TOSHIBA BiCD Process Integrated Circuit Silicon Monolithic

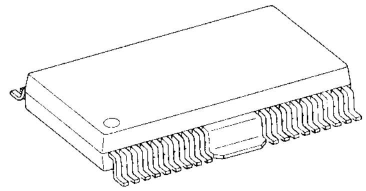
TB62205F

Single-Stepping Motor Driver IC with Dual DC/DC Converter Driven by Chopper Micro-Step Pseudo Sine Wave

The TB62205F is a single-stepping motor driver with dual DCDC converter driven by chopper micro-step pseudo sine wave.

To drive a two-phase bipolar-type stepping motor, a 16-bit latch and a 16-bit shift register are built in the IC. The TB62205F is suitable for driving stepping motors at high efficiency and with low-torque ripple, and supports Selectable Mixed Decay Mode for switching the attenuation ratio at chopping.

Also, the IC incorporates two DCDC converters, enabling two individually configurable power supplies.



Weight: 0.79 g (typ.)

Features

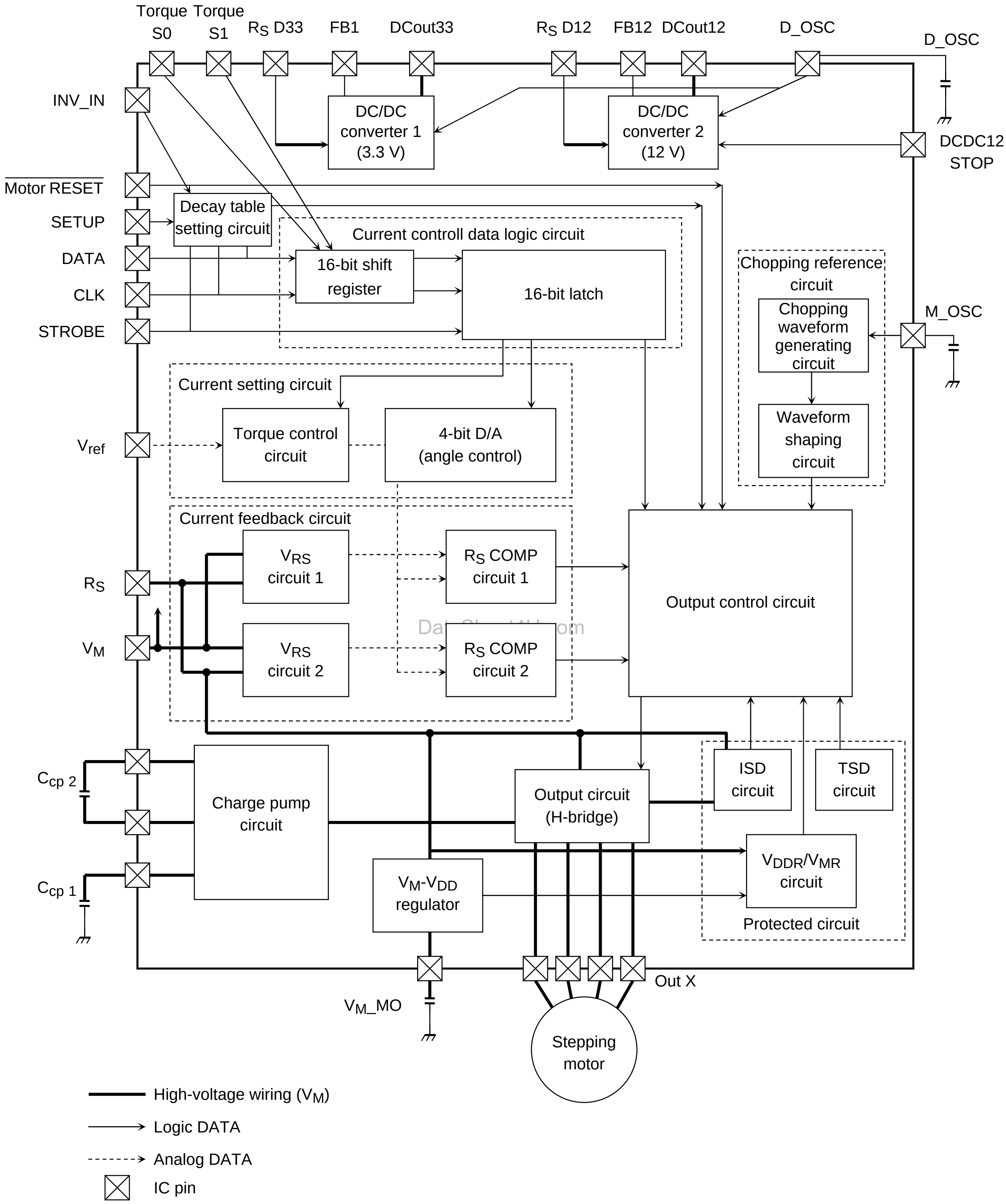
- One stepping motor driven by micro-step pseudo sine wave is controlled by a single driver IC
- Enables to drive two-way supply voltage using a pair of step-down DC/DC converters
- Monolithic Bi-CMOS IC
  Low ON-resistance of R_{on} = 0.7 Ω (@T_j = 25°C, 1.0 A: typ.)
- Motor block incorporating 16-bit serial-in shift register, 16-bit latch and 4-bit D/A converter for micro step drives
- On-chip 5-V regulator for internal circuit, enabling single power supply operation (VM) for the motor
- On-chip ISD and TSD circuits, and internal VDD/VM power-on reset circuit as protection circuits
- On-chip charge pump circuit (two external capacitors)
- Package: 36-pin power flat package (P-HSOP 3620-450-0.65)
- Motor maximum power supply voltage: 30 V (max), motor output current: 0.7 A (max)
- DCDC converter maximum input current: 1.2 A (max), maximum load current: 0.96 (A)
- On-chip Mixed Decay Mode enables specification of four-stage attenuation ratio.
- Chopping frequency can be set by external oscillator. High-speed chopping is possible at 100 kHz or higher.
- Also, DCDC frequency can be set by the external OSC.
- To set chopping at 100 kHz or higher is possible

Note: When using the IC, pay attention to thermal conditions.
These devices are easily damaged by high static voltage.
In regards to this, please handle with care.

A schottky barrier diode (SBD) should be inserted between the output pin of the DCDC converter and ground. (Recommended device: Toshiba CMS07)

Block Diagram

1. Overview

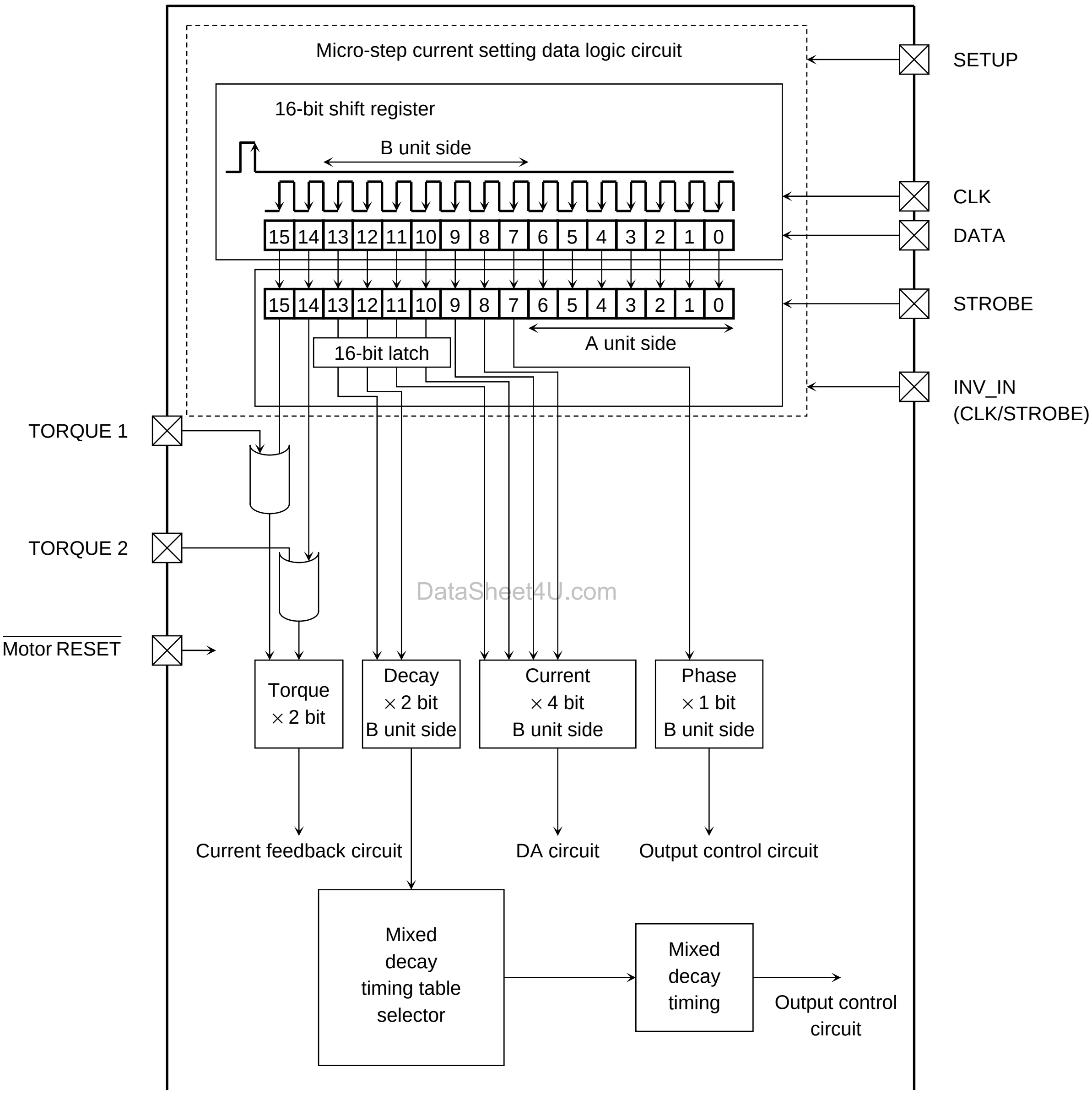


2. Logic unit for motor driver

Function

This circuit is used to input from the DATA pins micro-step current setting data and to transfer them to the subsequent stage. By switching the SETUP pin, the data in the mixed decay timing table can be rewrite

External input data and the 2-bit input signal from 16-bit shift register can be used to set the torque circuit. When 1 is input to one of them, 1 is reflected such as a function of OR gate.

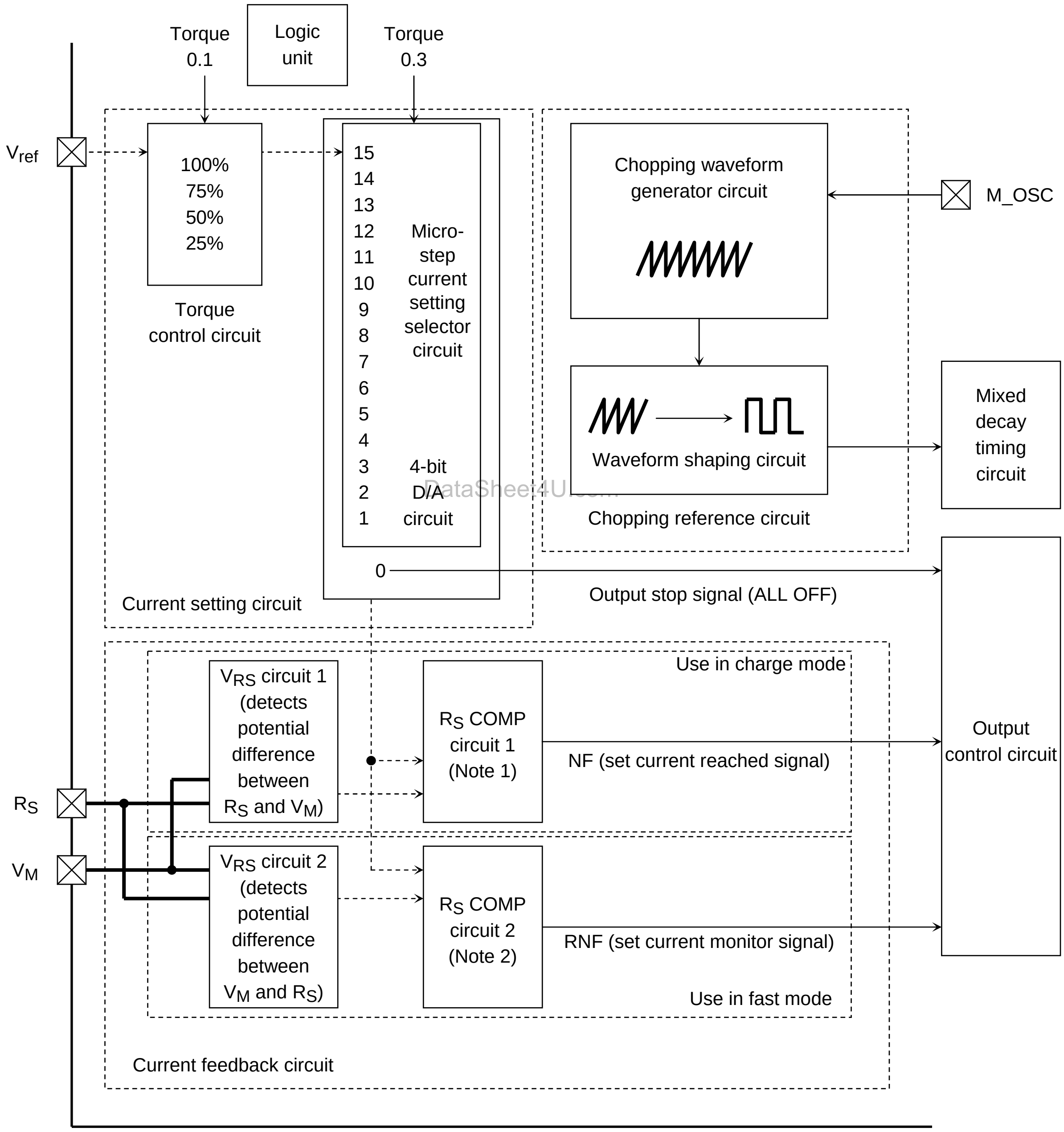


Note: The $\overline{\text{Motor RESET}}$ and SETUP pins are pulled down in the IC by 100 kΩ resistor.
When the SETUP pin and the TORQUE pin are not used, connect them to ground. Otherwise, malfunction may occur.

3. Current feedback circuit and current setting circuit for motor driver

Function

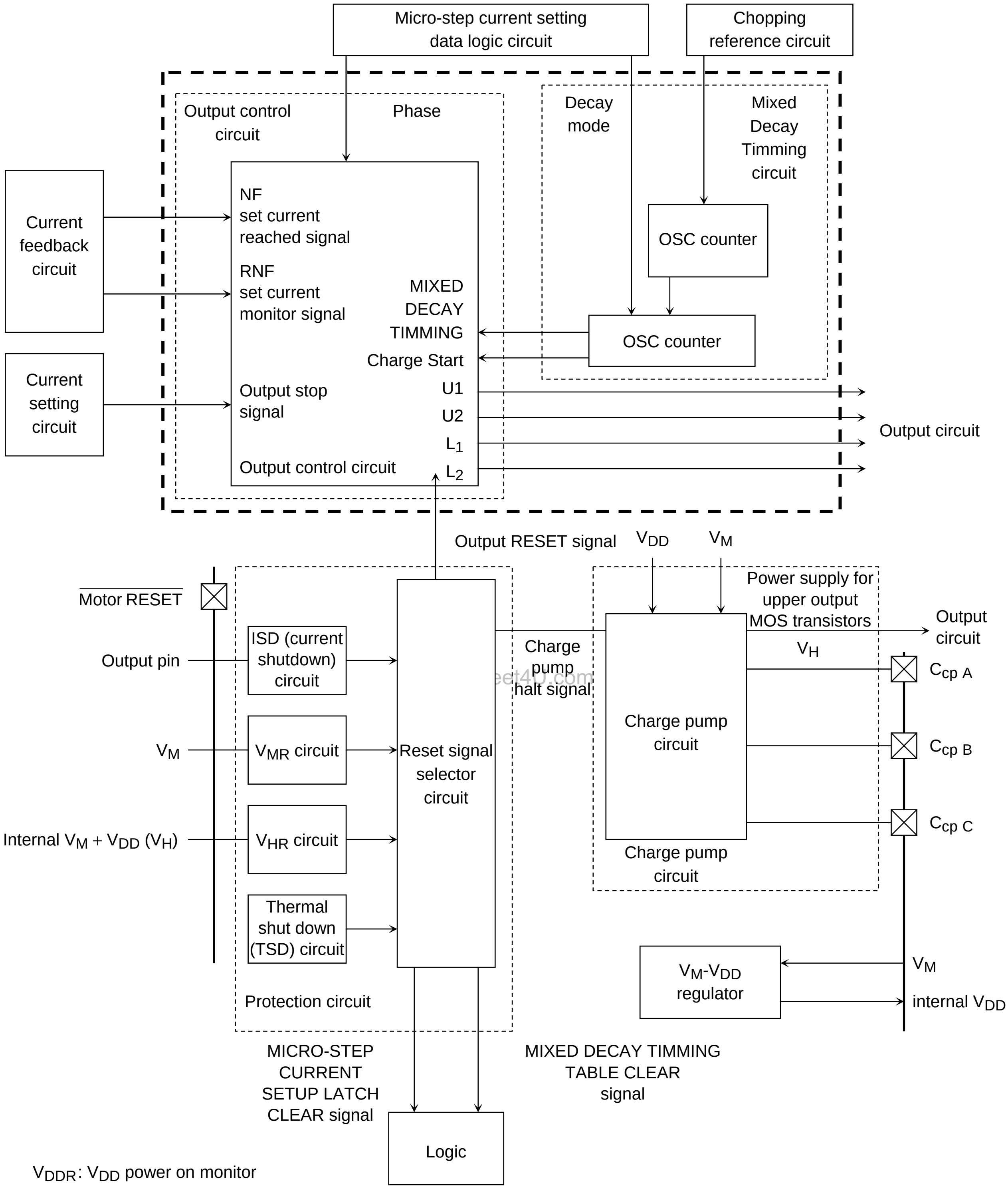
The current setting circuit is used to set the reference voltage of the output current using the micro-step current setting data input from the DATA pins.
The current feedback circuit is used to output to the output control circuit the relation between the set current value and output current. This is done by comparing the reference voltage output to the current setting circuit with the potential difference generated when current flows through the current sense resistor connected between R_S and V_M.
The chopping waveform generator, to which a capacitor is connected, generates clock (OSC-CLK) used as reference for the chopping frequency, so that these two circuits are pure digital logic.



Note 1: R_S COMP1: Compares the set current with the output current and outputs a signal when the output current reaches the set current.

Note 2: R_S COMP2: Compares the set current with the output current at the end of Fast mode during chopping. Outputs a signal when the set current is below the output current.

4. Output control circuit, current feedback circuit and current setting circuit for motor driver



V_{DDR}: V_{DD} power on monitor

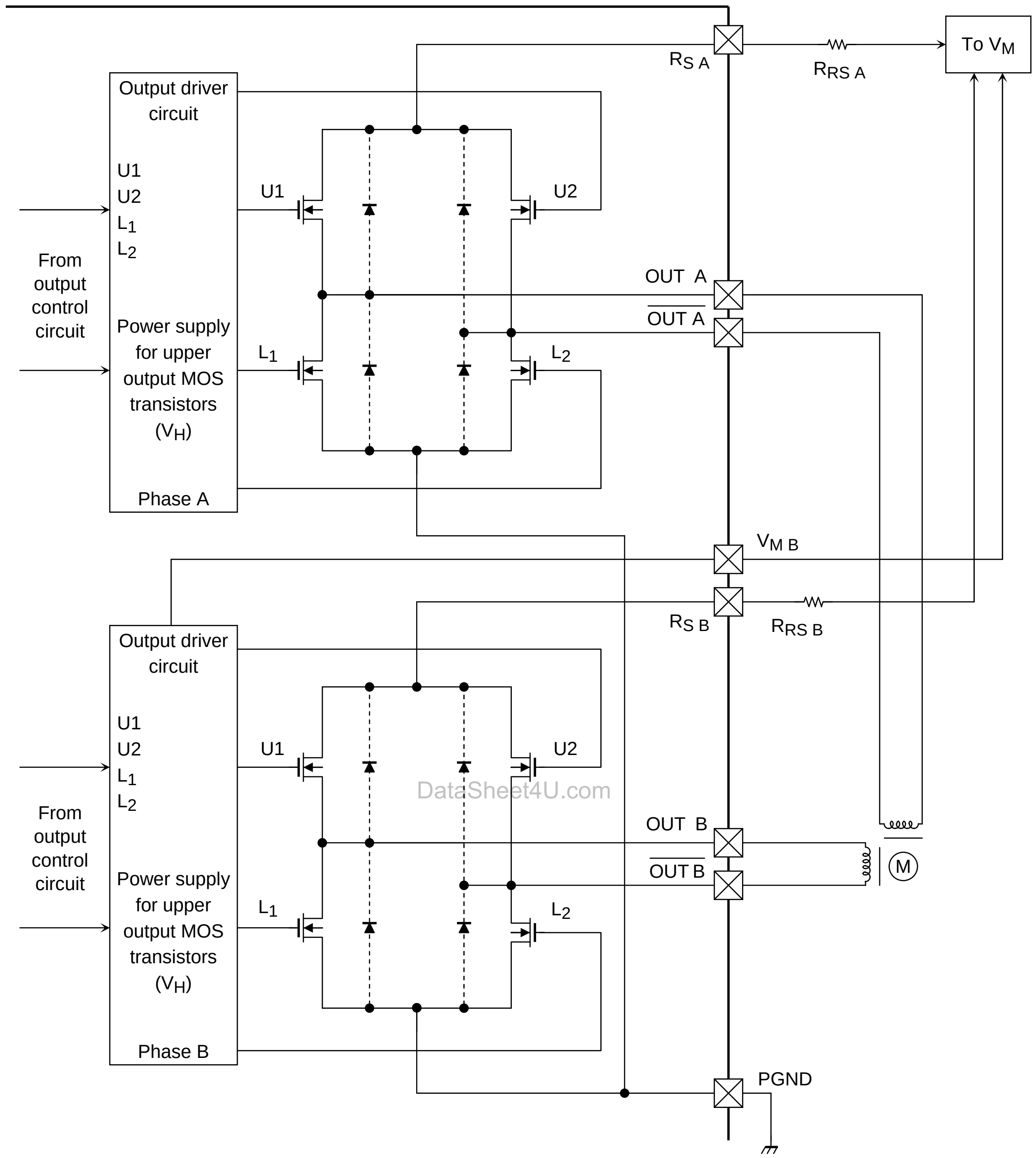
V_{MR} : V_M power on monitor

ISD : Current shutdown circuit

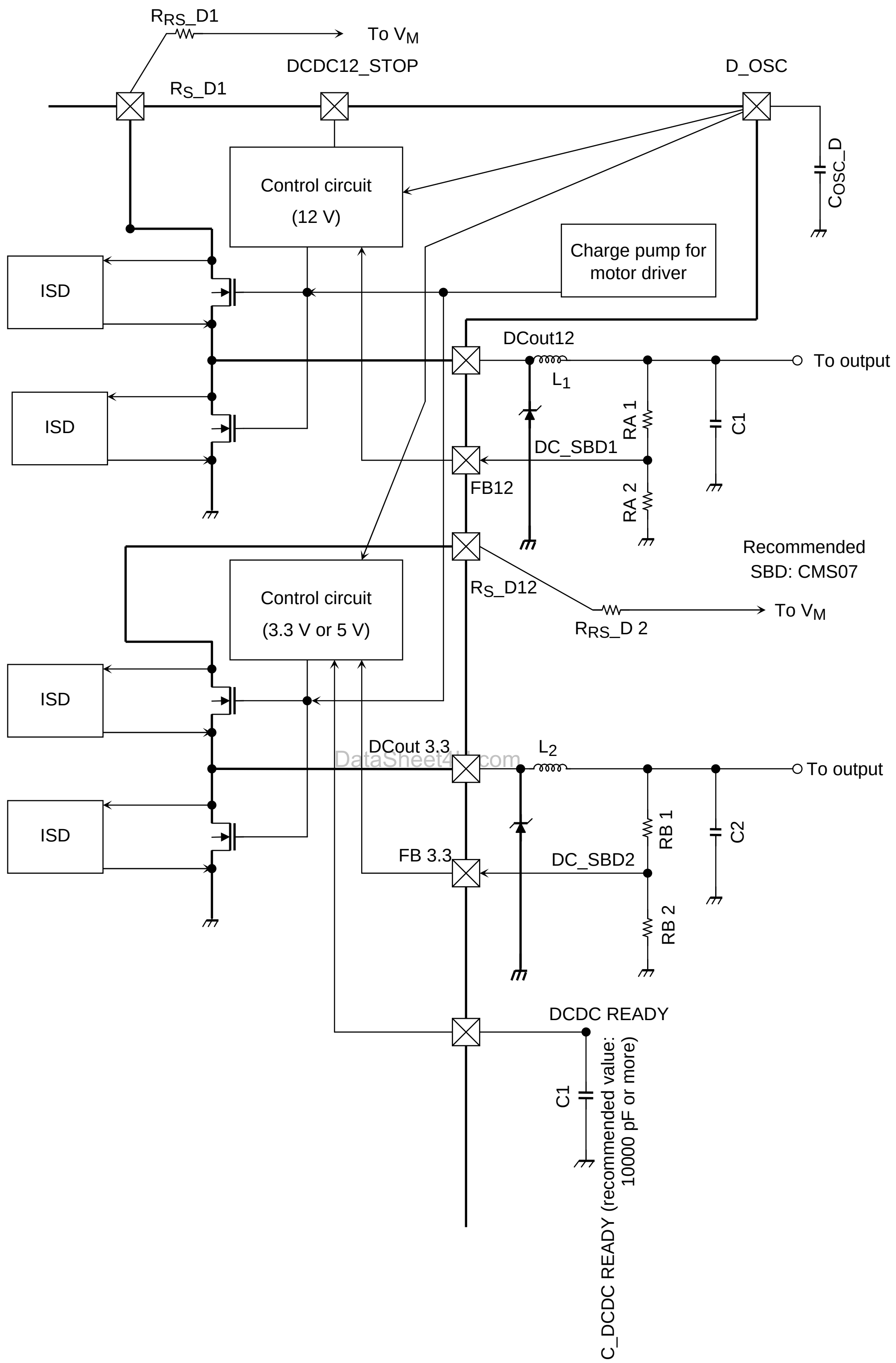
TSD : Thermal shutdown circuit

Note: The $\overline{\text{Motor RESET}}$, and SETUP pins are pulled down in the IC by a 100-kΩ resistor.
When these pins are not used, connect them to ground. If they are left open, malfunction may occur.

5. Output equivalent circuit for motor driver



6. DCDC conversion circuit



Pin Descriptions

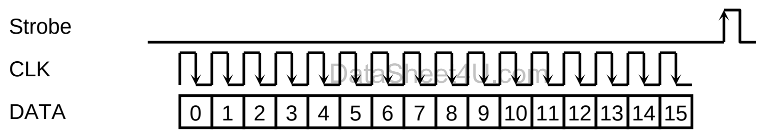
Pin No.	Pin Symbol	Pin Description
1	V_M	Power supply monitor pin for output part
2	TORQUE S0	External motor torque setting pin for motor
3	TORQUE S1	External motor torque setting pin for motor
4	INV_IN	Inverse input pin for motor CLK and STROBE
5	V_{SS1}	Ground pin for LOGIC part (Please connect the pin 5 to F_{IN}.)
6	NC	Not connected
7	OUT $\overline{A}$	Motor $\overline{A}$ output pin
8	$R_{S\ A}$	Motor A channel current detection pin (power supply pin)
9	OUT A	Motor A output pin
F_{IN}	F_{IN}	F_{IN} (V_{SS}): Ground pin for LOGIC
10	OUT $\overline{B}$	Motor $\overline{B}$ output pin
11	$R_{S\ B}$	Motor B channel current detection pin (power supply pin)
12	OUT B	Motor B output pin
13	NC	Not connected
14	V_{SS2}	Ground pin for LOGIC part (Please connect the pin 14 to F_{IN}.)
15	STROBE	Motor STROBE (latch) signal input pin (↓: LATCH @ INV_IN: L)
16	CLK	Motor lock input pin (↑: CLK @ INV_IN: L)
17	DATA	Motor serial data signal input pin
18	OSC_M	External chopping reference pin for motor, that sets the chopping frequency.
19	V_{DD}_MO	Internal power supply monitor pin for logic part (Internal power supply)
20	V_{ref}	Motor V_{ref} input pin
21	SETUP	Mode switching pin for Motor SETUP (L: Motor operation, H: Motor switching)
22	$\overline{\text{Motor RESET}}$	Motor stopping pin (L: RESET)
23	DCDC12STOP	Output stopping pin for DCDC 12 V
24	DCDC12FB	Voltage feedback pin for DCDC 12 V
25	P-GND12	PGND for DCDC 12 V
26	R_S_DC12	Power supply input pin (sense resistor connecting pin) for DCDC 12 V
27	DCDC12OUT	Power voltage output pin for DCDC 12 V
F_{IN}	F_{IN}	F_{IN} (V_{SS}): Ground pin for LOGIC part
28	DCDC3.3OUT	Power voltage output pin for DCDC 3.3 V
29	R_S_D3.3	Power supply input pin (sense resistor connecting pin) for DCDC 3.3 V
30	PGND3.3	PGND for DCDC 3.3 V
31	DCDC3.3FB	Power voltage feedback pin for DCDC 3.3 V
32	DCDC READY	Pin for setting start delay time of DCDC 3.3V
33	OSC_D	Capacitor connection pin for DCDC oscillating frequency
34	$C_{cp\ C}$	Capacitor pin for charge pump ($C_{cp\ 2}$)
35	$C_{cp\ B}$	Capacitor pin for charge pump ($C_{cp\ 2}$)
36	$C_{cp\ A}$	Capacitor pin for charge pump ($C_{cp\ 1}$)

Note: When the IC is mounted in the wrong orientation, high voltage will be applied to the low-withstand-voltage block, which causes the IC to be destroyed. Please check the pin 1 positioning mark when mounting it. While the IC is powered-on, do not connect the motor to the IC or vice-versa.

Function

16-bit serial input signals for motor
(apply the signals in reverse order of TB62201AF serial input signals.)

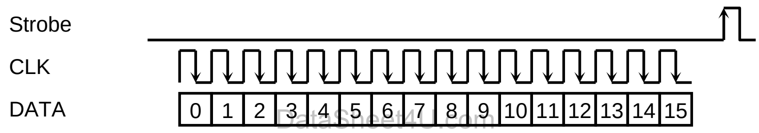
Data Bit	Name	Function
0	Phase A	Phase information (H: out A is high)
1	Current A3	A-channel current setting
2	Current A2	
3	Current A1	
4	Current A0	
5	Decay Mode A1	A-channel current attenuation ratio setting
6	Decay Mode A0	
7	Phase B	Phase information (H: out B is high)
8	Current B3	B-channel current setting
9	Current B2	
10	Current B1	
11	Current B0	
12	Decay Mode B1	B-channel current attenuation ratio setting
13	Decay Mode B0	
14	Torque 1	Torque setting
15	Torque 0	



Note: The direction of DATA and CLK indicated above is under the condition of when INV_IN = H.

Data input signal at setting mixed decay timing table
(Apply the signals in reverse order of TB62201AF data input signals.)

Data Bit	Name	Function	Initial Value
0	Current Mode 3	Selects Slow or Mixed Decay Mode	1: Mixed Decay Mode
1	Decay Mode 3-2	Sets decay 3 ratio (decay 3 ratio)	1
2	Decay Mode 3-1		1
3	Decay Mode 3-0		1: 100%
4	Current Mode 2	Selects Slow or Mixed Decay Mode	1: Mixed Decay Mode
5	Decay Mode 2-2	Sets decay 2 ratio	1
6	Decay Mode 2-1		0
7	Decay Mode 2-0		1: 75%
8	Current Mode 2	Selects Slow or Mixed Decay Mode	1: Mixed Decay Mode
9	Decay Mode 1-2	Sets decay 1 ratio	0
10	Decay Mode 1-1		1
11	Decay Mode 1-0		0: 37.5%
12	Current Mode 0	Selects Slow or Mixed Decay Mode	0: Mixed Decay Mode
13	Decay Mode 0-2	Sets decay 0 ratio	0
14	Decay Mode 0-1		0
15	Decay Mode 0-0		0: 12.5%



Note: The direction of DATA and CLK indicated above is under the condition of when INV_IN = H.

Table for Setting (1) D0

Setting Phase A

Data Bit	Name	Function	Phase	Setting Value Phase
0	Phase A	Switching phases	0	OUT A = L, OUT $\overline{A}$ = H
			1	OUT A = H, OUT $\overline{A}$ = L

Table for Setting (2) D1, D2, D3, D4, D8, D9, D10, D11

Setting Current

Data Bit	Step	A3	A2	A1	A0	B3	B2	B1	B0	Setting Angle (degree)
1	16	1	1	1	1	0	0	0	0	90
2	15	1	1	1	1	0	0	0	1	84
3	14	1	1	1	0	0	0	1	0	79
4	13	1	1	0	1	0	0	1	1	73
	12	1	1	0	0	0	1	0	0	68
8	11	1	0	1	1	0	1	0	1	61
9	10	1	0	1	0	0	1	1	0	56
10	9	1	0	0	1	0	1	1	1	51
11	8	1	0	0	0	1	0	0	0	45
	7	0	1	1	1	1	0	0	1	39
	6	0	1	1	0	1	0	1	0	34
	5	0	1	0	1	1	0	1	1	28
	4	0	1	0	0	1	1	0	0	23
	3	0	0	1	1	1	1	0	1	17
	2	0	0	1	0	1	1	1	0	11
	1	0	0	0	1	1	1	1	1	6
	0	0	0	0	0	1	1	1	1	0

Table for Setting (3) D5, D6, D12, D13

Setting Decay Mode

Data Bit	Name	Function	Decay Mode 1	Decay Mode 0	Setting Value Decay Mode
5	Decay Mode A1	Setting Decay Mode	0	0	Mixed Decay Mode: 12.5%
6	Decay Mode A0		0	1	Mixed Decay Mode: 37.5%
			1	0	Mixed Decay Mode: 75.0%
			1	1	Fast Decay Mode

Table for Setting (3) D7

Setting Phase B

Data Bit	Name	Function	Phase	Setting Value Phase
7	Phase B	Switching phases	0	OUT B = L, OUT $\overline{B}$ = H
		(+side, –side)	1	OUT B = H, OUT $\overline{B}$ = L

Table for Setting (3) D14, D15

Setting Torque

Data Bit	Name	Function	Torque 1	Torque 0	Setting Value Torque (typ.)
0	Torque 0	Setting current range	0	0	25%
1	Torque 1		0	1	50%
			1	0	75%
			1	1	100%

Function of External Input Pins

External Torque 1.2

Pin Number	Name	Function	Torque 1	Torque 0	Setting Value Torque (typ.)
3	TORQUE S1	Setting current range	0	0	25%
2	TORQUE S0		0	1	50%
			1	0	75%
			1	1	100%

When 1 is applied to either the external Torque 1.2 or the serial data Torque 1.2, 1 is reflected such as a function of OR gate.

INV_IN

Pin number	Name	Function	Torque 1	Setting Value Torque (typ.)
4	INV_IN	Determine which direction to reflect the STROBE CLK of the serial data input.	H	The same direction as TB62201AF Down CLK Up Edge Strobe
			L	The opposite direction from TB62201AF Up CLK Down Edge Strobe

Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit	Remarks
Motor/DCDC power supply voltage	V_M	30	V	
Motor output current	I_{OUT}	0.7	A/phase	(Note 1)
Maximum DCDC converter input current	I_{DCOUT}	1.2	A	(Note 2)
Maximum DCDC initial charge current	I_{DCOUT_S}	0.8	A	(Note 3)
Maximum constant output current	$I_{DCconst}$	$I_{DCOUT} \times 0.8$	A	(Note 4)
Maximum Vref voltage range	V_{erf}	4.0	V	
Current detect pin voltage	V_{RS}	$V_M \pm 4.5$	V	
Maximum voltage at charge pump (CCP1) pin	V_H	$V_M + 7.0$	V	Inside regulator
Logic input voltage	V_{IN}	Up to 5.7	V	(Note 5)
Power dissipation	P_D	1.4	W	(Note 6)
		3.2		(Note 7)
Operating temperature	T_{opr}	−40 to 85	°C	
Storage temperature	T_{stg}	−55 to 150	°C	
Junction temperature	T_j	150	°C	

Note 1: Perform thermal calculations for the maximum current value of the motor under normal conditions. Use the IC at 0.6 A or less per phase.

Note 2: Under the condition of DCDC output voltage × 0.9 V or higher (typ.)
In this case, the input current to the power supply becomes the current value (1.2 A) that is controlled by the sense resistor.

Note 3: Under the condition of DCDC output voltage × 0.9 V or lower (typ.)

Note 4: The output current is lower by 20% than the input current value of the DCDC converter (calculated value).
When The value of IDC_{OUT} is 1.2 A (max), the output current will be 0.96 A (max).

Note 5: Input 5.5 V or less as V_{IN}.

Note 6: Measured for the IC only. (Ta = 25°C)

Note 7: Measured when mounted on the board. (Ta = 25°C)
Ta: IC ambient temperature
T_{opr}: IC ambient temperature when starting operation
T_j: IC chip temperature during operation T_j (max) is controlled by TSD (thermal shutdown circuit)

Note : Notes on maximum voltage
This device does not incorporate an overvoltage protection circuit. When an excessive voltage is applied to the device, it may be destroyed. Thus, make sure that the power supply voltage is within the specification value.

Recommended Operating Conditions (Ta = 0°C to 85°C)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Voltage range	V_M	—	14	24	28	V
Motor output current	I_{OUT}	Ta = 25°C, per phase	—	0.4	0.6	A
DCDC converter current range	I_{DCOUT}	—	—	1.0	1.1	A
DCDC initial charge current	I_{DCOUT_S}	—	—	0.6	0.7	A
Maximum constant output current	I_{DCOut_Const}	Maximum DCDC initial charge current × 0.8	—	0.8	0.84	A
Logic input voltage	V_{IN}	—	GND	—	5	V
Clock frequency	f_{CLK}	—	—	1.0	25	MHz
Motor chopping frequency	f_{chop_M}	V_M = 24 V	40	100	150	kHz
DCDC chopping frequency	f_{chop_D}	V_M = 24 V	40	100	150	kHz
V_{ref} reference voltage	V_{ref}	V_M = 24 V	0	2.0	3.0	V
Current detect pin voltage	V_{RS}	V_M = 24 V	0	±1.0	±1.5	V

Note: In terms of the temperature withstand capability, the maximum value of T_j should be approximately 120°C.

Operating Precaution

This device does not incorporate an overvoltage protection circuit. Thus, if an excess voltage is applied to the IC, the IC may be destroyed. Please design the IC so that an excess voltage will not be applied to the IC.

Motor Electrical Characteristics 1
(unless otherwise specified, Ta = 25°C, V_M = 24 V, Ccp1 = 0.22 μF, Ccp2 = 0.022 μF)

Characteristics		Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Input voltage	High	$V_{IN\ (H)}$	DC	CLK, $\overline{\text{Motor RESET}}$, STROBE, DATA Torque 0, Torque 1, SETUP pins	2.0	3.3	5.4	V
	Low	$V_{IN\ (L)}$			GND – 0.4	GND	0.8	
Input hysteresis		$V_{IN\ (HIS)}$	DC	CLK input pin	—	0.3	—	V
Input current 1		$I_{IN1\ (H)}$	DC	CLK, STROBE, DATA pins	—	—	1.0	μA
		$I_{IN1\ (L)}$			—	—	1.0	
Input current 2		$I_{IN2\ (H)}$		$\overline{\text{Motor RESET}}$, SETUP pins	—	—	100	μA
		$I_{IN2\ (L)}$			—	—	100	
Current dissipation (Pin V_M)		IM1	DC	OUT = open, motor logic = L DCDC3.3 ON (100-kHz external operation) V_M = 24 V, motor output stage = OFF Charge pump = charged C_{cp1} = 0.22 μF, C_{cp2} = 0.02 μF	8	12	15	mA
		IM2		OUT = open, fchop = 100 kHz (phase input 200 kHz) DCDC3.3 ON (100-kHz external operation) V_M = 24 V, motor output stage = open Charge pump = charged C_{cp1} = 0.22 μF, C_{cp2} = 0.02 μF	22	24	26	
		IM3		OUT = open, chopping = 100 kHz DCDC3.3 ON (100-kHz external operation) DCDC12 ON (100-kHz external operation) Charge pump = charged C_{cp1} = 0.22 μF, C_{cp2} = 0.02 μF	24	30	35	
Output standby current	Upper	I_{OH}	DC	V_{RS} = V_M = 24 V, V_{out} = 0 V, $\overline{\text{Motor RESET}}$ = H, DATA = all L	–400	–300	–200	μA
Output bias current	Upper	I_{OB}		V_{RS} = V_M = 24 V, V_{out} = 24 V, RESET = H, DATA = all L	–200	–120	–80	μA
Output leakage current	Lower	I_{OL}		V_{RS} = V_M = $C_{cp\ A}$ = V_{out} = 24 V, $\overline{\text{Motor RESET}}$ = L	—	—	1.0	μA
Comparator reference voltage ratio	HIGH (reference)	$V_{RS\ (H)}$	DC	V_{ref} = 3.0 V, V_{ref} (gain) = 1/4.0 TORQUE = (H.H) = 100% setting	—	100	—	%
	MID HIGH	$V_{RS\ (MH)}$		V_{ref} = 3.0 V, V_{ref} (gain) = 1/4.0 TORQUE = (H.L) = 75% setting	73	75	77	
	MID LOW	$V_{RS\ (ML)}$		V_{ref} = 3.0 V, V_{ref} (gain) = 1/4.0 TORQUE = (L.H) = 50% setting	48	50	52	
	LOW	$V_{RS\ (L)}$		V_{ref} = 3.0 V, V_{ref} (gain) = 1/4.0 TORQUE = (L.L) = 25% setting	23	25	27	
Output current differential		ΔI_{out1}	DC	Differences between output current channels I_{out} = 700 mA	–5	—	5	%
Output current setting differential		ΔI_{out2}	DC	I_{out} = 700 mA	–5	—	5	%
R_S pin current		I_{RS}	DC	V_{RS} = 24 V, V_M = 24 V, $\overline{\text{Motor RESET}}$ = L (RESET status)	—	—	10	μA
Output transistor drain-source On-resistance		$R_{ON\ (D\text{-}S)\ 1}$	DC	I_{out} = 1.0 A, T_j = 25°C, Drain-source	—	0.7	0.85	Ω
		$R_{ON\ (S\text{-}D)\ 1}$		I_{out} = 1.0 A, T_j = 25°C, Source-drain	—	0.7	0.85	
		$R_{ON\ (D\text{-}S)\ 2}$		I_{out} = 1.0 A, T_j = 105°C, Drain-source	—	0.9	1.1	
		$R_{ON\ (S\text{-}D)\ 2}$		I_{out} = 1.0 A, T_j = 105°C, Source-drain	—	0.9	1.1	

Motor Electrical Characteristics 2
(unless otherwise specified, Ta = 25°C, V_M = 24 V, Ccp1 = 0.22 μF, Ccp2 = 0.022 μF)

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Internal logic power supply voltage	V_{DD}	DC	Automatically created	4.7	5.0	5.3	V
V_{ref} input voltage	V_{ref}	DC	$\overline{\text{Motor RESET}}$ = H, Output on	0	—	3.3	V
V_{ref} input current	I_{ref}	DC	$\overline{\text{Motor RESET}}$ = H, Output off, V_{ref} = 3.0 V	20	45	60	μA
V_{ref} attenuation ratio	$V_{ref\ (gain)}$	DC	$\overline{\text{Motor RESET}}$ = H, Output on, V_{ref} = 0 V to 3.3 V	1/3.8	1/4	1/4.2	—
TSD temperature	T_jTSD (Note 1)	DC	—	130	150	170	°C
V_M return voltage	V_{MR}	DC	$\overline{\text{Motor RESET}}$ = H, STRBE = H	10.5	11.0	11.5	V
Over current protected circuit operation current	I_{SD} (Note 2)	DC	f_{chop} = 100 kHz set	—	3.0	—	A

Note 1: Thermal shutdown (TSD) circuit
When the IC junction temperature reaches the specified value and the TSD circuit is activated, the internal reset circuit is activated switching the outputs of both motors to off.
When the temperature is set between 130 (min) to 170°C (max), the TSD circuit operates. When the TSD circuit is activated, the function data latched at that time are cleared. Output is halted until the reset is released. While the TSD circuit is in operation, the charge pump is halted.

Note 2: Overcurrent protection circuit
When current exceeding the specified value flows to the DCDC output, the internal reset circuit is activated switching the outputs of both shafts to off.
When the ISD circuit is activated, the function data latched at that time are cleared.
The overcurrent protection circuit remains activated until the V_M voltage is reapplied. Activating the ISD initializes all the circuits in the IC, which causes the charge pump to be stopped. For the failsafe operation, insert a fuse in the power supply.

Motor Electrical Characteristics 3
(Ta = 25°C, V_M = 24 V, I_{out} = 0.7 A, C_{cp1} = 0.22 μF, C_{cp2} = 0.022 μF)

Characteristics	Symbol	Test Circuit	Test Condition		Min	Typ.	Max	Unit
Chopper current	Vector	DC	θA = 90 (θ16)	—	—	100	—	%
			θA = 84 (θ15)		—	100	—	
			θA = 79 (θ14)		93	98	—	
			θA = 73 (θ13)		91	96	—	
			θA = 68 (θ12)		87	92	97	
			θA = 62 (θ11)		83	88	93	
			θA = 56 (θ10)		78	83	88	
			θA = 51 (θ9)		72	77	82	
			θA = 45 (θ8)		66	71	76	
			θA = 40 (θ7)		58	63	68	
			θA = 34 (θ6)		51	56	61	
			θA = 28 (θ5)		42	47	52	
			θA = 23 (θ4)		33	38	43	
			θA = 17 (θ3)		24	29	34	
			θA = 11 (θ2)		15	20	25	
			θA = 6 (θ1)		5	10	15	
			θA = 0 (θ0)		—	0	—	

DCDC Converter Electrical Characteristics 1 (unless otherwise specified, Ta = 25°C, V_{DD} = 3.3 V, V_M = 24 V, C_{cp1} = 0.22 μF, C_{cp2} = 0.022 μF)

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
DCDC output voltage error (DCDC load regulation)	ΔV_{out1}	DC	Output voltage error V_{out} = 3.3 V, FB with 1% resistor	–5	0	5	%
			0.96 A, C = 470 μF, L = 470 μF				
	ΔV_{out2}		Output voltage error				
			V_{out} = 3.3 V, FB with 1% resistor				
			I_{out} = 0.7 A, C = 470 μF, L = 470 μF, V_M = 12–28 V				
DCDC Pin FB input current	$I_{IN\ (FB)}$	DC	V_M = 24 V, $V_{IN\ (FB)}$	—	—	500	nA
Pin FB threshold voltage	$V_{th\ (FB)}$	DC	—	—	2.5	—	V
Soft/full switching voltage ratio	V_{DC}_SF	DC	I_{out} = 700 mA	90	92	94	%
DCDC output off leak current	I_{ODC}	DC	V_M = 24 V, upper	–200	—	—	nA
			V_M = 24 V, lower	–400	—	—	
DCDC Maximum duty cycle	DC_duty	DC	—	—	90	—	%
Output transistor drain – source ON resistance	RON (D-S) 1	DC	I_{out} = 1.0 A, T_j = 25°C, forward direction	—	0.7	0.84	Ω
	RON (D-S) 1		I_{out} = 1.0 A, T_j = 25°C, opposite direction	—	0.7	0.84	
	RON (D-S) 2		I_{out} = 1.0 A, T_j = 105°C, forward direction	—	0.9	1.1	
	RON (D-S) 2		I_{out} = 1.0 A, T_j = 105°C, opposite direction	—	0.9	1.1	

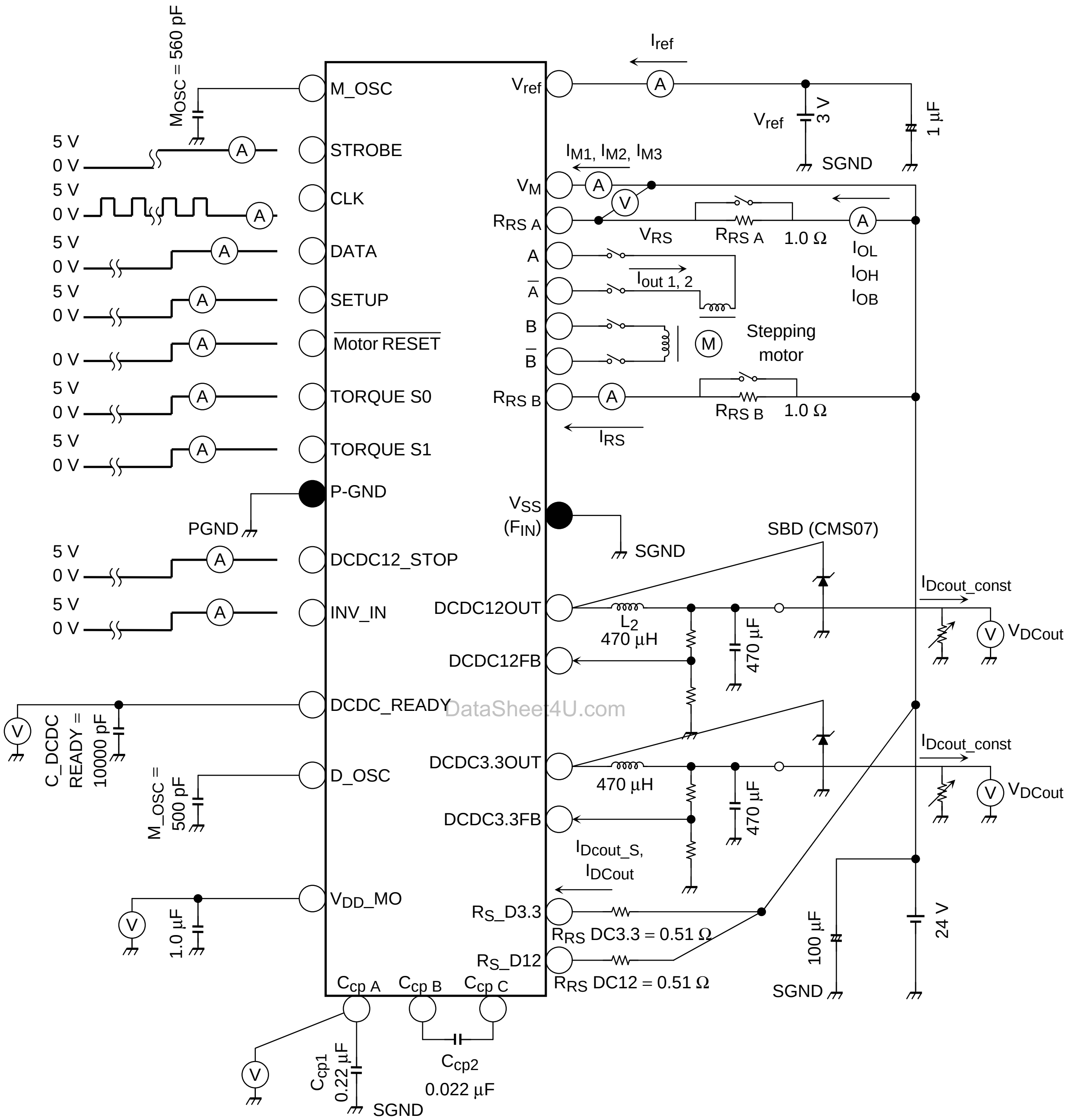
AC Characteristics for Motor Driver
(Ta = 25°C, V_M = 24 V, 6.8 mH/5.7 Ω, C_{cp1} = 0.22 μF, C_{cp2} = 0.022 μF)

Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Motor clock frequency	f_{CLK}	AC	—	1.0	—	25	MHz
Motor minimum clock pulse width	t_w (CLK)	AC	—	40	—	—	ns
	t_{wp} (CLK)			20	—	—	
	t_{wn} (CLK)			20	—	—	
Motor minimum STROBE pulse width	t_{STROBE}	AC	—	40	—	—	ns
	$t_{STROBE\ (H)}$			20	—	—	
	$t_{STROBE\ (L)}$			20	—	—	
Motor data setup time	$t_{suSIN\text{-}CLK}$	AC	—	20	—	—	ns
	$t_{suST\text{-}CLK}$			20	—	—	
Motor data hold time	$t_{hSIN\text{-}CLK}$	AC	—	20	—	—	ns
	$t_{hCLK\text{-}ST}$			20	—	—	
Motor output transistor switching characteristic	t_r	AC	Output load: 6.8 mH/5.7 Ω	—	0.1	—	μs
	t_f			—	0.1	—	
	$t_{pLH\ (ST)}$		STROBE (↑) to V_{OUT} Output load: 6.8 mH/5.7 Ω	—	15	—	
	$t_{pHL\ (ST)}$			—	10	—	
	$t_{pLH\ (CR)}$		CR to V_{OUT} Output load: 6.8 mH/5.7 Ω	—	1.2	—	
	$t_{pHL\ (CR)}$			—	2.5	—	
Motor noise rejection dead band time	t_{BLNK}	AC	I_{out} = 0.7 A	180	300	400	ns
Motor CR reference signal oscillation frequency	f_{CR}	AC	C_{osc} = 560 pF	640	840	1000	kHz
Motor chopping frequency range	$f_{chop\ (min)}$	AC	Output active (I_{out} = 0.7 A) Step fixed, $C_{cp\ 1}$ = 0.22 μF, $C_{cp\ 2}$ = 0.022 μF	40	100	150	kHz
	$f_{chop\ (typ.)}$						
	$f_{chop\ (max)}$						
Motor motor chopping frequency	$f_{chop\ (M)}$	AC	Output active (I_{out} = 0.7 A) M_osc CLK = 800 kHz	—	105	—	kHz
Charge pump rising time	t_{ONG}	AC	C_{cp2} = 0.22 μF, C_{cp} = 0.02 μF V_M = 24 V, V_{MR} = OFF are reference voltages	—	0.5	1.0	ms

AC Characteristics for DCDC Converter
(Ta = 25°C, V_M = 24 V, 470 μH, 470 μF)

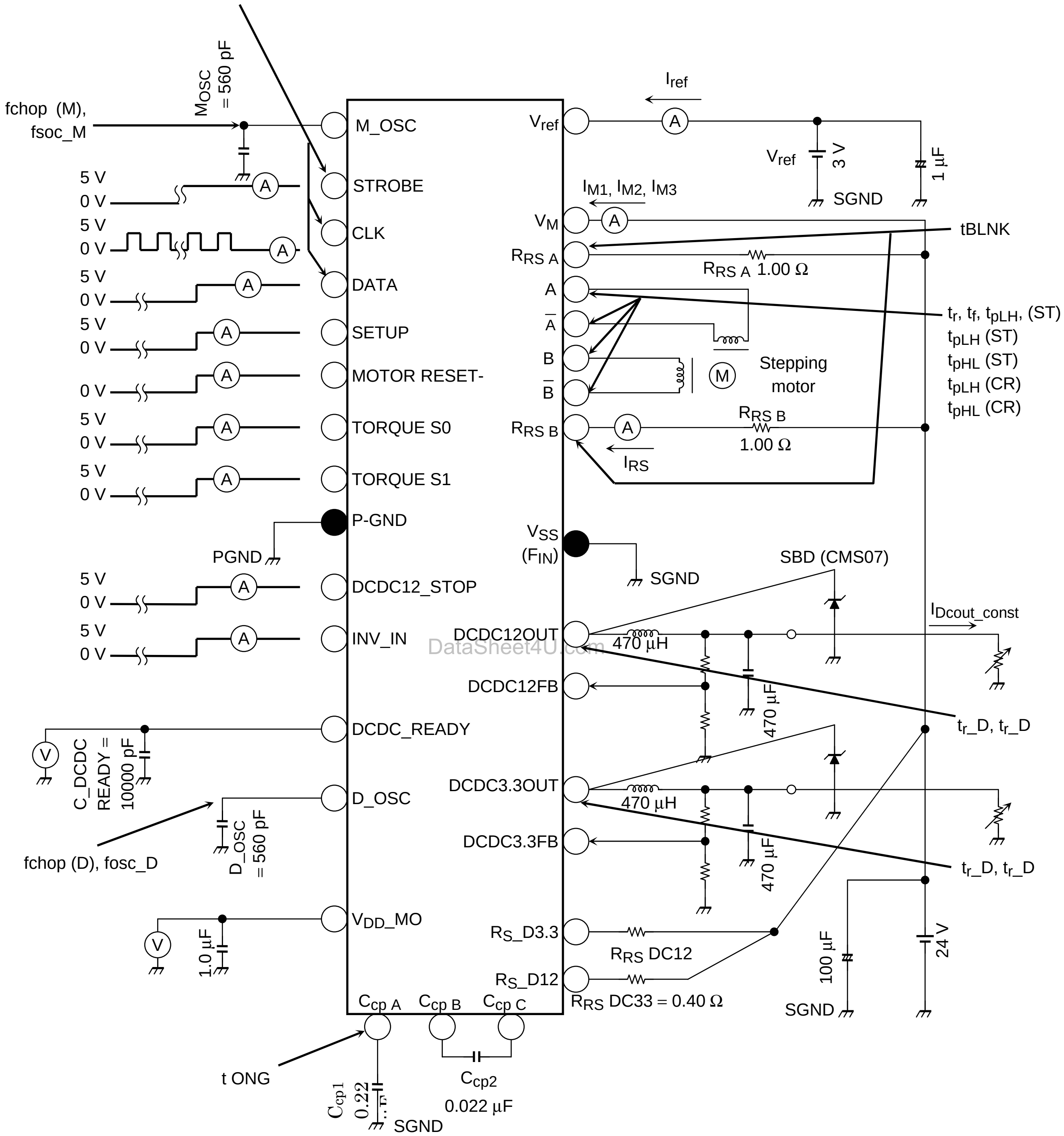
Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Output transistor switching characteristic	t_{r_D}	AC	470 μH/470 μF	—	0.1	—	μs
	t_{f_D}			—	0.1	—	
DCDC reference signal oscillation frequency	f_{OSC_D}	AC	C_{osc} = 560 pF	—	90	—	kHz
DCDC setting frequency range	f_{chop_D}	AC	—	40	100	150	kHz

Test Circuit (DC characteristics)



Test Circuit (AC characteristics)

FCLK, tw (CLK), twp (CLK), twn (CLK)
TSTROBE, tSTROBE (H), tSTROBE (L)
TsuSin-CLK, tsuST-CLK, thSin-CLK, thCLK-ST



Calculation of Set Current

To obtain the motor setting current value (peak current), values of R_{RS}, V_{ref} and Torque should be determined according to the equation below.

$$I_{out}\ (\max) = \frac{1}{V_{ref}\ (\text{gain})} \times V_{ref}\ (\text{V}) \times \frac{\text{Torque (torque} = 100, 75, 50, 25\%\text{: input serial data)}}{R_{RS}\ (\Omega)}$$

$1/V_{ref}$ (gain): $1/V_{ref}$ attenuation ratio is 1/4.0 (typ.).

For example,
to input V_{ref} = 1 V and Torque = 100% and to output I_{out} = 0.25 A,
R_{RS} = 1.0 Ω (0.1 W or more) is required.

Formulas for Calculating Reference Oscillation Frequency (chopping reference frequency)

The M_osc oscillation frequency (f_{osc_M}) and, chopping frequency (f_{chop}) can be calculated by the following formulas :

$$\text{fosc\_M} = \frac{1}{KA \times (CR \times 36000R + KB \times C)}\ [\text{Hz}]$$

KA (constant): 0.523

KB (constant): 600

R = 3.6 kΩ (internal resistor)

$$f_{chop} = \frac{\text{M\_osc}}{8}\ [\text{Hz}]$$

Example: When C_{OSC} = 560 pF is connected, M_osc = 813 kHz.
At this time, the chopping frequency f_{chop} is: $f_{chop} = f_{osc}/8$ = 101 kHz.

Note: $f_{chopc} = \frac{1}{f_{osc}}$

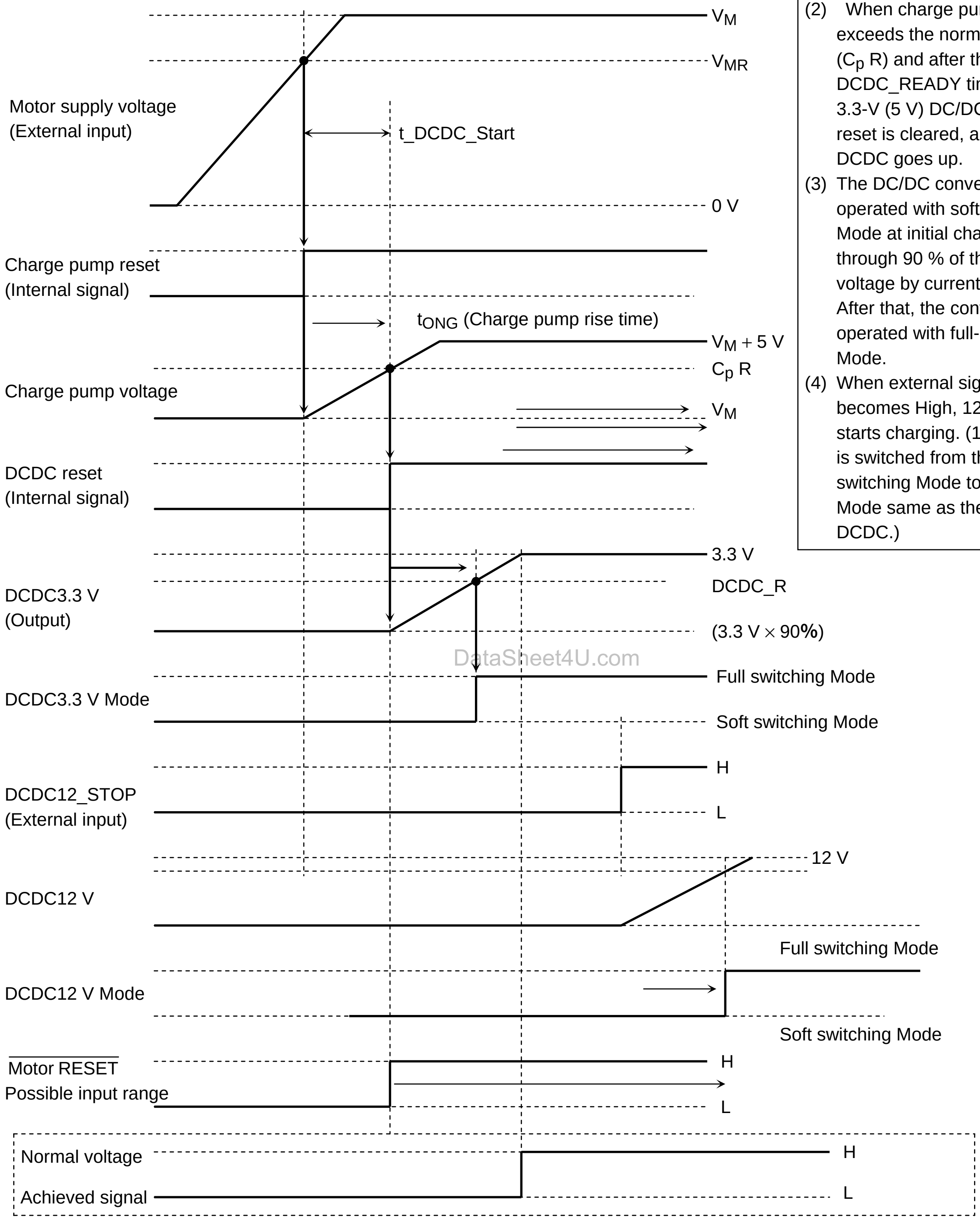
t_{osc_M} = t (charge) + t (discharge)
t_{osc_M}: Motor OSC oscillation cycle
t (charge): Motor OSC charge time

DCDC Converter Oscillating Frequency

f_{DCDC} (DCDC PWM frequency) = 50 (μ)/(0.8 × C_{OSC}_D) (Hz)
PWM frequency for DCDC block is about 100 kHz when C_{OSC}_D is 620 pF.

Example:
C_{OSC}_D = 680 pF: 91 kHz
= 620 pF: 100 kHz
= 560 pF: 111 kHz
= 510 pF: 122 kHz
= 470 pF: 133 kHz
= 390 pF: 160 kHz

Startup Sequence of Power Supply (Voltage)



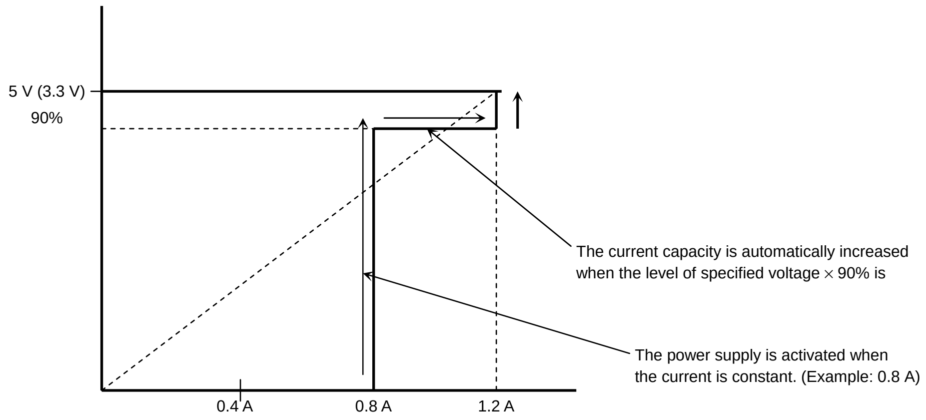
(1) When V_M supply voltage exceeds V_{MR} voltage, charge pump reset is cleared.

(2) When charge pump voltage exceeds the normal voltage (C_p R) and after the DCDC_READY time delayed, 3.3-V (5 V) DC/DC converter reset is cleared, and 3.3-V DCDC goes up.

(3) The DC/DC converter operated with soft switching Mode at initial charging up through 90 % of the normal voltage by current controlling. After that, the converter is operated with full-charging Mode.

(4) When external signal becomes High, 12-V DCDC starts charging. (12-V DCDC is switched from the soft switching Mode to the full Mode same as the 3.3-V DCDC.)

Graph of the Power Supply on DCDC Input Side



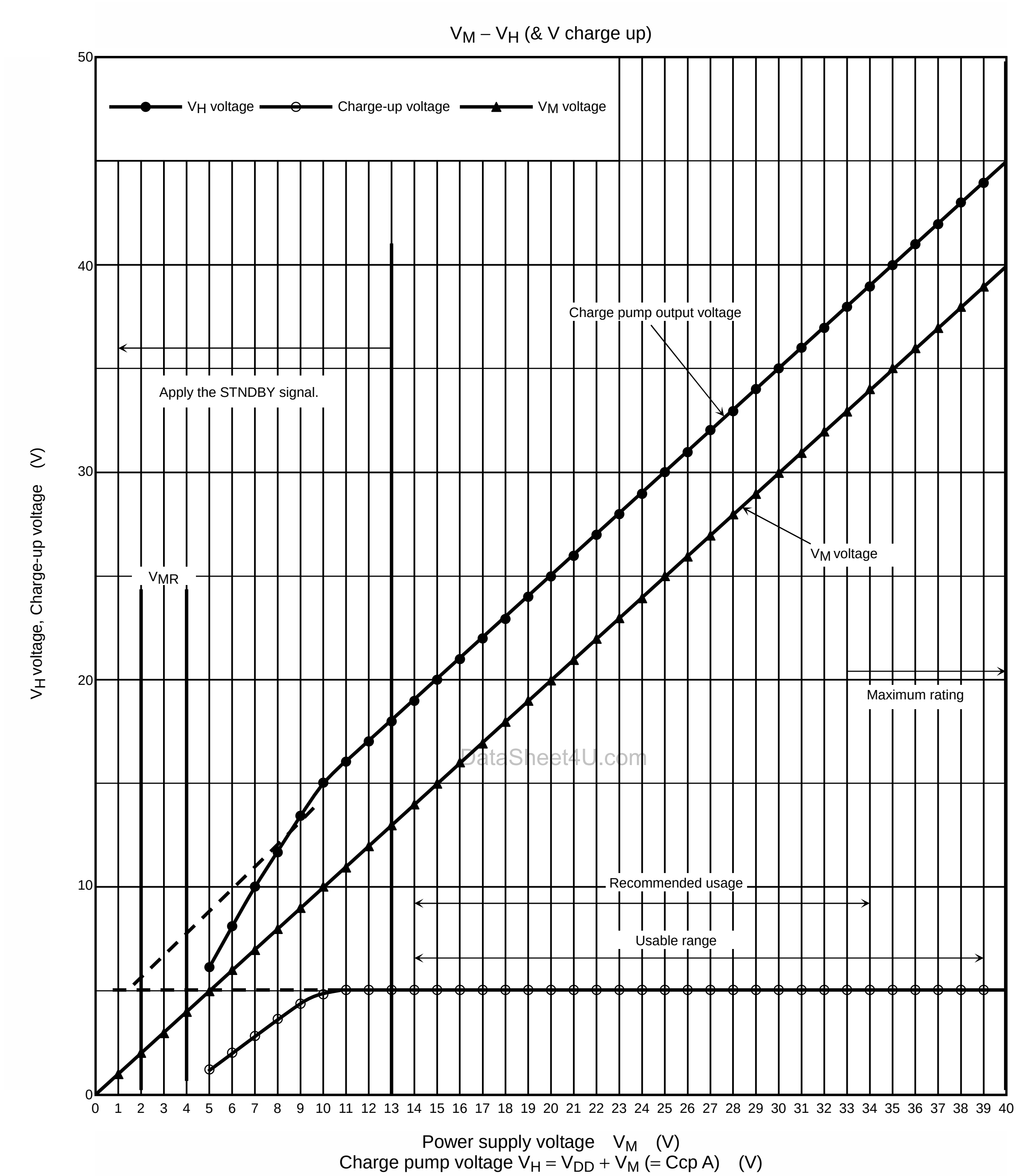
Equations for Calculating Maximum Current Values in Soft-Start Mode and Full Mode

The values of limited current of the DCDC block in Soft-start Mode and Full Mode are obtained using the following equations.

(1) When the specified voltage is 0% to 90% of the voltage range
The maximum current value in Soft-start Mode : I DCout_S = 0.33/R RS_D33 (or D12) (A)

(2) When the specified voltage is 90% to 100% of the voltage range
The maximum current value in Full Mode : I DC_out = I DCout_S × 1.5 (A)
When the current is specified in Full Mode, the current value which can be driven out is obtained using the following equation.
The maximum load current : I DCout_const = I DC_out × 0.8 (A)

Relationship between V_M and V_H (charge pump voltage)

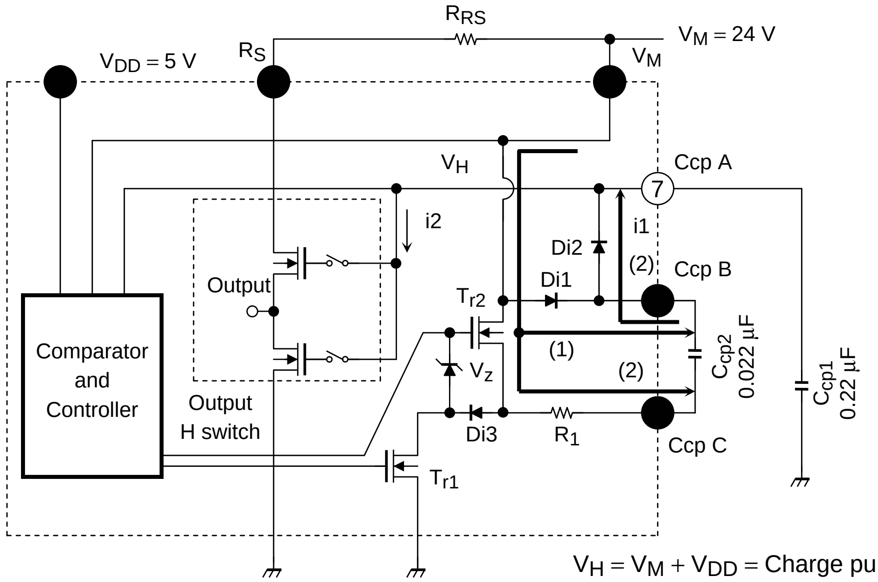


Note: $V_{DD} = 5$ V

$C_{cp1} = 0.22$ µF, $C_{cp2} = 0.022$ µF, $f_{chop} = 150$ kHz

(Keep in mind that the temperatures of the charge pump capacitors change.)

Charge Pump Circuit Operation

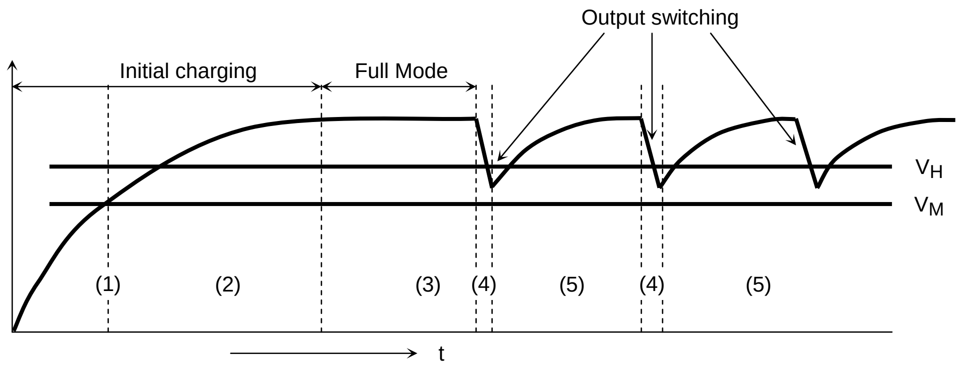


$V_H = V_M + V_{DD}$ = Charge pump voltage

i1 = Charge pump output current

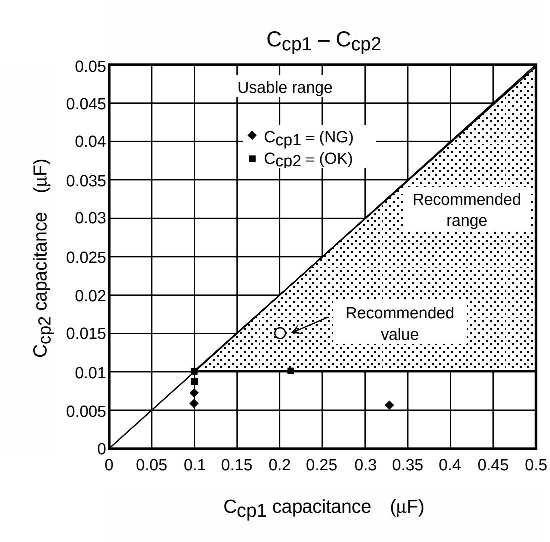
i2 = Gate consumption current

- At initial charging
  - (1) When the RESET circuit is released, Tr1 is turned on. Then Tr2 is turned off and C_{cp2} is charged from the V_M power supply via Di1.
  - (2) When Tr1 is turned off and Tr2 is turned on, C_{cp1} is charged from $C_{cp}2$ via Di2.
  - (3) When the potential difference between V_M and V_H (C_{cp} A pin voltage = charge pump voltage) reaches V_{DD} or higher, the operation of the charge pump circuit stops. (In Full Mode)
- When IC is operating
  - (4) C_{cp1} charge is used at f_{chop} switching and the V_H potential drops.
  - (5) Charges up by (1) and (2) above.



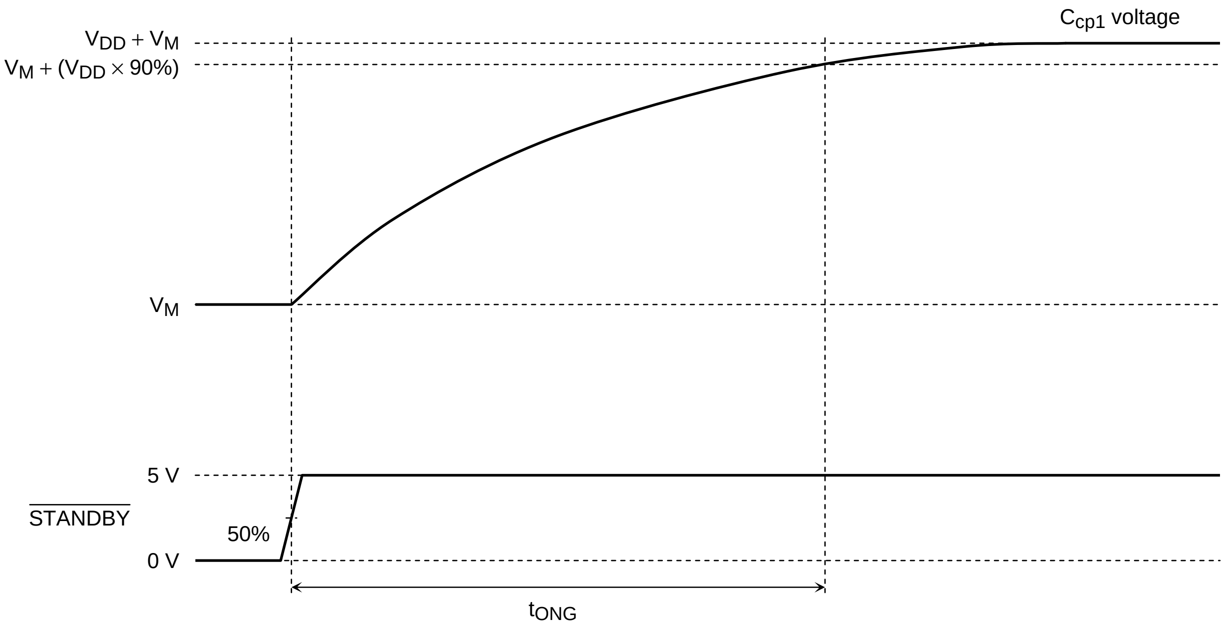
External Constant of Charge Pump

When V_{DD} = 5V, f_{chop} = 100 kHz, and L = 10 mH is driven with V_M = 24 V, I_{out} = 1000 mA, the theoretical values for C_{cp1} and C_{cp2} are as shown below:



For the combination of C_{cp1} and C_{cp2}, please refer to the shaded area in the figure above.
Toshiba recommends the relation of $C_{cp1} : C_{cp2} \geq 10 : 1$.
When the values of C_{cp1} and C_{cp2} are specified, perform an adequate test and allow sufficient margins for the values.
Please use the recommended values of C_{cp1} = 0.22 μF and C_{cp2} = 0. 022 μF for normal operation.

Startup Time of Charge Pump



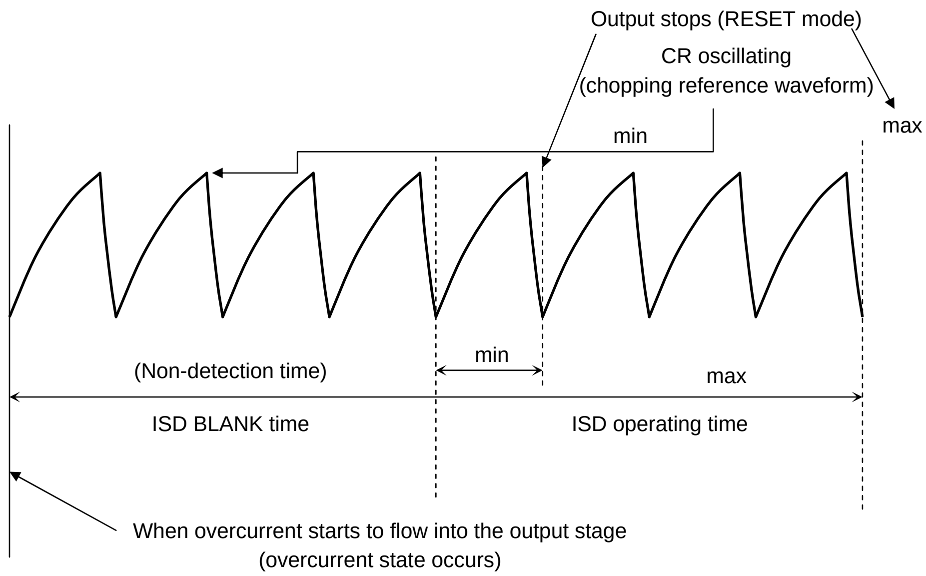
t_{ONG}: Time taken for capacitor C_{cp2} (charging capacitor) to fill up C_{cp1} (capacitor used to save charge) to V_M + V_{DD} after a reset is released.
Until the voltage of C_{cp1} reaches $V_M + V_{DD}$, the motor and the DCDC converter do not operate normally.
To prevent erroneous operations, the TB62205F incorporates a protection circuit.
When the voltage of the charge pump is increased up to the specified level, the motor can operate standalone. However, the initial charging of the DCDC converter starts at this timing. Thus, the DCDC converter startup time should be included when the system startup time is set.

Basically, the larger the C_{cp1} capacitance, the longer the initial charge-up time but the smaller the voltage fluctuation.
The smaller the C_{cp1} capacitance, the shorter the initial charge-up time but the larger the voltage fluctuation.

Depending on the combination of capacitors (especially with small capacitance), voltage may not be sufficiently boosted. Thus, use the capacitors under the capacitor combination conditions (C_{cp1} = 0.22 μF, C_{cp2} = 0.022 μF) recommended by Toshiba.

Operating Time of Overcurrent Protection Circuit

ISD non-detection time and ISD operating time



The overcurrent protection circuit has a non-detection time to prevent erroneous detection of spike current generated in diode recovery current (I_{RR}) or at switching. The non-detection time being synchronized with the CR cycle for setting chopping frequency is expressed as follows.

Non-detection time = 4 × CR cycle

Time required to stop the output after overcurrent flows into the output stage is expressed as follows.

Minimum time = 5 × CR cycle
Maximum time = 8 × CR cycle

Note that the operating times as shown above are achieved when overcurrent flows as it is expected. Depends on the timing of output control mode, the circuit may not be triggered.
Thus, to ensure safe operation, please insert a fuse in the V_M power supply.
(The capacity of the fuse is determined according to a condition to be used. Please select one whose capacity does not exceed the power dissipation for the IC to avoid any operating problems.)

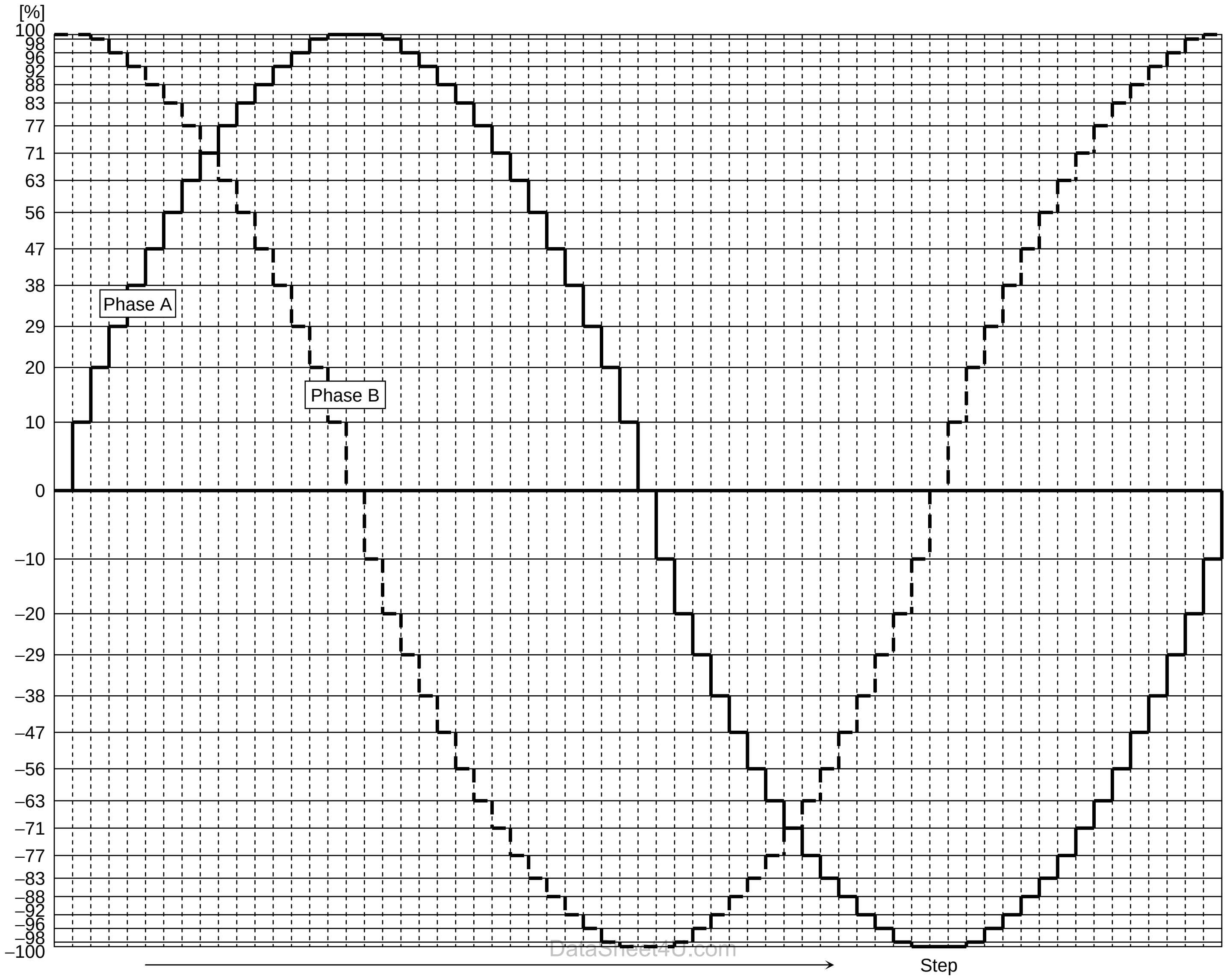
Example of Application Operation Input Data (4-bit micro-step drive)

	Torque 0	Torque 1	Decay B_0	Decay B_1	B_0	B_1	B_2	B_3	Phase B	Decay A_0	Decay A_1	A_0	A_1	A_2	A_3	Phase A
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0	1
2	1	1	1	0	1	1	1	1	1	1	0	1	0	0	0	1
3	1	1	1	0	0	1	1	1	1	1	0	0	1	0	0	1
4	1	1	1	0	1	0	1	1	1	1	0	1	1	0	0	1
5	1	1	1	0	0	0	1	1	1	1	0	0	0	1	0	1
6	1	1	1	0	1	1	0	1	1	1	0	1	0	1	0	1
7	1	1	1	0	0	1	0	1	1	1	0	0	1	1	0	1
8	1	1	1	0	1	0	0	1	1	1	0	1	1	1	0	1
9	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	1
10	1	1	1	0	1	1	1	0	1	1	0	1	0	0	1	1
11	1	1	1	0	0	1	1	0	1	1	0	0	1	0	1	1
12	1	1	1	0	1	0	1	0	1	1	0	1	1	0	1	1
13	1	1	1	0	0	0	1	0	1	1	0	0	0	1	1	1
14	1	1	1	0	1	1	0	0	1	1	0	1	0	1	1	1
15	1	1	1	0	0	1	0	0	1	1	0	0	1	1	1	1
16	1	1	1	0	1	0	0	0	1	1	0	1	1	1	1	1
17	1	1	1	0	0	0	0	0	1	1	0	1	1	1	1	1
18	1	1	1	0	0	0	0	0	0	1	0	1	1	1	1	1
19	1	1	1	0	1	0	0	0	0	1	0	1	1	1	1	1
20	1	1	1	0	0	1	0	0	0	1	0	0	1	1	1	1
21	1	1	1	0	1	1	0	0	0	1	0	1	0	1	1	1
22	1	1	1	0	0	0	1	0	0	1	0	0	0	1	1	1
23	1	1	1	0	1	0	1	0	0	1	0	1	1	0	1	1
24	1	1	1	0	0	1	1	0	0	1	0	0	1	0	1	1
25	1	1	1	0	1	1	1	0	0	1	0	1	0	0	1	1
26	1	1	1	0	0	0	0	1	0	1	0	0	0	0	1	1
27	1	1	1	0	1	0	0	1	0	1	0	1	1	1	0	1
28	1	1	1	0	0	1	0	1	0	1	0	0	1	1	0	1
29	1	1	1	0	1	1	0	1	0	1	0	1	0	1	0	1
30	1	1	1	0	0	0	1	1	0	1	0	0	0	1	0	1
31	1	1	1	0	1	0	1	1	0	1	0	1	1	0	0	1
32	1	1	1	0	0	1	1	1	0	1	0	0	1	0	0	1
33	1	1	1	0	1	1	1	1	0	1	0	1	0	0	0	1
34	1	1	1	0	1	1	1	1	0	1	0	0	0	0	0	1

	Torque 0	Torque 1	Decay B_0	Decay B_1	B_0	B_1	B_2	B_3	Phase B	Decay A_0	Decay A_1	A_0	A_1	A_2	A_3	Phase A
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
35	1	1	1	0	1	1	1	1	0	1	1	0	0	0	0	0
36	1	1	1	0	1	1	1	1	0	1	1	1	0	0	0	0
37	1	1	1	0	0	1	1	1	0	1	1	0	1	0	0	0
38	1	1	1	0	1	0	1	1	0	1	1	1	1	0	0	0
39	1	1	1	0	0	0	1	1	0	1	1	0	0	1	0	0
40	1	1	1	0	1	1	0	1	0	1	1	1	0	1	0	0
41	1	1	1	0	0	1	0	1	0	1	1	0	1	1	0	0
42	1	1	1	0	1	0	0	1	0	1	1	1	1	1	0	0
43	1	1	1	0	0	0	0	1	0	1	1	0	0	0	1	0
44	1	1	1	0	1	1	1	0	0	1	1	1	0	0	1	0
45	1	1	1	0	0	1	1	0	0	1	1	0	1	0	1	0
46	1	1	1	0	1	0	1	0	0	1	1	1	1	0	1	0
47	1	1	1	0	0	0	1	0	0	1	1	0	0	1	1	0
48	1	1	1	0	1	1	0	0	0	1	1	1	0	1	1	0
49	1	1	1	0	0	1	0	0	0	1	1	0	1	1	1	0
50	1	1	1	0	1	0	0	0	0	1	1	1	1	1	1	0
51	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	0
52	1	1	1	0	0	0	0	0	1	1	0	1	1	1	1	0
53	1	1	1	0	1	0	0	0	1	1	0	1	1	1	1	0
54	1	1	1	0	0	1	0	0	1	1	0	0	1	1	1	0
55	1	1	1	0	1	1	0	0	1	1	0	1	0	1	1	0
56	1	1	1	0	0	0	1	0	1	1	0	0	0	1	1	0
57	1	1	1	0	1	0	1	0	1	1	0	1	1	0	1	0
58	1	1	1	0	0	1	1	0	1	1	0	0	1	0	1	0
59	1	1	1	0	1	1	1	0	1	1	0	1	0	0	1	0
60	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	0
61	1	1	1	0	1	0	0	1	1	1	0	1	1	1	0	0
62	1	1	1	0	0	1	0	1	1	1	0	0	1	1	0	0
63	1	1	1	0	1	1	0	1	1	1	0	1	0	1	0	0
64	1	1	1	0	0	0	1	1	1	1	0	0	0	1	0	0
65	1	1	1	0	1	0	1	1	1	1	0	1	1	0	0	0
66	1	1	1	0	0	1	1	1	1	1	0	0	1	0	0	0
67	1	1	1	0	1	1	1	1	1	1	0	1	0	0	0	0
68	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0

Data are applied on the rising edge of CLK. Every input of a data string (16-bit) requires input of the Strobe signal.
For the function of the input signals, please refer to the section "Function".
In the above input data example, Decay Mode has a Mixed Decay mode (37.5%) setting for both the rising and falling directions of the sine wave, and a torque setting of 100%.

4W 1-2 Phase Excitation Output Current Waveform (4-bit micro-step drive)



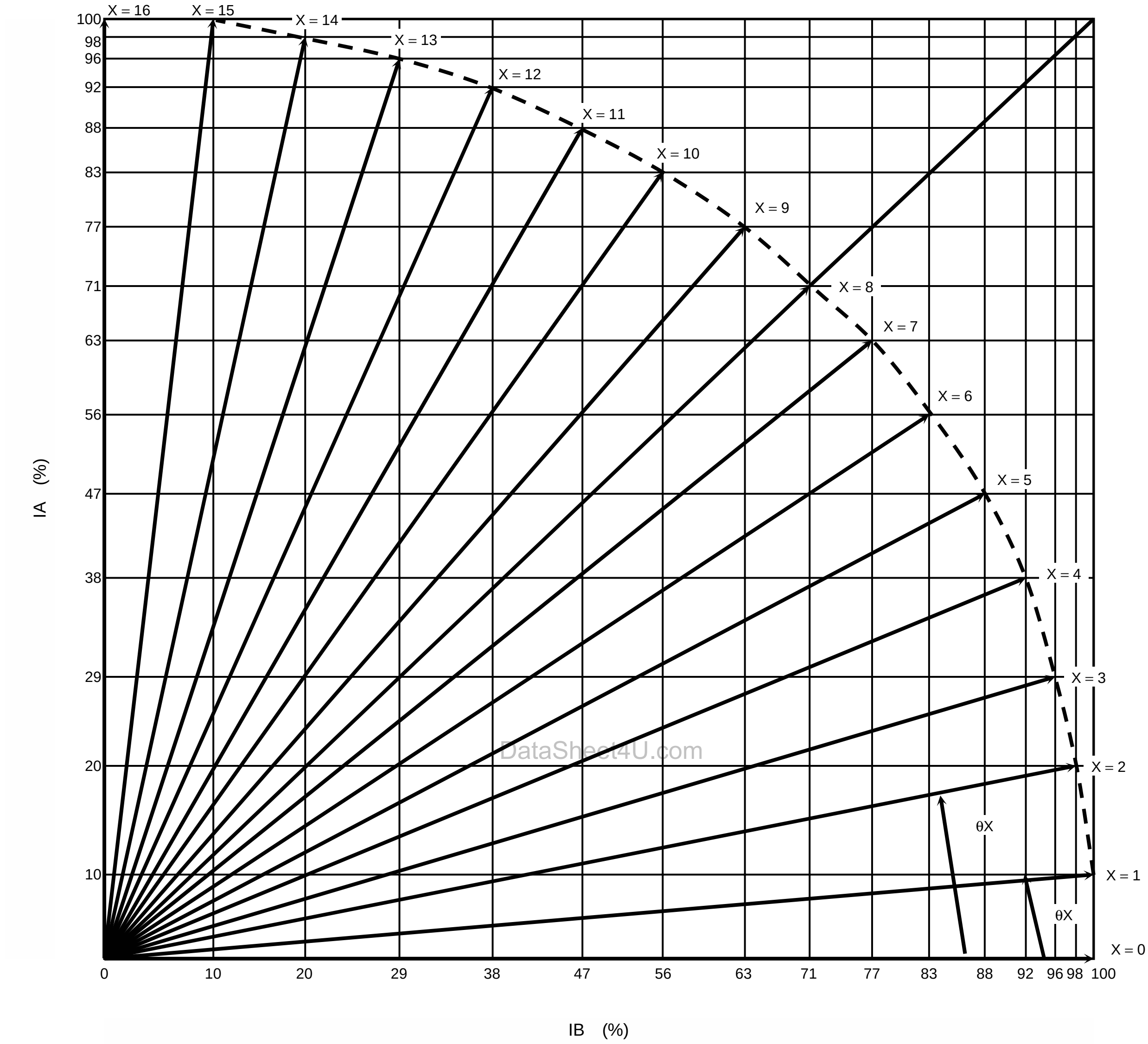
17-step micro-step drive from 0° to 90° can be achieved by combining Current DATA (AB and CD) and phase data.

For the input current data, please refer to “Current A0 to A3 and B0 to B3” in the section “Function”.

Depending on the load, the optimum condition changes for selecting Mixed Decay Mode when the sine wave rises and falls. Select the appropriate Mixed Decay timing according to the load.

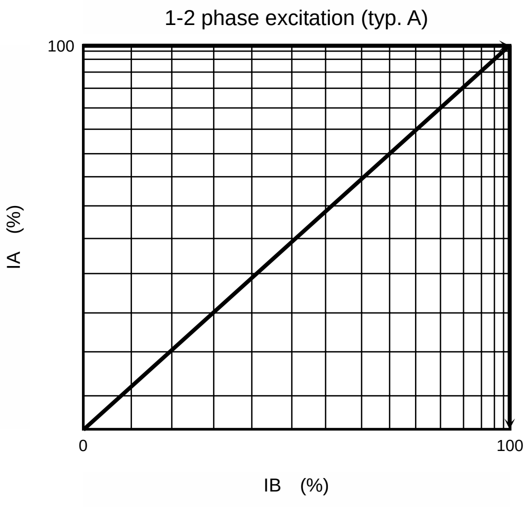
Output Current Vector Locus

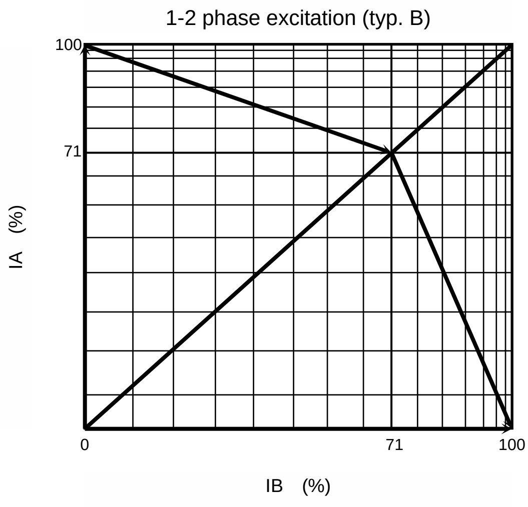
4W 1-2 Phase Excitation (4-bit micro-step drive)

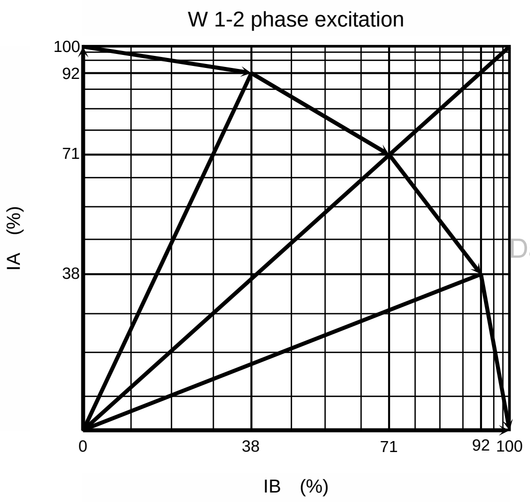


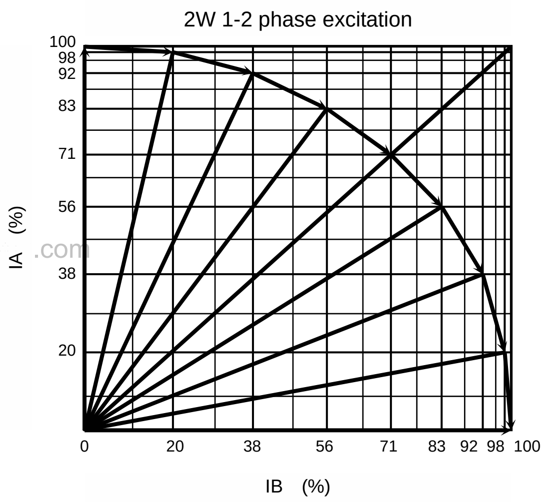
For the input data, please refer to the "Function" column in the "Current" row in the section "Function".

Output Vector Locus 2 (Modes other than 4 W 1-2 phase)

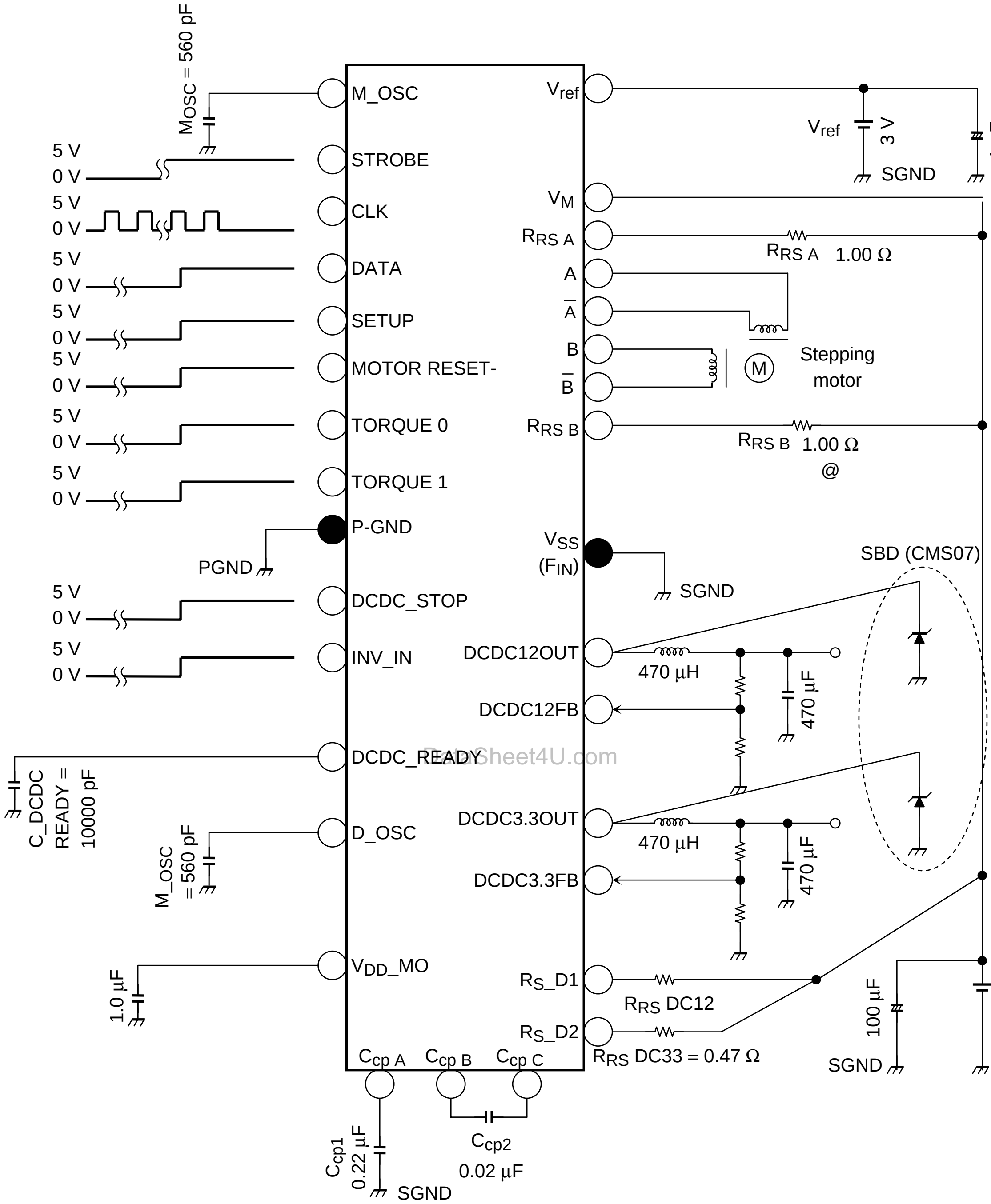








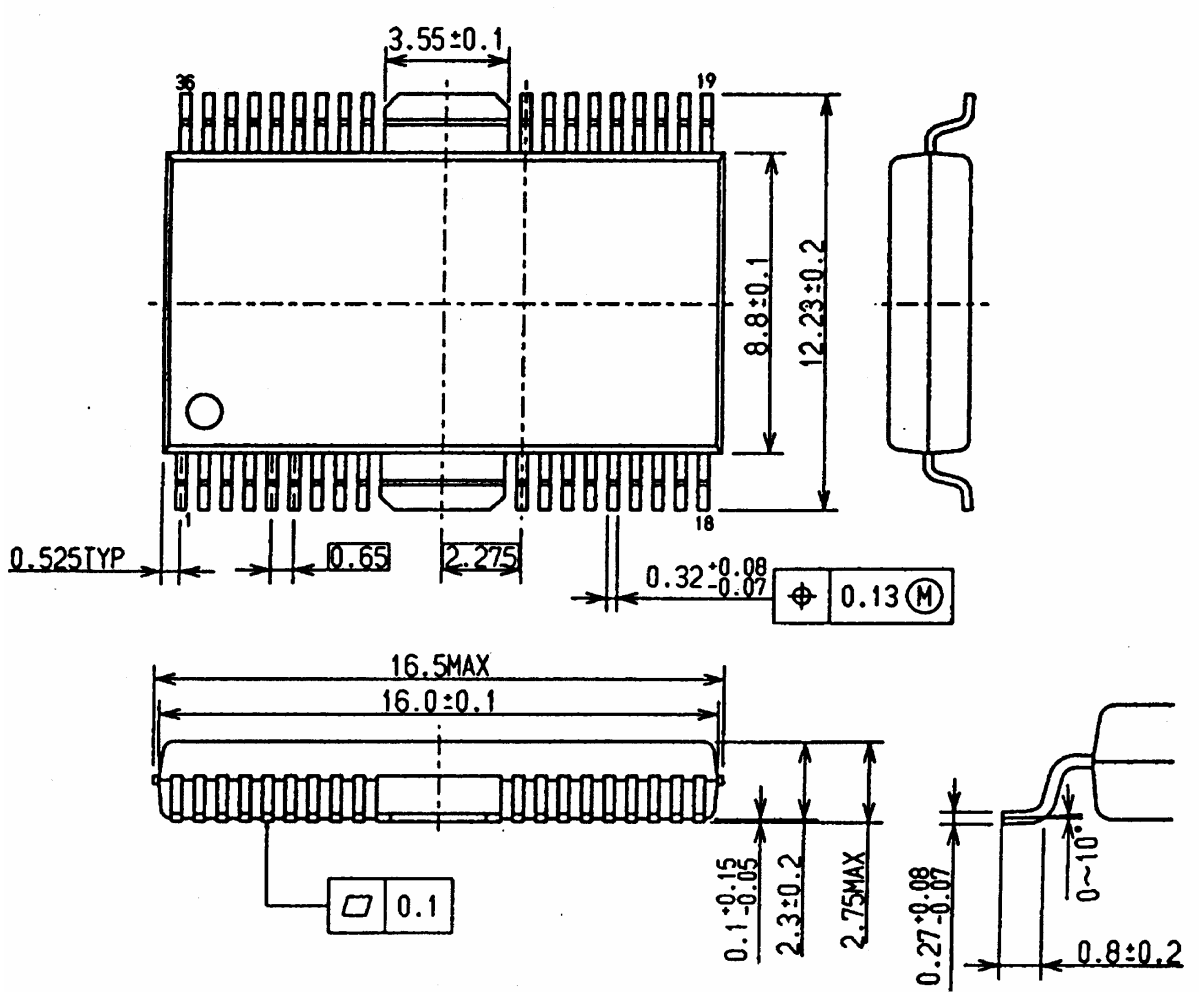
Application Circuit



Package Dimensions

HSOP36-P-450-0.65

Unit: mm



Weight: 0.79 g (typ.)

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