

TOSHIBA BIPOLAR DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

# TC9242P, TC9242F

## QUARTZ PLL MOTOR CONTROL

The TC9242P, TC9242F are CMOS LSIs developed for controlling the motor speed.

Since an 8bit D/A converter system has been employed for each of the speed control system (AFC) and the phase control system (APC).

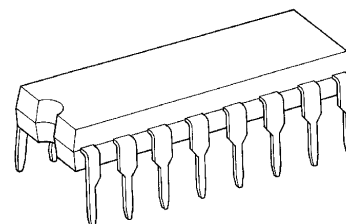
Offers improved linearity.

With frequency division ratios of 1/3, 1/4 and 1/5 the standard divider is ideal for laser scanner motors.

### FEATURES

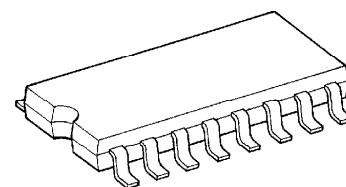
- Crystal can be used up to 20MHz, and crystal reference dividing frequency is selectable from three positions of 1/3, 1/4 and 1/5.
- Lock range can be selected from two positions of 1/20 and 1/27.
- External oscillator makes possible fine adjustment of speed.
- Lock detection output and reverse rotation signal output are provided.
- Package is DIP16PIN and SOP16PIN.

TC9242P



DIP16-P-300-2.54A

TC9242F

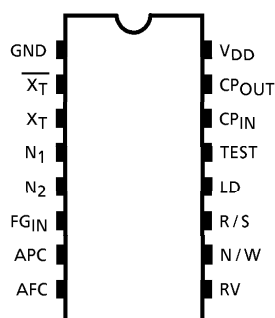


SOP16-P-300-1.27

### Weight

DIP16-P-300-2.54A : 1.00g (Typ.)  
SOP16-P-300-1.27 : 0.16g (Typ.)

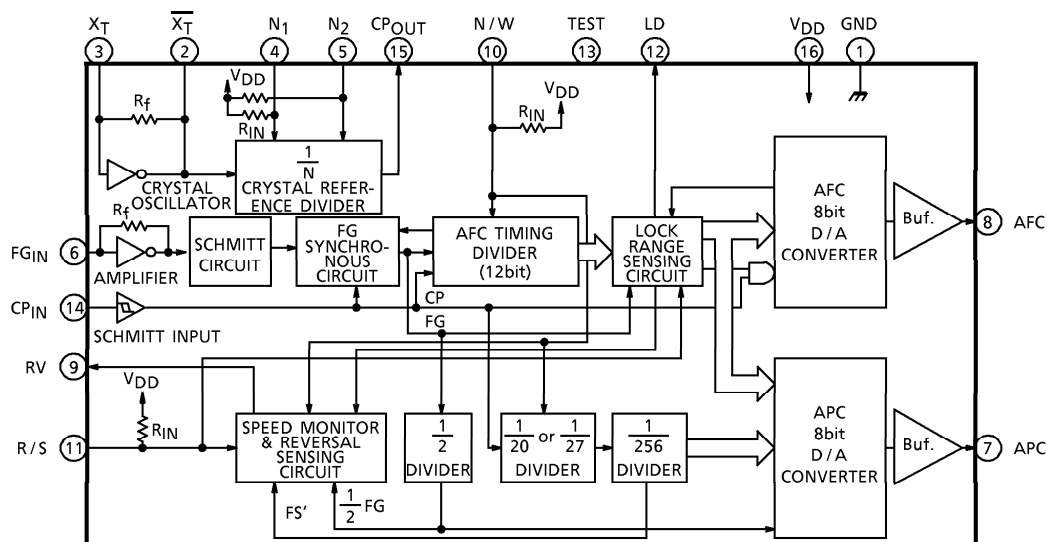
### PIN CONNECTIONS (TOP VIEW)



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## BLOCK DIAGRAM



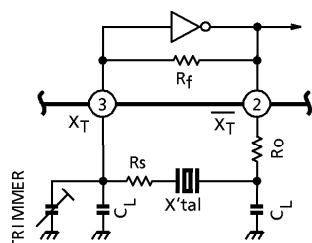
## FUNCTIONAL EXPLANATION OF EACH TERMINAL

PIN No.	SYMBOL	PIN NAME	FUNCTIONAL & OPERATION EXPLANATION	REMARKS
16	$V_{DD}$	Power Terminal	$V_{DD} = 5V \pm 0.5V$ is applied.	—
1	GND	Ground Terminal	Ground	—
2	$X_T$	Crystal Oscillation Terminal	Crystal oscillator is connected.	With a built-in feedback resistor.
3	$X_T$			
4	$N_1$	Reference Divided Frequency Switching Terminal	Switching of divided frequency from the crystal reference frequency divider into 1/3, 1/4 and 1/5 is possible.	With a built-in pull-up resistor.
5	$N_2$			
6	FGIN	FG Pulse Input Terminal	Input terminal for pulse showing motor speed.	With a built-in amplifier.
7	APC	APC Output Terminal	Output terminal for motor phase control system. Output of 8bit D/A converter.	With a built-in buffer.
8	AFC	AFC Output Terminal	Output terminal for motor speed control system. Output of 8bit D/A converter.	With a built-in buffer.
9	RV	Reverse Signal Output Terminal	Terminal for motor reverse signal output.	CMOS OUTPUT
10	N/W	Lock range Switching Terminal	Terminal for switching motor speed. $L = 1/27$ , H or $NC = 1/20$ .	With a built-in pull-up resistor.
11	R/S	RUN/STOP Input Terminal	Motor RUN/STOP signal input terminal $L = RUN$ , H or $NC = STOP$	With a built-in pull-up resistor.
12	LD	Lock Detecting Terminal	This terminal becomes "H" when the motor speed is within the lock range and otherwise "L".	CMOS OUTPUT
14	CPIN	Reference Frequency Input Terminal	Normally connected to CPOUT. For external fine adjustment input from an external oscillator.	CMOS SCHMITT INPUT
15	CPOUT	Reference Frequency Output Terminal	Terminal for divided output from the crystal reference frequency divider. Normally connected to CPIN.	CMOS OUTPUT
13	TEST	Output Terminal for INTERNAL TEST	Output terminal for INTERNAL TEST. Generally open.	—

## EXPLANATION OF OPERATION

1. Crystal Oscillation Terminals ( $X_T$ ,  $\overline{X_T}$ )

- The crystal oscillator is used by connecting as shown below.



※ CL of 10~30pF is appropriate.

- Crystal oscillation frequency is calculated by the following equation according to number of FG pulses of a motor to be used.

$$f_X = \frac{R}{60} \times FG' \times 128 \times (20 \text{ or } 27) \times N \text{ (Hz)}$$

Note : (20 or 27) : 20 at N/W = "H" or NC  
27 at N/W = "L"

Further,  $f_X$ : Crystal oscillation frequency,  $FG'$ : No. of FG pulses generated per revolution of motor.

N : Ratio of frequency division of the crystal reference frequency divider.  
N = 3, 4, 5 (Refer to Item 9.)

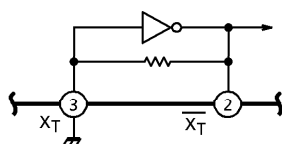
- Maximum operating frequency is above 20MHz and crystals up to 20MHz can be used.
- If necessary, adjust  $R_o$ ,  $R_s$  and  $C_L$  to control noise from the crystal oscillator circuit or to control overtone oscillation.

## &lt;Reference values&gt;

$f_{XT}$ (MHz)	$R_o$ ( $\Omega$ )	$R_s$ ( $\Omega$ )	$C_L$ (pF)
20	—	220	22
12	—	220	27
8	—	220	30
4.5	2.2k	—	30
1.5	4.7k	—	30

Note : The values in the table are the reference values. Determine the values suitable for the characteristics of the crystal used.

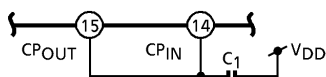
Note : When not using the crystal oscillator circuit, always connect pin 3 ( $X_T$ ) to GND as shown in the diagram to overcome the effects of noise and to reduce current consumption.



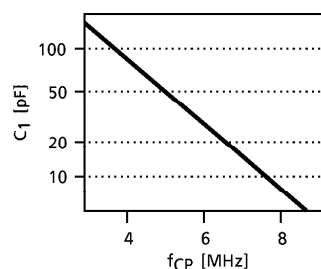
<When not using the crystal oscillator circuit>

2. Reference Frequency Input/Output Terminals (CP<sub>OUT</sub>, CP<sub>IN</sub>)

- Divided output  $\frac{f_x}{N}$  from the crystal reference frequency divider is available at CP<sub>OUT</sub>, which is normally connected to CP<sub>IN</sub>.
- When an external oscillator (CR oscillator, etc.) is connected to CP<sub>IN</sub>, motor speed can be finally adjusted.
- If the effects of noise from CP<sub>IN</sub> input signal overshoot must be controlled, connect capacitor C<sub>1</sub> as in the following diagram.



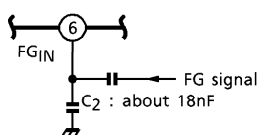
Note : When connecting capacitor C<sub>1</sub>, make sure that the input level of pin 14 (CP<sub>IN</sub>) does not fall below the standard ( $V_{IH} \geq 0.8 \times V_{DD}$ ,  $V_L \leq 0.2 \times V_{DD}$ )



<Reference value>

3. FG Pulse Input Terminal (FG<sub>IN</sub>)

- This is the input terminal of FG pulse that shows the motor speed. This FG pulse becomes comparison frequency.
- This terminal has built-in Amplifier and Schmitt circuit. FG pulses are applied through capacitor coupling and small amplitude is enough for proper operation.
- If there is noise in the FG signal, connect capacitor C<sub>2</sub> as shown in the diagram to control the noise.



Note : Determine the values of capacitors C<sub>1</sub> and C<sub>2</sub> after checking their characteristics with f<sub>CP</sub> and f<sub>FG</sub> used.

Note : When connecting capacitor C<sub>2</sub>, make sure that the input level of pin 6 (FG<sub>IN</sub>) does not fall below the standard ( $V_{inFG} \geq 0.5V_{p-p}$ )

## 4. Lock Range Switching Terminal (N/W)

This terminal is for switching the Lock range with a pull-up resistor and chattering preventive circuit.

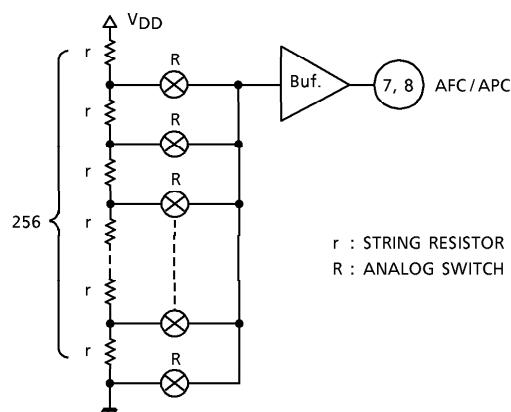
(TRUTH TABLE)

N / W	DIVIDED FREQUENCY	LOCK RANGE
L	$\frac{1}{27}$	+ 3.4 ~ - 3.9% of reference cycle
H or NC	$\frac{1}{20}$	+ 4.6 ~ - 5.3% of reference cycle

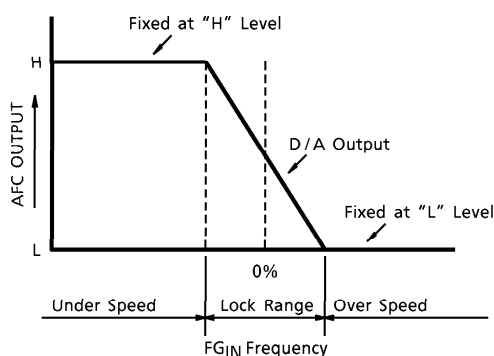
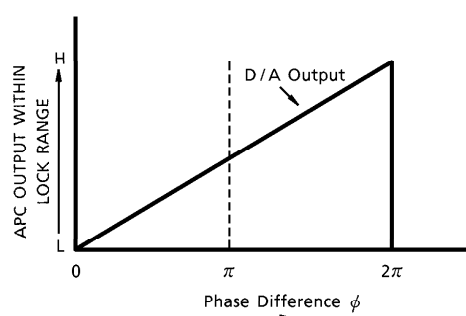
CAUTION reference frequency  $FS = f_x / N \times (20 \text{ or } 27) \times 128 \text{ (Hz)}$ ,  $FS' = \frac{FS}{2}$

## 5. APC, AFC Output Terminal (APC, AFC)

- AFC (speed control output) is a F-V converter for FG frequency and is consisting of a 8bit D/A converter.
- APC (phase control output) is a phase comparator ( $\phi$ -V converter) that compares phase difference  $\phi$  between 1/2 FG and reference frequency  $FS'$ , and is also consisting of a 8bit D/A converter.

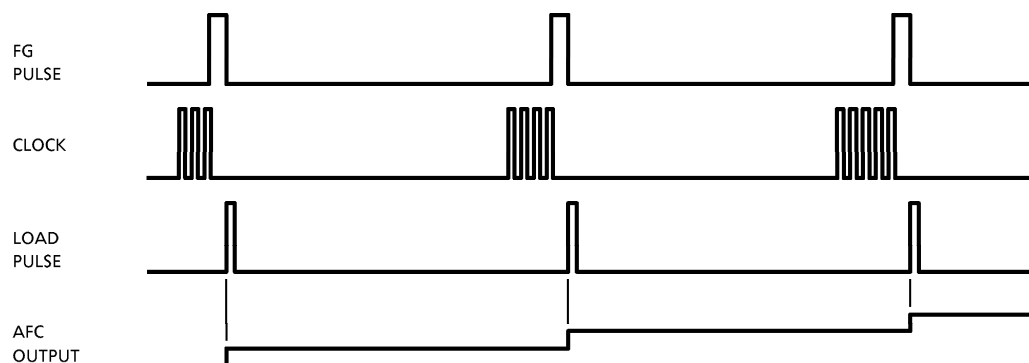


- Both APC and AFC perform the following 3 operations according to  $FG_{IN}$  frequency.
  - When  $FG_{IN}$  frequency is within the lock range:  
Both APC and AFC perform the normal operation for  $FG_{IN}$ .
  - When  $FG_{IN}$  frequency is below the lock range (under speed):  
APC and AFC outputs are both fixed at "H" level.
  - When  $FG_{IN}$  frequency is above the lock range (over speed):  
APC and AFC outputs are both fixed at "L" level.
- When a motor is in STOP state ( $P/S = H$  or  $NC$ ), both AFC and APC are fixed "L" level.

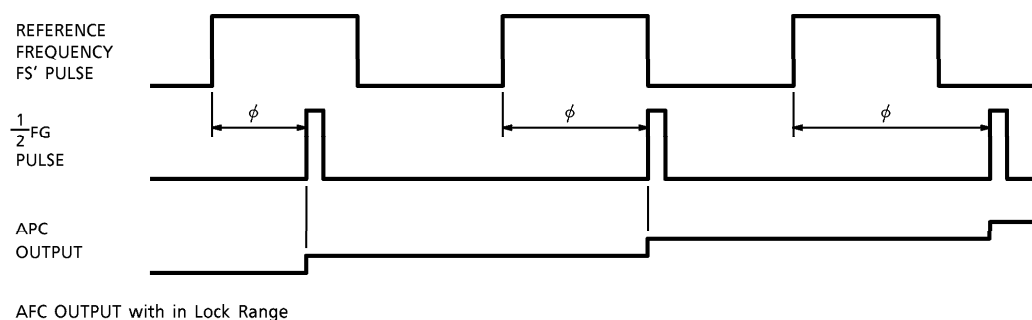
AFC output change status for  $FG_{IN}$  frequencyAPC output change status for phase difference  $\phi$ 

- AFC and APC timing chart within lock range.

a. AFC (SPEED CONTROL SYSTEM)



b. APC (PHASE CONTROL SYSTEM)



6. Lock Detecting Terminal (LD)

- This terminal is the lock detecting output and is placed at "H" level when  $FG_{IN}$  frequency is within the lock range and otherwise, placed at "L" level.

7. RUN/STOP Input Terminal (R/S)

- RUN/STOP signals of the motor are input to this terminal.  
PLAY = L, STOP = H or NC.
- This terminal has a pull-up resistor and a chattering preventive circuit.
- During RUN ( $R/S = L$ ), AFC, APC and LD perform the above-mentioned operations for  $FG_{IN}$  frequency, and during STOP ( $R/S = H$  or NC), AFC, APC and LD are all fixed at "L" level.

## 8. Reverse Signal Output Terminal (RV)

- Reverse signal for braking the motor at time of switching of Lock range from 1/20 to 1/27 or the operation from RUN to STOP is output through this terminal.
- Change of RV output status

PREVIOUS STATUS	RV OUTPUT CHANGE TO "H" LEVEL	RV OUTPUT CHANGE TO "L" LEVEL
During Normal Rotation (During Lock) at 1/20	When the Lock range is switched from 1/20 to 1/27.	When the Lock range is locked at 1/27, or When $FG_{IN} \leq 1/8FS$ , or when the Lock range is switched from 1/27 to 1/20.
During Normal Rotation (During Lock) at 1/20 or 1/27	When the operation is switched from RUN to STOP.	When $FG_{IN} \leq 1/8FS$ or when the operation is switched from STOP to RUN.

- In other cases than above, RV output is not changed and fixed at "L" level.
- Further, if FG frequency rises up to 1.5 times of normal rotation at 1/20 (2 times of normal rotation at 1/27), RV output is reset.

9. Reference Divided Frequency Switching Terminal (N<sub>1</sub>, N<sub>2</sub>)

- Divided frequency 1/N of the crystal reference frequency divider can be switched to 1/5, 1/4 or 1/3 by number of FG pulses or a crystal used.
- This terminal has a built-in pull-up resistor.

(TRUTH TABLE)

N1	N2	1/N
H	H	1/5
L	H	1/4
H	L	1/3

1/N : Crystal reference divided frequency

Note : Do not use N1 = N2 = L, which is used for internal test only.

## MAXIMUM RATINGS (Ta = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	V <sub>DD</sub>	-0.3~7.0	V
Input Voltage	V <sub>IN</sub>	-0.3~V <sub>DD</sub> + 0.3	V
Power Dissipation	P <sub>D</sub>	300	mW
Operating Temperature	T <sub>opr</sub>	-40~85	°C
Storage Temperature	T <sub>stg</sub>	-65~150	°C

ELECTRICAL CHARACTERISTICS (Unless otherwise specified Ta = 25°C, V<sub>DD</sub> = 5V)

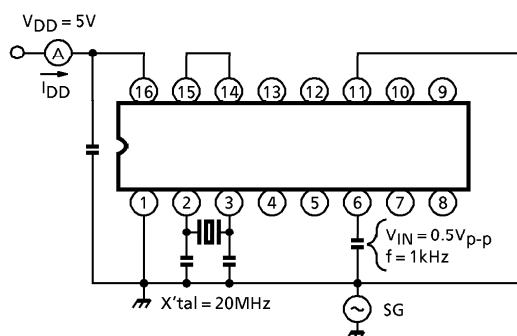
CHARACTERISTIC		SYMBOL	TEST CIRCUIT	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Operating Supply Voltage		V <sub>DD</sub>	—	※	4.5	5.0	5.5	V
Operating Supply Current		I <sub>DD</sub>	1	X'tal = 20MHz, CP <sub>in</sub> = CP <sub>out</sub>	—	15.0	25.0	mA
Operating Frequency Range	X <sub>T</sub>	f <sub>XT</sub>	2	※	1.5	~	20.0	MHz
	CP <sub>in</sub>	f <sub>CP</sub>	3	V <sub>in</sub> Square Wave ※	0.3	~	10.0	MHz
	FG <sub>in</sub>	f <sub>FG</sub>	—	V <sub>in</sub> = 0.5V <sub>p-p</sub> Sine Wave ※	—	~	4.0	kHz
Input Amplitude Voltage	FG <sub>in</sub>	V <sub>inFG</sub>	4	f <sub>FG</sub> = 4kHz, Sine Wave, AC input ※	0.5	~	V <sub>DD</sub> - 0.5	V <sub>p-p</sub>
AFC, APC D/A Converter	Deviation	—	—	—	—	±2.0	±4.0	LSB
	Resolution	—	—	—	—	V <sub>DD</sub> /256	—	V
Pull-up Resistor		R <sub>in</sub>	—	N1, N2, N/W, R/S	15	30	60	kΩ
Input Voltage	"H" Level	V <sub>IH</sub>	—	N1, N2, N/W, R/S, CP <sub>in</sub>	V <sub>DD</sub> × 0.8	~	V <sub>DD</sub>	V
	"L" Level	V <sub>IL</sub>		N1, N2, N/W, R/S, CP <sub>in</sub>	0	~	V <sub>DD</sub> × 0.2	
Input Leak Current		I <sub>IH</sub>	—	CP <sub>in</sub>	—	—	±1.0	μA
		I <sub>IL</sub>		CP <sub>in</sub>				
Output Current	"H" Level	I <sub>OH</sub>	—	RV, LD, CP <sub>out</sub> V <sub>OH</sub> = 4.5V	-0.5	-2.5	—	mA
	"L" Level	I <sub>OL</sub>		RV, LD, CP <sub>out</sub> V <sub>OL</sub> = 0.5V	0.5	2.5	—	
	"H" Level	I <sub>OH</sub>	—	APC, AFC V <sub>OH</sub> = 4.5V	-0.3	-1.0	—	μA
	"L" Level	I <sub>OL</sub>		APC, AFC V <sub>OL</sub> = 0.5V	25	75	—	
Amplifier Feedback Resistor	X <sub>T</sub>	R <sub>f</sub>	5	—	150	330	660	kΩ
	FG <sub>in</sub>	R <sub>f</sub>	5	—	150	330	660	kΩ

※ : Guaranteed within the range of V<sub>DD</sub> = 4.5~5.5V, Ta = -40~85°C

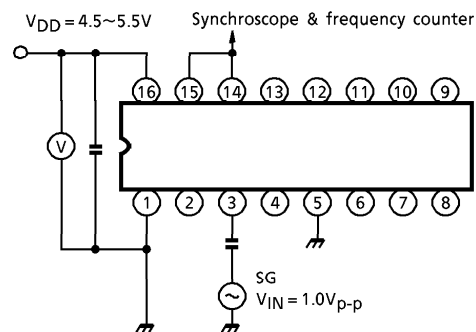


# TEST CIRCUIT

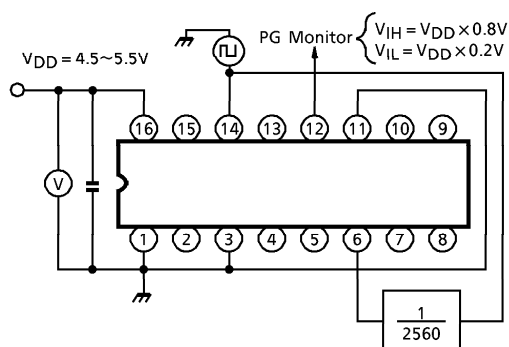
## 1. Operating Supply Current $I_{DD}$



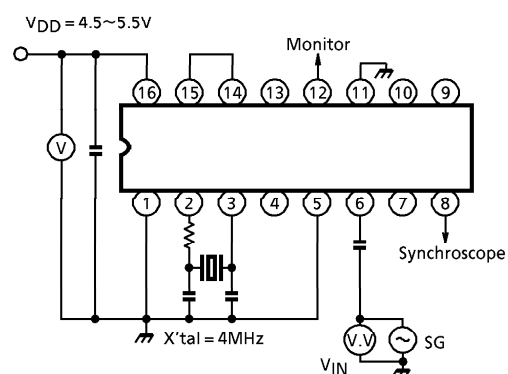
## 2. $X_T$ Operating Frequency Range $f_{MAX}$ ( $f_{XT}$ )



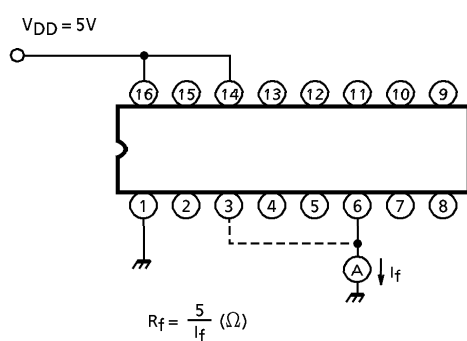
## 3. $CP_{IN}$ Operating Frequency Range $f_{MAX}$ ( $f_{CP}$ )



## 4. $FG_{IN}$ Input Sensitivity $V_{INFG}$

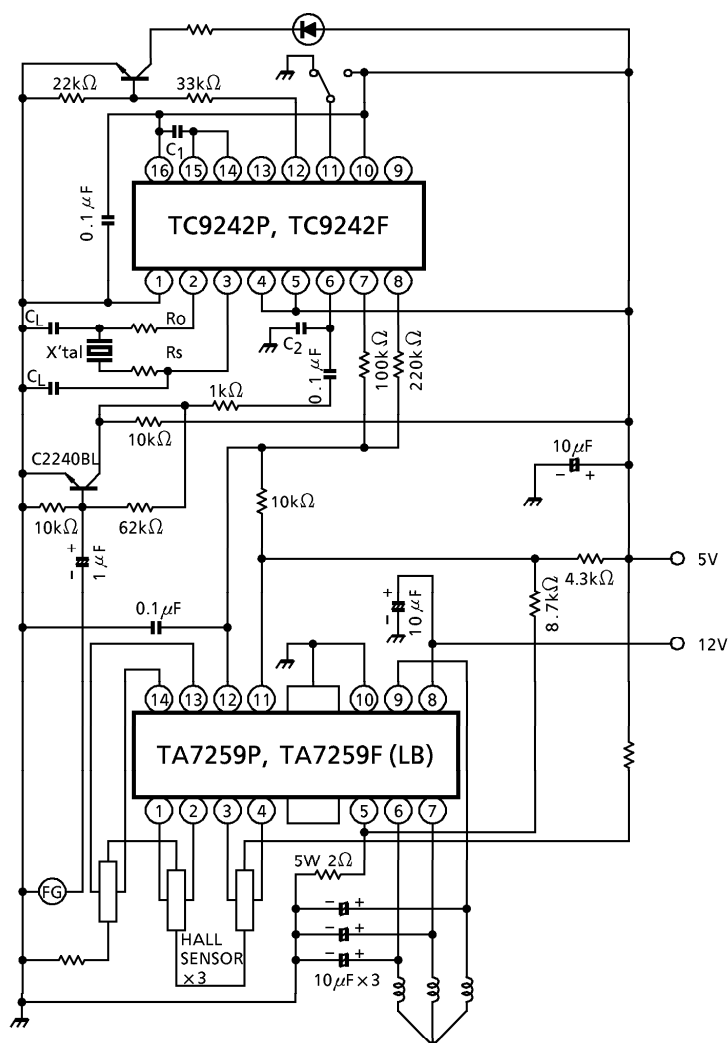


## 5. Amplifier Feedback Resistor $R_f$



$$R_f = \frac{5}{I_f} (\Omega)$$

## APPLICATION CIRCUIT



- Example of crystal oscillation frequency calculation.

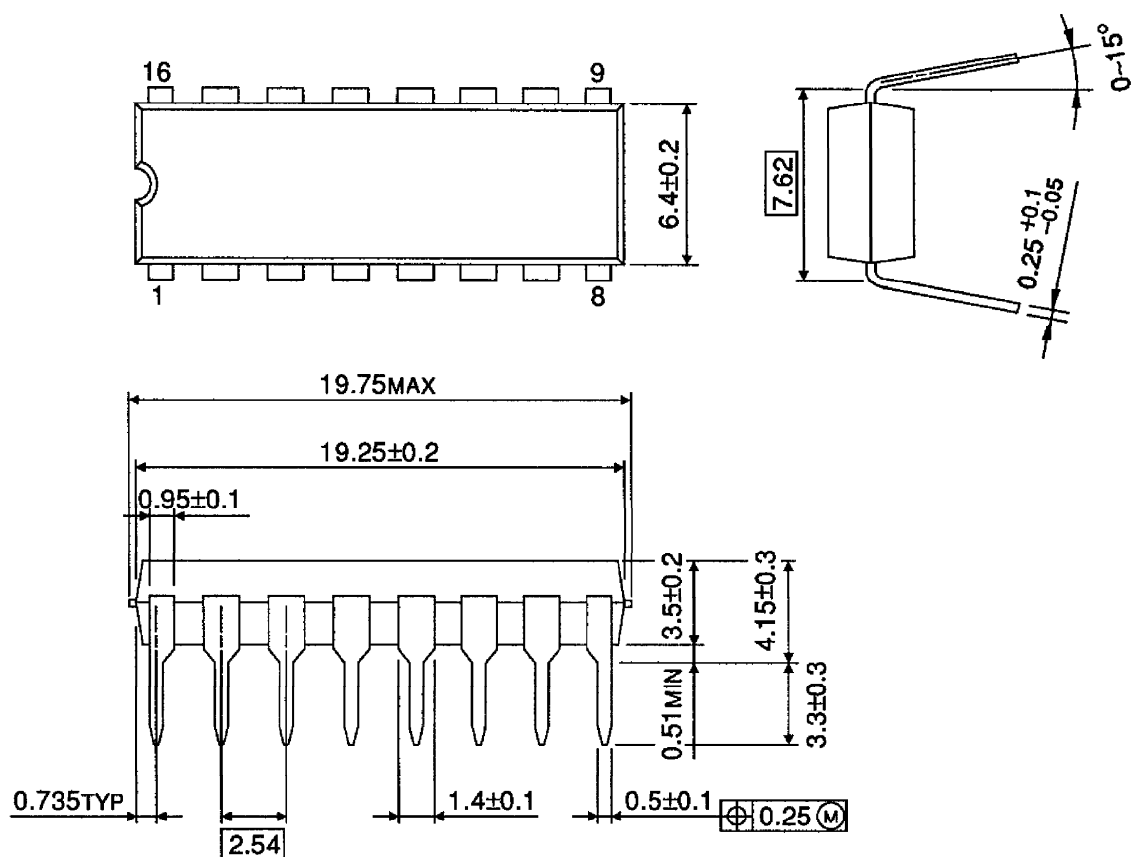
When FG' (number of FG pulse) = 180 pulses and R (revolution of motor) = 200rpm., if the dividing frequency of reference divider and lock range is set at N = 5 dividing frequency and N/W = 20, the crystal oscillation frequency  $f_x$  is as follows :

$$f_x = \frac{R}{60} \times FG' \times 128 \times 20 \times N = \frac{200}{60} \times 180 \times 128 \times 20 \times 5 = 7.68\text{MHz}$$

- Select the external filter of the differential amplifier in the application circuit depending on the response characteristics of the motor used.
- Determine values C1, C2, CL, Ro and Rs in the application circuit depending on the characteristics of the circuit.

## OUTLINE DRAWING DIP16-P-300-2.54A

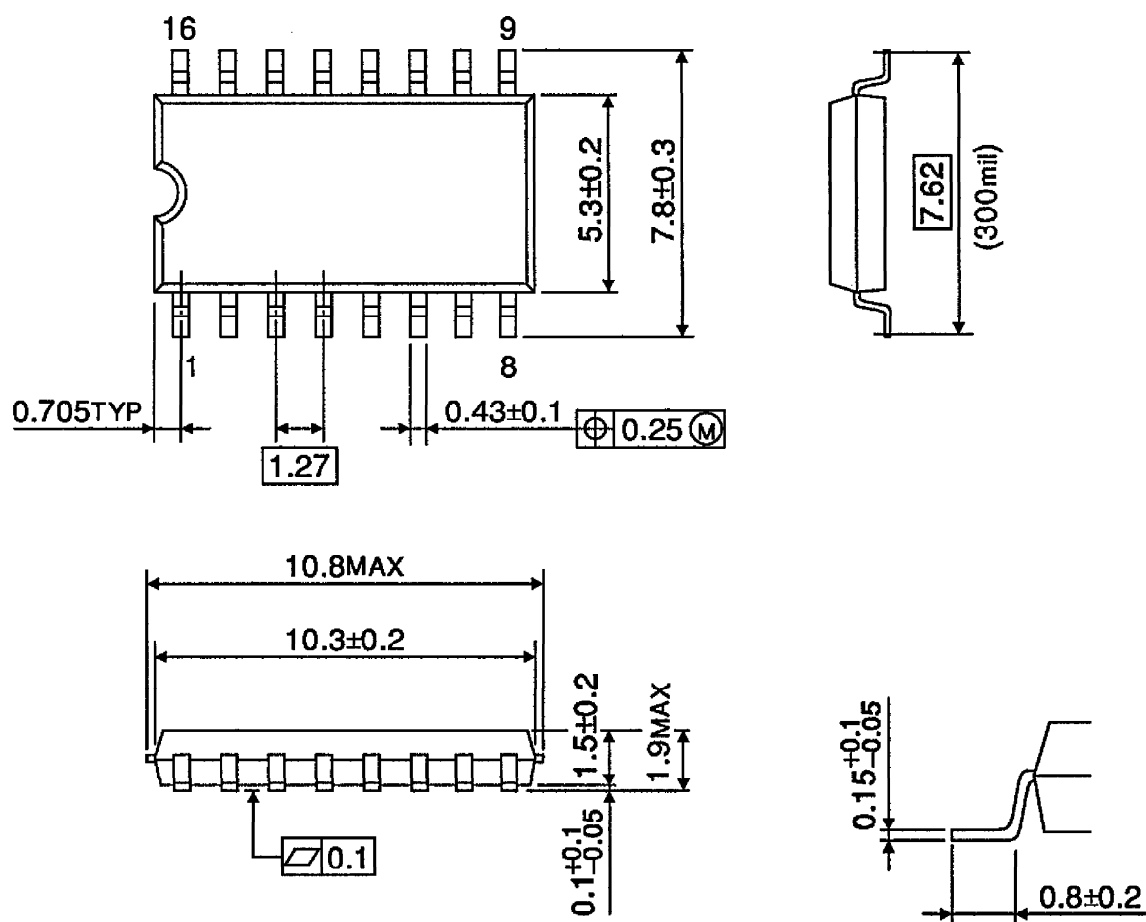
Unit : mm



Weight : 1.00g (Typ.)

**OUTLINE DRAWING**  
SOP16-P-300-1.27

Unit : mm



Weight : 0.16g (Typ.)