Brushless Motor Controller – SiS33035

Brushless DC Motor Controller in bare die form

Rev 1.0
25/10/22

Description

SiS33035 is a high performance monolithic brushless DC motor controller containing all of the active functions required to implement a full featured open loop, three or four phase motor control system. This device consists of a rotor position decoder for proper commutation sequencing, temperature compensated reference capable of supplying sensor power, frequency programmable sawtooth oscillator, three open collector top drivers, and three high current totem pole bottom drivers ideally suited for driving power MOSFETs. Also included are protective features consisting of undervoltage lockout, cycle−by−cycle current limiting with a selectable time delayed latched shutdown mode, internal thermal shutdown, and a unique fault output that can be interfaced into microprocessor controlled systems. Typical motor control functions include open loop speed, forward or reverse direction, run enable, and dynamic braking. SiS33035 is designed to operate with electrical sensor phasings of 60°/300° or 120°/240°, and can also efficiently control brush DC motors. requiring very high integration and reliability over temperature.

Features:

- 10 to 30V Operation
- Undervoltage Lockout
- 6.25V Reference Capable of Supplying Sensor Power
- Fully Accessible Error Amplifier for Closed Loop Servo Applications
- High Current Drivers Can Control External 3−Phase MOSFET Bridge
- Cycle−By−Cycle Current Limiting
- Pinned−Out Current Sense Reference
- Internal Thermal Shutdown
- Selectable 60°/300° or 120°/240° Sensor Phasings
- Can Efficiently Control Brush DC Motors with External MOSFET H−Bridge
- Wide temperature range.

Ordering Information

The following part suffixes apply:

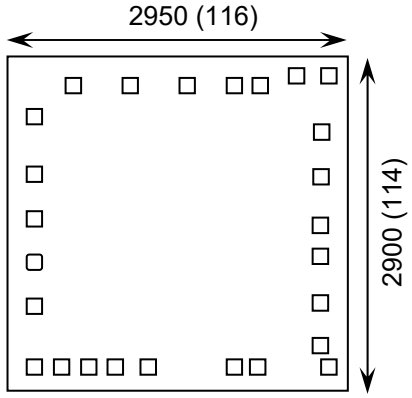
- No suffix - MIL-STD-883 /2010B Visual Inspection
- "**H**" - MIL-STD-883 /2010B Visual Inspection
  + MIL-PRF-38534 Class H LAT
- "**K**" - MIL-STD-883 /2010A Visual Inspection (Space)
  + MIL-PRF-38534 Class K LAT

LAT = Lot Acceptance Test.

For further information on LAT process flows see below.

www.siliconsupplies.com\quality\bare-die-lot-qualification

Die Dimensions in µm (mils)



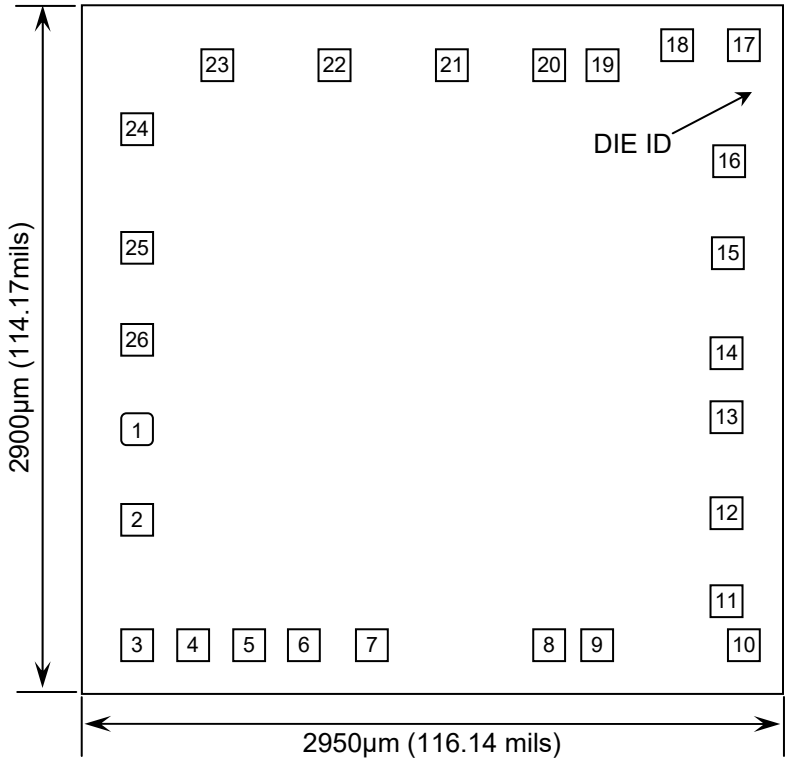
Supply Formats:

- Default – Die in Waffle Pack (100 per tray capacity)
- Sawn Wafer on Tape – On request
- Unsawn Wafer – On request
- Die Thickness <> 380µm(15 Mils) – On request
- Assembled into Ceramic Package – On request

Mechanical Specification

Die Size (Un-sawn)	2950 x 2900 116 x 114	µm mils
Minimum Bond Pad Size	125 x 125 4.92 x 4.92	µm mils
Die Thickness	380 (±20) 14.96 (±0.79)	µm mils
Top Metal Composition	Al	
Back Metal Composition	N/A – Bare Si	

Pad Layout and Functions



PAD	FUNCTION	COORDINATES (mm)	
		X	Y
1	B_T	0.165	1.062
2	A_T	0.165	0.679
3	FWD/REV	0.165	0.149
4	S_A	0.400	0.149
5	S_B	0.635	0.149
6	S_C	0.870	0.149
7	OUTPUT ENABLE	1.150	0.149
8	NO CONNECT	1.906	0.149
9	REFERENCE OUTPUT	2.106	0.149
10	CURRENT SENSE + INPUT	2.718	0.100
11	OSCILLATOR	2.648	0.334
12	ERROR AMP + INPUT	2.648	0.707
13	ERROR AMP – INPUT	2.648	1.113
14	ERROR AMP OUT/ PWM INPUT	2.648	1.378
15	$\overline{\text{FAULT}}$ OUT	2.648	1.802
16	CURRENT SENSE – INPUT	2.663	2.187
17	GND	2.721	2.675
18	GND	2.439	2.675
19	V_{CC}	2.126	2.590
20	V_C	1.905	2.590
21	C_B	1.492	2.590
22	B_B	0.995	2.590
23	A_B	0.498	2.590
24	60° / $\overline{120°}$ SELECT	0.165	2.322
25	BRAKE	0.165	1.822
26	C_T	0.165	1.438

Pad Descriptions (Please note assembled package pin-outs differ from die pad-outs)

PAD	SYMBOL	DESCRIPTION
1, 2, 26	B_T , A_T, C_T	These three open collector Top Drive outputs are designed to drive the external upper power switch transistors.
3	Fwd/Rev	The Forward/Reverse Input is used to change the direction of motor rotation.
4, 5, 6	S_A, S_B, S_C	These three Sensor Inputs control the commutation sequence.
7	Output Enable	A logic high at this input causes the motor to run, while a low causes it to coast.
8	No connect	Not used for device operation
9	Reference Output	This output provides charging current for the oscillator timing capacitor C_T and a reference for the error amplifier. It may also serve to furnish sensor power.
10	Current Sense Non-inverting Input	A 100 mV signal, with respect to Pad 16, at this input terminates output switch conduction during a given oscillator cycle. This pad normally connects to the top side of the current sense resistor.
11	Oscillator	The Oscillator frequency is programmed by the values selected for the timing components, R_T and C_T.
12	Error Amp Non-inverting Input	This input is normally connected to the speed set potentiometer.
13	Error Amp Inverting Input	This input is normally connected to the Error Amp Output in open loop applications.
14	Error Amp Out /PWM Input	This pad is available for compensation in closed loop applications.
15	$\overline{\text{Fault}}$ Output	This open collector output is active low during one or more of the following conditions: Invalid Sensor Input code, Enable Input at logic 0, Current Sense Input greater than 100 mV (Pad 10 with respect to Pad 18), Undervoltage Lockout activation, and Thermal Shutdown.
16	Current Sense Inverting Input	Reference pad for internal 100 mV threshold. This pad is normally connected to the bottom side of the current sense resistor.
17, 18	Gnd	These pads supply a ground for the control circuit and should be referenced back to the power source ground.
19	V_{CC}	This pad is the positive supply of the control IC. The controller is functional over a minimum V_{CC} range of 10 to 30 V.
20	V_C	The high state (V_{OH}) of the Bottom Drive Outputs is set by the voltage applied to this pad. The controller is operational over a minimum V_C range of 10 to 30 V.
21, 22, 23	C_B, B_B, A_B	These three totem pole Bottom Drive Outputs are designed for direct drive of the external bottom power switch transistors.
24	60°/$\overline{120}$° Select	The electrical state of this pad configures the control circuit operation for either 60° (high state) or $\overline{120}$° (low state) sensor electrical phasing inputs.
25	Brake	A logic low state at this input allows the motor to run, while a high state does not allow motor operation and if operating causes rapid deceleration.

Absolute Maximum Ratings[1] (Voltages referenced to GND unless otherwise stated)

PARAMETER	SYMBOL	VALUE	UNIT
Supply Voltage	V_{CC}	40	V
Digital Inputs (Pads 3, 4, 5, 6, 24, 25)	V_{IN}	V_{ref}	V
Oscillator Input Current (Source or Sink)	I_{OSC}	30	mA
Error Amp Input Voltage Range[2] (Pads 12, 13)	V_{IR}	-0.3 to V_{ref}	V
Error Amp Output Current[3] (Source or Sink)	I_{OUT}	10	mA
Current Sense Input Voltage Range (Pads 10, 16)	V_{Sense}	-0.3 to 5.0	V
$\overline{\text{Fault}}$ Output Voltage	$V_{CE(\overline{Fault})}$	20	V
$\overline{\text{Fault}}$ Output Sink Current	$I_{SINK(\overline{Fault})}$	20	mA
Top Drive Voltage (Pads 1, 2, 26)	$V_{CE(top)}$	40	V
Top Drive Sink Current (Pins 1, 2, 26)	$I_{SINK(top)}$	50	mA
Bottom Drive Supply Voltage (Pad 20)	V_C	30	V
Bottom Drive Output Current (Source or Sink, Pads 21,22, 23)	I_{DRV}	100	mA
Maximum Power Dissipation[4], T_A = 85°C	P_D	860	mW
Thermal Resistance[4], Junction-to-Air	$R_{\theta JA}$	100	°C/W
Operating Junction Temperature	T_J	150	°C
Operating Ambient Temperature Range	T_A	-40 to +85	°C
Storage Temperature Range	T_{STG}	-65 to 150	°C

1. Operation above the absolute maximum rating may cause device failure. Operation at the absolute maximum ratings, for extended periods, may reduce device reliability. **2.** The input common mode voltage or input signal voltage should not be allowed to go negative by more than 0.3V **3.** The compliance voltage must not exceed the range of −0.3 to V_{ref}. **4.** Measured in plastic DIP package, results in die form are dependent on die attach and assembly method.

DC Electrical Characteristics

V_{CC} = V_C = 20V, R_T = 4.7kΩ, C_T = 10nF, T_A = 25°C unless otherwise noted

PARAMETER	SYMBOL	CONDITIONS	LIMITS			UNITS
			MIN	TYP	MAX	
REFERENCE SECTION						
Reference Output Voltage	V_{ref}	I_{ref} = 1mA, T_A = 25°C	5.9	6.24	6.5	V
		I_{ref} = 1mA, T_A = -40 to 85°C	5.82	-	6.57	
Line Regulation	Reg_{line}	V_{CC} = 10 to 30V, I_{ref} = 1mA	-	1.5	30	mV
Load Regulation	Reg_{load}	I_{ref} = 1mA to 20mA	-	16	30	mV
Output Short Circuit Current	I_{SC}	-	40	75	-	mA
Reference Under Voltage Lockout Threshold	V_{th}	-	4.0	4.5	5.0	V

DC Electrical Characteristics

V_{CC} = V_C = 20V, R_T = 4.7kΩ, C_T = 10nF, T_A = 25°C unless otherwise noted

PARAMETER	SYMBOL	CONDITIONS		LIMITS MIN	LIMITS TYP	LIMITS MAX	UNITS
ERROR AMPLIFIER							
Input Offset Voltage	V_{IO}	T_A = -40 to 85°C		-	0.4	10	mV
Input Offset Current	I_{IO}	T_A = -40 to 85°C		-	8.0	500	nA
Input Bias Current	I_{IB}	T_A = -40 to 85°C		-	-46	-1000	nA
Input Common Mode Voltage Range	V_{ICR}	-		0	-	V_{ref}	V
Open Loop Voltage Gain	A_{VOL}	V_O = 3V, R_L = 15kΩ		70	80	-	dB
Input Common Mode Rejection Ratio	CMRR	-		55	86	-	dB
Power Supply Rejection Ratio	PSRR	V_{CC} = V_C = 10 to 30V		65	105	-	dB
Output Voltage Swing High State	V_{OH}	R_L = 15kΩ to Gnd		4.6	5.3	-	V
Output Voltage Swing Low State	V_{OL}	R_L = 15kΩ to V_{ref}		-	0.5	1.0	V
OSCILLATOR SECTION							
Oscillator Frequency	f_{OSC}	-		22	25	28	kHz
Frequency Change with Voltage	$\Delta f_{OSC}/\Delta V$	V_{CC} = 10 to 30V		-	0.01	5.00	%
Sawtooth Peak Voltage	$V_{OSC(P)}$	-		-	4.1	4.5	V
Sawtooth Valley Voltage	$V_{OSC(V)}$	-		1.2	1.5	-	V
LOGIC INPUTS							
Input Threshold Voltage High State	V_{IH}	Pads 3, 4, 5, 6, 7, 24, 25		3.0	2.2	-	V
Input Threshold Voltage Low State	V_{IL}			-	1.7	0.8	V
High State Input Current	I_{IH}	Sensor Inputs	V_{IH} = 5.0V	-150	-70	-20	µA
		Forward/Reverse		-75	-36	-10	
		60°/$\overline{120°}$ Select		-75	-36	-10	
		Output Enable		-60	-29	-10	
Low State Input Current	I_{IL}	Sensor Inputs	V_{IL} = 0V	-600	-337	-150	µA
		Forward/Reverse		-300	-175	-75	
		60°/$\overline{120°}$ Select		-300	-175	-75	
		Output Enable		-60	-29	-10	

DC Electrical Characteristics

V_{CC} = V_C = 20V, R_T = 4.7kΩ, C_T = 10nF, T_A = 25°C unless otherwise noted

PARAMETER	SYMBOL	CONDITIONS	LIMITS			UNITS
			MIN	TYP	MAX	
CURRENT-LIMIT COMPARATOR						
Threshold Voltage	V_{th}	-	85	101	115	mV
Input Common Mode Voltage Range	V_{ICR}	-	-	3.0	-	V
Input Bias Current	I_{IB}	-	-	-0.9	-5.0	μA
OUTPUTS AND POWER SECTIONS						
Top Drive Output Sink Saturation	$V_{CE(sat)}$	I_{sink} = 25 mA	-	0.5	1.5	V
Top Drive Output Off−State Leakage	$I_{DRV(leak)}$	V_{CE} = 30V	-	0.06	100	μA
Top Drive Output Switching Time	t_r	C_L = 47pF, R_L = 1kΩ	-	107	300	ns
	t_f		-	26	300	
Bottom Drive Output Voltage High State	V_{OH}	V_{CC} = 20V, V_C = 30V, I_{SOURCE} = 50mA	(V_{CC}-2.0)	(V_{CC} -1.1)	-	V
Bottom Drive Output Voltage Low State	V_{OL}	V_{CC} = 20V, V_C = 30V, I_{SINK} = 50mA	-	1.5	2.0	V
Bottom Drive Output Switching Time	t_r	C_L = 1000 pF	-	38	200	ns
	t_f		-	30	200	
$\overline{\text{Fault}}$ Output Sink Saturation	$V_{CE(sat)}$	I_{sink} = 16 mA	-	225	500	mV
$\overline{\text{Fault}}$ Output Off-State Leakage	$I_{FLT(leak)}$	V_{CE} = 20V	-	1.0	100	μA
Under Voltage Lockout	$V_{th(on)}$	Drive Output Enabled, V_{CC} or V_C Increasing	8.2	8.9	10	V
	V_H	Hysteresis	0.1	0.2	0.3	
Power Supply Current	I_{CC}	Pad 19 V_{CC} = V_C = 20V	-	12	16	mA
		Pad 19 V_{CC}=20V,V_C=30V	-	14	20	
	I_C	Pad 20 V_{CC} = V_C = 20V	-	3.5	6.0	
		Pad 20 V_{CC}=20V,V_C=30V	-	5.0	10	

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Three Phase, Six Step Commutation Truth Table

Inputs (Note 1, 2)										Outputs (Note 3)							
Sensor Electrical Phasing (Note 4)										Top Drives			Bottom Drives				
60°			120°														
S_A	S_B	S_C	S_A	S_B	S_C	F/R	Enable	Brake	Current Sense	A_T	B_T	C_T	A_B	B_B	C_B	$\overline{Fault}$	
1	0	0	1	0	0	1	1	0	0	0	1	1	0	0	1	1	(Note 5)
1	1	0	1	1	0	1	1	0	0	1	0	1	0	0	1	1	F/R = 1
1	1	1	0	1	0	1	1	0	0	1	0	1	1	0	0	1	
0	1	1	0	1	1	1	1	0	0	1	1	0	1	0	0	1	
0	0	1	0	0	1	1	1	0	0	1	1	0	0	1	0	1	
0	0	0	1	0	1	1	1	0	0	0	1	1	0	1	0	1	
1	0	0	1	0	0	0	1	0	0	1	1	0	1	0	0	1	(Note 5)
1	1	0	1	1	0	0	1	0	0	1	1	0	0	1	0	1	F/R = 0
1	1	1	0	1	0	0	1	0	0	0	1	1	0	1	0	1	
0	1	1	0	1	1	0	1	0	0	0	1	1	0	0	1	1	
0	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	1	
0	0	0	1	0	1	0	1	0	0	1	0	1	1	0	0	1	
1	0	1	1	1	1	X	X	0	X	1	1	1	0	0	0	0	(Note 6)
0	1	0	0	0	0	X	X	0	X	1	1	1	0	0	0	0	Brake = 0
1	0	1	1	1	1	X	X	1	X	1	1	1	1	1	1	0	(Note 7)
0	1	0	0	0	0	X	X	1	X	1	1	1	1	1	1	0	Brake = 1
V	V	V	V	V	V	X	1	1	X	1	1	1	1	1	1	1	(Note 8)
V	V	V	V	V	V	X	0	1	X	1	1	1	1	1	1	0	(Note 9)
V	V	V	V	V	V	X	0	0	X	1	1	1	0	0	0	0	(Note 10)
V	V	V	V	V	V	X	1	0	1	1	1	1	0	0	0	0	(Note 11)

NOTES:
1. V = Any one of six valid sensor or drive combinations X = Don't care.
2. The digital inputs (Pins 3, 4, 5, 6, 7, 22, 23) are all TTL compatible. The current sense input (Pin 9) has a 100 mV threshold with respect to Pin 15. A logic 0 for this input is defined as < 85 mV, and a logic 1 is > 115 mV.
3. The fault and top drive outputs are open collector design and active in the low (0) state.
4. With 60°/$\overline{120°}$ select (Pin 22) in the high (1) state, configuration is for 60° sensor electrical phasing inputs. With Pin 22 in low (0) state, configuration is for 120° sensor electrical phasing inputs.
5. Valid 60° or 120° sensor combinations for corresponding valid top and bottom drive outputs.
6. Invalid sensor inputs with brake = 0; All top and bottom drives off, $\overline{Fault}$ low.
7. Invalid sensor inputs with brake = 1; All top drives off, all bottom drives on, $\overline{Fault}$ low.
8. Valid 60° or 120° sensor inputs with brake = 1; All top drives off, all bottom drives on, $\overline{Fault}$ high.
9. Valid sensor inputs with brake = 1 and enable = 0; All top drives off, all bottom drives on, $\overline{Fault}$ low.
10. Valid sensor inputs with brake = 0 and enable = 0; All top and bottom drives off, $\overline{Fault}$ low.
11. All bottom drives off, $\overline{Fault}$ low.

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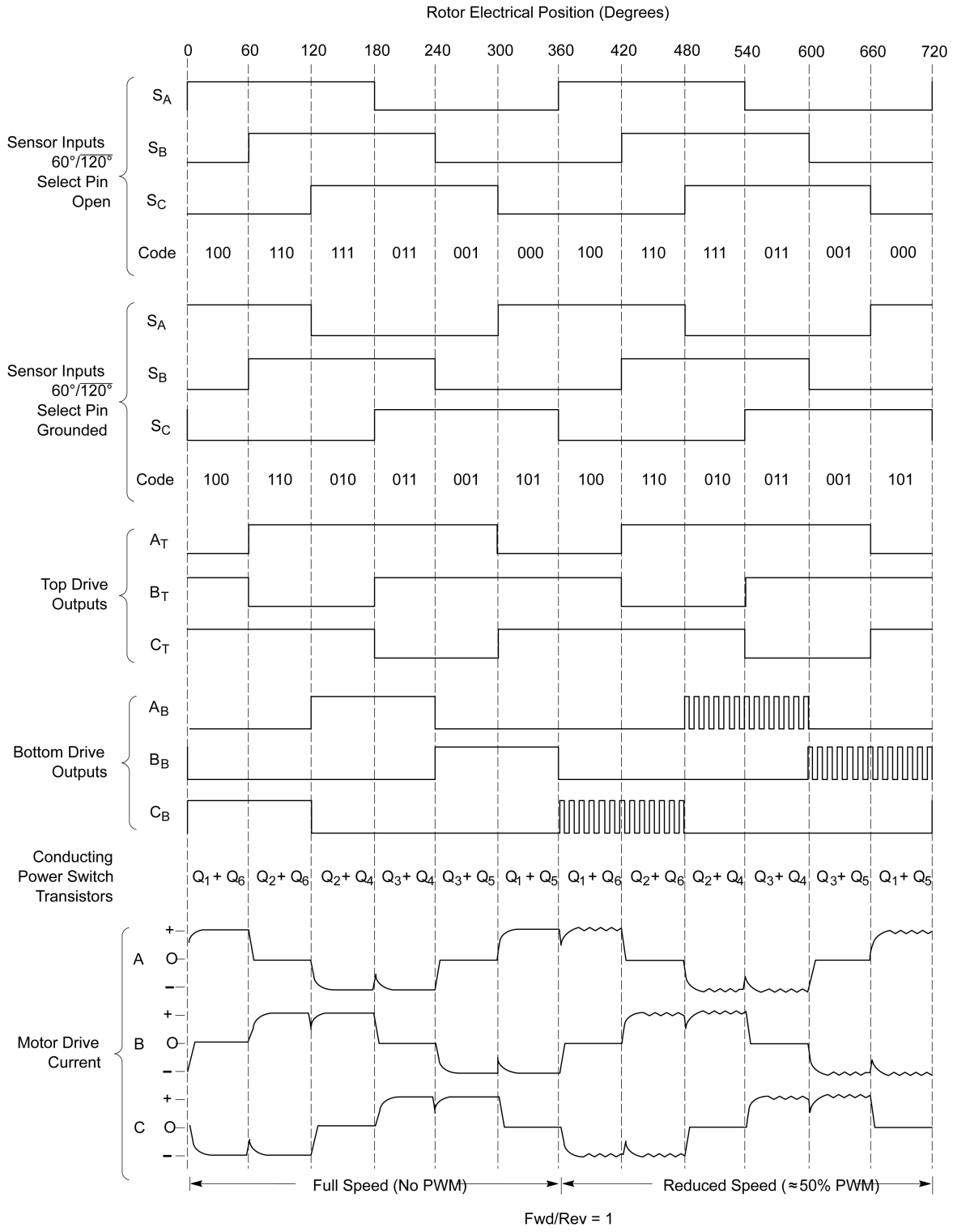
Three Phase, Six Step, Full Wave Commutation Waveforms



Representative Schematic Diagram