LIST OF FIGURES

Fig. 2.1	Different rotor configurations for BLDC (a) Surface magnets type (b)	
	Interior magnets type [55]	1.
Fig. 2.2	Basic block diagram of BLDC motor closed-loop control	1
Fig. 2.3	Equivalent circuit of BLDC motor	1
Fig. 2.4	Commutation sequence for 2-ΦO (a) prior to commutation (b)	
	commutation using two switches and one diode (c) three-diode	
	commutation (d) after commutation	2
Fig. 2.5	(a)trapezoidal back emf and ideal quasi square wave currents one	
	electrical cycle; motor operation at (b) base speed (c) above base	
	speed (d) below base speed	2
Fig. 2.6	Performance of BLDC motor 2-ΦO with conventional SSC at a speed	
	of 1000 rpm with applied load of 2.5Nm	2
Fig. 2.7	Performance of BLDC motor 2-ΦO with conventional SSC at a speed	
	of 1500 rpm with applied load of 2.5Nm	2
Fig. 2.8	Performance of BLDC motor 2-ΦO with conventional SSC at a speed	
	of 2000 rpm with applied load of 2.5Nm	2
Fig. 2.9	Performance of BLDC motor 2-ΦO with conventional SSC at a speed	
	of 3000 rpm with applied load of 2.5Nm	3
Fig. 3.1	Block diagram of hysteresis current control technique	3
Fig. 3.2	Ideal back emf and current waveforms	3
Fig. 3.3	Tuning of PI controller	3
Fig. 3.4	Investigation of hysteresis current control for phase A	4
Fig. 3.5	Variation in back emf with a speed change at 0.8 sec and 1.5 sec with	
	a constant load of 0.1 Nm	4
Fig. 3.6	Zoomed view of three-phase back emf at a speed of 2000 rpm	4
Fig. 3.7	Variation in stator current with a speed change at 0.8 sec and 1.5 sec	
	with a constant load of 0.1 Nm	4
Fig. 3.8	Zoomed view of three-phase stator current at a speed of 2000 rpm	4
Fig. 3.9	Speed change at 0.8 sec and 1.5 sec with a constant load of 0.1 Nm	4
Fig. 3.10	Variation in motor torque with a speed change at 0.8 sec and 1.5 sec	

	with a constant load of 0.1 Nm
Fig. 3.11	Zoomed view of (a) stator current (b) electromagnetic torque at a
	speed of 1000rpm
Fig. 3.12	Zoomed view of (a) stator current (b) electromagnetic torque at a
	speed of 1500rpm
Fig. 3.13	Zoomed view of (a) stator current (b) electromagnetic torque at a
	speed of 2000rpm
Fig. 3.14	Schematic block diagram of overall system
Fig. 3.15	Hardware System with STM32 Discovery Card
Fig. 3.16	Back emf and stator current at a speed of 2000 rpm
Fig. 3.17	Back emf and theta at a speed of 2000 rpm
Fig. 3.18	Theta and stator phase current at a speed of 2000 rpm
Fig. 3.19	Variation in actual speed with set speed
Fig. 4.1	Generalized theory of voltage vector selection
Fig. 4.2	Schematic diagram for the proposed MTSDTC technique
Fig. 4.3	Three-phase inverter circuit
Fig. 4.4	SSDTC stator flux linkage space vector representation
Fig. 4.5	For the TSDTC approach, voltage vector selection with the stator
	reference flux vector in sector I
Fig. 4.6	Three-phase inverter circuit operation with twelve-step DTC
	technique
Fig. 4.7	Phasor representation of the twelve voltage vectors defined for six
	sectors and the overlap region
Fig. 4.8	Phasor representation of voltage vector selection for the MTSDTC
	ONPWM and PWMON technique
Fig. 4.9	BLDC motor inverter switching states with the MTSDTC ONPWM
	control in the(a)conduction region (b)commutation region and (c)
	conduction region with +ve and -ve with torque error
Fig. 4.10	Inverter switching states of BLDC motor for the MTSDTC PWMON
	control with the transition of the voltage vector from sector V to sector
	VI
Fig. 4.11	Gate pulses for inverter switches with (a)SSDTC (b)MTSDTC
	(c)TSDTC (d)MTSDTC ONPWM (e)MTSDTC PWMON

Fig. 4.12	Variable speed operation of BLDC drive with a set speed of 500 rpm,	
	1000 rpm and 2000 rpm with a load of 1.2 Nm	78
Fig. 4.13	Zoomed view of speed change from 500rpm to 1000rpm	78
Fig. 4.14	Zoomed view of speed change from 1000rpm to 2000 rpm	79
Fig. 4.15	Variation in the electromagnetic torque with an initial load of 0.6 Nm	
	and with an increase in load at 0.25 sec to 1.2 Nm	79
Fig. 4.16	Variation in motor phase current with applied speed change and load	80
Fig. 4.17	Zoomed view of phase current at a speed of 1000 rpm (a) MTSDTC	
	PWMON	81
Fig. 4.18	Zoomed view of phase current at a speed of 2000 rpm (a) MTSDTC	
	PWMON	82
Fig. 4.19	Motor (a) phase current (b) torque ripple at a speed of 500 rpm for one	
	cycle	83
Fig. 4.20	Motor (a) phase current (b) torque ripple at a speed of 1000 rpm	84
Fig. 4.21	Motor (a) phase current (b) torque ripple at a speed of 2000 rpm	85
Fig. 4.22	Stator flux linkage plot for (a) MTSDTC PWMON (b) MTSDTC	
	ONPWM (c) TSDTC (d) SSDTC (e) MSSDTC	86
Fig. 4.23	Performance of BLDC motor drive at a speed of 1000rpm with a	
	constant load of 0.5Nm with (a)TSDTC (b) ONPWM and (c)	
	PWMON control	88
Fig. 4.24	Performance of BLDC motor with (a)TSDTC (b) ONPWM and (c)	
	PWMON control with (i)phase current Ia (ii)gate pulse S1(iii)motor	
	torque Tm and (iv) sector at speed of 1000 rpm with a constant load of	
	0.5Nm	90
Fig. 4.25	Performance of BLDC motor with (a)TSDTC (b) ONPWM and (c)	
	PWMON control with variation in (i)phase current Ia (ii)gate pulse	
	S1(iii)motor torque Tm and (iv) sector at speed of 2000 rpm with a	
	constant load of 0.5Nm	91
Fig. 4.26	Dynamic motor performance comparison with an applied speed	
	change at 0.2s and 0.4s with a constant load of 0.5Nm showing	
	variation in (i)speed (ii) motor torque (iii) phase current for variable	
	speed operation between (a)TSDTC (b)proposed MTSDTC ONPWM	
	and (b) proposed MTSDTC PWMON	93

Fig. 4.27	Dynamic motor performance comparison with a set speed of 1000rpm	
	and applied load changes at 0.2s and 0.4s between showing variation	
	in (i)speed (ii) motor torque (iii) phase current between (a)TSDTC	
	(b)proposed MTSDTC ONPWM and (b) proposed MTSDTC	
	PWMON	94
Fig. 4.28	Dynamic motor performance comparison with applied load changes at	
	0.2s and 0.4s with a set speed of 2000 rpm showing variation in	
	(i)gate pulses (ii)three-phase current (iii) motor torque (iv) speed	
	between (a)TSDTC (b)proposed MTSDTC ONPWM and (c)	
	proposed MTSDTC PWMON	95
Fig. 4.29	Schematic block diagram of the overall system	97
Fig. 4.30	Steady-state performance of BLDC motor (i) current and theta (ii)	
	sector and theta (iii) gating pulse for switch S1 and S2 (iv) speed and	
	torque at a speed of 1000 rpm with an applied load of 2A for	
	proposed (a) MTSDTC ONPWM and (b) MTSDTC PWMON	98
Fig. 4.31	Steady-state performance of motor with proposed DTC technique at a	
	speed of 1000 rpm with an applied load of 2A for (a) MTSDTC	
	ONPWM and (b) MTSDTC PWMON	99
Fig. 4.32	Steady-state performance of motor with proposed DTC technique at a	
	speed of 2000 rpm with an applied load of 2A for (a) MTSDTC	
	ONPWM (b) MTSDTC PWMON	100
Fig. 4.33	Behavior of BLDC motor current and torque in the conduction and	
	commutation region with under steady-state at a speed of 2000rpm	
	with an applied load of 2A for the proposed (a) MTSDTC ONPWM	
	(b) MTSDTC PWMON	101
Fig. 4.34	Dynamic performance of BLDC motor with speed change from	
	1000rpm to 2000rpm and from 2000rpm to 1000 rpm (i) zoomed view	
	of current and speed at 2000rpm (ii)) zoomed view of current and	
	speed at 1000rpm with a constant applied load of 2A for the	
	proposed(a) MTSDTC ONPWM (b) MTSDTC PWMON	102
Fig. 4.35	Dynamic performance of BLDC motor with a constant speed of	
	1000rpm under applied load change condition for the proposed(a)	
	MTSDTC ONPWM and (b) MTSDTC PWMON	103

Fig. 4.36	Dynamic performance of BLDC motor with applied load change and	
	constant speed of 1000 rpm for the proposed(a) MTSDTC ONPWM	
	and (b) MTSDTC PWMON	10
Fig. 4.37	Comparative plot showing % torque ripple for various DTC	
	techniques	10
Fig. 5.1	Schematic block diagram of the overall system with MSPWM	
	technique	11
Fig. 5.2	Voltage vector representation	11
Fig. 5.3	Performance comparison of BLDC motor with (a) Conventional SSC	
	technique at a speed of 2500 rpm with an applied load of 5 Nm (b)	
	MSPWM technique at a speed of 2500 rpm with applied load of 5 Nm	
	(c) MSPWM technique at a speed of 2500 rpm with applied load of	
	2.5 Nm	11
Fig. 5.4	Performance comparison of BLDC motor with (a) Conventional SSC	
	& (b) MSPWM technique at a speed of 3000 rpm with applied load of	
	2.5 Nm	11
Fig. 5.5	Performance comparison of BLDC motor with (a) Conventional SSC	
	& (b) MSPWM technique at a speed of 3000 rpm with applied load of	
	5Nm	12
Fig. 5.6	Performance comparison of BLDC motor with MSPWM technique	
	at a speed of 1750 rpm with applied load of (a) 5 Nm (b) 2.5 Nm	12
Fig. 5.7	Performance comparison of BLDC motor with MSPWM technique	
	at a speed of 3000 rpm with applied load of (a) 5 Nm (b) 2.5 Nm	12
Fig. 5.8	Comparison of current, speed, and torque at a speed of 3000rpm with	
	(a) Load of 2.5 Nm (b) Load of 5 Nm between the conventional SSC	
	and the proposed MSPWM technique	12
Fig. 5.9	Comparison of current, speed, and torque at a speed of 2500rpm with	
	(a) Load of 2.5 Nm (b) Load of 5 Nm between the conventional SSC	
	and the proposed MSPWM technique	12
Fig. 5.10	Comparison of current, speed, and torque motor at a speed of 1750rpm	
	with (a) Load of 2.5 Nm (b) Load of 5 Nm between the conventional	
	SSC and the proposed MSPWM technique	12
Fig. 5.11	Schematic block diagram of the overall system	12

Fig. 5.12	Experimental waveforms of modulating voltage, theta, phase current,	
	gate pulses for switch S1 at a speed of 1000 rpm under full load	
	condition	12
Fig. 5.13	Experimental waveforms of back emf, theta, phase current, gate pulses	
	for switch S1 with MSPWM technique at a speed of 1000 rpm under	
	full load condition	12
Fig. 5.14	Experimental waveforms of modulating voltage, theta, phase current,	
	gate pulses for switch S1 at a speed of 1500rpm under full load	
	condition	12
Fig. 5.15	Experimental waveforms of back emf, theta, phase current, gate pulses	
	for switch S1 with MSPWM technique at a speed of 1500rpm under	
	full load condition	12
Fig. 5.16	Experimental waveforms of (a) comparison between actual speed and	
	set speed, stator phase current with applied load change at a speed of	
	1000rpm	12
Fig. 5.17	Experimental waveforms of the behavior of actual motor speed, motor	
	torque, and stator phase current with applied load change at a speed	
	of 1000rpm	12
Fig. 5.18	Experimental waveforms of comparison between actual speed and set	
	speed, stator phase current with applied load change at a speed of	
	1500rpm	12
Fig. 5.19	Experimental waveforms of the behavior of stator phase current and	
	actual motor speed with change in set speed from 1500rpm to	
	1000rpm under constant load condition	13
Fig. 5.20	Experimental waveforms of the behavior of actual motor speed, motor	
	torque, and stator phase current with applied load change at a speed of	
	1500rpm	13
Fig. 5.21	Experimental waveforms of the behavior of actual motor torque,	
	motor speed, and stator phase current with applied speed change from	
	1500rpm to 1000rpm under constant load condition	13
Fig. 5.22	Experimental waveforms of comparison between actual speed and set	
	speed, stator phase current with applied load change at a speed of	
	3500rpm	13

Fig. 5.23	Experimental waveforms of actual motor speed, motor torque, and	
	stator phase current with applied load change at a speed of 3500rpm	
		132
Fig. 5.24	Comparative analysis between the proposed MSPWM technique and	
	six-step control showing torque ripple attenuation at different speed	
	and loading condition	135