

**8051-Based MCU**



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# **CGH081A**

# **Data Sheet**

***8Bit Single-Chip Microcontroller***  
***Embedded 600V 3-Phase Gate-Driver***

**Version: 0.30**

## Features

### Motor Driving Engine (MDE)

- Space Vector PWM (SVPWM)
- Supports Sine-Wave and Square-Wave Solutions
- Supports Hall Latch Input
- Supports Digital OCP and Analog OCP (Over Current Protection)
- Programmable Dead Band
- Programmable Angle Shift Control (-59° to 59° in 128 steps)
- Frequency Generator (FG)

### Gate Driver

- Embedded 600V 3-phase gate-driver
- Under voltage lockout for VCC15 and VBS
- Built-in 15V/5V LDO

### Embedded MCU

- MCS<sup>®</sup>-51 Compatible
- 1T 8052 Central Processing Unit
- 4.5V to 5.5V Operation Range
- 4 Level Priority Interrupt
- 13 Interrupt Sources
  - 1 External Interrupts (INT1N)
  - 2 External Interrupts (INT0N, INT1N)
  - 2 External OCP Interrupts (AOCP, OCP)
- Memory Size:
  - 8KB Flash Program Memory
  - 256 x 8-bit IRAM
  - 512 x 8-bit XRAM
- Up to 25 General-Purpose Input / Output (GPIO) Pins
- Three 16-bit Timer/Counters
- Watchdog (WD) Timer
- 8CH 10-bit ADC
- Full Duplex UART Serial Channel
- Fast Multiplication-Division Unit (MDU): 16\*16,32/16, 16/16, 32-bit L/R shifting and 32-bit normalization

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## 1. Description

The CGH081A is a 3-phase BLDC motor controller which embedded 3-phase 600V gate-driver and supports the hall-latch interfaces. The CGH081A supports both the six-phase-drive for torque intensive application and sine-wave-drive to effectively suppress motor vibration and with the built-in, innovated speed control mechanism; an ultra-high RPM can be achieved.

The OCP protection circuitry to prevent motor damage and enhance system reliability is built-in as well. The block diagram is shown in Figure 2.1

## 2. Block Diagram

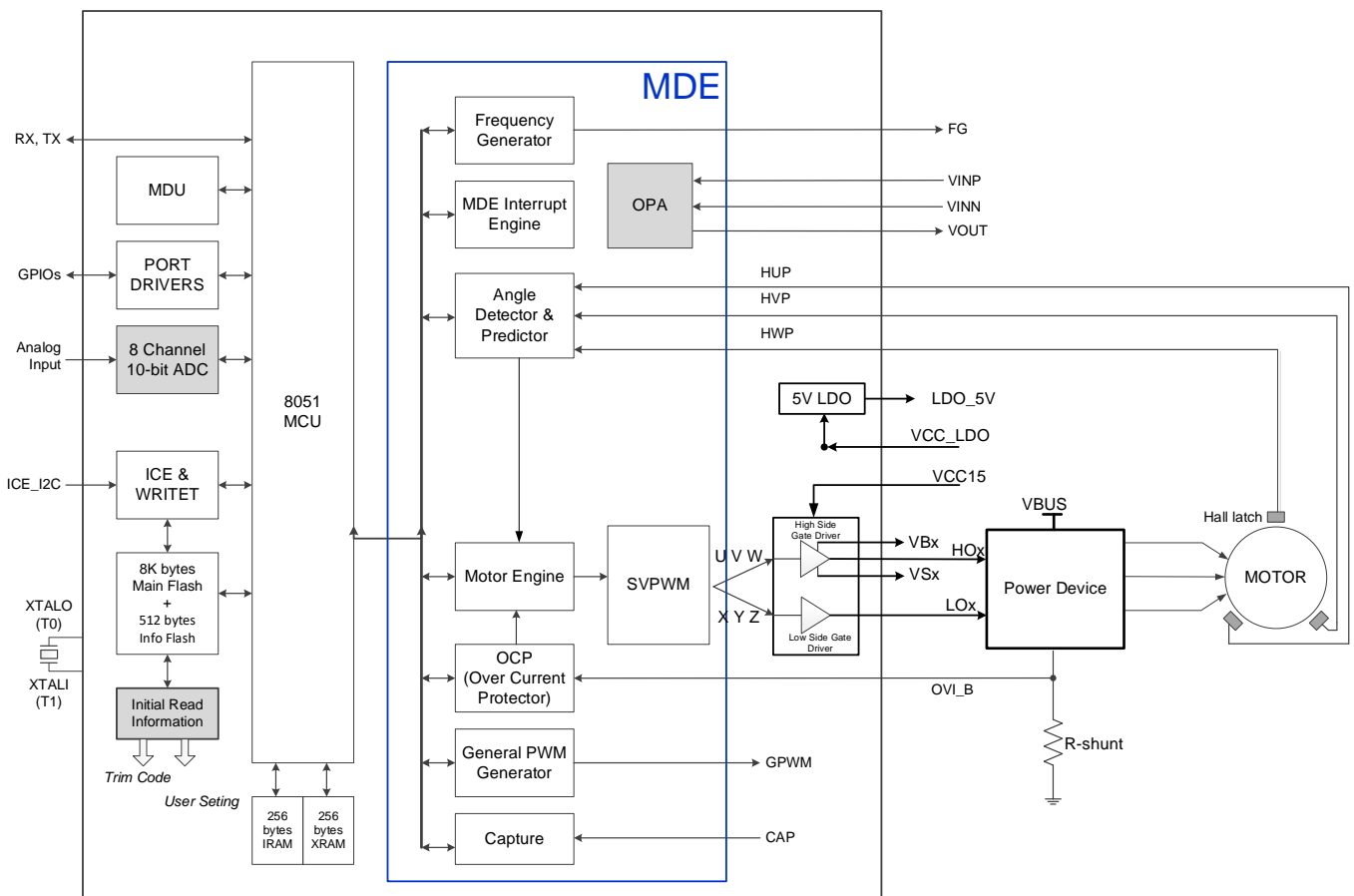
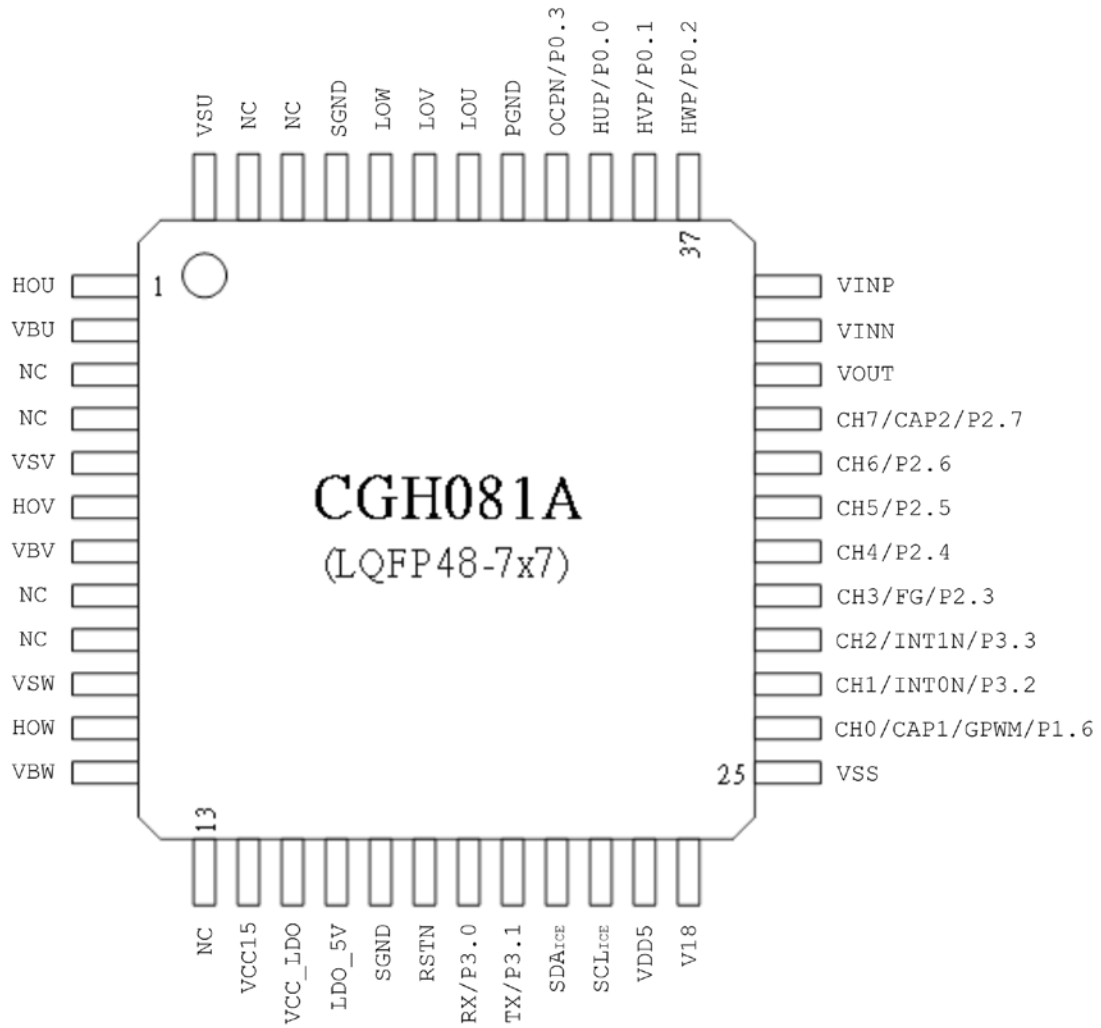


Figure 2.1 CGH081A BLDC motor controller block diagram



### 3. Pin Assignments

#### 3.1 Package Instruction LQFP7x7- 48(AD48)



## 4. Pin Definitions

Table 4.1 Pin Definitions

PIN	Name	Type	Description
48	VSU		High-side driver U-phase floating supply offset voltage
1	HOU	HV O	High-side driver U-phase gate driver output
2	VBU		High-side driver U-phase floating supply
5	VSV		High-side driver V-phase floating supply offset voltage
6	HOV	HV O	High-side driver V-phase gate driver output
7	VBV		High-side driver V-phase floating supply
10	VSW		High-side driver W-phase floating supply offset voltage
11	HOW	HV O	High-side driver W-phase gate driver output
12	VBW		High-side driver W-phase floating supply
14	VCC15	Power	Logic and low-side gate drivers power supply voltage
15	VCC_LDO	Power	LDO power supply voltage
16	LDO_5V	Power	5V LDO output
17	SGND	Ground	Logic ground
18	RSTN	I	System Reset.
33	CH7	I	Analog Input Ch7.
	CAP2	I	Capture Input 2
	P2.7	I/O	Bit 7 of Port 2.
32	CH6	I	Analog Input Ch6.
	P2.6	I/O	Bit 6 of Port 2.
31	CH5	I	Analog Input Ch5.
	P2.5	I/O	Bit 5 of Port 2.
30	CH4	I	Analog Input Ch4.
	P2.4	I/O	Bit 4 of Port 2.
29	CH3	I	Analog Input Ch3.
	FG	O	Frequency Generator Output
	P2.3	I/O	Bit 3 of Port 2.
19	RX	I	Serial Data Transmit (UART)
	P3.0	I/O	Bit 0 of Port 3.
20	TX	O	Serial Data Receive (UART)
	P3.1	I/O	Bit 1 of Port 3.
21	SDA <sub>ICE</sub>		For ICE (In Circuit Emulator).
22	SCL <sub>ICE</sub>		For ICE (In Circuit Emulator).
23	VDD5	Power	5.0V Voltage Input. A 0.1uF and 10uF (minimum) capacitor should be

			connected between this pin and VSS.
24	V18	O	1.8V Voltage Output. A 0.1uF and 1uF (minimum) capacitor should be connected between this pin and VSS.
25	VSS	Ground	Power Ground.
26	CH0	I	Analog Input Ch0.
	CAP1	I	Capture Input 1
	GPWM	O	General PWM output.
	P1.6	I/O	Bit 6 of Port 1.
27	CH1	I	Analog Input Ch1.
	INT0N	I	External Interrupt 0. Low level trigger or falling edge trigger.
	P3.2	I/O	Bit 2 of Port 3.
28	CH2	I	Analog Input Ch2.
	INT1N	I	External Interrupt 1. Low level trigger or falling edge trigger.
	P3.3	I/O	Bit 3 of Port 3.
37	HWP	I	Hall Latch input positive input. (HALL W)
	P0.2	I/O	Bit 2 of Port 0.
38	HVP	I	Hall Latch input positive input. (HALL V)
	P0.1	I/O	Bit 1 of Port 0.
34	VOUT	O	OPA output
35	VINN	I	OPA input (-)
36	VINP	I	OPA input (+)
39	HUP	I	Hall Latch input positive input.(HALL U)
	P0.0	I/O	Bit 0 of Port 0.
40	OCPN	I	Over current protection. Active-low.
	P0.3	I/O	Bit 3 of Port 0.
41	PGND	Ground	Low-side gate drivers ground
42	LOU	O	Low-side gate driver U-phase output
43	LOV	O	Low-side gate driver V-phase output
44	LOW	O	Low-side gate driver W-phase output
45	SGND	Ground	Logic ground

## 5. Absolute Maximum Ratings

Table 5.1 Absolute Maximum Ratings

Item	Min.	Typ.	Max.
VDD5 Supply Voltage	$V_{SS}-0.3V$		$V_{SS}+6.0V$
VDD5 Input Voltage	$V_{SS}-0.3V$		$V_{DD}+0.3V$
VCC15 Supply Voltage	-0.3V		20V
VB High Side floating supply Voltage	-0.3V		600V
VS High Side offset Voltage	$VB-18V$		$VB+0.3V$
VHO High Side gate-driver output Voltage	$VS-0.3V$		$VS+0.3V$
VLO Low Side gate-driver output Voltage	$PGND-0.3V$		$VCC15+0.3V$
$\Theta_{JA}$ Thermal Resistance, Junction-to-ambient (SSOP-28L)		82°C/W	
$\Theta_{JA}$ Thermal Resistance, Junction-to-ambient (QFN32-4x4)		30°C/W	
Storage Temperature	-50°C		150°C
Operating Temperature	-20°C		105°C
$I_{OH}$ Total		-80mA	
$I_{OL}$ Total		80mA	
Total Power Dissipation		500mW	
Electrostatic Discharge Capability – Human Body Mode		2000 (KV)	
Electrostatic Discharge Capability – Machine Mode		200 (V)	

## 6. D.C. Characteristics

Table 6.1 D.C. Characteristics

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V <sub>DD</sub>	Conditions				
Vcc15	Low side supply voltage	—	—	11	—	18	
LDO-5V Voltage	LDO-5V Output Range	—	VCC = 12V	4.5	5	5.5	V
LDO-5V Current	LDO-5V Current Range	—	VCC = 12V	—	20	30	mA
VB (U.V.W)	High side floating supply voltage	—	—	-8	—	600	V
VS (U.V.W)	High side offset voltage	—	—	$VB-18$	—	$VB-11$	V
VHO (U.V.W)	High side gate driver output voltage			VS		VB	V

VLO (U.V.W)	Low side gate driver output voltage			PGND		VCC	V
V <sub>DD</sub>	Operating Voltage	—	f <sub>sys</sub> =48MHz	4.5	5.0	5.5	V
V <sub>18</sub>	V <sub>18</sub> Output Range	—	Load Current < 10mA	1.62	1.80	1.98	V
I <sub>DD</sub>	Operating Current	5V	No load, f <sub>sys</sub> =48Mhz, ADC off, MDE off	—	9	12	mA
V <sub>IL</sub>	Input Low Voltage for I/O Ports.	—	—	0	—	0.3 V <sub>DD</sub>	V
V <sub>IH</sub>	Input High Voltage for I/O Ports.	—	—	0.7 V <sub>DD</sub>	—	V <sub>DD</sub>	V
V <sub>OL</sub>	Output Low Voltage for I/O Ports.	5V	I <sub>OL</sub> =5mA	—	—	0.5	V
V <sub>OH</sub>	Output High Voltage for I/O Ports.	5V	I <sub>OH</sub> =-3.8mA	4.5	—	—	V
R <sub>PU</sub>	Pull-up Resistance for I/O Ports	5V	—	10	35	50	KΩ
R <sub>PD</sub>	Pull-down Resistance for I/O Ports	5V	—	10	35	50	KΩ

## 7. A.C. Characteristics

Table 7.1 A.C. Characteristics

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V <sub>DD</sub>	Conditions				
f <sub>sys</sub>	System Frequency	4.5V~5.5V	Ta=-40°C to 125°C	TBD	48.0	TBD	MHz
			Ta=-20°C to 85°C	TBD	48.0	TBD	MHz
			Ta=25°C	-1%	48.0	+1%	MHz
f <sub>TIMER</sub>	Timer Input Pin Frequency	—	—	—	—	4	f <sub>sys</sub>
t <sub>INT</sub>	Interrupt Pulse Width	—	—	1	5	10	t <sub>sys</sub>
t <sub>V18</sub>	V <sub>18</sub> Stable Time	—	—	60	120	240	us
t <sub>RSDT</sub>	System Reset Delay Time(Power On Reset)	—	—	25	50	100	ms

## 8. OPA Characteristics

Table 8.1 OPA Characteristics

 $T_a=25^{\circ}\text{C}$ ,  $V_{DD}=5\text{V}$ ,  $V_{SS}=\text{GND}$ 

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{CRM}$	Common Mode Input Range		$V_{SS}-0.3$	—	$V_{DD}+0.3$	V
$V_{OS}$	Input Offset Voltage	$V_{CM}=V_{SS}$	-4.5		4.5	mV
$A_{OL}$	DC Open-Loop Gain	$V_{OUT}=0.3\text{V}\sim V_{DD}-0.3\text{V}$ $V_{CM}=V_{SS}$	88	112		dB
GBWP	Gain Bandwidth Product	$R_L=10\text{K}\Omega$ $C_L=60\text{pF}$		1		MHz
SR	Slew Rate	$C_L=60\text{pF}$		0.6		V/us

## 9. A/D Converter Characteristics

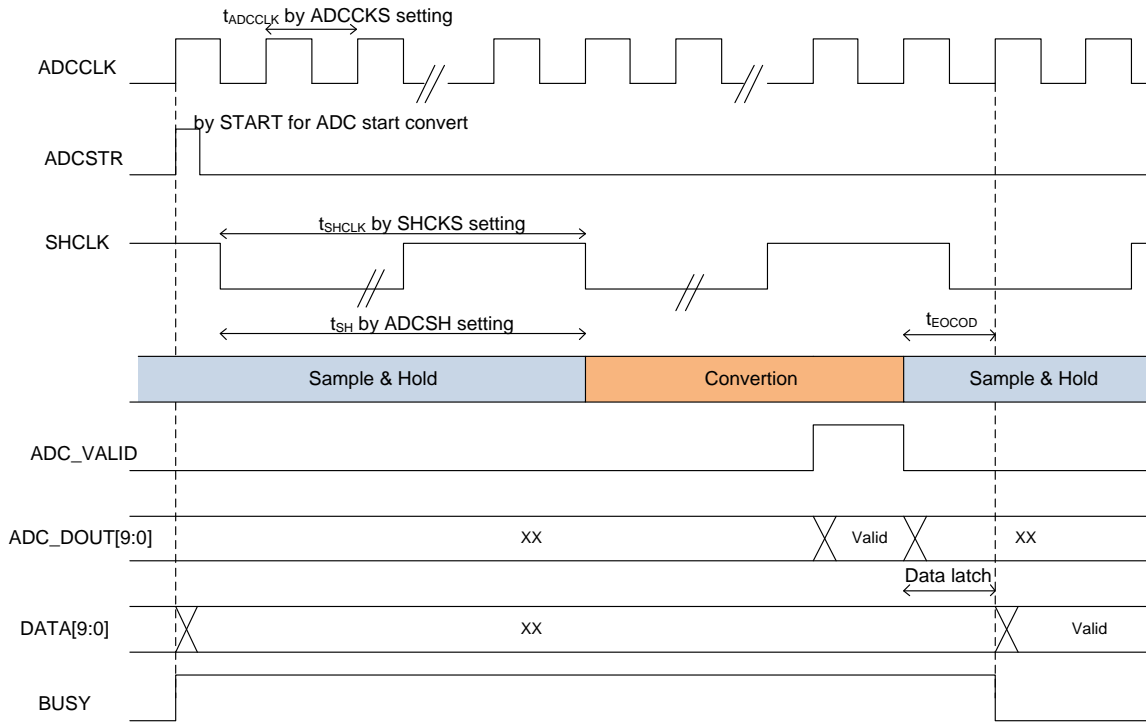


Figure 9.1 A/D Converter Characteristics

Table 9.1 A/D Converter Characteristics

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V <sub>DD</sub>	Conditions				
I <sub>AD</sub>	Additional Power Consumption if A/D Converter is Used	5V	—	—	4.5	—	mA
I <sub>ADSTB</sub>	A/D Converter Standby Current	—	Load Current < 10mA	—	—	4	uA
t <sub>ADCCLK</sub>	A/D Converter Clock Time	—	4MHz	—	0.25	—	us
		—	2MHz	—	0.5	—	us
t <sub>CONV</sub>	A/D Conversion Time	—	4MHz	—	3.25	—	us
		—	2MHz	—	6.5	—	us
t <sub>SHCLK</sub>	A/D Sample and Hold Clock Time	—	1MHz	—	1	—	us
		—	500KHz	—	2	—	us
		—	400KHz	—	2.5	—	us
		—	333KHz	—	3	—	us
t <sub>SH</sub>	A/D Sample and Hold Time	—	1MHz	1	—	2	us
		—	500KHz	2	—	4	us
		—	400KHz	2.5	—	5	us



		—	333KHz	3	—	6	us
DNL	Differential Non-linearity	4.5V	No load,	-1	—	+3	LSB
		5.5V	$t_{CONV}=2.5us$				
		4.5V	No load,	-1	—	+3	LSB
		5.5V	$t_{CONV}=5us$				
INL	Integral Non-linearity	4.5V	No load,	-4	—	+4	LSB
		5.5V	$t_{CONV}=2.5us$				
		4.5V	No load,	-4	—	+4	LSB
		5.5V	$t_{CONV}=5us$				
G <sub>ERR</sub>	Gain Error	—	—	-10	—	+10	LSB

## 10. Special Function Registers (SFR)

### 10.1 SFRs Memory Map

Table 10.1 SFRs Memory Map

	8	9	A	B	C	D	E	F	
F8	PINCONG1	PINCONG2	PINCONG3	PINCONG4	PINCONG5	PINCONG6	RSTS	TAKEY	FF
F0	B	PINSET1	PINSET2	PINSET3	PINSET4	PINSET5	PINSET6	PINSET7	F7
E8	ASUD1_1	ASUD1_2	ASUD1_3	ASUD1_4	ASUD2_1	ASUD2_2	ASUD2_3	ASUD2_4	EF
E0	ACC	AS_MD_CONT	MD0	MD1	MD2	MD3	MD4	MD5	E7
D8	CAPCONT	VRHALL	SVPWMAMPFT	MD_CONT	ASUR1	ASUR2	ASUR3	ASUR4	DF
D0	PSW	PFCON	ADCCONT	ADCSTR	----	ADCD1	ADCD2	SYNC	D7
C8	T2CON	CAPT_H	CAPT_L	CAPH_H	CAPH_L	----	----	----	CF
C0	IRCON1	SVPWMANGL	SVPWMANGH	SVPWMAMPL	SVPWMAMPH	FG_CTRL	----	----	C7
B8	IEN1	IP1	GPWMCONT	GPWMMAXL	GPWMMAXH	GPWMDYL	GPWMDYH	MIN_DUTY	BF
B0	P3	MPWMCONT1	MPWMCONT2	MPWMINV	TL2	TH2	WDTC	WDTK	B7
A8	IEN0	IP0	MPWMDYVL	MPWMDYVH	MCONT3	MPWMDYWL	MPWMDYWH	IMPMISC_FUN	AF
A0	P2	OCPCONT	MCONT2	MPWM_CYC_L	MPWM_CYC_H	MPWMDYUL	MPWMDYUH	MPWMDT	A7
98	SCON	SBUF	SRELL	SRELH	HALLDBT	MCONT1	AOCPCONT	IMPMISC_KEY	9F
90	P1	HALLSET1	HALLSET2	HALLSET3	HALLST	ONE_HALLSET	ROTORSPEEDL	ROTORSPEEDH	97
88	TCON	TMOD	TL0	TL1	TH0	TH1	AUX	AS	8F
80	P0	SP	DP0L	DP0H	DP1L	DP1H	RCON	PCON	87
	0	1	2	3	4	5	6	7	

## 10.2 CGH081A SFRs and Reset Value

Table 10.2 CGH081A SFRs and Reset Value

SYMBOL	DESCRIPTION	DIRECT ADDRESS	RESET VALUE
ACC	Accumulator	E0H	00H
ADCCONT	ADC Control Register	D2H	80H
ADCD1	ADC Data Register 1	D5H	00H
ADCD2	ADC Data Register 2	D6H	00H
ADCSTR	ADC Start Convert and Setting Register	D3H	00H
AOCPCONT	Analog OCP Control Register	9EH	0FH
AS	Angle Shift Control Register	8FH	00H
AS_MD_CONT	ASU and MDU Control Register	E1H	10H
ASUD1_1	ASU Data 1 byte 1	E8H	00H
ASUD1_2	ASU Data 1 byte 2	E9H	00H
ASUD1_3	ASU Data 1 byte 3	EAH	00H
ASUD1_4	ASU Data 1 byte 4	EBH	00H
ASUD2_1	ASU Data 2 byte 1	ECH	00H
ASUD2_2	ASU Data 2 byte 2	EDH	00H
ASUD2_3	ASU Data 2 byte 3	EEH	00H
ASUD2_4	ASU Data 2 byte 4	EFH	00H
ASUR1	ASU Result Register 1	DCH	00H
ASUR2	ASU Result Register 2	DDH	00H
ASUR3	ASU Result Register 3	DEH	00H
ASUR4	ASU Result Register 4	DFH	00H
AUX	Auxiliary	8EH	11H
B	B Register	F0H	00H
CAPCONT	Capture Control Register	D8H	03H
CAPH_H	Capture High-level Count High	CBH	00H
CAPH_L	Capture High-level Count Low	CCH	00H
CAPT_H	Capture Total Count High	C9H	00H
CAPT_L	Capture Total Count Low	CAH	00H
DPTR0:	Data Pointer (2 bytes)		
DP0H	Data Pointer 0 High	83H	00H
DP0L	Data Pointer 0 Low	82H	00H
DPTR1:	Data Pointer 1 (2 bytes)		
DP1H	Data Pointer 1 High	85H	00H
DP1L	Data Pointer 1 Low	84H	00H
FG_CTRL	Frequency Generator Control Register	C5H	00H

GPWMCONT	General PWM Control Register	BAH	00H
GPWMDYH	General PWM Duty Register High	BEH	FFH
GPWMDYL	General PWM Duty Register Low	BDH	FFH
GPWMMAXH	General PWM Max Register High	BCH	00H
GPWMMAXL	General PWM Max Register Low	BBH	02H
HALLDBT	Hall De-bounce Time Register	9CH	0EH
HALLSET1	Hall Setting Register 1	91H	45H
HALLSET2	Hall Setting Register 2	92H	26H
HALLSET3	Hall Setting Register 3	93H	13H
HALLST	Hall Status Register	94H	XXH
IEN0	Interrupt Enable Register 0	A8H	00H
IEN1	Interrupt Enable Register 1	B8H	00H
IMPMISC_FUN	Improve Miscellaneous Function Setting Register	AFH	10H
IMPMISC_KEY	Improve Miscellaneous Function Turn On Key Register	9FH	00H
IP0	Interrupt Priority Register 0	A9H	00H
IP1	Interrupt Priority Register 1	B9H	00H
IRCON1	Interrupt Request Register 1	C0H	00H
MCONT1	Motor Control Register 1	9DH	X0110000B
MCONT2	Motor Control Register 2	A2H	00H
MCONT3	Motor Control Register 3	ACH	03H
MD_CONT	MDU Control Register	DBH	00H
MD0	Multiplication Division Register 0	E2H	00H
MD1	Multiplication Division Register 1	E3H	00H
MD2	Multiplication Division Register 2	E4H	00H
MD3	Multiplication Division Register 3	E5H	00H
MD4	Multiplication Division Register 4	E6H	00H
MD5	Multiplication Division Register 5	E7H	00H
MIN_DUTY	Minimum Duty Limit Register	BFH	00H
MPWMCONT1	MPWM Control Register 1	B1H	00H
MPWMCONT2	MPWM Control Register 2	B2H	00H
MPWMDT	Motor PWM Dead-Time Register	A7H	00H
MPWMDYUH	Motor PWM Duty Register U High (Phase U)	A6H	07H
MPWMDYUL	Motor PWM Duty Register U Low (Phase U)	A5H	FFH
MPWMDYVH	Motor PWM Duty Register V High (Phase V)	ABH	07H
MPWMDYVL	Motor PWM Duty Register V Low (Phase V)	AAH	FFH
MPWMDYWH	Motor PWM Duty Register W High (Phase W)	AEH	07H
MPWMDYWL	Motor PWM Duty Register W Low (Phase W)	ADH	FFH
MPWMINV	MPWM Inverse Selection Register	B3H	00H

MPWM_CYC_H	Motor PWM Cycle High Byte	A4H	00H
MPWM_CYC_L	Motor PWM Cycle Low Byte	A3H	02H
OCPCONT	OCP Control Register	A1H	04H
ONE_HALLSET	One Hall Setting Register	95H	04H
P0	Port 0	80H	FFH
P1	Port 1	90H	FFH
P2	Port 2	A0H	FFH
P3	Port 3	B0H	FFH
PCON	Power Control Register	87H	00H
PFCON	Peripheral Frequency Control Register	D1H	00H
PINCONG1	Pin Configure Register 1	F8H	AAH
PINCONG2	Pin Configure Register 2	F9H	AAH
PINCONG3	Pin Configure Register 3	FAH	A0H
PINCONG4	Pin Configure Register 4	FBH	AAH
PINCONG5	Pin Configure Register 5	FCH	AAH
PINCONG6	Pin Configure Register 6	FDH	A0H
PINSET1	Pin I/O Setting Register 1	F1H	AAH
PINSET2	Pin I/O Setting Register 2	F2H	AAH
PINSET3	Pin I/O Setting Register 3	F3H	0AH
PINSET4	Pin I/O Setting Register 4	F4H	00H
PINSET5	Pin I/O Setting Register 5	F5H	80H
PINSET6	Pin I/O Setting Register 6	F6H	2AH
PINSET7	Pin I/O Setting Register 7	F7H	FFH
PSW	Program Status Word Register	D0H	00H
RCON	Internal RAM Control Register	86H	F0H
ROTORSPEEDH	Rotor Speed Count Register High	97H	FFH
ROTORSPEEDL	Rotor Speed Count Register Low	96H	FFH
RSTS	Reset Source Register	FEH	0AH
SBUF	Serial Port Data Buffer	99H	00H
SCON	Serial Port Control Register	98H	00H
SP	Stack Pointer	81H	07H
SRELH	Serial Port Reload Register High	9BH	00H
SRELL	Serial Port Reload Register Low	9AH	00H
SVPWMAMPFT	SVPWM Amplitude Fine-Tune Register	DAH	00H
SVPWMAMPH	SVPWM Amplitude Register High	C4H	00H
SVPWMAMPL	SVPWM Amplitude Register Low	C3H	00H
SVPWMANGH	SVPWM Angular Register High	C2H	00H
SVPWMANGL	SVPWM Angular Register Low	C1H	00H

SYNC	MDE Sync Register	D7H	00H
T2CON	Timer2 Control Register	C8H	00H
TAKEY	Time Access Key Register	FFH	00H
TCON	Timer 0/1 Control Register	88H	00H
TH0	Timer0 High byte	8CH	00H
TH1	Timer1 High byte	8DH	00H
TH2	Timer2 High byte	B5H	00H
TL0	Timer0 Low byte	8AH	00H
TL1	Timer1 Low byte	8BH	00H
TL2	Timer2 Low byte	B4H	00H
TMOD	Timer 0/1 Mode Register	89H	00H
VRHALL	Virtual Hall Register	D9H	05H
WDTC	Watchdog Timer Control Register	B6H	04H
WDTK	Watchdog Timer Refresh Key	B7H	00H

## 11. Memory

**CGH081A** memory structure follows the general 8052 structures.

There are three memory areas: Program Memory (Flash), External Data Memory (XRAM) and Internal Data Memory (IRAM). In addition, **CGH081A** integrates 8Kbytes Flash, 256bytes IRAM and 256bytes XRAM.

### 11.1. Program Memory

**CGH081A** contains 8Kbytes of on-chip Flash memory for program storage.

### 11.2. Data Memory

**CGH081A** contains 256bytes of general internal data memory (IRAM) and 256 bytes of external data memory (XRAM).

#### 11.2.1 Data Memory (IRAM)(00H~FFH)

The lower 128 bytes of IRAM may be accessed through both direct and indirect addressing. The upper 128 bytes of IRAM and the 128 bytes of SFR registers share the same address space. The upper 128 bytes of data memory may only be accessed using indirect addressing. The SFR registers can only be accessed through direct addressing. The lowest 32 bytes (00H -1FH) of data memory are grouped into 4 banks of 8 registers each. The **RS0** and **RS1** bits (**PSW.3** and **PSW.4**) select which register bank is in use. Instructions using register addressing will only access the currently specified bank.

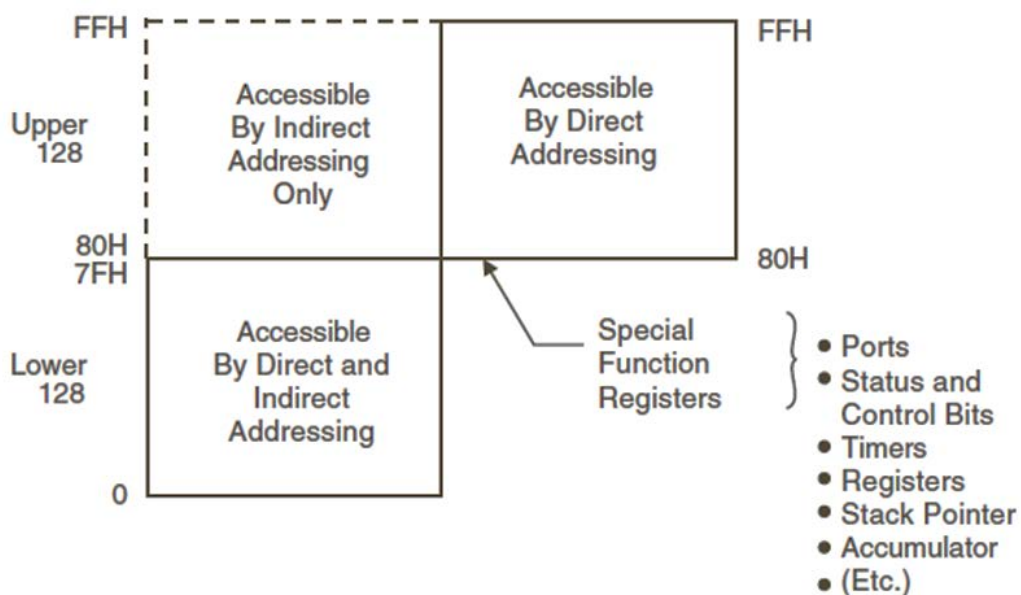


Figure 11.2.1 Data Memory (IRAM)(00H~FFH)

### 11.2.2 Data Memory (XRAM)(F000H~F0FFH)

External addresses F000H to F0FFh contain the on-chip expanded SRAM. This memory can be accessed via external direct addressing mode (with **MOVX** instructions). The address space of instruction **MOVX @Ri, A** (i=0,1) is determined by **RCON** [7:0] of SFR 86**HRCON**(internal RAM control register). The default setting of **RCON** [7:0] is F0h (page0). One page of XRAM is 256 bytes.

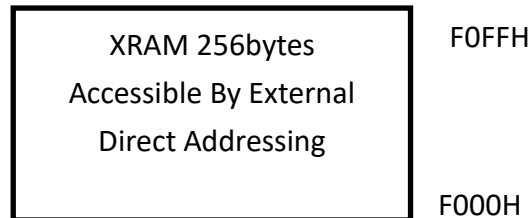


Figure 11.2.2 Data Memory (XRAM)(F000H~F0FFH)



## 12. Instruction Set

CGH081A is fully binary compatible with the MCS-51 instruction set.

Table 12.1 Instruction Set

Arithmetic operations	Description	Bytes	Cycles	Hex Code
ADD A,Rn	Add register to accumulator	1	1	0x28-0x2F
ADD A,direct	Add directly addressed data to accumulator	2	2	0x25
ADD A,@Ri	Add indirectly addressed data to accumulator	1	2	0x26-0x27
ADD A,#data	Add immediate data to accumulator	2	2	0x24
ADDC A,Rn	Add register to accumulator with carry	1	1	0x38-0x3F
ADDC A,direct	Add directly addressed data to accumulator with carry	2	2	0x35
ADDC A,@Ri	Add indirectly addressed data to accumulator with carry	1	2	0x36-0x37
ADDC A,#data	Add immediate data to accumulator with carry	2	2	0x34
SUBB A,Rn	Subtract register from accumulator with borrow	1	1	0x98-0x9F
SUBB A,direct	Subtract directly addressed data from accumulator with borrow	2	2	0x95
SUBB A,@Ri	Subtract indirectly addressed data from accumulator with borrow	1	2	0x96-0x97
SUBB A,#data	Subtract immediate data from accumulator with borrow	2	2	0x94
INC A	Increment accumulator	1	1	0x04
INC Rn	Increment register	1	2	0x08-0x0F
INC direct	Increment directly addressed location	2	3	0x05
INC @Ri	Increment indirectly addressed location	1	3	0x06-0x07
INC DPTR	Increment data pointer	1	1	0xA3
DEC A	Decrement accumulator	1	1	0x14
DEC Rn	Decrement register	1	2	0x18-0x1F
DEC direct	Decrement directly addressed location	2	3	0x15
DEC @Ri	Decrement indirectly addressed location	1	3	0x16-0x17
MUL AB	Multiply A and B	1	5	0xA4
DIV	Divide A by B	1	5	0x84
DA A	Decimally adjust accumulator	1	1	0xD4

Logic operations	Description	Bytes	Cycles	Hex Code
ANL A,Rn	AND register to accumulator	1	1	0x58-0x5F
ANL A,direct	AND directly addressed data to accumulator	2	2	0x55
ANL A,@Ri	AND indirectly addressed data to accumulator	1	2	0x56-0x57
ANL A,#data	AND immediate data to accumulator	2	2	0x54
ANL direct,A	AND accumulator to directly addressed location	2	3	0x52
ANL direct,#data	AND immediate data to directly addressed location	3	4	0x53
ORL A,Rn	OR register to accumulator	1	1	0x48-0x4F
ORL A,direct	OR directly addressed data to accumulator	2	2	0x45
ORL A,@Ri	OR indirectly addressed data to accumulator	1	2	0x46-0x47
ORL A,#data	OR immediate data to accumulator	2	2	0x44
ORL direct,A	OR accumulator to directly addressed location	2	3	0x42
ORL direct,#data	OR immediate data to directly addressed location	3	4	0x43
XRL A,Rn	Exclusive OR register to accumulator	1	1	0x68-0x6F
XRL A,direct	Exclusive OR directly addressed data to accumulator	2	2	0x65
XRL A,@Ri	Exclusive OR indirectly addressed data to accumulator	1	2	0x66-0x67
XRL A,#data	Exclusive OR immediate data to accumulator	2	2	0x64
XRL direct,A	Exclusive OR accumulator to directly addressed location	2	3	0x62
XRL direct,#data	Exclusive OR immediate data to directly addressed location	3	4	0x63
CLR A	Clear accumulator	1	1	0xE4
CPL A	Complement accumulator	1	1	0xF4
RL A	Rotate accumulator left	1	1	0x23
RLC A	Rotate accumulator left through carry	1	1	0x33
RR A	Rotate accumulator right	1	1	0x03
RRC A	Rotate accumulator right through carry	1	1	0x13
SWAP A	Swap nibbles within the accumulator	1	1	0xC4

Data transfer operations	Description	Bytes	Cycles	Hex Code
MOV A,Rn	Move register to accumulator	1	1	0xE8-0xEF
MOV A,direct	Move directly addressed data to accumulator	2	2	0xE5
MOV A,@Ri	Move indirectly addressed data to accumulator	1	2	0xE6-0xE7

MOV A,#data	Move immediate data to accumulator	2	2	0x74
MOV Rn,A	Move accumulator to register	1	2	0xF8-0xFF
MOV Rn,direct	Move directly addressed data to register	2	4	0xA8-0xAF
MOV Rn,#data	Move immediate data to register	2	2	0x78-0x7F
MOV direct,A	Move accumulator to direct	2	3	0xF5
MOV direct,Rn	Move register to direct	2	3	0x88-0x8F
MOV direct1,direct2	Move directly addressed data to directly addressed location	3	4	0x85
MOV direct,@Ri	Move indirectly addressed data to directly addressed location	2	4	0x86-0x87
MOV direct,#data	Move immediate data to directly addressed location	3	3	0x75
MOV @Ri,A	Move accumulator to indirectly addressed location	1	3	0xF6-0xF7
MOV @Ri,direct	Move directly addressed data to indirectly addressed location	2	5	0xA6-0xA7
MOV @Ri,#data	Move immediate data to in directly addressed location	2	3	0x76-0x77
MOV DPTR,#data16	Load data pointer with a 16-bit immediate	3	3	0x90
MOVC A,@A+DPTR	Load accumulator with a code byte relative to DPTR	1	3	0x93
MOVC A,@A+PC	Load accumulator with a code byte relative to PC	1	3	0x83
MOVX A,@Ri	Move external RAM (8-bit addr.) to accumulator	1	3	0xE2-0xE3
MOVX A,@DPTR	Move external RAM (16-bit addr.) to accumulator	1	3	0xE0
MOVX @Ri,A	Move accumulator to external RAM (8-bit addr.)	1	4	0xF2-0xF3
MOVX @DPTR,A	Move accumulator to external RAM (16-bit addr.)	1	4	0xF0
PUSH direct	Push directly addressed data onto stack	2	4	0xC0
POP direct	Pop directly addressed location from stack	2	3	0xD0
XCH A,Rn	Exchange register with accumulator	1	2	0xC8-0xCF
XCH A,direct	Exchange directly addressed location with accumulator	2	3	0xC5
XCH A,@Ri	Exchange indirect RAM with accumulator	1	3	0xC6-0xC7
XCHD A,@Ri	Exchange low-order nibbles of indirect and accumulator	1	3	0xD6-0xD7

Program branches	Description	Bytes	Cycles	Hex Code
ACALL addr11	Absolute subroutine call	2	6	xxx10001b
LCALL addr16	Long subroutine call	3	6	0x12
RET	Return from subroutine	1	4	0x22
RETI	Return from interrupt	1	4	0x32

AJMP addr11	Absolute jump	2	3	xxx00001b
LJMP addr16	Long jump	3	4	0x02
SJMP rel	Short jump (relative address)	2	3	0x80
JMP @A+DPTR	Jump indirect relative to the DPTR	1	2	0x73
JZ rel	Jump if accumulator is zero	2	3	0x60
JNZ rel	Jump if accumulator is not zero	2	3	0x70
JC rel	Jump if carry flag is set	2	3	0x40
JNC	Jump if carry flag is not set	2	3	0x50
JB bit,rel	Jump if directly addressed bit is set	3	4	0x20
JNB bit,rel	Jump if directly addressed bit is not set	3	4	0x30
JBC bit,rel	Jump if directly addressed bit is set and clear bit	3	4	0x10
CJNE A,direct,rel	Compare directly addressed data to accumulator and jump if not equal	3	4	0xB5
CJNE A,#data,rel	Compare immediate data to accumulator and jump if not equal	3	4	0xB4
CJNE Rn,#data,rel	Compare immediate data to register and jump if not equal	3	4	0xB8-0xBF
CJNE @Ri,#data,rel	Compare immed. to ind. and jump if not equal	3	4	0xB6-0xB7
DJNZ Rn,rel	Decrement register and jump if not zero	2	3	0xD8-0xDF
DJNZ direct,rel	Decrement directly addressed location and jump if not zero	3	4	0xD5
NOP	No operation	1	1	0

Boolean manipulation	Description	Bytes	Cycles	Hex Code
CLR C	Clear carry flag	1	1	0xC3
CLR bit	Clear directly addressed bit	2	3	0xC2
SETB C	Set carry flag	1	1	0xD3
SETB bit	Set directly addressed bit	2	3	0xD2
CPL C	Complement carry flag	1	1	0xB3
CPL bit	Complement directly addressed bit	2	3	0xB2
ANL C,bit	AND directly addressed bit to carry flag	2	2	0x82
ANL C,/bit	AND complement of directly addressed bit to carry	2	2	0xB0
ORL C,bit	OR directly addressed bit to carry flag	2	2	0x72
ORL C,/bit	OR complement of directly addressed bit to carry	2	2	0xA0
MOV C,bit	Move directly addressed bit to carry flag	2	2	0xA2
MOV bit,C	Move carry flag to directly addressed bit	2	3	0x92

## 13. MCU

### 13.1 8051 Engine

Table 13.1 8051 Engine

SFR	Description	address	Reset value
ACC	Accumulator	E0H	00H
B	B Register	F0H	00H
PSW	Program Status Word Register	D0H	00H
SP	Stack Pointer	81H	07H
DP0H	Data Pointer 0 High	83H	00H
DP0L	Data Pointer 0 Low	82H	00H
DP1H	Data Pointer 1 High	85H	00H
DP1L	Data Pointer 1 Low	84H	00H
AUX	Auxiliary	8EH	11H
RCON	Internal RAM Control Register	86H	F0H

#### 13.1.1 ACC (Accumulator)

The most important of all special function registers, that's the first comment about **Accumulator** which is also known as **ACC** or **A**. The **Accumulator** (sometimes referred to as Register A also) holds the result of most of arithmetic and logic operations.

Table 13.1.1 ACC (Accumulator)

ACC		Address = E0H				Reset Value = 00000000B			
Accumulator									
		ACC.7	ACC.6	ACC.5	ACC.4	ACC.3	ACC.2	ACC.1	ACC.0
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

#### 13.1.2 B (B Register)

The **B** register is used during multiplying and division instructions. It can also be used as a scratch-pad register to hold temporary data.

Table 13.1.2 B Register

B		Address = F0H				Reset Value = 00000000B			
B Register									
		B.7	B.6	B.5	B.4	B.3	B.2	B.1	B.0
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

### 13.1.3 PSW (Program Status Word Register)

The **PSW** register contains status bits that reflect the current state of the CPU. Note that the Parity bit can only be modified by hardware upon the state of **ACC** register.

Table 13.1.3.1 PSW

PSW		Address = D0H				Reset Value = 0000000B		
Program Status Word Register								
	CY	AC	F0	RS1	RS0	OV	F1	P
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R
CY	Carry flag : Carry bit in arithmetic operations and accumulator for Boolean operations.							
AC	Auxiliary Carry flag : Set if there is a carry-out from third bit of Accumulator in BCD Operations.							
F0	General purpose Flag0 : General purpose flag available for user.							
RS1	Register bank select control bit 1, used to select working register bank.							
RS0	Register bank select control bit 0, used to select working register bank.							
OV	Overflow flag : Set in case of overflow in Accumulator during arithmetic operations.							
F1	General purpose Flag 1 : General purpose flag available for user.							
P	Parity flag : Reflects the number of '1's in the Accumulator. P = '1' if Accumulator contains an odd number of '1's P = '0' if Accumulator contains an even number of '1's							

The state of **RS1** and **RS0** bits selects the working register bank as follows:

Table 13.1.3.2 RS1

RS1	RS0	Selected Register Bank	Location
0	0	Bank 0	00H – 07H
0	1	Bank 1	08H – 0FH
1	0	Bank 2	10H – 17H
1	1	Bank 3	18H – 1FH

### 13.1.4 SP (Stack Pointer)

This register points to the top of stack in internal data memory space. It is used to store the return address of program before executing interrupt routine or subprograms. The **SP** is incremented before executing **PUSH** or **CALL** instruction and it is decremented after executing **POP** or **RET(I)** instruction (it always points the top of stack). A reset initializes the stack pointer to location 0x07. Therefore, the first value pushed on the stack is placed at location 0x08.

Table 13.1.4 Stack Pointer

SP		Address = 81H				Reset Value = 0000111B			
Stack Pointer									
		SP.7	SP.6	SP.5	SP.4	SP.3	SP.2	SP.1	SP.0
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

### 13.1.5 DP0 (Data Pointer 0)

These registers are intended to hold 16-bit address in the indirect addressing mode used by **MOVX** (move external memory), **MOVC** (move program memory) or **JMP** (computed branch) instructions. They may be manipulated as 16-bit register or as two separate 8-bit registers. **DP0H** holds higher byte and **DP0L** holds lower byte of indirect address.

It is generally used to access external code or data space, e.g.:

**MOVCA, @A+DPTR** (code space)

**MOVA, @DPTR** (data space)

Table 13.1.5 DP0 (Data Pointer 0)

DP0H		Address = 83H				Reset Value = 00000000B			
Data Pointer 0 High									
		DP0H[7:0]							
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

DP0L		Address = 82H				Reset Value = 00000000B			
Data Pointer 0 Low									
		DP0L[7:0]							
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

### 13.1.6 DP1 (Data Pointer 1)

The dual data pointer accelerates the movement of block data. The standard **DPTR** is a 16-bit register that is used to address external memory, or peripherals. The standard data pointer is called **DPTR0** and the second data pointer is called **DPTR1**. The data pointer select bit chooses the active pointer. The data pointer select bit (**DPS**) is located in the LSB of **AUX** register (AUX.1).

The user switches between **DPTR0** and **DPTR1** by toggling the **DPS** bit. All DPTR-related instructions use the currently selected **DPTR** for any activity.

Table 13.1.6 DP1 (Data Pointer 1)

DP1H		Address = 85H				Reset Value = 0000000B			
Data Pointer 1 High		DP1H[7:0]							
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

DP1L		Address = 84H				Reset Value = 0000000B			
Data Pointer 1Low		DP1L[7:0]							
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	



### 13.1.7 AUX (Auxiliary Register)

Table 13.1.7 AUX(Auxiliary Register)

AUX		Address = 8EH			Reset Value = 00010001B			
Auxiliary Register								
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	R/W	R/W	R/W	R/W	R
ITS	MCU instruction timing select. : 0:1T 1:2T							
SMOD	Serial Port (UART) baud rate select.							
BRS	Serial Port (UART) baud rate generator select.							
DPS	Data pointer register select : 0 : Select DPTR Register DP0H, DP0L 1 : Select DPTR Register DP1H, DP1L							
CP	Code protect : 0 : Non-protect 1: Protect							

### 13.1.8 RCON (Internal RAM Control Register)

256 bytes of on-chip expanded RAM are provided and can be accessed by external memory addressing method only (instruction **MOVX**). The address space of instruction **MOVX @Ri, A** (i= 0,1) is determined by **RCON** [7:0] of **RCON**. The default setting of **RCON** [7:0] is F0H.

Table 13.1.8 RCON (Internal RAM Control Register)

RCON		Address = 86H			Reset Value = 11110000B			
Internal RAM Control Register								
RCON[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

## 13.2 GPIO

Four I/O ports are available: **Port0**, **Port1**, **Port2**, and **Port3**.

All 25port pins on **CGH081A** can configure to one of four modes : quasi-bidirectional (standard 8051 port outputs),push-pull output, open drain output, or input-only. All port pins default to input-only mode after reset.

Two configuration registers ( **PINSETx**, **PINCONFGx** ) for each port select the output mode for each port pin.

Table 13.2 GPIO

SFR	Description	address	Reset value
P0	Port 0	80H	FFH
P1	Port 1	90H	FFH
P2	Port 2	A0H	FFH
P3	Port 3	B0H	FFH
PINCONG1	Pin Configure Register 1	F8H	AAH
PINCONG2	Pin Configure Register 2	F9H	AAH
PINCONG3	Pin Configure Register 3	FAH	A0H
PINCONG4	Pin Configure Register 4	FBH	AAH
PINCONG5	Pin Configure Register 5	FCH	AAH
PINCONG6	Pin Configure Register 6	FDH	A0H
PINSET1	Pin I/O Setting Register 1	F1H	AAH
PINSET2	Pin I/O Setting Register 2	F2H	AAH
PINSET3	Pin I/O Setting Register 3	F3H	0AH
PINSET4	Pin I/O Setting Register 4	F4H	00H
PINSET5	Pin I/O Setting Register 5	F5H	80H
PINSET6	Pin I/O Setting Register 6	F6H	2AH
PINSET7	Pin I/O Setting Register 7	F7H	FFH

### 13.2.1 Port

Table 13.2.1 Port

P0		Address = 80H				Reset Value = 11111111B			
Port 0		-----	-----	-----	-----	P0.3	P0.2	P0.1	P0.0
Bit		7	6	5	4	3	2	1	0
Type		X	X	X	X	R/W	R/W	R/W	R/W

P1		Address = 90H				Reset Value = 11111111B			
Port 1		-----	P1.6	P1.5	P1.4	P1.3	P1.2	P1.1	P1.0
Bit	7	6	5	4	3	2	1	0	
Type	X	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

P2		Address = A0H				Reset Value = 11111111B			
Port 2		P2.7	P2.6	P2.5	P2.4	P2.3	-----	-----	-----
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	X	X	X	

P3		Address = B0H				Reset Value = 11111111B			
Port 3		-----	-----	P3.5	P3.4	P3.3	P3.2	P3.1	P3.0
Bit	7	6	5	4	3	2	1	0	
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W	R/W

### 13.2.2 PINCONG (Pin Configure Register)

Table 13.2.2 PINCONG (Pin Configure Register)

PINCONG1		Address = F8H				Reset Value = 10101010B		
Pin Configure Register 1		CH4CONG[1:0]		CH5CONG[1:0]		CH6CONG[1:0]		CH7CONG[1:0]
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
00 :	Quasi-bidirectional(standard 8051 port outputs)							
01 :	Push-pull output							
10 :	Input-only (High impedance)							
11 :	Open drain output							
PINCONG2		Address = F9H				Reset Value = 10101010B		
Pin Configure Register 2		CH0CONG[1:0]		CH1CONG[1:0]		CH2CONG[1:0]		CH3CONG[1:0]
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

00 :	Quasi-bidirectional(standard 8051 port outputs)								
01 :	Push-pull output								
10 :	Input-only (High impedance)								
11 :	Open drain output								
PINCONG3		Address = FAH				Reset Value = 10100000B			
Pin Configure Register 3									
	XCONG[1:0]		UCONG[1:0]		XTALOCONG[1:0]		XTALICONG[1:0]		
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
00 :	Quasi-bidirectional(standard 8051 port outputs)								
01 :	Push-pull output								
10 :	Input-only (High impedance)								
11 :	Open drain output								
PINCONG4		Address = FBH				Reset Value = 10101010B			
Pin Configure Register 4									
	ZCONG[1:0]		WCONG[1:0]		YCONG[1:0]		VCONG[1:0]		
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
00 :	Quasi-bidirectional(standard 8051 port outputs)								
01 :	Push-pull output								
10 :	Input-only (High impedance)								
11 :	Open drain output								
PINCONG5		Address = FCH				Reset Value = 10101010B			
Pin Configure Register 5									
	OCPNCONG[1:0]		HWPCONG[1:0]		HVPCONG[1:0]		HUPCONG[1:0]		
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
00 :	Quasi-bidirectional(standard 8051 port outputs)								
01 :	Push-pull output								
10 :	Input-only (High impedance)								
11 :	Open drain output								
PINCONG6		Address = FDH				Reset Value = 00000000B			
Pin Configure Register 6									
	---	---	---	---	RXCONG[1:0]		TXCONG[1:0]		
Bit	7	6	5	4	3	2	1	0	

Type	X	X	X	X	R/W	R/W	R/W	R/W
00 :	Quasi-bidirectional(standard 8051 port outputs)							
01 :	Push-pull output							
10 :	Input-only (High impedance)							
11 :	Open drain output							

13.2.3 PINSET (Pin I/O Setting Register)

Table 13.2.3 PINSET (Pin I/O Setting Register)

PINSET1									Address = F1H			Reset Value = 10101010B		
Pin I/O Setting Register 1														
		CH4SET[1:0]		CH5SET[1:0]		CH6SET[1:0]		CH7SET[1:0]						
Bit		7	6	5	4	3	2	1	0					
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W					
00 : No pull														
01 : Pull down														
10 : Pull up														
11 : No pull														
PINSET2									Address = F2H			Reset Value = 10101010B		
Pin I/O Setting Register 2														
		CH0SET[1:0]		CH1SET[1:0]		CH2SET[1:0]		CH3SET[1:0]						
Bit		7	6	5	4	3	2	1	0					
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W					
00 : No pull														
01 : Pull down														
10 : Pull up														
11 : No pull														
PINSET3									Address = F3H			Reset Value = 00001010B		
Pin I/O Setting Register 3														
		XSET[1:0]		USET[1:0]		XTAL0SET[1:0]		XTAL1SET[1:0]						
Bit		7	6	5	4	3	2	1	0					
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W					
00 : No pull														
01 : Pull down														
10 : Pull up														
11 : No pull														
PINSET4									Address = F4H			Reset Value = 00000000B		
Pin I/O Setting Register 4														
		ZSET[1:0]		WSET[1:0]		YSET[1:0]		VSET[1:0]						
Bit		7	6	5	4	3	2	1	0					
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W					
00 : No pull														
01 : Pull down														
10 : Pull up														

11 :	No pull								
PINSET5		Address = F5H				Reset Value = 1000000B			
Pin I/O Setting Register 5									
	OCPNSET[1:0]		HWPSET[1:0]		HVPSET[1:0]		HUPSET[1:0]		
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
00 :	No pull								
01 :	Pull down								
10 :	Pull up								
11 :	No pull								
PINSET6		Address = F6H				Reset Value = 00101010B			
Pin I/O Setting Register 6									
	-----	-----	MDES	GPWMS	RXSET[1:0]		TXSET [1:0]		
Bit	7	6	5	4	3	2	1	0	
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W	
TXSET[1:0], RXSET[1:0], HUNSET[1:0]									
00 :	No pull								
01 :	Pull down								
10 :	Pull up								
11 :	No pull								
GPWMS: GPWM Port Select									
0 :	CH0 is GPIO or AD								
1 :	CH0 is GPWM								
MDES: Motor Driving Engine Port Select									
0 :	U, V, W, X, Y, Z, HUP, HVP, HWP, and OVI_B are GPIO								
1 :	U, V, W, X, Y, Z, HUP, HVP, HWP, and OVI_B are MDE interface								
PINSET7		Address = F7H				Reset Value = 1111111B			
Pin I/O Setting Register 7									
	OCPNDBT[1:0]		HWPDBT[1:0]		HVPDBT[1:0]		HUPDBT[1:0]		
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
PIN De-bounce time									
00 :	0nS								
01 :	250nS								
10 :	500nS								
11 :	1000nS								

### 13.3 Clock Structure

The clock source of CGH081A uses an internal oscillator. The internal clock source (on-chip oscillator) is run at 12MHz. The choice of internal, clock source is setting by **Writer**.

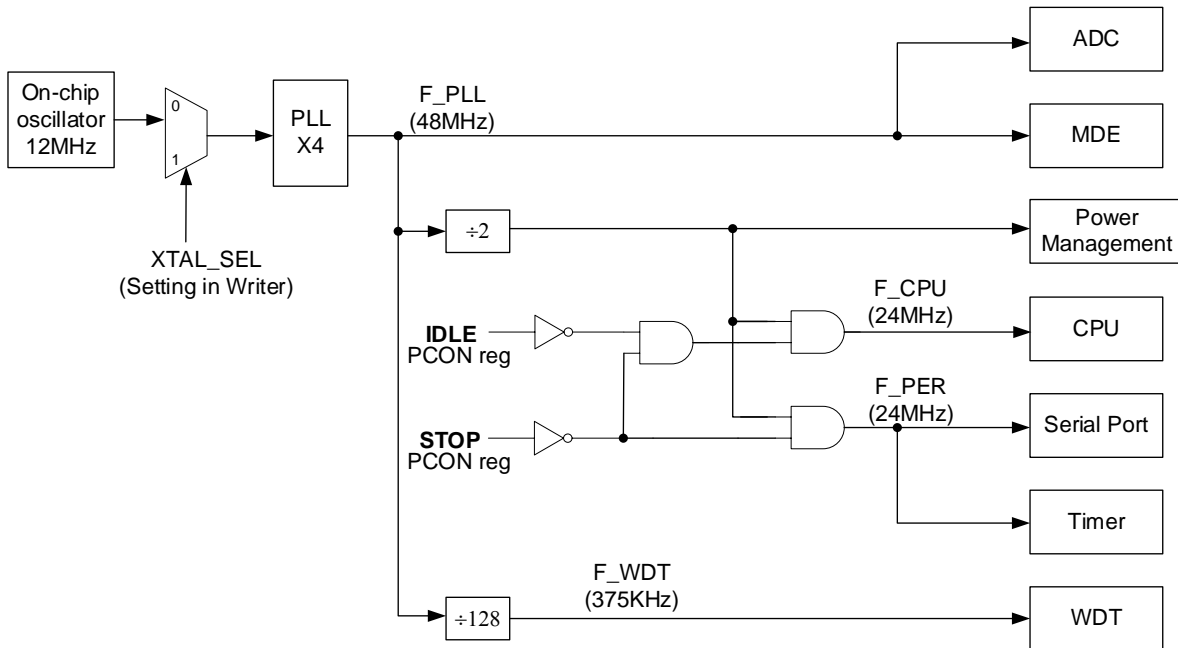


Figure 13.3 Clock Structure



### 13.4 Timer

The **CGH081A** has three 16-bit timer/counter registers: **Timer0**, **Timer1** and **Timer2**. All can be configured for counter, or timer, operations.

In addition to the “timer” or “counter” selection, **Timer0** and **Timer1** have four operating modes from which to select which are selected by bit-pairs (**M1**, **M0**) in **TMOD**. Modes 0, 1, and 2 are the same for both timer/counters. Mode 3 is different.

Table 13.4.1 Timer Modes

	<b>Timer0</b>	<b>Timer1</b>	<b>Timer2</b>
Mode 0	13-bit timer/counter	13-bit timer/counter	13-bit timer/counter
Mode 1	16-bit timer/counter	16-bit timer/counter	16-bit timer/counter
Mode 2	8-bit auto-reload timer/counter	8-bit auto-reload timer/counter	8-bit auto-reload timer/counter
Mode 3	two independent 8-bit timers/counters	stop	8-bit timers/counters

Two Special Function registers (**TMOD** and **TCON**) are used to select the appropriate mode.

Table 13.4.2 Timer Related SFR

<b>SFR</b>	<b>Description</b>	<b>address</b>	<b>Reset value</b>
PFCON	Peripheral Frequency Control Register	D1H	00H
TMOD	Timer 0/1 Mode Register	89H	00H
TCON	Timer 0/1 Control Register	88H	00H
T2CON	Timer2 Control Register	C8H	00H
TH0	Timer0 High byte	8CH	00H
TL0	Timer0 Low byte	8AH	00H
TH1	Timer1 High byte	8DH	00H
TL1	Timer1 Low byte	8BH	00H
TH2	Timer2 High byte	B5H	00H
TL2	Timer2 Low byte	B4H	00H

### 13.4.1 PFCON (Peripheral Frequency Control Register)

Table 13.4.1.1 PFCON (Peripheral Frequency Control Register)

PFCON		Address = D1H		Reset Value = 0000000B				
Peripheral Frequency Control Register								
	-----	-----	SRELPS[1:0]		T1PS[1:0]		T0PS[1:0]	
Bit	7	6	5	4	3	2	1	0
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
<p>SRELPS[1:0] Serial port (UART) Prescaler select :</p> <p>00 :F_PER/64</p> <p>01 :F_PER/32</p> <p>10 :F_PER/16</p> <p>11 :F_PER/8</p>								
<p>T1PS[1:0] Timer1(T1) Prescaler select :</p> <p>00 :F_PER/12</p> <p>01 :F_PER</p> <p>10 :F_PER/96</p> <p>11 :-----</p>								
<p>T0PS[1:0] Timer0(T0) Prescaler select :</p> <p>00 :F_PER/12</p> <p>01 :F_PER</p> <p>10 :F_PER/96</p> <p>11 :-----</p>								

### 13.4.2 TMOD (Timer 0/1 Mode Register)

TMOD register is used in configuration of MCUTimer0 and Timer1.

Table 13.4.2 TMOD (Timer 0/1 Mode Register)

TMOD		Address = 89H		Reset Value = 0000000B				
Timer 0/1 Mode Register								
	GATE1	C/T1	T1M1	T1M0	GATE0	C/T0	T0M1	T0M0
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
GATE1	Timer1 gate control :							
	If set, enables external gate control (pin <b>INT1N</b> ) for Counter1. When <b>INT1N</b> is high, and TR1 bit is set, the Counter1 is incremented every falling edge on <b>INT1N</b> input pin							
C/T1	Timer1 counter/timer select :							
	0 : Timer							
	1 : Counter							
GATE0	Timer 0 gate control :							
	If set, enables external gate control (pin <b>INT0N</b> ) for Counter0. When <b>INT0N</b> is high, and TR0 bit is set, the Counter0 is incremented every falling edge on <b>INT0N</b> input pin							
C/T0	Timer0 counter/timer select :							
	0 : Timer							
	1 : Counter							
T1M1 /T0M1	T1M0 /T0M0	Mode	Function					
0	0	Mode0	13-bit Counter/Timer, with 5 lower bits in TL0 (TL1) register and 8 bits in TH0 (TH1) register (for Timer0 or Timer1, respectively). The 3 high-order bits of TL0 (TL1) are zeroed whenever Mode 0 is enabled. (Not auto-reload)					
0	1	Mode1	16-bit Counter/Timer. (Not auto-reload)					
1	0	Mode2	8-bit auto-reload Counter/Timer. The reload value is kept in TH0 (TH1), while TL0 (TL1) is incremented every clock cycle. Reloaded from TH0 (TH1) at overflow.					
1	1	Mode3	For Timer1: Timer1 is stopped. For Timer0: Timer0 acts as two independent 8 bit Timers / Counters – TL0, TH0. (Not auto-reload)					

### 13.4.3 TCON (Timer 0/1 Control Register)

**TCON** register is used to control operation of these modules. **CGH081A** includes two external digital interrupt sources (**INT0N** and **INT1N**), with dedicated interrupt sources. **INT0N** and **INT1N** are configurable as falling edge or low level. The **IT0** and **IT1** bits in **TCON** select level- or edge-sensitive. **IE0** and **IE1** in the **TCON** register serve as the interrupt-pending flags for the **INT0N** and **INT1N** external interrupts, respectively.

Table 13.4.3 TCON (Timer 0/1 Control Register)

TCON		Address = 88H				Reset Value = 0000000B		
Timer 0/1 Control Register								
	TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
TF1	Timer1 overflow flag : Bit set by hardware when Timer1 overflows. This flag can be cleared by software and is automatically cleared when interrupt is processed.							
TR1	Timer1 run control : 0 : Stop 1 : Run							
TF0	Timer0 overflow flag : Bit set by hardware when Timer1 overflows. This flag can be cleared by software and is automatically cleared when interrupt is processed.							
TR0	Timer0run control : 0 : Stop 1 : Run							
IE1	External interrupt 1 flag : Set by hardware, when External interrupt ( <b>INT1N</b> ) is observed. Cleared by hardware when interrupt is processed.							
IT1	External interrupt 1 type control : 0 : External interrupt 1 is activated at low level on input pin 1 : External interrupt 1 is activated at falling edge on input pin							
IE0	External interrupt 0 flag : Set by hardware, when External interrupt ( <b>INT0N</b> ) is observed. Cleared by hardware when interrupt is processed.							
IT0	External interrupt 0 type control : 0 : External interrupt 0 is activated at low level on input pin 1 : External interrupt 0 is activated at falling edge on input pin							

The **TF0**, **TF1** (**Timer0** and **Timer1** overflow flags), **IE0** and **IE1** (External interrupt 0 and 1 flags) will be automatically cleared by hardware when the corresponding service routine is called.

### 13.4.4 T2CON (Timer2 Control Register)

T2CON is used to control Timer2run/stop, mode, prescaler.

Table 13.4.4 T2CON (Timer2 Control Register)

T2CON		Address = C8H		Reset Value = 0000000B				
Timer2 Control Register								
Bit	7	6	5	4	3	2	1	0
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
TF2	Timer2 overflow flag : Bit set by hardware when Timer2 overflows. This flag can be cleared by software and is automatically cleared when interrupt is processed.							
TR2	Timer2run control : 0 : Stop 1 : Run							
T2PS[1:0]	Timer2(T2) Prescaler select : 00 : F_PER/12 01 : F_PER 10 : F_PER/96 11 :-----							
T2M1	T2M0	Mode	Function					
0	0	Mode0	13-bit Timer, with 5 lower bits in TL2 register and 8 bits in TH2 register.(Not auto-reload)					
0	1	Mode1	16-bit Timer. (Not auto-reload)					
1	0	Mode2	8 -bit auto-reload Timer. The reload value is kept in TH2, while TL2 is incremented every clock cycle. Reloaded from TH2 at overflow.					
1	1	Mode3	8 bit Timers. (Not auto-reload)					

### 13.4.5 Timer0 Mode 0

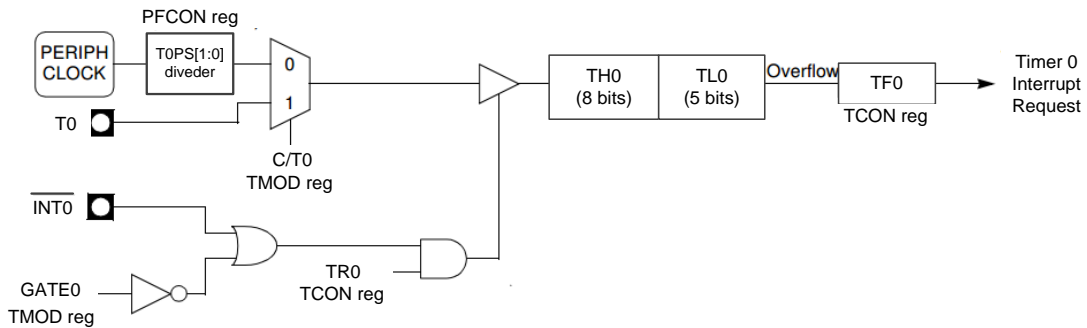


Figure 13.4.5 Timer0 Mode 0

### 13.4.6 Timer0 Mode 1

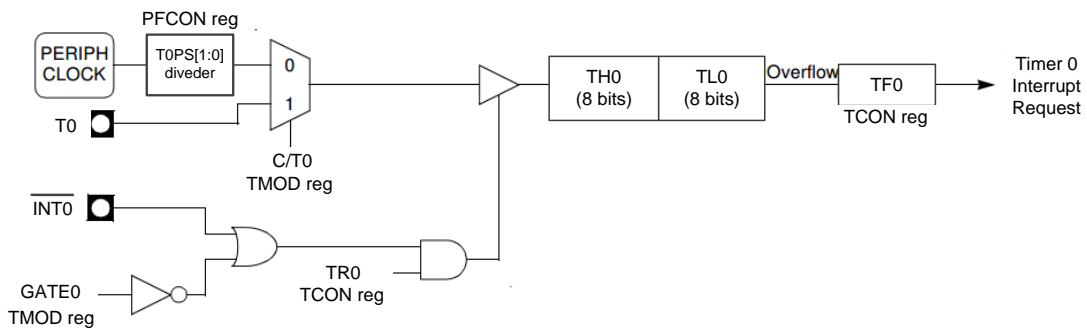


Figure 13.4.6 Timer0 Mode 1

### 13.4.7 Timer0 Mode 2

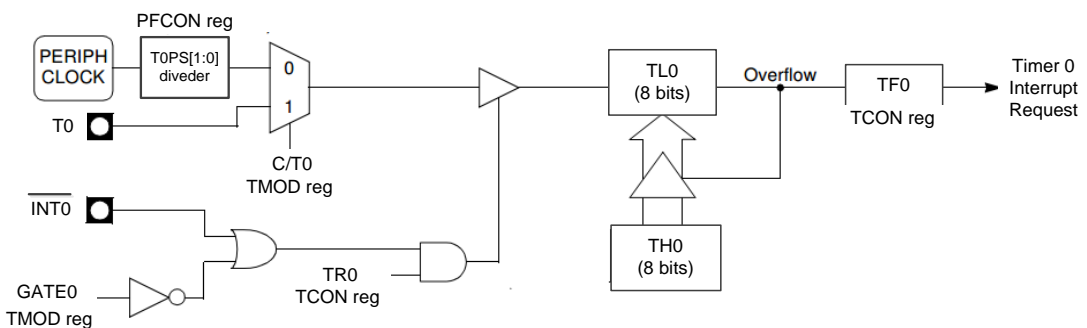


Figure 13.4.7 Timer0 Mode 2

### 13.4.8 Timer0 Mode 3

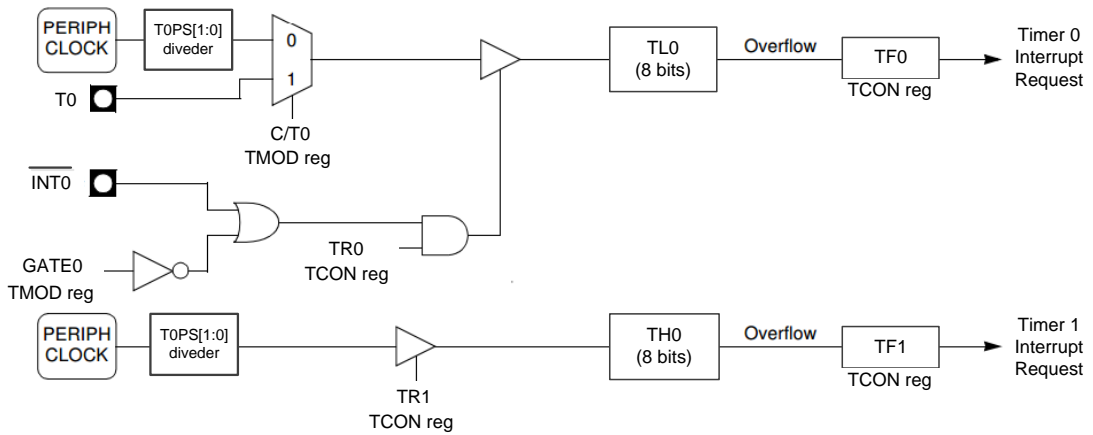


Figure 13.4.8 Timer0 Mode 3

### 13.4.9 Timer1 Mode 0

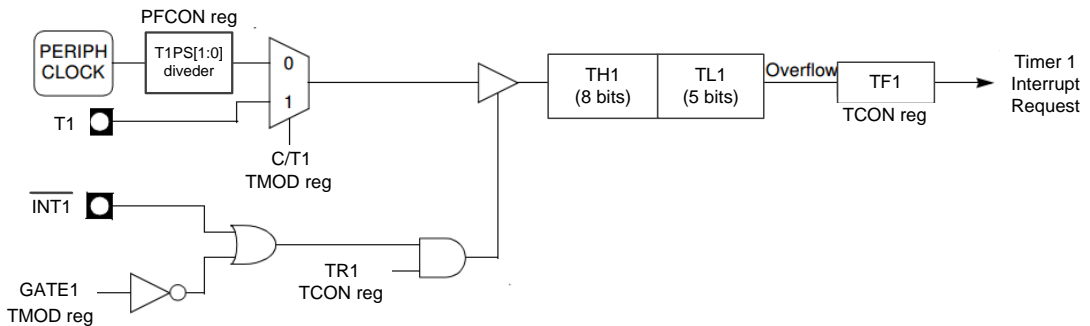


Figure 13.4.9 Timer1 Mode 0

### 13.4.10 Timer1 Mode 1

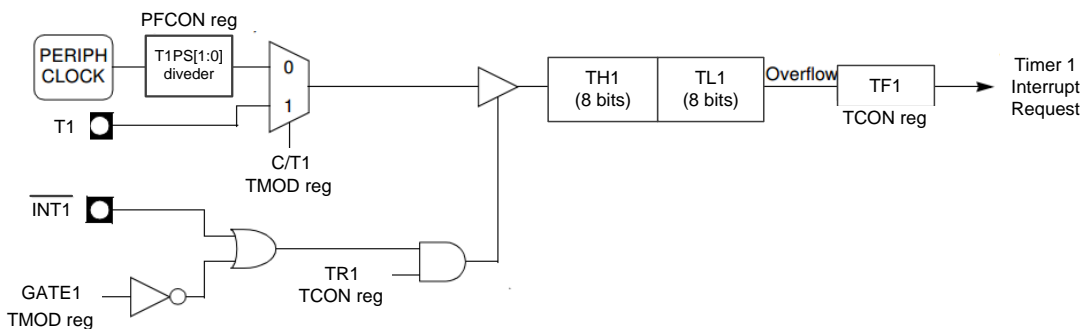


Figure 13-4.10 Timer1 Mode 1

### 13.4.11 Timer1 Mode 2

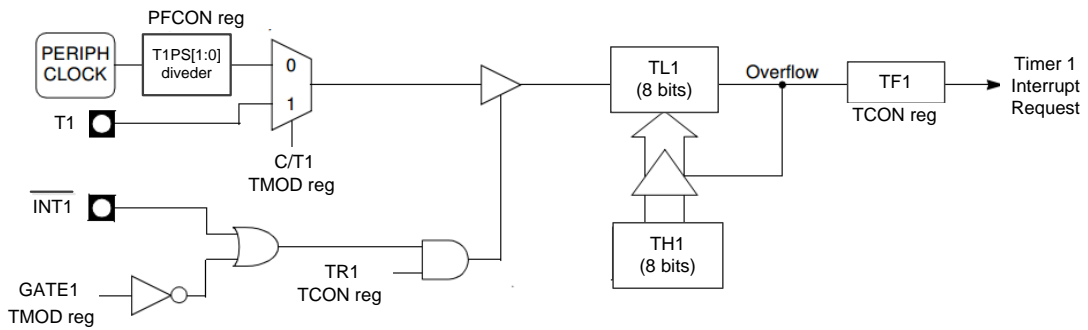


Figure 13.4.11 Timer1 Mode 2

### 13.4.12 Timer2 Mode 0

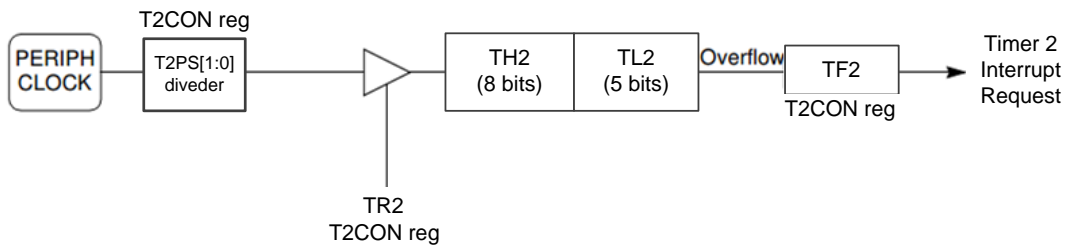


Figure 13.4.12 Timer2 Mode 0

### 13.4.13 Timer2 Mode 1

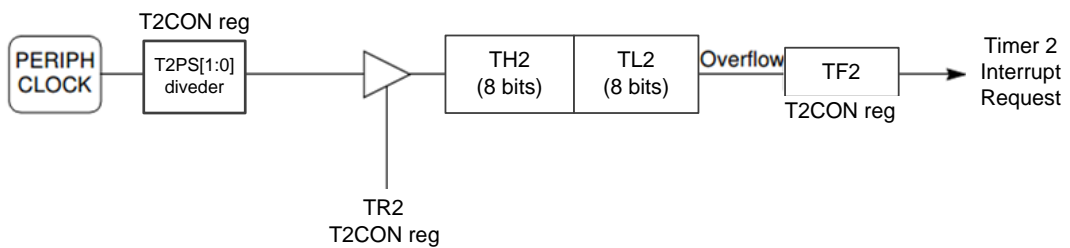


Figure 13.4.13 Timer2 Mode 1



### 13.4.14 Timer2 Mode 2

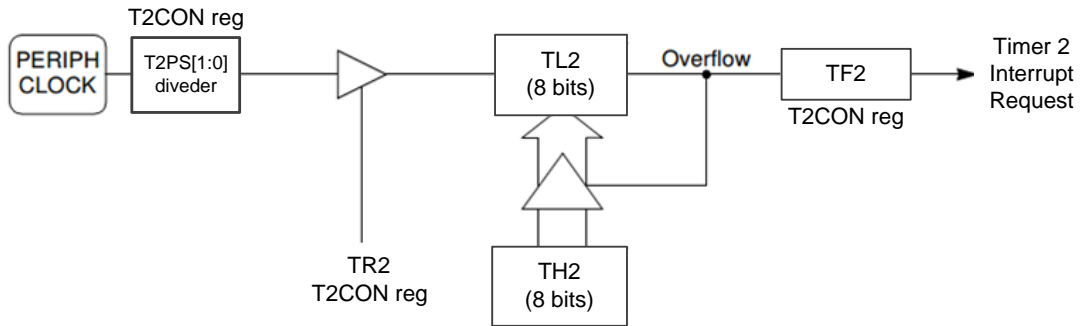


Figure 13.4.14 Timer2 Mode 2

### 13.4.15 Timer2 Mode 3

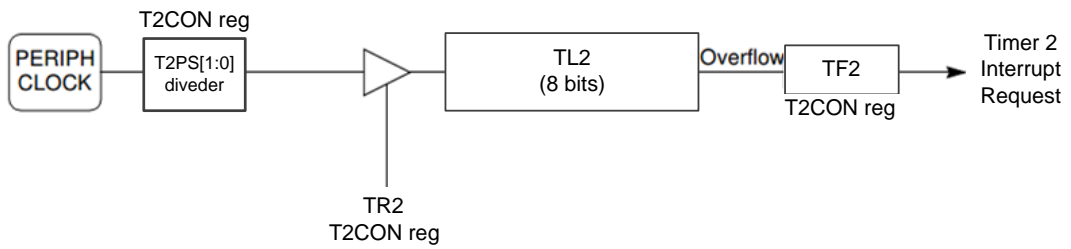


Figure 13.4.15 Timer2 Mode 3

### 13.5 Watchdog Timer

The Watchdog Timer (**WDT**) is a 8-bit free-running counter that generates a reset signal or interrupt (**WDT.C.6**) if it overflows. It can help the application software to recover from an abnormal condition. The **WDT** is independent from **Timer0**, **Timer1**, or **Timer2**. The **F\_WDT** is 375KHz, it is from on-chip RC oscillator.

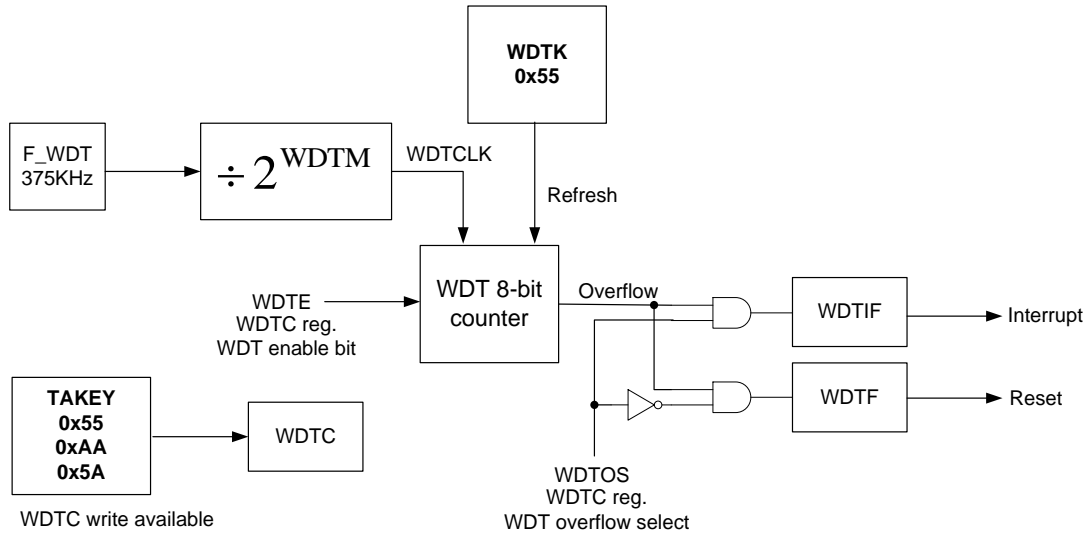


Figure 13.5 Watchdog Timer

$$WDTCLK = F\_WDT \times \frac{1}{2^{WDTM}}$$

WDT (8-bit counter) overflow time = 256/WDTCLK

Table 13.5 Watchdog Related SFR

SFR	Description	address	Reset value
RSTS	Reset Source Register	FEH	0AH
TAKEY	Time Access Key Register	FFH	00H
WDT.C	Watchdog Timer Control Register	B6H	04H
WDTK	Watchdog Timer Refresh Key	B7H	00H

RSTS								
Reset Source Register								
Address = FEH      Reset Value = 00001010B								
	-----	-----	-----	WDTRF	PINRF[1:0]		PORF[1:0]	
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	R/W	R/W	R/W	R/W	R/W
WDTRF	Watchdog timer reset flag. This flag is set to 1 if the Watchdog Timer Reset caused the reset.							
PINRF[1:0]	RSTN pin reset flag. This flag is set to 10b if the RSTN pin caused the reset. Clear by firmware.							
PORF[1:0]	POR reset flag. This flag is set to 10b if the POR caused the reset. Clear by firmware.							

### 13.5.1 WDTC (Watchdog Timer Control Register)

Table 13.5.1 WDTC (Watchdog Timer Control Register)

WDTC								
Watchdog Timer Control Register								
Address = B6H      Reset Value = 00000100B								
	-----	WDTOS	WDTE	-----	WDTM[3:0]			
Bit	7	6	5	4	3	2	1	0
Type	X	R/W	R/W	X	R/W	R/W	R/W	R/W
WDTOS	Watchdog timer overflow select : 0 : When WDT overflow, enable WDT reset. 1 : When WDT overflow, enable WDT interrupt.							
WDTE	Watchdog timer enable : 0 : Disable WDT. 1 : Enable WDT.							
WDTM[3:0]	WDT clock divider :  $\text{WDTCLK} = 375\text{KHz} \times \frac{1}{2^{\text{WDTM}}} \quad (\text{default is } 375\text{KHz} / 16)$							

### 13.5.2 TAKEY (Time Access Key Register)

Table 13.5.2 TAKEY (Time Access Key Register)

TAKEY		Address = FFH				Reset Value = 0000000B		
Time Access Key Register								
		TAKEY[7:0]						
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
<p>WDTC default is read only, must write three specific values 55H, AAH and 5AH to the TAKEY enable the WDTC write available.</p> <p>The sequence is:</p> <pre>MOV TAKEY, #55h MOV TAKEY, #AAh MOV TAKEY, #5Ah</pre>								

### 13.5.3 WDTK (Watchdog Timer Refresh Key)

Table 13.5.3 WDTK (Watchdog Timer Refresh Key)

WDTK		Address = B7H				Reset Value = 0000000B		
Watchdog Timer Refresh Key								
		WDTK[7:0]						
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
<p>The application must write 0x55 into the WDTK register, for the Watchdog timer to be cleared.</p>								

For example, enable the watchdog with a time-out reset period of 5.461ms.

Following write sequence:

```
MOV TAKEY, #55h
```

```
MOV TAKEY, #AAh
```

```
MOV TAKEY, #5Ah ; WDTC write is available.
```

```
MOV WDTC, #23h ; WDTM [3:0] = 0011b. WDTE =1 to enable the WDT.
```

```
MOV WDTK, #55h ;Refresh WDT.
```

## 13.6 Serial Port (UART)

The Serial Port provides a flexible full-duplex synchronous/asynchronous receiver/transmitter, called **UART**. The communication rate can be set by configuring the baud rate in **SFRs**. The two serial buffers consist of two separate registers, a transmit buffer and a receive buffer. Writing data to the SFR **SBUF**, transfers the data to the serial output buffer and starts the transmission. Reading from the **SBUF**, reads data from the serial receive buffer. The serial port can simultaneously transmit and receive data. It can also buffer 1 byte at receive, which prevents the receive data from being lost if the CPU reads the second byte before the transmission of the first byte is completed.

Table 13.6 Serial Port (UART) Related SFR

SFR	Description	address	Reset value
AUX	Auxiliary	8EH	11H
PFCON	Peripheral Frequency Control Register	D1H	00H
SCON	Serial Port Control Register	98H	00H
SBUF	Serial Port Data Buffer	99H	00H
SRELH	Serial Port Reload Register High	9BH	00H
SRELL	Serial Port Reload Register Low	9AH	00H

AUX		Address = 8EH			Reset Value = 00010001B			
Auxiliary Register								
	LVD_EN	LVD	----	ITS	SMOD	BRS	DPS	CP
Bit	7	6	5	4	3	2	1	0
Type	R/W	R	X	R/W	R/W	R/W	R/W	R
LVD_EN	Low voltage detect enable : 1: Enable							
LVD	Low voltage detect status. : 1: Low voltage occur							
ITS	MCU instruction timing select. : 0:1T 1:2T							
SMOD	Serial Port (UART) baud rate select.							
BRS	Serial Port (UART) baud rate generator select.							
DPS	Data pointer register select : 0 : Select DPTR Register DP0H, DP0L 1 : Select DPTR Register DP1H, DP1L							
CP	Code protect : 0 : Non-protect 1: Protect							

PFCON		Address = D1H		Reset Value = 0000000B						
Peripheral Frequency Control Register										
		----	----	SRELPS[1:0]		T1PS[1:0]		T0PS[1:0]		
Bit		7	6	5	4	3	2	1	0	
Type		X	X	R/W	R/W	R/W	R/W	R/W	R/W	
SRELPS[1:0]		Serial port (UART) Prescaler select :								
		00 :F_PER/64								
		01 :F_PER/32								
		10 :F_PER/16								
		11 :F_PER/8								
T1PS[1:0]		Timer1(T1) Prescaler select :								
		00 :F_PER/12								
		01 :F_PER								
		10 :F_PER/96								
		11 :----								
T0PS[1:0]		Timer0(T0) Prescaler select :								
		00 : F_PER/12								
		01 : F_PER								
		10 : F_PER/96								
		11 :----								

### 13.6.1 SCON (Serial Port Control Register)

The **SCON** register controls the function of Serial Port (**UART**).

Table 13.6.1 SCON (Serial Port Control Register)

SCON		Address = 98H		Reset Value = 0000000B				
Serial Port Control Register								
Bit	SM0	SM1	SM2	REN	TB8	RB8	TI	RI
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
SM0	SM1	Mode	Description	Baud Rate				
0	0	Mode 0	Shift register	F_PER/12				
0	1	Mode 1	8bit UART	Variable				
1	0	Mode 2	9bit UART	Depends on SMOD (AUX.3)				
				SMOD		Baud Rate		
				0	F_PER/64			
1	1	Mode 3	9bit UART	Variable				
SM2	Multiprocessor communication enable							
REN	Serial reception enable : 0 : Serial reception at Serial Port is disabled. 1 :Serial reception at Serial Port is enabled.							
TB8	Transmitter bit 8 : This bit is used while transmitting data through Serial Port in Modes 2 and 3. The state of this bit corresponds with the state of the 9th transmitted bit (e.g. parity check or multiprocessor communication). It is controlled by software.							
RB8	Received bit 8 : This bit is used while receiving data through Serial Port 0 in Modes 2 and 3. It reflects the state of the 9th received bit. In Mode 1, if multiprocessor communication is enabled (sm2 = 0), this bit is the stop bit that was received. In Mode 0 this bit is not used.							
TI	Transmit interrupt flag : (completion of a serial transmission) It is set by hardware at the end of bit 8 in mode 0 or at the beginning of a stop bit in other modes. It must be cleared by software.							
RI	Receive interrupt flag : (It must be cleared by software.) It is set by hardware after completion of a serial reception at Serial Port 0. It is set by hardware at the end of bit 8 in mode 0 or in the middle of a stop bit in other modes.							

Serial Port working in modes 1 or mode 3:

When BRS = 0 (AUX.2)

TIPS[1:0] = 00b

$$\text{baud rate} = \frac{2^{\text{SMOD}}}{32 \times (256 - \text{TH1})} \times \frac{\text{F\_PER}}{12}$$

TIPS[1:0] = 01b

$$\text{baud rate} = \frac{2^{\text{SMOD}}}{32 \times (256 - \text{TH1})} \times \text{F\_PER}$$

TIPS[1:0] = 10b

$$\text{baud rate} = \frac{2^{\text{SMOD}}}{32 \times (256 - \text{TH1})} \times \frac{\text{F\_PER}}{96}$$

When BRS = 1 (AUX.2)

SRELPS[1:0] = 00b

$$\text{baud rate} = \frac{2^{\text{SMOD}}}{2^{10} - \text{SREL}[\text{H,L}]} \times \frac{\text{F\_PER}}{64}$$

SRELPS [1:0] = 01b

$$\text{baud rate} = \frac{2^{\text{SMOD}}}{2^{10} - \text{SREL}[\text{H,L}]} \times \frac{\text{F\_PER}}{32}$$

SRELPS [1:0] = 10b

$$\text{baud rate} = \frac{2^{\text{SMOD}}}{2^{10} - \text{SREL}[\text{H,L}]} \times \frac{\text{F\_PER}}{16}$$

SRELPS [1:0] = 11b

$$\text{baud rate} = \frac{2^{\text{SMOD}}}{2^{10} - \text{SREL}[\text{H,L}]} \times \frac{\text{F\_PER}}{8}$$



### 13.6.2 SBUF (Serial Port Data Buffer)

Writing data to this register sets data in serial output buffer and starts the transmission through Serial Port. Reading from the **SBUF**, reads data from the serial receive buffer.

Table 13.6.2 SBUF (Serial Port Data Buffer)

SBUF		Address = 99H				Reset Value = 00000000B		
Serial Port Data Buffer								
SBUF[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

### 13.6.3 SREL (Serial Port Reload Register)

Serial Port Reload Register is used for Serial Port baud rate generation. Only 10 bits are used, where 8 bits from the **SRELL** as lower bits and 2 bits from the **SRELH** (SRELH.1, SRELH.0) as higher bits.

Table 13.6.3 SREL (Serial Port Reload Register)

SRELH		Address = 9BH				Reset Value = 00000000B		
Serial Port Reload Register High								
		----	----	----	----	----	SREL.9	SREL.8
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	X	R/W	R/W

SRELL		Address = 9AH				Reset Value = 00000000B		
Serial Port Reload Register Low								
SREL[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

### 13.7 Power Management

The Power Control Register (**PCON**) is used to control the **CGH081A STOP** and **IDLE** power management modes.

Table 13.7 Power Management

PCON		Address = 87H					Reset Value = 0000000B	
Power Control Register								
	----	----	----	----	----	----	STOP	IDLE
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	X	R/W	R/W
STOP	Stop mode bit. Setting this bit activates STOP operation. (read as 0)							
IDLE	Idle mode bit. Setting this bit activates IDLE mode operation. (read as 0)							

#### 13.7.1 STOP MODE

Setting the **STOP** Mode Select bit (**PCON.1**) causes the controller core to enter **STOP** mode as soon as the instruction that sets the bit completes execution. In **STOP** mode the CPU, GPIO, UART, and Timers are stopped, but the ADC, MDE, and WDT is still work.

**STOP** mode can terminate by an internal or external reset. On reset, the device performs the normal reset sequence and begins program execution at address 0x0000.

The assertion of an enabled interrupt will cause the **STOP** Mode Selection bit (**PCON.1**) to be cleared and the CPU to resume operation.

#### 13.7.2 IDLE MODE

Setting the **IDLE** Mode Select bit (**PCON.0**) causes the hardware to halt the CPU and enter **IDLE** mode as soon as the instruction that sets the bit completes execution.

In **IDLE** mode only the CPU is stop. All internal registers and memory maintain their original data.

**IDLE** mode can terminate by an internal or external reset. On reset, the device performs the normal reset sequence and begins program execution at address 0x0000.

The assertion of an enabled interrupt will cause the **IDLE** Mode Selection bit (**PCON.0**) to be cleared and the CPU to resume operation.

### 13.8 Reset

The reset logic is used to place the device into a known state.

**CGH081A** provides Power-on Reset flag, External Reset **RSTN** flag and Watchdog timer Reset flag to monitor reset status. The source of the reset can be monitor.

#### 13.8.1 RSTS (Reset Source Register)

Table 13.8.1 Reset

RSTS		Address = FEH			Reset Value = 00001010B			
Reset Source Register								
	-----	-----	-----	WDTRF	PINRF[1:0]		PORF[1:0]	
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	R/W	R/W	R/W	R/W	R/W
WDTRF	Watchdog timer reset flag. This flag is set to 1 if the Watchdog Timer Reset caused the reset.							
PINRF[1:0]	<b>RSTN</b> pin reset flag. This flag is set to 10b if the <b>RSTN</b> pin caused the reset. Clear by firmware.							
PORF[1:0]	POR reset flag. This flag is set to 10b if the POR caused the reset. Clear by firmware.							

### 13.9 Interrupt Controller

The **ISR** - Interrupt Service Routine unit, is a subcomponent responsible for interrupt handling. It receives up to **14** interrupt requests. Each interrupt source has its own request flag that is located in devices which is a source of interrupt. No interrupt request flags are located directly in **ISR**. All interrupts are requested by high level on correspondent inputs to **ISR**. Each of the interrupt sources can be individually enabled or disabled by corresponding enable flag in **IEN0**, **IEN1**SFR registers. Additionally all interrupts can be globally enabled or disabled by the **—EA** flag in the **IEN0** SFR. All interrupt sources are divided into 6 interrupts groups. Each of the interrupt groups can have one of four interrupt priority levels assigned. The interrupt priority level is defined by flags located in the **IP0** and **IP1** SFR registers.

Table 13.9.1 Interrupt vectors

Interrupt Number (use Keil C Tool)	Interrupt Address	Vector	Interrupt Request Flags
0	0003H		IE0 – External interrupt 0
1	000BH		TF0 – Timer0 interrupt
2	0013H		IE1 – External interrupt 1
3	001BH		TF1 – Timer1 interrupt
4	0023H		SPIF(TI, RI)– Serial port interrupt
5	002BH		TF2 – Timer2 interrupt
6	0033H		-----
7	003BH		CAPIF – Capture interrupt
8	0043H		OCPSIF – OCP Short interrupt
9	004BH		HALLIF – HALL interrupt
10	0053H		MPWMMINIF–MPWM MIN interrupt
11	005BH		MPWMMAXIF–MPWM MAX interrupt
12	0063H		GPWMMAXIF – GPWM MAX interrupt
13	006BH		-----
14	0073H		WDTIF – Watchdog timer interrupt
15	007BH		OCPLIF – OCP Limit interrupt

Table13.9.2 Interrupt vectors

Group priority	Interrupt Group	Highest priority in group		Lowest priority in group
Highest	Group0	-----	IE0	-----
	Group1	WDTIF	TF0	-----
	Group2	OCPSIF	HALLIF	IE1
	Group3	MPWMMINIF	MPWMMAXIF	TF1
	Group4	GPWMMAXIF	SPIF(TI, RI)	-----

Lowest	Group5	OCPLIF	TF2	CAPIF
--------	--------	--------	-----	-------

Table 13.9.3 Interrupt Related SFR

<b>SFR</b>	<b>Description</b>	<b>address</b>	<b>Reset value</b>
IEN0	Interrupt Enable Register 0	A8H	00H
IEN1	Interrupt Enable Register 1	B8H	00H
IRCON1	Interrupt Request Register 1	C0H	00H
IP0	Interrupt Priority Register 0	A9H	00H
IP1	Interrupt Priority Register 1	B9H	00H

### 13.9.1 IEN0 (Interrupt Enable Register 0)

Table 13.9.1.1 IEN0 (Interrupt Enable Register 0)

IEN0		Address = A8H			Reset Value = 0000000B			
Interrupt Enable Register 0								
	EA	-----	ET2	ESP	ET1	EX1	ET0	EX0
Bit	7	6	5	4	3	2	1	0
Type	R/W	X	R/W	R/W	R/W	R/W	R/W	R/W
EA	Interrupts enable : 0: Disable all interrupts. 1: Enable interrupt.							
ET2	Timer2 interrupt enable: 0: Disable Timer2 overflow interrupt. 1: When EA = 1, enable Timer2 overflow interrupt.							
ESP	Serial port interrupt enable: 0: Disable Serial port interrupt. 1: When EA = 1, enable Serial port interrupt.							
ET1	Timer1 interrupt enable: 0: Disable Timer1 overflow interrupt. 1: When EA = 1, enable Timer1 overflow interrupt.							
EX1	External interrupt 1 enable: 0: Disable External interrupt 1. 1: When EA = 1, enable External interrupt 1.							
ET0	Timer0 interrupt enable: 0: Disable Timer0 overflow interrupt. 1: When EA = 1, enable Timer0 overflow interrupt.							
EX0	External interrupt 0 enable: 0: Disable External interrupt 0. 1: When EA = 1, enable External interrupt 0.							

**13.9.2 IEN1 (Interrupt Enable Register 1)**

Table 13.9.2.1 IEN1 (Interrupt Enable Register 1)

IEN1		Address = B8H		Reset Value = 0000000B				
Interrupt Enable Register 1								
	OCPLIE	WDTIE	-----	GPWMIE	MPWMMAXIE	MPWMMINIE	HALLIE	OCPSIE
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	-----	R/W	R/W	R/W	R/W	R/W
OCPLIE	OCP (Over current protect) Limit interrupt enable: 0: Disable OCP Limit interrupt. 1: When EA = 1, enable OCP Limit interrupt.							
WDTIE	Watchdog timer interrupts enable : 0: Disable WDT interrupt. 1: When EA = 1 and WDTOS = 1, enable WDT overflow interrupt.							
GPWMIE	GPWM interrupt enable: 0: Disable GPWM interrupt. 1: When EA = 1, enable GPWM interrupt.							
MPWMMAXIE	MPWM maximum interrupt enable: 0: Disable MPWM maximum interrupt. 1: When EA = 1, enable MPWM maximum interrupt.							
MPWMMINIE	MPWM minimum interrupt enable: 0: Disable MPWM minimum interrupt. 1: When EA = 1, enable MPWM minimum interrupt.							
HALLIE	HALL interrupt enable: 0: Disable HALL interrupt. 1: When EA = 1, enable HALL interrupt.							
OCPSIE	OCP (Over current protect) Short interrupt enable: 0: Disable OCP Short interrupt. 1: When EA = 1, enable OCP Short interrupt.							

### 13.9.3 IRCON1 (Interrupt Request Register 1)

Table 13.9.3.1 IRCON1 (Interrupt Request Register 1)

IRCON1		Address = C0H			Reset Value = 0000000B			
Interrupt Request Register 1								
	OCPLIF	WDTIF	----	GPWMIF	MPWMMAXIF	MPWMMINIF	HALLIF	OCPSIF
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	----	R/W	R/W	R/W	R/W	R/W
OCPLIF	OCP Limit interrupt flag.							
WDTIF	Watchdog timer interrupts flag.							
GPWMIF	GPWM interrupt flag.							
MPWMMAXIF	MPWM maximum interrupt flag.							
MPWMMINIF	MPWM minimum interrupt flag.							
HALLIF	HALL interrupt flag.							
OCPSIF	OCP Short interrupt flag.							

### 13.9.4 IP (Interrupt Priority Register)

The 14 interrupt sources are grouped into 6 priority groups. For each of the groups, one of four priority levels can be selected. It is achieved by setting appropriate values in **IP0** and **IP1** registers. The contents of the Interrupt Priority Registers define the priority levels for each interrupt source according to the tables below.

Table 13.9.4.1 IP (Interrupt Priority Register)

IP0		Address = A9H			Reset Value = 0000000B			
Interrupt Priority Register 0								
	----	----	G5IP0	G4IP0	G3IP0	G2IP0	G1IP0	G0IP0
Bit	7	6	5	4	3	2	1	0
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
G5IP0	Group5 interrupt priority bit 0							
G4IP0	Group4 interrupt priority bit 0							
G3IP0	Group3 interrupt priority bit 0							
G2IP0	Group2 interrupt priority bit 0							
G1IP0	Group1 interrupt priority bit 0							
G0IP0	Group0 interrupt priority bit 0							



IP1		Address = B9H    Reset Value = 0000000B						
Interrupt Priority Register 1								
	-----	-----	G5IP1	G4IP1	G3IP1	G2IP1	G1IP1	G0IP1
Bit	7	6	5	4	3	2	1	0
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
G5IP1	Group5 interrupt priority bit 1							
G4IP1	Group4 interrupt priority bit 1							
G3IP1	Group3 interrupt priority bit 1							
G2IP1	Group2 interrupt priority bit 1							
G1IP1	Group1 interrupt priority bit 1							
G0IP1	Group0 interrupt priority bit 1							

Table 13.9.4.2 Priority Level

Level	Priority	GxIP1	GxIP0
Level 0	Lowest	0	0
Level 1		0	1
Level 2		1	0
Level 3	Highest	1	1

## 14. 10-bit Analog-to-Digital Converter (ADC)

The CGH081A provides eight channels 10-bit ADC. The result of the conversion is provided at **ADCD** [9:0].

Table 14.1 10 bit Analog-to-Digital Converter (ADC)

SFR	Description	address	Reset value
ADCCONT	ADC Control Register	D2H	80H
ADCSTR	ADC Start Convert and Setting Register	D3H	00H
ADCD1	ADC Data Register 1	D5H	00H
ADCD2	ADC Data Register 2	D6H	00H

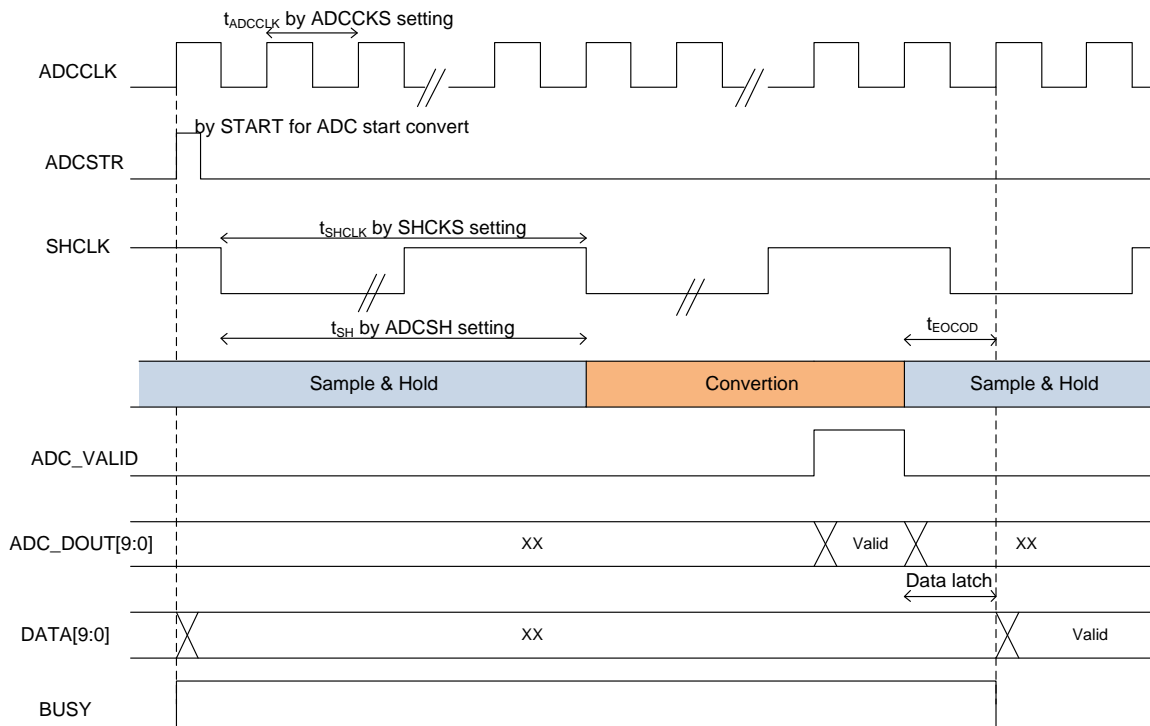


Figure14.1 ADC conversion timing

**14.1 ADCCONT (ADC Control Register)**

Table 14.1.1 ADCCONT (ADC Control Register)

ADCCONT		Address = D2H		Reset Value = 100000B				
ADC Control Register								
	ADCPD	ADCSH[1:0]		ADCDS	ADCCKS	ADDCH[2:0]		
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ADCPD	ADC power down control register :							
	0 : Normal							
	1 : Power down							
ADCSH[1:0]	ADC sample and hold time : (base on SHCLK)							
	00 : 1 clock							
	01 : 2 clock							
	10 : 3 clock							
	11 : 4 clock							
ADCDS	ADC data select :							
		MSB	10 bit result				LSB	
0 :	ADCD2[7:0]			ADCD1.1		ADCD1.0		
1 :	ADCD1.1		ADCD1.0		ADCD2[7:0]			
ADCCKS	ADC conversion clock select : (ADCCLK)							
	0 : 4MHz							
	1 : 2MHz							
ADCCH[2:0]	ADC conversion channel select :							
	000:CH0			100:CH4				
	001: Reserve			101: Reserve				
	010:CH2			110:CH6				
	011 : Reserve			111 :Reserve				

### 14.2 ADCSTR (ADC Start Convert and Setting Register)

Table 14.2.1 ADCCONT (ADC Control Register)

ADCSTR		Address = D3H		Reset Value = 0000000B				
ADC Start Convert and Setting Register								
	SHCKS[1:0]		-----	BUSY	-----	-----	-----	START
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	X	R	X	X	X	W
SHCKS[1:0]		ADC sample and hold clock select : (SHCLK)						
		00 : 1MHz						
		01 : 500KHz						
		10 : 400KHz						
		11 : 333KHz						
BUSY		ADC conversion busy flag :						
		0 : ADC conversion finish						
		1 : ADC conversion busy						
START		ADC start conversion register : (write 1 only)						
		1 : ADC start conversion						

### 14.3 ADCD1 (ADC Data Register 1)

Table 14.3.1 ADCD1 (ADC Data Register 1)

ADCD1		Address = D5H		Reset Value = 00000000B				
ADC Data Register 1								
	-----	-----	-----	-----	-----	-----	ADCD1.1	ADCD1.0
Bit	7	6	5	4	3	2	1	0
Type	R	R	R	R	R	R	R	R

### 14.4 ADCD2 (ADC Data Register 2)

Table 14.4.1 ADCD2 (ADC Data Register 2)

ADCD2		Address = D6H		Reset Value = 00000000B				
ADC Data Register 2								
	ADCD2[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R	R	R	R	R	R	R	R

## 15. General PWM (GPWM)

CGH081A have one 16-bit general PWM output (**PINSET6.4 = '1'**) and six 11-bit PWM (compensation with Dead-Time) for Motor Controller.

GPWM is count up and down timer.(fixed)

Table 15.1 General PWM (GPWM)

SFR	Description	address	Reset value
GPWMCONT	General PWM Control Register	BAH	00H
GPWMMAXH	General PWM Max Register High	BCH	00H
GPWMMAXL	General PWM Max Register Low	BBH	02H
GPWMDYH	General PWM Duty Register High	BEH	FFH
GPWMDYL	General PWM Duty Register Low	BDH	FFH

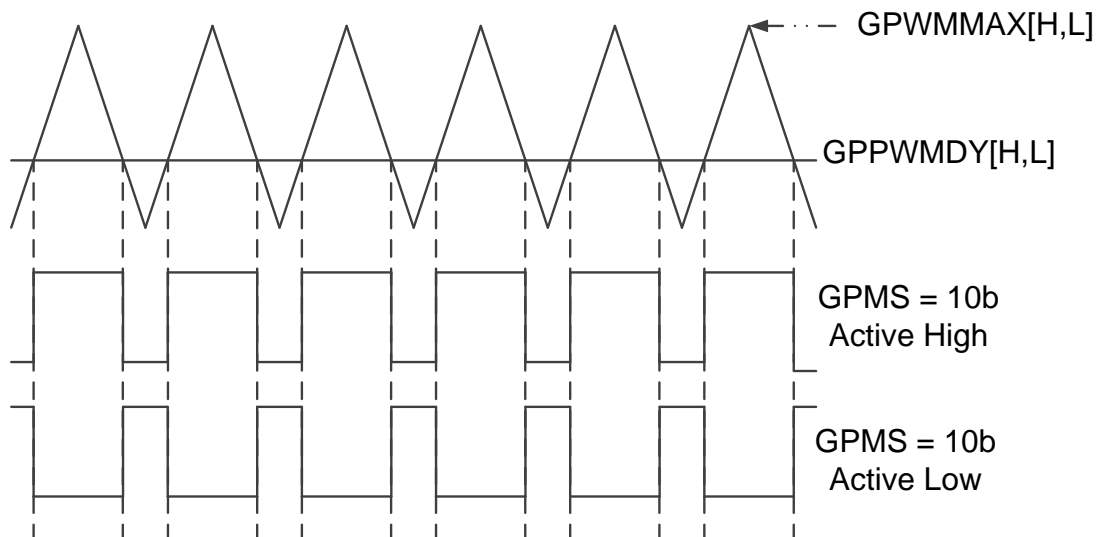


Figure 15.1 General PWM (GPWM)

### 15.1 GPWMCONT (General PWM Control Register)

Table 15.1.1 GPWMCONT (General PWM Control Register)

GPWMCONT		Address = BAH		Reset Value = 0000000B				
General PWM Control Register								
	GPWMTR	GPMS[1:0]		----	----	----	GPCKS[1:0]	
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	X	X	X	R/W	R/W
GPWMTR	GPWM timer run control :							
	0 : Stop							
	1 : Run							
GPMS[1:0]	GPWM output mode select							
(SYNC)	00 : Force Low							
	01 : Force High							
	10 : Active High							
	11 : Active Low							
GPCKS[1:0]	GPWM clock select :							
(SYNC)	00 : 48MHz							
	01 : 48MHz/2							
	10 : 48MHz/4							
	11 : 48MHz/8							

### 15.2 GPWMMAX (General PWM Max Register)

Table 15.2.1 GPWMMAX (General PWM Max Register)

GPWMMAXH (SYNC)		Address = BCH		Reset Value = 00000000B				
General PWM Max Register High								
	GPWMMAXH[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
GPWMMAXL (SYNC)		Address = BBH		Reset Value = 00000010B				
General PWM Max Register Low								
	GPWMMAXL[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

### 15.3 GPWMDY (General PWM Duty Register)

Table 15.3.1 GPWMDY (General PWM Duty Register)

GPWMDYH (SYNC)                      Address = BEH                      Reset Value = 11111111B								
General PWM Duty Register High								
GPWMDYH[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
GPWMDYL (SYNC)                      Address = BDH                      Reset Value = 11111111B								
General PWM Duty Register Low								
GPWMDYL[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

## 16. Capture

Table 16.1 Capture

SFR	Description	address	Reset value
CAPCONT	Capture Control Register	D8H	03H
CAPH_H	Capture High-level Count High	CBH	00H
CAPH_L	Capture High-level Count Low	CCH	00H
CAPT_H	Capture Total Count High	C9H	00H
CAPT_L	Capture Total Count Low	CAH	00H

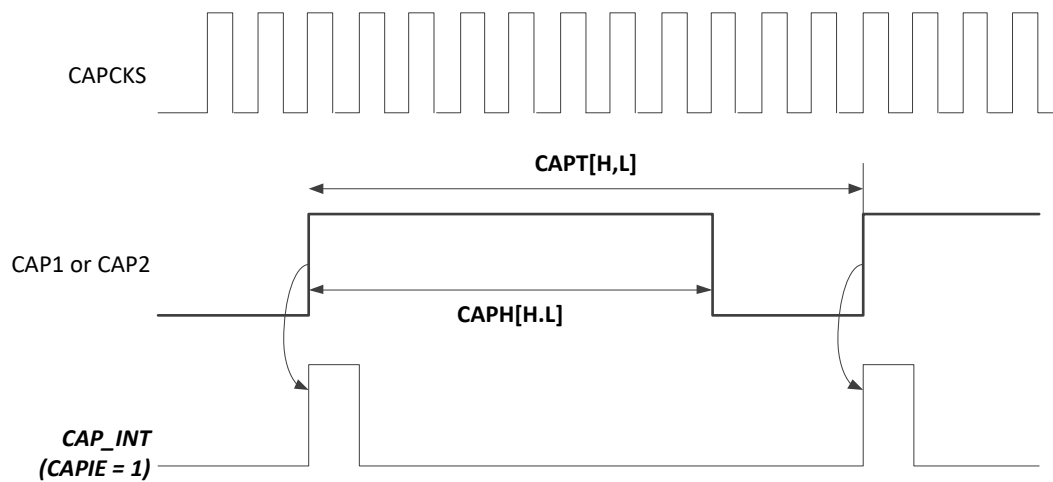


Figure 16.1 Capture



**16.1 CAPCONT (Capture Control Register)**

Table 16.1.1 CAPCONT (Capture Control Register)

CAPCONT		Address = D8H		Reset Value = 00000011B				
Capture Control Register								
	CAPIF	CAPIE	-----	CAPPINSEL	-----	CAPCKS[2:0]		
Bit	7	6	5	4	3	2	1	0
Type	R	W	X	R/W	X	R/W	R/W	R/W
CAPIF		Capture Interrupt flag						
CAPIE		Capture Interrupt enable						
CAPPINSEL		Capture input pin select :						
		0: CAP2(PIN <b>CH7</b> )						
		1: CAP1(PIN <b>CH0</b> )						
CAPCKS[2:0]		Capture clock select :						
		000 : 48MHz/4			100 : 48MHz/64			
		001 : 48MHz/8			101 : 48MHz/128			
		010 : 48MHz/16			110 : 48MHz/256			
		011 : 48MHz/32			111 : 48MHz/512			

### 16.2 CAPT (Capture Total Count)

Table 16.2.1 CAPT (Capture Total Count)

CAPT_H		Address = C9H				Reset Value = 00000000B		
Capture Total Count High								
CAPT[15:8]								
Bit	7	6	5	4	3	2	1	0
Type	R	R	R	R	R	R	R	R
CAPT_L		Address = CAH				Reset Value = 00000000B		
Capture Total Count Low								
CAPT[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	R	R	R	R	R	R	R	R

### 16.3 CAPH (Capture High-level Count)

Table 16.3.1 CAPH (Capture High-level Count)

CAPH_H		Address = CBH				Reset Value = 00000000B		
Capture High-level Count High								
CAPH[15:8]								
Bit	7	6	5	4	3	2	1	0
Type	R	R	R	R	R	R	R	R
CAPH_L		Address = CCH				Reset Value = 00000000B		
Capture High-level Count Low								
CAPH[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	R	R	R	R	R	R	R	R

## 17. Addition and Subtraction Unit (ASU)

ASU provides 32-bit Addition and Subtraction calculation.

Table 17.1 Addition and Subtraction Unit (ASU)

SFR	Description	address	Reset value
AS_MD_CONT	ASU and MDU Control Register	E1H	10H
ASUD1_1	ASU Data 1 byte 1	E8H	00H
ASUD1_2	ASU Data 1 byte 2	E9H	00H
ASUD1_3	ASU Data 1 byte 3	EAH	00H
ASUD1_4	ASU Data 1 byte 4	EBH	00H
ASUD2_1	ASU Data 2 byte 1	ECH	00H
ASUD2_2	ASU Data 2 byte 2	EDH	00H
ASUD2_3	ASU Data 2 byte 3	EEH	00H
ASUD2_4	ASU Data 2 byte 4	EFH	00H
ASUR1	ASU Result Register 1	DCH	00H
ASUR2	ASU Result Register 2	DDH	00H
ASUR3	ASU Result Register 3	DEH	00H
ASUR4	ASU Result Register 4	DFH	00H

	MSB			LSB
ASUD1	ASUD1_4	ASUD1_3	ASUD1_2	ASUD1_1
ASUD2	ASUD2_4	ASUD2_3	ASUD2_2	ASUD2_1
ASUR	ASUR4	ASUR3	ASUR2	ASUR1

Addition Calculation (AS_MD_CONT.0 = 0)	$ASUR = ASUD1 + ASUD2$	ASUR4 limit at 0x7F
Subtraction Calculation (AS_MD_CONT.0 = 1)	$ASUR = ASUD1 - ASUD2$	ASUR4 limit at 0x81

## 17.1 AS\_MD\_CONT (ASU and MDU Control Register)

Table 17.1.1 AS\_MD\_CONT (ASU and MDU Control Register)

AS_MD_CONT		Address = E1H				Reset Value = 00010000B			
ASU and MDU Control Register									
		----	----	----	MDUF	----	----	MDUS	ASUS
Bit		7	6	5	4	3	2	1	0
Type		X	X	X	R	X	X	R/W	R/W
MDUF	MDU finish flag : 0 : MDU busy. 1 : MDU calculation finished.								
MDUS	MDU Signed select : 0 : Signed calculation. 1 : Unsigned calculation.								
ASUS	ASU Subtraction select : 0 : Addition calculation. 1 : Subtraction calculation.								

## 17.2 ASUD1 (ASU Data 1)

Table 17.2.1 ASUD1 (ASU Data 1)

ASUD1_1		Address = E8H				Reset Value = 00000000B			
		ASUD1_1[7:0]							
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ASUD1_2		Address = E9H				Reset Value = 00000000B			
		ASUD1_2[7:0]							
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ASUD1_3		Address = EAH				Reset Value = 00000000B			
		ASUD1_3[7:0]							
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ASUD1_4		Address = EBH				Reset Value = 00000000B			

		ASUD1_4[7:0]							
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

### 17.3 ASUD2 (ASU Data 2)

Table 17.3.1 ASUD2 (ASU Data 2)

ASUD2_1		Address = ECH				Reset Value = 00000000B			
		ASUD2_1[7:0]							
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ASUD2_2		Address = EDH				Reset Value = 00000000B			
		ASUD2_2[7:0]							
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ASUD2_3		Address = EEH				Reset Value = 00000000B			
		ASUD2_3[7:0]							
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ASUD2_4		Address = EFH				Reset Value = 00000000B			
		ASUD2_4[7:0]							
Bit		7	6	5	4	3	2	1	0
Type		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

## 17.4 ASUR (ASU Result Register)

Table 17.4.1 ASUR (ASU Result Register)

ASUR1		Address = ECH				Reset Value = 0000000B		
		ASUR1[7:0]						
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ASUR2		Address = EDH				Reset Value = 0000000B		
		ASUR2[7:0]						
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ASUR3		Address = EEH				Reset Value = 0000000B		
		ASUR3[7:0]						
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
ASUR4		Address = EFH				Reset Value = 0000000B		
		ASUR4[7:0]						
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

## 18. Multiplication and Division Unit (MDU)

The **MDU** is an on-chip arithmetic co-processor which enables the **CGH081A** to perform additional extended arithmetic operations. All operations are signed/unsigned integer operations. Operands and results are stored in **MD0–MD5** registers. The module is controlled by the **AS\_MD\_CONT** and **MD\_CONT** register. Any calculation of the **MDU** overwrites its operands. The **MDU** support five operations: Division 32-bit/16-bit, Division 16-bit/16-bit, Multiplication, Shift and Normalize.

Table 18.1 Multiplication and Division Unit (MDU)

SFR	Description	address	Reset value
AS_MD_CONT	ASU and MDU Control Register	E1H	10H
MD_CONT	MDU Control Register	DBH	00H
MD0	Multiplication Division Register 0	E2H	00H
MD1	Multiplication Division Register 1	E3H	00H
MD2	Multiplication Division Register 2	E4H	00H
MD3	Multiplication Division Register 3	E5H	00H
MD4	Multiplication Division Register 4	E6H	00H
MD5	Multiplication Division Register 5	E7H	00H

### 18.1 AS\_MD\_CONT (ASU and MDU Control Register)

Table 18.1.1 AS\_MD\_CONT (ASU and MDU Control Register)

AS_MD_CONT		Address = E1H		Reset Value = 00010000B							
ASU and MDU Control Register											
Bit	7	6	5	MDUF	4	3	2	MDUS	1	0	ASUS
Type	X	X	X	R	X	X	X	R/W	R/W	R/W	R/W
MDUF	MDU finish flag : 0 : MDU busy. 1 : MDU calculation finished.										
MDUS	MDU Signed select : 0 :Signed calculation. 1 :Unsigned calculation.										
ASUS	ASU Subtraction select : 0 : Addition calculation. 1: Subtraction calculation.										

## 18.2 MD\_CONT (MDU Control Register)

Table 18.2.1 MD\_CONT (MDU Control Register)

MD_CONT		Address = DBH		Reset Value = 00010000B				
MDU Control Register								
	MDEF	MDOV	SLR	SC[4:0]				
Bit	7	6	5	4	3	2	1	0
Type	R	R	R/W	R/W	R/W	R/W	R/W	R/W
MDEF	MDU Error flag : Indicates an improperly performed operation (when one of the arithmetic operations has been restarted or interrupted by a new operation).							
MDOV	MDU Overflow flag : Overflow occurrence in the MDU operation.							
SLR	Shift direction : 0 : shift left operation 1 : shift right operation							
SC[4:0]	Shift counter : When set to all '0's, normalize operation is selected. After normalization, the SC[4:0] contain the number of normalizing shifts performed. When at least one of these bit is set high shift operation is selected. The number of shifts performed is determined by the number written to SC[4:0], where SC.4 is the MSB.							

### 18.2.1 MDEF

The **MDEF** error flag indicates an improperly performed operation (when one of the arithmetic operations has been restarted or interrupted by a new operation). The error flag mechanism is automatically enabled with the first write operation to **MD0** and disabled with the final read instruction from **MD3** (multiplication or shift/norm) or **MD5** (division) in phase three.

The error flag is set when:

There is a write access to MDx registers (any of **MD0-MD5** and **MD\_CONT**) during phase two of **MDU** operation (restart or calculations interrupting) There is a read access to one of MDx registers during phase two of **MDU** operation when the error flag mechanism is enabled. In such condition error flag is set but the calculation is not interrupted. The error flag is reset only after read access to **MD\_CONT** register. The error flag is read only.



### 18.2.2 MDOV

The **MDOV** overflow flag is set when one of the following conditions occurs: Division by zero multiplication with a result greater than FFFFH

Start of normalizing if the ('**MD3.7**' = '1') most significant bit of **MD3** is set any operation of the **MDU** that does not match the above conditions clears the overflow flag. Note that the overflow flag is exclusively controlled by hardware. It cannot be written.

### 18.3 MD0 – MD5 (Multiplication Division Register)

Table 18.3.1 MD0 – MD5 (Multiplication Division Register)

<b>MD0</b>		Address = E2H							Reset Value = 0000000B
Multiplication Division Register 0									
		MD0[7:0]							
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

<b>MD1</b>		Address = E3H							Reset Value = 0000000B
Multiplication Division Register 1									
		MD1[7:0]							
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

<b>MD2</b>		Address = E4H							Reset Value = 0000000B
Multiplication Division Register 2									
		MD2[7:0]							
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

<b>MD3</b>		Address = E5H							Reset Value = 0000000B
Multiplication Division Register 3									
		MD3[7:0]							
Bit	7	6	5	4	3	2	1	0	
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	

MD4		Address = E6H		Reset Value = 0000000B				
Multiplication Division Register 4								
		MD4[7:0]						
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

MD5		Address = E7H		Reset Value = 0000000B				
Multiplication Division Register 5								
		MD5[7:0]						
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

## 18.4 MDU Operation Description

The operation of the **MDU** consists of three phases:

### 18.4.1 Loading the MDx registers

The type of calculation the **MDU** has to perform is selected by the order in which the MDx registers are written to. A write to **MD0** is the first transfer to be done in any case. Next writes must be done as shown in the table below to determine the **MDU** operation. The last write will start the selected operation.

Table 18.4.1 Loading the MDx registers

Operation	32-bit/16-bit	16-bit-/16bit	16-bit x 16-bit	Shift/ normalizing
First write	MD0 Dividend Low	MD0 Dividend Low	MD0 Multiplicand Low	MD0 LSB
	MD1 Dividend	MD1 Dividend High	MD4 Multiplier Low	MD1
	MD2 Dividend		MD1 Multiplicand High	MD2
	MD3 Dividend High			MD3 MSB
	MD4 Divisor Low	MD4 Divisor Low		
Last write	MD5 Divisor High	MD5 Divisor High	MD5 Multiplier High	MD_CONT start conversion

### 18.4.2 Executing calculation

During the calculation period, the **MDU** works in parallel to the CPU. When the calculation is complete, the hardware will set the **MDUF** bit to one (**MDUF** = '1'). The flag will be cleared at the next calculation.

The following table provides the execution time for each mathematical operation.

Table 18.4.2 Executing calculation

Operation	Number of clock cycles	
Division 32-bit/16-bit	17 clock cycles	
Division 16-bit/16-bit	9 clock cycles	
Multiplication	11 clock cycles	
Shift	Min 3 clock cycles (SC = 01H)	Max 18 clock cycles (SC = 1FH)
Normalize	Min 4 clock cycles (SC <= 01H)	Max 19 clock cycles (SC = 1FH)

### 18.4.3 Reading the result from the MDx registers

The Read-out sequence of the first "MDx" registers is not critical but the last read determines the end of a whole calculation.

Table 18.4.3 Reading the result from the MDx registers

Operation	32-bit/16-bit	16-bit/16-bit	16-bit x 16-bit	Shift/ normalizing
First read	MD0 Quotient Low	MD0 Quotient Low	MD0 Product Low	MD0 LSB
	MD1 Quotient	MD1 Quotient High	MD1 Product	MD1
	MD2 Quotient		MD2 Product	MD2
	MD3 Quotient High			
	MD4 Remainder Low	MD4 Remainder Low		
Last read	MD5 Remainder High	MD5 Remainder High	MD3 Product High	MD3 MSB

#### 18.4.4 Shifting

In shift operation, 32-bit integer variable stored in **MD0** to **MD3** registers (the latter contains the most significant byte) is shifted left or right by a specified number of bits. The **SLR** bit (**MD\_CONT.5**) defines the shift direction, and bits **SC[4:0]** (**MD\_CONT.4 –MD\_CONT.0**) specifies the shift count (which must not be 0). During shift operation, zeroes come into the left end of **MD3** for shifting right or right end of the **MD0** for shifting left.

#### 18.4.5 Normalizing

All leading zeroes of 32-bit integer variable stored in **MD0** to **MD3** registers, the latter contains the most significant byte are removed by shift left operations. The whole operation is completed when the MSB (most significant bit) of **MD3** register contains a '1'. After normalizing, bits **SC[4:0]** (**MD\_CONT.4 –MD\_CONT.0**) contain the number of shift left operations, which were done.

## 19. Motor Driving Engine (MDE)

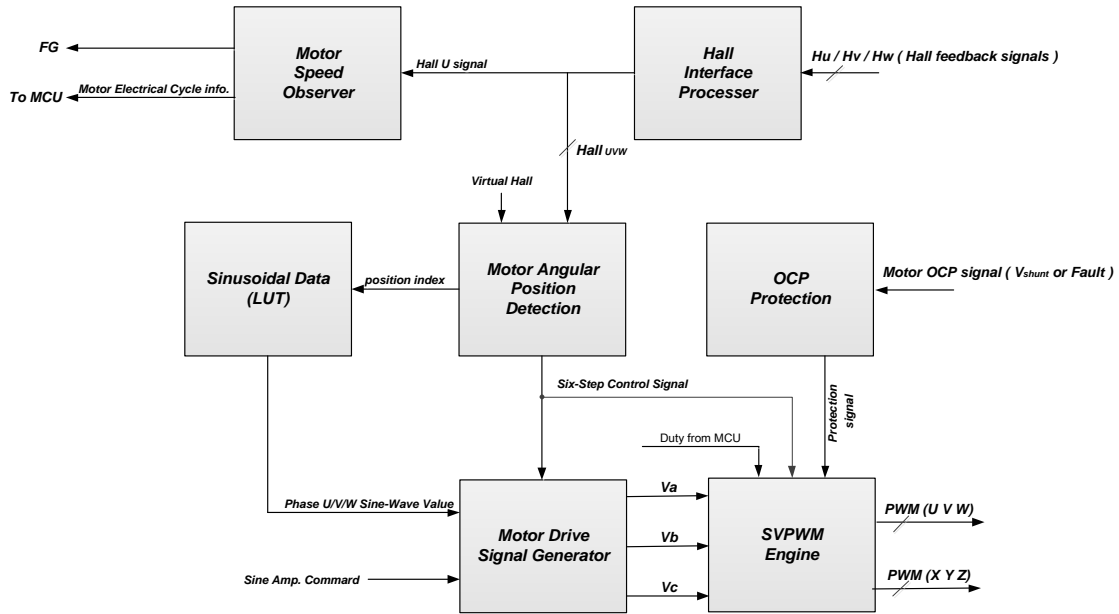


Figure 19.1 : MDE Architecture

CGH081A has built-in MDE (Motor Driving Engine), which provides motor sine-wave and square wave control drive architecture. The description is shown in Figure 19.1, which includes Hall Interface Processor, Motor Speed Observer, Motor Angular Position Detection, Sinusoidal Data (LUT), Motor Drive Signal Generator, SVPWM Engine and OCP Protection and other 7 control blocks.

First, the hall signals (Hu, Hv and Hw) fed back by the three-phase motor are processed by the de-bounce of the Hall Interface Processor Block and then output to the Motor Speed Observer and Motor Angular Position Detection. The Motor Speed Observer Block calculates the motor speed. , Motor Angular Position Detection estimates the position index of the three-phase sinusoidal wave and six-step control signal.

In sine-wave control drive, the position index of Motor Angular Position Detection Block of the three-phase sine wave is input to the Sinusoidal Data (LUT). After performing a table lookup of the three-phase sine wave, the three-phase sine wave value is output to the Motor Signal Generator Block to perform three-phase sine wave calculations (Va, Vb and Vc). In the square wave control drive, the Motor Angular Position Detection Block generates six-step control signal according to the hall status and outputs it to the Motor Signal Generator Block.

The last stage performs SVPWM modulation and outputs PWM<sub>UVW</sub> and PWM<sub>XYZ</sub> to the motor frequency conversion circuit.

OCP Protection Block, when an overcurrent occurs in the system, is protected by hardware and turns off six PWM signals. Detailed descriptions of the control functions of each block are detailed in the following chapters.

### 19.1 HALL Interface Processor

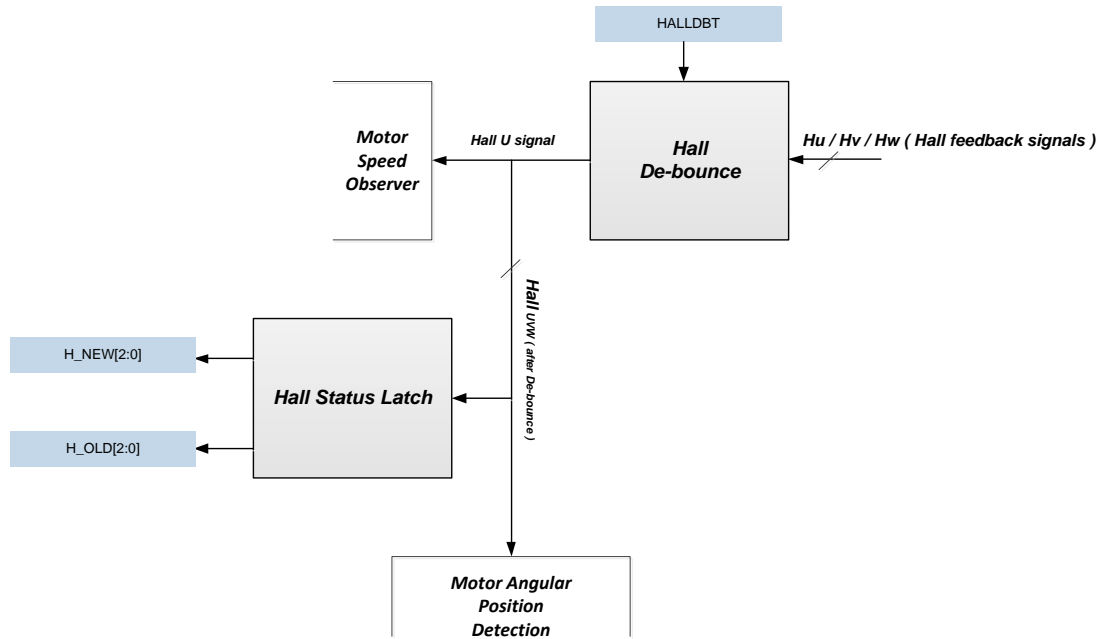


Figure 19.1.1 : Hall I/F Processor Architecture

The Hall sensor is installed in the motor. When the motor is running, it will generate a lot of noise, causing the hall feedback signals (Huvw) to have a lot of noise. If filtering is not performed, it will cause error commutation of the motor drive.

In the HALL Interface Processor Block, design a de-bounce circuit to filter the three Hall signals. Set the de-bounce time of Hu, Hv and Hw through HALLDBT (see Table 19.1.1), and set the Hall de-bounce settings. The set time is:  $1/3\text{MHz} \times \text{HALLDBT} [5:0]$ .

HALLDBT		Address = 9CH		Reset Value = 00001110B				
Hall De-bounce Time Register								
	----	----	HALLDBT[5:0]					
Bit	7	6	5	4	3	2	1	0
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
HALLDBT is use to filter the HALL signal.								
De-bounce time = $1/3\text{MHz} \times \text{HALLDBT} [5:0]$								

Table 19.1.1 : HALLDBT SFR Description

Hu (after de-bounce) is connected to the Motor Speed Observer Block to calculate the motor speed, and Hu, Hv and Hw (after de-bounce) are connected to the Motor Angular Position Detection Block to estimate the motor rotor position and six-step control signal.

In the HALL Interface Processor Block, latch the current and previous Hall status and put them in HALLST (see Table 19.1.2) for the MCU to read and use.

HALLST		Address = 94H				Reset Value = 0000000B		
Hall Status Register								
	-----	H_OLD[2:0]			-----	H_NEW[2:0]		
Bit	7	6	5	4	3	2	1	0
Type	X	R	R	R	X	R	R	R
H_OLD[2:0]	Hall old status : [2] : HALL U status. [1] : HALL V status. [0] : HALL W status.							
H_NEW[2:0]	Hall new status : [2] : HALL U status. [1] : HALL V status. [0] : HALL W status.							

Table 19.1.2 : HALLST SFR Description

## 19.2 Motor Speed Observer

The Motor Speed Observer provides motor electrical cycle (motor speed) information to the MCU for motor speed close-loop control. The Motor Speed Observer has a built-in counter whose input signal is HALLU. It counts the time from rise edge to rise edge of HALLU to obtain the motor electrical cycle (motor speed) information. See Figure 19.2.1.

First, after setting HCKS (see Table 19.2.1 MCONT1. HCKS SFR) according to the motor speed range, select the clock frequency of the Observer, the hardware starts counting the time of motor electrical cycle, and the MCU can start counting from the ROTORSPEED SFR (see Table 19.2. 2 ROTORSPEED SFR) reads the 16-bits counter value. In the next step, the MCU can perform speed close-loop control according to the ROTORSPEED SFR. Timing diagram, please see Figure 19.2.2.

According to the motor speed range, the value range read by ROTORSPEED SFR must be in the range of 0x0200~0xFFFF to avoid control abnormalities; if the value read by ROTORSPEED SFR is not between 0x0200~0xFFFF, HCKS needs to be changed. In addition, if the value of ROTORSPEED SFR is 0xFFFF, it means that the motor may be rotating very slowly or has stopped running. At this time, the value of MOTOSTOP (see Table 19.2.1 MCONT1. MOTOSTOP SFR) will be "1".

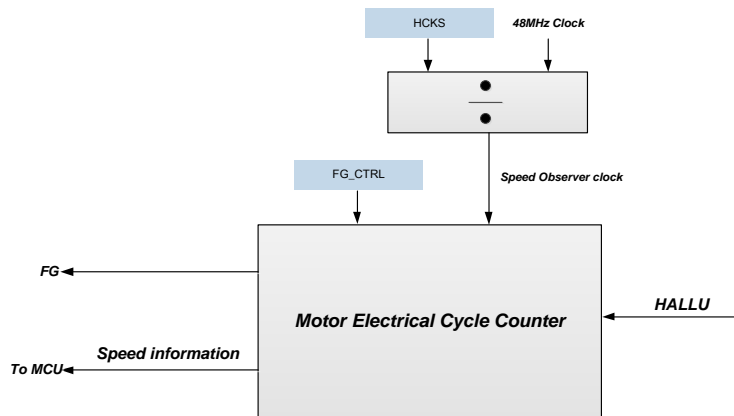


Figure 19.2.1 Motor Speed Observer Architecture

MCONT1		Address = 9DH		Reset Value = X0110000B				
Motor Control Register 1								
	MOTOSTOP	HCKS[2:0]			HALLALS	DMS	MPWMA	AMDS
Bit	7	6	5	4				
Type	R	R/W	R/W	R/W				
MOTOSTOP	1 : Motor Stop							
HCKS[2:0]	Hall clock select :							
	000 : 48MHz/4			100 : 48MHz/64				
	001 : 48MHz/8			101 : 48MHz/128				



010 : 48MHz/16	110 : 48MHz/256
011 : 48MHz/32	111 : 48MHz/512

Table 19.2.1 MCONT1. HCKS and MOTOSTOP SFR

ROTORSPEEDH		Address = 97H		Reset Value = 1111111B				
Rotor Speed Count Register High								
ROTORSPEED[15:8]								
Bit	7	6	5	4	3	2	1	0
Type	R	R	R	R	R	R	R	R
ROTORSPEEDL		Address = 96H		Reset Value = 1111111B				
Rotor Speed Count Register Low								
ROTORSPEED[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	R	R	R	R	R	R	R	R

Table 19.2.2 ROTORSPEED SFR (Rotor Speed Count Register)

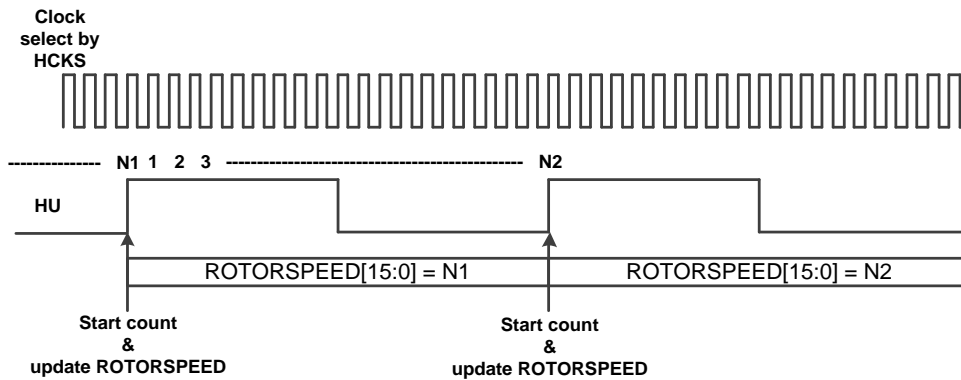


Figure 19.2.2 Rotor electrical cycle counter

In addition to providing motor electrical cycle (motor speed) information, Motor Speed Observer can also output a fixed pulse number in a hall cycle according to the setting of FG\_CTRL SFR (see Table 19.2.3), that is, it can be used as a frequency generator (FG). Figure 19.2.3 shows an FG output waveform when the control bits in the FG\_CTRL SFR are FG\_EN=1, FG10P\_8P=0, and FGPULSE\_SEL=5.

FG_CTRL		Address = C5H		Reset Value = 0x00H				
Frequency Generator Control Register								
	FG_EN	FG10P_8P	----	----	FGOUT_SEL	FGPULSE_SEL		
Bit	7	6	5	4	3	2	1	0
Type	W	W	X	X	W	W		
FG_EN	FG output enable:							

	0 : Disable 1 : Enable
FG10P_8P	10 poles or 8 poles Motor: 0 : 8 poles 1 : 10 poles
FGOUT_SEL	FG output pin select: 0 : out to CH3 pin 1 : out to TX pin
FGPULSE_SEL	FG pulse number selection: 000 : 1 pulse 001 : 2 pulses 010 : 4 pulses 011 : 5 pulses 100 : 8 pulses 101 : 12 pulses

Table 19.2.3 FG\_CTRL SFR (Frequency Generator Register)

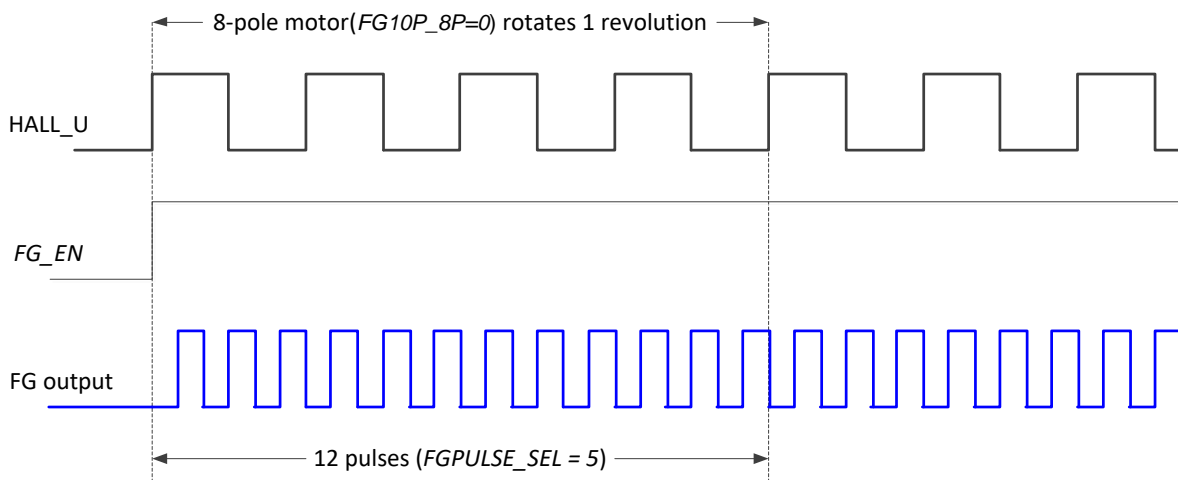


Figure 19.2.3 FG output when FG\_EN=1, FG10P\_8P=0, and FGPULSE\_SEL=5

### 19.3 Motor Angular Position Detection

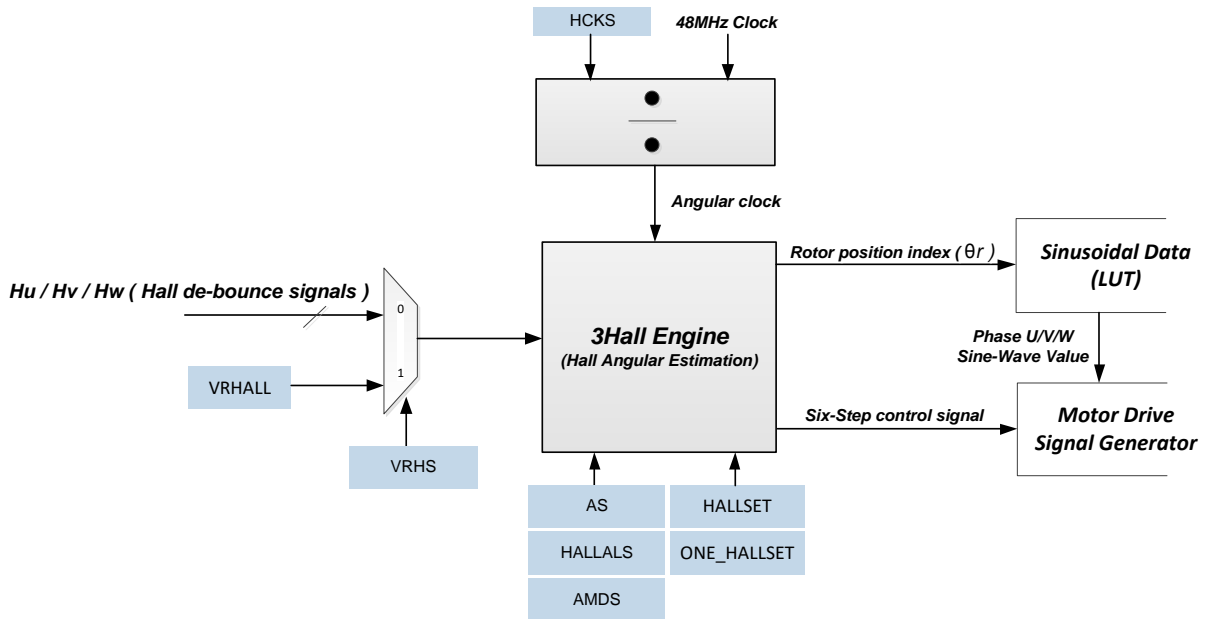


Figure 19.3.1 Motor Angular Position Architecture

Motor Angular Position Detection Block has a built-in 3Hall Engine, which estimates the rotor position index and six-step control signal based on the hall input signal. Its input signal can be selected through VRHS. When VRHS=0 (see Table 19.3.1), its 3Hall Engine The input signal is Real hall (i.e. external hall signals input). Otherwise, VRHS=1, the input signal is VRHALL SFR (see Table 19.3.2).

MCONT2		Address = A2H				Reset Value = 0000000B		
Motor Control Register 2								
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	X
VRHS	Virtual Hall select : 0 : Real Hall. (HALL U, HALL V, HALL W) 1 : Virtual Hall.							

Table 19.3.1 VRHS SFR

VRHALL		Address = D9H				Reset Value = 00000101B		
Virtual Hall Register								
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
VRH[2:0]	Virtual Hall value.							

VRH.2 is Virtual HALL U. VRH.1 is Virtual HALL V. VRH.0 is Virtual HALL W.
--

Table 19.3.2 VRHALL SFR

First, after setting HCKS (Table 19.3.3 MCONT1. HCKS SFR) according to the motor speed range, select the clock frequency of angular estimate, the hardware starts counting the time of motor angle step, the 1 angle step is 0.9375° ( 384 step / 360°), according to the motor speed range, setting the appropriate HCKS can count each angle step to have the best resolution.

Hall sensor has two installation methods that hall signal is aligned with Line Voltage or Phase Voltage. Hall alignment select HALLALS = 0 (see Table 19.3.3), Hall signal is aligned with Line Voltage, in addition, when HALLALS = 1, Hall signal is aligned with Phase Voltage.

MCONT1		Address = 9DH			Reset Value = X0110000B			
Motor Control Register 1								
Bit	MOTOSTOP	HCKS[2:0]			HALLALS	DMS	MPWMA	AMDS
Type	7	6	5	4	3	2	1	0
Type	R	R/W	R/W	R/W	R/W	R/W	R/W	R/W
HCKS[2:0]	Hall clock select :							
	000 : 48MHz/4			100 : 48MHz/64				
	001 : 48MHz/8			101 : 48MHz/128				
	010 : 48MHz/16			110 : 48MHz/256				
	011 : 48MHz/32			111 : 48MHz/512				
HALLALS	Hall alignment select :							
	0 : Line voltage (Line to Line)							
	1 : Phase voltage							
AMDS	Auto mode direction select :							
	0 : When MPWMA = '1', driving direction is forward.							
	1 : When MPWMA = '1', driving direction is reverse.							

Table 19.3.3 MCONT1.HCKS / HALLALS / AMDS SFR

CGH081A must set the forward direction HALL sequence to the HALLSET SFR so that CGH081A can automatically generate the signals required for its motor driving. When HALLALS = 0, Figure 19.3.2 and Figure 19.3.3 are HALLSET (see Table 19.3.4) settings determine the description.

Figure 19.3.3, when HALLALS = 1, the hall signals is aligned with Phase voltage, Phase to Phase voltage sequence is Vuv leads Vvw by 120 degrees and Vvw leads Vwu by 120 degrees. (Forward direction defines in CGH081A). As

shown in the figure, hall signals forward sequence is 5 4 6 2 3 1, filled in HALLSET1\_1, HALLSET1\_2, HALLSET2\_1, HALLSET2\_2, HALLSET3\_1 and HALLSET3\_2 in order.

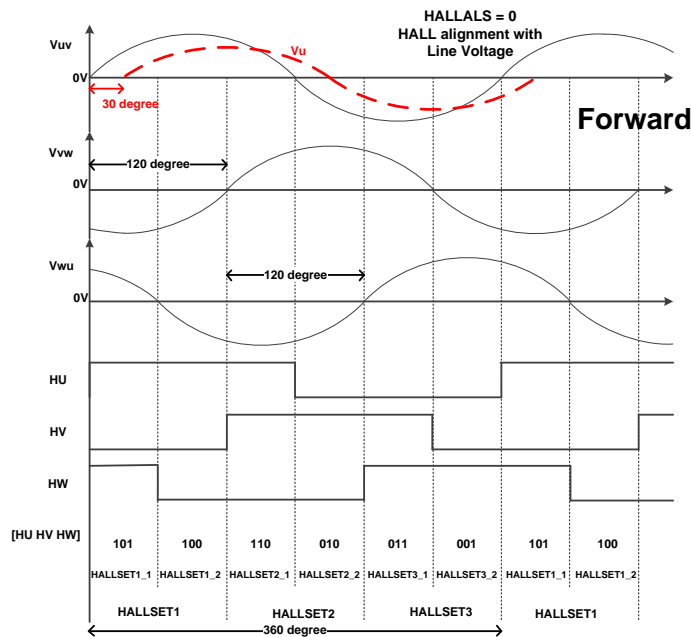


Figure 19.3.2 HALLSET (Hall Setting Register 1, 2, 3)

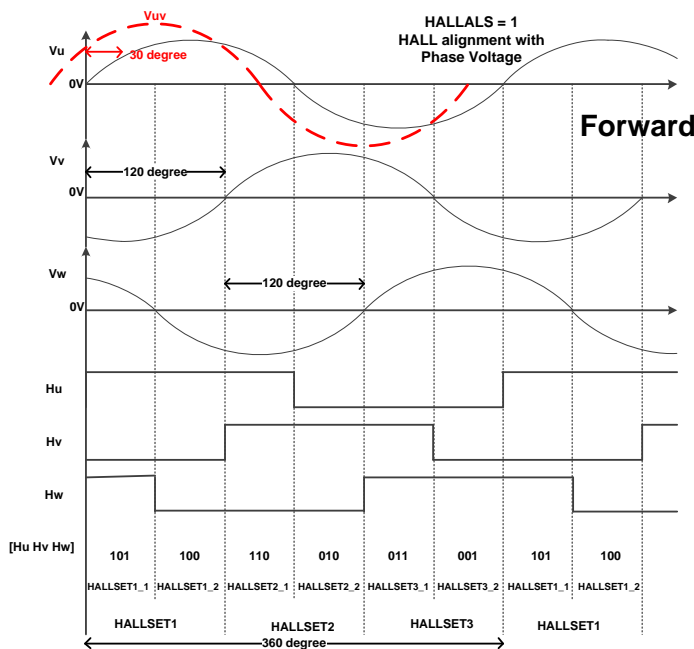


Figure 19.3.3 Hall signal is alignment with Phase Voltage.

AS (see Table 19.3.5 ) is setting for leading angle, AS resolution is 0.9375°/bit, AS setting range is -59.0625° ~ 59.0625.

When MWPMA = '1' (auto mode), AS is active.

MDE provides motor reverse setting and simply set AMDS (see Table 19.3.3) to reverse the motor.

HALLSET1 (SYNC) Address = 91H Reset Value = 01000101B								
Hall Setting Register 1								
	-----	HALLSET1_2[2:0]			-----	HALLSET1_1[2:0]		
Bit	7	6	5	4	3	2	1	0
Type	X	R/W	R/W	R/W	X	R/W	R/W	R/W
[2] : HALL U status. [1] : HALL V status. [0] : HALL W status.								
HALLSET2 (SYNC) Address = 92H Reset Value = 00100110B								
Hall Setting Register 2								
	-----	HALLSET2_2 [2:0]			-----	HALLSET2_1[2:0]		
Bit	7	6	5	4	3	2	1	0
Type	X	R/W	R/W	R/W	X	R/W	R/W	R/W
[2] : HALL U status. [1] : HALL V status. [0] : HALL W status.								
HALLSET3 (SYNC) Address = 93H Reset Value = 00010011B								
Hall Setting Register 3								
	-----	HALLSET3_2[2:0]			-----	HALLSET3_1[2:0]		
Bit	7	6	5	4	3	2	1	0
Type	X	R/W	R/W	R/W	X	R/W	R/W	R/W
[2] : HALL U status. [1] : HALL V status. [0] : HALL W status.								

Table 19.3.4 HALLSET123 SFR

AS (SYNC) Address = 8FH Reset Value = 00000000B								
Angle Shift Control Register								
	AS_LS	-----	AS_VALUE[5:0]					
Bit	7	6	5	4	3	2	1	0
Type	R/W	X	R/W	R/W	R/W	R/W	R/W	R/W
AS_LS	Angle Shift Lag select: 0 : 0° ~59.0625° = 0~ 63(AS_VALUE) 1 : 0° ~-59.0625° = 0~ -63(AS_VALUE)							

Table 19.3.5 AS SFR

The main function of 3Hall Engine is to estimate the U, V, and W phase rotor position index (θr). The 3Hall Engine mainly generates the U, V, and W phase rotor position index (θr) based on the 3 Hall signal status and current speed, combined with the settings of AS, HALLALS, and AMDS, and then generates sine data by looking up the Sinusoidal Data (LUT) Block. In addition, in order to reduce external PCB costs, 3Hall Engine also supports observing the status

and current speed of a single Hall signal (Hall\_U). Through additional settings of ONE\_HALLSET (see Table 19.3.6), it can also generate U, V, and W phase rotor position indexes ( $\theta_r$ ).

ONE_HALLSET		Address = 95H				Reset Value = 0000_0000B		
One Hall Setting Register (when SFR IMPMISC_KEY = 0xa5)								
Bit	STA_ZONE_EN	3TO1_RUN	-----	-----	1HALL_ONLY	ZONE[2:0]		
Type	7	6	5	4	3	2	1	0
Type	W	W	X	X	W	W	W	W
STA_ZONE_EN	Hall U rising edge start zone setting enable (for 3-Hall Start and 1-Hall Rotation or One Hall solution using) 0 : Hall U rising edge start zone setting by hardware when 1-hall run 1 : Hall U rising edge start zone setting by software when 1-hall run							
3TO1_RUN	3-Hall Start and 1-Hall Rotation enable 0 : 3-Hall Rotation or 1-Hall Start up and Rotation 1 : 3-Hall Start and 1-Hall Rotation							
1HALL_ONLY	One Hall Only enable (Only Hall U for One Hall Rotation) 0 : Disable One Hall Only 1 : Enable One Hall Only							
ZONE	Hall U rising edge start ZONE ( <b>when STA_ZONE_EN =1</b> ) 000: Hall U rising edge start at ZONE0 (HALLSET1_1), start angle is 0 001: Hall U rising edge start at ZONE1 (HALLSET1_2), start angle is 64 010: Hall U rising edge start at ZONE2 (HALLSET2_1), start angle is 128 011: Hall U rising edge start at ZONE3 (HALLSET2_2), start angle is 192 100: Hall U rising edge start at ZONE4 (HALLSET3_1), start angle is 256 101: Hall U rising edge start at ZONE5 (HALLSET3_2), start angle is 320							

Table 19.3.6 ONE\_HALLSET SFR

The usage of a single hall operation can be set by the three bits STA\_ZONE\_EN, 3TO1\_RUN, and 1HALL\_ONLY in the ONE\_HALLSET SFR and the area aligned with the rising edge of Hall\_U (determined by HALL\_SET). As shown in Figure 19.3.4, when the rising edge of Hall\_U is aligned with ZONE1, if you want to use **3 halls to start up and then 1 hall to rotate**, the ONE\_HALLSET SFR should be set to 0x41.

If the **1 hall solution** is adopted, that is, the software planning startup program is used with the hardware to automatically calculate the rotor position index; when the rotor is started and you want to switch to the 1 hall fully automatic auxiliary rotor rotation supported by the hardware, after executing the 1 hall start After the program, set the ONE\_HALLSET SFR to 0x89 (Hall\_U rising edge is aligned in ZONE1), which means MDE will take over the 1 hall automatic rotation program.

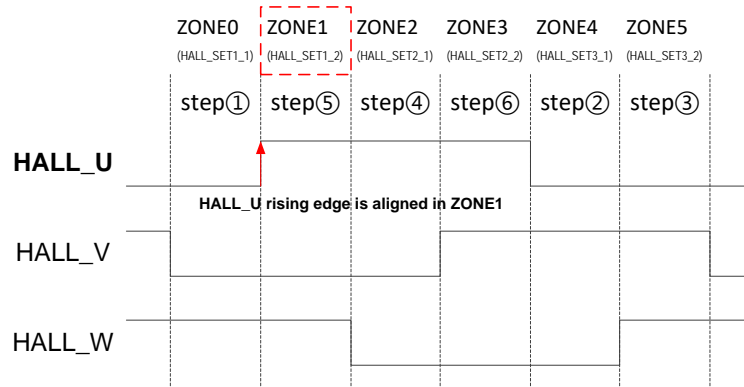


Figure 19.3.4 Hall\_U rising edge is aligned in ZONE1.

19.4 Sinusoidal Data ( LUT )

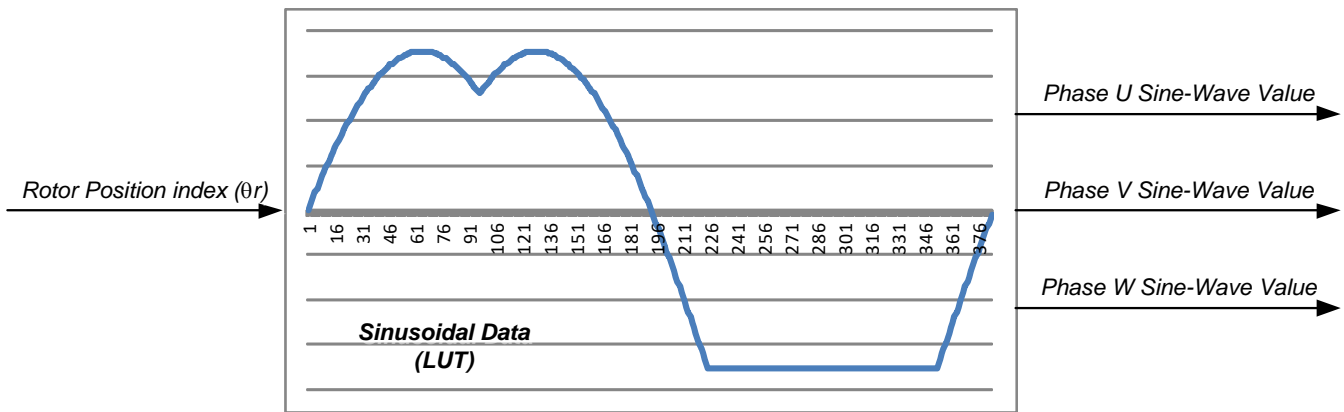


Figure 19.4.1 : Sinusoidal Data (LUT) Architecture,  $\theta_r$  resolution is 0.9375°/bit

The Sinusoidal Data (LUT) Block has a built-in three-phase SVPWM look-up table. The input signal is the U, V and W phase Rotor position index ( $\theta_r$ ) estimated by the Motor Angular Position Detection Block. After looking up the table, the three-phase sine wave value is output to the Motor Signal Generator Block to perform three-phase sine wave calculations.

19.5 Motor Drive Signal Generator

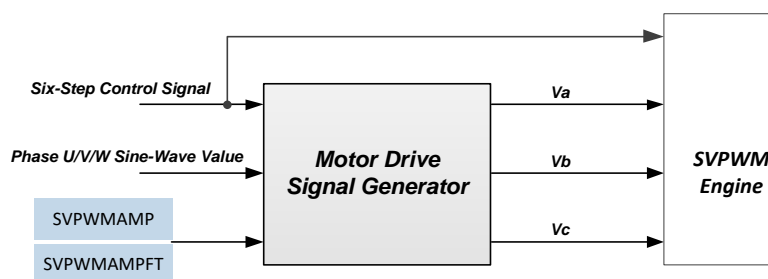


Figure 19.5.1 : Motor Drive Signal Generator Architecture



Motor Drive Signal Generator Block sets SVPWMAMP and SVPWMAMPFT SFR (see Table 19.5.1) to change the amplitude of the three-phase sine wave according to the required speed of the motor drive. The corresponding sine wave value is determined by the Sinusoidal Data (LUT) Block table lookup.

Through the operation of SVPWMAMP and SVPWMAMPFT and Phase U V W sine-wave vale, the output voltage values of Va, Vb and Vc are obtained and provided to the SVPWM Engine Block for SVPWM modulation.

The SVPWM of CGH081A has two modes: seven-segment and five-segment (see Section 19.6.2) SVPWM. The setting range of SVPWMAMP is 0 ~ MPWM\_CYC/2. When the value is larger, the three-phase voltage output by it will be larger.

SVPWMAMPFT is the fine tune of SVPWMAMP. Its function is between the two levels of SVPWMAMP. It can have 8 levels of fine tune to achieve accurate speed control.

SVPWMAMPH(SYNC)		Address = C4H		Reset Value = 0000000B				
SVPWM Amplitude Register High								
	-----	-----	-----	-----	-----	SVPWMAMP[10:8]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
SVPWAMAMPL(SYNC)		Address = C3H		Reset Value = 0000000B				
SVPWM Amplitude Register Low								
	SVPWMAMP[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
SVPWMAMPFT		Address = DAH		Reset Value = 0000000B				
SVPWM Amplitude Fine-Tune Register								
	-----	-----	-----	-----	-----	SVPWMAMPFT[2:0]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W

Table 19.5.1 SVPWMAMP and SVPWMAMPFT SFR

## 19.6 SVPWM Engine

### 19.6.1 SVPWM Engine Architecture

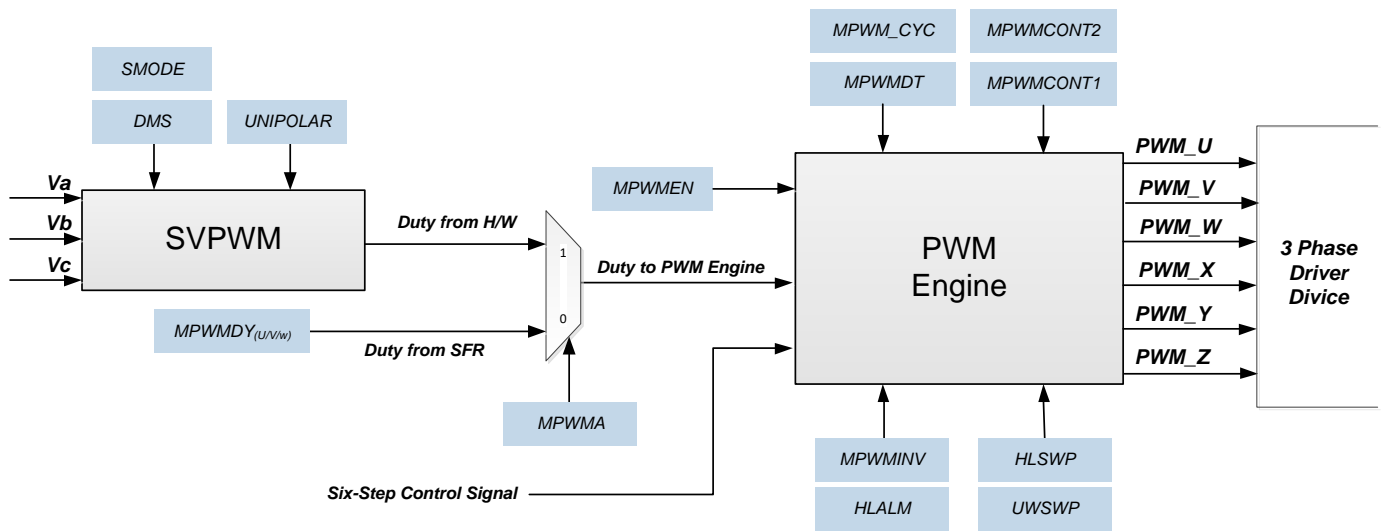


Figure 19.6.1 : SVPWM Engine Block Architecture

### 19.6.2 SVPWM Current Drive

Motor sinusoidal drive is based on providing sinusoidal current changes to each motor winding at the rotor position. These currents are phase-shifted by 120° from each other, relative to its corresponding Hall sensor. In BLDC motor control, the drive signals that are used require variable voltages that change with respect to the speed and position of the motor. This variable voltage is applied using the PWM technique. Provide PWM signals of sine wave to MOSFET inverter through PWM Engine. In this application, the sinusoidal current drive is applied using data extracted from the Space Vector Pulse-Width Modulation (SVPWM) technique.

The SVPWM method is a vector-based scheme used in three-phase systems, such as motor control applications. Rather than producing pure sinusoid waveform from the drive signals for each motor terminals with respect to ground, SVPWM generates three sinusoidal line-to-line voltage (differential voltage) between two terminals. A space vector representation is created, where the spaces between unit vectors are separated by 60.0° correspond to every state in an electrical cycle, as shown in Figure 19.6.2. Each desired voltage can be simulated by adding the components of two adjacent active vectors and null vectors represented by the 000 and 111 logic states (located at the origin). The resulting desired voltage is represented by the manipulated duty cycle of PWM peripheral.

Table 19.6.1 provides the equation for the PWM switching time for each sector. Once the approximate angular position is identified, the resultant vector magnitude is calculated, with respect to the adjacent voltage space vectors and null vector T0, T1 and T2 representing conduction time within a period.

Sector	Switching Time Equation
1	$PWM1 = T1 + T2 + T0/2$ $PWM2 = T2 + T0/2$ $PWM3 = T0/2$
2	$PWM1 = T1 + T0/2$ $PWM2 = T1 + T2 + T0/2$ $PWM3 = T0/2$
3	$PWM1 = T0/2$ $PWM2 = T1 + T2 + T0/2$ $PWM3 = T2 + T0/2$
4	$PWM1 = T0/2$ $PWM2 = T1 + T0/2$ $PWM3 = T1 + T2 + T0/2$
5	$PWM1 = T2 + T0/2$ $PWM2 = T0/2$ $PWM3 = T1 + T2 + T0/2$
6	$PWM1 = T1 + T2 + T0/2$ $PWM2 = T0/2$ $PWM3 = T1 + T0/2$

Table 19.6.1 Equations for PWM Switching Time by each Sensor

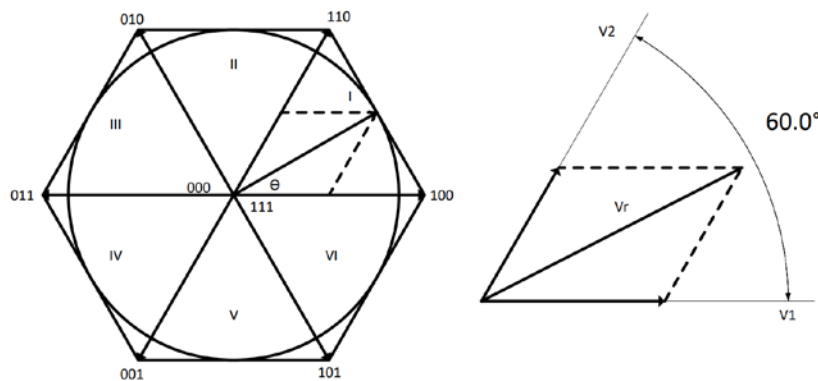


Figure 19.6.2 : SVPWM Representation in an Orthogonal Plane

The approximate PWM output from SVPWM, with respect to its angular position, is plotted in Figure 19.6.3. The waveform produced has a shape of a saddle due to the third harmonic injection by SVPWM. Each PWM output is shifted 120° from each other. The angular position is scaled from 360° to 384 for more convenient implementation in this application.

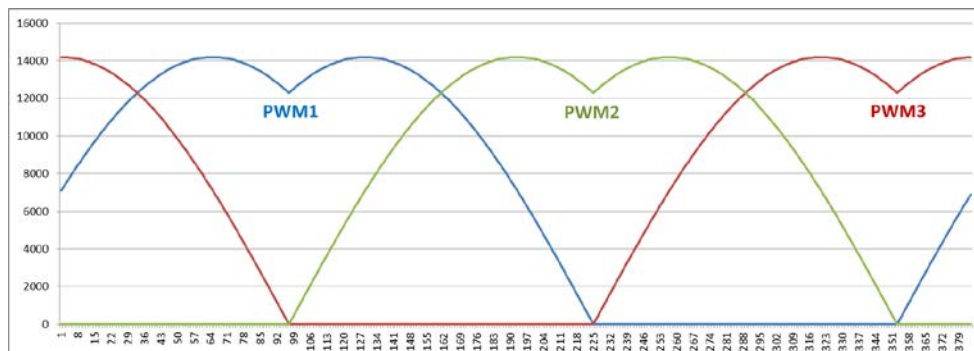


Figure 19.6.3 : SVPWM Voltage Waveform

CGH081A provides two types of SVPWM, namely seven-segment SVPWM (see Figure19.6.4) and five-segment SVPWM (see Figure19.6.5). Seven-segment SVPWM current waveform is smoother, and its harmonic interference is smaller. Five-segment SVPWM reduces switching losses because each of its three phases does not switch for one-third of a cycle. In sine wave drive, you can use SMODE to set the SVPWM mode to seven-segment SVPWM or five-segment SVPWM (see Table19.6.2).

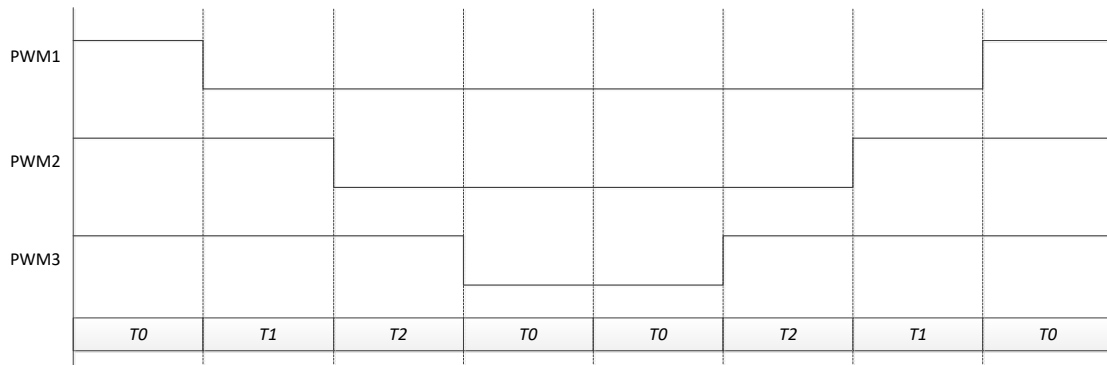


Figure 19.6.4 : Seven-Segment SVPWM Output Level

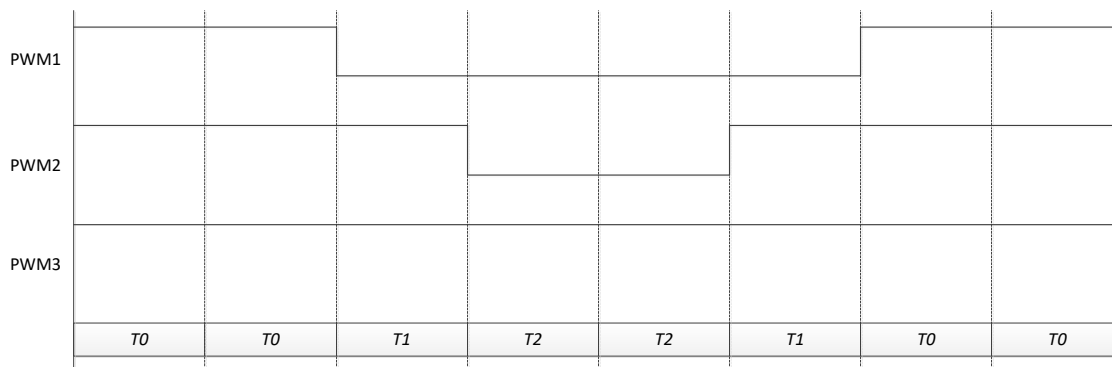


Figure 19.6.5 : Five-Segment SVPWM Output Level

IMPMISC_FUN		Address = AFH		Reset Value = 00010000B				
Improve Miscellaneous Function Setting Register (when SFR IMPMISC_KEY = 0xa5)								
	SMODE	CSHC	SIN_USER	MINDUTY_EN	UNIPOLAR	----	----	----
Bit	7	6	5	4	3	2	1	0
Type	W	W	X	W	W	X	X	X
SMODE	SVPWM Mode (when MCONT1.DMS = 1) :							
	0 : Seven-segment SVPWM							
	1 : Five-segment SVPWM							

Table19.6.2 : IMPMISC\_FUN SMODE SFR

### 19.6.3 Motor PWM Output Setting

Motor PWM Engine is based MPWMEN (see Table19.6.3) to active PWM counter, when MPWMEN = 1, Motor PWM output (U, V, W, X, Y, Z).

MPWMA (see Table19.6.4) can select the Duty input source of Motor PWM. When MPWMA = 0, Motor PWM determines PWM Duty by MPWMDY<sub>(U/V/W)</sub> (see Table19.6.5), and outputs PWM signal.

MPWMA = 1, the calculated PWM Duty value of Va, Vb and Vc is directly input to the SVPWM Engine for PWM modulation.

CGH081A supports sine wave and square wave drive modes. Simply set DMS (see Table19.6.4) to switch sine wave or square wave mode. When DMS = 0, it is square wave drive mode. On the contrary, DMS = 1 is sine wave drive model.

MCONT3								
			Address = ACH			Reset Value = 00000011B		
Motor Control Register 3								
	MPWMEN	----		ERS_MASK	----		I_SHORT[2:0]	
Bit	7	6	5	4	3	2	1	0
Type	R/W	X	X	W	X	R/W	R/W	R/W
MPWMEN	MPWM timer Enable :							
	0 : Stop							
	1 : Run							

Table19.6.3 : MCONT3. MPWMEN SFR (NHOL=1)

MCONT1								
			Address = 9DH			Reset Value = X0110000B		
Motor Control Register 1								
	MOTOSTOP	HCKS[2:0]			HALLALS	DMS	MPWMA	AMDS
Bit	7	6	5	4	3	2	1	0
Type	R	R/W	R/W	R/W	R/W	R/W	R/W	R/W
DMS	Driving mode select :							
	0 : 120° Square-Wave							
	1 : Sin-Wave							
MPWMA	MPWM auto mode :							
	0 : Disable. (control by firmware)							
	1 : Enable. (control by MDE)							

Table19.6.4 : MCONT1. DMS & MPWMA SFR

MPWMDYUH (SYNC)                      Address = A6H                      Reset Value = 0000111B								
Motor PWM Duty Register U High (Phase U)								
	----	----	----	----	----	MPWMDYU[10:8]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
MPWMDYUL (SYNC)                      Address = A5H                      Reset Value = 1111111B								
Motor PWM Duty Register U Low (Phase U)								
	MPWMDYU[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
MPWMDYVH (SYNC)                      Address = ABH                      Reset Value = 0000111B								
Motor PWM Duty Register V High (Phase V)								
	----	----	----	----	----	MPWMDYV[10:8]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
MPWMDYVL (SYNC)                      Address = AAH                      Reset Value = 1111111B								
Motor PWM Duty Register V Low (Phase V)								
	MPWMDYV[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
MPWMDYWH (SYNC)                      Address = AEH                      Reset Value = 0000111B								
Motor PWM Duty Register W High (Phase W)								
	----	----	----	----	----	MPWMDYW[10:8]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
MPWMDYWL (SYNC)                      Address = ADH                      Reset Value = 1111111B								
Motor PWM Duty Register W Low (Phase W)								
	MPWMDYW[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Table19.6.5 : MPWMDY<sub>(U/V/W)</sub> SFR

In square wave drive mode, CGH081A provides unipolar PWM switching technology to reduce static power losses

when using MOSFET switches. Unipolar PWM switching means that when the lower side switches PWM, the upper side switches the complementary PWM signal to the lower side. Therefore, during unipolar PWM switching, dead time insertion is introduced in the complementary upper and lower PWM signals (see Figure19.6.6). When in square wave drive mode and setting UNIPOLAR = 1, it enables unipolar PWM switching (see Table 19.6.6). It should be noted that before enabling unipolar PWM switching, the PWM output mode must also be set: High side PWM (U, V, W) to "Active High" and Low side PWM (X, Y, Z) to "Active Low" (see Table19.6.8).

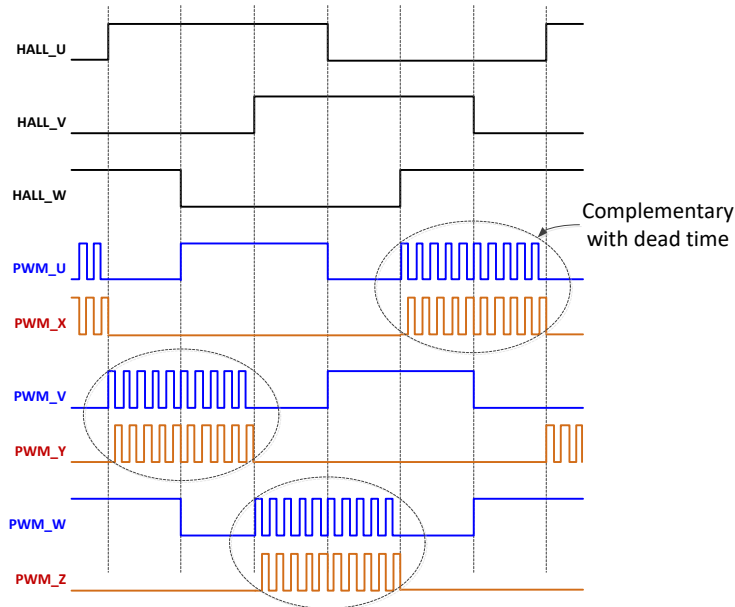


Figure 19.6.6 : Unipolar PWM Switching

IMP_MISC_FUN		Address = AFH		Reset Value = 00010000B			
Improve Miscellaneous Function Setting Register (When SFR IMP_MISC_KEY = 0xa5)							
	S_MODE	CSHC	SIN_USER	MINDUTY_EN	UNIPOLAR	----	----
Bit	7	6	5	4	3	2	1
Type	W	W	X	W	W	X	X
UNIPOLAR		Enable unipolar PWM Switching (when MCONT1.DMS = 0) :					
		0 : Disable Unipolar PWM Switching					
		1 : Enable Unipolar PWM Switching					

Table19.6.6 : IMP\_MISC\_FUN UNIPOLAR SFR

Period of Motor PWM is based on MPWM\_CYC (see Table19.6.7) setting value. The base frequency of Motor PWM counter is 48MHz. The counter counts up to MPWM\_CYC and then counts down to 0 (see Figure19.6.7). Therefore, the value set by MPWM\_CYC determines the frequency of Motor PWM. For example: MPWM\_CYC = 1250, Period of Motor PWM = 1250 x 2 x 1/(48MHz) = 52.08us, Freq. of Motor PWM is 19.2KHz.

MPWM_CYC_H (SYNC)	Address = A4H	Reset Value = 00000000B
-------------------	---------------	-------------------------

Motor PWM Cycle Register High								
	----	----	----	----	----	MPWM_CYC[10:8]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
MPWM_CYC_L (SYNC)      Address = A3H      Reset Value = 0000010B								
Motor PWM Cycle Register Low								
	MPWM_CYC[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Table19.6.7 : MPWM\_CYC SFR Description

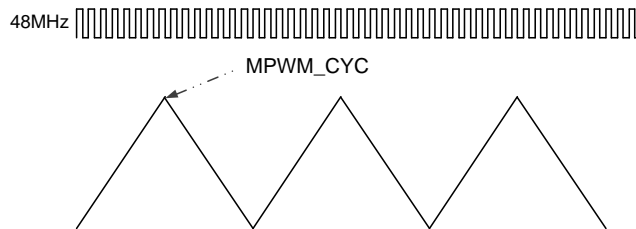


Figure 19.6.7 : Motor PWM is count up and down timer

Motor PWM output (U, V, W, X, Y, Z) has 4 type modes to be setting. High side PWM (U, V, W) can be setting mode by MPWMCONT1 (see Table19.6.8) , Low side PWM (X, Y, Z) can be setting mode by MPWMCONT2 (see Table19.6.8), the 4 type mode is “Force Low”, “Force High”, “Active High” and “Active Low”.

MPWMCONT1 (SYNC)      Address = B1H      Reset Value = 0000000B								
MPWM Control Register 1								
	----	----	PWMW[1:0]		PWMV[1:0]		PWMU[1:0]	
Bit	7	6	5	4	3	2	1	0
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
PWMW	Phase W High-side (W) output mode select :							
	00 : Force Low							
	01 : Force High							
	10 : Active High							
	11 : Active Low							
PWMV	Phase V High-side (V) output mode select :							
	00 : Force Low							



	01 : Force High 10 : Active High 11 : Active Low																											
PWMU	Phase U High-side (U) output mode select : 00 : Force Low 01 : Force High 10 : Active High 11 : Active Low																											
<b>MPWMCONT2 (SYNC)                      Address = B2H                      Reset Value = 0000000B</b> <b>MPWM Control Register 2</b>																												
	<table border="1"> <tr> <td></td> <td>-----</td> <td>-----</td> <td colspan="2">PWMZ[1:0]</td> <td colspan="2">PWMY[1:0]</td> <td colspan="2">PWMX[1:0]</td> </tr> <tr> <td>Bit</td> <td>7</td> <td>6</td> <td>5</td> <td>4</td> <td>3</td> <td>2</td> <td>1</td> <td>0</td> </tr> <tr> <td>Type</td> <td>X</td> <td>X</td> <td>R/W</td> <td>R/W</td> <td>R/W</td> <td>R/W</td> <td>R/W</td> <td>R/W</td> </tr> </table>		-----	-----	PWMZ[1:0]		PWMY[1:0]		PWMX[1:0]		Bit	7	6	5	4	3	2	1	0	Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
	-----	-----	PWMZ[1:0]		PWMY[1:0]		PWMX[1:0]																					
Bit	7	6	5	4	3	2	1	0																				
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W																				
PWMZ	Phase W Low-side (Z) output mode select : 00 : Force Low 01 : Force High 10 : Active High 11 : Active Low																											
PWMY	Phase V Low-side (Y) output mode select : 00 : Force Low 01 : Force High 10 : Active High 11 : Active Low																											
PWMX	Phase U Low-side (X) output mode select : 00 : Force Low 01 : Force High 10 : Active High 11 : Active Low																											

Table19.6.8 : MPWMCONT1/2 SFR Description

MPWMDT (see Table19.6.9) compensation PWM output with Dead-Time is use to prevent short-though between high-side and low-side power device. Dead-Time setting example: if MPWMDT = 100, Dead Time = 100 x (1 / 48MHz) = 2.08us.

<b>MPWMDT (SYNC)                      Address = A7H                      Reset Value = 0000000B</b> <b>Motor PWM Dead-Time Register</b>																		
	<table border="1"> <tr> <td colspan="8">MPWMDT[7:0]</td> </tr> <tr> <td>Bit</td> <td>7</td> <td>6</td> <td>5</td> <td>4</td> <td>3</td> <td>2</td> <td>1</td> <td>0</td> </tr> </table>	MPWMDT[7:0]								Bit	7	6	5	4	3	2	1	0
MPWMDT[7:0]																		
Bit	7	6	5	4	3	2	1	0										

Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
------	-----	-----	-----	-----	-----	-----	-----	-----

Table19.6.9 : MPWMDT SFR Description

Via MPWMINV (see Table18.6.10) setting , Motor U, V, W, X, Y, Z PWM output support Inverse function that is to inverse the PWM output signal at the last stage output.

MPWMINV(SYNC)		Address = B3H		Reset Value = 0000000B				
MPWM Inverse Selection Register								
	-----	-----	ZINV	WINV	YINV	VINV	XINV	UINV
Bit	7	6	5	4	3	2	1	0
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
ZINV	Low-side PWM Z output inverse select : 0 : Non-inverse 1 : Inverse							
WINV	High-side PWM W output inverse select : 0 : Non-inverse 1 : Inverse							
YINV	Low-side PWM Y output inverse select : 0 : Non-inverse 1 : Inverse							
VINV	High-side PWM V output inverse select : 0 : Non-inverse 1 : Inverse							
XINV	Low-side PWM X output inverse select : 0 : Non-inverse 1 : Inverse							
UINV	High-side PWM U output inverse select : 0 : Non-inverse 1 : Inverse							

Table19.6.10 : MPWMINV SFR Description

Figure19.6.8 illustrates the waveform output by Motor PWM when MPWMCONT1, MPWMCONT2, MPWMINV and MPWMDT are set at the same time.

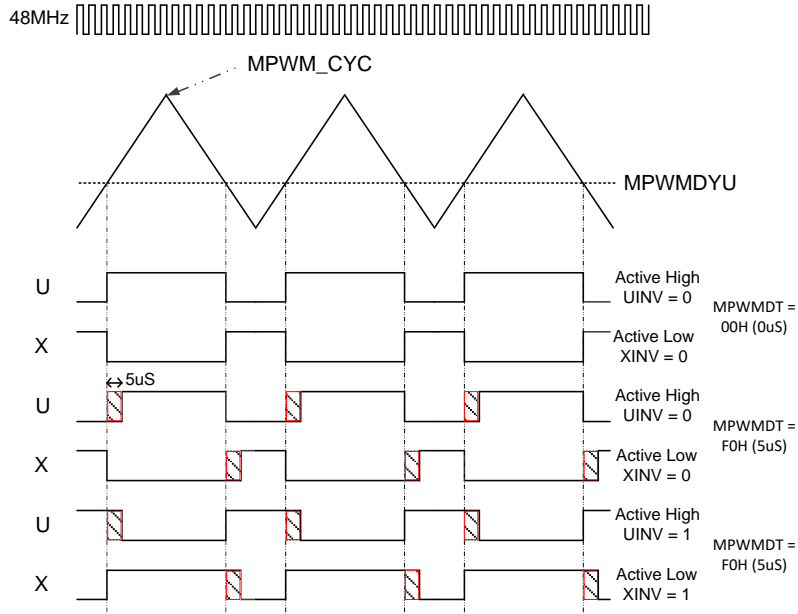


Figure 19.6.8 : PWM Output with Dead Time and PWM mode

In order to connect with the 3 phase Gate-driver and optimize PCB Layout considerations, the Motor PWM output (U, V, W, X, Y, Z) has a swap function, which can be performed via HLALM, HLSWP, UWSWP (see Table19.6.10). The combination of swap is shown in Figure 19.6.9.

IMPMISC_FUN		Address = AFH		Reset Value = 00010000B				
Improve Miscellaneous Function Setting Register (When SFR IMPMISC_KEY = 0xa5)								
Bit	SMODE	CSHC	SIN_USER	MINDUTY_EN	UNIPOLAR	HLALM	HLSWP	UWSWP
7	6	5	4	3	2	1	0	
Type	W	W	X	W	W	W	W	W
HLALM	PWM High/Low Side Alignment: 0 : PWM_U, PWM_X, PWM_V, PWM_Y, PWM_W, PWM_Z 1 : PWM_U, PWM_V, PWM_W, PWM_X, PWM_Y, PWM_Z							
HLSWP	PWM High and Low Side Swap 0 : PWM_U, PWM_X, PWM_V, PWM_Y, PWM_W, PWM_Z 1 : PWM_X, PWM_U, PWM_Y, PWM_V, PWM_Z, PWM_W							
UWSWP	PWM_U/PWM_X and PWM_W/PWM_Z Swap 0 : PWM_U, PWM_X, PWM_V, PWM_Y, PWM_W, PWM_Z 1 : PWM_W, PWM_Z, PWM_V, PWM_Y, PWM_U, PWM_X							

Table19.6.10 : IMPMISC\_FUN HLALM, HLSWP, and UWSWP SFR

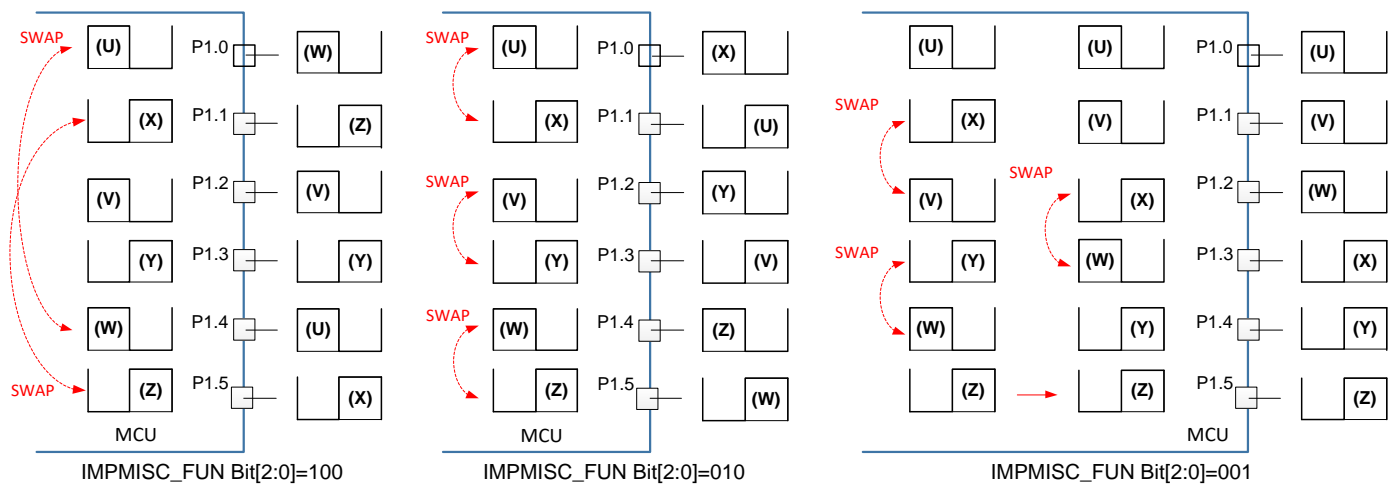


Figure 19.6.9 : PWM Pin Swap

## 19.7 OCP Protection (Over Current Protection)

### 19.7.1 OCP Block Architecture

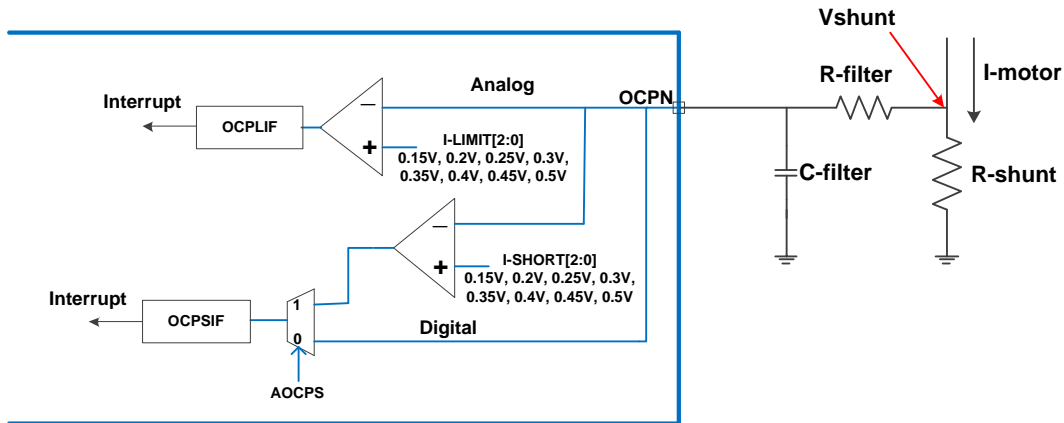


Figure 19.7.1 : OCP Unit Architecture

### 19.7.2 OCP Block description and setting

CGH081A is embedded H/W Over Current Protection Circuit, supports Analog and Digital OCP two modes, when AOCPS = 1 (see Table19.7.1), that is, set to Analog OCP, the built-in OCP comparator will be used to detect over current status, the voltage setting value of its comparator is I\_ SHORT (see Table19.7.2), When the OCPN voltage value is greater than the I\_ SHORT set voltage value, H/W will immediately force the PWM to 0 to protect the Power Device (MOS, IGBT..). In addition, CGH081A is embedded 2nd OCP protection, when the OCPN voltage value is greater than the I\_ LIMIT (see Table19.7.3) set voltage value, OCP H/W will only send I\_LIMIT interrupt signal and will not turn off the PWM signal. In case of overload, perform load reduction operation first.

AOCPS = 0 (see Table19.7.1), turn on Digital OCP mode, Digital OCP is generally used when connected to the IPM module. The Fault PIN of the IPM is directly connected to the OCPN pin for OCP protection.

MCONT2		Address = A2H				Reset Value = 0000000B		
Motor Control Register 2								
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	X
AOCPS	Analog OCP select : 0 : Digital OCP 1 : Analog OCP							

Table19.7.1 : AOCPS SFR Description

MCONT3		Address = ACH			Reset Value = 0000011B			
Motor Control Register 3								
	MPWMEN	----		ERS_MASK	----	I_SHORT[2:0]		
Bit	7	6	5	4	3	2	1	0
Type	R/W	X	X	W	X	R/W	R/W	R/W
I_SHORT[2:0]	OCP SHORT level select : (OCPSIF) 000 : 0.15V 001 : 0.2V 010 : 0.25V 011 : 0.3V (default) 100 : 0.35V 101 : 0.4V 110 : 0.45V 111 : 0.5V							

Table19.7.2 : MCONT3. I\_SHORT SFR (NHOL=1)

AOCPCONT		Address = 9EH			Reset Value = 00001111B			
Analog OCP Control Register								
	OCPLT	----	----	I_LIMIT[2:0]			----	
Bit	7	6	5	4	3	2	1	0
Type	R	X	X	R/W	R/W	R/W	R/W	R/W
OCPLT	OCP Limit status 0 : No Over current Limit. 1 : Over current Limit occur.							
I_LIMIT[2:0]	OCP LIMIT level select : (OCPLIF) 000 : 0.15V 001 : 0.2V 010 : 0.25V 011 : 0.3V (default) 100 : 0.35V 101 : 0.4V 110 : 0.45V 111 : 0.5V							

Table19.7.3 : AOCPCONT SFR Description

The MCU may read the OCPST (see Table19.7.4) to observe the over current status of the system. When OCPST =1,

the system is in the over current state. In addition, The MCU may read the OCPLT (see Table19.7.3) to observe the OCP Limit current status of the system. When OCPLT =1, the system is in the OCP Limit current state.

Analog OCP can set digital de-bounce time to avoid OCP malfunction caused by noise. By setting OCPDBT (see Table19.7.4), Analog OCP 0~1.291uS de-bounce time can be set.

There are 2 modes to release OCP status, Auto Mode and User Mode. For its setting and action, please refer to Figure 19.7.2 and Figure 19.7.3.

OCPCONT		Address = A1H					Reset Value = 00000100B	
OCP Control Register								
	OCPST	OCPDBT[4:0]					OCPC	OCPMS
Bit	7	6	5	4	3	2	1	0
Type	R	R/W	R/W	R/W	R/W	R/W	W	R/W
OCPST	OCP Short status: 0 : No Over current Short 1 : Over current Short occur. Six PWM output is high-impedance.							
OCPDBT[4:0]	PIN OCPN input de-bounce time (default 41.67nS) 0~31 = 0~1.291uS (48MHz/2 fixed)							
OCPC	OCP status clear bit : In User mode, user can write '1' to clear OCP status, the PWM will output at next PWM cycle.							
OCPMS	OCP mode select : 0 : Auto mode 1: User mode							

Table19.7.4 : OCPCONT SFR Description

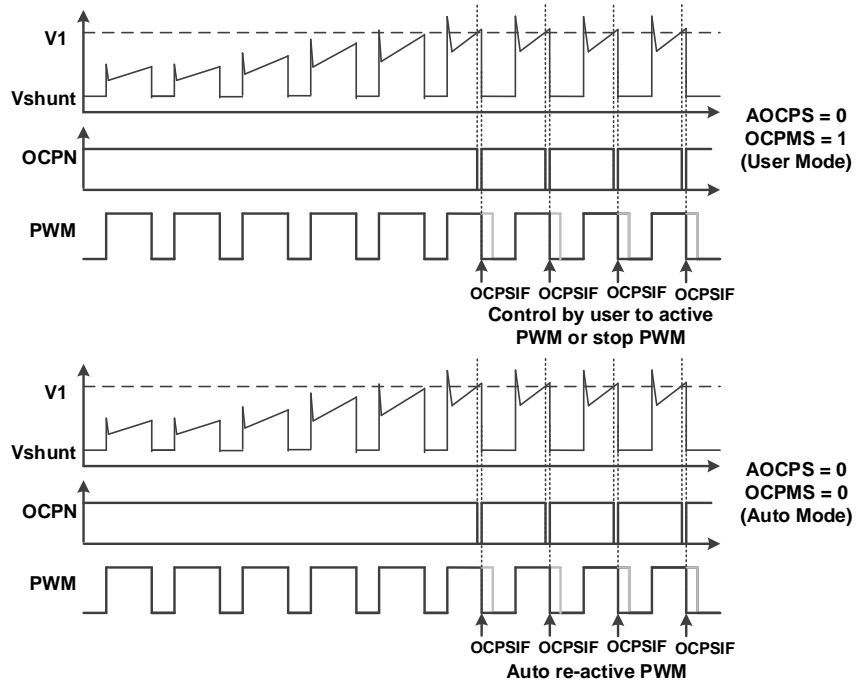


Figure 19.7.2 : Digital OCP Short occur and PWM out

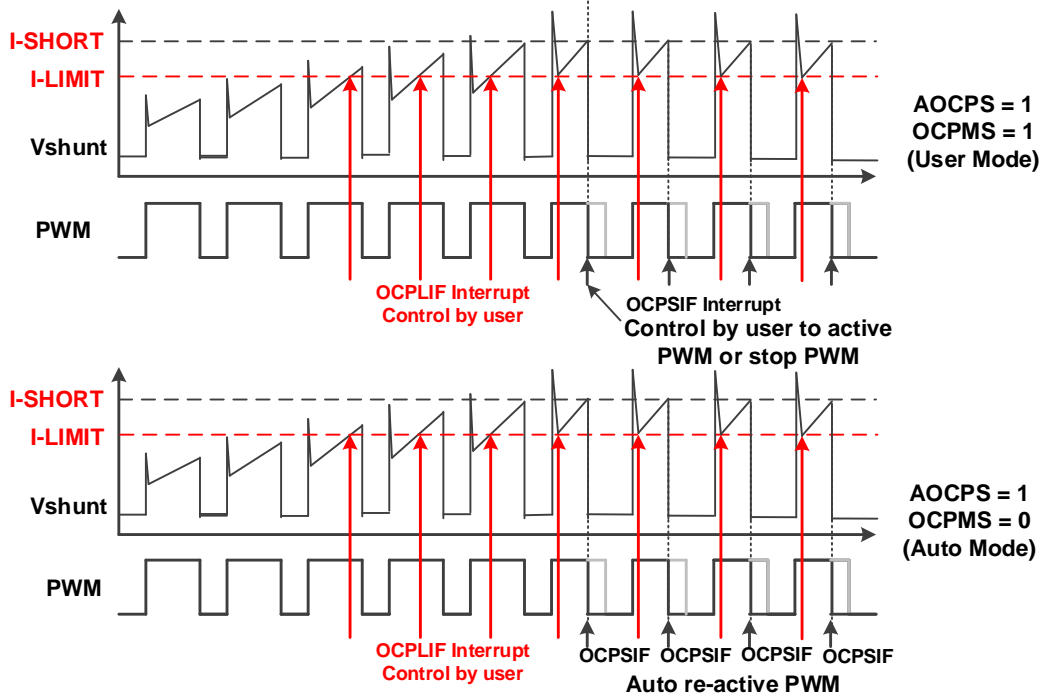


Figure 19.7.3 : Analog OCP Short occur and PWM out



**19.8 MDE SFR List**
**19.8.1 MCONT1 SFR**

MCONT1		Address = 9DH				Reset Value = X0110000B		
Motor Control Register 1								
	MOTOSTOP	HCKS[2:0]			HALLALS	DMS	MPWMA	AMDS
Bit	7	6	5	4	3	2	1	0
Type	R	R/W	R/W	R/W	R/W	R/W	R/W	R/W
MOTOSTOP	1 : Motor Stop							
HCKS[2:0]	Hall clock select :							
	000 : 48MHz/4			100 : 48MHz/64				
	001 : 48MHz/8			101 : 48MHz/128				
	010 : 48MHz/16			110 : 48MHz/256				
	011 : 48MHz/32			111 : 48MHz/512				
HALLALS	Hall alignment select :							
	0 : Line voltage (Line to Line)							
	1 : Phase voltage							
DMS	Driving mode select :							
	0 : 120° Square-Wave							
	1 : Sin-Wave							
MPWMA	MPWM auto mode :							
	0 : Disable. (control by firmware)							
	1 : Enable. (control by MDE)							
AMDS	Auto mode direction select :							
	0 : When MPWMA = '1', driving direction is forward.							
	1 : When MPWMA = '1', driving direction is reverse.							

**19.8.2 MCONT2 SFR**

MCONT2		Address = A2H			Reset Value = 0000000B			
Motor Control Register 2								
	-----	-----			-----	VRHS	AOCPS	-----
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	X
VRHS	Virtual Hall select : 0 : Real Hall. (HALL U, HALL V, HALL W) 1 : Virtual Hall.							
AOCPS	Analog OCP select : 0 : Digital OCP 1 : Analog OCP							

**19.8.3 MCONT3 SFR**

MCONT3		Address = ACH			Reset Value = 00000011B			
Motor Control Register 3								
	MPWMEN	-----	-----	ERS_MASK	-----	I_SHORT[2:0]		
Bit	7	6	5	4	3	2	1	0
Type	R/W	X	X	W	X	R/W	R/W	R/W
MPWMEN	MPWM timer run control : [7] 0 : Stop 1 : Run							
ERS_MASK	PWM Mask(1~2 PWM cycles) Enable when Error Step Occur (Enable when SFR IMPMISC_KEY=0xa5): [4] 0 : No Mask (Driving by Previous Step) 1 : PWM Mask 1~2 PWM cycles in the end of Error Step							
I_SHORT[2:0]	OCP SHORT level select : (OCPSIF) [2:0] 000 : 0.15V 001 : 0.2V 010 : 0.25V 011 : 0.3V (default) 100 : 0.35V 101 : 0.4V 110 : 0.45V 111 : 0.5V							

**19.8.3 HALLDBT (Hall De-bounce Time Register) SFR**

HALLDBT		Address = 9CH		Reset Value = 00001110B				
Hall De-bounce Time Register								
	-----	-----	HALLDBT[5:0]					
Bit	7	6	5	4	3	2	1	0
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
HALLDBT is use to filter the HALL signal.								
De-bounce time = 1/3MHz X HALLDBT [5:0]								

### 19.8.4 HALLSET (Hall Setting Register 1, 2, 3) SFR

HALLSET1 (SYNC)		Address = 91H				Reset Value = 01000101B			
Hall Setting Register 1									
	-----	HALLSET1_2[2:0]			-----	HALLSET1_1[2:0]			
Bit	7	6	5	4	3	2	1	0	
Type	X	R/W	R/W	R/W	X	R/W	R/W	R/W	
[2] : HALL U status. [1] : HALL V status. [0] : HALL W status.									
HALLSET2 (SYNC)		Address = 92H				Reset Value = 00100110B			
Hall Setting Register 2									
	-----	HALLSET2_2 [2:0]			-----	HALLSET2_1[2:0]			
Bit	7	6	5	4	3	2	1	0	
Type	X	R/W	R/W	R/W	X	R/W	R/W	R/W	
[2] : HALL U status. [1] : HALL V status. [0] : HALL W status.									
HALLSET3 (SYNC)		Address= 93H				Reset Value = 00010011B			
Hall Setting Register 3									
	-----	HALLSET3_2[2:0]			-----	HALLSET3_1[2:0]			
Bit	7	6	5	4	3	2	1	0	
Type	X	R/W	R/W	R/W	X	R/W	R/W	R/W	
[2] : HALL U status. [1] : HALL V status. [0] : HALL W status.									

### 19.8.5 HALLST (Hall Status Register) SFR

HALLST		Address = 94H				Reset Value = xxxxxxxxB			
Hall Status Register									
	-----	H_OLD[2:0]			-----	H_NEW[2:0]			
Bit	7	6	5	4	3	2	1	0	
Type	X	R	R	R	X	R	R	R	
H_OLD[2:0]	Hall old status :								
	[2] : HALL U status. [1] : HALL V status. [0] : HALL W status.								
H_NEW[2:0]	Hall new status :								
	[2] : HALL U status. [1] : HALL V status. [0] : HALL W status.								

**19.8.6 ROTORSPEED (Rotor Speed Count Register) SFR**

ROTORSPEEDH		Address = 97H				Reset Value = 1111111B		
Rotor Speed Count Register High								
ROTORSPEED[15:8]								
Bit	7	6	5	4	3	2	1	0
Type	R	R	R	R	R	R	R	R
ROTORSPEEDL		Address = 96H				Reset Value = 1111111B		
Rotor Speed Count Register Low								
ROTORSPEED[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	R	R	R	R	R	R	R	R

**19.8.7 VRHALL (Virtual Hall Register) SFR**

VRHALL		Address = D9H				Reset Value = 00000101B		
Virtual Hall Register								
VRH[2:0]								
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
VRH[2:0]	Virtual Hall value. VRH.2 is Virtual HALL U. VRH.1 is Virtual HALL V. VRH.0 is Virtual HALL W.							

**19.8.8 MPWM\_CYC (Motor PWM Cycle Register) SFR**

MPWM_CYC_H (SYNC)		Address = A4H			Reset Value = 0000000B			
Motor PWM Cycle Register High								
	-----	-----	-----	-----	-----	MPWM_CYC [10:8]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
MPWM_CYC_L (SYNC)		Address = A3H			Reset Value = 00000010B			
Motor PWM Cycle Register Low								
	MPWM_CYC [7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

**19.8.9 MPWMDY (Motor PWM Duty Register) SFR**

MPWMDYUH (SYNC)                      Address = A6H                      Reset Value = 0000111B								
Motor PWM Duty Register U High (Phase U)								
	-----	-----	-----	-----	-----	MPWMDYU[10:8]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
MPWMDYUL (SYNC)                      Address = A5H                      Reset Value = 1111111B								
Motor PWM Duty Register U Low (Phase U)								
	MPWMDYU[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
MPWMDYVH (SYNC)                      Address = ABH                      Reset Value = 0000111B								
Motor PWM Duty Register V High (Phase V)								
	-----	-----	-----	-----	-----	MPWMDYV[10:8]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
MPWMDYVL (SYNC)                      Address = AAH                      Reset Value = 1111111B								
Motor PWM Duty Register V Low (Phase V)								
	MPWMDYV[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
MPWMDYWH (SYNC)                      Address = AEH                      Reset Value = 0000111B								
Motor PWM Duty Register W High (Phase W)								
	-----	-----	-----	-----	-----	MPWMDYW[10:8]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
MPWMDYWL (SYNC)                      Address = ADH                      Reset Value = 1111111B								
Motor PWM Duty Register W Low (Phase W)								
	MPWMDYW[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

**19.8.10 MIN\_DUTY (Minimum Duty Limit Register) SFR**

MIN_DUTY		Address = BFH		Reset Value = 00000000B				
Minimum Duty Limit Register								
MIN_DUTY[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	W	W	W	W	W	W	W	W

**19.8.11 MPWMDT (Motor PWM Dead-Time Register) SFR**

MPWMDT (SYNC)		Address = A7H		Reset Value = 00000000B				
Motor PWM Dead-Time Register								
MPWMDT[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

**19.8.12 MPWMCONT1 (MPWM Control Register 1) SFR**

MPWMCONT1 (SYNC)		Address = B1H		Reset Value = 00000000B				
MPWM Control Register 1								
	-----	-----	PWMW[1:0]		PWMV[1:0]		PWMU[1:0]	
Bit	7	6	5	4	3	2	1	0
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
PWMW	Phase W High-side (W) output mode select :							
	00 : Force Low							
	01 : Force High							
	10 : Active High							
	11 : Active Low							
PWMV	Phase V High-side (V) output mode select :							
	00 : Force Low							
	01 : Force High							
	10 : Active High							
	11 : Active Low							
PWMU	Phase U High-side (U) output mode select :							
	00 : Force Low							
	01 : Force High							
	10 : Active High							
	11 : Active Low							



**19.8.13 MPWMCONT2 (MPWM Control Register 2) SFR**

MPWMCONT2 (SYNC)		Address = B2H		Reset Value = 0000000B				
MPWM Control Register 2								
	-----	-----	PWMZ[1:0]		PWMY[1:0]		PWMX[1:0]	
Bit	7	6	5	4	3	2	1	0
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
PWMZ	Phase W Low-side (Z) output mode select :							
	00 : Force Low							
	01 : Force High							
	10 : Active High							
	11 : Active Low							
PWMY	Phase V Low-side (Y) output mode select :							
	00 : Force Low							
	01 : Force High							
	10 : Active High							
	11 : Active Low							
PWMX	Phase U Low-side (X) output mode select :							
	00 : Force Low							
	01 : Force High							
	10 : Active High							
	11 : Active Low							

## 19.8.14 MPWMINV (MPWM Inverse Selection Register) SFR

MPWMINV(SYNC)		Address = B3H		Reset Value = 0000000B				
MPWM Inverse Selection Register								
	-----	-----	ZINV	WINV	YINV	VINV	XINV	UINV
Bit	7	6	5	4	3	2	1	0
Type	X	X	R/W	R/W	R/W	R/W	R/W	R/W
ZINV	Low-side PWM Z output inverse select :							
	0 : Non-inverse							
	1 : Inverse							
WINV	High-side PWM W output inverse select :							
	0 : Non-inverse							
	1 : Inverse							
YINV	Low-side PWM Y output inverse select :							
	0 : Non-inverse							
	1 : Inverse							
VINV	High-side PWM V output inverse select :							
	0 : Non-inverse							
	1 : Inverse							
XINV	Low-side PWM X output inverse select :							
	0 : Non-inverse							
	1 : Inverse							
UINV	High-side PWM U output inverse select :							
	0 : Non-inverse							
	1 : Inverse							

**19.8.15 SVPWMAMP (SVPWM Amplitude Register) SFR**

SVPWMAMPH(SYNC)		Address = C4H				Reset Value = 00000000B		
SVPWM Amplitude Register High								
	-----	-----	-----	-----	-----	SVPWMAMP[10:8]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W
SVPWMAMPL(SYNC)		Address = C3H				Reset Value = 00000000B		
SVPWM Amplitude Register Low								
	SVPWMAMP[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

**19.8.16 SVPWMAMPFT (SVPWM Amplitude Fine-Tune Register) SFR**

SVPWMAMPFT		Address = DAH				Reset Value = 00000000B		
SVPWM Amplitude Fine-Tune Register								
	-----	-----	-----	-----	-----	SVPWMAMPFT[2:0]		
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	R/W	R/W	R/W

**19.8.17 SVPWMANG (SVPWM Angular Register) SFR**

SVPWMANGH(SYNC)		Address = C2H				Reset Value = 00000000B		
SVPWM Angular Register High								
	-----	-----	-----	-----	-----	-----	SVPWMANG[8]	
Bit	7	6	5	4	3	2	1	0
Type	X	X	X	X	X	X	X	R/W
SVPWMANGL(SYNC)		Address = C1H				Reset Value = 00000000B		
SVPWM Angular Register Low								
	SVPWMANG[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

**19.8.18 AS (Angle Shift Control Register) SFR**

AS (SYNC)		Address = 8FH		Reset Value = 00000000B				
Angle Shift Control Register								
	AS_LS	-----	AS_VALUE[5:0]					
Bit	7	6	5	4	3	2	1	0
Type	R/W	X	R/W	R/W	R/W	R/W	R/W	R/W
AS_LS		Angle Shift Lag select:						
		0 : 0° ~ -59.0625° = 0~ 63(AS_VALUE)						
		1 : 0° ~ -59.0625° = 0~ -63(AS_VALUE)						

**19.8.19 Over Current Protect (OCP) SFR**

OCPCONT		Address = A1H				Reset Value = 00000100B		
OCP Control Register								
	OCPST	OCPDBT[4:0]					OCPC	OCPMS
Bit	7	6	5	4	3	2	1	0
Type	R	R/W	R/W	R/W	R/W	R/W	W	R/W
OCPST	<p>OCP Short status:</p> <p>0 : No Over current Short</p> <p>1 : Over current Short occur.</p> <p>Six PWM output is high-impedance.</p>							
OCPDBT[4:0]	<p>PIN OCP input de-bounce time (default 41.67nS)</p> <p>0~31 = 0~1.291uS (48MHz/2 fixed)</p>							
OCPC	<p>OCP status clear bit :</p> <p>In User mode, user can write '1' to clear OCP status, the PWM will output at next PWM cycle.</p>							
OCPMS	<p>OCP mode select :</p> <p>0 : Auto mode</p> <p>1: User mode</p>							

### 19.8.20 Analog Over Current Protect (AOCP) SFR

AOPCONT		Address = 9EH			Reset Value = 00001111B			
Analog OCP Control Register								
	OCPLT	-----	-----	I_LIMIT[2:0]			-----	
Bit	7	6	5	4	3	2	1	0
Type	R	X	X	R/W	R/W	R/W	X	X
OCPLT	OCP Limit status 0 : No Over current Limit. 1 : Over current Limit occur.							
I_LIMIT[2:0]	OCP LIMIT level select : (OCPLIF) 000 : 0.15V 001 : 0.2V 010 : 0.25V 011 : 0.3V (default) 100 : 0.35V 101 : 0.4V 110 : 0.45V 111 : 0.5V							

### 19.8.21 IMPMISC\_KEY (IMPROVE Miscellaneous Function Turn On Key) SFR

IMPMISC_KEY		Address = 9FH			Reset Value = 00000000B			
Improve Miscellaneous Function Turn On Key Register								
	IMPMISC_KEY[7:0]							
Bit	7	6	5	4	3	2	1	0
Type	W	W	W	W	W	W	W	W
Write down the <b>0xa5</b> , turn on the switch of miscellaneous function in SFR IMPMISC_FUN								

**19.8.22 IMPMISC\_FUN (IMPROVE Miscellaneous Function Setting) SFR**

IMPMISC_FUN		Address = AFH			Reset Value = 00010000B			
Improve Miscellaneous Function Setting Register (when SFR IMPMISC_KEY = 0xa5)								
Bit	SMODE	CSHC	SIN_USER	MINDUTY_EN	UNIPOLAR	-----	-----	-----
Type	W	W	W	W	W	X	X	X
SMODE	SVPWM Mode (when MCONT1[2] = 1)							
[7]	0: Seven-segment SVPWM 1: Five-segment SVPWM							
CSHC	Change Step in Hall Change (6-Step)							
[6]	0: Change Step in PWM Minimum 1: Change Step in PWM Minimum or Hall Change							
SIN_USER	Sine wave user mode							
[5]	0: Sine Wave angle write by Auto 1: Sine Wave angle write by User (duty auto generate by MDE)							
MINDUTY_EN	Minimum Duty Limit enable (SFR 0xBF)							
[4]	1: Enable Minimum Duty Limit							
UNIPOLAR	6-Step Control with Unipolar PWM Switching (PWM output mode select SFR must set active "High" or active "Low")							
[3]	1: Enable Unipolar PWM Switching in 6-Step Control							
HLALM	PWM High/Low Side Alignment:							
[2]	0 : PWM_U, PWM_X, PWM_V, PWM_Y, PWM_W, PWM_Z 1 : PWM_U, PWM_V, PWM_W, PWM_X, PWM_Y, PWM_Z							
HLSWP	PWM High and Low Side Swap							
[1]	0 : PWM_U, PWM_X, PWM_V, PWM_Y, PWM_W, PWM_Z 1 : PWM_X, PWM_U, PWM_Y, PWM_V, PWM_Z, PWM_W							
UWSWP	PWM_U/PWM_X and PWM_W/PWM_Z Swap							
[0]	0 : PWM_U, PWM_X, PWM_V, PWM_Y, PWM_W, PWM_Z 1 : PWM_W, PWM_Z, PWM_V, PWM_Y, PWM_U, PWM_X							

19.8.23 ONE\_HALLSET (One Hall Setting) SFR

ONE_HALLSET		Address = 95H				Reset Value = 0000_0000B		
One Hall Setting Register (when SFR IMPMISC_KEY = 0xa5)								
	STA_ZONE_EN	3TO1_RUN	----	----	1HALL_ONLY	ZONE[2:0]		
Bit	7	6	5	4	3	2	1	0
Type	W	W	X	X	W	W	W	W
STA_ZONE_EN	Hall U rising edge start zone setting enable (for 3-Hall Start and 1-Hall Rotation or One Hall solution using) 0 : Hall U rising edge start zone setting by hardware when 1-hall run 1 : Hall U rising edge start zone setting by software when 1-hall run							
3TO1_RUN	3-Hall Start and 1-Hall Rotation enable 0 : 3-Hall Rotation or 1-Hall Start up and Rotation 1 : 3-Hall Start and 1-Hall Rotation							
1HALL_ONLY	One Hall Startup and One Hall Rotation enable 0 : Disable One Hall Only 1 : Enable One Hall Only							
ZONE	Hall U rising edge start ZONE ( <b>when STA_ZONE_EN =1</b> ) 000: Hall U rising edge start at ZONE0 (HALLSET1_1), start angle is 0 001: Hall U rising edge start at ZONE1 (HALLSET1_2), start angle is 64 010: Hall U rising edge start at ZONE2 (HALLSET2_1), start angle is 128 011: Hall U rising edge start at ZONE3 (HALLSET2_2), start angle is 192 100: Hall U rising edge start at ZONE4 (HALLSET3_1), start angle is 256 101: Hall U rising edge start at ZONE5 (HALLSET3_2), start angle is 320							



**19.8.24 FG\_CTRL (Frequency Generator Control) SFR**

FG_CTRL		Address = C5H				Reset Value = 0x00H		
Frequency Generator Control Register								
	FG_EN	FG10P_8P	-----	-----	FGOUT_SEL	FGPULSE_SEL		
Bit	7	6	5	4	3	2	1	0
Type	W	W	X	X	W	W		
FG_EN	FG output enable: 0 : Disable 1 : Enable							
FG10P_8P	10 poles or 8 poles Motor: 0 : 8 poles 1 : 10 poles							
FGOUT_SEL	FG output pin select: 0 : out to CH3 pin 1 : out to TX pin							
FGPULSE_SEL	FG pulse number selection:							
					<i>FG10PT8P = 0</i>	<i>FG10PT8P = 1</i>		
	000 :				1 pulse	4 pulses/5-cycle		
	001 :				2 pulses	8 pulses/5-cycle		
	010 :				4 pulses	16 pulses/5-cycle		
	011 :				5 pulses	20 pulses/5-cycle		
	100 :				8 pulses	32 pulses/5-cycle		
	101 :				12 pulses	48 pulses/5-cycle		

## 19.9 SYNC

**MDE** behavior is synchronized with **MPWM**, many **MDE** SFRs have **shadow register** that is used to update these SFRs at the same time with **SYNC** register. Write **SYNC** any value will synchronization update these SFRs at the same time.

Table 19.9.1 SYNC

SYNC		Address = D7H							Reset Value = 00000000B
MDE Sync Register									
		SYNC[7:0]							
Bit	7	6	5	4	3	2	1	0	
Type	W	W	W	W	W	W	W	W	

Write only.

Shadow register: (need SYNC)

HALLSET1

HALLSET2

HALLSET3

AS

MPWM\_CYC\_H, MPWM\_CYC\_L

MPWMDYUH, MPWMDYUL

MPWMDYVH, MPWMDYVL

MPWMDYWH, MPWMDYWL

MPWMDT

MPWMINV

MPWMCNT1

MPWMCNT2

GPWMMAX

GPWMDY

GPWMOCNT.GPMS, GPWMOCNT.GPCT, GPWMOCNT.GPCKS

SVPWMAMP

SVPWANG

## 20. HV Gate-Driver Function Description

### 20.1 Low Side Power Supply (VCC15, SGND, PGND)

VCC15 is the low side supply and it provides power to both input logic and low side output power stage. In CGF081A, input logic is referenced to SGND as well as the under-voltage detection circuit. Output power stage is referenced to PGND. PGND ground is floating respect to SGND ground with a recommended range of operation of +/-5V, which guarantees enough margin of gate to source voltage, VGS, to driver power devices such as power MOSFET.

The built-in under-voltage lockout circuit enables the device to operate at sufficient power on when a typical VCC15 supply voltage higher than  $V_{CCUV+} = 9.5$  is present, shown as Figure 20.1.1. The IC shuts down all the gate drivers outputs, when the VCC15 supply voltage is below  $V_{CCUV-} = 8.8$  V, shown as Figure 20.1.1. This prevents the external power devices from extremely low gate voltage levels during on-state and therefore from excessive power dissipation.

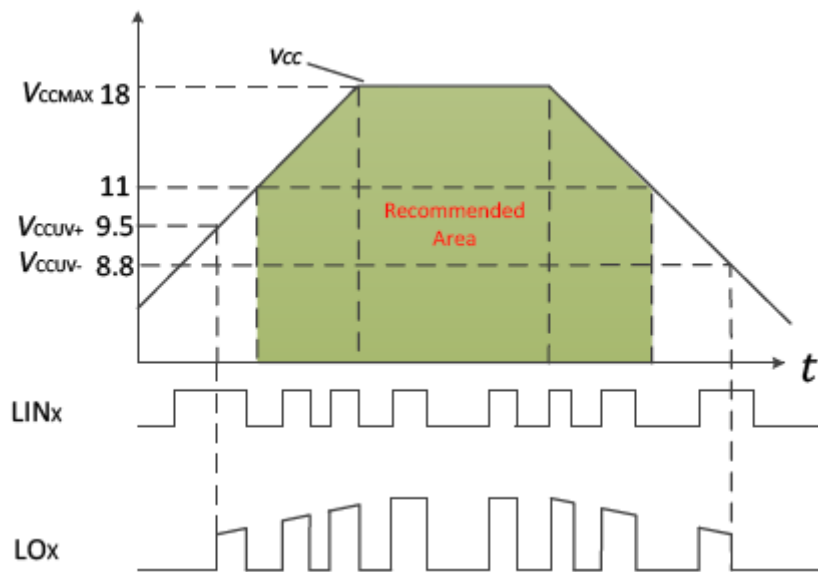


Figure 20.1.1 VCC15 supply UVLO operating area

## 20.2 High Side Power Supply (VBU-VSU, VBU-VSU, VBU-VSU)

VB to VS is the high side supply voltage. The totally high side circuitry can float with respect to SGND following the external high side power device emitter/source voltage. Due to the internally low power consumption, the whole high side circuitry can be supplied by bootstrap topology connected to VCC15, and it can be powered with small bootstrap capacitors.

The device operating area as a function of the supply voltage is given in Figure 20.2.1.

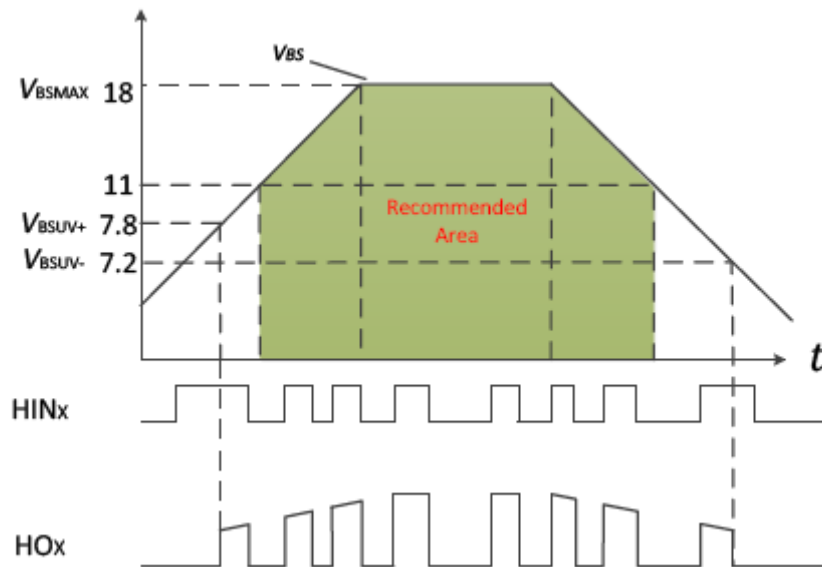


Figure 20.2.1 VBS supply UVLO operating area

## 20.3 Low Side and High Control Input Logic (HU,V,W / LU,V,W)

The Schmitt trigger threshold of each input is designed enough low such to guarantee LSTTL and CMOS compatibility down to 3.3 V controller outputs. Input Schmitt trigger and advanced noise filter provide beneficial noise rejection to short input pulses. An internal pull-down resistor of about 200k (positive logic) pre-biases each input during VCC15 supply start-up state. It is anyway recommended for proper work of the driver not to provide input pulse-width lower than 400ns.

## 20.4 Dead-Time

The IC features integrated a fixed dead-time protection circuitry. The dead time feature inserts a time period (a minimum dead time) in which both the high- and low-side power switches are held off; this is done to ensure that the power switch being turned off has fully turned off before the second power switch is turned on. This minimum dead time is automatically inserted whenever the external dead time is shorter than DT; external dead times larger than DT are not modified by the gate driver. Figure 19.5.1 illustrates the dead time period and the relationship between the output gate signals.

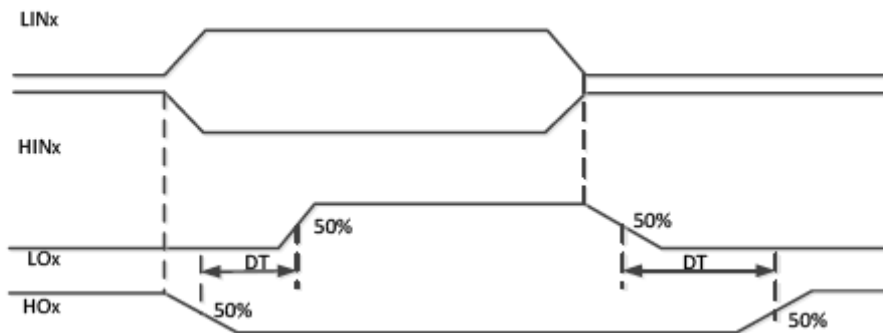


Figure 19.5.1 Dead Time

## 20.5 Gate Driver (HOU,V,W, LOU,V,W)

Low side and high side driver outputs are specifically designed for pulse operation and dedicated to drive the power devices such as IGBT and MOSFET. Low side outputs (i.e. LOU, V, W) are state triggered by the respective inputs, while high side outputs (i.e. HOU, V, W) are only changed at the edge of the respective inputs. In particular, after releasing from an under voltage condition of the VBS supply, a new turn-on signal (edge) is necessary to activate the respective high side output, while after releasing from a under voltage condition of the VCC15 supply, the low side outputs can directly switch to the state of their respective inputs and don't suffer from the trouble as high side driver.

## 20.6 Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device or make the function abnormal. All the voltage parameters are absolute voltages referenced to IC SGND unless otherwise stated in the table.

Parameter	Symbol	Min.	Max.	Units
High-side floating supply voltage	VB.U.V.W	-0.3	600	V
High-side offset voltage	VS.U.V.W	VB.U.V.W -18	VB.U.V.W + 0.3	
High-side gate driver output voltage	VHO.U.V.W	VS.U.V.W -0.3	VS.U.V.W +0.3	
Low-side gate driver output voltage	VLO.U.V.W	PGND-0.3	VCC15+0.3	
Logic input voltage	VH.U.V.W VL.U.V.W	-0.3	20	
Low-side supply voltage	VCC15	-0.3	20	
Logic gate driver return	PGND	VCC15-18	VCC15+0.3	
Allowable Offset Voltage Slew Rate	dV/dt		40	V/ns

## 20.7 Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Units
Low-side supply voltage	VCC15	11	18	V
High-side Floating Supply Offset Voltage(note1)	VS.U.V.W	VB. -18	VB-11	
High-side Floating Supply Voltage	VB.U.V.W	-8	600	
High-side gate driver output voltage	VHO.U.V.W	VS	VB	
Low-side gate driver output voltage	VLO.U.V.W	PGND	VCC15	

Note1: For VBS=12V, normal Logic operation for VS of -8 V to 600 V. The parameter is only guaranteed by design.

## 20.8 Static Electrical Characteristics

(VCC15-SGND) = (VB-VS) = 12V. TAMB = 25°C unless otherwise specified. The VIN, VTH and IIN Parameters are reference to SGND and are applicable to all six channels. The VO and IO parameters are referenced to respective VS and PGND and are applicable to the respective output leads. The VCCUV parameters are referenced to SGND. The VBSUV parameters are referenced to VS.

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
<b>Low Side Power Supply Characteristics</b>						
VCC15 quiescent current in UVLO mode	IQVCC	VH.U.V.W =VL.U.V.W=0 or 5V	200	350	500	μA
VCC15 operating VCC15 supply current	IVCCOP	f L.U.V.W=20k, f H.U.V.W=20k,	-	1200	-	
VCC15 supply under-voltage positive going threshold	VCCUV+		8	9	10	V
VCC15 supply under-voltage negative going threshold	VCCUV-		8	8	10	
VCC15 supply under-voltage lockout hysteresis	VCCHYS		-	0.7	-	
<b>High Side Floating Power Supply Characteristics</b>						
High side VBS supply under-voltage positive going threshold	VBSUV+		8	9	10	V
High side VBS supply under-voltage negative going threshold	VBSUV-		7	8	9	
High side VBS supply under-voltage lockout hysteresis	VBSUVHYS		-	0.6	-	
High side VBS quiescent current in UVLO mode	IQBS	VBS=12V	35	54	75	μA
Offset supply leakage current	ILK	VB=VS=600V VCC15=0V	-	-	1	
<b>Gate Driver Output Section</b>						
High Side Output High Short-Circuit Pulse Current	IHO+	VHO=VS=0	-	160	-	mA
High Side Output Low Short-Circuit Pulse Current	IHO-	VHO=VB=12V	-	340	-	
Low Side Output High Short-Circuit Pulse Current	ILO+	VLO=PGND=0	-	160	-	
Low Side Output Low Short-Circuit Pulse Current	ILO-	VLO=VCC15=12V	-	340	-	
Allowable Negative VS Pin Voltage for HU.V.W Signal Propagation to HOU.V.W	VSN	VBS=12V	-	-10	-	V

## 20.9 Dynamic Electrical Characteristics

( VCC15-SGND ) = (VB-VS)=12V ,Vs.u.v.w=SGND=PGND, and C load=1nF unless otherwise specified,

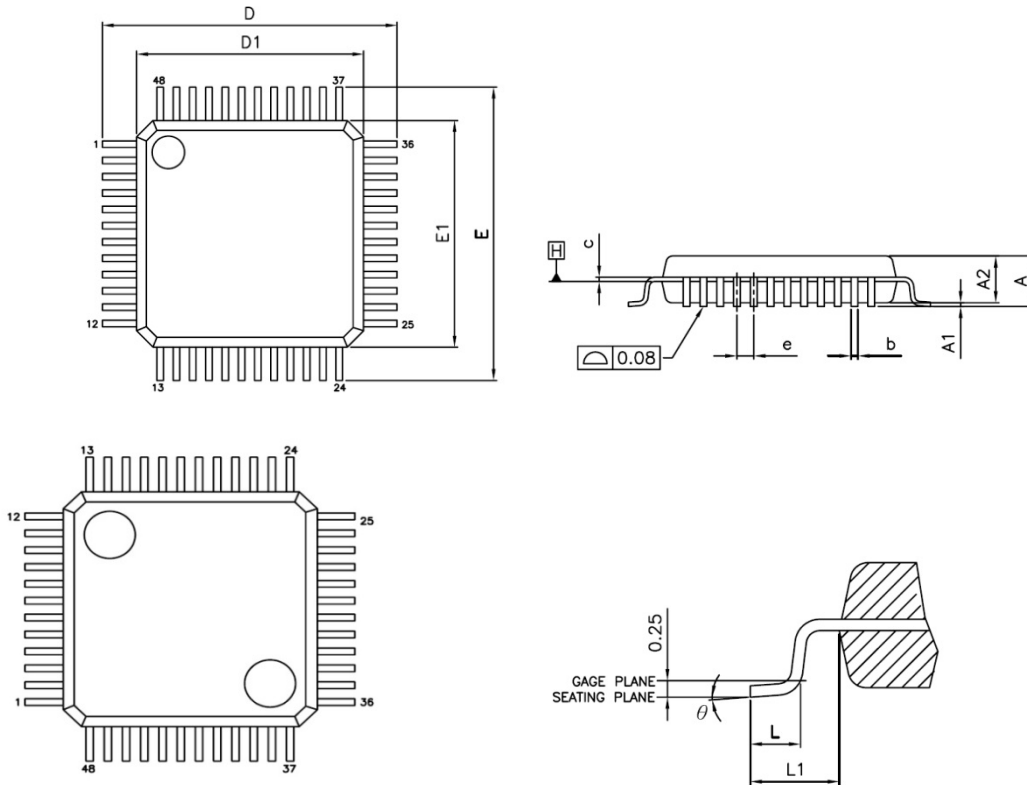
TAMB=25°C.

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Turn-On propagation delay	t <sub>ON</sub>	VH.U.V.W or VL.U.V.W=5V, VS.U.V.W=0	300	510	700	ns
Turn-Off Propagation delay	t <sub>OFF</sub>	VH.U.V.W or VL.U.V.W=0, VS.U.V.W=0	300	570	700	
Turn-On Rise time	t <sub>R</sub>	VH.U.V.W or VL.U.V.W=5V, VS.U.V.W=0	-	90	-	
Turn-Off Fall time	t <sub>F</sub>	VH.U.V.W or VL.U.V.W=0, VS.U.V.W=0	-	40	-	
Input Filtering Time	t <sub>FLT,IN</sub>			400		
Dead Time	DT		150	230	310	
Dead-Time Matching(All Six Channels)	MDT		-	-	100	
Delay Matching(All Six Channels)	MT		-	-	150	
Output Pulse-Width Matching	PM	PWIN=10us, PM=PWOUT-PWIN	-	-	100	



## 21. Package Information

### 21.1 LQFP-48 7x7mm (AD48) Outline Dimensions



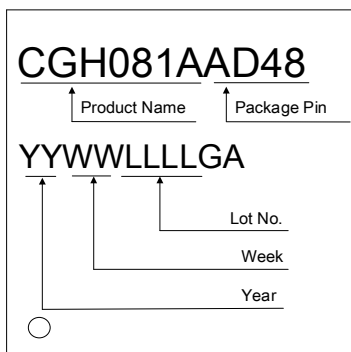
Unit	mm			inch		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	---	---	1.60	---	---	0.063
A1	0.05	---	0.15	0.002	---	0.006
A2	1.35	1.40	1.45	0.053	0.055	0.057
b	0.17	0.22	0.27	0.007	0.009	0.011
c	0.09	---	0.20	0.004	---	0.008
D	9.00 BSC			0.354 BSC		
D1	7.00 BSC			0.276 BSC		
E	9.00 BSC			0.354 BSC		
E1	7.00 BSC			0.276 BSC		
e	0.50 BSC			0.020 BSC		
L	0.45	0.60	0.75	0.018	0.024	0.030
L1	1.00 REF			0.039 REF		
$\theta$	0°	3.5°	7°	0°	3.5°	7°

## 22. Marking Distinguish

### 22.1 Standard Ink (w/o code)

Figure 22.1 Standard Ink (w/o code)

LQFP48



### 22.2 Customization Ink (with customization code)

Figure 22.2 Customization Ink (with customization code)

LQFP48



## 23. Ordering Information

### 23.1 Standard Product Name

Figure 23.1 Standard Product Name

<b><u>CG</u></b>	<b><u>H081A</u></b>	<b><u>AD48</u></b>
<i>CheerGoal</i>	<i>Product Name</i>	<i>Package AD48 : LQFP-48</i>

### 23.2 Customization Product Name

- With customization code, produce by order.

Figure 23.2 Customization Product Name

<b><u>CG</u></b>	<b><u>H081A</u></b>	<b><u>AD48</u></b>	<b>-</b>	<b><u>XXXX</u></b>
<i>CheerGoal</i>	<i>Product Name</i>	<i>Package AD48 : LQFP-48</i>		<i>Customization Code NO.</i>

## 24. Revision History

Table 24 Revision History

Update Date	Version	Modify content
2024/05/06	v0.00	Preliminary edition
2024/08/16	v0.10	The links of contents updated
2025/01/22	v0.20	Update P2 、 103 、 123 、 125.
2025/08/27	v0.30	Updated Pin Assignments & Pin Definitions to reflect latest design change.