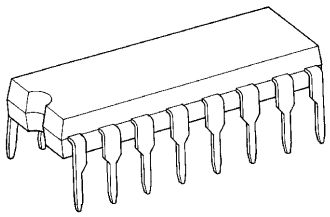
TOSHIBA BIPOLAR DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

TC9242P, TC9242F

QUARTZ PLL MOTOR CONTROL

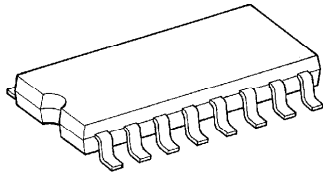
The TC9242P, TC9242F are CMOS LSIs developed for controlling the motor speed.
Since an 8bit D / A converter system has been employed for each of the speed control system (AFC) and the phase control system (APC).
Offers improved linearity.
With frequency division ratios of 1 / 3, 1 / 4 and 1 / 5 the standard divider is ideal for laser scanner motors.

TC9242P



DIP16-P-300-2.54A

TC9242F



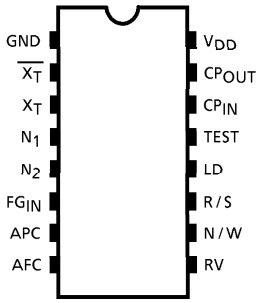
SOP16-P-300-1.27

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

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.

PIN CONNECTIONS (TOP VIEW)



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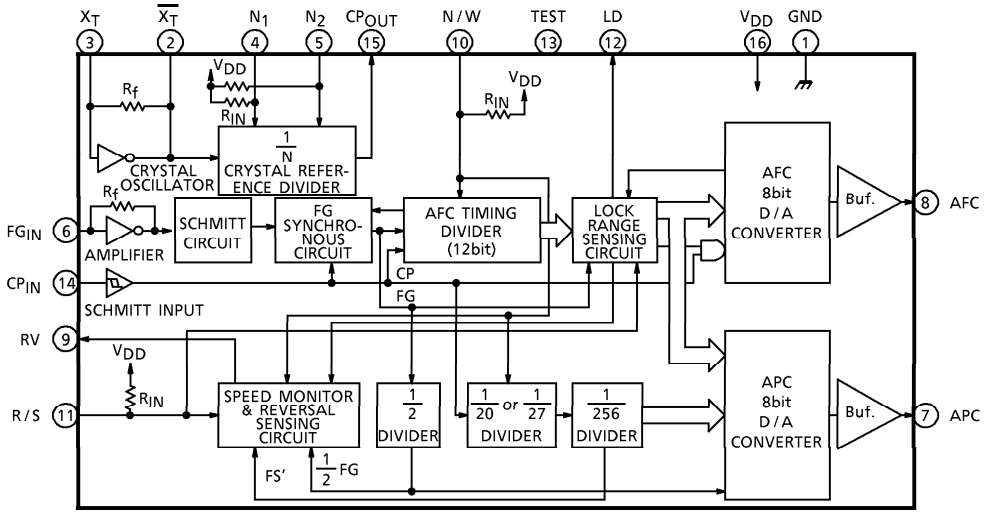
BLOCK DIAGRAM



FUNCTIONAL EXPLANATION OF EACH TERMINAL

PIN No.	SYMBOL	PIN NAME	FUNCTIONAL & OPERATION EXPLANATION	REMARKS
16	V_{DD}	Power Terminal	V_{DD} = 5V ± 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	$\overline{X_T}$			
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	FG_{IN}	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	CP_{IN}	Reference Frequency Input Terminal	Normally connected to CP_{OUT}. For external fine adjustment input from an external oscillator.	CMOS SCHMITT INPUT
15	CP_{OUT}	Reference Frequency Output Terminal	Terminal for divided output from the crystal reference frequency divider. Normally connected to CP_{IN}.	CMOS OUTPUT
13	TEST	Output Terminal for INTERNAL TEST	Output terminal for INTERNAL TEST. Generally open.	—

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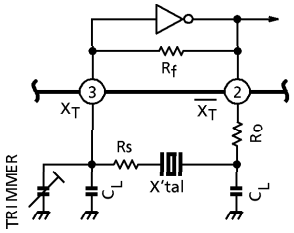
EXPLANATION OF OPERATION

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, fX : 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.)

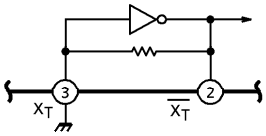
- Maximum operating frequency is above 20MHz and crystals up to 20MHz can be used.
- If necessary, adjust Ro, Rs and CL to control noise from the crystal oscillator circuit or to control overtone oscillation.

<Reference values>

f_{XT} (MHz)	Ro (Ω)	Rs (Ω)	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 (XT) 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>

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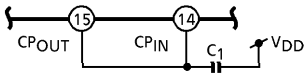
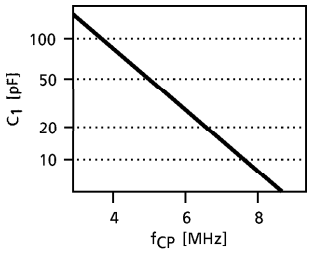
2. Reference Frequency Input / Output Terminals (CP_{OUT}, CP_{IN})
   - Divided output $\frac{f_x}{N}$ from the crystal reference frequency divider is available at CP_{OUT}, which is normally connected to CP_{IN}.
   - When an external oscillator (CR oscillator, etc.) is connected to CP_{IN}, motor speed can be finally adjusted.
   - If the effects of noise from CP_{IN} input signal overshoot must be controlled, connect capacitor C1 as in the following diagram.

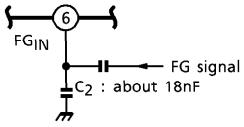


Note : When connecting capacitor C1, make sure that the input level of pin 14 (CP_{IN}) does not fall blow the standard ($V_{IH} \geqq 0.8 \times V_{DD}$, $V_L \leqq 0.2 \times V_{DD}$)



<Reference value>

3. FG Pulse Input Terminal (FG_{IN})
   - 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 C2 as shown in the diagram to control the noise.



Note : Determine the values of capacitors C1 and C2 after checking their characteristics with f_{CP} and f_{FG} used.

Note : When connecting capacitor C2, make sure that the input level of pin 6 (FG_{IN}) does not fall below the standard ($V_{in}FG \geqq 0.5V_{p\text{-}p}$)

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

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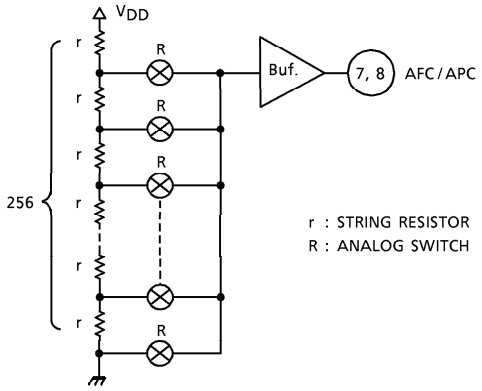
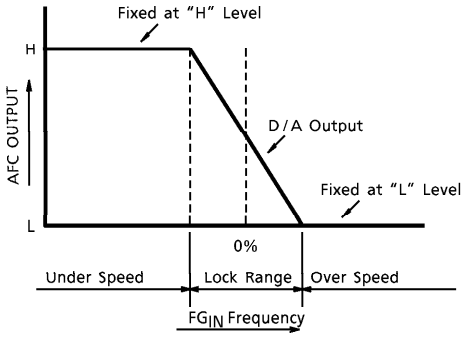
5. APC, AFC Output Terminal (APC, AFC)

- 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 (ϕ-V converter) that compares phase difference ϕ between 1 / 2 FG and reference frequency FS', and is also consisting of a 8bit D / A converter.

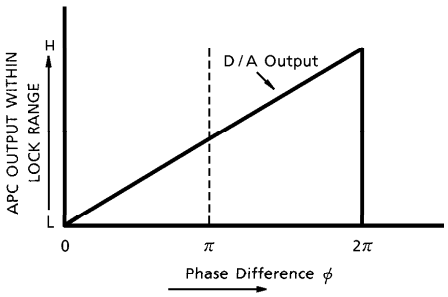


- Both APC and AFC perform the following 3 operations according to FG_{IN} frequency.
  a. When FG_{IN} frequency is within the lock range:
  Both APC and AFC perform the normal operation for FG_{IN}.
  b. When FG_{IN} frequency is below the lock range (under speed):
  APC and AFC outputs are both fixed at "H" level.
  c. 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} frequency



APC output change status for phase difference ϕ



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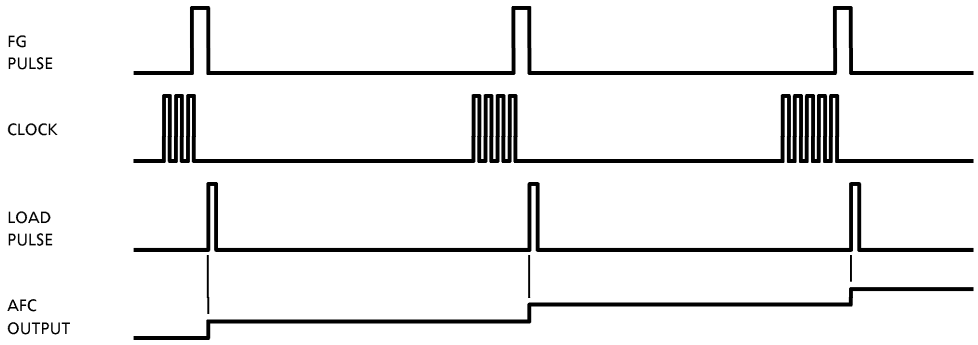
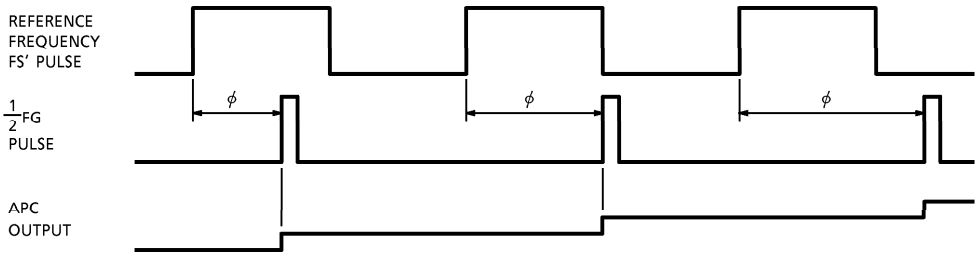
- AFC and APC timing chart within lock range.

  a. AFC (SPEED CONTROL SYSTEM)



  b. APC (PHASE CONTROL SYSTEM)



AFC OUTPUT with in Lock Range

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.

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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 $FG_{IN} \leqq 1/8FS$, 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 $FG_{IN} \leqq 1/8FS$ 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_1, N_2)

- 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.

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MAXIMUM RATINGS (Ta = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	V_{DD}	−0.3~7.0	V
Input Voltage	V_{IN}	−0.3~V_{DD} + 0.3	V
Power Dissipation	P_D	300	mW
Operating Temperature	T_{opr}	−40~85	°C
Storage Temperature	T_{stg}	−65~150	°C

ELECTRICAL CHARACTERISTICS (Unless otherwise specified Ta = 25°C, V_{DD} = 5V)

CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Operating Supply Voltage		V_{DD}	—	※	4.5	5.0	5.5	V
Operating Supply Current		I_{DD}	1	X'tal = 20MHz, CP_{in} = CP_{out}	—	15.0	25.0	mA
Operating Frequency Range	X_T	f_{XT}	2	※	1.5	~	20.0	MHz
	CP_{in}	f_{CP}	3	V_{in} Square Wave ※	0.3	~	10.0	MHz
	FG_{in}	f_{FG}	—	V_{in} = 0.5V_{p-p} Sine Wave ※	—	~	4.0	kHz
Input Amplitude Voltage	FG_{in}	$V_{in}FG$	4	f_{FG} = 4kHz, Sine Wave, AC input ※	0.5	~	V_{DD} − 0.5	V_{p-p}
AFC, APC D / A Converter	Deviation	—	—	—	—	±2.0	±4.0	LSB
	Resolution	—	—	—	—	V_{DD} / 256	—	V
Pull-up Resistor		R_{in}	—	N1, N2, N / W, R / S	15	30	60	kΩ
Input Voltage	"H" Level	V_{IH}	—	N1, N2, N / W, R / S, CP_{in}	V_{DD} × 0.8	~	V_{DD}	V
	"L" Level	V_{IL}		N1, N2, N / W, R / S, CP_{in}	0	~	V_{DD} × 0.2	
Input Leak Current		I_{IH}	—	CP_{in}	—	—	±1.0	μA
		I_{IL}		CP_{in}				
Output Current	"H" Level	I_{OH}	—	RV, LD, CP_{out} V_{OH} = 4.5V	−0.5	−2.5	—	mA
	"L" Level	I_{OL}		RV, LD, CP_{out} V_{OL} = 0.5V	0.5	2.5	—	
	"H" Level	I_{OH}	—	APC, AFC V_{OH} = 4.5V	−0.3	−1.0	—	
	"L" Level	I_{OL}		APC, AFC V_{OL} = 0.5V	25	75	—	μA
Amplifier Feedback Resistor	X_T	R_f	5	—	150	330	660	kΩ
	FG_{in}	R_f	5	—	150	330	660	kΩ

※ : Guaranteed within the range of V_{DD} = 4.5~5.5V, Ta = −40~85°C

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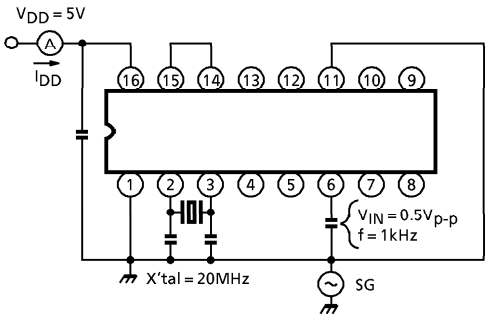
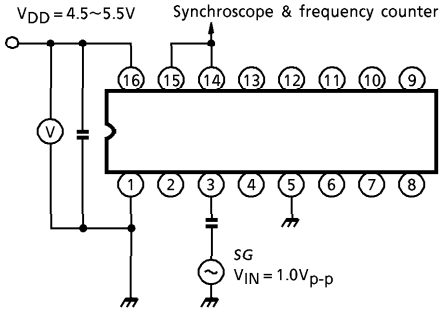
TEST CIRCUIT

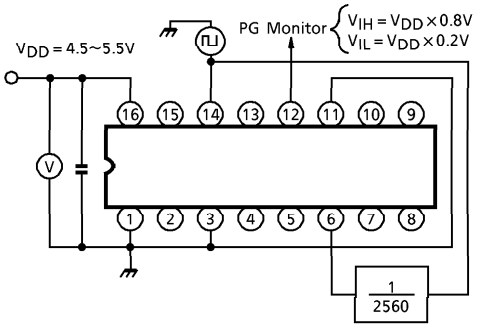
1. Operating Supply Current I_{DD}



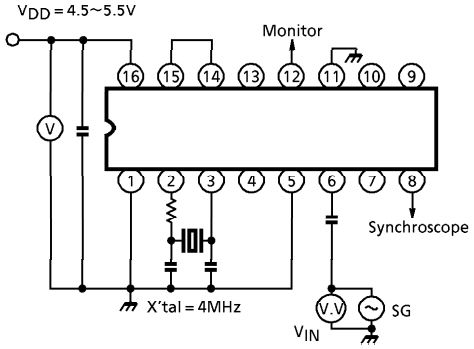
2. X_T Operating Frequency Range f_{MAX} (f_{XT})



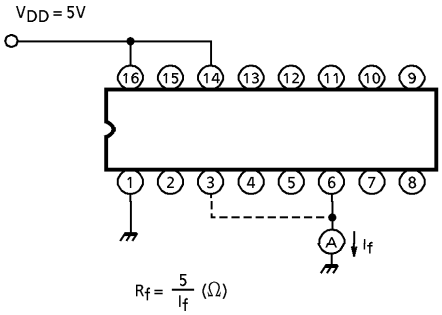
3. CP_{IN} Operating Frequency Range f_{MAX} (f_{CP})



4. FG_{IN} Input Sensitivity $V_{IN}FG$



5. Amplifier Feedback Resistor R_f



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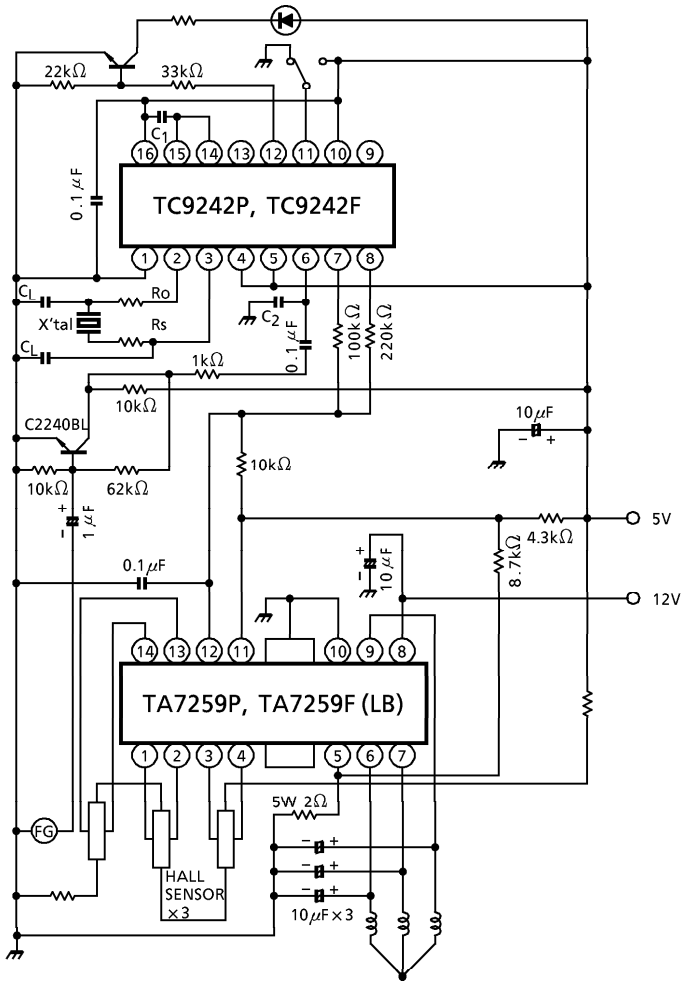
APPLICATION CIRCUIT



- 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 :

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

- 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.

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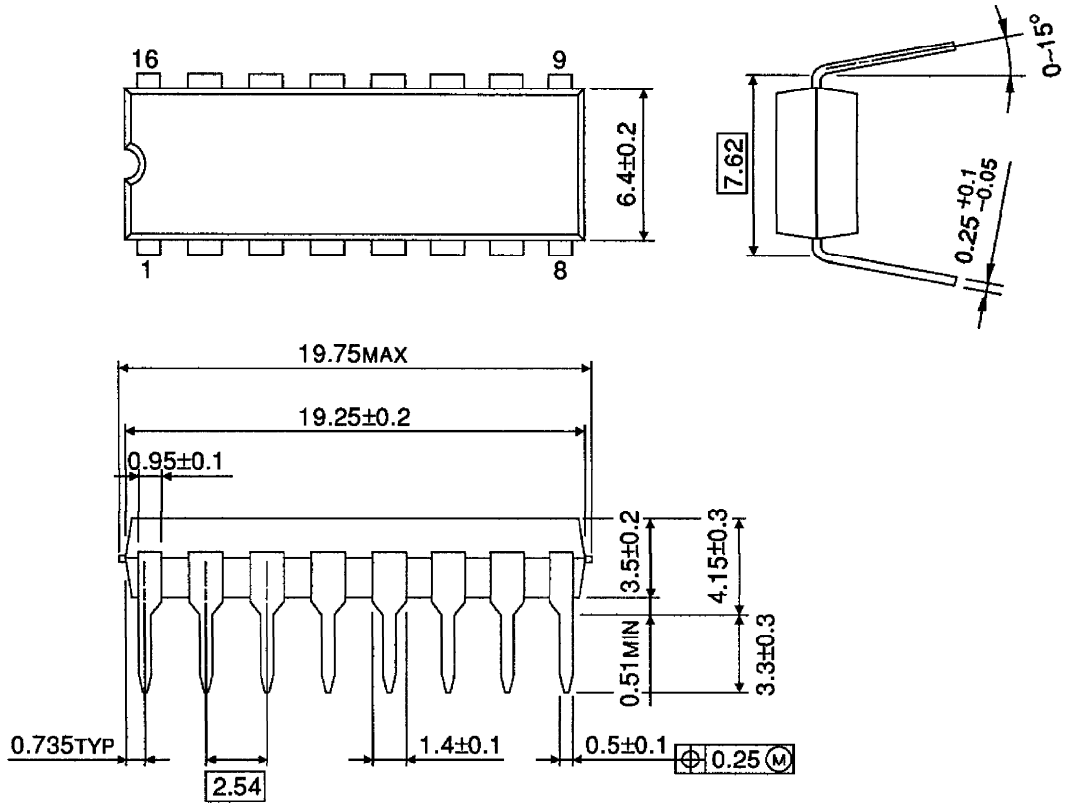
OUTLINE DRAWING

DIP16-P-300-2.54A

Unit : mm



Weight : 1.00g (Typ.)

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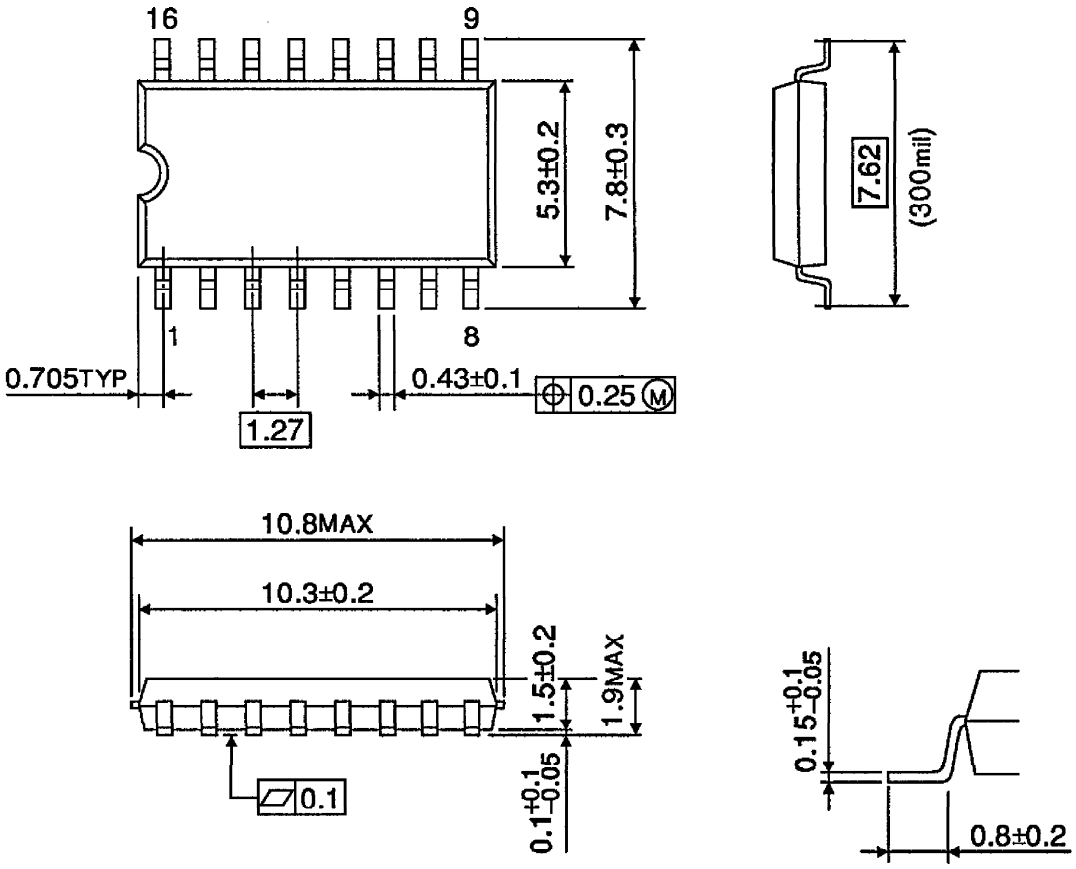
OUTLINE DRAWING

SOP16-P-300-1.27

Unit : mm



Weight : 0.16g (Typ.)

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