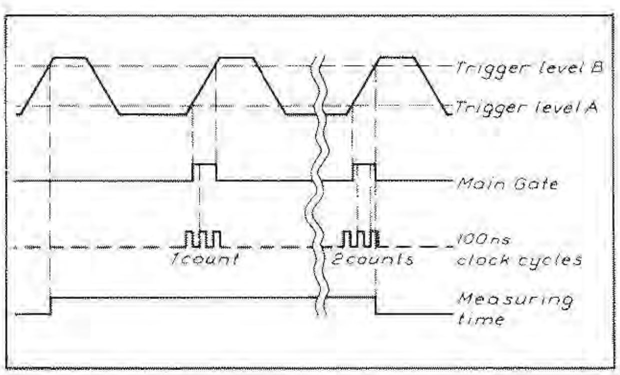


Fig. 7.14 Time interval average mode, PM 6652.

For a signal as illustrated in Fig. 7.14, approximately 10000 time intervals are being averaged during a measuring time of 10ms. Say that 6000 are measured as 200ns (2 clock cycles) and 4000 as 100ns. The statistical average is calculated in the microcomputer. In this case the average is 160ns. The resolution is $100\text{ns}/\sqrt{10000} = 1\text{ns}$.

Note that the input signal must be repetitive and asynchronous with respect to the time base and that the minimum dead time from stop to start is 50ns for the PM 6654 and 250ns for the PM 6652.

In time interval average mode in the PM 6654, the internal clock resolution is 10ns, not 2ns as in single shot measurements. The PM 6652 has the same internal clock resolution (100ns) for both average and single measurements.

Phase delay measurements

The timer/counters can measure the phase delay between two signals connected to inputs A and B. The measurement is performed by simultaneously measuring the time interval A-B and period. The phase delay is calculated as:

$$\text{Phase delay} = \frac{\text{Time Interval A-B}}{\text{Period}} \times 360^\circ$$

The measurement is made as an average measurement to improve accuracy and resolution; see Fig. 7.15.

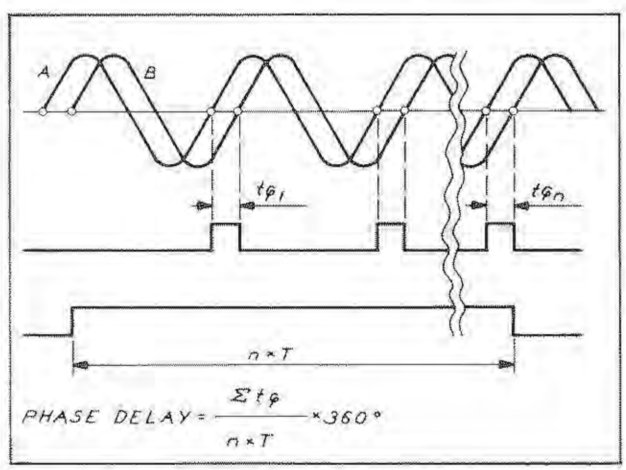


Fig. 7.15 The phase delay measurement.

In order to obtain a high accuracy time interval measurement in the phase delay function, the setting of the trigger level is very important. The trigger levels should be identical for both channels and as close to zero as possible. This is normally achieved with AC coupling and trigger levels = 0mV. Unequal settings of the trigger levels will result in inaccurate time interval measurements; see Fig. 7.16.

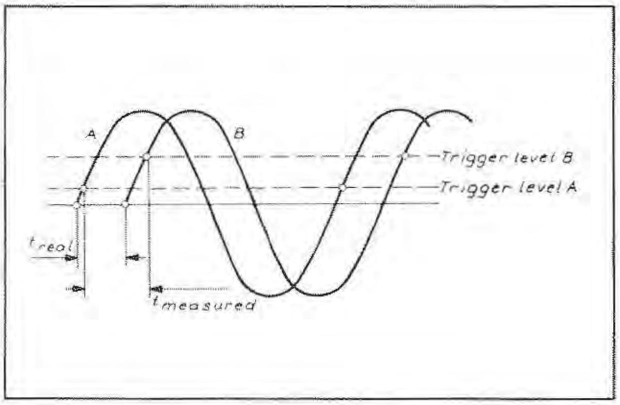


Fig. 7.16 Unequal settings of the trigger levels will result in inaccurate time interval measurements.

Very large differences in slew rate between the two signals, can result in a systematic phase error, which can be up to 1.5°. This is caused by the hysteresis band (typically ±5mV after hysteresis compensation). Although the trigger level is set to 0mV, the actual trigger point could be +5mV. With variations in slew rate, the time before crossing the +5mV limit will vary, It is therefore important to keep the signals at about equal amplitude (sine and triangular waves). see Fig. 7.17.

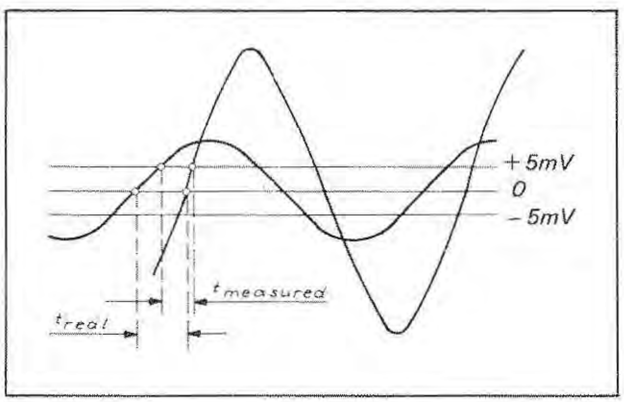


Fig. 7.17 Variation in slew rate will result in phase error.

The systematic phase error for sine waves can be expressed as:

$$\arcsin(5mV / U_{max}A) - \arcsin(5mV / U_{max}B)$$

Since a normal time interval average measurement is made, there is also a restriction concerning minimum dead time between stop and start of the time interval (i.e. 250ns). The dead time also determines the maximum signal frequency, which is 2MHz.

Note that the PM 6654 has exactly the same performance as the PM 6652 in phase measurements.

Duty factor measurements

Duty factor (or duty cycle) measurements are similar to phase measurements. A simultaneous measurement of pulse width and period is performed. The duty factor is then calculated as:

$$\text{Duty factor} = \frac{\text{Pulse width}}{\text{Period}}$$

Fig. 7.18 illustrates the measurement.

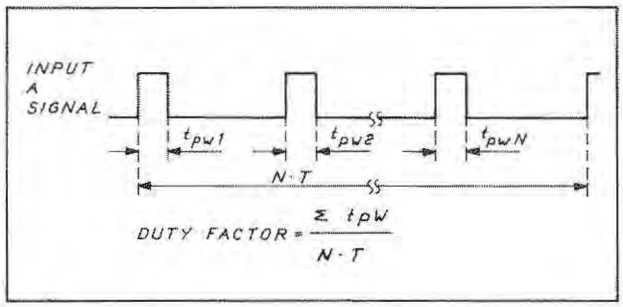


Fig. 7.18 Duty factor measurements

Voltage Measurements

Measurement of the input voltage levels Vmax Vmin on channel A can be performed on DC input voltages and on repetitive signals in the frequency range 100Hz...20MHz.

For input signals up to 20MHz the measurement has "voltmeter performance" (i.e. an accuracy of about 3% of the reading). Voltage measurements can be performed up to 80MHz with reduced accuracy.

Vpp is the calculated result of a V_{min} and V_{max} measurement, which means that both functions "V_{max} V_{min} A" and "V_{pp} A" are the same as far as voltage measurement is concerned. The displayed result when "V_{pp} A" is selected is then calculated as V_{max} - V_{min}.

When the shape (sine, pulse) of the input signal is known, half the crest factor can be set as the constant K in the mathematical function. The display will then show the actual V_{RMS} value of the input signal.

EXAMPLE: A sine wave has a crest factor of 0.707 ($\sqrt{2}/2$).Half the value is loaded as the MATH constant "K=" = 0.354. With AC coupled inputs and with V_{pp} selected, the display will now show the RMS value of any sine wave input.

If the sine wave is superimposed on a DC voltage, the RMS value is found as: $0.354 \times V_{pp} + V_{dc}$. If V_{dc} is not known it can be found as:

$$V_{dc} = \frac{V_{max} + V_{min}}{2}$$

External Control

General

EXT CONTROL is a switch located on the rear panel. This switch allows an external signal to start or stop measurement. With ARMING the start is defined; with EXT GATE the start/stop is defined; and with AVG a number of samples is taken during the set measuring time. The start and stop of sampling is defined by the AVG control signal.

The active slope of the EXT CONTR signal can be set to NORMAL or INVERTED with the SLOPE-button*. The selection is indicated on the front panel. NORMAL-slope will be presumed in the following text.

*) Only on PM6652C,-54C.

Arming

Arming enables the counter to avoid starting on unwanted signals. The external ARMING input (input E on the rear panel) allows an additional trigger condition. When input E goes high (above 2 V), the counter is prevented from starting a new measurement. However, the counter makes all preparations for a measurement. When input E returns to low (below 0.5 V), the measurement will start with a minimum of delay. The delay is approx 50 ns; see Fig. 7.19.

NOTE: Arming cannot be used for TOT A manual mode, phase and duty factor measurements.

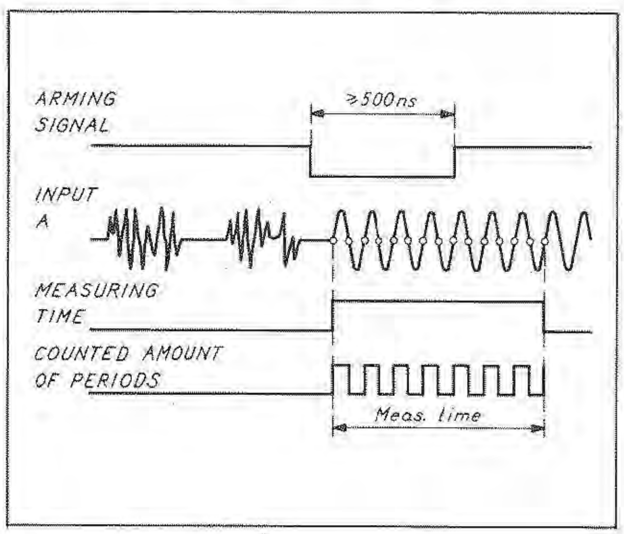


Fig. 7.19 The ARMING function.

Ext Gate

The External Gate function allows full control of the start and stop of the measurement. When EXT GATE is selected and the control input signal is low the counter makes all necessary preparations for a measurement.

On a low-to-high transition of the gate signal, measurement starts when the input signal triggers. Measurement stops on the first trigger after the gate signal goes high to low. See Fig. 7.20.

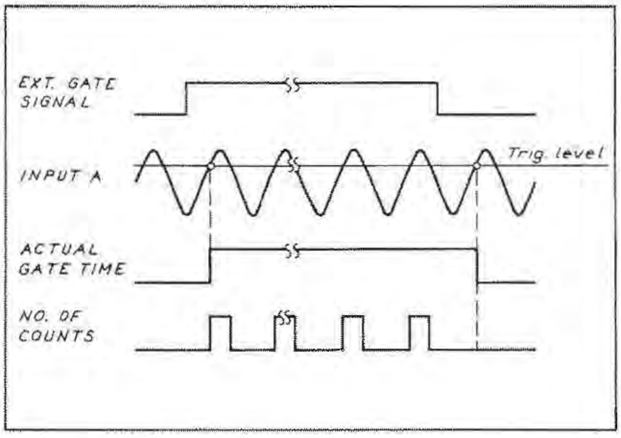


Fig. 7.20 External gate

External gate can be used in FREQ A, FREQ C and PERIOD measurements. Note that the use of EXT GATE in a PM 6652 will result in reciprocal frequency measurements for all frequencies.

Also note that the use of EXT GATE in a PM 6654 will result in the same performance as a PM 6652 (i.e. a 100ns internal clock is used and relative resolution (in 1s) is altered from $2x10^{-9}$ (normal PM 6654 resolution) to 10^{-7}).

Average

By using the average function it is possible to take samples of the input signal during measurement. This can be useful (when for instance, measuring the frequency in repetitive bursts; see Fig 7.21. The input frequency range is for PM 6652 channel A, 0...100MHz, for PM 6654 channel A, 0...120MHz. When the C-channel option is used 50...1500MHz for both counters.

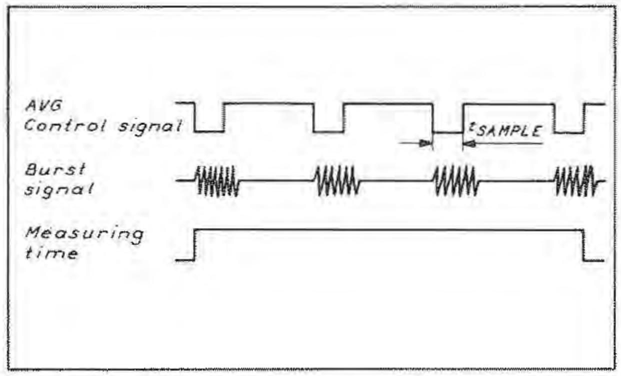


Fig. 7.21 Frequency average.

The bursts can be as short as 200ns (PM 6654) or 500ns (PM 6652). The measurement is interrupted when the ext. control input is high (>2V). The effective gate time is thus the sum of the "sample pulses" during the set measuring time, according to Fig. 7.21.

In order to ensure synchronization of measurement, each sample pulse must stop before the burst input stops.

In the PM 6654 the control signal (sample pulse) must go high at least 50ns before the burst stops; see Fig. 7.22.

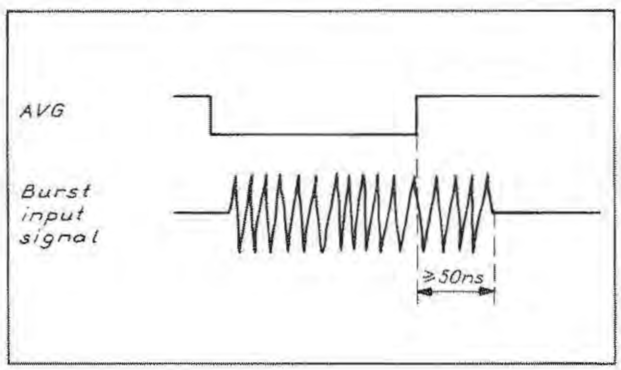


Fig. 7.22 AVG signal in the PM 6654 must go high at least 50ns before the burst stops.

In the PM 6652 the input signal must contain at least 20 cycles; 10 of these before the AVG signal goes high and then at least another 10 cycles after the low to high transition of the AVG signal; see Fig. 7.23.

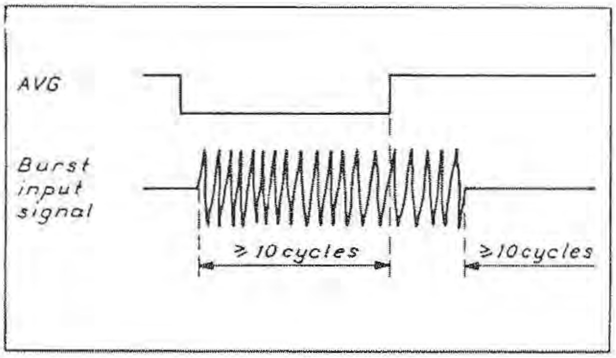


Fig. 7.23 The AVG signal in the PM 6652 must go high at least 10 input cycles before the burst stops.

The use of AVG in a PM 6652 will result in reciprocal measurements (FREQ A, FREQ C) for all frequencies.

The difference in propagation delay in the two internal channels for input event counts and clock pulses is very small; approx. 15 ns for the PM 6652 and approx 1 ns for the PM 6654. In FREQ A AVG mode with very short sample pulse times, this delay will cause a measurable error as the 1ns or 15 ns will be repeated for each external sample pulse.

It is possible, however, to compensate for this error. Measure a stable, continuous signal of approx. the same frequency, in the normal mode without external control signal (measured value = F1). Then measure the same signal with an external control signal having the same number of samples and the same sample pulse duration as will, ultimately be used (measured value = F2). To compensate for the error obtained in the frequency average mode, multiply the reading with the factor K=F1/F2 using the MATH function.

The total relative error for a multiple frequency average measurement in PM 6652 is approx:

$$\pm \frac{15 \text{ ns}}{t_{EC}} \pm \frac{100 \text{ ns} \pm \text{trig error}_A}{t_{EC} \times \sqrt{N}} \pm$$

± rel. time-base error.

The relative error in PM 6654 is approx:

$$\pm \frac{1 \text{ ns}}{t_{EC}} \pm \frac{2 \text{ ns} \pm \text{trig error}_A}{t_{EC} \times \sqrt{N}} \pm$$

± rel. time-base error.

Where: t_{EC} = sample time duration
N = number of burst samples

External reset

External reset (rear panel input) provides an equivalent function to the front panel reset push button except for the LOCAL-function of the button in the PM 6652C,-54C. The counter is always reset when the input is set to high logic level (above 2 V). A new measurement can be made when input E has returned to low (below 0.5 V).

Hold-Off

The counters are equipped with trigger Hold-Off, which avoids false stop triggering on spurious or unwanted signals. The Hold-Off function is valid in all time modes (TIME A-B, PWIDTH A and RISE/FALL time A). A typical example is to suppress the effect of pulses from relay contact bounce, as illustrated in Fig. 7.24.

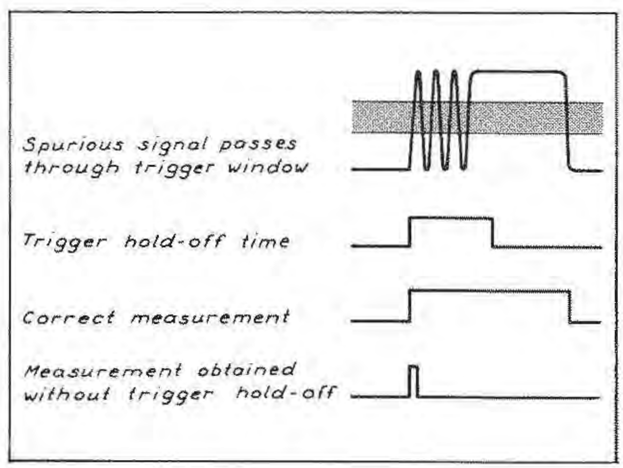


Fig. 7.24 Hold-off avoids false triggering.

Hold-Off can also be used in FREQ A and PERIOD A measurements as a digital noise suppression filter for input frequencies between 5 Hz and 150 kHz. Fig. 7.25 shows a low frequency signal with added noise.

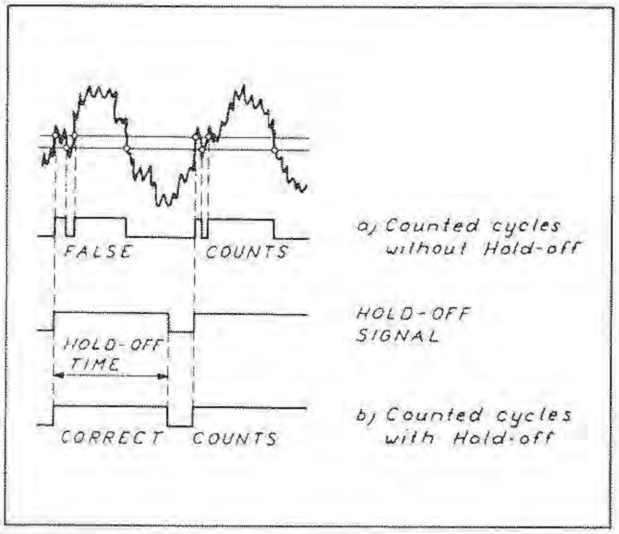


Fig. 7.25 Hold-Off as a noise rejection filter.

Without Hold-Off, the counter might trigger on the noise, thereby causing some erroneous extra counts. See Fig. 7.25.

With Hold-Off set to approx. 3/4 of the period time of the input signal, additional noise triggerings are ignored until the signal reaches its maximum negative amplitude. Retriggering is then allowed and will occur at the beginning of the next input cycle (a new Hold-Off period starts, etc). Hold-Off is also active in the RATIO A/B and TOTALIZING A modes.

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.

When Time-Interval Delay is selected, the counter rejects stop-pulses for a time equal to the set **Measuring time.**

The use of the function is the same as that of Hold-Off. It is applicable to the following functions:

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

NOTE: Time-Interval Delay cannot be selected together with Hold-Off, and it can only be programmed via the IEEE-488 bus.

Gate open

The PM 6652,-54 is equipped with a gate open output for monitoring on an oscilloscope. Fig. 7.26 is an illustration of the gate open function. Note that the gate open signal is longer than the set measuring time due to the synchronization time.

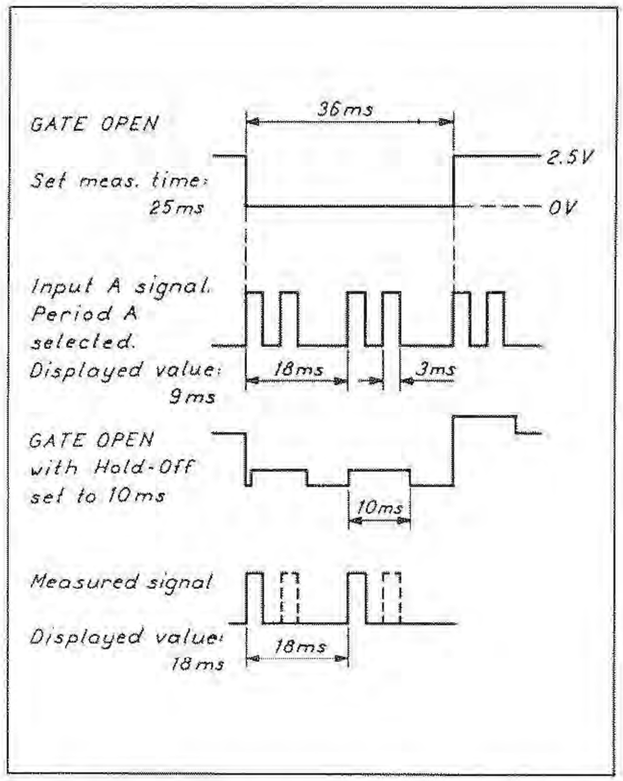


Fig. 7.26 An illustration of the gate open function, with and without Hold-Off.

Chapter 8

PERFORMANCE CHECK

CONTENTS Page

INTERNAL TEST PROGRAMS

Both the PM 6652 and PM 6654 have built in test programs, which can be activated and monitored by the user. To activate these programs:

- Set the FUNCTION cursor to TEST.
- Press any of the keyboard buttons 1...6.

When a test is activated, the display indicates the relevant test number. When the test is completed satisfactorily, the display will return to show zeroes.

Test No.	What is tested	Duration (s)
1	Program memory	12
2	Working memory	2
3	Non-volatile memory	12
4	Measuring logic	4
5	Display	50
6	Test no 1...5 in one sequence	80

Table 8.1

Test 5 is a check of the display and all LED:s. The test has the following sequence:

- The display shows 0000000000 EXP 0
  1111111111 EXP 1
  2222222222 EXP 2
  3333333333 EXP 3
  4444444444 EXP 4
  5555555555 EXP 5
  6666666666 EXP 6
  7777777777 EXP 7
  8888888888 EXP 8
  9999999999 EXP 9

- The display shows all decimal points.

- The display shows a shifting 8 plus the "-" in front of the exponent.

- All unit indicators, function cursors and LED:s in the control buttons are lit in sequence.

- The entire display and all LED:s will light at the same time, except for the function cursor FREQ A...TEST and ST BY.

All test programs can be stopped by pressing RESET. The counter then returns to normal working mode.

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

The indication "E4" could be caused by incorrect setting of the INT/EXT STD IN switch on the rear panel.

In most cases, any error indication generated in a test program can be cleared by activating RESET. Measurements may be possible, but the results of any such measurement are likely to be inaccurate.

A POWER ON TEST is activated whenever power is switched from ST BY to ON. This test consists of tests numbers 2, 4 and part of number 5.

FRONT PANEL CONTROLS

START/STOP TOTALIZE A

- Select the function TOT A/MAN and check that it is possible to turn the gate indicator on and off using START/STOP TOTALIZE A.

LOCAL/RESET

- Check that the display is turned off while this control is pressed, and that it reverts to zeroes when it is released.

DISP = K x X + L

- Check that the LED can be turned on and off.

K=, L= and KEYBOARD

- Press K=. The ENTER LED should light.
- Press 1 2 3 4 5 6 7 8 9 ± EE 9 ±.
- Check that the display shows:-123456789 EXP-9.
- The ENTER LED should be blinking.
- Press ENTER. The value on the display should disappear.

- Press K= again. The display should indicate: -123.456789 EXP-3
- Press K= again.
- Press L=.

- Check that the ENTER LED is lit.
- Press 1234.5.
- Check that the ENTER LED is blinking.

- Press ENTER and L=.
- The display should indicate 1.2345 EXP 3.
- Press L= again.

HOLD OFF

- Press HOLD OFF ON. The LED should light.

- Press READ. Now both LEDs should light.

- Adjust the potentiometer and check the display reading against table 8.2.

	Display readings	
	Potentiometer setting	
	counter-clockwise	clockwise
Pulled	$< 999 \times 10^{-6}$	$> 200 \times 10^{-3}$
Pushed	$< 5 \times 10^{-6}$	$> 1.00 \times 10^{-3}$

Table 8.2

- Press the potentiometer and switch the HOLD OFF and the READ function off.

DISPLAY HOLD

- Check that the LED can be turned on and off.

Measuring time, READ and potentiometer

- Press the READ button. The LED should light.
- Turn the potentiometer fully CCW.
- Check that the display shows 0.1 ms.
- Turn the potentiometer fully CW.
- The display should indicate 96 s.
- Switch the measuring time READ off.

MINIMUM/SINGLE

- Check that the LED can be turned on and off.

FUNCTION

- Check that the cursor can be moved through all functions and programs both stepwise and in repetitive "scrolling" mode. The cursor jumps over the C function if the option is not installed. It hesitates in position FREQ A and TEST.
- Test both pushbuttons

STORE

- Press STORE once. The LED should light.
- Press RESET. The STORE LED should be turned off. Be careful with any existing stored panel programs. Only press STORE once.

Input controls

- Check that each LED is lit and turned off by the relevant push button.

Triggering controls

- Press AUTO and check that the LED is turned on and off.
- Press KEYBOARD and leave it on (LED on).
- Press AUTO twice. Both AUTO and KEYBOARD should be turned off.
- Press READ (LED on).
- Check that both attenuators are off.
- Turn both potentiometers fully CCW.
- Check the set levels. They should be below -5.00 V.
- Repeat for the fully clockwise position, The values should be above +5.00 V.

SET A and SET B

- Press SET A. The ENTER LED should light.
- Enter 123, the display should read 1.23.
- The ENTER LED should be blinking.
- Press ENTER, the LED should go off.
- Repeat the same exercise for channel B.
- Press the KEYBOARD button.
- Press READ.
- Check that the attenuator is in position x1.
- The display should now show 1.23 and 1.23.

REAR PANEL CONTROLS

External control

- Set the switch on the rear panel to position EXT GATE.
- Check that the front indicator EXT GATE is on.
- Repeat for FREQ AVG and ARMING.
- Depress the SLOPE button.
- Check that the indicator on the front panel is on.
- Set the EXT CONTR back to off and SLOPE back to NORMAL.

EXT/INT standard

- Set the switch to position EXT STD.
- Switch the counter off and on.
- With no signal connected to the rear EXT STD input the counter should indicate error E4.
- Set the switch back to position INT.

SHORT FORM SPECIFICATION TEST

Test equipment required

LF-Synthesizer e.g. Philips PM 5190
Voltmeter e.g. Philips PM 2517
Lowpass filter e.g. Philips PM 9665B
PM 9584 50 Ohm T-piece
50 Ohm termination PM 9581 or PM 9585
Oscilloscope e.g. Philips PM 3215
HF signal generator e.g. Wavetek 2002A
Frequency counter e.g. Philips PM 6672
IEC-Bus controler e.g. HP 85
Sampling oscilloscope BW min. 500 MHz

Sensitivity and frequency range, inputs A and B

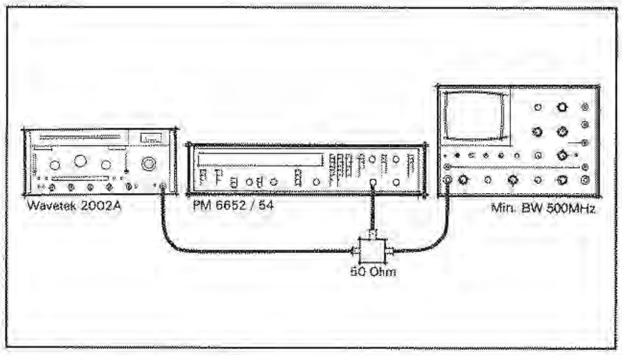


Fig. 8.1 Measuring set up.

- Switch on the counter in non programmed mode.
- Select "50 Ohm" on channel A and KEYBOARD.
- Adjust the measuring time to approx. 10 ms.
- Connect the units according to fig. 8.1.
- Set the HF generator to 60 MHz and -15 dBm.
- The oscilloscope should indicate approx. 56 mV_{pp} and the counter 60 MHz.
- Change the HF-generator to 120 MHz and -12 dBm.
- Check that the oscilloscope indicates approx. 80 mV_{pp} and the counter 120 MHz.

- Select RATIO A/B and COMMON. Change the HF-generator to 10 MHz and -17 dBm.
- The oscilloscope should indicate approx 45 mV_{pp}.
- The counter shows 1.00 E.

Sensitivity and frequency range, input C

- Select the function FREQ C.
- Connect the HF generator to input C.
- Check that the counter counts correctly from 100...1000MHz at a signal level of -27dBm.
- Check the correct counting at -17dBm signal level from 1000...1500MHz.

Check V_{max} and V_{min}

- Select the function V_{max} V_{min}, but do not connect any input signal.
- The counter should now indicate $V_{max} = 0 \pm 30mV$ and $V_{min} = 0 \pm 30mV$.
- Connect a 4.00V DC level to channel A, using a low pass filter on the input.
- The readings should be V_{max}=4.00 ±0.09V, V_{min}=4.00 ±0.09V.
- Change the DC level to 40V.
- The counter should indicate V_{max}=40.0 ±1.3V, V_{min}=40.0 ±1.3V.

- Repeat the measurement with inverted polarity.

- Connect a sinusoidal signal to channel A from the PM 5190 with an amplitude 4.00V_{pp} and a frequency of 100kHz.
- The indication should be V_{max}=2.00 ±0.15V, V_{min}=-2.00 ±0.15V.

- Change the amplitude to 18V_{pp}.
- The display should read V_{max}=9.0 ±1.2V, V_{min}=-9.0 ±1.2V

The relatively high inaccuracy is due to the specification of the generator.

Trigger indicators and controls

- Start the counter in non programmed mode.
- Connect the following signal to channel A: sinus, 10kHz, 1.0V_{pp} and +0.50V_{DC}.
- Select trigger level setting via potentiometer.
- Turn the potentiometer for channel A and verify that the three modes of the trigger indicator are working properly.
- Repeat the exercise with channel B.
- Connect the generator to channel A and check:

Trigger setting	Trigger indicator
level -200mV	blinking
DC	on
level +700mV	blinking
50 Ohm	off
level +200mV	blinking
AC, 1MOhm	blinking
x 10	off
level ±0V	blinking
x 1	blinking

- Select AC coupling on channel B and repeat the previous settings for channel B.
- Connect the signal to channel A.
- Only the trigger indicator for channel A should be blinking.
- Press common.
- Both indicators should be blinking.
- Connect the signal to channel B.
- No trigger indicator should be blinking.

Check of the Time interval function

- Switch the counter on in non programmed mode.
- Select the functions TIME A-B, KEYBOARD, COM, 50 Ohm and negative slope on channel A, measuring time approx. 10 microseconds.
- Set a LF generator to 1.5MHz and 2V_{pp}.
- Connect the generator to channel A.
- The counter should show approx. 333ns.
- Select positive slope for channel A and negative for channel B.
- The display should indicate approx. 333ns.

Rear inputs

EXT CONTR, EXT RESET and EXT STD IN

- Start the counter in a non programmed position.
- Measuring time 100ms and select CHECK.
- Ext control to ARMING.
- The counter should measure and display 10MHz.
- Connect a 1.9V DC level to the EXT control input.
- The counter should not measure (gate diode off)

- Reduce the DC level at the EXT input to 0.50 V.
- The counter should measure and display 10 MHz.
- Depress the SLOPE button so that the indicator for INVERTED is switched on.
- The counter should not measure.

- Set the rear EXT CONTR to OFF.
- Connect the DC-level of 1.9 V to EXT RESET input.
- The display should show zero.
- Reduce the EXT RESET DC level to 0.50 V.
- The counter should indicate 10 MHz.

- Set the INT/EXT STD switch to EXT STD.
- The counter should not measure.
- Connect a 10.00 MHz signal with an amplitude of 400 mV_{RMS} (terminate with 50 Ohm) to the EXT STD input.
- The counter should measure and show 10 MHz.
- Set the EXT STD switch to position INT STD.

Rear outputs

TRIGG LEVEL OUT

- Set the counter to position FREQUENCY A.
- Connect a voltmeter to TRIGG LEVEL OUT A.
- Select a trigger level via the potentiometer (KEYBOARD and AUTO off) and press READ.
- Adjust the trigger level to 5.00 V ±0.01 V.
- Check that the voltmeter shows 4.92...5.08 V.
- Adjust the trigger level to -5.00 V.
- Check that the voltmeter shows -5.08..-4.92 V.

- Select KEYBOARD.
- Set 5.12 V, the voltmeter should read 5.07...5.17 V.
- Set -5.11 V and check: -5.16...-5.06 V.
- Set 0 V and check: -10...+10 mV.

10 MHz OUT

- Connect an oscilloscope to the 10 MHz output. Use coaxial cable and 50 Ohm termination.
- The output voltage should be above 1.3 V_{pp}.

GATE monitor

- Switch the counter off when in non programmed mode. Switch on again.
- Select CHECK, KEYBOARD triggering and RATIO A/B.
- Turn the measuring time potentiometer fully counter clockwise.
- Connect, via a coaxial cable, an oscilloscope (no 50 Ohm termination) to the GATE monitor output.
- Switch the HOLD OFF on with the potentiometer pressed in and turned to the fully counter clockwise position. There should be a signal as in fig. 8.2 , where the frequency of the superimposed pulses on the square wave is adjustable by means of the HOLD OFF.

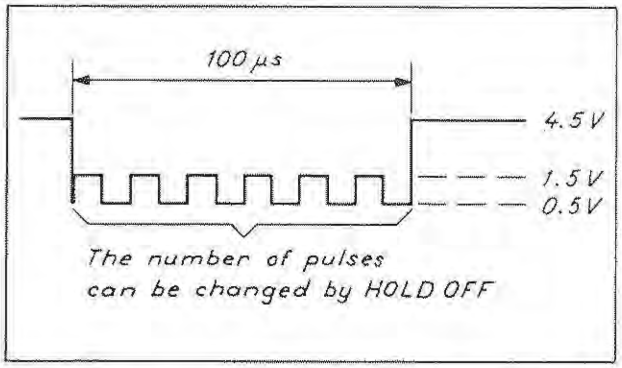


Fig. 8.2 Gate monitor pulse with HOLD OFF pressed and turned to minimum position.

IEEE BUS INTERFACE

- Connect a controller to the IEEE Bus interface PM 9696 in the PM 6652,-54.
- Set the PM 9696 to position "talker only" off.
- Select an address (all allowed except 31).
- Switch on the PM 6652,-54.
- Select measuring time 100 ms and press CHECK.
- The counter should display 10MHz.
- Do not change the measuring time setting during the test.

- Via the controller, give bus command REMOTE.
- The counter should go to remote mode, the indicator "REMOTE" should light and the measurements should continue with all front panel controls disabled.
- From the controller, program the unit to measure PERIOD A, send the command F3 from the controller.
- The counter should measure and display 100 ns.

- Give bus command LOCAL.
- The counter should go back to LOCAL mode; the remote indicator should go off.
- Activate the DISPLAY HOLD function by pressing the control.
- Give bus command REMOTE.
- The counter should go over to remote, the indicator "REMOTE" should be on, all controls disabled and no measurements take place; the display shows only zeros.

- Ask, via the controller for the status byte of the counter (serial poll).
- The result should be 19 (decimal).

- Give a bus TRIGGER command (GET) via the controller.
- The counter should perform one measurement.
- The result should be 100 ns.
- Read the result via the controller. For a PM 6652 it should be: PA 000100.0000E-9 ± 2 in the LSD-position. For a PM 6654 it should be: PA 00100.00000E-9 ± 2 in the LSD-position. If the reading fails then check the set DEFAULT DELIMITER in the PM 9696.

- The counter should not be measuring.
- Give a bus TRIGGER command (GET) via the controller.
- The counter should perform one measurement; check the GATE indicator.

- Give bus command SELECTIVE DEVICE CLEAR (SDC).
- The counter should go to the FREQ A function.

- The functions DISPLAY HOLD and CHECK should be switched off.
- The display should only show zeros.

- Program the CHECK function, command CH1.
- Send the command F17 via the controller.
- The counter should stop the measurement and give the message SERVICE REQUEST.

- Ask, via the controller, for the status byte of the counter (serial poll).
- The answer should be 111 (decimal).
- The counter should start to measure and display 10 MHz.

- Give bus command SELECTIVE DEVICE CLEAR (SDC).
- The function CHECK shall be switched off.
- The counter should not measure and the display should show only zeros.

- Give bus command LOCAL.
- The counter should go to local mode, the remote indicator goes off and all controls are activated again.

- Give bus command REMOTE.
- Make a quick depression of the LOCAL/RESET-button.
- The counter should go to local mode, the remote indicator goes off and all controls are activated again.

Chapter 9

TECHNICAL SPECIFICATION

CONTENTS Page

DEFINITIONS

Inaccuracy

The inaccuracy (relative error) of a measurement depends on 4 factors:

- rel. resolution
- rel. time base error (if any)
- rel. trigger error (if any)
- rel. systematic error (if any)

Inaccuracy = ± rel.resolution ± rel.time base error ± rel.trigger error ± rel.systematic error

Trigger error

Trigger error (T.E.) is the absolute measurement error due to input noise, causing triggering which is too early or too late.

FREQUENCY, PERIOD, RATIO

T.E.=±Noise Voltage (V_{pp})/Signal slew rate (V/s)
T.E.= ± 1/FREQ x π x S/N-ratio (sine wave)

TIME INTERVAL, RISE/FALL TIME, PULSE WIDTH, DUTY FACTOR

T.E.= ± Noise Voltage (V_p)/slew rate at START point ± Noise voltage (V_p)/slew rate at STOP point

PHASE

T.E.= ± 1/FREQ x π x S/N-ratio (Sine wave, same S/N-ratio for both channels)

Resolution

Multiple event measurements

FREQUENCY, PERIOD and RATIO, the resolution is the smallest increment between two measuring results. The measuring resolution is due to the ±1 count error. After calculation, the result to be displayed is truncated to include only significant digits giving a measuring resolution of 0.2...2 LSD units. Total resolution, including LSD resolution, is therefore 1 LSD unit (70% probability) or 2 LSD units (30% probability) but can always be reduced to 1 LSD unit by increasing the measuring time somewhat.

Single event measurements

PERIOD SINGLE and TIME INTERVAL SINGLE, resolution is one clock pulse period, regardless of the measuring time.

Statistical measurements

TIME INTERVAL AVERAGE, RISE/FALL TIME, PULSE WIDTH, PHASE and DUTY FACTOR, the resolution is the smallest increment between two measuring results with a confidence level of 95%.

Systematic error

When a systematic error is known, the measured value can be compensated before display by using the MATH functions.

TIME INTERVAL, PULSE WIDTH

Syst. error < ±2ns (PM6654) or < ±4ns (PM6652)

RISE/FALL TIME

$$\text{Syst. error} = \text{TIME INTERVAL syst. error} \pm \frac{2\% \text{ of } V_{pp}\text{ (A)} + 5\text{mV}}{\text{slew rate (A) at 10\% (V/s)}} \pm \frac{2\% \text{ of } V_{pp}\text{ (A)} + 5\text{mV}}{\text{slew rate (A) at 90\% (V/s)}}$$

PHASE (AC-coupling, trigger level = 0V)

Sine wave:
$$\text{Syst.error} < \arcsin(5\text{mV}/U_{max}\text{ A}) - \arcsin(5\text{mV}/U_{max}\text{B})$$

Triangular wave:

$$\text{Syst. error} < \frac{5\text{mV} \times 90°}{U_{max}\text{ A}} - \frac{5\text{mV} \times 90°}{U_{max}\text{ B}}$$

Syncronization modes

Conventional mode

Means that the gate time is synchronized with an integer number of clock pulses. The error is ±1 input cycle. (Only used in the PM 6652 above 10 MHz).

Reciprocal mode

Means that the gate time is synchronized with an integer number of input cycles. The error is ± 1 clock pulse, i.e. ± 100 ns (PM 6652) or ± 2 ns (PM 6654). The use of this mode gives 7 digits (PM 6652) or 9 digits (PM 6654) resolution for a one second measuring time.

LSD displayed

Unit value of the Least Significant Digit displayed. All calculated LSDs (see section Measuring modes) should be rounded to the nearest decade before displayed (e.g. 5 ns will be 10 ns and 0.4 Hz will be 0.1 Hz) and cannot exceed the 10th digit.

Time base error

The relative time base error is the relative deviation of the clock pulse frequency from 10 MHz. Rel. time base error = Δf/10 MHz. See specification for oscillators version/01...05.

OSCILLATORS

PM 6652,-54 VERSION / RELATIVE FREQUENCY DEVIATION CAUSED BY:	/.1. standard crystal oscillator	/.2. PM 9678 TCXO oscillator	/.3. PM 9679 oven enclosed oscillator	/.4. PM 9690 oven enclosed oscillator	/.5. PM 9691 oven enclosed oscillator
Ageing: /24 h /month /year (continous operation)	n.a. $<5\times10^{-7}$ $<5\times10^{-6}$	n.a. $<1\times10^{-7}$ $<5\times10^{-7}$	n.a. $<1\times10^{-7}$ $<5\times10^{-7}$	$<1.5\times10^{-9}$ * $<3\times10^{-8}$ $<1.5\times10^{-7}$	$<5\times10^{-10}$ * $<1\times10^{-8}$ $<7.5\times10^{-8}$
Ambient temperature variation: Range 0...+50 °C Refered to +23 °C	$<1\times10^{-5}$	$<1\times10^{-6}$	$<1\times10^{-7}$	$<3\times10^{-8}$	$<5\times10^{-9}$
Supply voltage change of ± 10 %:	$<1\times10^{-8}$	$<1\times10^{-9}$	$<1\times10^{-9}$	$<5\times10^{-10}$	$<5\times10^{-10}$
WARMING-UP TIME: To reach a maximum deviation of 1×10^{-7} from final value	n.a.	n.a.	<10 min	<15 min	<15 min

* After 48 hours of continuous operation.

n.a. Not Applicable

PM 6652 MEASURING FUNCTIONS

FREQUENCY A

Range: 0.1 Hz...120 MHz. (0.01 Hz... 200 kHz when Hold Off is selected) Typically 0.1 Hz...160 MHz at 50 mV sensitivity.

Mode: Conventional above 10 MHz. Reciprocal below 10 MHz and when Hold Off EXT GATE or AVERAGE is selected.

LSD displayed: $\frac{2.5 \times 10^{-7}\ s \times FREQ}{measuring\ time}$ (reciprocal)

$\frac{2.5}{measuring\ time}$ (conventional)

Resolution: 1 or 2 LSD units

Inaccuracy: $\frac{resolution}{FREQ} \pm \frac{trigger\ error}{measuring\ time} \pm$ time base error

Signal mode: CW, SINGLE BURST, MULTIPLE BURST AVERAGE

Ext controls: EXT GATE, AVERAGE, ARMING

FREQUENCY C Optional

Range: 100 MHz...1.5 GHz Typically ...1.6 GHz

Mode: Conventional. (Recipr. when EXT. GATE and FREQ AVG is selected.)

LSD displayed: $\frac{40}{measuring\ time}$ (conventional)

$\frac{2.5 \times 10^{-7}\ s \times FREQ}{measuring\ time}$ (reciprocal)

Resolution: 1 or 2 LSD units

Inaccuracy: $\frac{resolution}{FREQ} \pm$ time base error

Signal mode: CW, SINGLE BURST, MULTIPLE BURST AVERAGE

EXT controls: EXT GATE, AVERAGE, ARMING

PERIOD A

Range: 100 ns...100 s (average)
100 ns...10^{10} s (single)

LSD displayed $\frac{2.5 \times 10^{-7}\ s \times PERIOD}{measuring\ time}$

Resolution: 1 or 2 LSD units. LSD and resolution is 100 ns when single period is selected

Inaccuracy: $\frac{resolution}{PERIOD} \pm \frac{trigger\ error}{measuring\ time} \pm$ time base error

No. of cycles averaged: $\frac{measuring\ time}{PERIOD}$ or a single period

Ext controls: EXT GATE, AVERAGE, ARMING

TIME INTERVAL A-B, PULSE WIDTH A, RISE/FALL A; SINGLE

Range: 100 ns...10^{10} s

LSD displayed: 100 ns (TIME below 10^3 s)
$\frac{5 \times TIME}{10^{10}}$ (TIME above 10^3 s)

Resolution: 1 LSD unit

Inaccuracy: $\frac{resolution}{TIME} \pm \frac{trigger\ error}{TIME} \pm$ time base error

Mininum amplitude RISE/FALL TIME measurements: 500 mV_{pp}. If any part of the signal is above +5 V or below -5 V, then: min. amplitude = 5 V_{pp}

Ext controls: ARMING

TIME INTERVAL A-B, PULSE WIDTH A, RISE/FALL A; AVERAGED

Range:

TIME INTERVAL	0 ns...100 s
PULSE WIDTH	4 ns...100 s
RISE/FALL TIME	10 ns..100 s

LSD displayed: $\frac{2.5 \times 10^{-8}\ s}{\sqrt{N}}$

Resolution: $\frac{100\ ns}{\sqrt{N}}$ or 1 LSD unit, whichever is greatest

Inaccuracy: $\frac{resolution}{TIME} \pm \frac{trigger\ error}{\sqrt{N} \times TIME}$

$\pm$ time base error $\pm \frac{syst.\ error}{TIME}$

Min dead time stop to start: 250 ns

Number of samples averaged: $\frac{measuring\ time}{pulse\ repetition\ time}$

Minimum amplitude: RISE/FALL TIME 500 mV_{pp}, if any part of the signal is above +5 V or below -5 V, then min. amplitude=5 V_{pp}

Ext controls: AVERAGE, ARMING

NOTE: EXT. CONTROL setting "AWG" results in an internal delay time of 40 ms. The range is then approx.: 40 ns...100 s.

PM 6654 MEASURING FUNCTIONS

FREQUENCY A

Range:	0.01 Hz...120 MHz. (0.01 Hz... 200 kHz when Hold Off is selected) Typically 0.1 Hz...160 MHz at 50 mV sensitivity.
Mode:	Reciprocal
LSD displayed:	$\frac{5 \times 10^{-9}\ s \times FREQ}{measuring\ time}$ When HOLD-OFF or EXT GATE is selected, see spec. for PM 6652
Resolution:	1 or 2 LSD units
Inaccuracy:	$\frac{resolution}{FREQ} \pm \frac{trigger\ error}{measuring\ time} \pm$ time base error
Signal mode:	CW, SINGLE BURST, MULTIPLE BURST AVERAGE
Ext controls:	EXT GATE, AVERAGE, ARMING

FREQUENCY C Optional

Range:	100 MHz...1.5 GHz
Mode:	Reciprocal
LSD displayed:	$\frac{5 \times 10^{-9}\ s \times FREQ}{measuring\ time}$ When EXT GATE is selected, see specification for PM 6652
Resolution:	1 or 2 LSD units
Inaccuracy:	$\frac{resolution}{FREQ} \pm$ time base error
Signal mode:	CW, SINGLE BURST, MULTIPLE BURST AVERAGE
Ext controls:	EXT GATE, AVERAGE, ARMING

PERIOD A

Range:	8ns...100 s (average) 100ns...10^{10} s (single)
LSD displayed:	$\frac{5 \times 10^{-9}\ s \times PERIOD}{measuring\ time}$ When Hold Off or EXT GATE is selected see PM 6652 specification
Resolution:	1 or 2 LSD units, LSD is 1 ns and resolution 2 ns, when single period is selected
Inaccuracy:	$\frac{resolution}{PERIOD} \pm \frac{trigger\ error}{measuring\ time} \pm$ time base error
No. of cycles averaged.	$\frac{measuring\ time}{PERIOD}$ or a single period
Ext controls:	EXT GATE, AVERAGE, ARMING

TIME INTERVAL A-B, PULSE WIDTH A, RISE/FALL A; SINGLE

Range:	8 ns...100 s
LSD displayed:	1 ns (TIME below 10 s) $\frac{5 \times TIME}{10^{10}}$ (TIME above 10 s)
Resolution:	2 ns (TIME below 10 s) 1 LSD unit (TIME above 10 s)
Inaccuracy:	$\frac{resolution}{TIME} \pm \frac{trigger\ error}{TIME}$ $\pm$ time base error $\pm \frac{syst.\ error}{TIME}$
Mininum amplitude	RISE/FALL TIME measurements: 500 mV_{pp}. If any part of the signal is above +5 V or below -5 V, then: min. amplitude = 5 V_{pp}
Ext controls:	ARMING

NOTE: When Hold Off is selected, see PM 6652 specification

TIME INTERVAL A-B, PULSE WIDTH A, RISE/FALL A; AVERAGED

Range:	TIME INTERVAL 0 ns...100 s PULSE WIDTH 4 ns...100 s RISE/FALL TIME 8 ns...100 s
LSD displayed:	$\frac{2.5 \times 10^{-9}\ s}{\sqrt{N}}$
Resolution:	$\frac{10\ ns}{\sqrt{N}}$ or 1 LSD unit, whichever is greatest
Inaccuracy:	$\frac{resolution}{TIME} \pm \frac{trigger\ error}{\sqrt{N} \times TIME}$ $\pm$ time base error $\pm \frac{syst.\ error}{TIME}$
Min dead time stop to start:	50 ns
Number of samples averaged:	$\frac{measuring\ time}{pulse\ repetition\ time}$
Minimum amplitude:	RISE/FALL TIME 500 mV_{pp}, if any part of the signal is above +5 V or below -5 V, then minimum amplitude = 5 V_{pp}
Ext controls:	AVERAGE, ARMING

NOTE: When Hold Off or AVERAGE is selected, see PM 6652 specification

PM 6652 and PM 6654 MEASURING FUNCTIONS

DUTY FACTOR A

Range:	0...(1 − 250 ns x Pulse rep. rate) Example: 0...0.9999 at 50 Hz 0...0.9997 at 1 kHz 0...0.5 at 2 MHz
Range:	0.03 Hz...2 MHz
LSD displ.:	$\frac{2.5 \times 10^{-7}\ \text{s}}{\text{measuring time}}$
Resolution:	100 ns x pulse rep. rate / $\sqrt{N}$ or 1 LSD unit, whichever is greatest
Inaccuracy:	$\frac{4\ \text{ns} \times \text{FREQ}}{\text{DUTY FACTOR}} \pm \frac{\text{resolution}}{\text{DUTY FACTOR}} \pm \frac{\text{trigg error}}{\sqrt{N} \times \text{PULSE WIDTH}}$
Cycles avg.:	Measuring time x pulse rep. rate
Ext controls:	None

PHASE A-B

Range:	0...360° x (1 − 250 ns x FREQ). Example: 0...360° at 50 Hz 0...359.9° at 1 kHz 0...180° at 2 MHz
Range:	0.03 Hz...2 MHz
LSD displ.:	1° measuring time below 180 μs 0.1° measuring time 180 μs..1.8 ms 0.01° measuring time above 1.8 ms
Resolution:	1 LSD unit
Cycles avg.:	Measuring time x FREQ A
Input voltage:	100mV...3.5V / 1V...35V (RMS sine)
Inaccuracy:	$\frac{4\ \text{ns} \times 360° \times \text{FREQ}}{\text{PHASE}} \pm \frac{\text{Resolution}}{\text{PHASE}}$ $\frac{\text{FREQ} \times 360° \times \text{trigger error}}{\sqrt{N} \times \text{PHASE}} \pm$ $\pm \frac{\text{systematic error}}{\text{PHASE}}$
Ext controls:	None

Vmax, Vmin, Vpp A

Range:	−50 V...+50 V; DC and 100Hz...80MHz
LSD displayed:	10 mV for signals within ± 5 V 100 mV for signals outside ± 5 V
Resolution:	1 LSD unit
Typical inaccuracy: DC, 100Hz..20MHz	Input signal within ± 5 V: 20 mV ± 2 % of reading Input signal outside ± 5 V: 200 mV ± 3 % of reading
20...80 MHz (50 Ohm)	Input signal within ± 5 V: 20 mV ± 6 % of reading Input signal outside ± 5 V: 200 mV ± 7 % of reading
V_{pp} displayed:	The result of simultaneous V_{max} and V_{min} measurements
High freq. error:	Above 80 MHz (50 ohm) or above 20 MHz (1 Mohm), the deviation is typically ±3 dB
Ext controls:	None

RATIO A/B

Range:	$10^{-9}...10^{10}$
Freq. range:	0.1 Hz...120 MHz/0.01 Hz...10 MHz and 0.01 Hz...200 kHz/0.01 Hz... 10 MHz when Hold Off is selected)
LSD displ.:	$\frac{2.5 \times \text{RATIO}}{\text{measuring time} \times \text{FREQ A}}$
Resolution:	1 or 2 LSD units
Inaccuracy:	$\frac{\text{resolution}}{\text{RATIO}} \pm \frac{\text{trigg error B}}{\text{measuring time}}$
Ext controls:	ARMING

RATIO C/B

Range:	$10^{1}...10^{11}$
Freq. range:	100 MHz...1.5 GHz/0.01 Hz...10 MHz
LSD displ.:	$\frac{40 \times \text{RATIO}}{\text{measuring time} \times \text{FREQ C}}$
Resolution:	1 or 2 LSD units
Inaccuracy:	$\frac{\text{resolution}}{\text{RATIO}} \pm \frac{\text{trigger error B}}{\text{measuring time}}$
Ext controls:	ARMING

TOTALIZE A

Range:	$1...10^{18}$
Freq. range:	0...120 MHz and 0.01 Hz...200 kHz when Hold Off is selected
Pulse pair resolution:	8 ns
Manual mode:	Controled by pushbutton START/STOP
Ext. mode:	Totalizing on A during pulse duration on B or between start/stop pulses on B
Min. Pulse-width B:	40 ns
Inaccuracy:	$\frac{\text{pulse rep rate A} \times \text{trigger error B}}{\text{total counts}}$
Ext controls:	ARMING (not valid in manual mode)

INPUT SPECIFICATIONS

Inputs A and B

Freq. range:	DC coupled: 0...160 MHz AC coupled: 20 Hz...160 MHz
Rise time:	approximately 1 ns
Sensitivity:	
– 0...60 MHz:	20 mV_{RMS} or 60 mV_{pp}
– 60..120 MHz:	30 mV_{RMS} or 90 mV_{pp}
–120..160 MHz:	50 mV_{RMS} or 140 mV_{pp}(typ.)
Pulse width:	Minimum 4 ns
Attenuation:	x1 x10 (fixed)
Hysteresis:	approx 40 mV_{pp}. Hysteresis compensation is automatically performed in TIME A-B, P Width A, RISE/FALL-A, PHASE A-B and DUTY FACTOR measuring modes; resulting in a residual hysteresis band which is virtually 10 mV_{pp}
Dynamic input voltage range:	60 mV_{pp}...5 V_{pp} within ±5 V_{DC} x1 600mV_{pp}..50V_{pp} within ±50V_{DC} x10
Trigg. level selection:	Manually via keyboard (10mV steps), Manually via potentiometers, Auto trigger.
Trigger level range:	-5 V...+5 V (x1) -50 V...+50 V (x10)
Trigger level setting accuracy:	±10 mV ±1 % of set value.
Trigg. slope:	Positive or negative
Trigger level output:	Set trigger levels for channel A and B, -5 V...+5 V, available at rear panel (BNC-connectors).
Trigger level read-out:	Set trigger levels for channel A and B are displayed with a resolution of 10 mV (x1) or 100 mV (x10)
Trigger indicators:	Three state LED indication: On: Signal is above the set trigger level Blinking: Triggering occurs Off: Signal is below the set trigger level
AUTO trigger:	The AUTO trigger will automatically set A and B trigger levels to 50 % of input signal amplitude (10 % and 90 % for RISE/FALL TIME measurements). The frequency range is 100 Hz...120 MHz. The measuring cycle time is approximately 300 ms plus the measuring time.

NOTE: Auto trigger requires a repetitive signal. The input signal may have any duty factor.

Coupling:	DC/AC
Channel input:	Separate A and B or common via A
Impedance:	Separate A and B 1 MOhm//35 pF nominal or 50 Ohm nominal (A and B) Common A 0.5 MOhm//70 pF nominal or 50 Ohm (A) open input (B)
Max. input voltage:	1 MOhm x1: 260 V_{RMS} up to 20 kHz declining to 12 V_{RMS} at 1 MHz 1 MOhm x10: 260V_{RMS} up to 20 kHz declining to 100 V_{RMS} at 1 MHz and to 25 V_{RMS} at 120 MHz 50 Ohm 12 V_{RMS} DC...120 MHz

Input C

Freq. range:	100 MHz...1.5 GHz.
Input voltage range:	10 mV_{RMS}...12 V_{RMS} from 100 MHz to 1 GHz, 30 mV_{RMS}... 12 V_{RMS} from 1 GHz to 1.5 GHz.
Coupling:	AC
Impedance:	50 Ohm nominal; VSWR below 2.
AM tolerance:	98 %; minimum signal must exceed minimum operating input voltage
Max.input:	12 V_{RMS}. Overload protection with PIN diodes.

Input D (ext. standard in)

Range:	100 kHz...10 MHz
Coupling:	AC
Impedance:	1.5 kOhm nominal
Sensitivity:	400 mV_{RMS}
Max input:	25 V_{RMS}

NOTE: As external reference frequency, only 10 MHz will give correct decimal point and unit indication. With the optional frequency multiplier PM 9697 references of 1 and 5 MHz can also be accepted.

Input F (ext. reset)

Electrical reset, equivalent to front panel RESET pushbutton. Counter is reset when input F is high. A new measurement can be made after input F has returned low. The measurement will start after a delay of approx. 50 ms to 100 ms (depending on selected function) plus time needed for synchronization with the input signal.

High level:	Above 2 V
Low level:	Below 0.5 V
Impedance:	2 kOhm (typical)
Max. input:	±25 V
Min.pulse duration:	50 ns

Input E (arming, ext. gate, average)

SLOPE:	The active slope of the INPUT E signal can be changed (inverted) by pushing the SLOPE button. (PM 6652C,-54C only). The NORMAL (default) setting gives the functions described below.

A 4-position rear panel switch gives choice of external control of the counter.

OFF:	No function selected.
ARMING:	The counter is prevented from starting a new measurement when input E is high. A high-to-low transition (normal slope) arms the counter to start a new measurement. Arming is not applicable in TOT A (manual), PHASE and DUTY FACTOR measurements.
AVERAGE:	Frequency (channel A or C), period A and time interval A-B measurements are interrupted when input E is high (normal slope). The measurement is continued again when input E is low.
EXT GATE:	The signal on input E defines start and stop of the measuring time and overrides the set MEASURING TIME. When input E goes high (normal slope), the measurement will start after a synchronization delay. The measurement will stop when input E returns low, after a synchronization delay.

High level:	Above 2 V
Low level:	Below 0.5 V
Impedance:	2 kOhm nominal
Max. input:	±25 V
Int. delay:	approx. 50 ns.

Minimum pulse duration:

- Arming:	200 ns
- Ext. gate:	500 ns
- Average:	PM 6652: 500 ns and PM 6654: 200 ns

OUTPUT SPECIFICATIONS

Output G (10 MHz out)

Output freq.:	10 MHz
Output level:	>1.3 V_{pp} into a 50 Ohm load
Protection:	Short cicuit proof

Output H (gate open)

The gate status output allows monitoring on an oscilloscope of the actual measuring time and the trigger Hold Off time.

Gate closed:	4.5 V output level (typical)
Gate open:	0 V output level (typical)
Hold Off time:	1.2 V output level (typical)
Output imped.:	1.5 kOhm (typical)
Internal delay:	150 ns (typical)
Protection:	Short circuit proof

Outputs I and J (trigg level out)

Buffered output for set trigger levels on channels A and B. The range is -5 V...+5 V unaffected by the input attenuator setting (x1 or x10). These can be used as two independent bus programmable DAC.

Output levels:	-5 V...+5 V
Impedance:	2 kOhm (typical)
Protection:	Short circuit proof
Nonlinearity:	less than ±10 mV
DC-offset:	less than ±7 mV
Settling time:	less than 1 ms

AUXILIARY FUNCTIONS

Measuring time/Display time

Setting of the measuring time can be made in three different ways:

1 Variable

The measuring time is continuously variable, 0.1 ms...96 s, with clear setpoints at 0.1 ms, 1 ms, 10 ms, 0.1 s, 1 s, 10 s, and 96 s. Selected variable measuring time is displayed, without any delay, when depressing the measuring time "READ" push button.

2 MINIMUM SINGLE

With MINIMUM/SINGLE activated the counter will perform single event measurements for: PERIOD A, RATIO A/B, RATIO C/B, TIME A-B, P WIDTH A and RISE/FALL A.

A minimum measuring time of approximately 2 μs is performed for FREQ A, FREQ C in PM 6654.

A minimum measuring time of approximately 1 μs is performed for FREQ A, FREQ C in PM 6652 and for PHASE A-B and DUTY FACTOR A in both PM 6652 and PM 6654.

The variable MEASURING TIME/DISPLAY TIME control will now act only as display time control. The measured result is displayed during the set display time and a new measurement will start at the next input signal. The MINIMUM/SINGLE function is useful for measurements of single-shot phenomena and measurements of signals present during a short time, e.g. single burst frequency.

3 EXT.GATE

The use of EXT. GATE (see INPUT E specification) will override the set measuring time. The external gate duration must be in the range 500 μs... 96 s. The resolution is always 100 ns, i.e. a PM 6654 will have the same specification as a PM 6652.

Actual measuring time

The actual measuring time equals the selected measuring time (whether being set continuously via MINIMUM/SINGLE or via EXT GATE) plus the time needed to synchronize the measurement with an integer number of cycles of the input signal, for all reciprocal measurements.

DISPLAY HOLD

Depressing the DISP HOLD pushbutton sets display time to infinity and freezes the last measurement result. A new measurement can be initiated using RESET.

Hold-off

With trigger Hold Off activated the counter ignores retriggering (channel A) or stop triggering (channel B) during the set Hold Off time.

The Hold Off function is applicable in all channel A measuring modes and also on channel B in the TIME A-B mode. The Hold Off function can be used as a low-pass filter with variable cut-off frequency between 5 Hz...150 kHz for FREQUENCY and PERIOD measurements.

Range:	5 μs...200 ms or 0 (off)
Read-out:	The Hold Off time is measured and displayed by pressing the read button
Monitor:	The set Hold Off duration is visible via the gate open output

NOTE: When Hold Off is active, the frequency range for period and frequency measurements is limited to 0.01 Hz...200 kHz (PM 6652 and PM 6654) and clock resolution in all measuring modes will always be 100 ns (PM 6654).

Time interval delay (programmable hold-off)

(Only the PM 6654C)

When Time Interval Delay is activated, the counter disables stop-pulses (Hold Off) for a time equal to the set **Measuring time.**

Range:	100 μs...99 s.
Accuracy:	±25 μs ±1 % of set value.
Applicable functions:	Single time interval A-B Single pulse width A Single rise/fall time A

NOTE: Hold Off cannot be selected at the same time as Time Interval Delay. Time interval delay is only accessible via the IEEE-488 bus.

Mathematics

The mathematical functions of PM 6652,-54 makes it possible to offset a measuring value or to change scale factor (normalizing).

The offset facility allows adding or subtracting a reference value to the measured value before display, e.g. measurement of tuned receiver frequency, by measuring the local oscillator frequency (IF-offset).

The scaling facility allows multiplying of the measured value by a constant before display, e.g. conversion of frequency to RPM. The scaling and offset features may be combined, so that the displayed value equals K x X + L. X is the measured value and K and L are constants. Mathematics cannot be applied to the function V_{max}, V_{min}.

Check

10 MHz internal reference is connected to the counting logic of input channels A and B. Self-test of most measuring functions can be selected.

Reset

Manual via pushbutton or electrical via input F. Reset will clear keyboard entry, status, an active STORE state, and/or start a new measurement.

Power on/Stand by

In "ST BY" position, power is available to maintain an ovenized crystal oscillator.

Test function

The counter performs a choice of 5 self test routines of the logic and computing functions. The functions tested are: ROM (No.1), RAM (No.2), EAROM (No.3), measuring logic (No.4) and display (No.5). Test No.6 when selected will perform all tests 1...5 in a sequence. At power-up a limited test sequence is performed.

Programs P1...P8

Eight front panel "menus" can be stored in and recalled from a non-volatile memory. All front- and rear panel settings can be stored, except Hold Off value (but status of pushbutton "Hold Off on/off" is stored). Programs P7 and P8 can not store the mathematical functions.

GENERAL

Display

Read out:	10 digits, sign and exponent (11 mm high-efficiency LED)
Unit indicators:	3 LEDs indicating Hz, s or V. Any prefix (kHz, µs) is indicated by the exponent on the display.
Gate lamp:	Indicates that main-gate is opened and measurement takes place.
ST BY:	Stand-by indication with LED when instrument is not switched ON.
REMOTE:	Indicates that the counter is remotely controlled via the BUS interface option (IEC-625/IEEE-488).
ARMED/FREQ	Indicates position of rear panel EXT CONTROL switch (LOCAL mode) or programmed setting of EXT CONTROL function (REMOTE mode)
INV EX CON	Indicates active slope of INPUT E
Cursor:	Indicates selected measuring function and/or selected front panel menu (Programs 1...P8).

Power requirements

In addition to the normal line voltage supply, the PM 6652 and PM 6654 can also be powered by an external DC voltage.

Line:	115/230 V ±15%; 45...440 Hz below 60VA.
DC source:	Voltage 17..29 V; max 2 A at 24 V.
Line interference:	Below VDE 0871 B and MIL STD 461.
Safety:	Accord. to IEC 348 and CSA 556B.

Dimensions and weight

Width:	440 mm (excluding 19" brackets)
Height:	89 mm
Depth:	440 mm
Weight:	Net: 8 kg. Shipping: approx. 10 kg

Environmental conditions

Ambient temperature

Storage and transport:	-40° C...+70° C.
Rated range:	-5° C...+50° C. To allow air convection, at least 2 cm free space is required above and below the counter. Without any free air space around the counter (tightly packed 19 inch racks), the built-in fan option PM 9612 is necessary at ambient temperatures above 40° C.
Humidity:	10...90 % RH, no condensation Storage: 5...95 % RH.
Altitude/ Barometric pressure:	Operating: 53.3 kN/m^2, 5000 m (15000 ft). Storage: 15.2 kN/m^2, 15000 m (50000 ft).
Vibration test:	According to IEC 68 Fc.
Bump test:	According to IEC 68 Eb.
Handling test:	According to IEC 68 Ec.
Transp. test:	According to NLN-L88.

OPTIONS

In the PM 6652,-54 several options can be used, the specification for some of these are described previously in this manual, i.e. different crystal oscillators, the IEEE bus interface and the 1.5 GHz Input-C.

This section will describe the analog recorder output PM 9695 and the external reference frequency multiplier PM 9697.

Analog recorder output PM 9695

The digital-to-analog converter PM 9695 provides a high resolution analog output e.g. for recording frequency stabilities of oscillators, filters and crystals on a strip chart recorder. In frequency control systems having analog feedback, the DAC serves as an accurate frequency-voltage converter. The PM 9695 permits conversion of any three consecutive digits; as such it functions as a magnifying class to focus on the most important part of the read-out.

Decade Conversion:	Any three consecutive digits can be selected. The value of the least significant of the 3 digits can be selected with a 12 position switch.
LSD range:	$10^{-13}...10^{-2}$(s) or $10^{-4}...10^{7}$(Hz, V, degrees, counts or ratio).
Normal mode:	Analog output is directly proportional to digital input. 000 produces 0.000 V and 999 produces 0.999 V.
Offset mode:	Adds 500 to digital input to obtain half scale offset. 500 produces 0.000 V and 499 produces 0.999 V.
Output:	Zero output 0 V Full scale deflection 0.999 V Impedance 100 Ohm ± 1% Connector BNC
Accuracy:	± 2 mV
Nonlinearity:	± 0.5 mV
Delay:	Output voltage settling time max 100 ms after end of measurement.
Temp coeff.:	±(0.1 mV+0.03 % of reading)/°C

External reference frequency multiplier PM 9697

To accept external reference frequencies other than 10 MHz, the frequency multiplier PM 9697 can be used.

With this option installed, the PM 6652 or PM 6654 can accept external reference frequencies of 1 MHz, 5 MHz or 10 MHz. All other input specifications as for "Input D".

ACCESSORIES

Supplied with the instrument

- Mains cable.
- Fuses 0.4 A and 0.8 A.
- Two adapter with screws M6 for 19"-rack.
- Operating Manual.
- Pocket Guide. (Only supplied with instruments with IEEE-488 bus interface.

To be ordered separately

	MATE/CIIL Interface, acc. to Mate System Control Interface Standard (No. 2806763).
PM 9610:	1,5 GHz option (Input-C).
PM 9611:	Built-in rear panel wiring option.
PM 9612:	Built-in fan option.
PM 9613:	Rack-mount slide kit.
PM 9614:	Training course set incl.: - Cassette tape for HP 85 controller - Pocket guide for PM 6652,-54. - Text book, (can be ordered separately: order No. 9498 465 01011)
PM 9665B:	Low pass filter, 50 kHz.
PM 9678:	TCXO oscillator (version/.2.).
PM 9679:	Oven encl. oscillator (version/.3.).
PM 9690:	Oven encl. oscillator (version/.4.).
PM 9691:	Oven encl. oscillator (version/.5.).
PM 9695:	Analog recorder output (DAC).
PM 9696B:	IEEE-488 bus interface.
PM 9697:	External reference frequency multiplier.
PM 2296/50:	IEEE/IEC adapter.
PM 2295/05:	IEEE-cable (length 0.5 m).
PM 2295/10:	IEEE-cable (length 1 m).
PM 2295/20:	IEEE-cable (length 2 m).
PM 9581:	50 Ohm feed-through termination 3W.
PM 9585:	50 Ohm feed-through termination 1W.
PM 8922:	120 MHz 1 MOhm probe 1:1 and 1:10.
PM 9639:	1.5 GHz 500 Ohm probe 1:10.
PM 8943:	650 MHz 50 Ohm/1 MOhm FET probe.

All options but the following are customer retro-fittable:
MATE/CIIL-interface, PM 9611 and PM 9612.

The multiplier PM 9697 can be installed only in the /.1.-version (standard oscillator).

The counters can only be equipped with one of the following options at a time: CIIL interface, Analog Recorder Output or IEEE-488 interface.

There are several versions of the IEEE-488 bus interface;

Timer/Counter	suitable bus interface
PM 6652,-54	PM 9696B and PM 9696
PM 6652C,-54C	PM 9696B and 'PM 9696 RTL update'

PM 6652 and PM 6654C versions and options

The ordering number conists of the basic type number and a 3 digit XYZ suffix, specifying the recuired customer version.

PM 6652C/XYZ
- X — Indicating maximum frequency.
- Y — Indicating reference oscillator.
- Z — Indicating interface.

Type-No.	Description
PM 6652C/011	Programmable high resolution timer/counter, 120 MHz basic frequency range, 100 ns single shot resolution, standard oscillator $5X10^{-7}$/month, incl. 19" rack mount brackets, excl. IEEE-488 bus interface.
PM 6654C/011	Idem, but with 2 ns single shot resolution.
/5..	including 1,5 GHz input channel PM 9610.
/.2.	including PM 9678 TCXO.
/.3.	including PM 9679 Oven-Oscillator.
/.4.	including PM 9690 Oven-Oscillator.
/.5.	including PM 9691 Oven-Oscillator.
/.8.	including standard oscillator and external reference frequency multiplier PM 9697.
/..2	Blind panel version including IEEE-488 bus interface PM 9696B.
/..5	normal panel version including analog recorder output PM 9695.
/..6	Normal panel version including IEEE-488 bus interface PM 9696B.
/..7	Normal panel version including MATE/CIIL interface.

Chapter 10

ADDENDUM

ADDENDUM

Introduction

The PM 6652C and PM 6654C are now available with two different HF-inputs, the 1.5 GHz input PM 9610 and the 2.3 GHz input PM 9619. This addendum describes the differences between the 1.5 GHz version described in the manual and the new 2.3 GHz version. It also describes how to identify which input that is fitted in your instrument.

Identification

Read the text on the strip at the top of the front panel edging. Strips like the one below indicate standard instruments without HF-inputs:

programmable high resolution timer/counter 120MHz	PHILIPS

The strip below is fitted on instruments equipped with factory installed PM 9610 1.5 GHz HF-inputs:

programmable high resolution timer/counter 120MHz / **1.5GHz**	PHILIPS

Strips like the one below are fitted on instruments equipped with factory installed PM 9619 2.3 GHz HF-inputs:

programmable high resolution timer/counter 120MHz / **2.3GHz**	PHILIPS

Adhesive labels indicating the frequency range should be fitted on the strips of instruments upgraded with HF-inputs. If the Timer/Counter is upgraded with a PM 9610, the strip with the label fitted should look like the one below. The label is included in the PM 9610 option:

programmable high resolution timer/counter 120MHz 0.1-1.5GHz	PHILIPS

If the Timer/Counter is upgraded with a PM 9619 the strip with fitted label should look like the one below. The label is included in the PM 9619 option:

programmable high resolution timer/counter 120MHz 0.1-2.1GHz	PHILIPS

Operation

Operating the Timer/Counter with the 2.3 GHz HF-input is done exactly in the same way as described in the Operators' Manual.

Specifications

Input C (Option PM 9619)

Frequency range: 100 MHz...2.3 GHz

Coupling: AC

Operating input voltage range:

20 mV_{rms}...12 V_{rms}; 100...300 MHz
10 mV_{rms}...12 V_{rms}; 300...2000 MHz
15 mV_{rms}...12 V_{rms}; 2000...2100 MHz
25 mV_{rms}...12 V_{rms}; 2100...2300 MHz [1)]

AM Tolerance: 94% at max 100 kHz modulation frequency. Minimum signal must exceed minimum operating input voltage requirement

Input impedance:
50 Ω nominal

VSWR:	Max 2.0:1	0.1...1.5 GHz
	Max 2.5:1	1.5...2.0 GHz
	Max 3.5:1	2.0...2.3 GHz

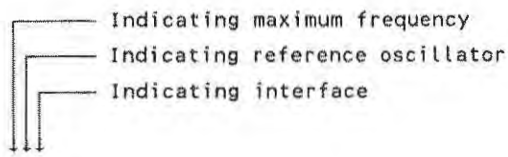
Max voltage without damage: 12 V_{rms};
overload protection with pin diodes

Ordering information

This is additional information to the ordering information on page 9-12 in the Operators' Manual.

When the new 2.3 GHz HF-input is to be ordered separately, order a PM 9619.

When a new counter is to be ordered the first digit after the stroke indicates the maximum frequency:



PM 6654C/XYZ

PM 6652C/0..	Is a PM 6652C Timer/Counter without HF-input.
PM 6652C/5..	Is a PM 6652C Timer/Counter with a 1.5 GHz HF-input, PM 9610.
PM 6652C/6..	Is a PM 6652C Timer/Counter with a 2.3 GHz HF-input, PM 9619.
PM 6654C/0..	Is a PM 6654C Timer/Counter without HF-input.
PM 6654C/5..	Is a PM 6654C Timer/Counter with a 1.5 GHz HF-input, PM 9610.
PM 6654C/6..	Is a PM 6654C Timer/Counter with a 2.3 GHz HF-input, PM 9619.

1) Only guaranteed when the PM 9619 is factory installed. When retro-fitted in the field, performance up to 2.1 GHz is guaranteed.