

CHT-MAGMA DATASHEET

Version: 1.8

8-Jul-14

(Last Modification Date)

High Temperature PWM Controller

General Description

MAGMA is a High Temperature Pulse Width Modulation (PWM) Controller with maximum duty cycle up to 90%. It operates at constant frequency, adjustable from 50KHz up to 500KHz.

MAGMA can operate with input voltages from 6 to 30V. It also features an internal voltage reference, input feed forward compensation making it less sensitive to input voltage variations, and a soft start activated whenever MAGMA comes out of stand-by or the output is enabled.

An under-voltage lockout function maintains the PWM output low until the controller has sufficient supply voltage for proper operation. A "power good" comparator returns a "good" signal when the DC-DC converter output voltage has reached a programmable threshold. A synchronization pin can be driven by an external clock while the internal clock is available on *CKOUT* pin.

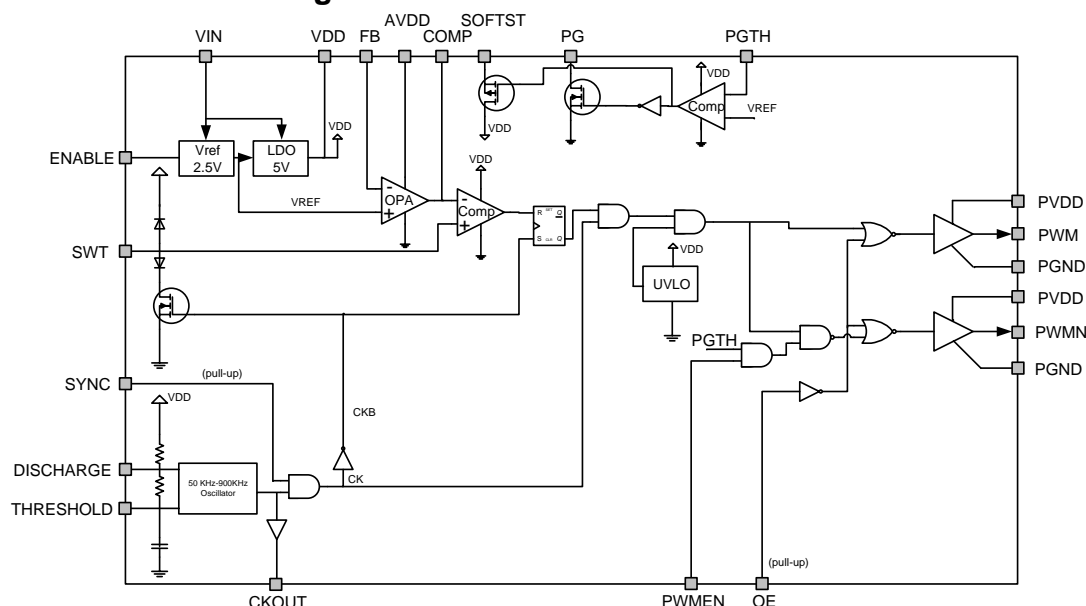
Features

- Voltage Mode PWM Controller
- Adjustable Max Duty Cycle up to 90%
- Constant Switching Frequency adjustable between 50KHz to 500KHz
- Input Voltage from 6V to 30V
- Input Voltage Feed Forward Compensation
- On-chip 2.5V Reference Voltage
- Stand-by Mode
- Under Voltage Lockout
- Soft-Start Capability
- Synchronization Capability
- Power Good Flag
- Output Enable
- Validated at 225°C for 43700 hours (CDIL28)/20000 hours(CSOIC28) (and still on-going)

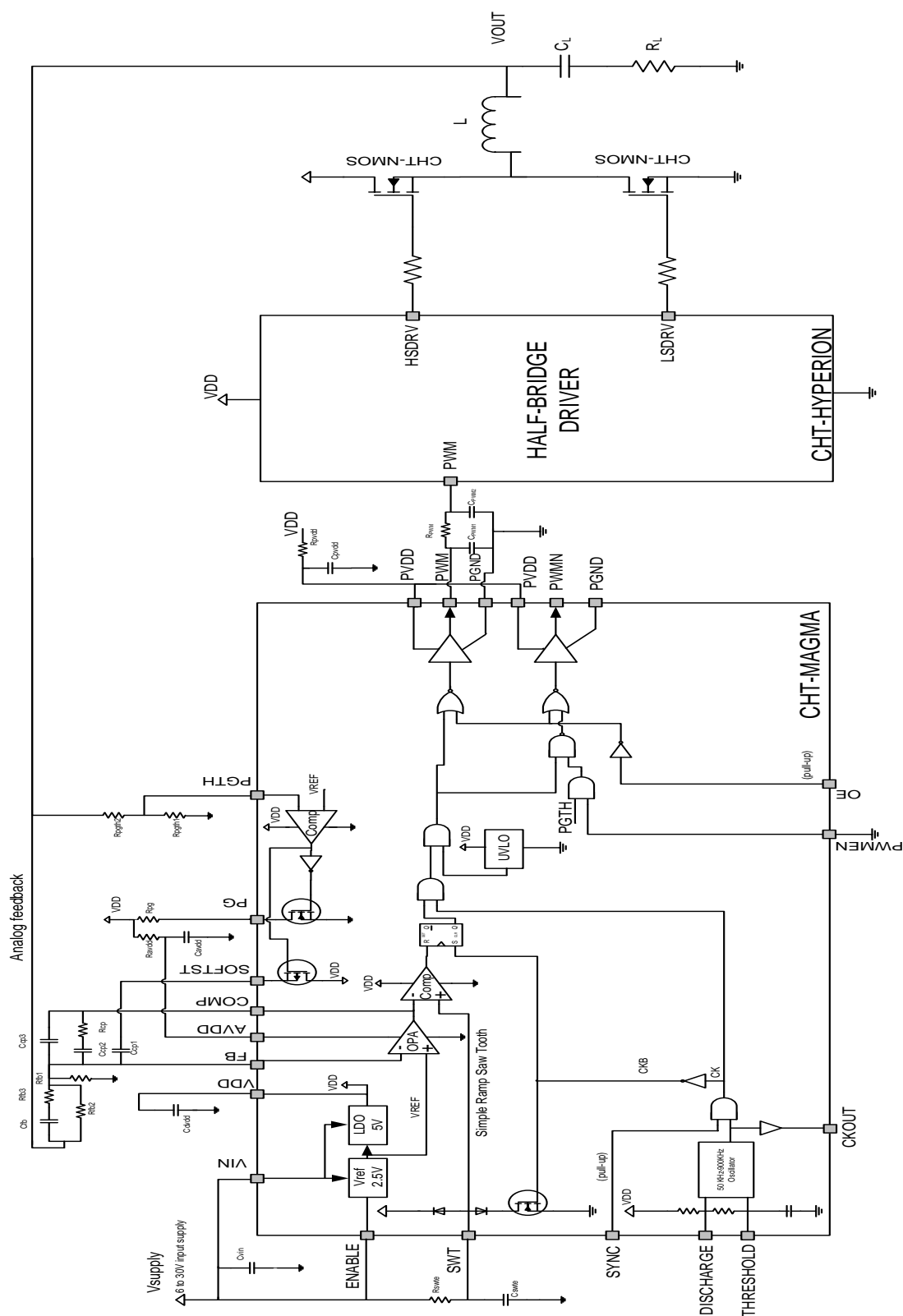
Applications

DC-DC Converters in Oil&Gas, Industrial, Aerospace & Automotive.

Functional Block Diagram



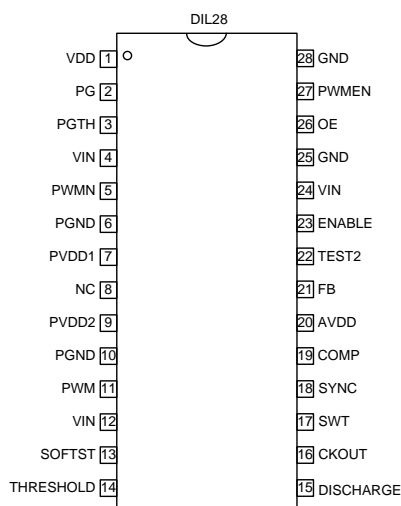
Typical Application: 5V DCDC BUCK CONVERTER



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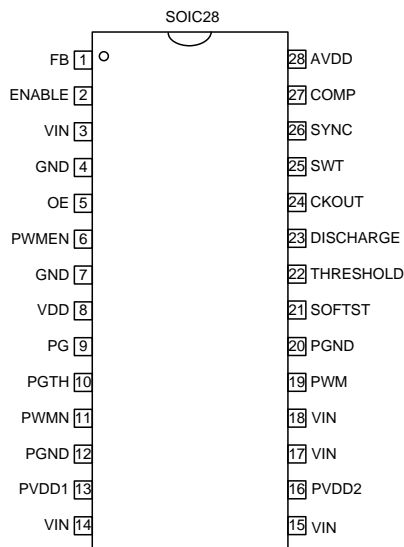
¹ Typical values for R_{pwm} and C_{pwm2} are : $R_{pwm} = 220\Omega$ and $C_{pwm2} = 47 \text{ pF}$; max value for C_{pwm2} : 100 pF Same recommendations/requirements apply to PWMN pin.

Package Configurations: CDIL28



Pin #	Pin Name	Pin Description
1	VDD	5V output of the internal LDO. This node needs to be externally decoupled and connected to other VDD, AVDD and PVDD.
2	PG	"Power Good". When the voltage on "PGTH" is lower than 2.5V, PG is pulled down. Otherwise, PG presents a high impedance. If used, this pin requires an external pull-up resistor.
3	PGTH	"Power Good Threshold". This node is compared to the internal 2.5V reference. If PGTH<2.5V, PG is pulled down and SOFTST is pulled up. If PGTH>2.5V, PG and SOFTST present a high impedance.
4	VIN	Input supply of the LDO.
5	PWMN	Inverse (non-overlapped) of "pulse Width Modulation" signal (5V logic level) (cfr General Description Section for more information)
6	PGND	Power ground of the PWM output buffer. Connect to ground.
7	PVDD1	Power supply of the PWM output buffer. Connect to VDD (pin1) with a 10Ω resistor and decoupling capacitance.
8	NC	Not connected
9	PVDD2	Connect to pin7
10	PGND	Power ground of the PWM output buffer. Connect to ground.
11	PWM	"Pulse Width Modulation" output (5V logic level).
12	VIN	Input pin. To be connected at PCB level with other VIN pins.
13	SOFTST	"Soft Start". An external capacitor must be connected between this node and the "FB" node. As long as the voltage on PGTH node is lower than 2.5V, SOFTST is internally pulled up to VDD.
14	THRESHOLD	Node of the internal oscillator. Reduce as much as possible parasitic capacitances on this node if the internal oscillator is used.
15	DISCHARGE	Node of the internal oscillator. Left this pin floating for the default 230kHz frequency.
16	CKOUT	The waveform on this node is a copy of the internal oscillator. It can be used for synchronisation purposes between various PWM controllers.
17	SWT	When the internal clock is low, SW is pulled down to approximately a forward diode voltage. An external RC must be connected on this node in order to generate a saw-tooth. Connecting the resistor to the input supply allows having a saw tooth slope proportional to the supply (input feed-forward).
18	SYNC	An external 5V clock can be applied on this node for synchronization purposes. In this case, the internal clock must be deactivated (connecting the "DISCHARGE" to ground). Note that the output PWM duty cycle cannot be larger than the duty-cycle of the external clock. If not used, SYNC must be floating or connected to VDD.
19	COMP	Output of the internal error amplifier & input of the PWM comparator.
20	AVDD	Analog 5V supply of the error amplifier. Connect to a well decoupled 5V source.
21	FB	Negative input of the error amplifier.
22	TEST2	Internal test node. Left floating
23	ENABLE	If grounded, the internal LDO is turned off and the PWM output is set to zero. A voltage between 4V and VIN on this node activates the LDO and allows a normal operation of the PWM output.
24	VIN	Input supply of the LDO.
25	GND	Ground pin
26	OE	Output Enable. Internally pulled-up to VDD. If low, it sets the PWM output to zero.
27	PWMNEN	Enable of PWMN signal (active high)(cfr General Description Section for more information)
28	GND	Ground pin

Package Configurations: CSOIC28



Pin #	Pin Name	Pin Description
1	FB	Negative input of the error amplifier.
2	ENABLE	If grounded, the internal LDO is turned off and the PWM output is set to zero. A voltage between 4V and VIN on this node activates the LDO and allows a normal operation of the PWM output.
3	VIN	Input supply of the LDO
4	GND	Ground pin
5	OE	Output Enable. Internally pulled-up to VDD. If low, it sets the PWM output to zero.
6	PWMEN	Enable of PWMN signal (active high)(cfr General Description Section for more information)
7	GND	Ground pin
8	VDD	5V output of the internal LDO. This node needs to be externally decoupled and connected to other VDD, AVDD and PVDD.
9	PG	"Power Good". When the voltage on "PGTH" is lower than 2.5V, PG is pulled down. Otherwise, PG presents a high impedance. If used, this pin requires an external pull-up resistor.
10	PGTH	"Power Good Threshold". This node is compared to the internal 2.5V reference. If PGTH<2.5V, PG is pulled down and SOFTST is pulled up. If PGTH>2.5V, PG and SOFTST present a high impedance.
11	PWMN	Inverse (non-overlapped) of "pulse Width Modulation" signal (5V logic level) (cfr General Description Section for more information)
12	PGND	Power ground of the PWM output buffer. Connect to ground.
13	PVDD1	Power supply of the PWM output buffer. Connect to VDD (pin8) with a 10Ω resistor and decoupling capacitance.
14	VIN	Input supply of the LDO
15	VIN	Input supply of the LDO
16	PVDD2	Connect to pin13
17	VIN	Input supply of the LDO
18	VIN	Input supply of the LDO
19	PWM	"Pulse Width Modulation" output (5V logic level).
20	PGND	Power ground of the PWM output buffer. Connect to ground.
21	SOFTST	"Soft Start". An external capacitor must be connected between this node and the "FB" node. As long as the voltage on PGTH node is lower than 2.5V, SOFTST is internally pulled up to VDD.
22	THRESHOLD	Node of the internal oscillator. Reduce as much as possible parasitic capacitances on this node if the internal oscillator is used.
23	DISCHARGE	Node of the internal oscillator. Left this pin floating for the default 230kHz frequency.
24	CKOUT	The waveform on this node is a copy of the internal oscillator. It can be used for synchronisation purposes between various PWM controllers.
25	SWT	When the internal clock is low, SW is pulled down to approximately a forward diode voltage. An external RC must be connected on this node in order to generate a saw-tooth. Connecting the resistor to the input supply allows having a saw tooth slope proportional to the supply (input feed-forward).
26	SYNC	An external 5V clock can be applied on this node for synchronization purposes. In this case, the internal clock must be deactivated (connecting the "DISCHARGE" to ground). Note that the output PWM duty cycle cannot be larger than the duty-cycle of the external clock. If not used, SYNC must be floating or connected to VDD.
27	COMP	Output of the internal error amplifier & input of the PWM comparator.
28	AVDD	Analog 5V supply of the error amplifier. Connect to a well decoupled 5V source.

Absolute Maximum Ratings

Devices stressed above these absolute maximum ratings could present permanent damage. Exposure to this maximum rating for extended periods may affect the device reliability. These ratings are considered individually (not in combination). If not specified, voltages are related to the ground GND.

Parameter	Min.	Max.	Units
VIN	-0.3	40	V
VDD	-0.3	7	V
OE, SYNC, PWMEN	-0.3	"VDD"+0.3	V
PWM, PWMN	-0.3	6	V
PGND	-0.3	0.3	V
PVDD1, PVDD2, AVDD	"VDD"-0.3	"VDD"+0.3	V
Junction Temperature		250	°C
ESD Rating (Human Body Model)	1 (expected)		kV

With high voltage/high frequency switching, parasitic inductors and capacitors could create current and voltage glitches beyond the absolute maximum rating. So, it is recommended to take special care when developing your application to minimize parasitic at PCB level on all high voltage nodes to prevent exceeding absolute maximum rating.

Also, probing on PWM and PWMN pins should be done with a lot of care; it is recommended to not perform any hot probing on those nodes.

Electrical Characteristics

Unless otherwise stated: $V_{DD}=5V$, $T_j=25^{\circ}C$. **Bold underlined** values indicate values over the whole temperature range ($-55^{\circ}C < T_j < +225^{\circ}C$).

Parameter	Condition	Min	Typ	Max	Units
Input Supply					
VIN supply		<u>6</u>		<u>30</u>	V
I(VIN) ¹	internal oscillator at 230kHz Vin=7V, 25°C		1.3		mA
Digital Input Controls (OE, SYNC, PWMNEN)					
Input Current	Internal pull-up	<u>25</u>		<u>85</u>	μA
High level input voltage		<u>3.7</u>		<u>VDD+0.3</u>	V
Low level input voltage		<u>-0.3</u>		<u>2</u>	V
Analog inputs²					
PGTH, FB, THRESHOLD, DISCHARGE		<u>0</u>		<u>VDD</u>	V
ENABLE	Low level ³			<u>0.5</u>	V
	High level	<u>3</u>		<u>VIN</u>	V
Input current	(Mostly from ESD diode)	<u>-100</u>		<u>100</u>	nA
Digital outputs					
PWM	Low level @100mA			<u>0.5</u>	V
	High level @100mA	<u>VDD-0.5</u>			V
PG ⁴	Pull down only. RON value	<u>1k</u>		<u>4k</u>	Ω
CKOUT	Low level @2mA			<u>0.5</u>	V
	High level @2mA	<u>VDD-0.5</u>			V
PWMN	Low level @100mA			<u>0.5</u>	V
	High level @100mA	<u>VDD-0.5</u>			V
Under Voltage LockOut (UVLO)					
VDD threshold for PWM enabling ⁵	-55°C		4.2		V
	25°C		3.8		V
	125°C		3.3		V
	225°C		2.8		V

¹ See Figure 2.

² Above 5V or below 0V, the ESD diode becomes forward biased.

³ When low, the internal LDO is turned OFF. VDD should therefore go to zero. However, due to the input feedforward resistor used on the node SWT, VDD could rise slightly above zero.

⁴ PG is ESD protected versus GND and VDD. The pull-up resistor should be connected to a voltage smaller or equal to VDD.

⁵ Above this threshold, the PWM modulator is functional. Below this threshold, the PWM output is low.

Electrical Characteristics (continued)

Unless otherwise stated: $V_{DD}=5V$, $T_j=25^{\circ}C$. **Bold underlined** values indicate values over the whole temperature range ($-55^{\circ}C < T_j < +225^{\circ}C$).

Parameter	Condition	Min	Typ	Max	Units
OPA					
Output voltage swing		0.15		AVDD-0.2	V
Output current			±15		mA
Input offset voltage			±2.5	±8	mV
Input offset drift			±5	±15	μV/°C
DC gain	$T_j=25^{\circ}C$ $T_j=225^{\circ}C$		100 87		dB dB
Gain-bandwidth product	$C_{load}=30pF$, $R_L=2k\Omega$	1.3	1.5		MHz
Power supply rejection ratio	0-100Hz	78			dB
Slew rate	$C_{load}=30pF$, $R_L=2k\Omega$ $T_j=25^{\circ}C$ $T_j=225^{\circ}C$	1.0 1.6	1.2 1.7		V/μs V/μs
Phase margin	$C_{load}=30pF$, $R_L=2k\Omega$	50	>60		Degree
Integrated input noise	DC to 10Hz		25		μV _{RMS}
Input current ("FB" pin)				±10	nA

Voltage Reference (2.5V)					
Accuracy	$T_j=125^{\circ}C$; $V_{in}=7V$	2.45 -2	2.5	2.55 +2	V %
Temperature drift	See Figure 4	+100 +25	+250 +100	+400 +160	μV/°C ppm/°C
Line regulation	See Figure 4	-1.5		+1.5	mV/V
Minimum dropout ($V_{in}-V_{ref}$) ¹			0.7		V

5V linear regulator (LDO)					
VDD accuracy	$T_j=125^{\circ}C$; $V_{in}=7V$	4.6 -8	5	5.4 +8	V %
Load current ²		0		25	mA
Temperature drift	$V_{in}=7V$	-1		+2	mV/°C
Load Regulation	$T_j=25^{\circ}C$ $T_j=225^{\circ}C$	1.2 2.7		2.3 3.6	mV/mA mV/mA
Line Regulation	$T_j=25^{\circ}C$ $T_j>125^{\circ}C$	-2 -1		+10 +6	mV/V
Min. dropout ($V_{in}-V_{DD}$) ³	$I_{load}=0mA$		0.5		V
Input capacitance required	Ceramic or other low ESR	470			nF
Output capacitance re- quired ⁴	Ceramic or other low ESR	220		2200	nF

PWM modulator (comparator, RS flip-flop, logic, output buffer)					
Input range (COMP, SWT) ⁵		-0.3		VDD+0.3	V
Delay to PWM (goes up) ⁶	PWM goes up		100		ns
Delay to PWM (goes down) ⁷	FAST slope		220		ns
	Slope=5V/μs		320		ns
	Slope=1V/μs		720		ns
Duty Cycle		0		D(ck) ⁸	%

¹ The **dropout** is defined as the input voltage minus the output voltage (V_{ref}). The "**minimum dropout**" is defined as the dropout for which the local line regulation ($\delta V_{ref}/\delta V_{in}$) is better than 10mV/V and $V_{ref}>2.4V$.

² The LDO is internally supplying most parts of the PWM controller. The load current considered here is an extra current (in order to supply an external driver for example).

³ The **dropout** is defined as the input voltage minus the output voltage (V_{DD}). The "**minimum dropout**" is defined as the dropout from which the local line regulation ($\delta V_{DD}/\delta V_{in}$) is better than 20mV/V and $V_{DD}>4.3V$.

⁴ Additional load capacitance can be used if they have an ESR of at least 10Ω.

⁵ The comparator inputs are the pins COMP & SWT. As COMP is also the output of the buffered OPA (error amplifier), no external input signal can directly be applied on COMP node.

⁶ Delay measured vs. the rising edge of the SYNC input (with the internal oscillator turned off)

⁷ Delay measured versus the crossing of a positive edge on the SWT node and V_{ref} (with SYNC high and COMP sets to V_{ref} using the OPA as a follower). Different SWT raising slopes are considered. At first order, the worst case delay as function of the SWT slope (expressed in V/μs) can be approximated as $220ns+500ns/(SWT_slope[V/\mu s])$.

⁸ The maximum PWM duty cycle cannot exceed the clock (SYNC or internal oscillator) duty cycle.

Electrical Characteristics (continued)

Unless otherwise stated: $V_{DD}=5V$, $T_j=25^{\circ}C$. **Bold underlined** values indicate values over the whole temperature range ($-55^{\circ}C < T_j < +225^{\circ}C$).

Parameter	Condition	Min	Typ	Max	Units
Internal oscillator (natural frequency)					
frequency ¹	THRESHOLD and DISCHARGE pads disconnected		230		kHz
Duty cycle	THRESHOLD and DISCHARGE pads disconnected	<u>89</u>	<u>91</u>	<u>93</u>	%
Frequency drift with temperature	THRESHOLD and DISCHARGE pads disconnected		0.18		kHz/°C

Internal oscillator (adjusting frequency) (See details in section "Clock signal" (page 10))					
Adjustable frequency range		20	230	700	kHz
Adjustable duty cycle		60		95	%

"Power Good" control					
Threshold	versus the internal Vref (2.5V)	-20	0	20	mV
Delay "PGTH" to "PG" ²			100		ns

Saw tooth (SWT)³					
Discharge current ⁴	Occurs when the oscillator (ck) is low. <ul style="list-style-type: none"> V(SWT=5V) V(SWT=2V) 	<u>20</u> <u>10</u>		<u>60</u> <u>20</u>	mA mA
Floating impedance ⁵	Occurs when the oscillator (ck) is high.		500		kΩ
Minimum SWT voltage	SWT voltage for which the discharge current is smaller than 100μA (for ck low) <ul style="list-style-type: none"> T_j=-55°C T_j=200°C 		0.9 0.55		V V

¹ As the internal oscillator capacitance is only 130pF, any additional parasitic capacitors on pins "THRESHOLD" and "DISCHARGE" can decrease the oscillation frequency.

² This delay is defined as the time between a voltage step (5V; 5ns slope) on PGTH and the switching of the PG pull down transistor. The output slope of PG then mostly depends on the external RC elements on this node. The delay is symmetrical versus the PGTH slope.

³ The SWT pin is an analog input with ESD diode protection to gnd and VDD. Above 5V or below 0V, the ESD diode becomes forward biased.

⁴ See Figure 1

⁵ When the SWT discharge transistor is OFF, the SWT node internally sees a 500kΩ resistor connected to an internal 2.5V voltage source.

Typical Performance Characteristics

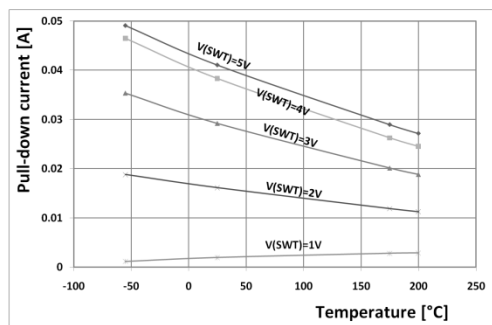


Figure 1: “SWT” pin pull-down current (when clock is low) over temperature as function of the SWT voltage.

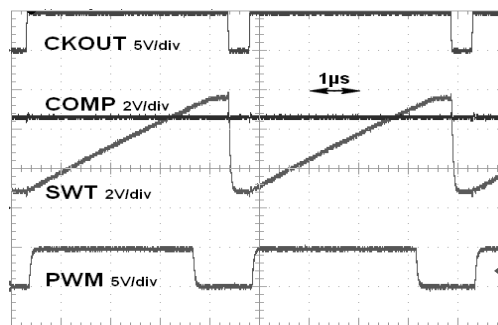


Figure 3: Typical waveform measured at 25°C on CKOUT, COMP, SWT and PWM nodes.

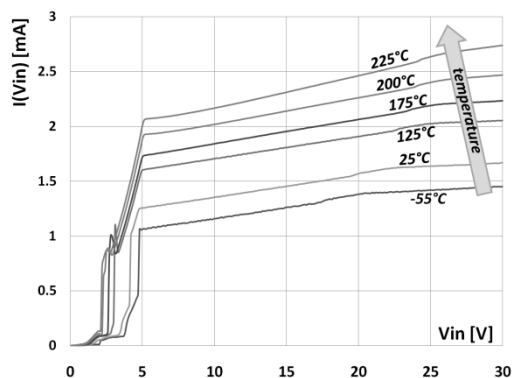


Figure 2: Total current consumption over temperature vs. input supply¹

¹ Measurement conditions: Use of the internal 230kHz oscillator; 100kΩ on the PG pad; 47kΩ between Vin and SWT; FB and PGTH to gnd; 30pF on the PWM output. If the internal oscillator is turned off, the current consumption is lowered by about 320μA (not represented in this figure).

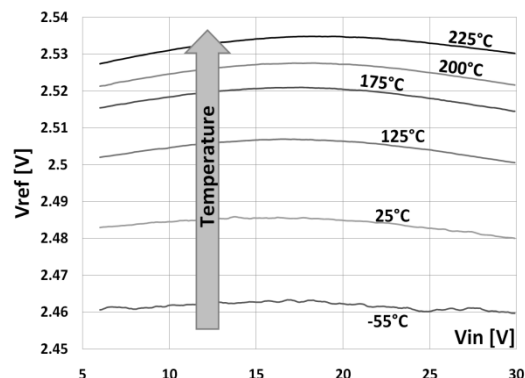


Figure 4: Typical internal voltage reference dependence on V_{in} and temperature.

General Description

The CHT-MAGMA circuit integrates a versatile pulse-width-modulation controller. The different blocks shown in the Functional Block Diagram section (page 1) are described hereafter. For these explanations, it is considered that the CHT-MAGMA is used in its typical application (5V DCDC buck converter) as sketched in page 1.

Error amplifier

It compares a fraction of the dc-dc converter output to the internal 2.5V reference. Its output V_{comp} is further compared to a saw-tooth in order to create a PWM signal.

Clock signal

The PWM controller is synchronized by a clock signal. This clock can either be internal or external (from SYNC node). In this last case, the internal clock needs to be turned off (connecting DISCHARGE to ground). The recommended frequency range is between 50kHz and 500kHz. Also, the duty-cycle of ck fixes the maximum duty-cycle of the PWM output. The positive edge of ck induces the positive edge of the PWM output after some delay (see delay in the Electrical Characteristics section). By default (when DISCHARGE and THRESHOLD are floating), the internal oscillator generates a typical ck signal of 230kHz at 25°C with a 90% duty cycle; this is based on following values for internal passive components:

- R between Vdd and DISCHARGE: 38.8KΩ
- R between DISCHARGE and THRESHOLD: 4.85KΩ
- C between THRESHOLD and GND: 130 pF.

External passive components can be used to change the default oscillator frequency; the clock frequency is then defined the following formula:

- $F_{clk} = 1.44 / [(R_a + 2 R_b) * C]$
- $DC (\%) = 100 * (R_a + R_b) / R_a + 2 * R_b$ where
- R_a is between Vdd and DISCHARGE
- R_b is between DISCHARGE and THRESHOLD

C is between THRESHOLD and GND.

Saw-tooth & input feed-forward.

The saw-tooth is generated by external Rswte and Cswte elements on the "SWT" pad (see the Typical Application 5V DCDC BUCK CONVERTER figure on page 2). The beginning of the charge of a series

RC circuit is quite linear as long as the charge time is smaller than the RC constant. Each time ck goes low, the Cswte capacitor is quickly discharged by the SWT pad and remains discharged as long as the ck signal is low. In practice, the minimum discharge voltage is about a forward diode voltage (~0.7V at 25°C).

PWM modulator

Figure 3 depicts a typical measurement on node SWT, COMP, CKOUT and PWM.

PWM output

Due to the high driver strength on PWM output pin, it is mandatory to connect PWM pin to a serial resistor (Rpwm) in order to damp glitches during switching phase. Cisoid recommends a resistance value of 220 Ω. Maximum external capacitance on this node is 100 pF

Power Good

The Power Good block (top right of the Functional Block Diagram figure) provides two different functionalities. By sensing a fraction of an output voltage (on PGTH pin) and comparing it to the internal 2.5V voltage reference, this block allows to activate the "PG" output flag and to deactivate the soft-start regime (see next section). Typically, for a 5V DCDC buck converter for example, the threshold of the power good is set to about 90% of the steady state DC output voltage, i.e. 4.5V. Resistors R_{pgth2} and R_{pgth1} of the Typical Application 5V DCDC BUCK CONVERTER figure should therefore be set in such a way that when the output voltage is 4.5V, the PGTH voltage is 2.5V.

Soft-start

When the input supply is connected and when the circuit is enabled, the output voltage should smoothly go from zero to its nominal voltage without overshoot (or smaller than about 10%) in order to protect sensitive loads.

Internally, the soft-start is also responsible for limiting the "inrush" current in a DCDC converter inductor. Such large current can produce large glitches that could damage the power driver.

Ccp1 (cfr typical application schematic) capacitance controls the start-up speed. To ensure smooth start-up of Magma, Cisoid recommends to use 330 nF for Ccp1. Ccp1 (connected between FB and SOFTST pins) is charged to VDD through the transistor connected to SOFTST; this forces FB pin voltage to gradually increase instead of having overshoot at turn-on of the DC/DC converter. To have this func-

tion working properly each time Magma is enabled, Ccp1 is shortcircuited (through an internal transistor between FB and SOFTST) while Magma is in disable state.

LDO and Vref

The internal 2.5V voltage reference is used by the internal linear low-dropout voltage regulator (LDO) in order to provide the 5V supply (VDD) required by the CHT-MAGMA. This 5V supply requires an external decoupling capacitor for stability and noise reduction. It can provide some current to an external circuit (for example, provide the supply of an external driver).

Activation of PWMN signal

To have this output pin carrying the non overlapped inverse of PWM output pin, following conditions need to be met:

- PWMNEN signal should be connected to VDD

- PGTH signal should be connected to VDD; in this case, power good function is not available anymore

When one of those conditions is not met, PWMN logical level is "0".

Application development

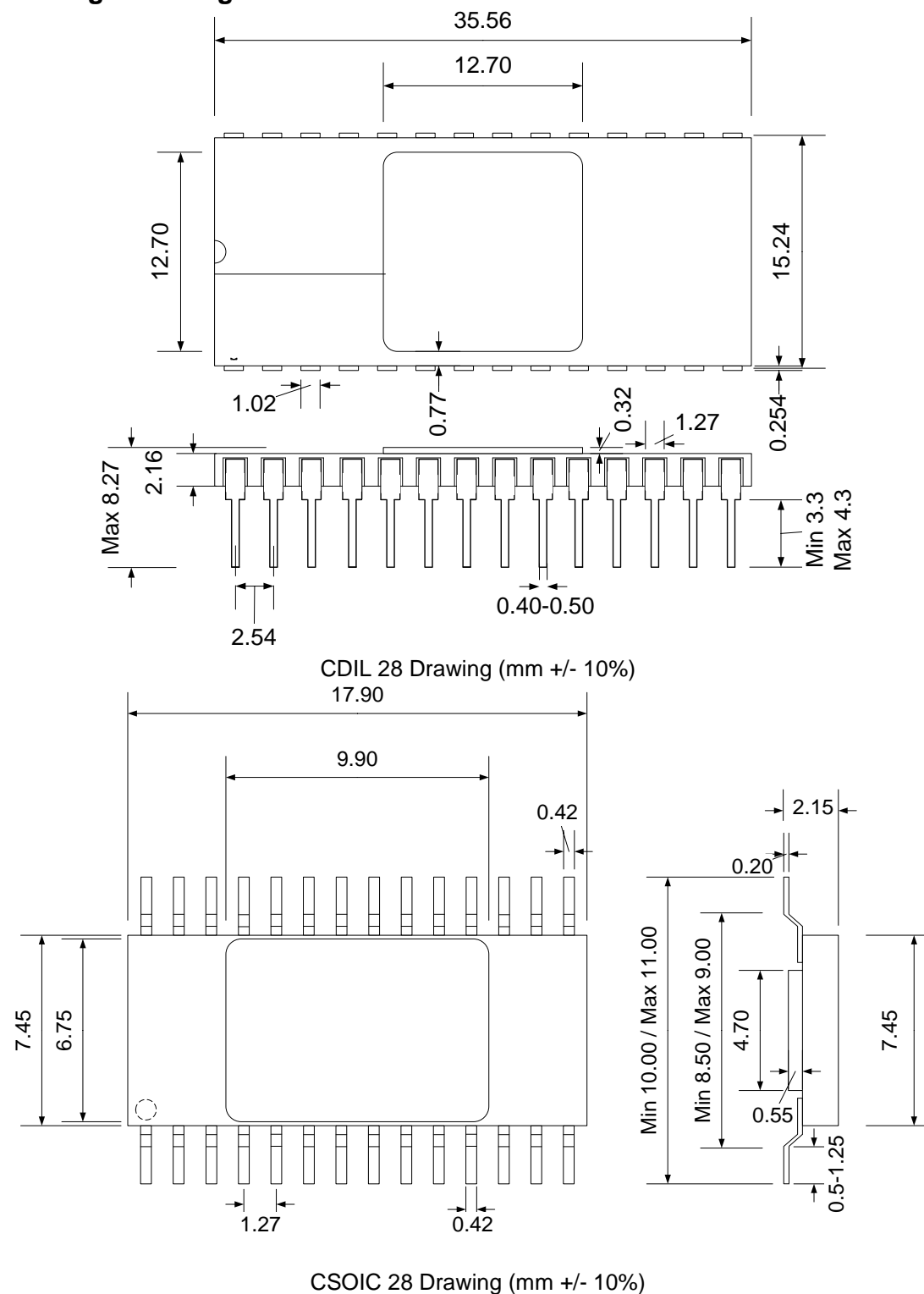
Cissoïd recommends that in the application testing process, the power supply is gradually increased starting from 7V; at each step, presence of glitches should be checked. If any and if those glitches are close to the maximum operating conditions, the application should be reworked to decrease drastically the amplitude of those glitches before increasing further the power supply level.

Be aware as well that when using Magma in a loop, any loop instability can lead to signals exceeding max rating values

Ordering Information

Ordering Reference	Package	Temperature Range	Marking
CHT-MAGMA-CDIL28-T	Ceramic DIL28	-55°C to +225°C	CHT-MAGMA
CHT-MAGMA-CSOIC28-T	Ceramic SOIC28	-55°C to +225°C	CHT-MAGMA

Package Drawing



Contact & Ordering

CISOID S.A.

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