AN6657, AN6657S

Micromotor Forward/ Reverse Electronic Governors

■ Overview

The AN6657 and the AN6657S are the electronic governors capable of controlling the forward/reverse speed, fast forward, rewind, and start/stop of the micromotors used for the radio/cassette tape recorders, automatic answering telephone sets, and so on.

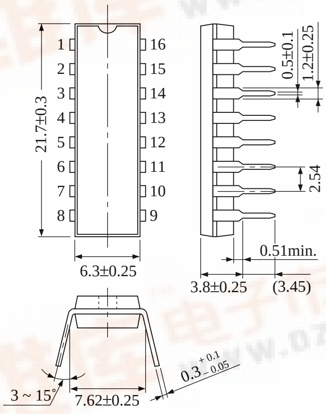
■ Features

- Wide operating supply voltage range ; V_{CC} =4.5V to 14V
- Stable reference voltage (1.3V) and easy speed control
- Large starting torque and maximum control torque
- Good secular drift because of external power transistor
- Provided with the motor stop function ; I_{CC} =20µA or less at stop time
- Capable of controlling forward/reverse rotation, fast forward/constant speed, and start/stop via 3 input pins

■ Applications

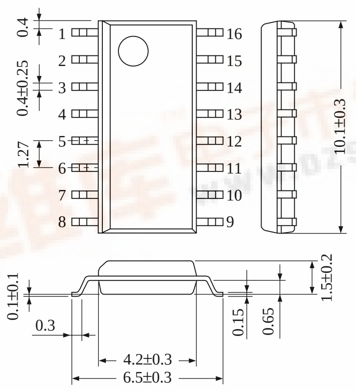
- Speed control of the micromotors for the radio cassettes
- Speed control of the micromotors for the microcassettes of the automatic answering telephone sets
- Control of the tape loading motors for the DATs, etc.

AN6657 Unit : mm



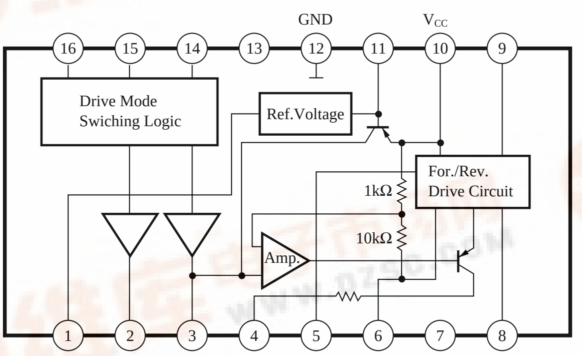
16-Lead DIP Package (DIP016-P-0300E)

AN6657S Unit : mm



16-Lead SOP Package (SOP016-P-0300)

■ Block Diagrom



■ Absolute Maximum Ratings (Ta= 25˚C)

Parameter		Symbol	Rating	Unit
Supply Voltage		V_{CC}	14.4	V
Supply Current		I_{CC}	50	mA
Output Current		I_O	700	mA
Power Dissipation	AN6657	P_D	500	mW
	AN6657S		380	
Operating Ambient Temperature		T_{opr}	–20 ~ + 70	˚C
Storage Temperature	AN6657	T_{stg}	–55 ~ +150	˚C
	AN6657S		–55 ~ +125	

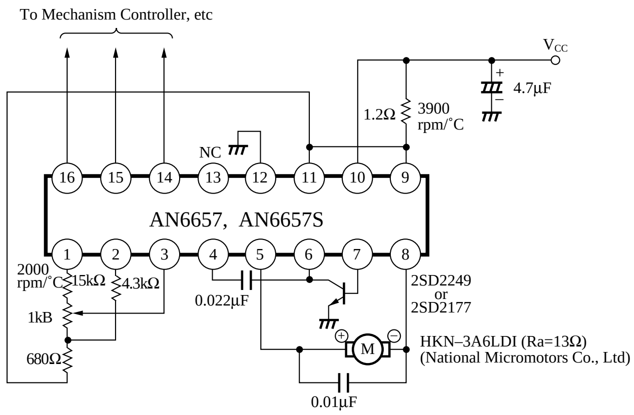
■ Recommended Operating Range (Ta = 25˚C)

Parameter	Symbol	Range
Operating Supply Voltage Range	V_{CC}	4.5V ~ 14V

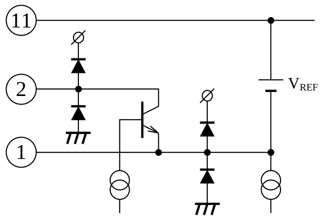
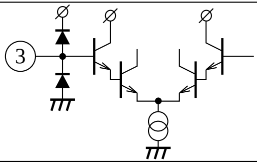
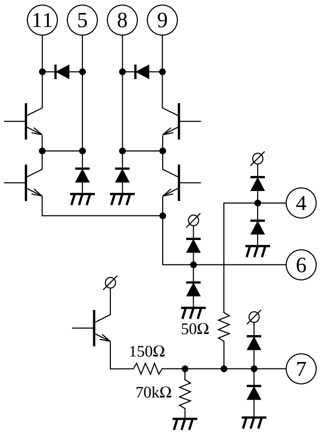
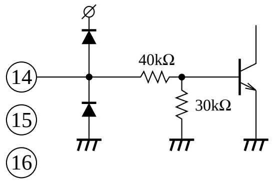
■ Electrical Characteristics (Ta = 25˚C)

Parameter	Symbol	Condition	min.	typ.	max.	Unit
Bias Current	I_{bias}	V_{CC} = 5V	—	4	10	mA
Prestart Current	I_{stop}	V_{CC} = 5V	—	—	20	µA
Reference Voltage	V_{ref}	V_{CC} = 5V	1.1	1.3	1.5	V
Start Voltage	$V_{CC(S)}$	Supply voltage at which a 50mA current flows to Ra	—	—	3	V
Start Current	I_{ST}	V_{CC} = 4.5V, Ra = 13Ω	130	—	—	mA
Rated Load r.p.m	N_L	V_{CC} = 5V, I_L = 55mA, N = 2000rpm	–10	0	10	%
Forward/Reverse r.p.m Difference	ΔN_{Logi}	V_{CC} = 5V, I_L = 55mA, N = 2000rpm	–5	0	5	%
FF/Rated r.p.m. Ratio	ΔN	V_{CC} = 5V, I_L = 55mA, N = 4000rpm	1.85	2	2.15	Times
r.p.m. Characteristics on Voltage Change	ΔN_V	V_{CC} = 4.5V ~ 9V, I_L = 55mA	—	—	50	rpm/V
r.p.m. Characteristics on Load Change	ΔN_L	V_{CC} = 4.5V, I_L = 55mA ~ 90mA	—	—	120	rpm
Switching Mode Input H	V_H	V_{CC} = 5V ~ 14V	3	—	6	V
Switching Mode Input L	V_L	V_{CC} = 5V ~ 14V	0	—	0.7	V
Current Limiting Starting Voltage	V_{Lim}	V_{CC} = 9V, R_T = 1.3Ω	0.55	0.62	0.7	V
Ref. Voltage Temperature Characteristics	ΔV_r/Ta	V_{CC} = 5V, Ta = 0˚C ~ 60˚C	—	0.015	—	%/˚C

■ Application Circuit



■ Pin Descriptions

Pin No.	Pin Name	Description	I/O	Voltage	Equivalent Circuit
1	Constant Speed Setting	Constant speed setting pin	O	$V_{CC} - 1.3V$	
2	FF Setting	FF speed setting pin	O	$V_{CC} - 1.3V$	
3	Speed Control	Controls the speed	I	—	
4	Phase Compensation	Oscillation preventive phase compensation pin	I	—	
5	Motor Drive ⊕	Motor ⊕ pin connection pin	O		
6	Collector Connection	Collector connection pin of the external NPN transistor	O		
7	Base Connection	Base connection pin of the external NPN transistor	O		
8	Motor Drive ⊖	Moror ⊖ pin connection pin	O		
9	Load Characteristics Setting	Motor torque load characteristics setting pin	O		
10	V_{CC}	V_{CC} pin	I		
11	To the pin 9.	Connect to the pin o.	O		
12	GND	GND pin	I	—	————
13	NC	No connection	—	—	————
14	Start/Stop	Start/stop control pin	I	—	
15	Forward/Reverse	Forward/reverse control pin	I		
16	Constant Speed/FF	Constant speed/FF control pin	I		

■ Supplementary Explanation

• Principle of Functioning

The AN6657 and the AN6657S are the electronic governors which control the motor speed constantly by making use of the fact that the counter electromotive force generated in the motor winding is proportional to the motor speed when the DC motor rotates. They have two motor drive systems which correspond to the forward and reverse rotations, respectively. The inter-pin voltage of the motor Em is given by the following expression.

$$Em = Ea + Ra\ Ia \quad \cdots\cdots (1)$$

Ea : Motor reverse electromotive voltage

Ra : Motor internal resistor

Ia : Motor current

There are the following relationships between the motor reverse electromotive voltage Ea and Motor speed, and motor torque T and motor current Ia, respectively.

$$Ea = Ka \cdot N \quad \cdots\cdots (2)$$

$$T = K_T \cdot Ia \quad \cdots\cdots (3)$$

Ka : Motor generation constant

K_T : Motor torque constant

In the expression (1), the inter-pin voltage of the motor Em includes the voltage Ra · Ia which changes depending on motor current Ia. The counter electromotive voltage Ea is taken out by configuring the bridge circuit and used as a motor speed signal. In Fig. 1, the motor speed N (∝ motor generated voltage Ea) in the motor control state can be expressed by the following formula.

$$Ea = V_{REF}\ \frac{r_2 + r_3}{r_3} \cdot \frac{r_5}{r_4 + r_5} + \left(\frac{r_1 r_2}{r_3} - Ra\right) Ia + V_{CE\ SAT1} \quad \cdots\cdots (4)$$

The expression (4) applies in case of motor forward rotation, in which a current flows from the motor ⊕ pin (5) to the motor ⊖ pin (8). The following expression applies in case of motor reverse rotation, in which a current flows form the motor ⊖ pin (8) to the motor ⊕ pin (5).

$$Ea = V_{REF}\ \frac{r_2 + r_3}{r_3} \cdot \frac{r_5}{r_4 + r_5} + \left(\frac{r_1 r_2}{r_3} - Ra\right) Ia + V_{CE\ SAT2} \quad \cdots\cdots (5)$$

V_{REF} : Reference voltage, Ra : Motor internal resistor

Ia : Motor current

r_2, r_3 : Diffusion resistance in the IC, r_4, r_5 : Resistance for speed control

r_1 : Torque control Resistance

$V_{CE\ SAT1}$: Forward/reverse drive circuit saturation voltage when motor forward rotation is set

$V_{CE\ SAT2}$: Forward/reverse drive circuit saturation voltage when motor reverce rotation is set

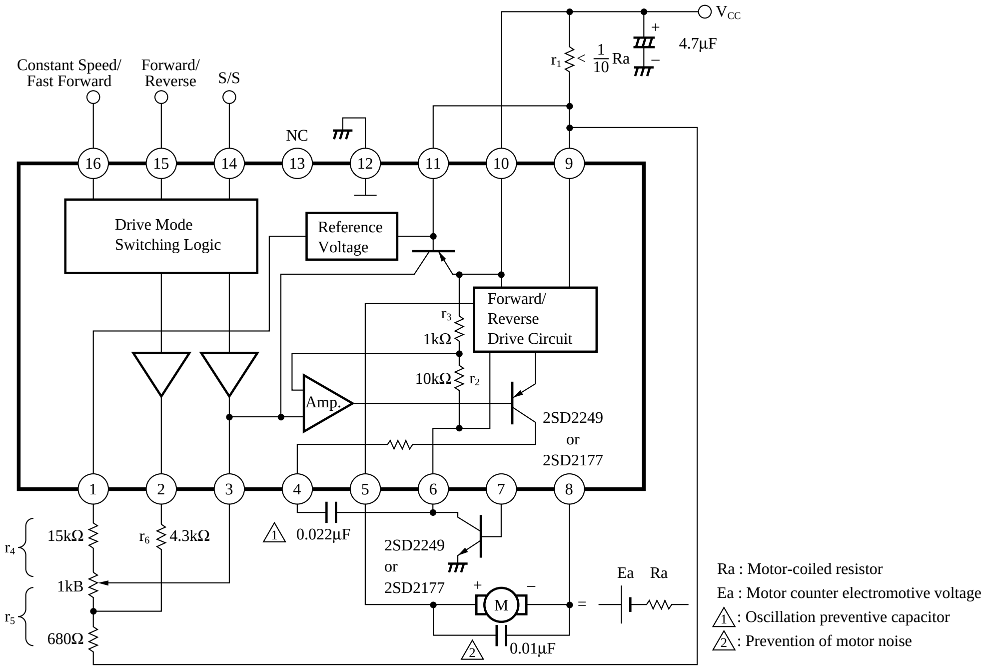


Fig.1 AN6657/AN6657S Motor Control Basic Circuit

As it is clear from the expression (4), $r_1r_2/r_3 - Ra = 0$, that is, when $r_1 = r_3/r_2 ÷ Ra$ is established, Ea (∝ motor speed N) becomes a constant value without depending on the motor current Ia (load torque T). This is also true for the expression (5).

• Switching the Various Modes

The AN6657 and the AN6657S have five motor drive modes as shown in Table 1. Those modes can be selected depending on the voltage H (3V to 6V) and voltage L (0V to 0.7V) signals applied to the input pins14, 15 and 16.

1) Forward/reverse switching : Forward/reverse rotation is switched over whether a current flows from the pin5 to the pin8 (forward rotation) or vice versa (reverse rotation).
2) Power-off (pause) mode : turning off the constant current source inside the IC stops a current to the motor and stops motor. In this mode, all the transistors of the IC are turned off and only a leak current (20µA) is available.
3) Setting the motor speed
   The motor speed at constant speed time can be expressed by the expression (4).

$$V_{REF}\ \frac{r_2+r_3}{r_3} \cdot \frac{r_5}{\frac{r_4 \cdot r_6}{r_4+r_6} + r_5}$$

   In the FF (REW) mode, the pin2 is turned on and the first term of the expression (4) is ;

$$Ea = V_{REF}\ \frac{r_2+r_3}{r_3} \cdot \frac{r_5}{\frac{r_4 \cdot r_6}{r_4+r_6} + r_5} + \left(\frac{r_1r_2}{r_3} - Ra\right) Ia + V_{CE\ SAT} \cdots\cdots (6)$$

and the motor speed N (motor generated voltage Ea) is expressed as follows.

From the expression (4), the motor speed at constant speed can be controlled with r_4 and r_5 (external VRs).

From the expression (6), the motor speed at the FF (REW) mode can be controlled with r_6.

• Setting the External Resistor r_1

The torque control resistance r_1 is important in setting the motor rotating state. Select the resistance which satisfies the condition of the expression (7) within a working temperature range. If this condition is not satisfied, the motor may have abnormal rotation such as hunting, etc.

$$r_1 \lessapprox \frac{r_3}{r_2} Ra$$

$(r_3/r_2 = 1/10$ for the AN6657, AN6657S$)$ ⋯⋯⋯⋯ (7)

Ra is the copper coiled resistor of the motor and has the temperature characteristics of + 3,900r.p.m/˚C, Therefore, it is necessary to set the value of r_1 so that the relationship in the expression (7) will be satisfied at the minimum working temperature. The diffusion resistance r_3/r_2 in the IC has the flat temperature characteristics, and if the temperature characteristics of r_1 is adjusted to that of Ra, + 3900 r.p.m/˚C, the value of the second term (r_1r_2r – Ra) of the expressions (4) and (5) shows the flat temperature characteristics and the torque characteristics of the motor speed becomes constant without depending on a temperature. Fig. 2 and Fig. 3 show this relationship.

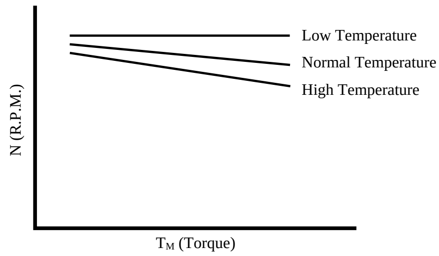


Fig. 2 r_1 Temperature Characteristics < Ra Temperature Characteristics

Table 1 AN6657/AN6657S Mode Switching Table

Input			Output			Motor Drive Mode
Pin14	Pin15	Pin16	Pin5 Motor ⊕	Pin8 Motor ⊖	Pin2	
L	—	—	—	—	OFF	Power OFF (pause)
H	H	L	H	L	OFF	Forward (constant speed)
H	L	L	L	H	OFF	Reverse (constant speed)
H	H	H	H	L	ON	FF
H	L	H	L	H	ON	REW

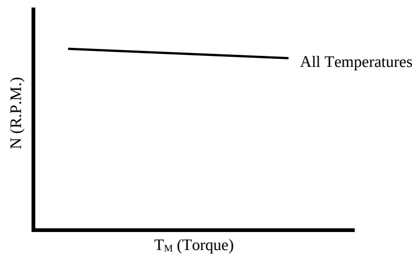


Fig. 3. r_1 Temperature Characteristics = Ra Temperature Characteristics

• Temperature Compensation of Motor Speed

For the normally used motor with core, the temperature compensation of the motor speed can be done by using 3,900 r.p.m/˚C metal coated or coiled resistor as the torque control resistance r_1, and metal coated resistor with a positive temperature coefficient of about 2,000r.p.m/˚C as the speed control resistance r_4.

• Current Limiting Function

The current limitting function detects the voltage drop of the torque control resistance r_1, operates the PNP transistor, and controls the input voltage of the amplifier in the IC to limit the current.

Limiting the current can reduce the useless current at start and motor lock time and prevent the supply voltage from dropping.

The limited current I_{Lim} is calculated by the following expression.

$$I_{Lim} = \frac{V_{Lim}}{r_1} \quad \cdots\cdots (8)$$

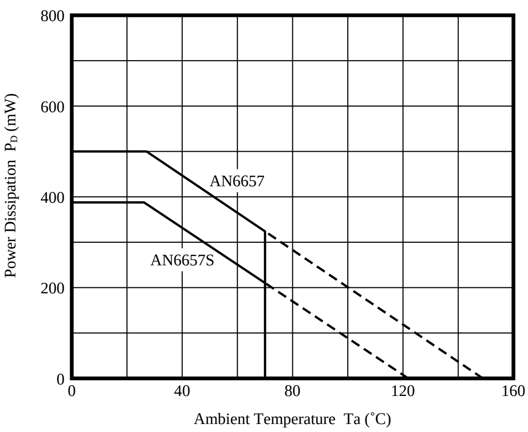
V_{Lim} : V_{BEON} Voltage < 0.6V

When $r_1 = 1.2\Omega$, from the expression (8) I_{Lim} is ;

$$I_{Lim} = \frac{0.6V}{1.2\Omega} = 500mA$$

■ Characteristics Curve

P_D – Ta



r.p.m. Load Torque