TENTATIVE

Mitsubishi Motor Controller
M63155FP
3 PHASE BRUSHLESS MOTOR CONTROLLER

REV. 010403

Outline

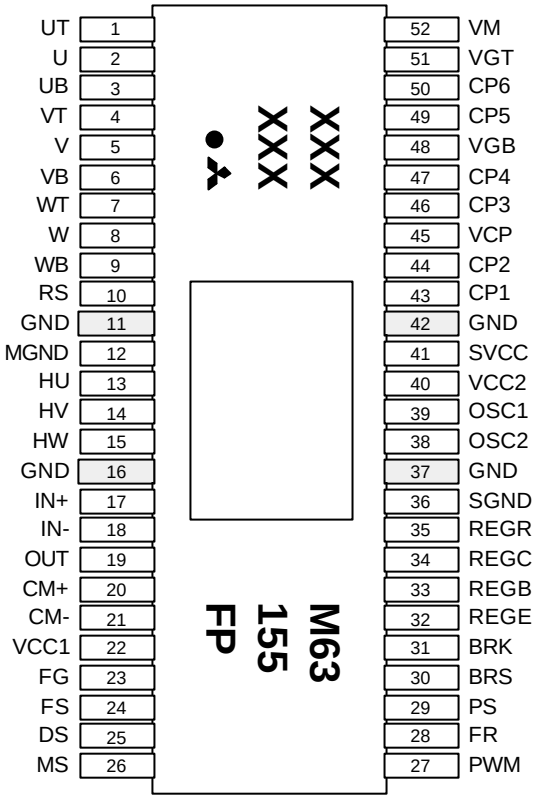
The M63155FP is a three phase brushless motor controller with six external N-channel Power MOSFETs which are connected to the output. The motor speed is controlled by the PWM input from an external controller. A pair of a FG amplifier and a comparator or an internal tachometer is available for tachometer signal generation.

Either fast or slow current-dacay, either 120 or 60 degree hall communication, or either coast(free-ran) or dynamic brake(short-brake) can be selected.

Several protection circuits are set for motor current limiting, thermal shut down and so on.

Direction control and power saving are also available.

Pin Configuration (TOP VIEW)



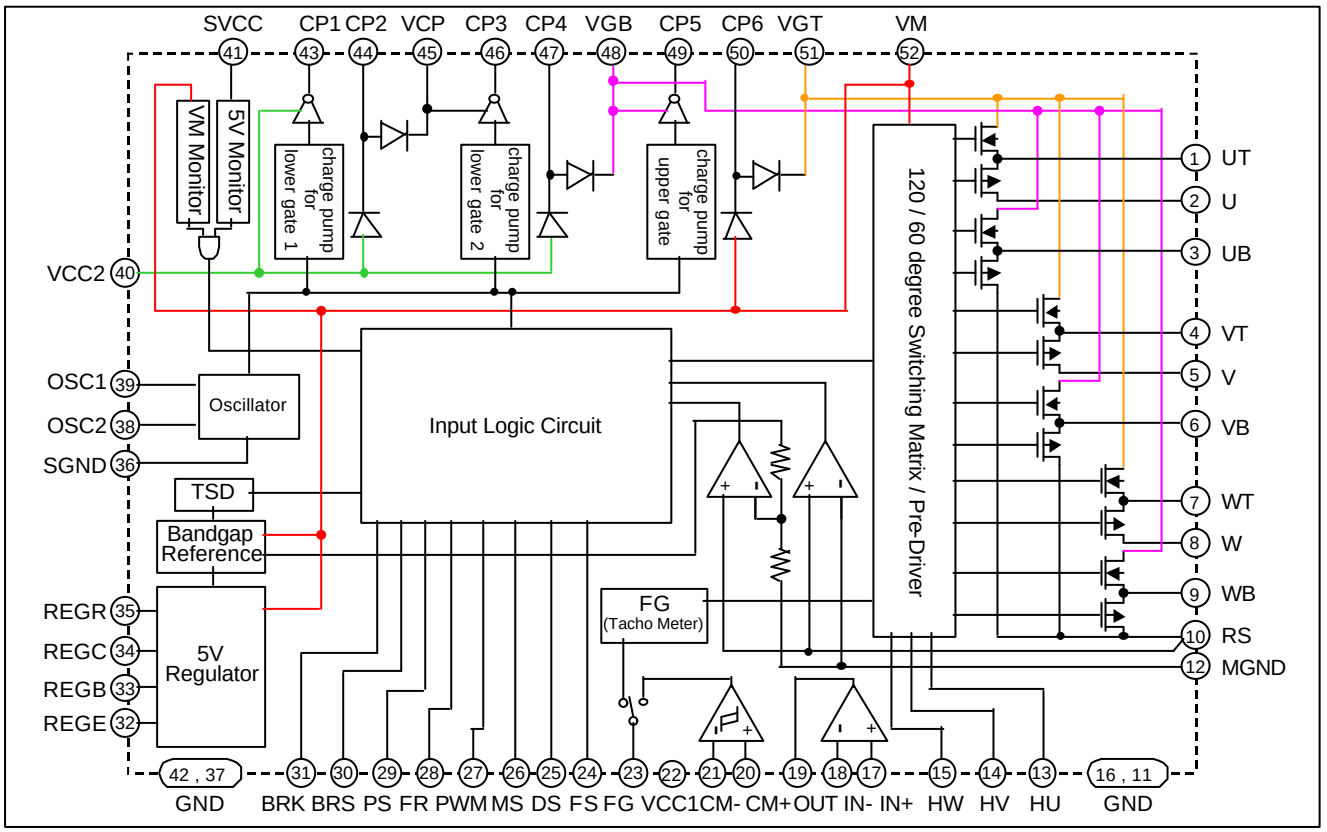
52pin HSSOP (52P9Y)

Features

*Wide voltage range: From 10V to 50V
*PWM input
*Current sensing & Zero current detect
*FG amplifier or internal tachometer is available
*Selectable fast or slow current-decay
*Selectable 120 or 60 degree hall commutation
*Selectable coast (free-ran) or dynamic brake (short-brake)
*5V regulator with the external PNP transistor
*Internal gate supply voltage generator (Charge pump)
*Thermal Shut Down (TSD)
*Power saving mode
*Direction control

Application

High Power Three Phase Brushless Motor.



Terminals Description

Terminal	Symbol	Function	Terminal	Symbol	Function
1	UT	Phase-U Top-side Gate Drive Output	52	VM	Motor Power Supply
2	U	Phase-U Motor Output	51	VGT	Top-side Gate Supply Voltage Output
3	UB	Phase-U Bottom-side Gate Drive Output	50	CP6	Charge-pump Capacitor 6
4	VT	Phase-V Top-side Gate Drive Output	49	CP5	Charge-pump Capacitor 5
5	V	Phase-V Motor Output	48	VGB	Bottom-side Gate Supply Voltage Output
6	VB	Phase-V Bottom-side Gate Drive Output	47	CP4	Charge-pump Capacitor 4
7	WT	Phase-W Top-side Gate Drive Output	46	CP3	Charge-pump Capacitor 3
8	W	Phase-W Motor Output	45	VCP	Charge-pump Voltage Output
9	WB	Phase-W Bottom-side Gate Drive Output	44	CP2	Charge-pump Capacitor 2
10	RS	Motor Current Sensing Input	43	CP1	Charge-pump Capacitor 1
11	GND	GND	42	GND	GND
12	MGND	Motor GND	41	SVCC	External 5V Sensing Input
13	HU	HU Hall Sensor Amp. Input	40	VCC2	Big Signal 5V Power Supply
14	HV	HV Hall Sensor Amp. Input	39	OSC1	Oscillator Output 1
15	HW	HW Hall Sensor Amp. Input	38	OSC2	Oscillator Output 2
16	GND	GND	37	GND	GND
17	IN+	Op. Amp. non-Inverted Input	36	SGND	Oscillator GND
18	IN-	Op. Amp. inverted Input	35	REGR	5V Regulator Voltage Sensing
19	OUT	Op. Amp. Output	34	REGC	5V Regulator Output
20	CM+	FG Com. non-Inverted Input	33	REGB	5V Regulator Current Sink
21	CM-	FG Com. Inverted Input	32	REGE	5V Regulator Current Sensing
22	VCC1	Small Signal 5V Power Supply	31	BRK	Braking Input
23	FG	FG Output	30	BRS	Braking Mode Select Input
24	FS	FG Select Input	29	PS	Power Saving Mode Select Input
25	DS	Fast / Slow Current Decay Mode Select Input	28	FR	Forward / Reverse Select Input
26	MS	60 / 120 degree Switching Matrix Select Input	27	PWM	PWM Input

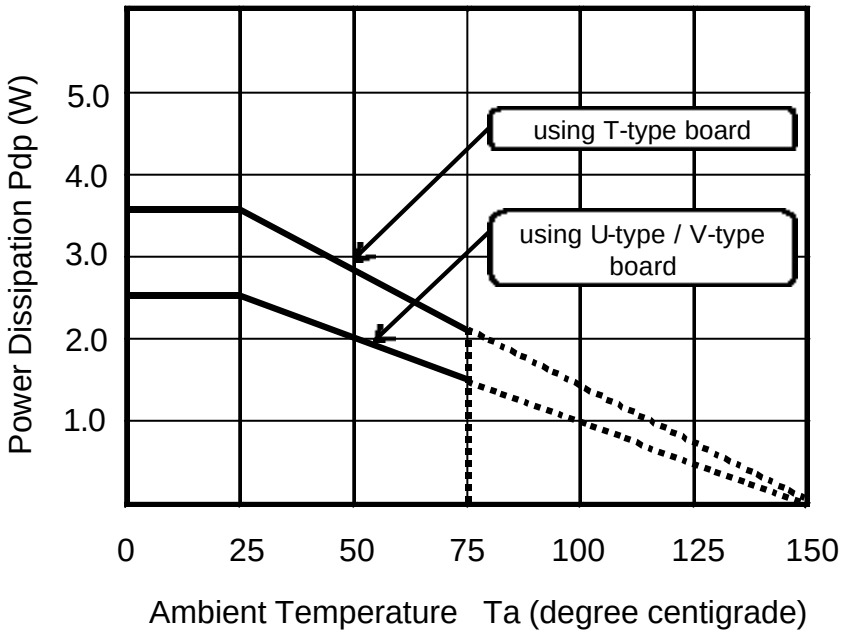
Absolute Maximum Rating (unless otherwise noted Ta=25 degrees centigrade)

Symbol	Parameter	Conditons	Limits			Units
			Min.	Typ.	Max.	
Vm	Motor Power Supply	at VM	10	-	40	V
Vcc	5V Power Supply	at VCC1, VCC2	4.0	-	6.0	V
Vto	Top Side Gate Drive Output Voltage	at UT, VT, WT	-	VM +10.8	-	V
Vo	Motor Output Voltage	at U, V, W	-	-	50	V
Vbo	Bottom Side Gate Drive Output Voltage	at UB, VB, WB	-	12.2	-	V
Vin	Logic Input Voltage	at BRK, BRS, PS, FR, PWM, MS, DS, FS, HU, HV, HW	-	-	5	V
Vopin	Op. Amp. Input Voltage	at IN+, IN-	-	-	5	V
Vopo	Op. Amp. Output Voltage	at OUT	-	-	5	V
Iopo	Op. Amp. Output Current	at OUT	-2	-	2	mA
Vcmin	Comparator Input Voltage	at CM+, CM-	-	-	5	V
Vfgo	FG Output Voltage	at FG	-	-	5	V
Ifgo	FG Output Current	at FG	0	-	5	mA
Pt	Power Dissipation	Free Air	-	1.2	-	W
Kt	Thermal Derating	Free Air	-	9.6	-	mW /degrees
Tj	Junction Temperature		-	-	150	degrees centigrade
Topr	Operating Temperature		0	-	75	degrees centigrade
Tstg	Storage Temperature		-20	-	125	degrees centigrade

Operating Condition (Unless otherwise noted Ta=25 deg., VM=32V, VCC1=VCC2=5V)

Symbol	Parameter	Conditons	Limits			Units
			Min.	Typ.	Max.	
Vm	Motor Power Supply	at VM	10	32	50	V
Vcc	5V Power Supply	at VCC1, VCC2	4.5	5.0	5.5	V
Fpwm	PWM Input Frequency	at PWM	10	20	30	kHz
Ffg	Op. Amp. Operation Frequency	at IN+, IN-	-	-	10	kHz

Thermal Derating



This IC's package is POWER-SSOP, so improving the board on which the IC is mounted enables a large power dissipation without a heat sink. For example, using an 1 layer glass epoxy resin board, the IC's power dissipation is 2.6W at least. And it comes to 3.6W by using an improved 2 layer board.

The information of the T, U, V type board is shown in next page.

The boards for thermal derating evaluation

Conditions

Board material ;
Glass-epoxy FR-4

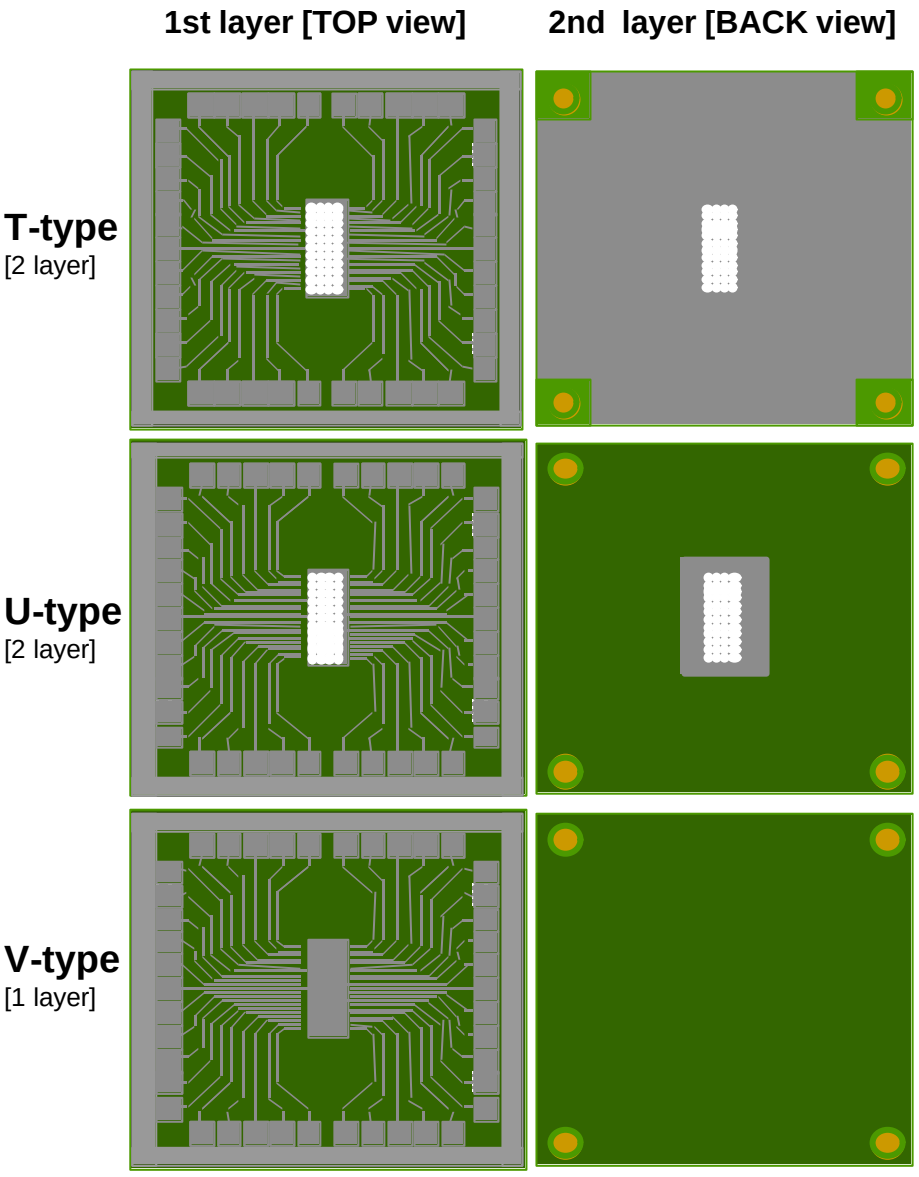
Size ; 70 X 70 mm^2

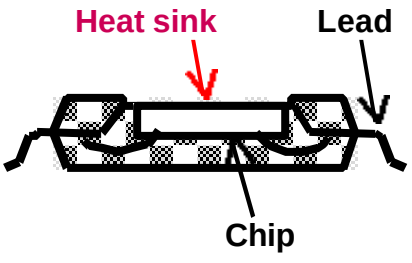
Board thickness ; 1.6 mm

1 and 2 layers

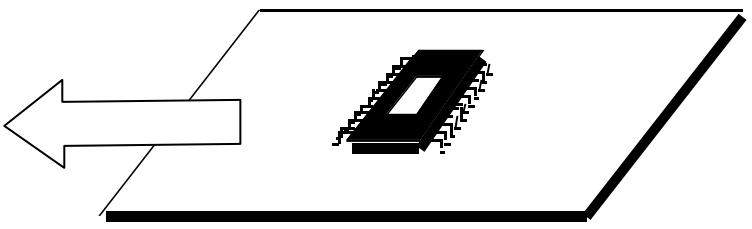
Metal material ; copper

Metal thickness ; 18 um





Package inner structure
52P9Y-K



IC mounting on the evaluation board

Electrical characteristics (Unless otherwise noted Ta=25 deg., VM=32V, VCC1=VCC2=5V)

Symbol	Parameter	Conditions	Limits			Units
			Min.	Typ.	Max.	
POWER SUPPLY (VM, VCC1, VCC2, VCP, VGB, VGT)						
Ims	Motor Power Supply Current in Power Saving Mode	at VM Power Saving Mode (PS: Low)	-	-	TBD	uA
Ivccs	5V Power Supply Current in Power Saving Mode	at VCC1, VCC2 Power Saving Mode (PS: Low)	-	-	TBD	uA
Im	Motor Power Supply Current	at VM Normal Control Mode The motor is not driven	-	TBD	TBD	mA
Ivcc	5V Power Supply Current	at VCC1, VCC2 Normal Control Mode The motor is not driven	-	TBD	TBD	mA
Vcp	Charge-pump Output Voltage	at VCP, *Note1	TBD	8.6	TBD	V
Vgb	Bottom-side Gate Supply Voltage	at VGB, *Note1	TBD	12.2	TBD	V
Vgt	Top-side Gate Supply Voltage	at VGT, *Note1	TBD	VM +10.8	TBD	V
Tcp	Charge-pump (VCP) Pre-charge Time	fosc=TBD,Cp1=TBD, Ccp=TBD, VCP>TBD *Note2	TBD	TBD	TBD	msec
Tgb	Charge-pump (VGB) Pre-charge Time	fosc=TBD,Cp2=TBD, Cgb=TBD, VGB>TBD *Note2	TBD	TBD	TBD	msec
Tgt	Charge-pump (VGT) Pre-charge Time	fosc=TBD,Cp3=TBD, Cgt=TBD, VGT>TBD *Note2	TBD	TBD	TBD	msec
Fosc	Oscillator Frequency	Rosc=TBD Kohm, Cosc=TBD uF	TBD	500	TBD	kHz
REGULATOR (REGE, REGB, REGC, REGR)						
Vr	Regulator Output Voltage	Io=TBDmA *Note3	TBD	5.0	TBD	V
Vrin	Regulator Output Voltage Stability for Input Vm Voltage	Vm=10~40V, Io=300mA *Note3	-	TBD	TBD	mV
Vrout	Regulator Output Voltage Stability for Load Current	Io=0~300mA *Note3	-	TBD	TBD	mV
Iolim	Regulator Output Limit Current	Vm=10~40V *Note3	450	550	650	mA

* Note1 : In condition of no gate driving.
* Note2 : Please refer to the Fig.1.
* Note3 : The values of the external parts are in the "The recommended values of the external parts" table. The hFE of External PNP transistor is "100" minimum.

Electrical characteristics (Unless otherwise noted Ta=25 deg., VM=32V, VCC1=VCC2=5V)

Symbol	Parameter	Conditions	Limits			Units
			Min.	Typ.	Max.	
LOGIC INPUT (PWM, FS, DS, MS, FR, PS, BRS, BRK)						
Vlgh	Logic High-State Input Voltage		3.5	-	-	V
Vlgl	Logic Low-State Input Voltage		-	-	1.0	V
Ilgh	Logic High-State Input Current	Vlg= 5V	TBD	TBD	TBD	uA
Ilgl	Logic Low-State Input Current	Vlg= 0V	TBD	TBD	TBD	uA
HALL INPUT (HU, HV, HW)						
Vhah	Hall High-State Input Voltage		3.5	-	-	V
Vhal	Hall Low-State Input Voltage		-	-	1.0	V
Ihah	Hall High-State Input Current	Vha= 5V	TBD	TBD	TBD	uA
Ihal	Hall Low-State Input Current	Vha = 0V	TBD	TBD	TBD	uA
OPERATIONAL AMPLIFIER (IN+, IN-, OUT) / FG COMPARATOR (CM+, CM-, FG)						
Vopi	Op. Amp. Input Voltage Range	at IN+, IN-	0	-	3.3	V
Iopi	Op. Amp. Input Current	at IN+, IN- IN+=IN-=2.5V	TBD	-0.2	TBD	uA
Voff	Op. Amp. Input Offset Voltage	Voff=(IN-)-(IN+) IN-=OUT (short), IN+=2.5V, Io=0mA	-10	-	10	mV
Vopo	Op. Amp. Output Voltage Range	at OUT, Io=+/-2mA	0.5	-	4.0	V
Vfhy	FG Comparator Input Hysteresis Voltage	differential voltage between OUT and IN+, IN+=2.5V, FS=0V	50	85.0	120	mV
Vsfg	FG Output Saturation Voltage	at FG, output sink current : 2mA	-	0.2	TBD	V
CURRENT LIMIT (RS)						
Vrs	RS Threshold Voltage		0.8	1.0	1.2	V
Tcl	Current Limit Time	*Note5	TBD	12.0	TBD	usec

* Note4 : Please refer to the "Function Explanation 13.RS terminal (Current Limit)".

Electrical characteristics (Unless otherwise noted Ta=25 deg., VM=32V, VCC1=VCC2=5V)

Symbol	Parameter	Conditons	Limits			Units
			Min.	Typ.	Max.	
VOLTAGE MONITOR (SVCC, VM)						
Vsvi	External 5V Monitor Input Voltage Range	TBD	TBD	-	TBD	V
Isvi	External 5V Monitor Input Current	TBD	TBD	TBD	TBD	uA
Vths	External 5V Monitor Threshold Voltage	TBD	TBD	4.0	TBD	V
Vshy	External 5V Monitor Hysteresis Voltage	TBD	TBD	100	TBD	mV
Vthm	VM Monitor Threshold Voltage	TBD	TBD	9.0	TBD	V
Vmhy	VM Monitor Hysteresis Voltage	TBD	TBD	500	TBD	mV
GATE DRIVE OUTPUTS (UT, VT, WT, UB, VB, WB)						
Vtoh	Top Side Gate Drive High State Voltage	Vtoh=VGT-UT, VGT-VT, VGT-WT Iload = TBD mA	-	-	100	mV
Vtol	Top Side Gate Drive Low State Voltage	Vtol=UT-U, VT-V, WT-W Iload = TBD mA	-	-	100	mV
Vboh	Bottom Side Gate Drive High State Voltage	Vboh=VGB-UB, VGB-VB, VGB-WB Iload = TBD mA	-	-	100	mV
Vbol	Bottom Side Gate Drive Low State Voltage	Vbol=UB-RS, VB-RS, WB-RS Iload = TBD mA	-	-	100	mV
Ton	Turn-on Delay	*Note6	TBD	TBD	TBD	nsec
Toff	Turn-off Delay	*Note6	TBD	TBD	TBD	nsec
Ttr	Top Side Switching Rise Time	CL =1200pF, Rg=0 ohm *Note6	TBD	200	TBD	nsec
Ttf	Top Side Switching Fall Time		TBD	80	TBD	nsec
Tbr	Bottom Side Switching Rise Time	CL=1200pF, Rg=0 ohm *Note6	TBD	200	TBD	nsec
Tbf	Bottom Side Switching Fall Time		TBD	80	TBD	nsec

* Note5 : Please refer to the Fig.2.

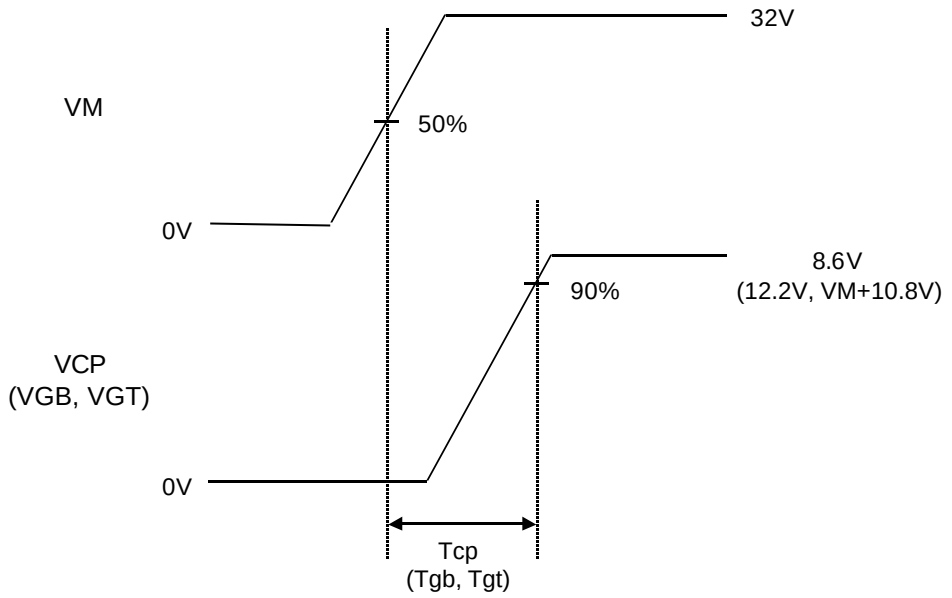


Fig.1 Charge-pump Pre-charge Time Definition

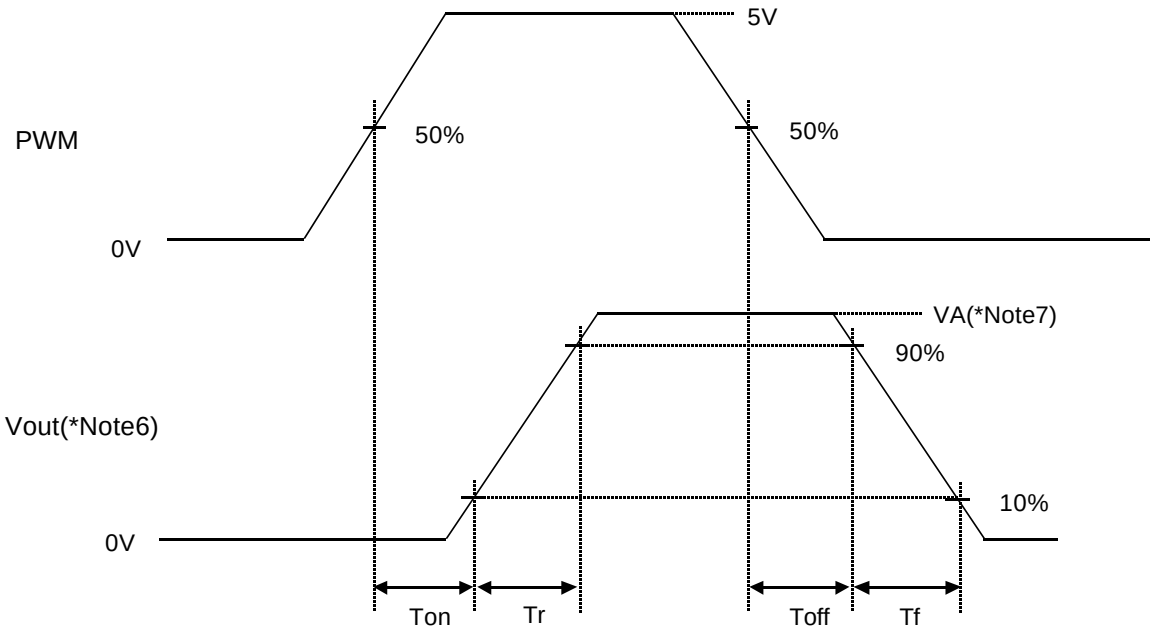


Fig.2 Gate Drive Output Time Characteristics Definition

* Note6 : Vout is the external Nch MOS FET 's gate-source voltage. The definition is,
UT-U, VT-V, WT-W, and U=V=W=VM=32V, Capacitor Load CL=1200pF.
UB-RS, VB-RS, WB-RS, and RS=0V, Capacitor Load CL=1200pF.
* Note7 : VA is the power supply voltage of the gate drive output. The definition is,
VGT-VM=10.8V for UT-U, VT-V, WT-W.
VGB=12.2V for UB-RS, VB-RS, WB-RS.
* Note8 : The waveform above-mentioned is one of the switching timing, because an gate drive output state is due to Hall sensor Amp. inputs. Please refer to the "Hall Signal Inputs and Motor Outputs Timing Diagram".

Function Explanation

1. VM terminal

The power supply for the M63155FP is connected between this terminal and GND.

2. VCC terminals (VCC1, VCC2)

The 5V power supply for the M63155FP is connected between these terminals and GND. The VCC1 supplies small signal 5V, and the VCC2 supplies big signal 5V (for Charge Pump).

3. Charge Pump (CP1, CP2, VCP / CP3, CP4, VGB / CP5, CP6, VGT)

The charge pump consists of an internal circuit and two external capacitors. One capacitor should be connected between the CP1 (CP3/CP5) terminal and the CP2 (CP4/CP6) terminal, and the other capacitor should be connected between the VCP (VGB/VGT) terminal and GND. The VGB (VGT) (the output of the charge pump circuit) is connected internally to the source of the bottom side P-channel pre-driver transistors. (the source of the top side P-channel pre-driver transistors.) So the bottom side gate drive transistors are powered by VGB and top side by VGT. The explanation of the charge pump function is as follows (Fig.3).

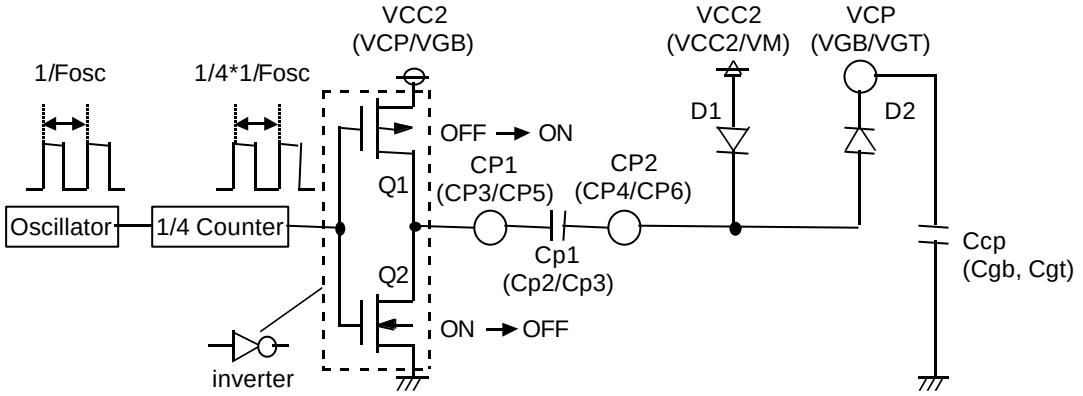


Fig.3 Charge Pump Circuit

(1) Q1=OFF, Q2=ON

The voltage of the CP2 terminal (Vcp2) is given by:

Vcp2 = VCC2 - VF

VF is the threshold voltage of the diodes D1, D2. At this time, a capacitor connected between the CP1 terminal and the CP2 terminal is charged up.

(2) Q1=ON, Q2=OFF

Then the Q1 and Q2 are switched (the Q1 is turned on and the Q2 is turned off).
The Vcp2 is given by:

Vcp2 = (VCC2 - VF) + VCC2

And the charge-pump voltage is given by:

VCP = (VCC2 - VF) + VCC2 - VF = 2VCC2-2VF

In case of VCC2=5V and VF=0.7V, VCP is 10-1.4=8.6V.

(3) VGB, VGT

Likewise VCP mentioned above, VGB and VGT voltage is given by:

VGB = (VCC - VF) + VCP - VF = VCC+VCP-2VF=5+8.6-1.4=12.2V

VGT = (VM - VF) + VGB - VF =VM+VGB-2VF=VM+12.2-1.4=VM+10.8V

4. 5V Regulator (REGE, REGB, REGC, REGR)

The 5V regulator with the external PNP Tr. included the internal gain resistors. It has the output current limit function which needs the external current sensing resistor and the short protect function.

The explanation of the 5V Regulator function is as follows (Fig.4).

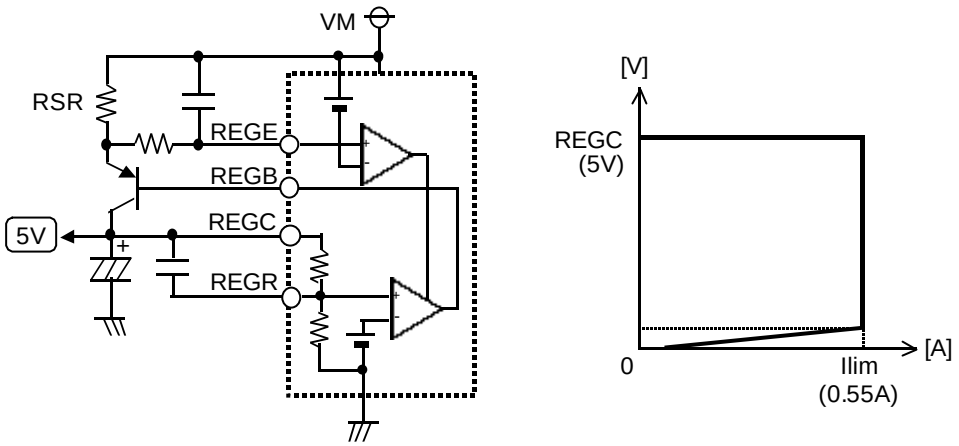


Fig. 4. 5V Regulator application circuit and characteristics

5. Voltage Monitor (VM, SVCC)

If either the motor power supply (VM) or the external 5V (SVCC) or both drops below the threshold, the output fault to AND gate, then the motor is latched into the braking mode. The braking mode whether coast (free-run) or break (short-brake) is selected by the BRS terminal (cf. 7. Brake Mode Selection).

And then, if the positive edge is applied into the BRK terminal (cf. 6. Brake Mode Enable), the latch will be canceled.

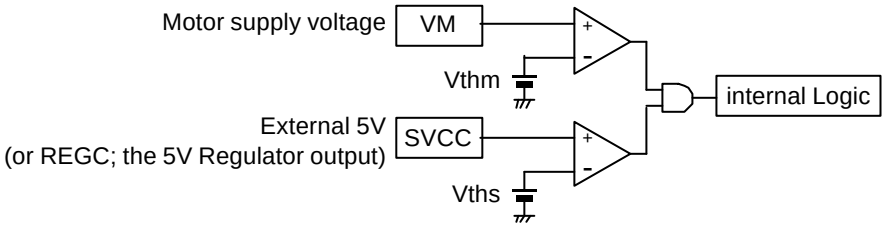


Fig.5 Voltage Monitor Circuit

Function Explanation

6. Braking Mode Enable (BRK)

In the normal motor rotation, the motor is able to be braked optionally by external control signal put into the BRK terminal. The braking mode, either coast (free-run) or break (short-brake) is selected by the BRS terminal (cf. 7. Brake Mode Selection).

Table 1. gives the BRK selection truth table.

TABLE 1. BRK Selection Truth Table

BRK	Function Mode
High	Normal Control Mode
Low	Brake Mode

7. Braking Mode Selection (BRS)

The braking mode whether coast (free-run) or break (short-brake) is selected by the BRS terminal. In the coast (free-run) mode, all of the output terminals are floating. On the other side, in the brake (short-brake) mode, the top side MOS FETs are turned off and the bottom side MOS FETs are turned on, then the motor outputs are winded together. This Braking Mode provides a braking torque which depends on the motor speed. At the brake (short-brake) mode, if the voltage monitor fault (cf. 5. Voltage Monitor), the positive power supply for the gate of the bottom side MOS FETs is provided by the charge-pump external capacitor (Cgb; cf. Application circuit).

Table 2. gives the BRS selection truth table.

TABLE 2. BRS Selection Truth Table

BRS	Function Mode
High	Brake (Short-brake)
Low	Coast (Free-run)

8. Output Terminals (UT, VT, WT, U, V, W, UB, VB, WB)

These terminals are the gate drive outputs for the external MOS FETs. UT, VT and WT are the gate drive outputs for the top side external MOS FETs. U, V and W are connected to the motor output terminals and the source terminals of the top side external MOS FETs. UB, VB and WB are the gate drive outputs for the bottom side external MOS FETs.

Function Explanation

9. PWM Input (PWM)

The PWM signal is applied to this terminal to control the motor speed. The motor speed is due to the duty of the PWM input signal.
Table 3. gives the PWM selection truth table.

TABLE 3. PWM Selection Truth Table

PWM	Function Mode
High	Normal circulate current
Low	Recirculate current

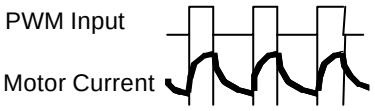
10. Oscillator (OSC1, OSC2, SGND)

The oscillation frequency (Fosc) of the oscillator is determined by the external capacitor and resistor which are connected to these terminals. The capacitor is connected between OSC2 and SGND, and the resistor is connected between OSC1 and OSC2.
SGND is the common terminal of the oscillator circuit. So it is connected to the root of the board GND due to getting the high accurate performance.

11. Current Limitation (RS, MGND)

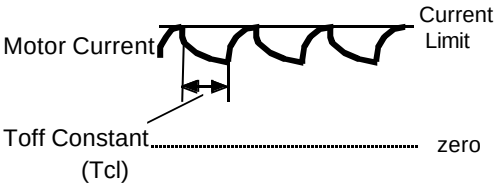
This terminal is the sensing input of the motor current. A sensing resistor should be connected between this terminal and the MGND terminal. The current limit circuit compares the voltage of the sensing resistor with the internal reference voltage, and determines whether the devise functions Normal PWM or Current Limitation.

(1) Normal PWM function



The motor current is controlled by the PWM input signal.

(2) Current limit function



When the motor current reaches the current limit value, the current limit circuit operates. The current limit circuit has a timer circuit, and during the current limitation the PWM off period is constant (Toff constant; Tcl). The limit value is given by:

$$\text{Current Limit} = \frac{Vrs}{Rs}$$

Vrs : Internal reference voltage of current limit circuit (RS Threshold Voltage)
Rs : Motor current sensing resistor

Fig. 6 Motor Current in PWM Function

Function Explanation

12. Current Decay Method (DS)

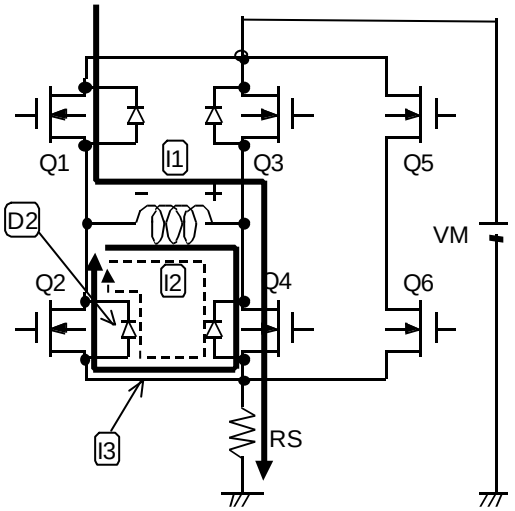
The current decay method is determined by the input into the DS terminal. In slow-decay mode, only the high side MOS FET is switched open during a PWM OFF (Low) cycle. The fast-decay mode switches both the high and low side MOS FETs.

Table 3. gives the DS selection truth table.

TABLE 4. DS Selection Truth Table

DS	Function Mode
High	Slow-Decay
Low	Fast-Decay

The output MOS FETs are controlled by PWM signal as follows.



(1)Condition: Q1 is ON and Q4 is ON,
(PWM ON period)
The motor current I1 goes to RS through the transistors Q1 and Q4.

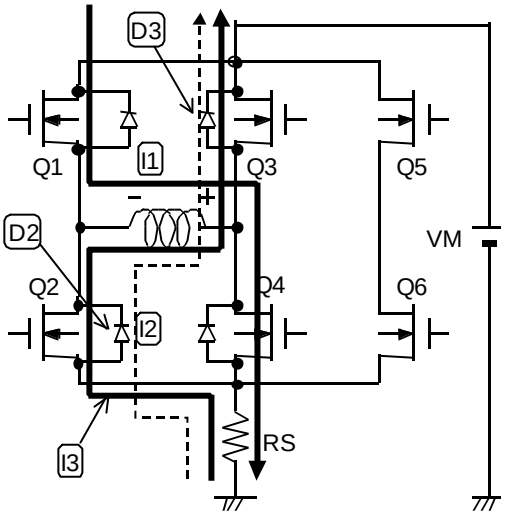
(2)Condition: Q4 is ON and Q2, Q1 are OFF,
(PWM ON-OFF switching period)
The discharge current I2 goes through the diode D2. This diode is a parasitic diode of the output power FET.

(3)Condition: Q2, Q4 are ON and Q1 is OFF,
(PWM OFF period)
The discharge current I3 goes through the transistor Q2.

(4)Condition: Q2, Q4 are ON and Q1 is OFF,
(PWM OFF-ON switching period)
Likewise state (2), the discharge current I2 goes through the diode D2.

* When all the output power FETs are OFF, for example as the phase change, the discharge current goes to VM through these parasitic diodes.

a) Slow-Decay Function



(1)Condition: Q1 is ON and Q4 is ON
(PWM ON period)
The motor current I1 goes to RS through the transistors Q1 and Q4.

(2)Condition: Q1, Q4, Q2 and Q3 are OFF,
(PWM ON-OFF switching period)
The discharge current I2 goes through the diode D2 and D3. This diode is a parasitic diode of the output power FET.

(3)Condition: Q2, Q3 are ON and Q1, Q4 are OFF,
(PWM OFF period)
The discharge current I3 goes through the transistor Q2 and Q3.

(4)Condition: Q2, Q3 are ON and Q1, Q4 are OFF,
(PWM OFF-ON switching period)
Likewise state (2), the discharge current I2 goes through the diode D2 and D3.

* When all the output power FETs are OFF, for example as the phase change, the discharge current goes to VM through these parasitic diodes.

b) Fast-Decay Function

Fig. 7 Current Decay Method at the MOS FETs Control with PWM Signal

Function Explanation

13. Zero Current Detect Function (RS, MGND)

During the PWM OFF period (PWM Low state) at the Fast Decay MODE (DS Low state), if the motor-generated BEMF is completely shorted out, the motor current direction will be reversed and the reverse motor torque will be generated.

Zero Current Detect comparator is monitoring the motor current through the external RS resistor voltage which is negative while the motor-generated BEMF is recirculating at Fast Decay MODE (cf. 12. Current Decay Method). It makes the motor be in Free-run MODE when the external RS resistor voltage becomes to be positive because the motor-generated BEMF is completely shorted out.

14. Op. Amp., FG Comparator and FG Selection (IN+, IN-, OUT, CM+, CM-, FG, FS)

The FS (FG Select) input determines whether the FG output is connected to the internal tachometer or the output of the FG comparator. Table 4. gives the FG selection truth table.

TABLE 5. FS Selection Truth Table

FS	Function Mode
High	Internal Tachometer Output
Low	FG Comparator Output

With a logic "High" input on the FS terminal, the FG terminal is connected to the output of the internal tachometer which generates 3 pulse signal per electrical revolution from the Hall sensor inputs. At this time, the operational amplifier which has the input terminals as IN+ and IN- ,and the output terminal as OUT can be used for general purpose.

With a logic "Low" input on the FS terminal, the FG terminal is connected to the output of the FG comparator. (cf. Application Circuit) This is for the tachometer High / Low signal generated from the external input signal, which is amplified by the op. amp. and comparated by the FG comparator. The FG output is an open drain.

Function Explanation

15. Hall Input Terminals (HU, HV, HW)

These terminals are connected to the Hall effect commutation IC's output of the brushless motor, which have open-collector outputs.

16. Hall commutation selection (MS)

The commutation logic of hall sensors is able to provide both the 120-degree spacing and the 60-degree spacing. Either the 120-degree spacing or the 60-degree spacing is selected by the MS terminal input. (cf. Hall Signal Inputs and Motor Outputs Timing Chart)
Table 5. gives the MS selection truth table.

TABLE 6. MS Selection Truth Table

MS	Function Mode
High	120-degree spacing
Low	60-degree spacing

17. Motor Rotation Direction (FR)

With the FR input at logic "High", the circuits are allowed to follow the commutation sequence for the motor rotation in the forward direction. With the FR input at logic "Low", the internal switching matrix logic is inverted to drive the motor in the reverse rotation.
Table 6. gives the FR selection truth table.

TABLE 7. FR Selection Truth Table

FR	Function Mode
High	Forward Rotation
Low	Reverse Rotation

The relationship of the Hall sensors and the rotor of the motor is as follows.

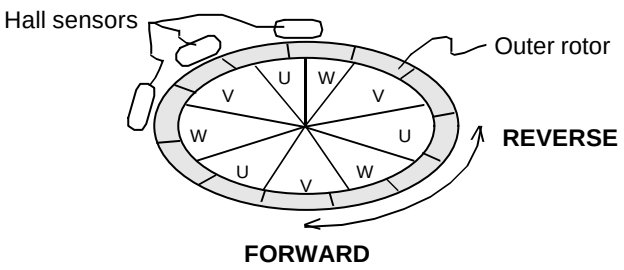


Fig. 8 Motor Rotation Direction

Function Explanation

18. Power Saving Mode (PS)

A logic "High" on this input allows the motor to be driven. And a logic "Low" on this input disables almost all of the circuits (Motor Pre-drive circuit, FG Amp. circuit and FG Comparator circuit). This Power Saving Mode is useful for reducing the power dissipation in the stand-by condition.

Table 7. gives the PS selection truth table.

TABLE 8. PS Selection Truth Table

PS	Function Mode
High	Enable Mode
Low	Power Saving Mode

19. Thermal Shut Down

This function is for thermal protection. The Thermal Shut Down (TSD) circuit has a thermal sensor for the junction temperature of the device. If the temperature goes above the TSD function start temperature, the TSD circuit shut down the almost all of the circuits (Likewise PS MODE; Motor Pre-drive circuit, FG Amp. circuit and FG Comparator circuit). Once the TSD circuit start the shut down function, it continues to the TSD function stop temperature.

The Table 8. gives the TSD function start / stop temperatures.

TABLE 9. FG Selection Truth Table

Parameter	Typical Value	Units
Function Start temperature	140	degrees centigrade
Function Stop Temperature	110	degrees centigrade

* Note: These TSD temperature are the target temperatures for circuit design, not the guaranteed value.

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Motor Input/Output Truth Table

No.	Input									Output							Condition
	MS	DS	FR	BRK	BRS	PWM	HU	HV	HW	UT	UB	VT	VB	WT	WB	FG	
1	H	H	H	H	H/L	H	H	H	H	L	L	L	L	L	L	H	
2	H	H	H	H	H/L	L	H	H	H	L	L	L	L	L	L	H	
3	H	H	H	H	H/L	H	H	L	H	L	H	H	L	L	L	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Forward *Current Decay MODE ; Slow Decay
4	H	H	H	H	H/L	L	H	L	H	L	H	L	H	L	L	L	
5	H	H	H	H	H/L	H	H	L	L	L	H	L	L	H	L	H	
6	H	H	H	H	H/L	L	H	L	L	L	H	L	L	L	H	H	
7	H	H	H	H	H/L	H	H	H	L	L	L	L	H	H	L	L	
8	H	H	H	H	H/L	L	H	H	L	L	L	L	H	L	H	L	
9	H	H	H	H	H/L	H	L	H	L	H	L	L	H	L	L	H	
10	H	H	H	H	H/L	L	L	H	L	L	H	L	H	L	L	H	
11	H	H	H	H	H/L	H	L	H	H	H	L	L	L	L	H	L	
12	H	H	H	H	H/L	L	L	H	H	L	H	L	L	L	H	L	
13	H	H	H	H	H/L	H	L	L	H	L	L	H	L	L	H	H	
14	H	H	H	H	H/L	L	L	L	H	L	L	L	H	L	H	H	
15	H	H	H	H	H/L	H	L	L	L	L	L	L	L	L	L	L	
16	H	H	H	H	H/L	L	L	L	L	L	L	L	L	L	L	L	
17	H	H	H	L	H	H	H	H	H	L	H	L	H	L	H	H	
18	H	H	H	L	H	L	H	H	H	L	H	L	H	L	H	H	
19	H	H	H	L	H	H	H	L	H	L	H	L	H	L	H	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Forward *Current Decay MODE ; Slow Decay *Short-Brake-State
20	H	H	H	L	H	L	H	L	H	L	H	L	H	L	H	L	
21	H	H	H	L	H	H	H	L	L	L	H	L	H	L	H	H	
22	H	H	H	L	H	L	H	L	L	L	H	L	H	L	H	H	
23	H	H	H	L	H	H	H	H	L	L	H	L	H	L	H	L	
24	H	H	H	L	H	L	H	H	L	L	H	L	H	L	H	L	
25	H	H	H	L	H	H	L	H	L	L	H	L	H	L	H	H	
26	H	H	H	L	H	L	L	H	L	L	H	L	H	L	H	H	
27	H	H	H	L	H	H	L	H	H	L	H	L	H	L	H	L	
28	H	H	H	L	H	L	L	H	H	L	H	L	H	L	H	L	
29	H	H	H	L	H	H	L	L	H	L	H	L	H	L	H	H	
30	H	H	H	L	H	L	L	L	H	L	H	L	H	L	H	H	
31	H	H	H	L	H	H	L	L	L	L	H	L	H	L	H	L	
32	H	H	H	L	H	L	L	L	L	L	H	L	H	L	H	L	
33	H	H	H	L	L	H	H	H	H	L	L	L	L	L	L	H	
34	H	H	H	L	L	L	H	H	H	L	L	L	L	L	L	H	
35	H	H	H	L	L	H	H	L	H	L	L	L	L	L	L	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Forward *Current Decay MODE ; Slow Decay *Free-Run-State
36	H	H	H	L	L	L	H	L	H	L	L	L	L	L	L	L	
37	H	H	H	L	L	H	H	L	L	L	L	L	L	L	L	H	
38	H	H	H	L	L	L	H	L	L	L	L	L	L	L	L	H	
39	H	H	H	L	L	H	H	H	L	L	L	L	L	L	L	L	
40	H	H	H	L	L	L	H	H	L	L	L	L	L	L	L	L	
41	H	H	H	L	L	H	L	H	L	L	L	L	L	L	L	H	
42	H	H	H	L	L	L	L	H	L	L	L	L	L	L	L	H	
43	H	H	H	L	L	H	L	H	H	L	L	L	L	L	L	L	
44	H	H	H	L	L	L	L	H	H	L	L	L	L	L	L	L	
45	H	H	H	L	L	H	L	L	H	L	L	L	L	L	L	H	
46	H	H	H	L	L	L	L	L	H	L	L	L	L	L	L	H	
47	H	H	H	L	L	H	L	L	L	L	L	L	L	L	L	L	
48	H	H	H	L	L	L	L	L	L	L	L	L	L	L	L	L	
49	H	H	L	H	H/L	H	H	H	H	L	L	L	L	L	L	H	
50	H	H	L	H	H/L	L	H	H	H	L	L	L	L	L	L	H	
51	H	H	L	H	H/L	H	H	L	H	H	L	L	H	L	L	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Reverse *Current Decay MODE ; Slow Decay *non-Brake-state
52	H	H	L	H	H/L	L	H	L	H	L	H	L	H	L	L	L	
53	H	H	L	H	H/L	H	H	L	L	H	L	L	L	L	H	H	
54	H	H	L	H	H/L	L	H	L	L	L	H	L	L	L	H	H	
55	H	H	L	H	H/L	H	H	H	L	L	L	H	L	L	H	L	
56	H	H	L	H	H/L	L	H	H	L	L	L	L	H	L	H	L	
57	H	H	L	H	H/L	H	L	H	L	L	H	H	L	L	L	H	
58	H	H	L	H	H/L	L	L	H	L	L	H	L	H	L	L	H	
59	H	H	L	H	H/L	H	L	H	H	L	H	L	L	H	L	L	
60	H	H	L	H	H/L	L	L	H	H	L	H	L	L	L	H	L	
61	H	H	L	H	H/L	H	L	L	H	L	L	L	H	H	L	H	
62	H	H	L	H	H/L	L	L	L	H	L	L	L	H	L	H	H	
63	H	H	L	H	H/L	H	L	L	L	L	L	L	L	L	L	L	
64	H	H	L	H	H/L	L	L	L	L	L	L	L	L	L	L	L	

* Note: “FG” output in this table indicates a tacho meter output.

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Motor Input/Output Truth Table

No.	Input									Output							Condition
	MS	DS	FR	BRK	BRS	PWM	HU	HV	HW	UT	UB	VT	VB	WT	WB	FG	
65	H	H	L	L	H	H	H	H	H	L	H	L	H	L	H	H	
66	H	H	L	L	H	L	H	H	H	L	H	L	H	L	H	H	
67	H	H	L	L	H	H	H	L	H	L	H	L	H	L	H	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Reverse *Current Decay MODE ; Slow Decay *Short-Brake-state
68	H	H	L	L	H	L	H	L	H	L	H	L	H	L	H	L	
69	H	H	L	L	H	H	H	L	L	L	H	L	H	L	H	H	
70	H	H	L	L	H	L	H	L	L	L	H	L	H	L	H	H	
71	H	H	L	L	H	H	H	H	L	L	H	L	H	L	H	L	
72	H	H	L	L	H	L	H	H	L	L	H	L	H	L	H	L	
73	H	H	L	L	H	H	L	H	L	L	H	L	H	L	H	H	
74	H	H	L	L	H	L	L	H	L	L	H	L	H	L	H	H	
75	H	H	L	L	H	H	L	H	H	L	H	L	H	L	H	L	
76	H	H	L	L	H	L	L	H	H	L	H	L	H	L	H	L	
77	H	H	L	L	H	H	L	L	H	L	H	L	H	L	H	H	
78	H	H	L	L	H	L	L	L	H	L	H	L	H	L	H	H	
79	H	H	L	L	H	H	L	L	L	L	H	L	H	L	H	L	
80	H	H	L	L	H	L	L	L	L	L	H	L	H	L	H	L	
81	H	H	L	L	L	H	H	H	H	L	L	L	L	L	L	H	
82	H	H	L	L	L	L	H	H	H	L	L	L	L	L	L	H	
83	H	H	L	L	L	H	H	L	H	L	L	L	L	L	L	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Reverse *Current Decay MODE ; Slow Decay *Free-Run-state
84	H	H	L	L	L	L	H	L	H	L	L	L	L	L	L	L	
85	H	H	L	L	L	H	H	L	L	L	L	L	L	L	L	H	
86	H	H	L	L	L	L	H	L	L	L	L	L	L	L	L	H	
87	H	H	L	L	L	H	H	H	L	L	L	L	L	L	L	L	
88	H	H	L	L	L	L	H	H	L	L	L	L	L	L	L	L	
89	H	H	L	L	L	H	L	H	L	L	L	L	L	L	L	H	
90	H	H	L	L	L	L	L	H	L	L	L	L	L	L	L	H	
91	H	H	L	L	L	H	L	H	H	L	L	L	L	L	L	L	
92	H	H	L	L	L	L	L	H	H	L	L	L	L	L	L	L	
93	H	H	L	L	L	H	L	L	H	L	L	L	L	L	L	H	
94	H	H	L	L	L	L	L	L	H	L	L	L	L	L	L	H	
95	H	H	L	L	L	H	L	L	L	L	L	L	L	L	L	L	
96	H	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	
97	H	L	H	H	H/L	H	H	H	H	L	L	L	L	L	L	H	
98	H	L	H	H	H/L	L	H	H	H	L	L	L	L	L	L	H	
99	H	L	H	H	H/L	H	H	L	H	L	H	H	L	L	L	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Forward *Current Decay MODE ; Fast Decay *non-Brake-state
100	H	L	H	H	H/L	L	H	L	H	H	L	L	H	L	L	L	
101	H	L	H	H	H/L	H	H	L	L	L	H	L	L	H	L	H	
102	H	L	H	H	H/L	L	H	L	L	H	L	L	L	L	H	H	
103	H	L	H	H	H/L	H	H	H	L	L	L	L	H	H	L	L	
104	H	L	H	H	H/L	L	H	H	L	L	L	H	L	L	H	L	
105	H	L	H	H	H/L	H	L	H	L	H	L	L	H	L	L	H	
106	H	L	H	H	H/L	L	L	H	L	L	H	H	L	L	L	H	
107	H	L	H	H	H/L	H	L	H	H	H	L	L	L	L	H	L	
108	H	L	H	H	H/L	L	L	H	H	L	H	L	L	H	L	L	
109	H	L	H	H	H/L	H	L	L	H	L	L	H	L	L	H	H	
110	H	L	H	H	H/L	L	L	L	H	L	L	L	H	H	L	H	
111	H	L	H	H	H/L	H	L	L	L	L	L	L	L	L	L	L	
112	H	L	H	H	H/L	L	L	L	L	L	L	L	L	L	L	L	
113	H	L	H	L	H	H	H	H	H	L	H	L	H	L	H	H	
114	H	L	H	L	H	L	H	H	H	L	H	L	H	L	H	H	
115	H	L	H	L	H	H	H	L	H	L	H	L	H	L	H	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Forward *Current Decay MODE ; Fast Decay *Short-Brake-state
116	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	
117	H	L	H	L	H	H	H	L	L	L	H	L	H	L	H	H	
118	H	L	H	L	H	L	H	L	L	L	H	L	H	L	H	H	
119	H	L	H	L	H	H	H	H	L	L	H	L	H	L	H	L	
120	H	L	H	L	H	L	H	H	L	L	H	L	H	L	H	L	
121	H	L	H	L	H	H	L	H	L	L	H	L	H	L	H	H	
122	H	L	H	L	H	L	L	H	L	L	H	L	H	L	H	H	
123	H	L	H	L	H	H	L	H	H	L	H	L	H	L	H	L	
124	H	L	H	L	H	L	L	H	H	L	H	L	H	L	H	L	
125	H	L	H	L	H	H	L	L	H	L	H	L	H	L	H	H	
126	H	L	H	L	H	L	L	L	H	L	H	L	H	L	H	H	
127	H	L	H	L	H	H	L	L	L	L	H	L	H	L	H	L	
128	H	L	H	L	H	L	L	L	L	L	H	L	H	L	H	L	

* Note: “FG” output in this table indicates a tacho meter output.

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Motor Input/Output Truth Table

No.	Input									Output							Condition
	MS	DS	FR	BRK	BRS	PWM	HU	HV	HW	UT	UB	VT	VB	WT	WB	FG	
129	H	L	H	L	L	H	H	H	H	L	L	L	L	L	L	H	
130	H	L	H	L	L	L	H	H	H	L	L	L	L	L	L	H	
131	H	L	H	L	L	H	H	L	H	L	L	L	L	L	L	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Forward *Current Decay MODE ; Fast Decay *Free-Run-state
132	H	L	H	L	L	L	H	L	H	L	L	L	L	L	L	L	
133	H	L	H	L	L	H	H	L	L	L	L	L	L	L	L	H	
134	H	L	H	L	L	L	H	L	L	L	L	L	L	L	L	H	
135	H	L	H	L	L	H	H	H	L	L	L	L	L	L	L	L	
136	H	L	H	L	L	L	H	H	L	L	L	L	L	L	L	L	
137	H	L	H	L	L	H	L	H	L	L	L	L	L	L	L	H	
138	H	L	H	L	L	L	L	H	L	L	L	L	L	L	L	H	
139	H	L	H	L	L	H	L	H	H	L	L	L	L	L	L	L	
140	H	L	H	L	L	L	L	H	H	L	L	L	L	L	L	L	
141	H	L	H	L	L	H	L	L	H	L	L	L	L	L	L	H	
142	H	L	H	L	L	L	L	L	H	L	L	L	L	L	L	H	
143	H	L	H	L	L	H	L	L	L	L	L	L	L	L	L	L	
144	H	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	
145	H	L	L	H	H/L	H	H	H	H	L	L	L	L	L	L	H	
146	H	L	L	H	H/L	L	H	H	H	L	L	L	L	L	L	H	
147	H	L	L	H	H/L	H	H	L	H	H	L	L	H	L	L	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Reverse *Current Decay MODE ; Fast Decay *non-Brake-state
148	H	L	L	H	H/L	L	H	L	H	L	H	H	L	L	L	L	
149	H	L	L	H	H/L	H	H	L	L	H	L	L	L	L	H	H	
150	H	L	L	H	H/L	L	H	L	L	L	H	L	L	H	L	H	
151	H	L	L	H	H/L	H	H	H	L	L	L	H	L	L	H	L	
152	H	L	L	H	H/L	L	H	H	L	L	L	L	H	H	L	L	
153	H	L	L	H	H/L	H	L	H	L	L	H	H	L	L	L	H	
154	H	L	L	H	H/L	L	L	H	L	H	L	L	H	L	L	H	
155	H	L	L	H	H/L	H	L	H	H	L	H	L	L	H	L	L	
156	H	L	L	H	H/L	L	L	H	H	H	L	L	L	L	H	L	
157	H	L	L	H	H/L	H	L	L	H	L	L	L	H	H	L	H	
158	H	L	L	H	H/L	L	L	L	H	L	L	H	L	L	H	H	
159	H	L	L	H	H/L	H	L	L	L	L	L	L	L	L	L	L	
160	H	L	L	H	H/L	L	L	L	L	L	L	L	L	L	L	L	
161	H	L	L	L	H	H	H	H	H	L	H	L	H	L	H	H	
162	H	L	L	L	H	L	H	H	H	L	H	L	H	L	H	H	
163	H	L	L	L	H	H	H	L	H	L	H	L	H	L	H	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Reverse *Current Decay MODE ; Fast Decay *Short-Brake-state
164	H	L	L	L	H	L	H	L	H	L	H	L	H	L	H	L	
165	H	L	L	L	H	H	H	L	L	L	H	L	H	L	H	H	
166	H	L	L	L	H	L	H	L	L	L	H	L	H	L	H	H	
167	H	L	L	L	H	H	H	H	L	L	H	L	H	L	H	L	
168	H	L	L	L	H	L	H	H	L	L	H	L	H	L	H	L	
169	H	L	L	L	H	H	L	H	L	L	H	L	H	L	H	H	
170	H	L	L	L	H	L	L	H	L	L	H	L	H	L	H	H	
171	H	L	L	L	H	H	L	H	H	L	H	L	H	L	H	L	
172	H	L	L	L	H	L	L	H	H	L	H	L	H	L	H	L	
173	H	L	L	L	H	H	L	L	H	L	H	L	H	L	H	H	
174	H	L	L	L	H	L	L	L	H	L	H	L	H	L	H	H	
175	H	L	L	L	H	H	L	L	L	L	H	L	H	L	H	L	
176	H	L	L	L	H	L	L	L	L	L	H	L	H	L	H	L	
177	H	L	L	L	L	H	H	H	H	L	L	L	L	L	L	H	
178	H	L	L	L	L	L	H	H	H	L	L	L	L	L	L	H	
179	H	L	L	L	L	H	H	L	H	L	L	L	L	L	L	L	Regular mode *Hall spasing ; 120deg. *Rotate Direction ; Reverse *Current Decay MODE ; Fast Decay *Free-Run-state
180	H	L	L	L	L	L	H	L	H	L	L	L	L	L	L	L	
181	H	L	L	L	L	H	H	L	L	L	L	L	L	L	L	H	
182	H	L	L	L	L	L	H	L	L	L	L	L	L	L	L	H	
183	H	L	L	L	L	H	H	H	L	L	L	L	L	L	L	L	
184	H	L	L	L	L	L	H	H	L	L	L	L	L	L	L	L	
185	H	L	L	L	L	H	L	H	L	L	L	L	L	L	L	H	
186	H	L	L	L	L	L	L	H	L	L	L	L	L	L	L	H	
187	H	L	L	L	L	H	L	H	H	L	L	L	L	L	L	L	
188	H	L	L	L	L	L	L	H	H	L	L	L	L	L	L	L	
189	H	L	L	L	L	H	L	L	H	L	L	L	L	L	L	H	
190	H	L	L	L	L	L	L	L	H	L	L	L	L	L	L	H	
191	H	L	L	L	L	H	L	L	L	L	L	L	L	L	L	L	
192	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	

* Note: “FG” output in this table indicates a tacho meter output.

Motor Input/Output Truth Table

No.	Input									Output							Condition
	MS	DS	FR	BRK	BRS	PWM	HU	HV	HW	UT	UB	VT	VB	WT	WB	FG	
193	L	H	H	H	H/L	H	H	L	H	L	L	L	L	L	L	L	
194	L	H	H	H	H/L	L	H	L	H	L	L	L	L	L	L	L	
195	L	H	H	H	H/L	H	L	L	L	L	H	H	L	L	L	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Forward *Current Decay MODE ; Slow Decay *non-Brake-state
196	L	H	H	H	H/L	L	L	L	L	L	H	L	H	L	L	L	
197	L	H	H	H	H/L	H	H	L	L	L	H	L	L	H	L	H	
198	L	H	H	H	H/L	L	H	L	L	L	H	L	L	L	H	H	
199	L	H	H	H	H/L	H	H	H	L	L	L	L	H	H	L	L	
200	L	H	H	H	H/L	L	H	H	L	L	L	L	H	L	H	L	
201	L	H	H	H	H/L	H	H	H	H	H	L	L	H	L	L	H	
202	L	H	H	H	H/L	L	H	H	H	L	H	L	H	L	L	H	
203	L	H	H	H	H/L	H	L	H	H	H	L	L	L	L	H	L	
204	L	H	H	H	H/L	L	L	H	H	L	H	L	L	L	H	L	
205	L	H	H	H	H/L	H	L	L	H	L	L	H	L	L	H	H	
206	L	H	H	H	H/L	L	L	L	H	L	L	L	H	L	H	H	
207	L	H	H	H	H/L	H	L	H	L	L	L	L	L	L	L	H	
208	L	H	H	H	H/L	L	L	H	L	L	L	L	L	L	L	H	
209	L	H	H	L	H	H	H	L	H	L	H	L	H	L	H	L	
210	L	H	H	L	H	L	H	L	H	L	H	L	H	L	H	L	
211	L	H	H	L	H	H	L	L	L	L	H	L	H	L	H	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Forward *Current Decay MODE ; Slow Decay *Short-Brake-state
212	L	H	H	L	H	L	L	L	L	L	H	L	H	L	H	L	
213	L	H	H	L	H	H	H	L	L	L	H	L	H	L	H	H	
214	L	H	H	L	H	L	H	L	L	L	H	L	H	L	H	H	
215	L	H	H	L	H	H	H	H	L	L	H	L	H	L	H	L	
216	L	H	H	L	H	L	H	H	L	L	H	L	H	L	H	L	
217	L	H	H	L	H	H	H	H	H	L	H	L	H	L	H	H	
218	L	H	H	L	H	L	H	H	H	L	H	L	H	L	H	H	
219	L	H	H	L	H	H	L	H	H	L	H	L	H	L	H	L	
220	L	H	H	L	H	L	L	H	H	L	H	L	H	L	H	L	
221	L	H	H	L	H	H	L	L	H	L	H	L	H	L	H	H	
222	L	H	H	L	H	L	L	L	H	L	H	L	H	L	H	H	
223	L	H	H	L	H	H	L	H	L	L	H	L	H	L	H	H	
224	L	H	H	L	H	L	L	H	L	L	H	L	H	L	H	H	
225	L	H	H	L	L	H	H	L	H	L	L	L	L	L	L	L	
226	L	H	H	L	L	L	H	L	H	L	L	L	L	L	L	L	
227	L	H	H	L	L	H	L	L	L	L	L	L	L	L	L	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Forward *Current Decay MODE ; Slow Decay *Free-Run-state
228	L	H	H	L	L	L	L	L	L	L	L	L	L	L	L	L	
229	L	H	H	L	L	H	H	L	L	L	L	L	L	L	L	H	
230	L	H	H	L	L	L	H	L	L	L	L	L	L	L	L	H	
231	L	H	H	L	L	H	H	H	L	L	L	L	L	L	L	L	
232	L	H	H	L	L	L	H	H	L	L	L	L	L	L	L	L	
233	L	H	H	L	L	H	H	H	H	L	L	L	L	L	L	H	
234	L	H	H	L	L	L	H	H	H	L	L	L	L	L	L	H	
235	L	H	H	L	L	H	L	H	H	L	L	L	L	L	L	L	
236	L	H	H	L	L	L	L	H	H	L	L	L	L	L	L	L	
237	L	H	H	L	L	H	L	L	H	L	L	L	L	L	L	H	
238	L	H	H	L	L	L	L	L	H	L	L	L	L	L	L	H	
239	L	H	H	L	L	H	L	H	L	L	L	L	L	L	L	H	
240	L	H	H	L	L	L	L	H	L	L	L	L	L	L	L	H	
241	L	H	L	H	H/L	H	H	L	H	L	L	L	L	L	L	L	
242	L	H	L	H	H/L	L	H	L	H	L	L	L	L	L	L	L	
243	L	H	L	H	H/L	H	L	L	L	H	L	L	H	L	L	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Reverse *Current Decay MODE ; Slow Decay *non-Brake-state
244	L	H	L	H	H/L	L	L	L	L	L	H	L	H	L	L	L	
245	L	H	L	H	H/L	H	H	L	L	H	L	L	L	L	H	H	
246	L	H	L	H	H/L	L	H	L	L	L	H	L	L	L	H	H	
247	L	H	L	H	H/L	H	H	H	L	L	L	H	L	L	H	L	
248	L	H	L	H	H/L	L	H	H	L	L	L	L	H	L	H	L	
249	L	H	L	H	H/L	H	H	H	H	L	H	H	L	L	L	H	
250	L	H	L	H	H/L	L	H	H	H	L	H	L	H	L	L	H	
251	L	H	L	H	H/L	H	L	H	H	L	H	L	L	H	L	L	
252	L	H	L	H	H/L	L	L	H	H	L	H	L	L	L	H	L	
253	L	H	L	H	H/L	H	L	L	H	L	L	L	H	H	L	H	
254	L	H	L	H	H/L	L	L	L	H	L	L	L	H	L	H	H	
255	L	H	L	H	H/L	H	L	H	L	L	L	L	L	L	L	H	
256	L	H	L	H	H/L	L	L	H	L	L	L	L	L	L	L	H	

* Note: “FG” output in this table indicates a tacho meter output.

Motor Input/Output Truth Table

No.	Input									Output							Condition
	MS	DS	FR	BRK	BRS	PWM	HU	HV	HW	UT	UB	VT	VB	WT	WB	FG	
257	L	H	L	L	H	H	H	L	H	L	H	L	H	L	H	L	
258	L	H	L	L	H	L	H	L	H	L	H	L	H	L	H	L	
259	L	H	L	L	H	H	L	L	L	L	H	L	H	L	H	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Reverse *Current Decay MODE ; Slow Decay *Short-Brake-state
260	L	H	L	L	H	L	L	L	L	L	H	L	H	L	H	L	
261	L	H	L	L	H	H	H	L	L	L	H	L	H	L	H	H	
262	L	H	L	L	H	L	H	L	L	L	H	L	H	L	H	H	
263	L	H	L	L	H	H	H	H	L	L	H	L	H	L	H	L	
264	L	H	L	L	H	L	H	H	L	L	H	L	H	L	H	L	
265	L	H	L	L	H	H	H	H	H	L	H	L	H	L	H	H	
266	L	H	L	L	H	L	H	H	H	L	H	L	H	L	H	H	
267	L	H	L	L	H	H	L	H	H	L	H	L	H	L	H	L	
268	L	H	L	L	H	L	L	H	H	L	H	L	H	L	H	L	
269	L	H	L	L	H	H	L	L	H	L	H	L	H	L	H	H	
270	L	H	L	L	H	L	L	L	H	L	H	L	H	L	H	H	
271	L	H	L	L	H	H	L	H	L	L	H	L	H	L	H	H	
272	L	H	L	L	H	L	L	H	L	L	H	L	H	L	H	H	
273	L	H	L	L	L	H	H	L	H	L	L	L	L	L	L	L	
274	L	H	L	L	L	L	H	L	H	L	L	L	L	L	L	L	
275	L	H	L	L	L	H	L	L	L	L	L	L	L	L	L	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Reverse *Current Decay MODE ; Slow Decay *Free-Run-state
276	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	
277	L	H	L	L	L	H	H	L	L	L	L	L	L	L	L	H	
278	L	H	L	L	L	L	H	L	L	L	L	L	L	L	L	H	
279	L	H	L	L	L	H	H	H	L	L	L	L	L	L	L	L	
280	L	H	L	L	L	L	H	H	L	L	L	L	L	L	L	L	
281	L	H	L	L	L	H	H	H	H	L	L	L	L	L	L	H	
282	L	H	L	L	L	L	H	H	H	L	L	L	L	L	L	H	
283	L	H	L	L	L	H	L	H	H	L	L	L	L	L	L	L	
284	L	H	L	L	L	L	L	H	H	L	L	L	L	L	L	L	
285	L	H	L	L	L	H	L	L	H	L	L	L	L	L	L	H	
286	L	H	L	L	L	L	L	L	H	L	L	L	L	L	L	H	
287	L	H	L	L	L	H	L	H	L	L	L	L	L	L	L	H	
288	L	H	L	L	L	L	L	H	L	L	L	L	L	L	L	H	
289	L	L	H	H	H/L	H	H	L	H	L	L	L	L	L	L	L	
290	L	L	H	H	H/L	L	H	L	H	L	L	L	L	L	L	L	
291	L	L	H	H	H/L	H	L	L	L	L	H	H	L	L	L	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Forward *Current Decay MODE ; Fast Decay *non-Brake-state
292	L	L	H	H	H/L	L	L	L	L	H	L	L	H	L	L	L	
293	L	L	H	H	H/L	H	H	L	L	L	H	L	L	H	L	H	
294	L	L	H	H	H/L	L	H	L	L	H	L	L	L	L	H	H	
295	L	L	H	H	H/L	H	H	H	L	L	L	L	H	H	L	L	
296	L	L	H	H	H/L	L	H	H	L	L	L	H	L	L	H	L	
297	L	L	H	H	H/L	H	H	H	H	H	L	L	H	L	L	H	
298	L	L	H	H	H/L	L	H	H	H	L	H	H	L	L	L	H	
299	L	L	H	H	H/L	H	L	H	H	H	L	L	L	L	H	L	
300	L	L	H	H	H/L	L	L	H	H	L	H	L	L	H	L	L	
301	L	L	H	H	H/L	H	L	L	H	L	L	H	L	L	H	H	
302	L	L	H	H	H/L	L	L	L	H	L	L	L	H	H	L	H	
303	L	L	H	H	H/L	H	L	H	L	L	L	L	L	L	L	H	
304	L	L	H	H	H/L	L	L	H	L	L	L	L	L	L	L	H	
305	L	L	H	L	H	H	H	L	H	L	L	L	L	L	L	L	
306	L	L	H	L	H	L	H	L	H	L	L	L	L	L	L	L	
307	L	L	H	L	H	H	L	L	L	L	H	L	H	L	H	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Forward *Current Decay MODE ; Fast Decay *Short-Brake-state
308	L	L	H	L	H	L	L	L	L	L	H	L	H	L	H	L	
309	L	L	H	L	H	H	H	L	L	L	H	L	H	L	H	H	
310	L	L	H	L	H	L	H	L	L	L	H	L	H	L	H	H	
311	L	L	H	L	H	H	H	H	L	L	H	L	H	L	H	L	
312	L	L	H	L	H	L	H	H	L	L	H	L	H	L	H	L	
313	L	L	H	L	H	H	H	H	H	L	H	L	H	L	H	H	
314	L	L	H	L	H	L	H	H	H	L	H	L	H	L	H	H	
315	L	L	H	L	H	H	L	H	H	L	H	L	H	L	H	L	
316	L	L	H	L	H	L	L	H	H	L	H	L	H	L	H	L	
317	L	L	H	L	H	H	L	L	H	L	H	L	H	L	H	H	
318	L	L	H	L	H	L	L	L	H	L	H	L	H	L	H	H	
319	L	L	H	L	H	H	L	H	L	L	L	L	L	L	L	H	
320	L	L	H	L	H	L	L	H	L	L	L	L	L	L	L	H	

* Note: “FG” output in this table indicates a tacho meter output.

Motor Input/Output Truth Table

No.	Input									Output							Condition
	MS	DS	FR	BRK	BRS	PWM	HU	HV	HW	UT	UB	VT	VB	WT	WB	FG	
321	L	L	H	L	L	H	H	L	H	L	L	L	L	L	L	L	
322	L	L	H	L	L	L	H	L	H	L	L	L	L	L	L	L	
323	L	L	H	L	L	H	L	L	L	L	L	L	L	L	L	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Forward *Current Decay MODE ; Fast Decay *Free-Run-state
324	L	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	
325	L	L	H	L	L	H	H	L	L	L	L	L	L	L	L	H	
326	L	L	H	L	L	L	H	L	L	L	L	L	L	L	L	H	
327	L	L	H	L	L	H	H	H	L	L	L	L	L	L	L	L	
328	L	L	H	L	L	L	H	H	L	L	L	L	L	L	L	L	
329	L	L	H	L	L	H	H	H	H	L	L	L	L	L	L	H	
330	L	L	H	L	L	L	H	H	H	L	L	L	L	L	L	H	
331	L	L	H	L	L	H	L	H	H	L	L	L	L	L	L	L	
332	L	L	H	L	L	L	L	H	H	L	L	L	L	L	L	L	
333	L	L	H	L	L	H	L	L	H	L	L	L	L	L	L	H	
334	L	L	H	L	L	L	L	L	H	L	L	L	L	L	L	H	
335	L	L	H	L	L	H	L	H	L	L	L	L	L	L	L	H	
336	L	L	H	L	L	L	L	H	L	L	L	L	L	L	L	H	
337	L	L	L	H	H/L	H	H	L	H	L	L	L	L	L	L	L	
338	L	L	L	H	H/L	L	H	L	H	L	L	L	L	L	L	L	
339	L	L	L	H	H/L	H	L	L	L	H	L	L	H	L	L	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Reverse *Current Decay MODE ; Fast Decay *non-Brake-state
340	L	L	L	H	H/L	L	L	L	L	L	H	H	L	L	L	L	
341	L	L	L	H	H/L	H	H	L	L	H	L	L	L	L	H	H	
342	L	L	L	H	H/L	L	H	L	L	L	H	L	L	H	L	H	
343	L	L	L	H	H/L	H	H	H	L	L	L	H	L	L	H	L	
344	L	L	L	H	H/L	L	H	H	L	L	L	L	H	H	L	L	
345	L	L	L	H	H/L	H	H	H	H	L	H	H	L	L	L	H	
346	L	L	L	H	H/L	L	H	H	H	H	L	L	H	L	L	H	
347	L	L	L	H	H/L	H	L	H	H	L	H	L	L	H	L	L	
348	L	L	L	H	H/L	L	L	H	H	H	L	L	L	L	H	L	
349	L	L	L	H	H/L	H	L	L	H	L	L	L	H	H	L	H	
350	L	L	L	H	H/L	L	L	L	H	L	L	H	L	L	H	H	
351	L	L	L	H	H/L	H	L	H	L	L	L	L	L	L	L	H	
352	L	L	L	H	H/L	L	L	H	L	L	L	L	L	L	L	H	
353	L	L	L	L	H	H	H	L	H	L	H	L	H	L	H	L	
354	L	L	L	L	H	L	H	L	H	L	H	L	H	L	H	L	
355	L	L	L	L	H	H	L	L	L	L	H	L	H	L	H	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Reverse *Current Decay MODE ; Fast Decay *Short-Brake-state
356	L	L	L	L	H	L	L	L	L	L	H	L	H	L	H	L	
357	L	L	L	L	H	H	H	L	L	L	H	L	H	L	H	H	
358	L	L	L	L	H	L	H	L	L	L	H	L	H	L	H	H	
359	L	L	L	L	H	H	H	H	L	L	H	L	H	L	H	L	
360	L	L	L	L	H	L	H	H	L	L	H	L	H	L	H	L	
361	L	L	L	L	H	H	H	H	H	L	H	L	H	L	H	H	
362	L	L	L	L	H	L	H	H	H	L	H	L	H	L	H	H	
363	L	L	L	L	H	H	L	H	H	L	H	L	H	L	H	L	
364	L	L	L	L	H	L	L	H	H	L	H	L	H	L	H	L	
365	L	L	L	L	H	H	L	L	H	L	H	L	H	L	H	H	
366	L	L	L	L	H	L	L	L	H	L	H	L	H	L	H	H	
367	L	L	L	L	H	H	L	H	L	L	H	L	H	L	H	H	
368	L	L	L	L	H	L	L	H	L	L	H	L	H	L	H	H	
369	L	L	L	L	L	H	H	L	H	L	L	L	L	L	L	L	
370	L	L	L	L	L	L	H	L	H	L	L	L	L	L	L	L	
371	L	L	L	L	L	H	L	L	L	L	L	L	L	L	L	L	Regular mode *Hall spasing ; 60deg. *Rotate Direction ; Reverse *Current Decay MODE ; Fast Decay *Free-Run-state
372	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	
373	L	L	L	L	L	H	H	L	L	L	L	L	L	L	L	H	
374	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	H	
375	L	L	L	L	L	H	H	H	L	L	L	L	L	L	L	L	
376	L	L	L	L	L	L	H	H	L	L	L	L	L	L	L	L	
377	L	L	L	L	L	H	H	H	H	L	L	L	L	L	L	H	
378	L	L	L	L	L	L	H	H	H	L	L	L	L	L	L	H	
379	L	L	L	L	L	H	L	H	H	L	L	L	L	L	L	L	
380	L	L	L	L	L	L	L	H	H	L	L	L	L	L	L	L	
381	L	L	L	L	L	H	L	L	H	L	L	L	L	L	L	H	
382	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	H	
383	L	L	L	L	L	H	L	H	L	L	L	L	L	L	L	H	
384	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	H	

* Note: “FG” output in this table indicates a tacho meter output.

I/O Circuit

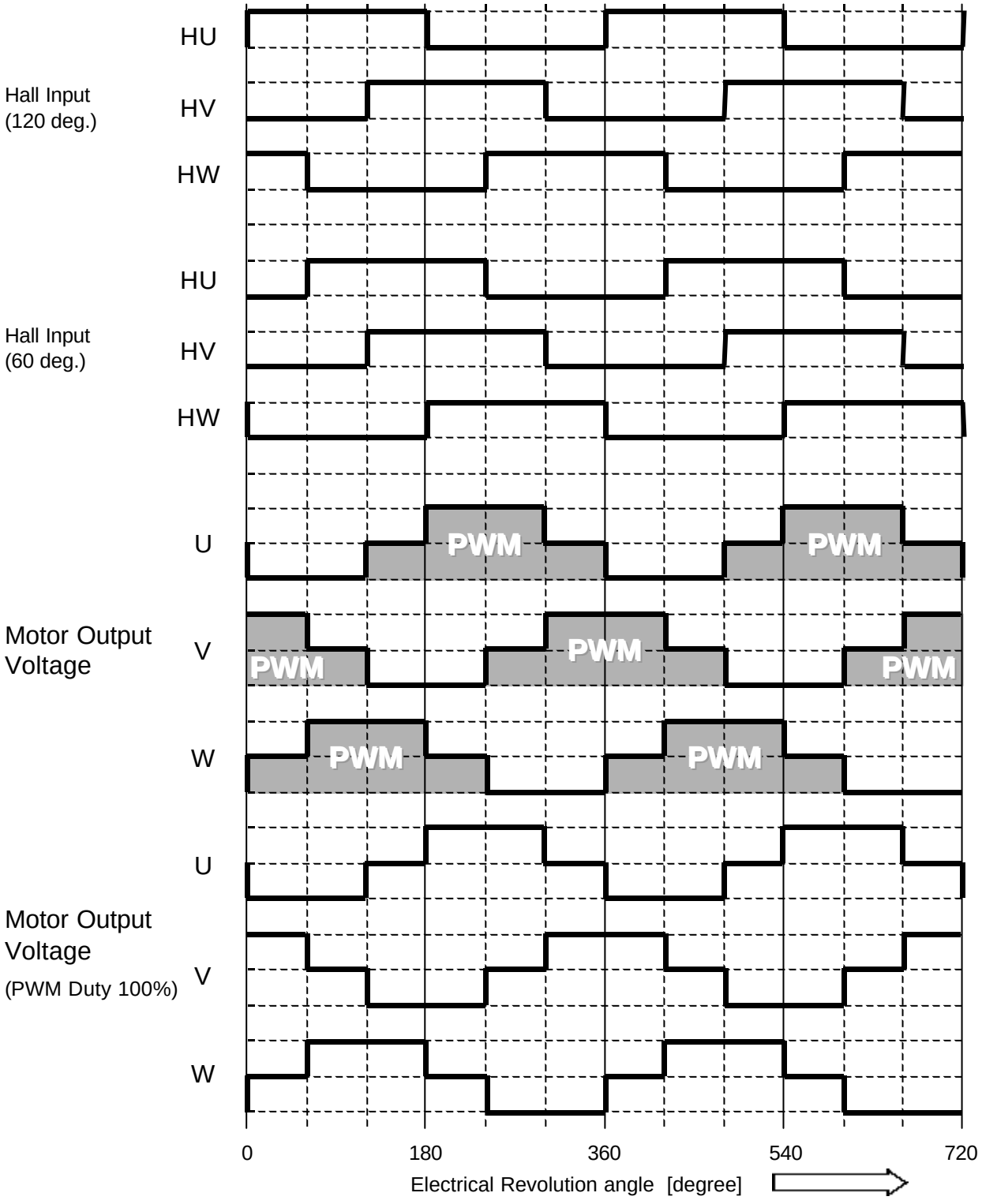
<PWM>	< FR, PS, BRK, BRS, MS, DS,FS >	<HU, HV, HW>	<SVCC>
TBD	TBD	TBD	TBD

< IN+, IN->	< OUT>	< CM+, CM->	<FG>
TBD	TBD	TBD	TBD

< VM, VGT, VGB, UT, U,UB, VT, V, VB, WT, W, WB, RS, MGND>	< VM, CP1, CP2, VCP, CP3, CP4, VGB, CP5, CP6, VGT>
TBD	TBD

<VCC1, VCC2>	< OSC1, OSC2, SGND>	< REGE, REGB, REGC, REGR>
TBD	TBD	TBD

Hall Inputs and Motor Outputs Timing Chart



* Note9 : These are the timing chart of the Hall commutation sensor outputs and the motor outputs, and the motor output voltage waveforms only show the High/Low/Middle state in each period. In details, these output voltage waveforms are different from the real waveforms of the actual motor outputs under rotation.

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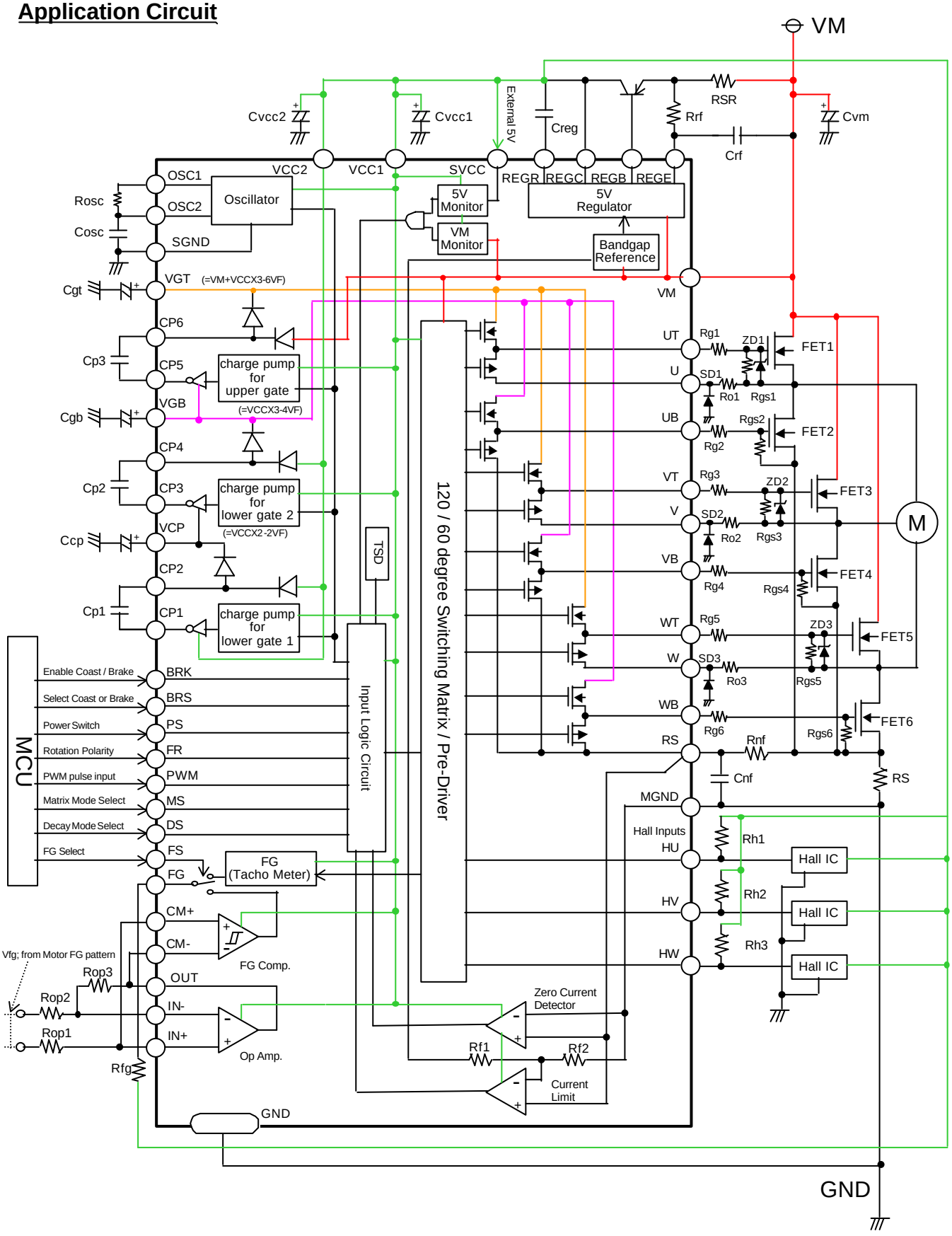
Application Circuit



Recommended Values of the External Parts

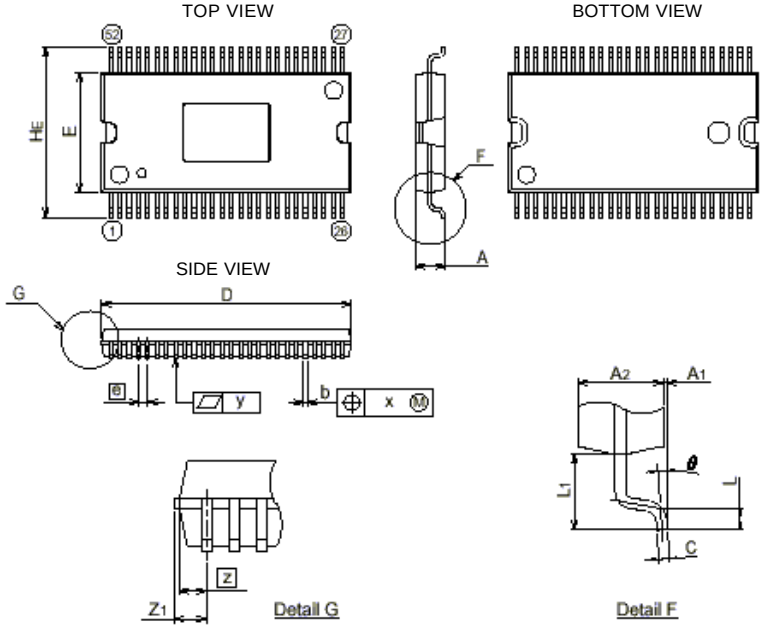
External Parts Name	Notes	Symbol	Value			Units
			Min.	Typ.	Max.	
Cvm	Bypass Condenser for VM	Cvm	TBD	33	TBD	uF
FET1~FET6	Nch Power MOS FET	Ciss	-	1200	-	pF
Rg1~Rg6	Gate Resistances of FETs	Rg	TBD	TBD	TBD	ohm
Ro1~Ro3	Output Resistances for Motor Coils	Ro	TBD	TBD	TBD	ohm
Rgs1~Rgs6	Gate-Source Resistances of FETs	Rgs	TBD	100	TBD	Kohm
SD1~SD3	Schottky Diode	VF	TBD	TBD	TBD	V
ZD1~ZD3	Zener Diode	Vak	TBD	TBD	TBD	V
RS	Motor Current Sensing Resister	RS	TBD	TBD	TBD	ohm
Rnf	RS terminal Filtering Resister	Rnf	TBD	100	TBD	ohm
Cnf	RS terminal Filtering Condenser	Cnf	TBD	1000	TBD	pF
Rh1~Rh3	Hall Input Pull-up Resister	Rh	TBD	TBD	TBD	ohm
Ccp, Cgb, Cgt	Bypass Condenser for Charge-pump Voltage	Ccp	TBD	4.7	TBD	uF
Cp1~3	Charge-pump Condenser	Cp	TBD	470	TBD	nF
Rosc	External Resistance for Oscillator	Rosc	TBD	7.2	TBD	Kohm
Cosc	External Condenser for Oscillator	Cosc	TBD	180	TBD	pF
PNP	External PNP Tr. for 5V Regulator	hfe	100	100	TBD	-
RSR	5V Regulator Current Sensing Resister	RSR	TBD	1.8	TBD	ohm
Creg	Phase Compensation Condenser for 5V Reg.	Creg	TBD	10	TBD	nF
Rrf	Filter Resistance for RSR	Rrf	TBD	1.5	TBD	Kohm
Crf	Filter Condenser for RSR	Crf	TBD	10	TBD	nF
Cvcc1	Bypass Condenser for VCC1	Cvcc1	TBD	10	TBD	uF
Cvcc2	Bypass Condenser for VCC2	Cvcc2	TBD	10	TBD	uF
Rop1~Rop3	Op. Amp. input gain resister	Rop	TBD	10	TBD	Kohm
Rfg	FG Output Pull-Up resister	Rfg	TBD	10	TBD	Kohm

* Note10 : This parameters are calculated values.

Package Outline

52P9Y-K (MMP) — Plastic 52pin 450mil HSSOP

EIAJ Package Code	JEDEC Code	Weight(g)	Lead Material
HSSOP52-P-450-0.65	–	–	Cu Alloy



Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	–	–	2.2
A_1	0	0.1	0.2
A_2	–	2.0	–
b	0.22	0.27	0.32
c	0.23	0.25	0.3
D	17.3	17.5	17.7
E	8.2	8.4	8.6
e	–	0.65	–
H_E	11.63	11.93	12.23
L	0.3	0.5	0.7
L_1	–	1.765	–
Z	–	0.625	–
Z_1	–	–	0.775
x	–	–	0.12
y	–	–	0.1
θ	0°	–	10°
b_2	–	0.5	–
e_1	–	11.43	–
l_2	1.27	–	–

TENTATIVE

Mitsubishi Motor Controller
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REV. 010403

Revision Record

Revision No.	Summary of Changes	Signature	Date
REV. 990308	First release.	T. Ishii	Mar. 8. '99
REV. 990723	Rnf terminal was changed from GND to Vm.	T. Ishii	Jul. 23. '99
REV. 990817	Rnf terminal was changed from Vm to GND. And, the spike cancellation circuit is designed instead of a filter circuit. Additional explanation: (1). Bootstrap function. (2). Current limit function. (3). PWM function.	T. Ishii	Aug. 17. '99
REV. 991007	1.Type No. was changed to M63155FP from M63XXXFP. 2.The following circuits and terminals were removed. (1) PWM control circuit and VCTL Input Amp. (2) Cfc, Rfc, VCTL terminals. And the PWM terminal was added. 3.The Vm's values of the Absolute Maximum Rating and Operating Condition were changed. Absolute Maximum Rating Vm Typ. : from 24V to Blank Operation Condition Vm(Typ.,Max.) : from 24V,45V to 40V,48V 4.The explanation of Rcf and Cfc terminal was removed. And the explanation of Current Limit Function was changed, because the PWM control circuit and VCTL Input Amp. were removed.	A. Ohmichi	Oct. 7. '99
REV. 991206	1.The Japanese explanation were added. 2.The package was determined to 36P2R-D. So the thermal derating graph of 36P2R was put in. 3.The pin configuration was determined. So the terminal description was added. 4.The following circuits, functions and terminals were added. (1) Internal FG circuit(tachometer), FG select circuit and Power Saving circuit and Hall Bias circuit. (2) FG selection, Power Saving, Reversible and Braking. (3) FGS, PS, F/R, BRK and HB terminals. And FGp, FGm, FGout, RNF are changed into IN+, IN- ,OUT, Rs. 5.The Block Diagram was changed to a small size without the external devices. 6.The source of the Hall commutation sensors are changed to Vm with the external NPN from Vreg in the Application Circuit. 7.The parameters in the Absolute Maximum Rating, the Operating Condition and the Electrical Characteristics were determined in details. 8.Some Function Explanations were added. And some sentences of the Function Explanation were changed. 9.In the Hall signal inputs and motor outputs timing chart, notes and waveforms were changed(ex. the PWM waveform). 10.The figure of the I/O circuits and the Application circuits ,and the table of an example value of the external parts were added.	A. Ohmichi	Dec. 6. '99

Revision No.	Summary of Changes	Signature	Date
REV. 000711	1.The Japanese explanations were removed. 2.The pin configuration was changed. Therefore the block diagram and the terminal description and the application circuit were changed. The Cshort terminal was removed. 3.The output voltage of the regulators were changed. And the VR terminal was added. 4.The oscillator was changed to be with an external capacitor and a resistor. And the OSC1 and OSC2 terminals were added. 4.Some definitions of the absolute maximum rating, the operating condition and the electrical charcteristics were changed. 5.The motor rotation direction was added to the function explanation.	A. Ohmichi	Jun. 11. '00
REV. 001001	1. The using S/W was changed to ppt. from idj.. 2. The package was changed to 52P9Y from 36P2R. 3. The pin configuration was changed. Therefore the block diagram and the terminal description and the application circuit were changed. 4. The detail change contents refers to the conversation result with customer (Quantum).	T. Yashita	Oct. 01. '00
REV. 001013	1. The Vm maximum voltage rating was changed from 40V to 50V	T. Yashita	Oct. 13. '00
REV. 001028	1. The Hall input form was changed from a differential input to an open-collector one. 2. The Hall input terminals name was changed from HU+, HU-, HV+, HV-, HW+, HW- to HU, HV, HW. Only three terminals is used in new form. 3. Pin configuration was changed. 13~15 and 17~26. 4. The HB terminal was removed and the TH terminal is added. 5. According to above mentioned, all of the related descriptions was changed.	T. Yashita	Oct. 28. '00
REV. 010201	1. The 5V regulator changed to the external PNP type from internal type. 2. Thermal monitor function was removed. 3. VCC(5V) was divided to VCC1 and VCC2. VCC1 is small signal 5V supply and VCC2 is big signal one. 4. The Zero current detect circuit was added. 5. According to the above mentioned revision, the pin configuration was changed. 17~41 pin. 6. According to the above mentioned revision, the Block Diagram, the Absolute Maximum rating, the Electrical characteristics, the Function explanation, the I/O circuit, the Application circuit and the Recommended values of the external parts were changed. 7. At the Hall inputs and Motor output timing chart, Motor output voltage waves in PWM was revised to up-side switching PMW method from bottom-side one. 8. Motor Input /Output Truth Table was added.	T. Yashita	Feb. 01. '01

Revision No.	Summary of Changes	Signature	Date
REV. 010403	1. (6/28) "PNP Tr. Bias Current" spec. was removed. 2. (27/28) "Recommended Values of the External Parts" typ. value was added.	T. Yashita	Apr. 03. '01
	3.		