お客様各位

カタログ等資料中の旧社名の扱いについて

2010年4月1日を以ってNECエレクトロニクス株式会社及び株式会社ルネサステクノロジが合併し、両社の全ての事業が当社に承継されております。従いまして、本資料中には旧社名での表記が残っておりますが、当社の資料として有効ですので、ご理解の程宜しくお願い申し上げます。

ルネサスエレクトロニクス ホームページ（http://www.renesas.com）

2010年4月1日
ルネサスエレクトロニクス株式会社

【発行】ルネサスエレクトロニクス株式会社（http://www.renesas.com）

【問い合わせ先】http://japan.renesas.com/inquiry

RENESAS

お客様各位

資料中の「三菱電機」、「三菱XX」等名称の株式会社ルネサス テクノロジへの変更について

2003年4月1日を以って株式会社日立製作所及び三菱電機株式会社のマイコン、ロジック、アナログ、ディスクリート半導体、及びDRAMを除くメモリ(フラッシュメモリ・SRAM等)を含む半導体事業は株式会社ルネサス テクノロジに承継されました。
従いまして、本資料中には「三菱電機」、「三菱電機株式会社」、「三菱半導体」、「三菱XX」といった表記が残っておりますが、これらの表記は全て「株式会社ルネサス テクノロジ」に変更されておりますのでご理解の程お願い致します。尚、会社商標・ロゴ・コーポレートステートメント以外の内容については一切変更しておりませんので資料としての内容更新ではありません。

注:「高周波・光素子事業、パワーデバイス事業については三菱電機にて引き続き事業運営を行います。」

2003年4月1日
株式会社ルネサス テクノロジ
カスタマサポート部

RENESAS

TENTATIVE

REV. 020414

Mitsubishi Motor Controller
M63155FP
3 PHASE BRUSHLESS MOTOR CONTROLLER

Outline

The M63155FP is a three phase brushless motor controller with six external N-channel Power MOSFETs. The motor coil current is controlled by either a PWM pulse duty or a D/A signal level from an external controller.

Both VCC1 and VCC2 can be supplied by either external power supply or internal 5V regulator. Also voltage monitor is available, and whichever of power supplies drops down, it generates an error signal.

Either fast or slow current-decay, either coast(free-run) or dynamic brake(short-brake) can be selected.

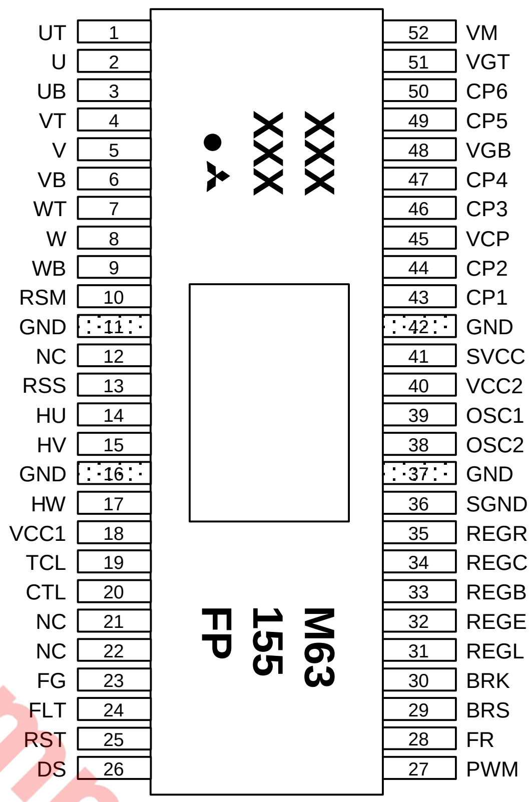
Several protection circuits are built in, thermal shut down and so on.

Internal tachometer, direction control and oscillator for internal logic are also available.

Features

- Wide voltage range: From 10V to 40V (VM)
- 5V regulator with the external PNP transistor
- Internal gate supply voltage generator (Charge pump)
- Voltage monitor (VM & SVCC)
- Motor current control by either a PWM duty or a D/A level
- Selectable fast or slow current-decay
- Selectable coast (free-run) or dynamic brake (short-brake)
- FG internal tachometer (3phase mixed)
- Direction control
- Thermal Shut Down (TSD)

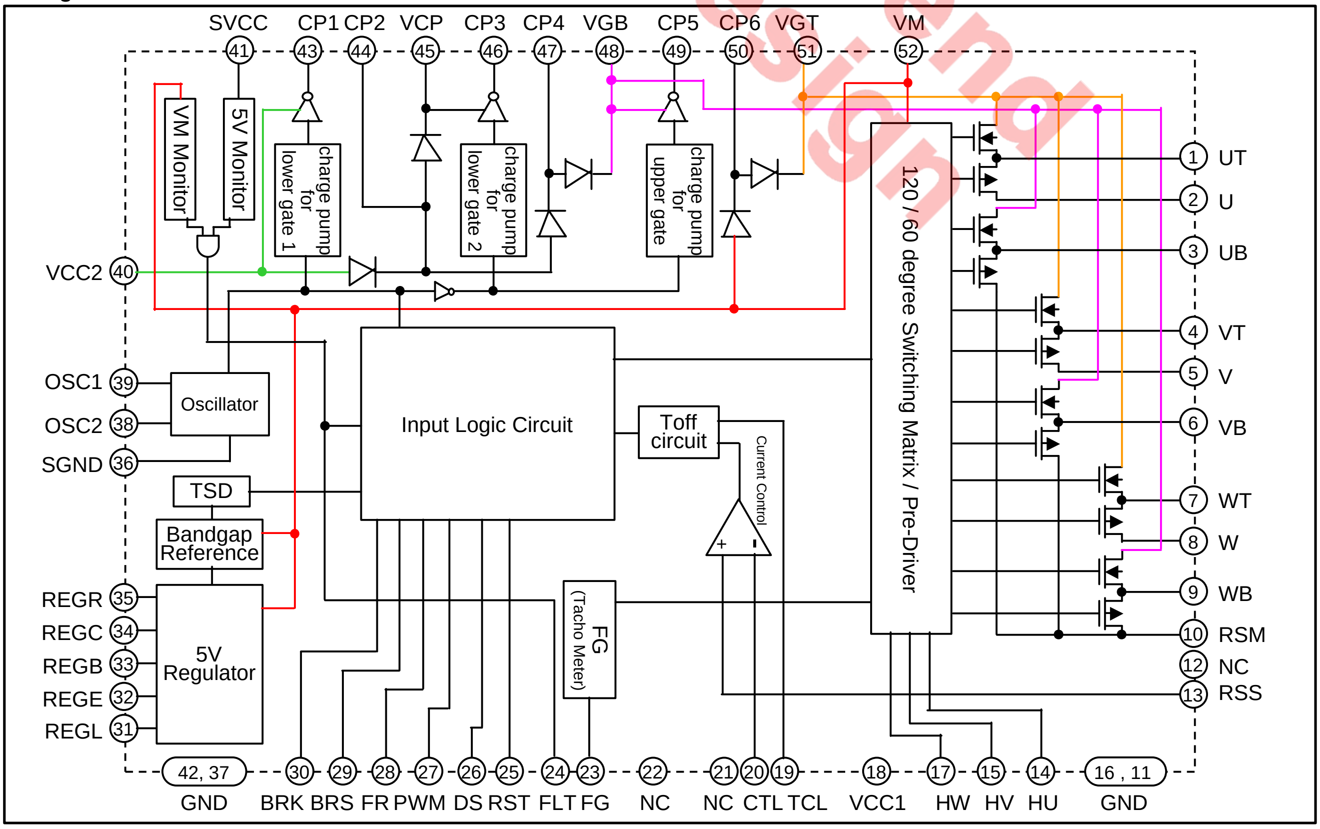
Pin Configuration (TOP VIEW)



52pin HSSOP (52P9Y)

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	RSM	Motor Current Sensing Input for big signal line	43	CP1	Charge-pump Capacitor 1
11	-	NC	42	GND	GND
12	-	NC	41	SVCC	External 5V Sensing Input
13	RSS	Motor Current Sensing Input for small signal line	40	VCC2	Big Signal 5V Power Supply
14	HU	HU Hall Sensor Amp. Input	39	OSC1	Oscillator Output 1
15	HV	HV Hall Sensor Amp. Input	38	OSC2	Oscillator Output 2
16	GND	GND	37	GND	GND
17	HW	HW Hall Sensor Amp. Input	36	SGND	Oscillator GND
18	VCC1	Small Signal 5V Power Supply	35	REGR	5V Regulator Phase Compensation
19	TCL	Current Control Off Time Input	34	REGC	5V Regulator Output
20	CTL	Current Control Input	33	REGB	5V Regulator Current Sink
21	-	NC	32	REGE	5V Regulator Current Sensing
22	-	NC	31	REGL	5V Regulator Phase Compensation
23	FG	FG Output	30	BRK	Braking Input
24	FLT	Voltage Monitor Fault Output	29	BRS	Braking Mode Select Input
25	RST	Reset Input	28	FR	Forward / Reverse Select Input
26	DS	Fast / Slow Current Decay Mode Select Input	27	PWM	PWM Input

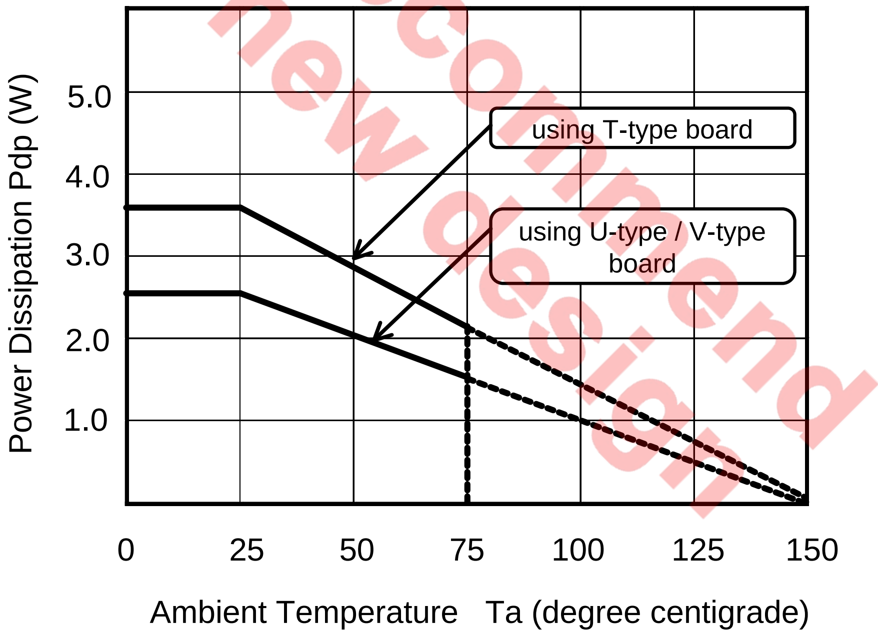
Absolute Maximum Rating (unless otherwise noted Ta=25 degrees centigrade)

Symbol	Parameter	Conditions	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 including motor coil over shoot	-	-	50	V
Vbo	Bottom Side Gate Drive Output Voltage	at UB, VB, WB	-	12.2	-	V
Vin	Logic Input Voltage	at BRK, BRS, FR, PWM, DS, RST, HU, HV, HW	-	-	6	V
Vdo	Open Drain Output Voltage	at FG, FLT, TCL	-	-	6	V
Ido	Open Drain Output Current	at FG, FLT, TCL	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	Conditions	Limits			Units
			Min.	Typ.	Max.	
Vm	Motor Power Supply	at VM	10	32	40	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

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

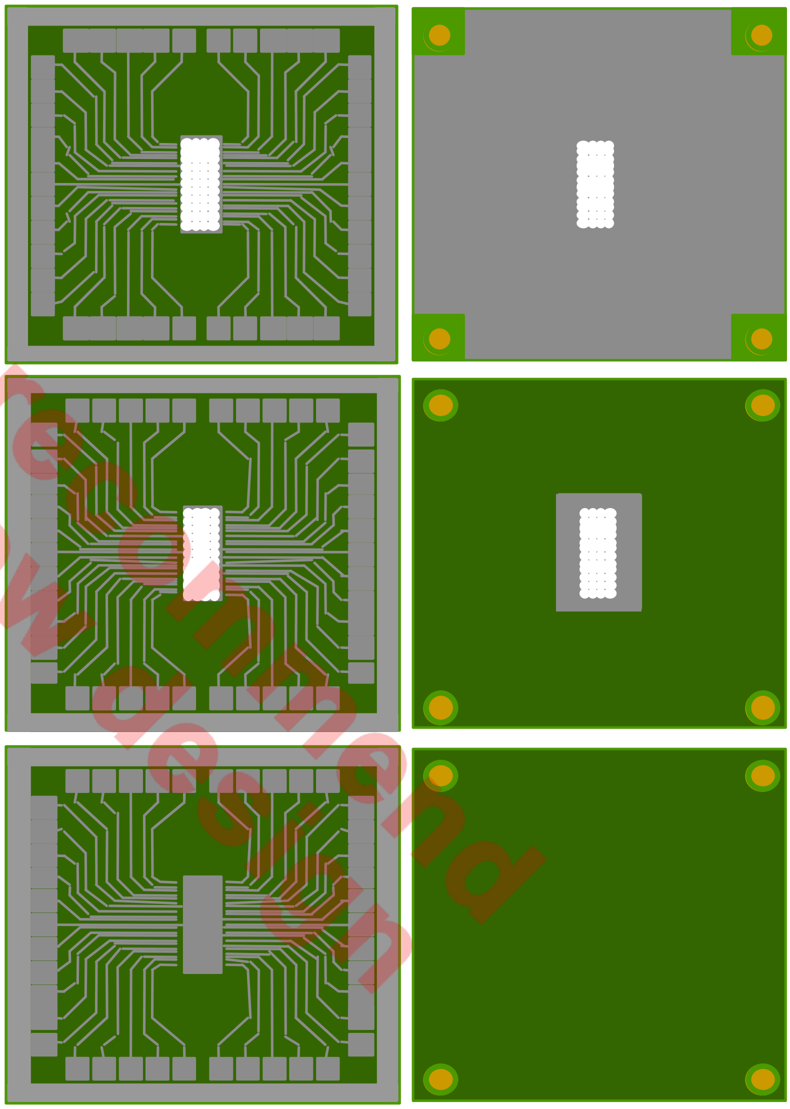
- Board material ;
  Glass-epoxy FR-4
- Size ; 70 X 70 mm^2
- Board thickness ; 1.6 mm
- 1 and 2 layers
- Metal material ; copper
- Metal thickness ; 18 um

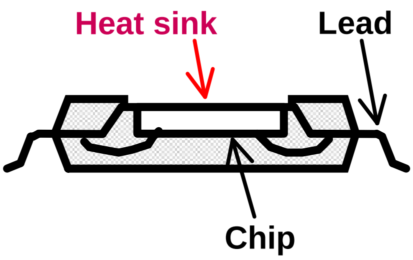
1st layer [TOP view] | 2nd layer [BACK view]

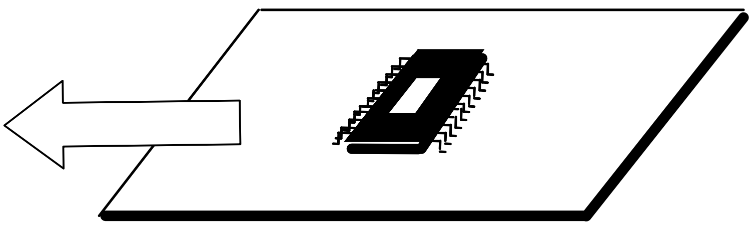
T-type
[2 layer]

U-type
[2 layer]

V-type
[1 layer]







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)						
Im	Motor Power Supply Current	at VM Normal Control Mode The motor is not driven	-	2.3	5.0	mA
Ivcc	5V Power Supply Current	at VCC1, VCC2 Normal Control Mode The motor is not driven	-	20	40	mA
Vcp	Charge-pump Output Voltage	at VCP, no gate driving	7.0	8.5	10.0	V
Vgb	Bottom-side Gate Supply Voltage	at VGB, ILVGB=ILVGT=7.0mA	8.5	11.5	-	V
Vgt	Top-side Gate Supply Voltage	at VGT, ILVGB=ILVGT=7.0mA	VM +7.5	VM +9.5	-	V
Tcp	Charge-pump (VCP) Pre-charge Time	fosc=1MHz, Cp1=470nF, Ccp=4.7uF *Refer to the Fig.1.	-	4.0	30.0	msec
Tgb	Charge-pump (VGB) Pre-charge Time	fosc=1MHz, Cp2=470nF, Cgb=4.7uF * Refer to the Fig.1.	-	4.0	30.0	msec
Tgt	Charge-pump (VGT) Pre-charge Time	fosc=1MHz, Cp3=470nF, Cgt=4.7uF * Refer to the Fig.1.	-	4.0	30.0	msec
Fosc	Oscillator Frequency	Rosc=3.0Kohm, Cosc=180pF	0.8	1.0	1.2	MHz

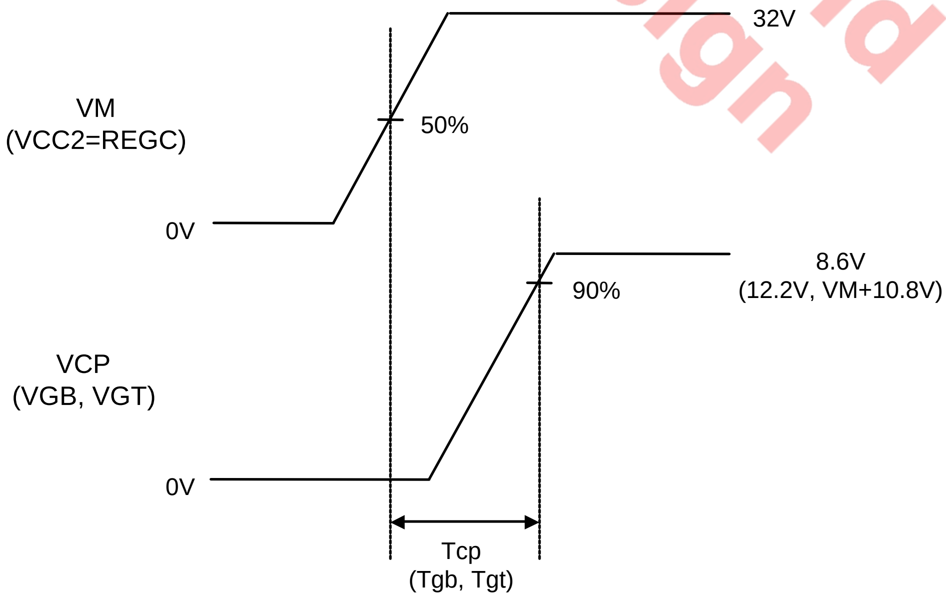


Fig.1 Charge-pump Pre-charge Time Definition

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

Symbol	Parameter	Conditions	Limits			Units
			Min.	Typ.	Max.	
REGULATOR (REGE, REGB, REGC, REGR)						
Vr	Regulator Output Voltage	Io=50mA *Note1	4.75	5.0	5.25	V
Vrin	Regulator Output Voltage Stability for Input Vm Voltage	Vm=10~40V, Io=50mA *Note1	-	0.0	30.0	mV
Vrout	Regulator Output Voltage Stability for Load Current	Io=0~200mA *Note1	-	0.0	30.0	mV
Vlim	RS Threshold Voltage	REGE terminal voltage *Note1	0.8	1.0	1.2	V
VOLTAGE MONITOR (VM, SVCC, FLT)						
Vsvi	External 5V Monitor Input Voltage Range	at SVCC	0	-	5.5	V
Isvi	External 5V Monitor Input Current	at SVCC SVCC=5V	30	50	75	uA
Vths	External 5V Monitor Threshold Voltage	External 5V Drop Down *Refer to the Fig.2.	3.95	4.25	4.55	V
Vshy	External 5V Monitor Hysteresis Voltage	External 5V Rise up *Refer to the Fig.2.	50	100	150	mV
Vthm	VM Monitor Threshold Voltage	VM Drop Down *Refer to the Fig.2.	9.0	9.5	10.0	V
Vmhy	VM Monitor Hysteresis Voltage	VM Rise Up *Refer to the Fig.2.	400	500	600	mV
Vsft	FLT Output Saturation Voltage	at FLT, output sink current: 2mA	-	0.15	0.5	V

* Note1 : 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.

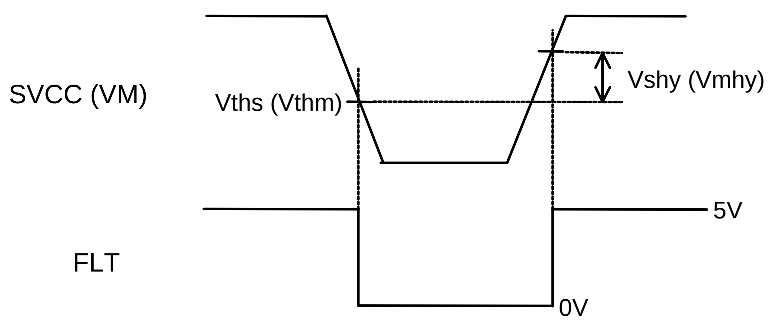


Fig.2 Supply Voltage Monitor Time Definition

Electrical characteristics

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

Symbol	Parameter	Conditions	Limits			Units
			Min.	Typ.	Max.	
CURRENT CONTROL (RSS, REF, CTL, TCL)						
Vcti	Current Control Input Voltage Range	at CTL	0	-	3.3	V
Icti	Current Control Input Current	at CTL, CTL=RSS=0V	-2.0	-0.4	-	uA
Vtcl	Current Control Off Time Threshold Voltage	at TCL	2.4	2.5	2.6	V
Vtclhy	Current Control Off Time Hysteresis Voltage	at TCL	1.2	1.25	1.3	V
Vstl	Off Time Input Saturation Voltage	at TCL, output sink current: 2mA RSS>CTL	-	0.15	0.5	V
LOGIC INPUT (PWM, DS, FR, BRS, BRK)						
Vlgh	Logic High-State Input Voltage		2.0	-	-	V
Vlgl	Logic Low-State Input Voltage		-	-	1.0	V
Ilgh	Logic High-State Input Current	Vlg= 5V	-	100	150	uA
Ilgl	Logic Low-State	Vlg= 0V	-1.0	0	-	uA
HALL SIGNAL (HU, HV, HW, FG)						
Vhah	Hall High-State Input Voltage		2.0	-	-	V
Vhal	Hall Low-State Input Voltage		-	-	1.0	V
Ihah	Hall High-State Input Current	Vha= 5V	-	0	1.0	uA
Ihal	Hall Low-State Input Current	Vha = 0V	-1.0	0	-	uA
Vsfg	FG Output Saturation Voltage	at FG, output sink current : 2mA	-	0.15	0.5	V

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

Symbol	Parameter	Conditions	Limits			Units
			Min.	Typ.	Max.	
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 = -10 mA , Rg=0ohm	-	0.7	1.2	V
Vtol	Top Side Gate Drive Low State Voltage	Vtol=UT-U, VT-V, WT-W Iload = 10 mA , Rg=0ohm	-	0.25	0.40	V
Vboh	Bottom Side Gate Drive High State Voltage	Vboh=VGB-UB, VGB-VB, VGB-WB Iload = -10 mA , Rg=0ohm	-	0.7	1.2	V
Vbol	Bottom Side Gate Drive Low State Voltage	Vbol=UB-RS, VB-RS, WB-RS Iload = 10 mA , Rg=0ohm	-	0.25	0.40	V
Ton	Turn-on Delay	*Refer to the Fig.3.	-	150	-	nsec
Toff	Turn-off Delay	*Refer to the Fig.3.	-	100	-	nsec
Ttr	Top Side Switching Rise Time	CL =1200pF, Rg=0 ohm *Refer to the Fig.3.	-	200	-	nsec
Ttf	Top Side Switching Fall Time		-	80	-	nsec
Tbr	Bottom Side Switching Rise Time	CL=1200pF, Rg=0 ohm *Refer to the Fig.3.	-	200	-	nsec
Tbf	Bottom Side Switching Fall Time		-	80	-	nsec

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

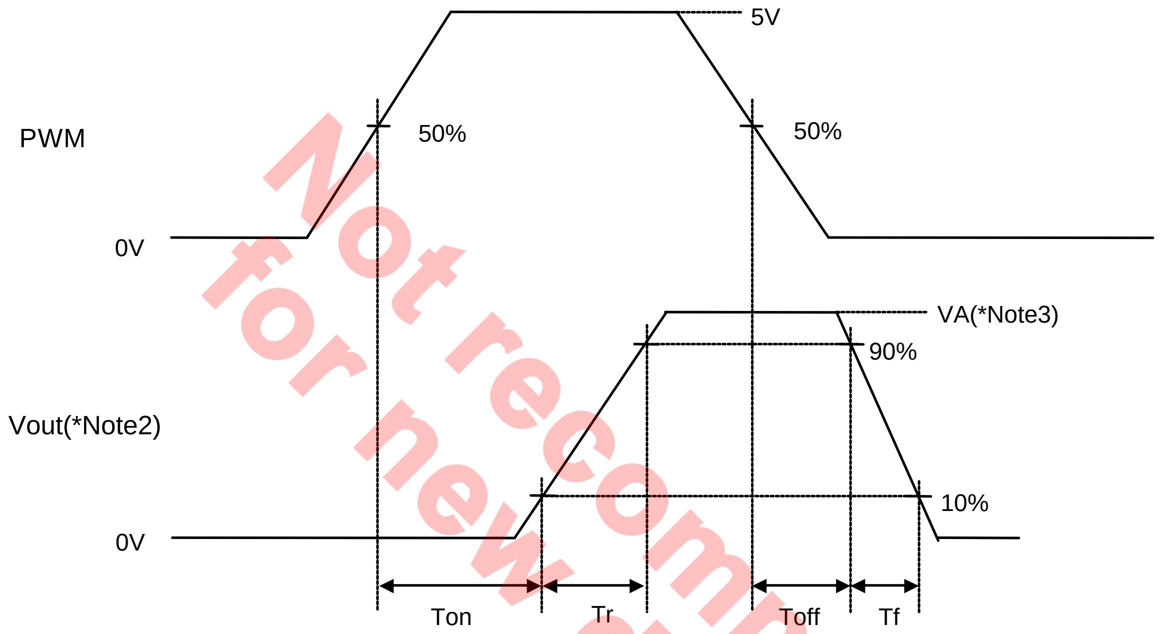


Fig.3 Gate Drive Output Time Characteristics Definition

* Note2 : 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.
* Note3 : 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.
* Note4 : 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 (VM)

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. 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.

4. 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.

5. 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. The oscillation frequency theoretical value is given by:

$$(Fosc) = \frac{1}{-2 \times Rosc \times Cosc \times ln(1/2)}$$

Rosc : External resistance for oscillator
Cosc : External condenser for oscillator

However, the actual oscillation frequency is different by influence of response of the oscillator circuit.
The characteristic of the theoretical oscillation Frequency – the actual oscillation frequency is as follows (Fig.4).

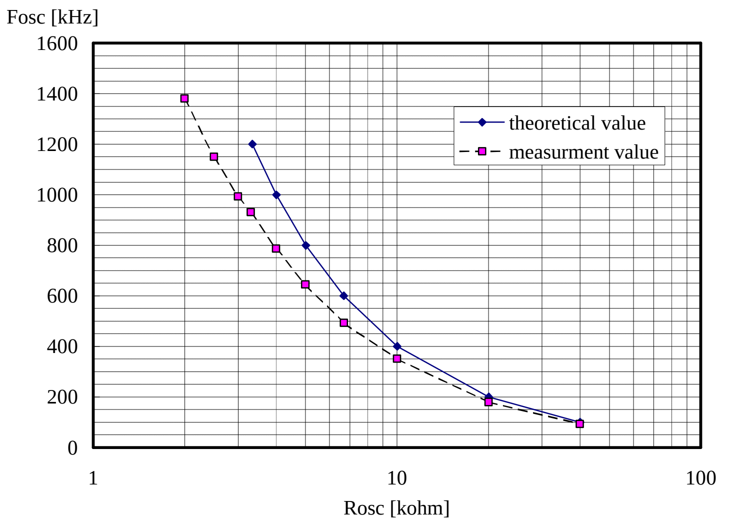


Fig.4 The characteristic of oscillation frequency (Cosc=180pF)

Function Explanation

6. 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.5).
And the characteristic of the PWM Input Frequency – the VGB(VGT) is as follows (Fig.6).

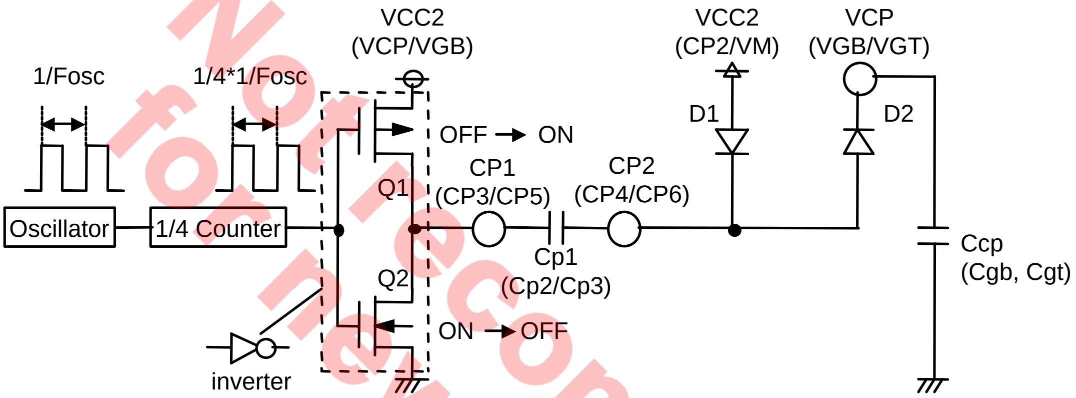


Fig.5 Charge Pump Circuit

(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 diodesD1, 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 = (CP2 - VF) + VCP - VF
= CP2+VCP-2VF
VGT = (VM - VF) + VGB - VF
= VM+VGB-2VF

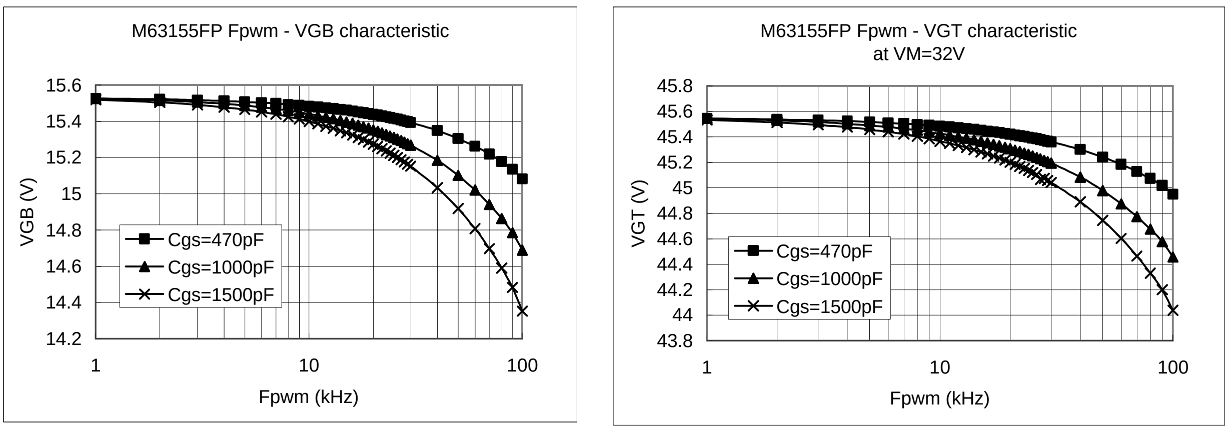


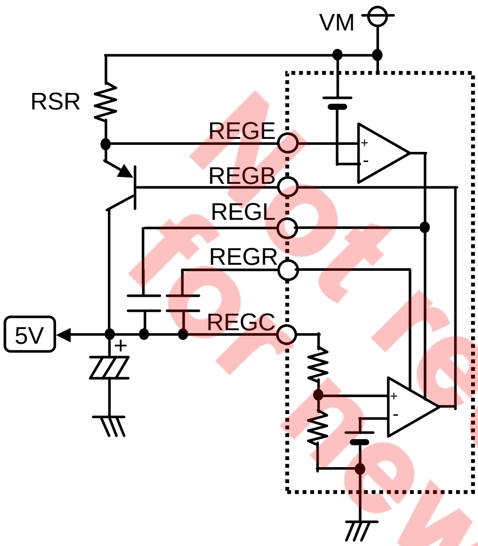
Fig.6 PWM Input Frequency (Fpwm) – VGB(VGT) characteristic

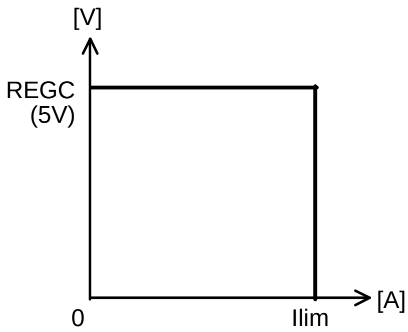
In case of VCC1=VCC2=5V, VM=32V, RST=PWM=FR=BRK=HV=5V,
DS=BRS=HU=HW=0V,Cp1~3=470nF,Ccp=Cgb=Cgt=4.7uF,Fosc=1MHz

Function Explanation

7. 5V Regulator (REGE, REGB, REGC, REGR, REGL)

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 .
The explanation of the 5V Regulator function is as follows (Fig.7).





The limit current value is given by:

$$(\text{Limit Current}) = \frac{\text{Vlim}}{\text{RSR}}$$

Vlim : 5V Regulator Rs threshold voltage (typ; 1.0V)
RSR : 5V Regulator current sensing resistor value

Fig. 7 5V Regulator application circuit and characteristics

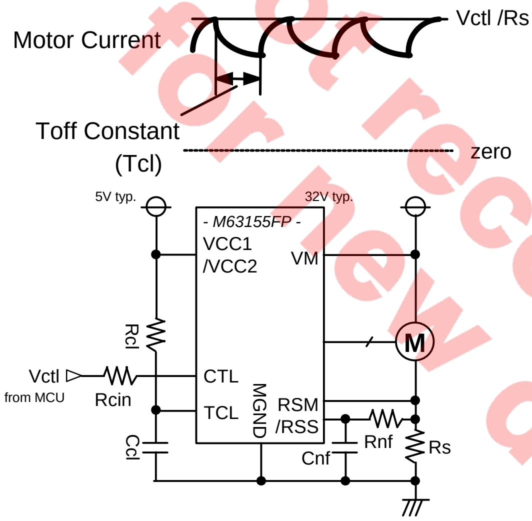
Function Explanation

8. Current Control (RSS, MGND, CTL, TCL)

The RSS is the sensing input of the motor current. A sensing resistor should be connected between this terminal and the MGND terminal. The current control circuit compares the voltage of the sensing resistor with the CTL terminal input voltage. When the motor current reaches the threshold voltage (the CTL terminal input voltage), the current control circuit shuts down the motor current with turning off the external FETs while the constant period determined by the external elements on the TCL terminal. This function acts independent of the PWM input signal.

If the motor current is controlled by the only PWM input signal, this current control circuit acts as a motor current limit protection circuit. In this case, the motor current limit value could be determined by the CTL input voltage.

(1) Current control function



The motor current is controlled by the CTL input voltage. When the motor current reaches the threshold voltage, the motor current is shut down while the constant period. The period of the motor shutting down is given by:

$$(\text{Off Time}) = -\text{Rcl}\times\text{Ccl}\times ln\left(\frac{\text{VCC1}-\text{Vtcl}}{\text{VCC1}}\right)$$

Rcl : Current control Off Time Resistance
Ccl : Current control Off Time Condenser
Vtcl : Current control Off Time Threshold Voltage (typ; 2.5V)

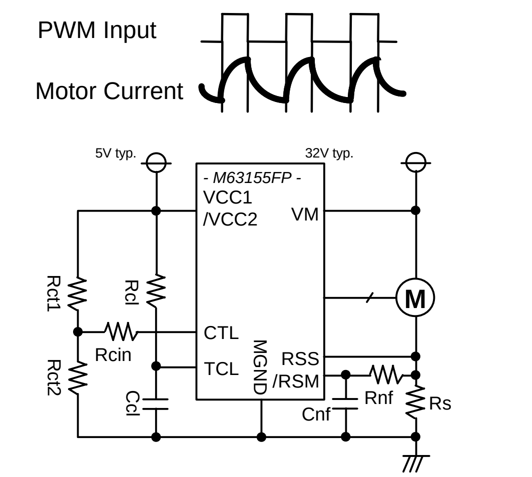
The motor control current value is given by:

$$(\text{Control Current}) = \frac{\text{Vctl}}{\text{Rs}}$$

Vctl : CTL terminal input voltage (from MCU)
Rs : Motor current sensing resistor value

The CTL input resistor(Rcin) sets the same value of the limit sensing low pass filter resistor(Rnf) to compensate the input impedance of current comparator.

(2) Current limit function



The Current control circuit could be acted as the current limit protection circuit. In this case, the motor current is controlled by the PWM input duty.

The value of the motor current limit is given by:

$$(\text{Limit Current}) = \text{Vref}\times\frac{\text{Rct2}}{\text{Rct1}+\text{Rct2}}\times\frac{1}{\text{Rs}}$$

Vref : output voltage (ex.; VCC1=5V)
Rct1, Rct2 : VCC1 into CTL dividing resistor value
Rs : Motor current sensing resistor value

When the motor current reaches the limit current value, the motor current is shut down while the constant period like as above mentioned in "(1) Current control function".

The CTL input resistor(Rcin) sets the below equation value to compensate the input impedance of current comparator.

$$\text{Rcin} + (\text{Rct1}//\text{Rct2}) = \text{Rnf}$$

Rct1, Rct2 : VCC1 into CTL dividing resistor value
Rnf : Limit sensing low pass filter resistor value

Fig. 8 Motor Current Control Function

Function Explanation

9. Current Decay Method (DS)

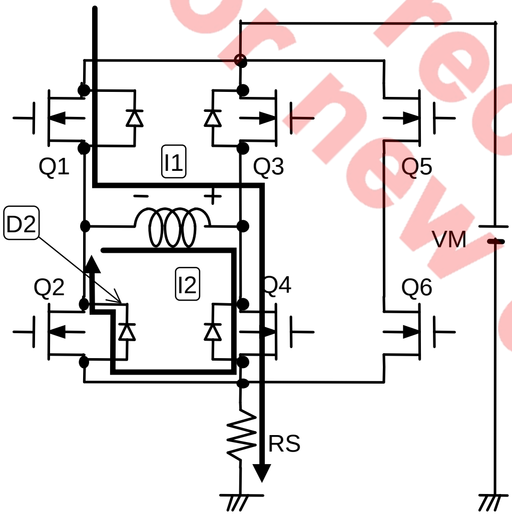
The current decay method is determined by the input into the DS terminal. In slow-decay mode, only the high side MOS FET is switched open during a PWM OFF (Low) cycle. The fast-decay mode switches both the high and low side MOS FETs.

Table 1. gives the DS selection truth table.

TABLE 1. DS Selection Truth Table

DS	Function Mode
High	Slow-Decay
Low	Fast-Decay

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



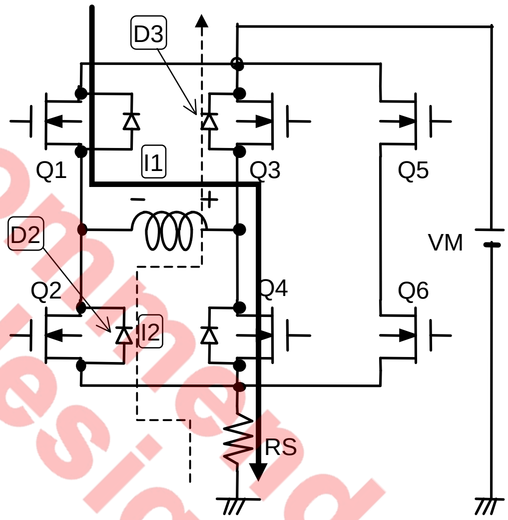
(1)Condition: Q1 is ON and Q4 is ON.
(PWM ON period)
The motor current I1 goes to RS through the transistors Q1 and Q4.

(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: Q4 is ON and Q2, Q1 are OFF.
(PWM OFF period)
The discharge current I2 keeps going through the diode D2. Q2 keeps being OFF.

(4)Condition: Q4 is ON and Q2, Q1 are OFF.
(PWM OFF -> ON switching period)
Likewise state (3), the discharge current I2 keeps going through the diode D2. Q2 keeps being OFF.

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: Q1, Q4, Q2 and Q3 are OFF.
(PWM OFF period)
The discharge current I2 keeps going through the diode D2 and D3.

(4)Condition: Q1, Q4, Q2 and Q3 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. 9 Current Decay Method at the MOS FETs Control with PWM Signal

Function Explanation

10. 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 brake (short-brake) is selected by the BRS terminal (cf. 12. Brake Mode Selection -1)).

Table 2. gives the BRK selection truth table.

TABLE 2. BRK Selection Truth Table

BRK	Function Mode
High	Normal Control Mode
Low	Brake Mode

11. Voltage Monitor (VM, SVCC, FLT)

If either the motor power supply (VM) or the 5V (SVCC) or both drops below the threshold, FLT is “Low”. At this time, the BRS state (cf. 12. Braking Mode Selection) is latched by this FLT “L” signal and keeps its state.
Then, the return of the FLT is decided by conditions of the Voltage Monitor comparator output and
Reset input (RST).

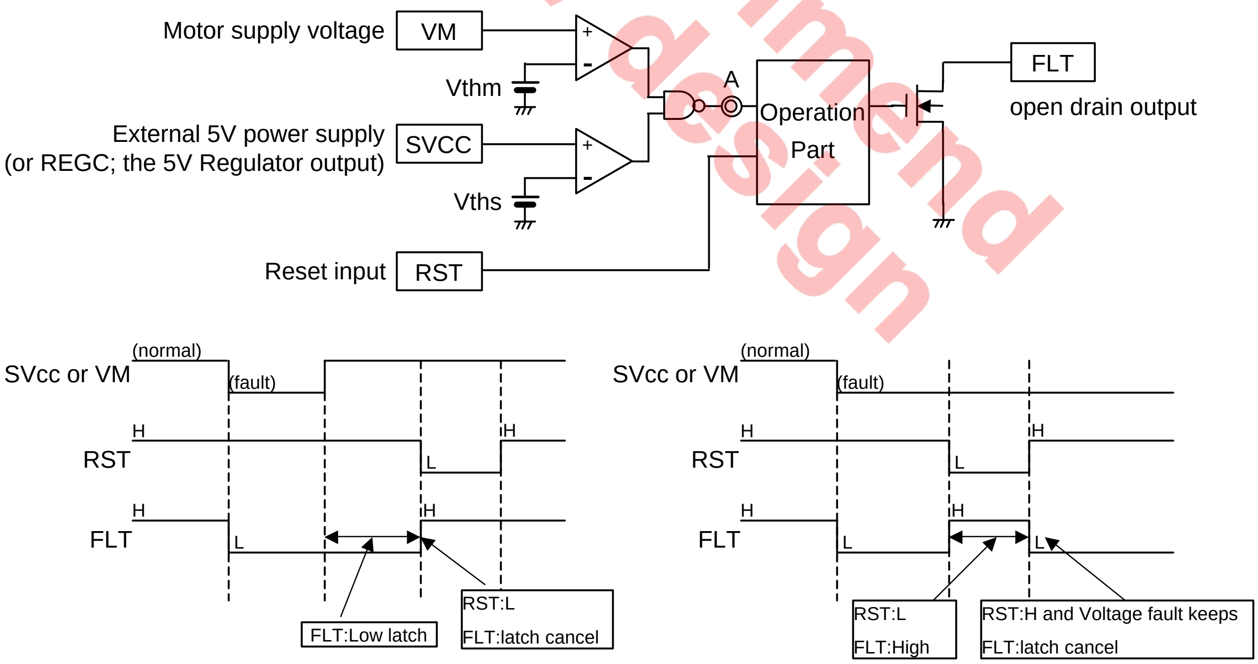


Fig.10 Voltage Monitor Circuit & Timing Chart

Function Explanation

12. Braking Mode Selection (BRS)

1) In the normal mode (FLT output is “H”)

The braking mode whether coast (free-run) or brake (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, all of the top side MOS FETs are turned off and all of the bottom side MOS FETs are turned on. This Braking Mode provides a braking torque which depends on the motor speed.

2) In the fault mode (FLT output is “L”)

In this case, the braking mode whether coast or brake is selected by the PWM signal irrelevant to the BRK signal and the Current Control (RSS, CTL, TCL) function. The BRS state is latched by the FLT “L” signal. In the BRS “L” state the coast mode is selected, while in the BRS “H” state the PWM signal determines the brake mode.

And at this time, 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 3. gives the BRS selection truth table.

TABLE 3. BRS Selection Truth Table

BRS	normal mode (FLT;H)		fault mode (FLT;L)	
	BRK; H	BRK; L	PWM; H	PWM; L
High	Normal	Brake	Brake	Coast
Low	Normal	Coast	Coast	

13. Reset input (RST)

This input used to enable the device. The “High” input allows the gate drive output to follow “Motor I/O truth table”. The “Low” input forces all gate drive output to 0V, coast(free-run) mode, and overrides the BRK state. And this “L” input also resets the BRS state latched by the FLT “L” signal.

Table 4. gives the RST selection truth table.

TABLE 4. RST Selection Truth Table

RST	Function Mode
High	Enable the device
Low	Disable the device (Reset the BRS and FLT state)

Function Explanation

14. 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 5. gives the FR selection truth table.

TABLE 5. 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.

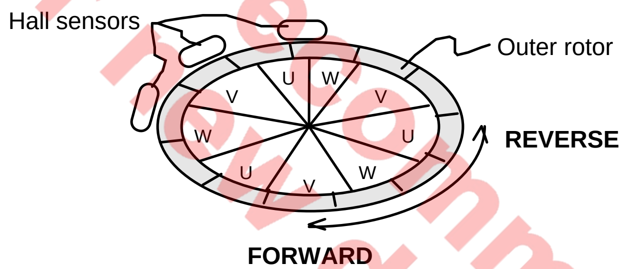


Fig. 11 Motor Rotation Direction

15. Motor Rotation Speed Signal (FG)

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. The relationship between the motor rotation speed and FG output signal frequency is given by;

$$(\text{Motor speed [rpm]}) = f_{FG} \times 60 \times \frac{1}{Np \times 2 \times 3}$$

f_{FG} : FG output signal frequency [Hz]
Np : Motor pole number

Function Explanation

16. PWM Input (PWM)

In the normal mode (FLT is "H"), 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. On the other side, in the case of the FLT "L" state and the BRS "H" state, the PWM signal determines the brake mode. (cf. 11. Voltage Monitor (VM, SVCC, FLT)).

Table 6. gives the PWM selection truth table.

TABLE 6. PWM Selection Truth Table

PWM	Function Mode
High	Normal circulate current
Low	Recirculate current

17. 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 Motor Pre-drive circuit. Once the TSD circuit start the shut down function, it continues to the TSD function stop temperature.

The Table 7. gives the TSD function start / stop temperatures.

TABLE 7. Thermal Shut Down Truth Table

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

* Note5: These TSD temperature are the target temperatures for circuit design, not the guaranteed value.

Motor Input/Output Truth Table

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

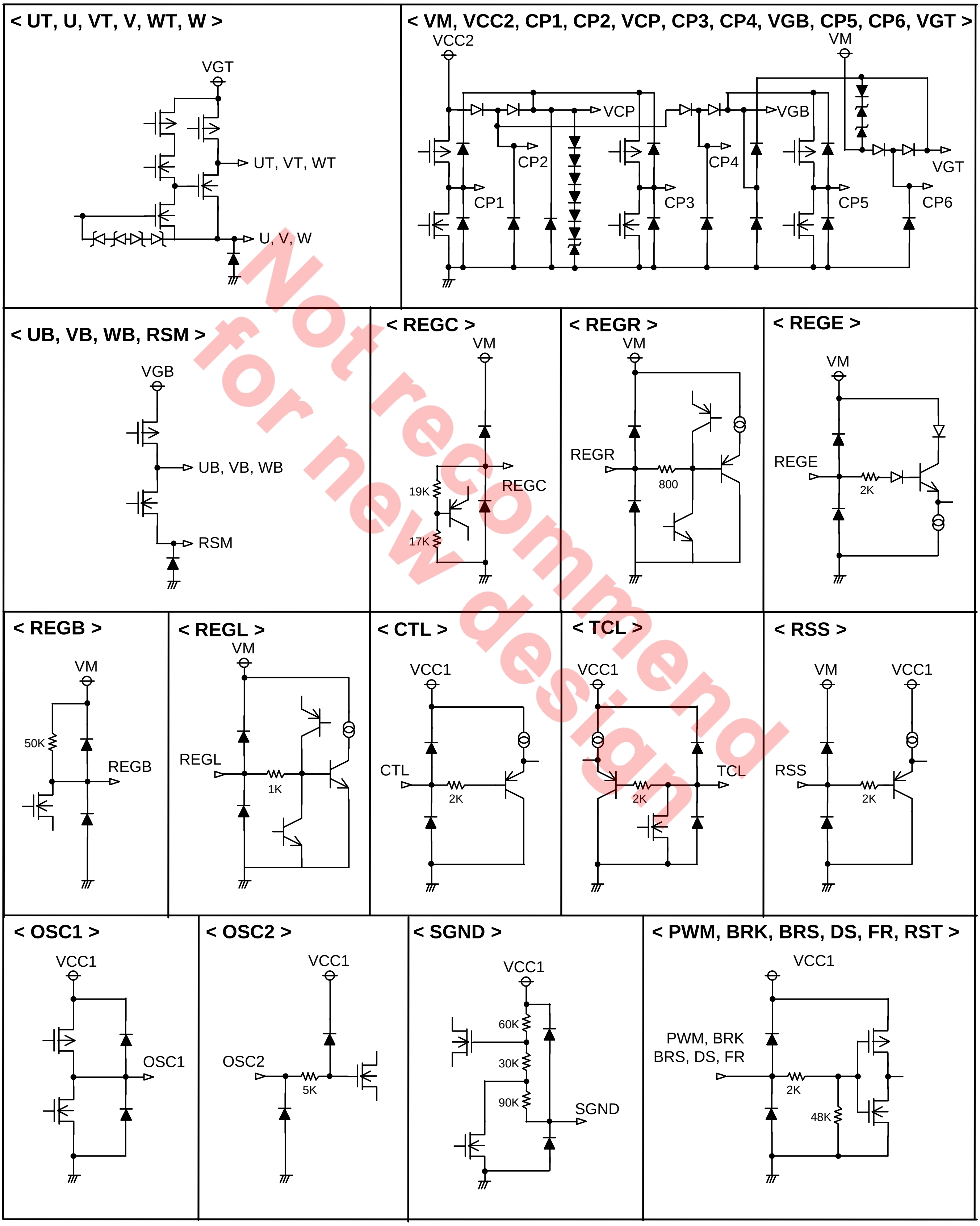
Motor Input/Output Truth Table

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

Motor Input/Output Truth Table

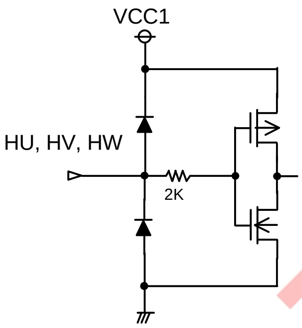
No.	Input								Output							Condition
	DS	FR	BRK	BRS	PWM	HU	HV	HW	UT	UB	VT	VB	WT	WB	FG	
129	L	H	L	L	H	H	H	H	L	L	L	L	L	L	H	
130	L	H	L	L	L	H	H	H	L	L	L	L	L	L	H	
131	L	H	L	L	H	H	L	H	L	L	L	L	L	L	L	Regular mode *Rotate Direction ; Forward *Current Decay MODE ; Fast Decay *Free-Run-state
132	L	H	L	L	L	H	L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

I/O Circuit

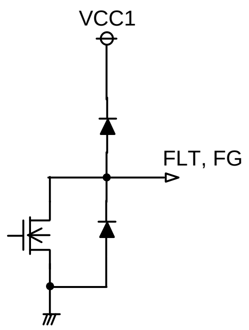

< UT, U, VT, V, WT, W >
VGT
UT, VT, WT
U, V, W
< VM, VCC2, CP1, CP2, VCP, CP3, CP4, VGB, CP5, CP6, VGT >
VCC2
VM
VCP
VGB
CP2
CP4
VGT
CP1
CP3
CP5
CP6
< UB, VB, WB, RSM >
VGB
UB, VB, WB
RSM
< REGC >
VM
19K
REGC
17K
< REGR >
VM
REGR
800
< REGE >
VM
REGE
2K
< REGB >
VM
50K
REGB
< REGL >
VM
REGL
1K
< CTL >
VCC1
CTL
2K
< TCL >
VCC1
TCL
2K
< RSS >
VM
VCC1
RSS
2K
< OSC1 >
VCC1
OSC1
< OSC2 >
VCC1
OSC2
5K
< SGND >
VCC1
60K
30K
90K
SGND
< PWM, BRK, BRS, DS, FR, RST >
VCC1
PWM, BRK
BRS, DS, FR
2K
48K

I/O Circuit

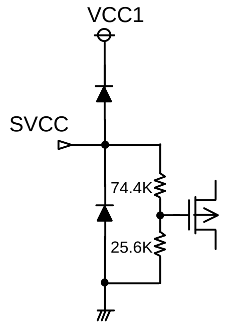
< HU, HV, HW >



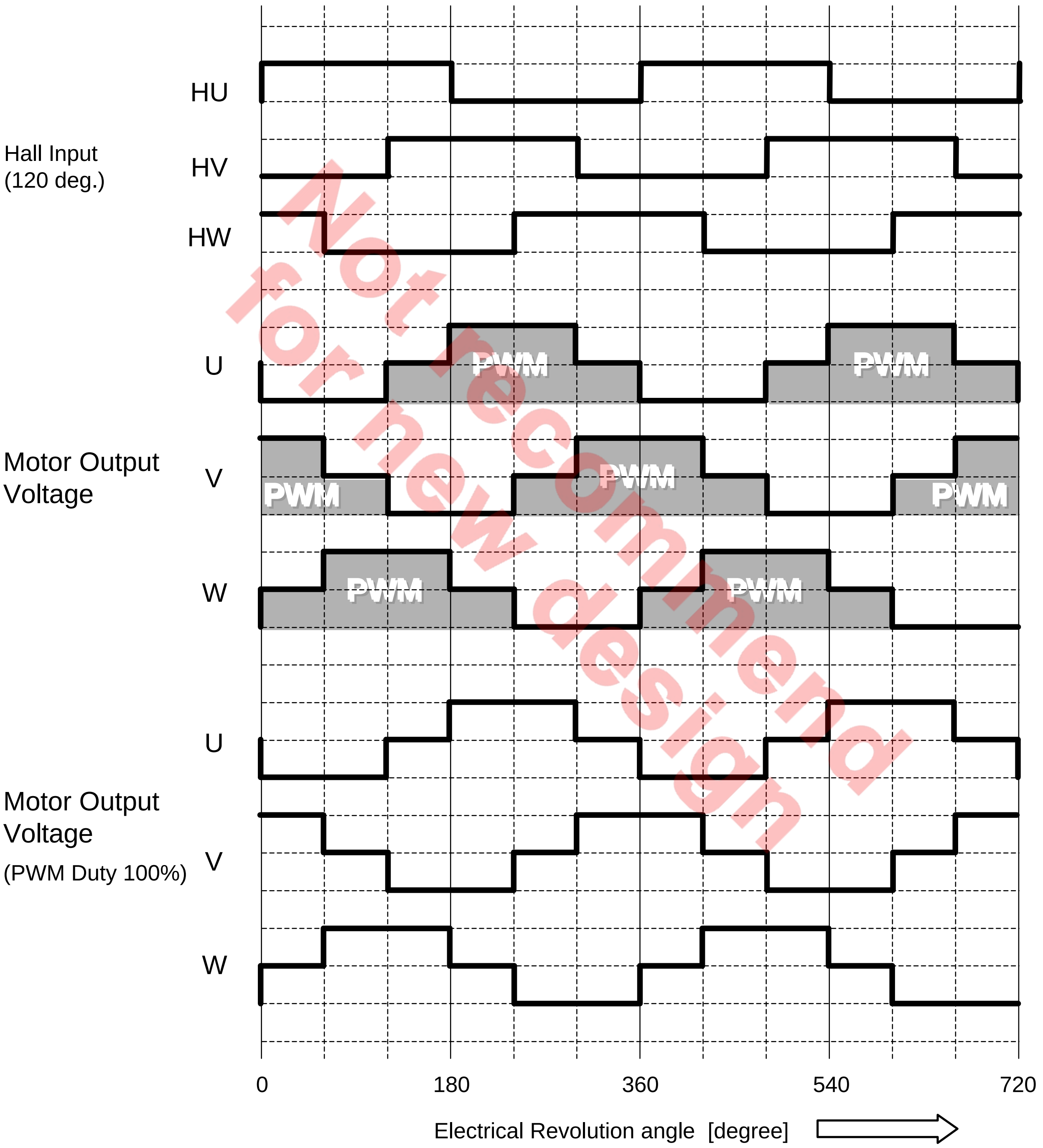
< FLT, FG >



< SVCC >



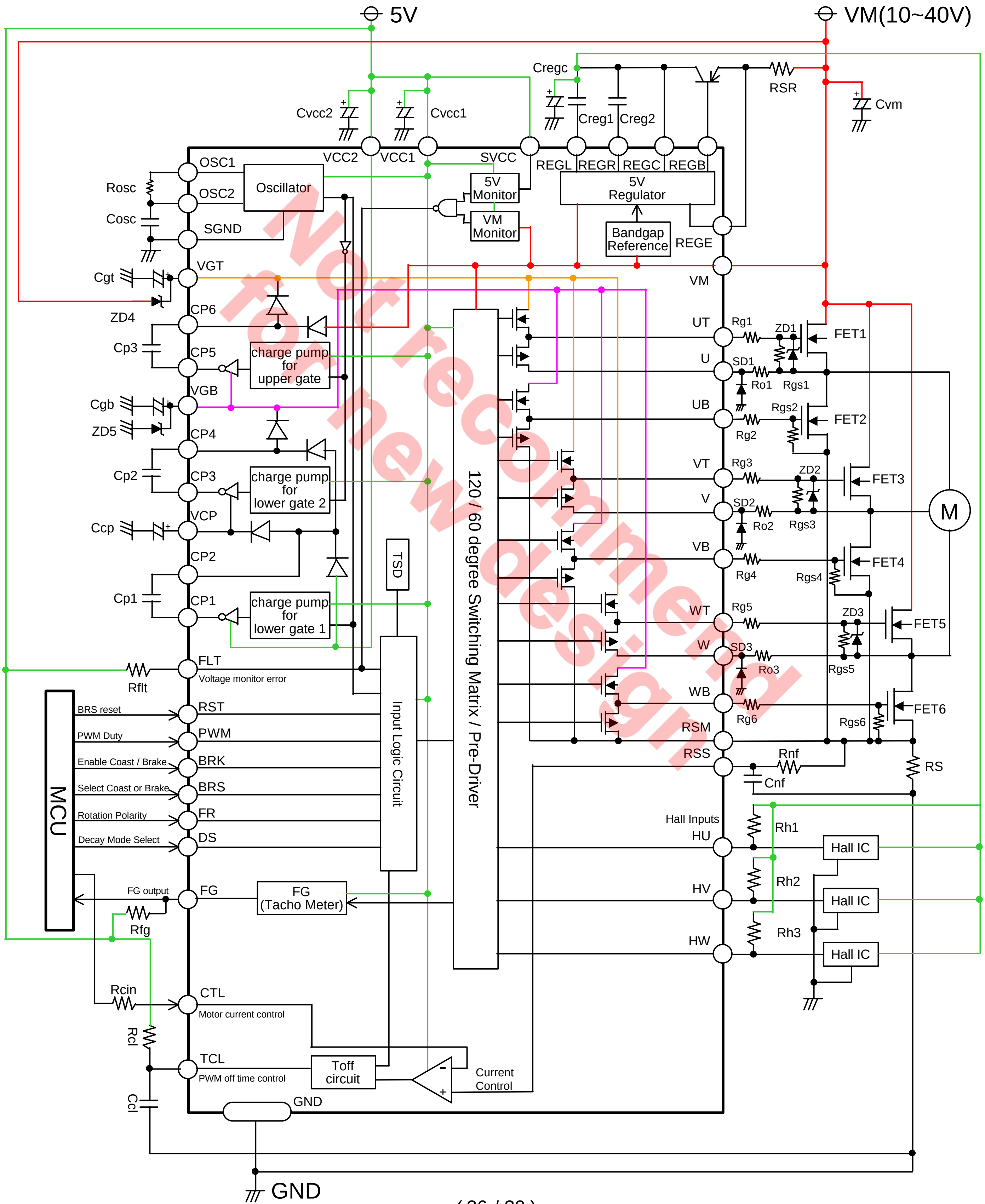
Hall Inputs and Motor Outputs Timing Chart



* Note6 : 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.

Application Circuit 1

▸ Motor current is controlled by D/A signal input level



TENTATIVE

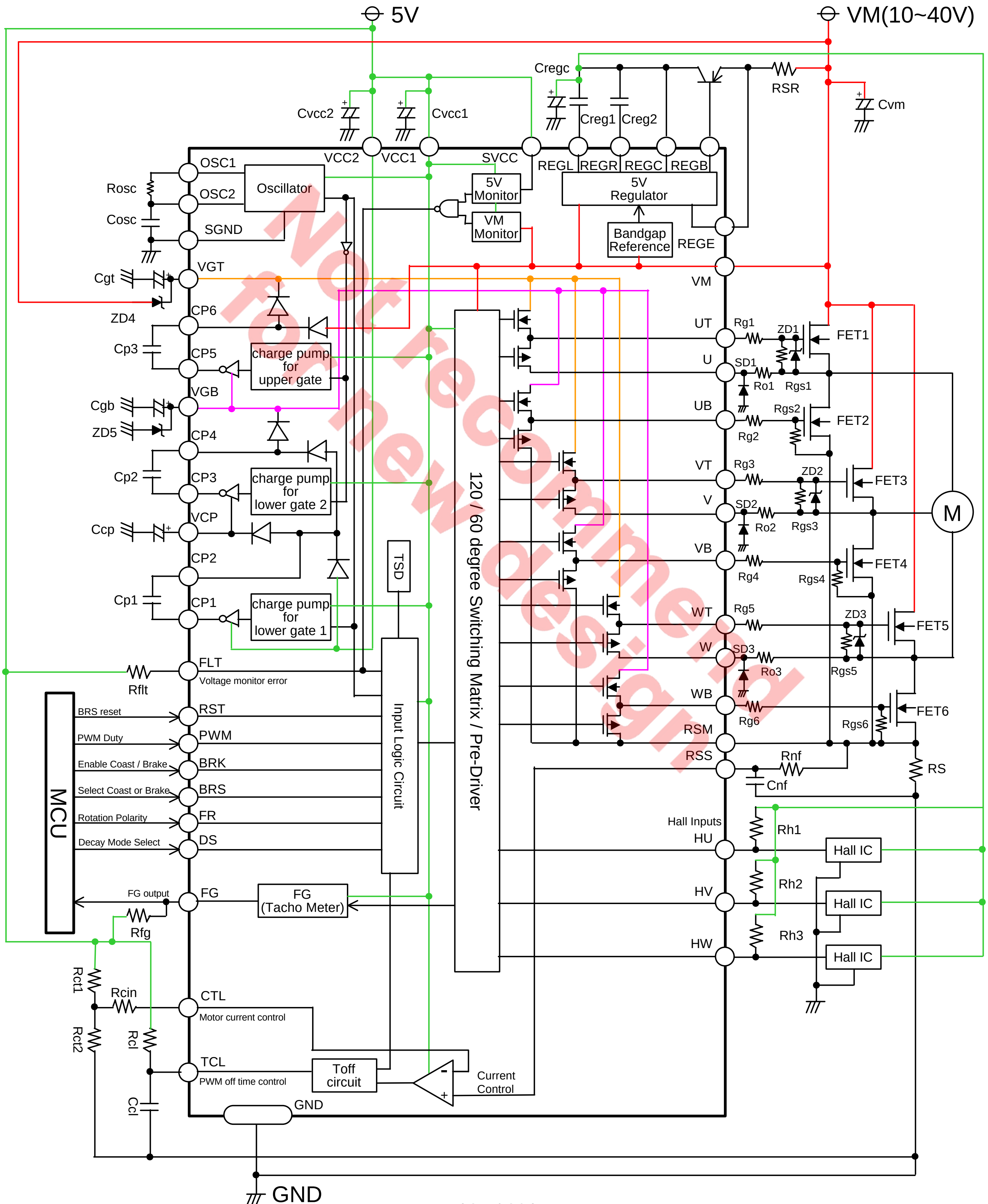
Mitsubishi Motor Controller
M63155FP

REV. 020414

3 PHASE BRUSHLESS MOTOR CONTROLLER

Application Circuit 2

▸ **Motor current is controlled by PWM pulse input duty**



Reference Values of the External Parts

External Parts Name	Notes	Symbol	Value			Units
			Min.	Typ.	Max.	
Cvm	Bypass Condenser for VM	Cvm	-	10	-	uF
FET1~FET6	Nch Power MOS FET	Ciss	-	1200	-	pF
Rg1~Rg6	Gate Resistances of FETs	Rg	-	10	-	ohm
Ro1~Ro3	Output Resistances for Motor Coils	Ro	-	10	-	ohm
Rgs1~Rgs6	Gate-Source Resistances of FETs	Rgs	-	100	-	Kohm
SD1~SD3	Schottky Diode	VF	-	-	0.5	V
ZD1~ZD5	Zener Diode	Vak	-	13	-	V
RS	Motor Current Sensing Resister	RS	-	0.4	-	ohm
Rnf	RS terminal Filtering Resister	Rnf	-	430	-	ohm
Cnf	RS terminal Filtering Condenser	Cnf	-	180	-	pF
Rh1~Rh3	Hall Input Pull-up Resister	Rh	-	10	-	Kohm
Ccp, Cgb, Cgt	Bypass Condenser for Charge-pump Voltage	Ccp	-	4.7	-	uF
Cp1~3	Charge-pump Condenser	Cp	-	470	-	nF
Rosc	External Resistance for Oscillator	Rosc	-	3.0	-	Kohm
Cosc	External Condenser for Oscillator	Cosc	-	180	-	pF
PNP	External PNP Tr. for 5V Regulator	hfe	100	-	-	-
RSR	5V Regulator Current Sensing Resistance	RSR	-	10	-	ohm
Creg1	Phase Compensation Condenser for 5V Reg. 1	Creg1	-	1	-	nF
Creg2	Phase Compensation Condenser for 5V Reg. 2	Creg2	-	1	-	nF
Cvcc1	Bypass Condenser for VCC1	Cvcc1	-	10	-	uF
Cvcc2	Bypass Condenser for VCC2	Cvcc2	-	10	-	uF
Cregc	Bypass Condenser for REGC	Cregc		10	-	uF
Rfg, Rflt	FG, FLT Output Pull- Up Resistances	Rd	-	100	-	Kohm
Rct1	Current Control input Gain Resistances 1	Rct1	-	2	-	Kohm
Rct2	Current Control input Gain Resistances 2	Rct2	-	0.5	-	Kohm
Rcl	Current Control Off Time Resistance	Rcl	2.5	-	-	Kohm
Rcin	Current Control input Impedance Compensation	Rci	-	0.03	-	Kohm
Ccl	Current Control Off Time Condenser	Ccl	-	440	-	pF

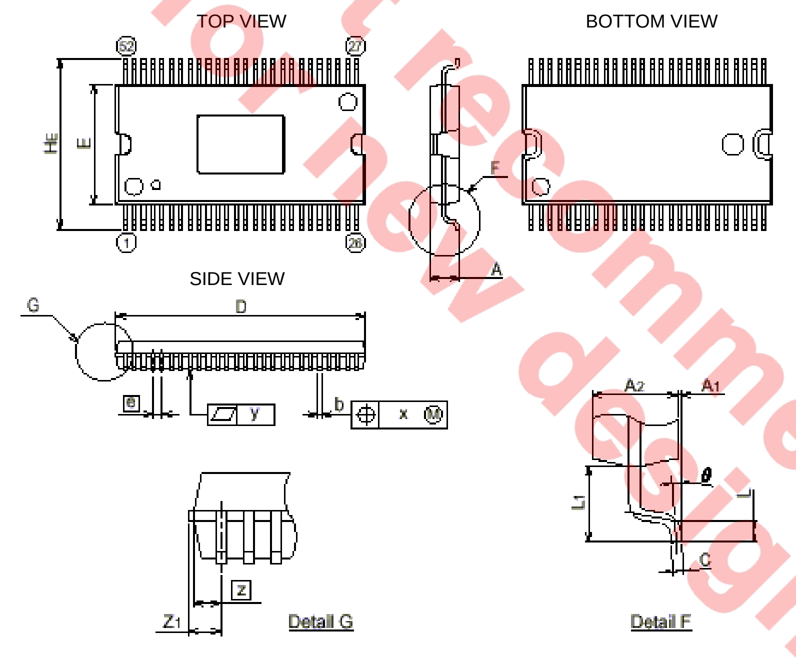
* Note10 : This parameters are calculated values.

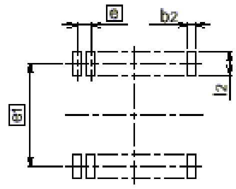
Package Outline

52P9Y-K (MMP)

Plastic 52pin 450mil HSSOP

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





Recommended Mount Pad

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	–
I_2	1.27	–	–