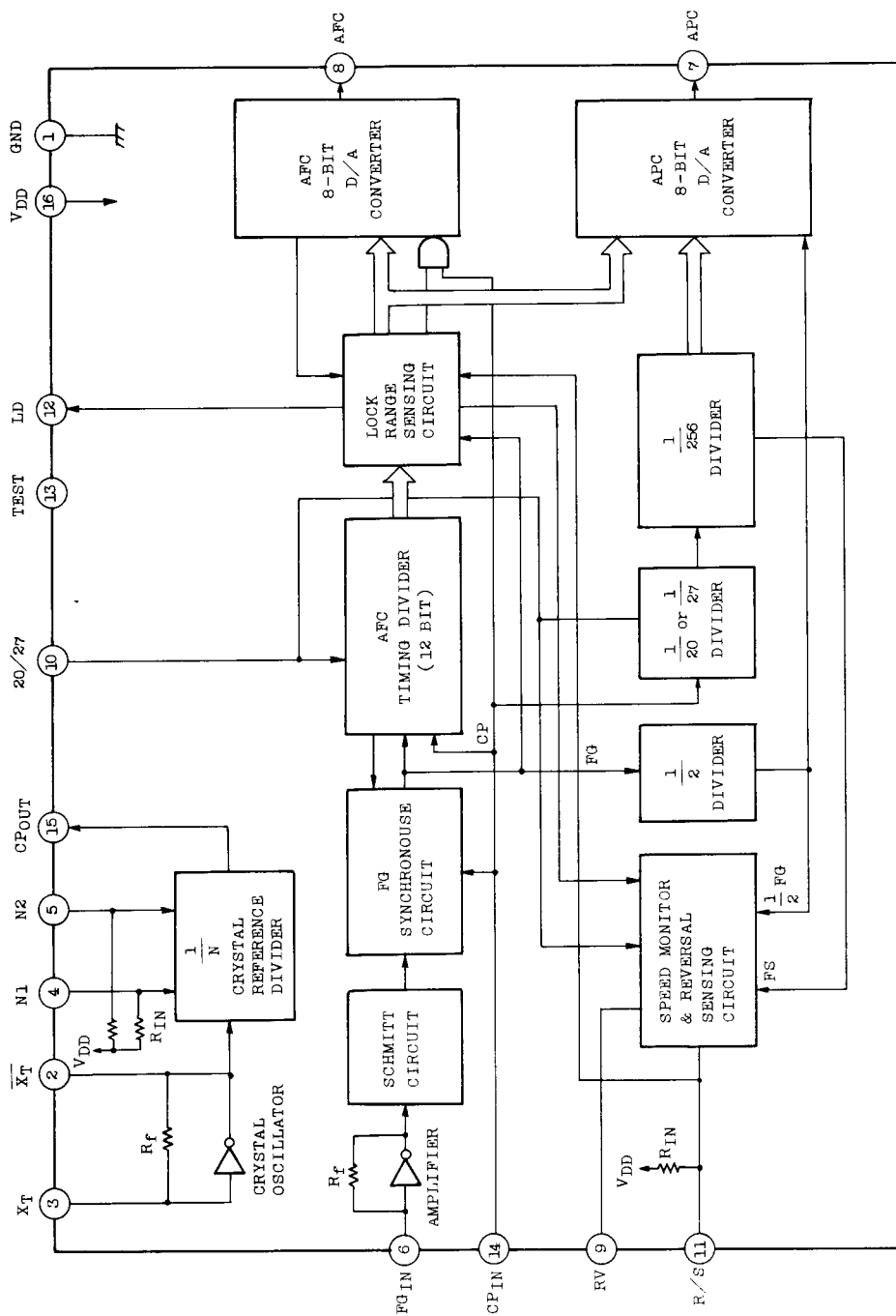


BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS (Unless otherwise specified, $V_{DD}=5V$, $T_a=25^{\circ}C$)

CHARACTERISTIC		SYMBOL	TEST CIRCUIT	TEST CONDITION		MIN.	TYP.	MAX.	UNIT	
Operating Supply Voltage		V _{DD}	-	*		4.5	5.0	5.5	V	
Operating Supply Current		I _{DD}	1	X'tal=8MHz CPIN=CP _{OUT}	*	-	5.0	12.0	mA	
Operating Frequency Range	XT	f _{XT}	2		*	1.0	~	8.0	MHz	
	CPIN	f _{CP}	3	Square wave	*	0.05	~	4.0		
	FGIN	f _{FG}	-	V _{IN} =0.5V _{p-p} Sin wave	*	-	~	10	kHz	
Input Operating Voltage		FGIN	V _{IN} FG	4	f _{FG} =10kHz Sine wave	*	0.5	~	V _{DD} -0.5	V _{p-p}
AFC, APC D/A Converter	Ladder Resistor		R _L	6			30	50	75	kΩ
	Max. Deviation				V _{DD} =4.5~5.5V		-	±2.5	±6.5	LSB
	Resolution			-			-	V _{DD} /256	-	V
	Temperature Drift						-	±1	-	LSB
Pullup Resistor		R _{IN}	-	N1,N2,20/27,R/S	*	10	30	50	kΩ	
Input Voltage	"H" Level	V _{IH}	-	N1,N2,20/27,R/S	*	V _{DD} ×0.8	~	V _{DD}	V	
	"L" Level	V _{IL}		CPIN		0	~	V _{DD} ×0.2		
Input Leak Current		I _{IH} /I _{IL}	-	CPIN	*	-	-	±1.0	μA	
Output Current	"H" Level	I _{OH}	-	RV, LD	V _{OH} =4V	-0.5	-1.0	-	mA	
	"L" Level	I _{OL}		CP _{OUT}	V _{OL} =1V	0.5	1.0	-		
Amplifier Feedback Resistor	XT	R _f	5			100	200	500	kΩ	
	FGIN					300	500	800		

* : Guaranteed within the range of $V_{DD}=4.5V\sim 5.5V$, $T_a=-40\sim 85^{\circ}C$.

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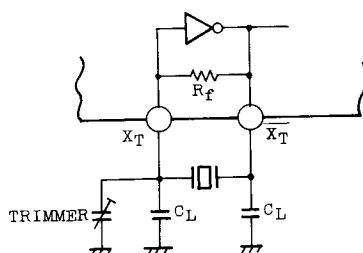
FUNCTIONAL EXPLANATION OF EACH TERMINAL

PIN No.	SYMBOL	TERMINAL NAME	FUNCTIONAL & OPERATION EXPLANATION	REMARKS
16	V _{DD}		Power supply voltage terminal and grunding terminal.	
1	GND			
2	$\overline{X_T}$	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 1/5, 1/6 and 1/12 is possible.	with a built-in pull-up resistor.
5	N ₂			
6	FG _{IN}	FG Pulse Input Terminal	Frequency generator input.	with a built-in amplifier.
7	APC	APC Output Terminal	8 bit DAC output terminal for phase-voltage conversion.	
8	AFC	AFC Output Terminal	8 bit DAC output terminal for frequency-voltage conversion.	
9	RV	Reverse Signal Output Terminal	Terminal for motor reverse signal Output.	
10	20/27	Lock Range Switching Terminal	Terminal for switching lock range. H or NC=1/20, L=1/27.	with a built-in pull-up resistor
11	R/S	RUN/STOP Input Terminal	Motor RUN/STOP signal input terminal. H or NC=STOP, L=RUN.	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.	
14	CP _{IN}	Reference Frequency Input Terminal	Normally connected to CP _{OUT} . For external fine adjustment input from an external oscillator.	
15	CP _{OUT}	Reference Frequency Output Terminal	Terminal for divided output from the crystal reference frequency divider. Normally connected CP _{IN} .	
13	TEST	Test Terminal	Input terminal of internal test. Generally ground.	

OPERATION

1. Crystal oscillation terminals (X_T , $\overline{X_T}$)

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



. C_L 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.

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

(Note) (20 or 27) : 20 at 20/27="H" or Open.

27 at 20/27="L".

f_X : Crystal oscillation frequency, FG' : number of FG pulse generated per revolution of motor, R : revolution of motor per minute,

N : Ratio of frequency division of the crystal reference frequency divider.

(Refer to Item 9.)

- Maximum operating frequency is above 8MHz and crystals up to 8MHz can be used.

2. Reference frequency input/output terminals (CP_{IN} , CP_{OUT})

- Divided output $\frac{f_X}{N}$ from the crystal reference frequency divider is available at CP_{OUT} , which is normally connected CP_{IN} .
- When an external oscillator (CR oscillator, etc.) is connected to CP_{IN} , motor speed can be finally adjusted.

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.

4. Lock range switching terminal (20/27)

- . This terminal is for switching lock range of motor, with a pull-up resistor and chattering preventive circuit.

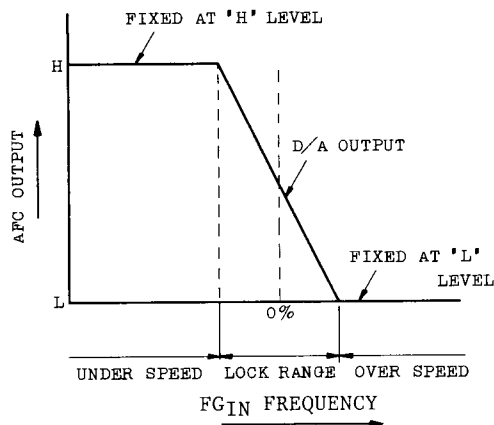
(TRUTH TABLE)

20/27	DIVIDED FREQUENCY	LOCK RANGE
L	1/27	+3.4~-3.9% of reference cycle
H or NC	1/20	+4.6~-5.3% of reference cycle

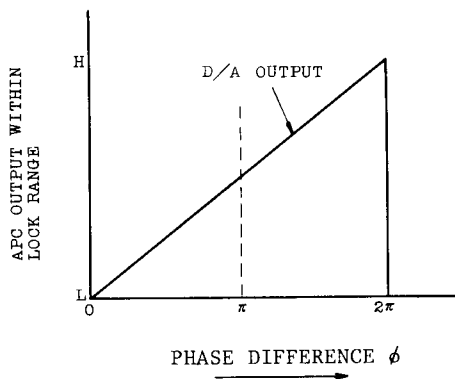
5. APC, AFC output terminal (APC, AFC)

- . AFC (speed control output) is a F-V converter for FG frequency, and is consisting of a 8 bit 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 8 bit 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

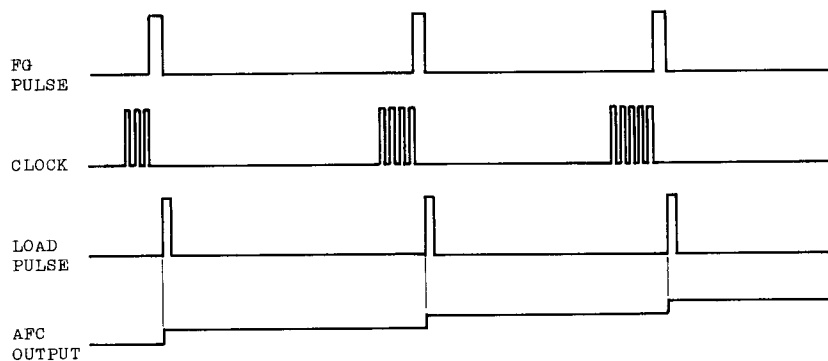


APC Output change status for phase difference ϕ .

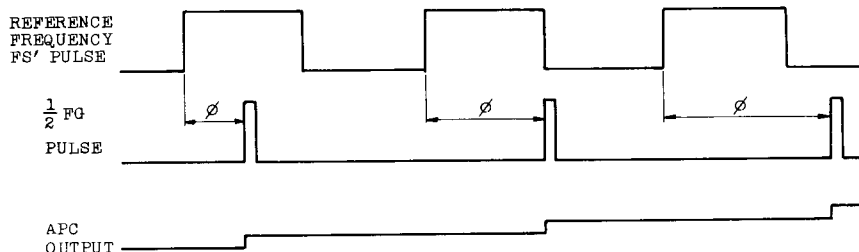


. AFC and APC timing chart within lock range.

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.
- . 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)

- . At the switching of lock range from 1/20 to 1/27 or the operating from RUN to STOP, reverse signal for braking the motor 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 motor speed is locked at 1/27, or when FG _{IN} 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} 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 (N1, N2)

- . Divided frequency 1/N of the crystal reference frequency divider can be switched to 1/5, 1/6 or 1/12 by number of FG pulses or a crystal used.

- . This terminal has a built-in pull-up resistor.

(TRUTH TABLE)

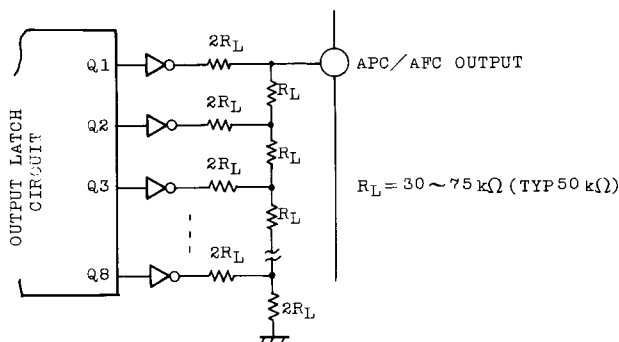
N1	N2	1/N
H	H	1/5
L	H	1/6
H	L	1/12

1/N: CRISTAL REFERENCE DIVIDED FREQUENCY

(Note) Don't use mode, N1=N2="L", because this mode is test mode.

CAUTION IN APPLICATION

- . APC and AFC terminals are for the 8-bit D/A converter outputs, which are directly output from the R-2R ladder type resistor network as shown in the following diagram. Impedance of these outputs becomes equal to the ladder resistor value R_L . Therefore, input impedance at the receiving side of these terminals shall be designed accordingly.

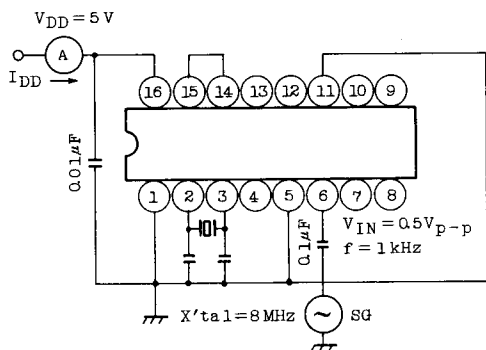


- . A filter for an externally mounted differential amplifier on an application circuit shall be selected to meet the response characteristic of a motor to be used.

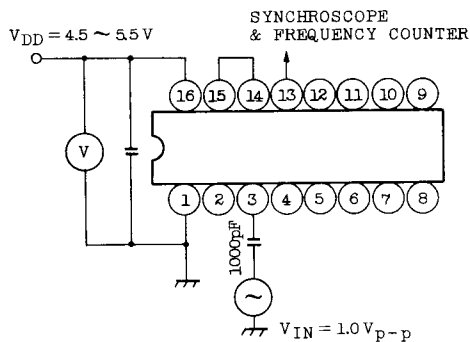
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CHARACTERISTIC TEST CIRCUIT

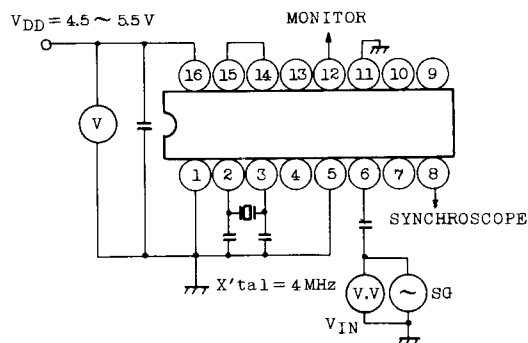
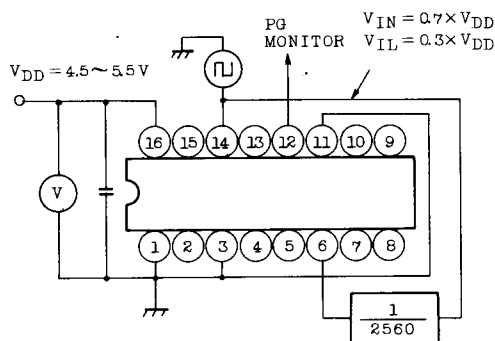
(1) Operating supply current I_{DD}



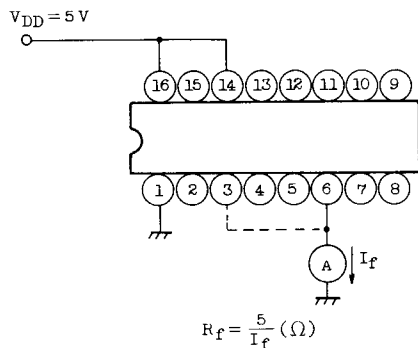
(2) XT Operating frequency range $f_{MAX}(f_{XT})$



(3) CP_{IN} Operating frequency range $f_{MAX}(f_{CP})$ (4) FG_{IN} Input sensitivity V_{INFG}

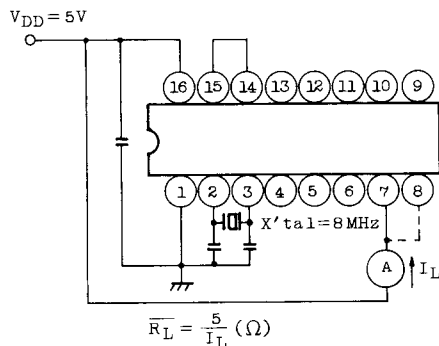


(5) Amplifier feedback resistor

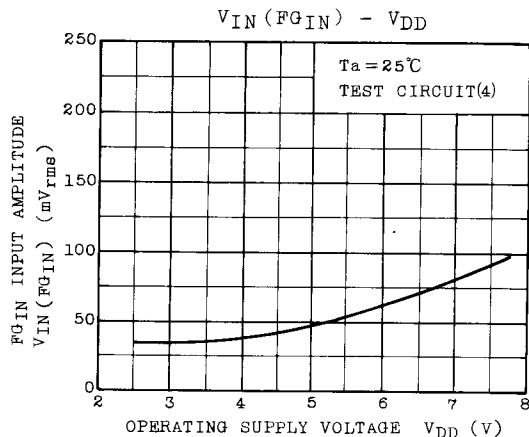
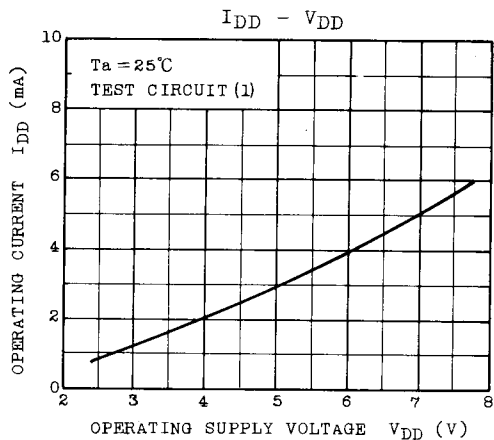
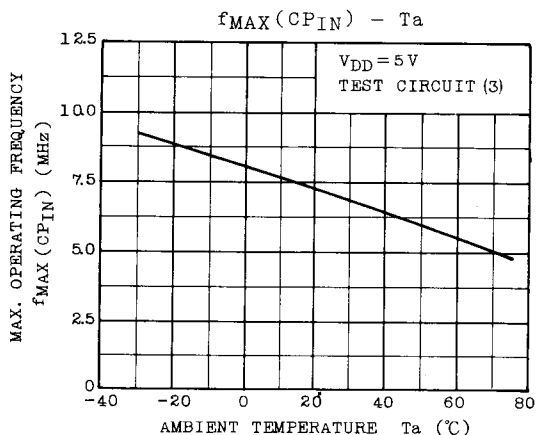
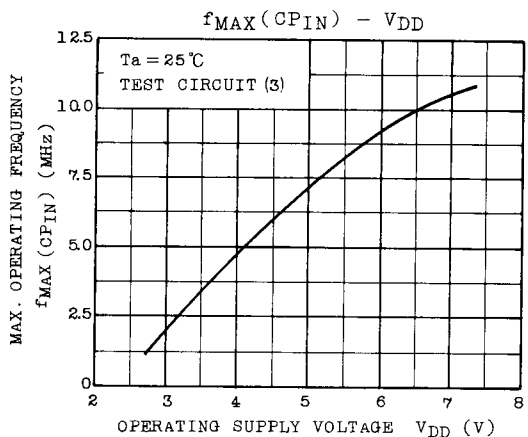
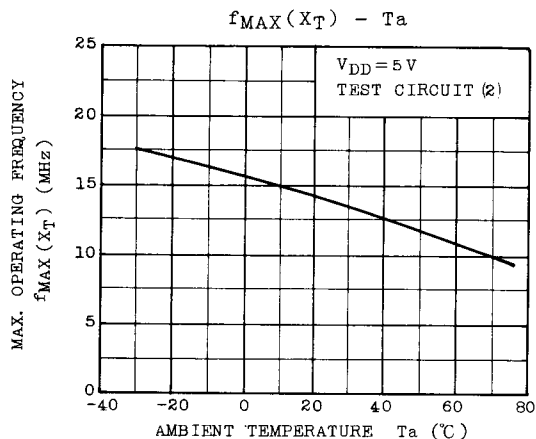
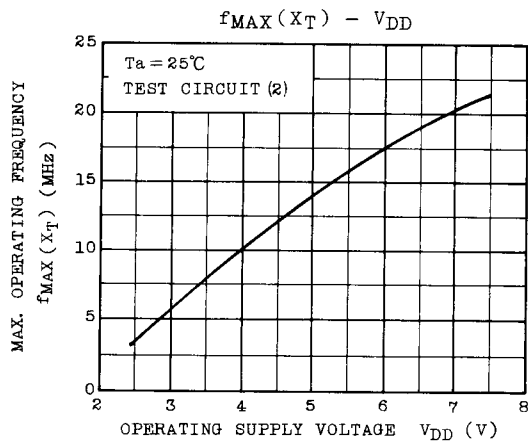


$$R_f = \frac{5}{I_f} (\Omega)$$

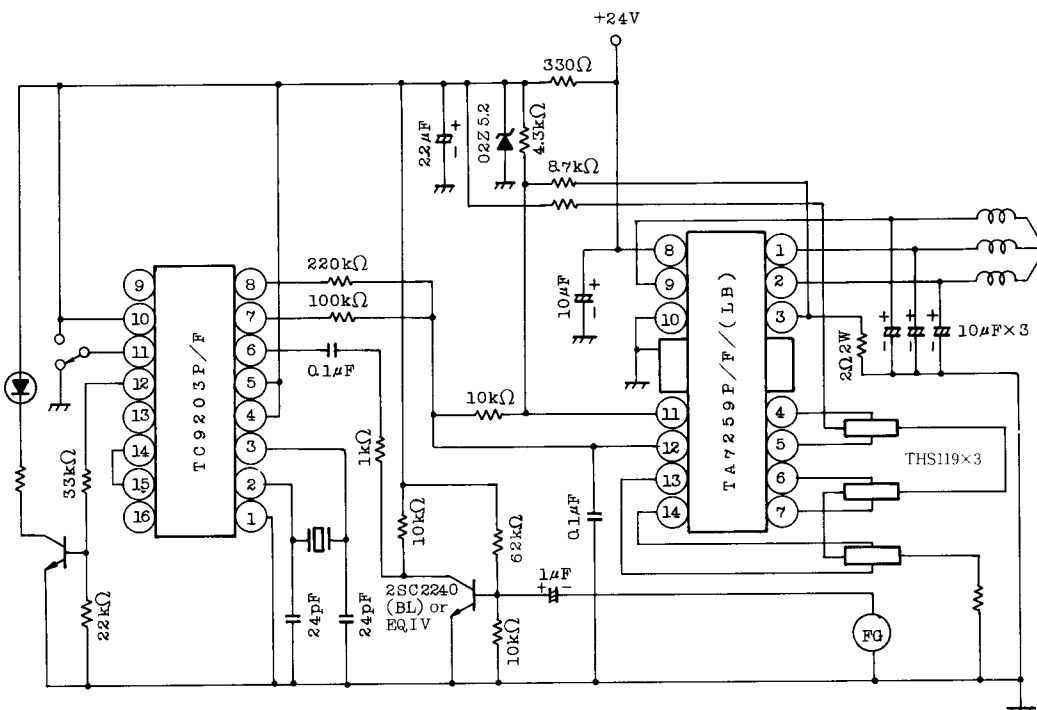
(6) D/A Converter ladder resistor $\overline{R}_L$



$$\overline{R}_L = \frac{5}{I_L} (\Omega)$$

CHARACTERISTIC DATA


EXAMPLE APPLICATION CIRCUIT



Example of crystal oscillation frequency calculation.

When FG' (number of FG pulse) = 180 pulses and R (revolution of motor) = 200r.p.m., if the dividing frequency of reference divider and lock range is set at N=5 dividing frequency and $20/27=20$, the crystal oscillation frequency f_x is as follows:

$$f_X = \frac{R}{60} \times FG' \times 128 \times 20 \times N = \frac{200}{60} \times 180 \times 128 \times 20 \times 5 = 7.680 \text{ MHz}$$