# 2-phase motor driver for VCR cylinder motors

## BA6970FS

The BA6970FS is a direct-drive motor driver suitable for 2-phase, full-wave linear motors. The IC consists of a Hall amplifier control circuit, driver circuits, FG / PG signal amplifiers, and hysteresis amplifiers.

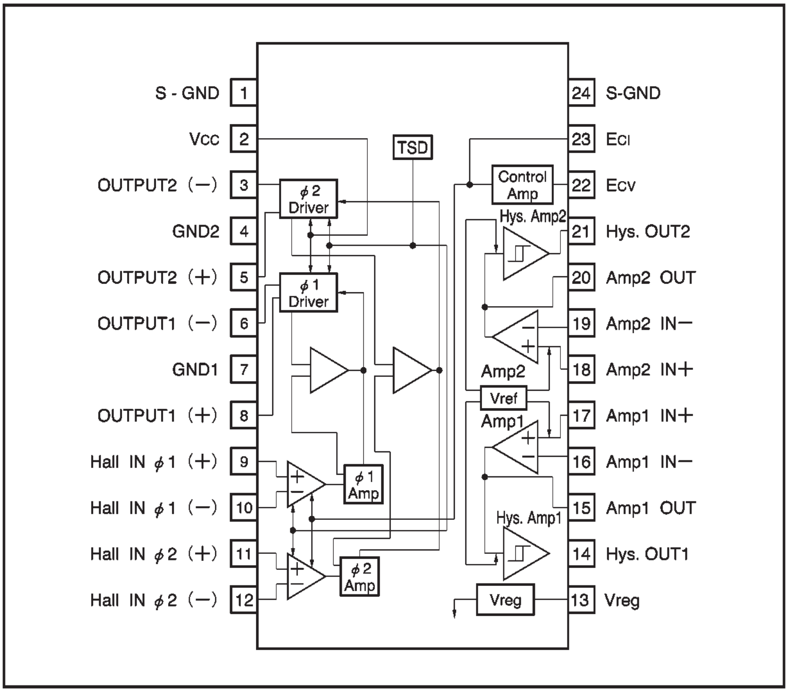
●Applications

VCR cylinder motors

●Features

1) Linear drive system provides low switching noise.
2) Output current can be controlled by either current or voltage input.
3) Two amplifiers and two hysteresis amplifiers.
4) Constant supply voltage pin for hall devices.
5) High ratio of output current and control current. (4000 typically)
6) Available in a compact surface-mount package.

●Block diagram



●Absolute maximum ratings (Ta = 25°C)

| Parameter | Symbol | Limits | Unit |
|---|---|---|---|
| Applied voltage | $V_{CC}$ | 18 | V |
| Power dissipation | Pd | 1000*1 | mW |
| Operating temperature | Topr | −25～+75 | ℃ |
| Storage temperature | Tstg | −55～+150 | ℃ |
| Output current | $I_{OMax.}$ | 1200*2 | mA |
| Input current | $I_{ECIMax.}$ | 5 | mA |

*1 When mounted on a glass epoxy board (90× 50×1.6 mm).
Reduced by 8 mW for each increase in Ta of 1℃ over 25℃.
*2 Should not exceed Pd or ASO values (for the current of one phase).

●Recommended operating conditions (Ta = 25°C)

| Parameter | Symbol | Limits | Unit |
|---|---|---|---|
| Operating power supply voltage | $V_{CC}$ | 8.0～16.0 | V |

●Electrical characteristics (unless otherwise noted, Ta = 25°C, $V_{CC}$ = 12V)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Supply current | $I_{CC}$ | — | 5.8 | 13.0 | mA | — |
| Constant output voltage | $V_{reg}$ | 4.6 | 5.0 | 5.4 | V | — |
| 〈MDA〉 | | | | | | |
| Hall element minimum input voltage | $V_{INH}$ | 50 | — | — | $mV_{P-P}$ | — |
| Hall input bias current | $I_{BH}$ | — | 0.25 | 2.0 | μA | $I_{cont}$=100μA |
| Output saturation high level voltage | $V_{OH}$ | 10.45 | 10.79 | — | V | $I_{OUT}$=800mA |
| Output saturation low level voltage | $V_{OL}$ | — | 1.33 | 2.16 | V | $I_{OUT}$=800mA |
| 〈ECV (voltage control)〉 | | | | | | |
| Allowable torque command input voltage | $E_{CV}$ | 0 | — | $V_{reg}$ | V | — |
| Torque control voltage offset | $E_{CVOFS}$ | −150 | 0 | 150 | mV | For 0.48 X $V_{reg}$ |
| Torque control input current | $I_{ECVIN}$ | — | 1.0 | 6 | μA | $E_{CV}$=2.5V |
| Output standby current | $I_{ECVidle}$ | — | 0 | 5 | mA | $E_{CV}$=2.5V |
| I/O gain | $G_{ECV}$ | 0.38 | 0.55 | 0.64 | A / V | Measured at $E_{CV}$ = 2.8 V, 3.3 V; $\Delta V_{IN}$ = 100 mV |
| 〈$E_{CI}$ (current control)〉 | | | | | | |
| Ratio of pin-23 current and output current | $I_{OUT}$ / $I_{cont}$ | 3300 | 4000 | 4700 | — | $\Delta V_{IN}$ = 100 mV; measured at $I_{cont}$ = 30μA, 50μA |
| Output current differential | $\Delta I_{OUT}$ | −30 | 0 | 30 | mA | $I_{cont}$=30μA |
| 〈Amp1, Amp2〉 | | | | | | |
| Input sink current | $I_{INA}$ | — | 0.2 | 2.0 | μA | $V_{IN}$=2.5V |
| Open loop gain | $G_A$ | 65 | 70 | — | dB | $f_{IN}$=500Hz |
| DC bias voltage variation | $\Delta V_{BA}$ | −10 | 0 | 10 | % | Variation from $V_{reg}$ |
| Output high level voltage | $V_{OH\,A}$ | $V_{reg}$ −1.48 | $V_{reg}$ −0.72 | — | V | $I_{OH\,A}$=0.5mA |
| Output low level voltage | $V_{OL\,A}$ | — | 0.85 | 1.45 | V | $I_{OL\,A}$=0.5mA |
| Input voltage of Amplifiers 1 and 2 | $V_{AB}$ | 1.2 | — | 4.0 | V | — |
| 〈Hys. Amp1, 2〉 | | | | | | |
| Hysteresis width | $V_{hys}$ | ±142 | ±180 | ±218 | mV | — |
| Output low level voltage | $V_{OLhys}$ | — | 0.12 | 0.32 | V | $I_{OLhys}A$=2mA |
| Out put pull-up resistance | $V_{Bhys}$ | 7.0 | 10.0 | 13.0 | kΩ | — |

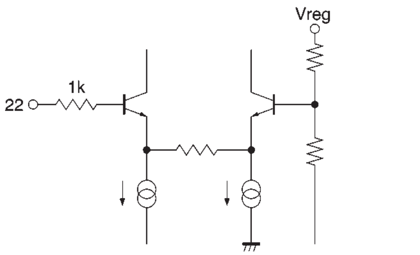
◎Not designed for radiation resistance.

● Pin descriptions

| Pin No. | Pin name | Function |
|---|---|---|
| 1 | S−GND | Signal ground |
| 2 | $V_{CC}$ | Output current control |
| 3 | OUTPUT2 (−) | Output |
| 4 | GND2 | OUTPUT2 GND |
| 5 | OUTPUT2 (+) | Output |
| 6 | OUTPUT1 (−) | Output |
| 7 | GND1 | OUTPUT1 GND |
| 8 | OUTPUT1 (+) | Output |
| 9 | Hall IN $\phi$1 (+) | Hall signal input |
| 10 | Hall IN $\phi$1 (−) | Hall signal input |
| 11 | Hall IN $\phi$2 (+) | Hall signal input |
| 12 | Hall IN $\phi$2 (−) | Hall signal input |
| 13 | Vreg | Constant voltage output |
| 14 | Hys.OUT1 | Hysteresis amplifier 1 output |
| 15 | Amp1OUT | Amplifier 1 output ; hysteresis amplifier 1 input |
| 16 | Amp1IN− | Amplifier 1 input , inverted |
| 17 | Amp1IN+ | Amplifier 1 input , non-inverted |
| 18 | Amp2IN+ | Amplifier 2 input , non-inverted |
| 19 | Amp2IN− | Amplifier 2 input , inverted |
| 20 | Amp2OUT | Amplifier 2 output ; hysteresis amplifier 2 input |
| 21 | Hys.OUT2 | Hysteresis amplifier 2 output |
| 22 | ECV | Output current control (voltage control) |
| 23 | ECI | Output current control (current control) |
| 24 | S−GND | Signal ground |

●Input / output circuits

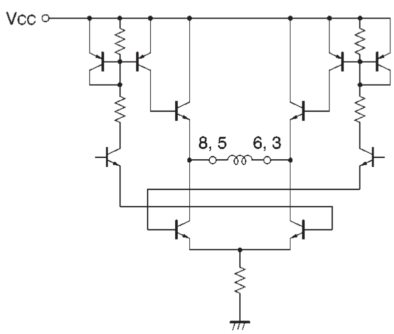
(1) $E_{CV}$ (22 pin)




(All resistances, in Ω, are typical values)

Fig.1

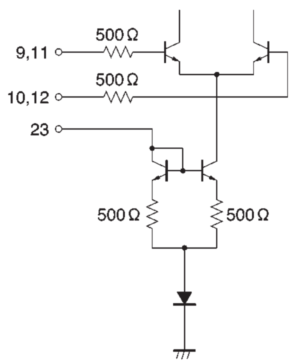
(2) Coil output (8, 6, 5, 3 pin)




(All resistances, in Ω, are typical values)

Fig.2

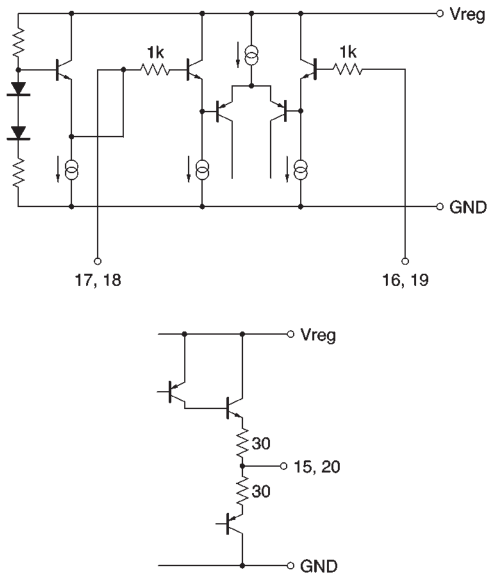
(3) Hall inputs (9, 10, 11, 12 pin), $E_{CI}$ input




(All resistances, in Ω, are typical values)

Fig.3

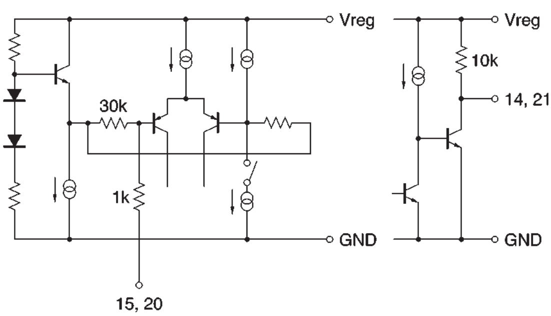
(4) I / O of amplifiers 1 and 2




(All resistances, in Ω, are typical values)

Fig.4

(5) I / O of hysteresis amplifiers




(All resistances, in Ω, are typical values)

Fig.5

∗Note that the resistance values can vary ±30%

●Circuit operation

(1) The signal from the Hall device is amplified by the Hall amplifier and then supplied to the driver circuit. The driver gain, which is constant, is regulated by changing the Hall amplifier gain with the $E_{CI}$ input current or the $E_{CV}$ input voltage ($E_{CI}$ and $E_{CV}$ are output current control pins). The motor rotational speed is sensed by the FG, and the output from which is F / I-converted and supplied to the $E_{CI}$ pin or F / V-converted and supplied to the $E_{CV}$ pin as a feedback signal, so that a constant rotational speed is maintained as follows (Fig. 6) :

1) The motor speed decreases.
2) The speed control IC outputs a feedback signal
3) The Hall amplifier gain increases.
4) The output current increases.
5) The motor speed increases.

(2) When the voltage on Hall IN$\phi_1$ (+) is higher than the voltage on Hall IN$\phi_1$ (−), an output current flows from OUT1 (+) to OUT1 (−) according to the voltage differential. When the voltage on Hall IN$\phi_1$ (−) is higher, on the other hand, an output current flows from OUT1 (−) to OUT1 (+).

Similarly, when the voltage on Hall IN$\phi_2$ (+) is higher than the voltage on Hall IN$\phi_2$ (−), an output current flows from OUT2 (+) to OUT2 (−) according to the voltage differential. When the voltage on Hall IN$\phi_2$ (−) is higher, on the other hand, an output current flows from OUT2 (−) to OUT2 (+).

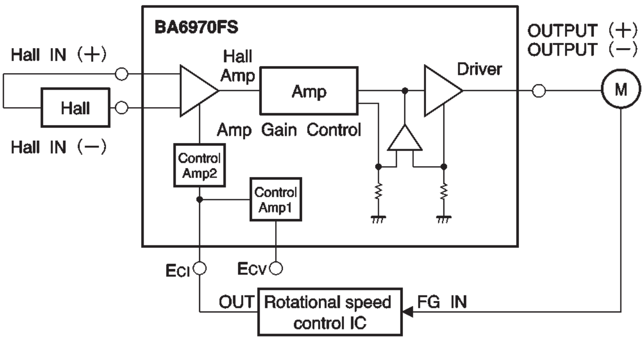



Fig.6

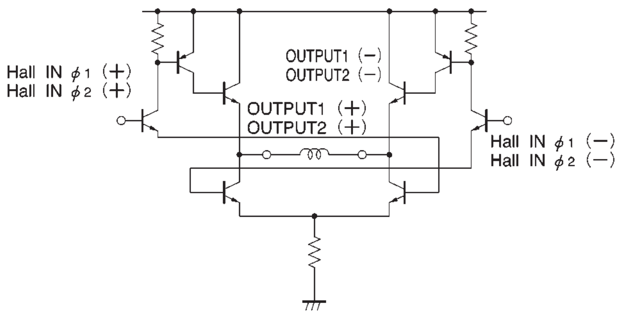



Fig.7

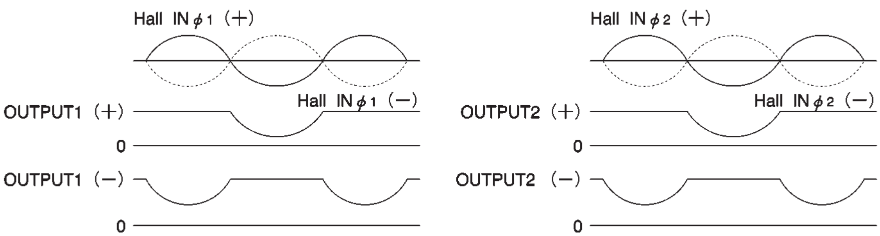



Fig.8

(3) Output waveforms are shown in Fig. 9. Because of the amplifier offset, the output is left OPEN when the output signal switches from positive to negative. The output waveform is determined by the external circuit because the IC impedance increases during this transition period. Since inductive loads are usually provided, a capacitor should be connected to suppress backlash voltages.

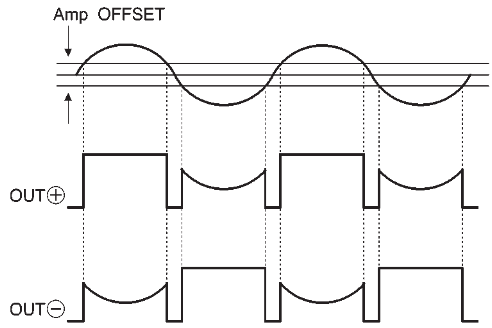



Fig.9

●Operation notes

(1) ECV input (pin 22)

The ECV input is plotted against the output current in Fig. 10.

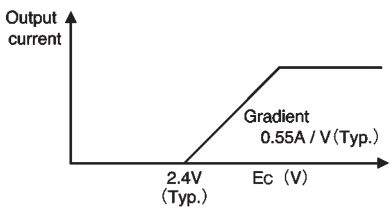



Fig.10

(2) Hall input

Hall input signals of 50mV (peak to peak) or greater should be applied between pins 9 and 10 and between pins 11 and 12. The DC input range is 2V to (Vreg – 1.5V). There will be no problem if the input is centered around Vreg / 2.

Because the Hall input impedance is 1MΩ or grater, any type of Hall device can be connected. No current flows when the transistor is off because pins 9 and 10 as well as pins 11 and 12 are differential inputs.

Because the IC is a linear driver, any DC offset in the Hall device will be amplified and appear in the output. Use Hall devices having a minimum offset. Hall devices can be connected in either series or parallel.

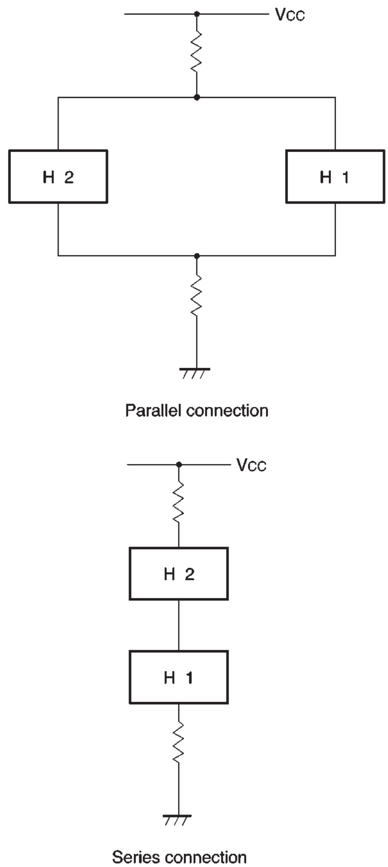



Fig.11

(3) $E_{CI}$ input

The $E_{CI}$ input circuit has $2V_F$ and a 500Ω resistor connected in series. Current is limited only by the 500Ω resistor.

(4) Amplifiers 1 and 2

An input range of 0.6V to ($V_{CC}$ – 1.2V) is recommended. Unpredictable outputs may occur when the input is outside this range.

(5) Hysteresis amplifier

An input range of 0.6V to ($V_{CC}$ – 1.2V) is recommended. Unpredictable outputs may occur when the input is outside this range.

(6) Thermal shutdown circuit

The thermal shutdown circuit puts the driver outputs (8, 6, 5, 3 pin) to the open state at the temperature of 175°C (typical). The circuit is deactivated when the temperature drops to about 155°C.

(7) Signal ground pin

Pins 1 and 24 are signal ground pins. Be noted that unpredictable outputs may occur if your application causes a large current between pins 1 and 24 via the bonding wire IC chip.

●Application example

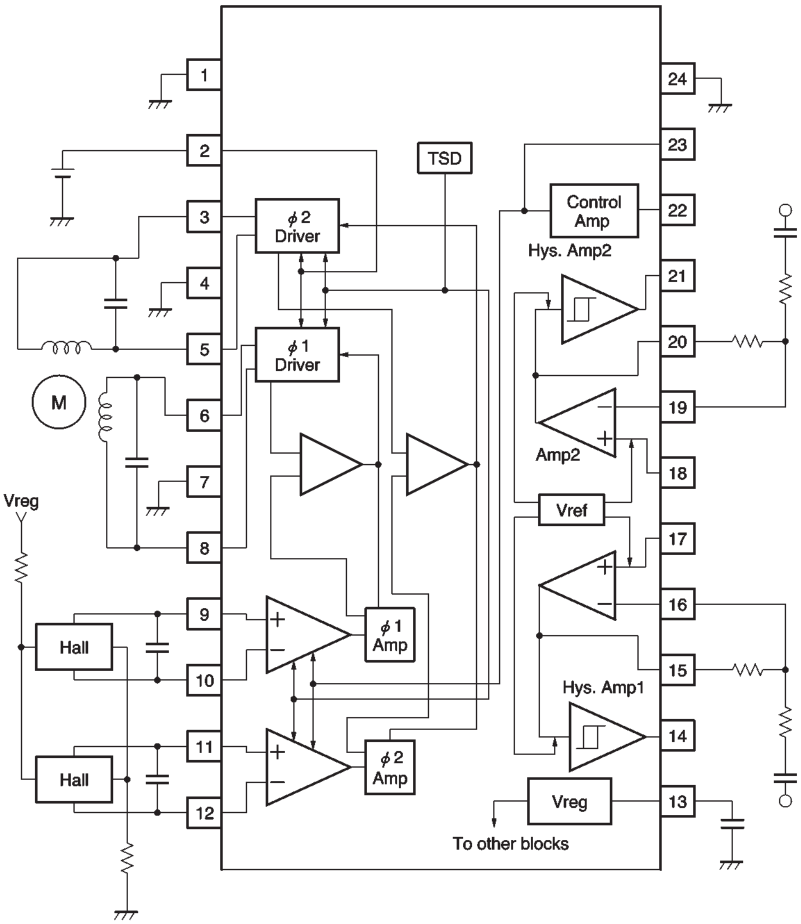



Fig.12

●Electrical characteristic curves

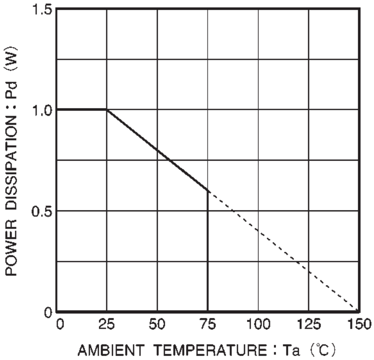



Fig.13 Thermal derating curve

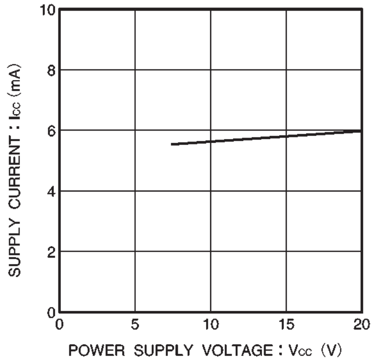



Fig.14 Supply current vs. power supply voltage

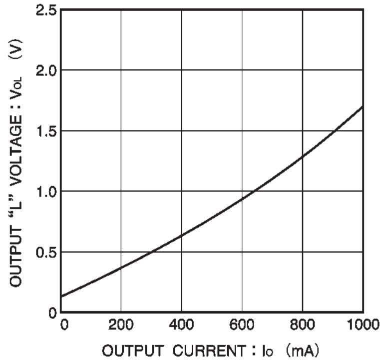



Fig.15 Output low level voltage vs. output current

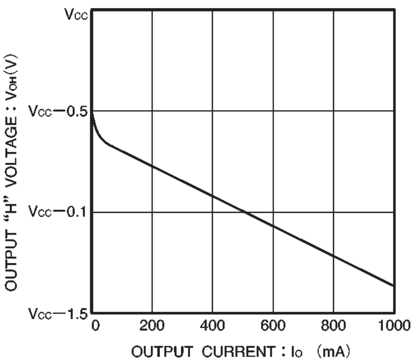
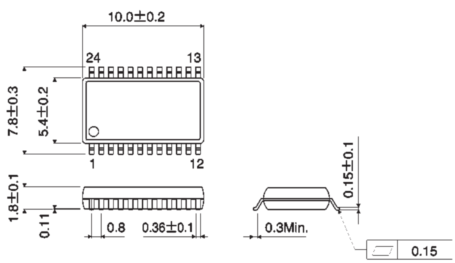



Fig.16 Output high level voltage vs. output current

●External dimensions (Units: mm)

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