

CC6421

Low Noise, High Efficiency, 5V/12V 800mA Single Coil Sine Wave Current Motor Driver

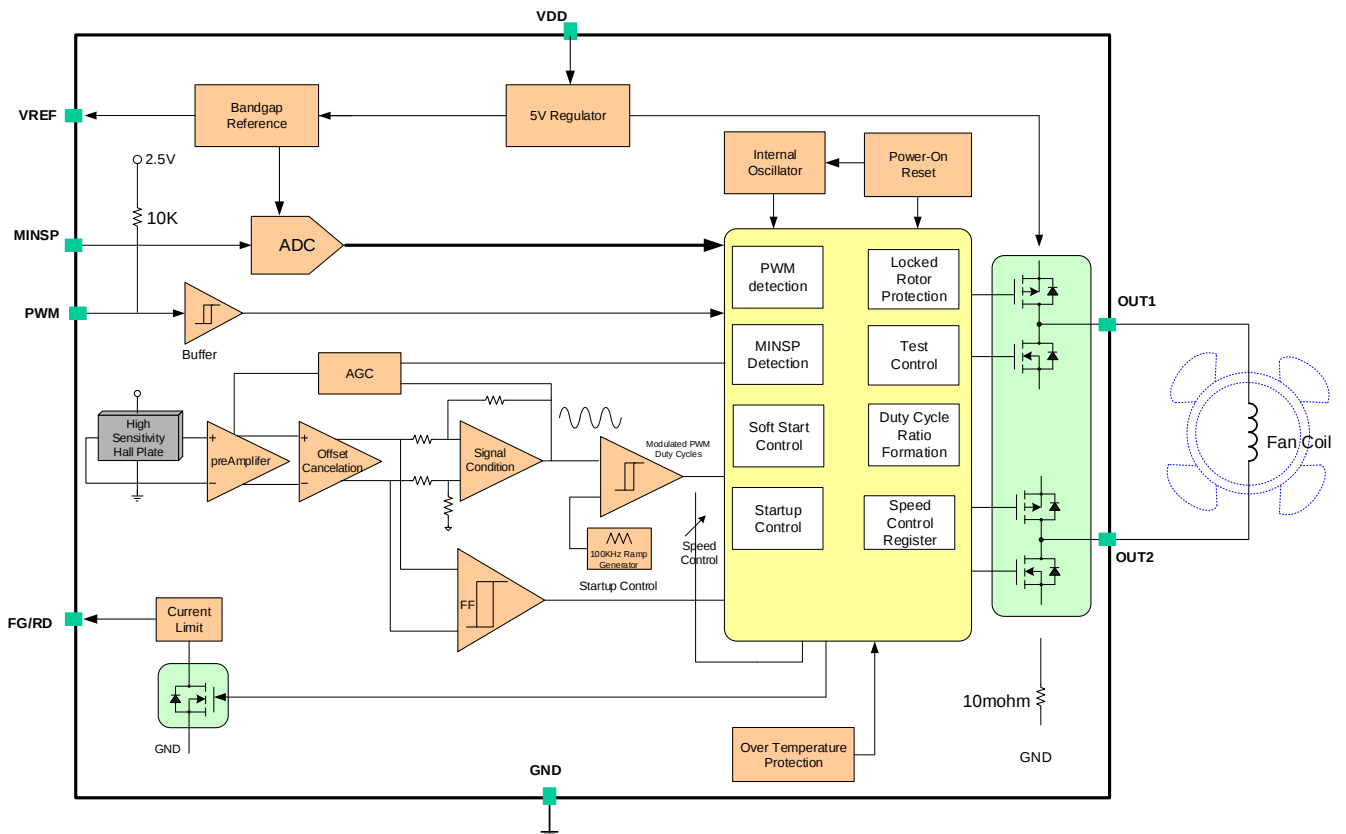
Features

- ◆ Built-in high sensitive hall sensor
- ◆ High efficiency,
- ◆ Zero Current Switch (ZCS) and Zero magnet Switch (ZBS)
- ◆ Low noise
- ◆ PWM speed control with minimal speed setting
- ◆ High output current, up to 800mA
- ◆ Wide operating voltage, 3.5V to 18V
- ◆ Rotation Detect (RD) and Frequency Generator (FG) are optional
- ◆ Protection: Thermal Protection, LRP (Lock Rotation Protection), Current Limit Protection
- ◆ AGC control
- ◆ Intelligent Soft Start
- ◆ The rotational speed curve is configurable
- ◆ ESD (HBM) 6000V

Application

- ◆ Single Coil Brushless DC Motor
- ◆ Single Coil Brushless DC Fan

Block Diagram



General Description

CC6421 is a one-chip solution for single-coil brushless DC motor/fan with PWM speed control.

The device is designed in BCD technology, it integrates regulator, hall sensor, offset cancellation, AGC amplifier, a power output H-bridge and digital control.

The voltage regulator operates from 3.5V to 18V.

The PWM input features a built-in pull-up resistor of 10Kohm. Since the interface providing the PWM signal is generally open-collector/drain type, an external resistor is not required. In addition, it provides a fail/safe functionality as it will drive the motor at full speed in case of signal wire-break.

The Intelligent Soft Start prevents very high peak current during start-up. After power on, the duty cycle of output signal will increase from 25% to 50% by 5% every 100ms.

During start up, CC6421 will detect magnet field strength and automatically adjust gain of amplifier. If CC6421 gets the right gain, or 1.5s after power on, it will change status from starting up to sine wave current mode. In sine wave current mode, CC6421 can change motor speed with PWM signal from 0.1Hz to 100KHz.

The Minimal Speed input allows setting of a minimum required rotation speed of the motor by using 2 inexpensive resistors. This is especially useful for applications where minimum cooling is a requirement to avoid system damage.

CC6421 can provide four rotational speed curves with different slopes by configuring different resistance between VREF and GND.

In sine wave current mode, the output signal is a PWM signal modulated by 100KHz triangle signal. The coil will filter the high frequency and recovery sine wave current by its impedance. Sine wave current mode will dramatically increase motor efficiency and decrease noise.

CC6421 provide FG and RD signal and its FG/RD pin is protected against short-circuit.

The device also features Locked Rotor Protection to avoid overheating issues in case of a mechanical blockage of the rotor or bearing failure.

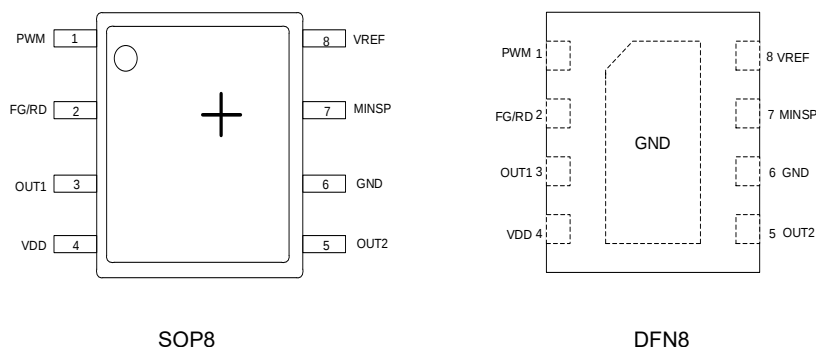
The on-chip Thermal Protection switches off the outputs if the junction temperature increases above an abnormally high threshold. It will automatically recover once the temperature decreases below a safe value.

CC6421 is available in two packages, which are SOP8 and DFN8 3*3.

Order Information

Part No.	Package Information	Package code
CC6421SO-FG	tape reel, 2500 pcs/reel	SOP8
CC6421SO-RD	tape reel, 2500 pcs/reel	SOP8
CC6421DN-FG	tape reel, 3000 pcs/reel	DFN8 3*3
CC6421DN-RD	tape reel, 3000 pcs/reel	DFN8 3*3

Pin Definition



Name	Pin No.		Function
	SOIC8	DFN8	
PWM	1	1	PWM speed control
FG/RD	2	2	Frequency generation/ Rotation Detect
OUT1	3	3	H bridge output 1
VDD	4	4	VDD
OUT2	5	5	H bridge output 2
GND	6	6	GND
MINSP	7	7	Minimal speed setting
VREF	8	8	Reference voltage

Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Supply Voltage	V_{DD}	22	V
Reverse Voltage	V_{DDREV}	-0.3	V
Output Current (Peak)	I_{OUTP}	1500	mA
Output Current (Continuous)	I_{OUTCS} (SOP8)	600	mA
	I_{OUTCD} (DFN8-3*3)	800	
FG/RD output current	$I_{FG/RD}$	30	mA
FG/RD reverse output current	$I_{FG/RD}$	-30	mA
PWM input voltage	V_{PWM}	7	V
Reverse PWM input voltage	V_{PWM}	-0.3	V
MINSP input voltage	V_{MINSP}	3.6	V
Reverse MINSP input voltage	V_{MINSP}	-0.3	V
Reverse MINSP input current	I_{MINSP}, I_{PWM}	-10	mA
Operating Temperature Range	T_A	-40~125	°C
thermal resistance	R_{thja} (SOP8)	150	°C/W
	R_{thja} (DFN8-3*3)	60	
Junction Temperature	T_J	150	°C
Storage Temperature	T_S	-55~150	°C
Magnetic Flux Density	B	Unlimited	mT
ESD (HBM)	ESD(HBM)	6000	V

Note: Exceeding the absolute maximum ratings may cause permanent damage. Exposure to absolute-maximum rated conditions for extended periods may degrade device reliability.

Recommended Operation Condition

Parameter	symbol	MIN	MAX	unit
Supply Voltage	V_{DD}	3.5	18	V
Operating Temperature Range	T_A	-40	125	°C
Continuous Output Current	I_{OUTC}	-	800	mA

Electrical Parameters (VDD=12V @ 25°C, unless specified otherwise)

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
Supply voltage	V _{DD}	-	3.5	-	20	V
Supply current	I _{DD}	-	-	6	8	mA
PWM input low voltage	V _{IL}	-	-	-	0.4	V
PWM input high voltage	V _{IH}	-	2.1	-	5.5	V
PWM input frequency	F _{IN}	-	0.1	-	100	kHz
PWM internal pull-up resistor	R _{IN}	-	-	10	-	kΩ
H bridge on resistance	R _{DS(on)}	T=25°C, 12V	-	0.8	-	Ω
H bridge on resistance	R _{DS(on)}	T=25°C, 4.5V	-	1	-	Ω
Soft start duty cycle range	DCout_ss	-	25	-	50	%
Soft start time	T _{SOFT}	DC _{OUT} increase from 25% to 50%	-	0.5	-	s
FG/RD output saturation voltage	V _{OL}	B>B _{OP} , I _{OUT} =5mA	-	0.2	0.5	V
FG/RD output current limit	I _{CL}	B>B _{OP}	-	50	-	mA
FG/RD output leakage current	I _{OFF}	V _{OUT} =16V, V _{DD} =12V, B<B _{RP}	-	0.1	2	uA
Reference output voltage	V _{REF}	-	2.45	2.5	2.55	V
Reference output current capability	I _{REF}	-	-	-	5	mA
Locked rotor protection ON time	T _{ON}	-	-	0.8	-	s
Locked rotor protection OFF time	T _{OFF}	-	-	5.0	-	s
Over temperature protection	T _{SD}	V _{IN} =18V	-	160	-	°C
Over temperature protection hysteresis	ΔT _{SD}	-	-	30	-	°C

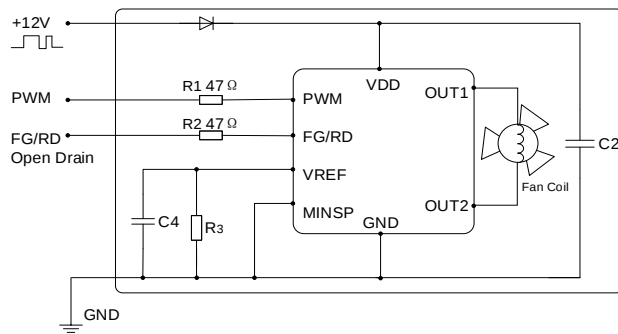
Magnetic Specifications

Parameter	Symbol	Min	Typ.	Max	Unit
Start up	operating point	B _{OP}	-	20	Gauss
	Release point	B _{RP}	-	-20	Gauss
	hysteresis	B _{HYS}	-	40	Gauss
Sine wave current mode	operating point	B _{OP}	-	5	Gauss
	Release point	B _{RP}	-	-5	Gauss
	hysteresis	B _{HYS}	-	10	Gauss

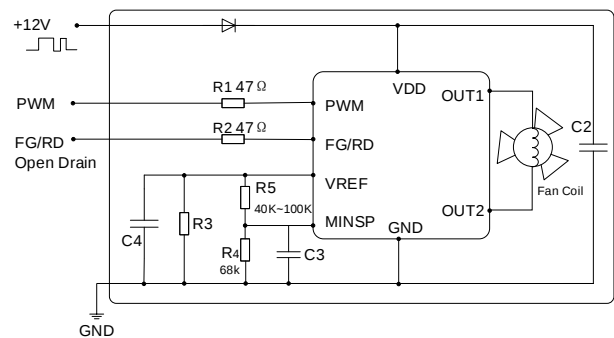
Driver Output vs. Magnetic Pole

Parameter	Test Condition	OUT1	OUT2	FG
North pole	B<B _{RP}	High	Low	High
South pole	B>B _{OP}	Low	High	Low

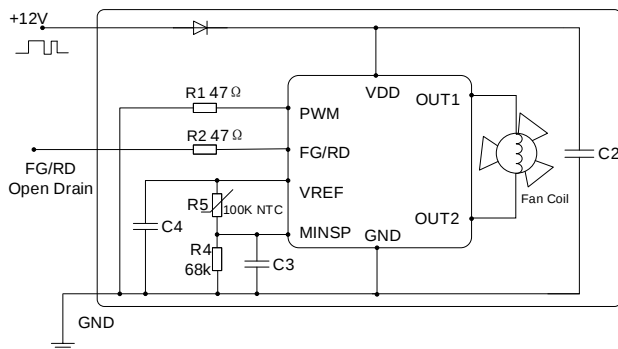
Typical Application Circuit



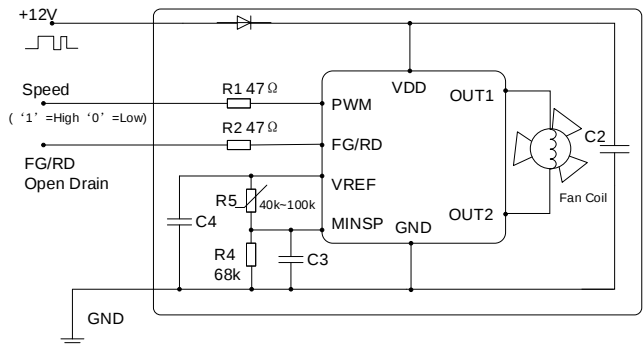
4-wire PWM Cooling Fan (no minimal speed setting)



4-wire PWM Cooling Fan (with minimal speed setting)



Temperature Controlled Cooling Fan



2-Speed Cooling Fan

Application information

PWM Pin

The resistance R1 should not be too large or too small, R1 will help to filter out the spike burr on PWM signal. If the resistance is too small, the effect is not good, the resistance should not be too large, When the fan external wire is too long, RC filtering will be formed with the distributed capacitance. When the PWM frequency is high, the duty cycle and amplitude of the signal will be distorted, resulting in the fan speed inconsistent with the preset duty cycle. In case of this situation, please use oscilloscope to monitor the waveform on PWM pin. The waveform should be clean without signal distortion.

The PWM input features a built-in pull-up resistor of 10Kohm, and the external input signal can be open drain signal or digital signal (V_{IL} range is 0-0.4V, V_{IH} range is 2.1-5.5V). When the peak value of the input signal exceeds 5.5V, the method of resistance voltage attenuation must be used to control the signal amplitude within 5.5V.

FG/RD Pin

The 2 Pin of CC6421 can be selected as FG / RD signal according to the demand, which is open leakage output. Its limit withstand voltage is 22V, and the limit output current is 30mA. The 2 Pin cannot directly drive the circuit with external voltage higher than 22V or control the power circuit with current greater than 30mA. Since the FG/RD pin is directly output to external, it is recommended that the pin be connected with a certain resistance before output. When the external abnormality occurs, it will protect the chip and reduce the damage events.

When external voltage signal is needed, appropriate resistance can be connected between VDD and FG / RD.

Special application scenario: Fan needs minimum rotational speed, and it should be able to shut down completely, and FG/RD signal is output to external.

Add PMOS or PNP triode on VDD to control VDD turn off. Do not use NPN / NMOS to turn off GND ground wire of fan.

There is a circuit inside the chip. When GND circuit is turned off, the current loop will be formed from VDD -> FG / RD.

VDD & GND Pin

VDD and GND are the power pins of the chip. When the H-bridge

is disconnected, the reverse voltage on the coil inductance will also be fed into the pin.

Do not connect any components in GND circuit in series, such as 0 Ω resistor, magnetic bead, etc.

Benefit from the characteristics of SVPWM sine wave, the chip will achieve Zero Current Switch (ZCS) and Zero magnet Switch (ZBS), and the burst voltage will be relatively small. In each SVPWM modulation, when H-bridge disconnects, the current on the coil inductor cannot change suddenly, a certain surge voltage will still be generated. Please add appropriate capacitance to the VDD Pin and GND Pin according to the total coil current. Generally speaking, the greater the current, the greater the capacitance value. The 2.2-4.7uF ceramic capacitor can absorb the surge voltage.

When the Fan has the following bad conditions, it is necessary to consider whether the chip power supply is subject to high-frequency interference:

1. When the working voltage is relatively low, the chip enters the square wave working state (the output pin keeps the high-level, the output is not the PWM wave).
2. One FG signal is lost for every 15 signals (which may cause the detected value of the rotational speed is lower than the actual rotational speed of the fan in the application of the terminal customer).
3. There are a lot of burr on the edge of FG signal output (Resulting the detected value of rotational speed is higher than the actual rotational speed in the application of terminal customers).

In general, a small capacitance high frequency decoupling capacitor is directly connected to the VDD Pin and GND Pin to filter out the high frequency interference in the power supply, which can effectively solve the above undesirable phenomenon. The capacitor is usually 0.1 uF ceramic capacitor. In PCB layout and wiring, the high-frequency decoupling capacitor should be placed as close to the chip as possible, and using the shortest and thickest copper foil connects the capacitor to the VDD Pin and GND Pin.

In most cases, CC6421 chip has good anti-interference ability, even if there is no high-frequency decoupling capacitor, it also can normal working. Whether the capacitor is paralleled needs to

Application information

be determined by the prototype measurement.

According to experience, when the working voltage of the chip is lower than 6V, the chip is vulnerable to medium and high frequency interference of the power supply, which may lead to the above adverse conditions. Therefore, it is recommended that the capacitor position should be reserved in PCB design to facilitate the subsequent debugging of fan.

OUT1 & OUT2 Pin

The OUT1 Pin and OUT2 Pin are connected to both ends of the coil L1 & L2, the control coil will generate the correct magnetic field, and the fan can rotate continuously.

In application, the loop area of OUT1, L1 – L2 and OUT2 should be smaller, so that the electromagnetic radiation released by the fan will be reduced.

In addition, one end of the coil, such as L1 and OUT1 connected in series with a magnetic bead, can also absorb the external electromagnetic radiation energy.

VREF Pin

VREF pin is the internal reference and external output pin, and the reference voltage is the basis of signal processing in analog circuit. If VREF is pulled down to 1V, the whole chip will work abnormally.

Note: VREF is recommended to add a capacitance to the ground, 0.1uF, to enhance the stability of the system loop.

Sensing point (Layout) Position

CC6421 is based on the principle of linear Hall. The chip needs to sample the current magnetic stripe strength in real time, adjust AGC gain, and output SVPWM signal corresponding to duty cycle. Therefore, the chip has the following two requirements for the position of the sensing point on the PCB (Figure 1):

1. The sensing point should be located on the straight line from the axis to the big end of the silicon steel sheet.
2. The sensing point should be placed on the projection plane of magnetic stripe as far as possible. If it is limited by structure, it should be close to the projection plane of magnetic stripe.

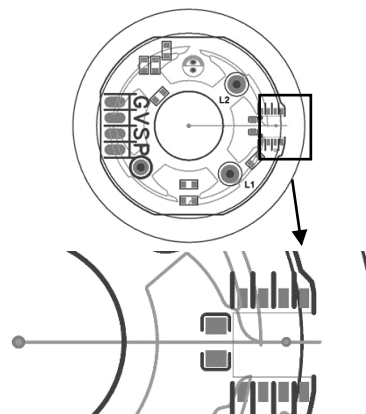


Figure 1

Sensing distance

The gap between the chip and the magnetic stripe should not be too large, and the intensity of the magnetic stripe should not be too small. Otherwise, when the internal automatic gain adjustment circuit is adjusted to the maximum gain, the maximum duty cycle of OUT1 & OUT2 cannot reach 100%. At this time, the gap between the chip and the magnetic stripe should be reduced, or the magnetic stripe with greater magnetic field strength should be replaced.

EMI

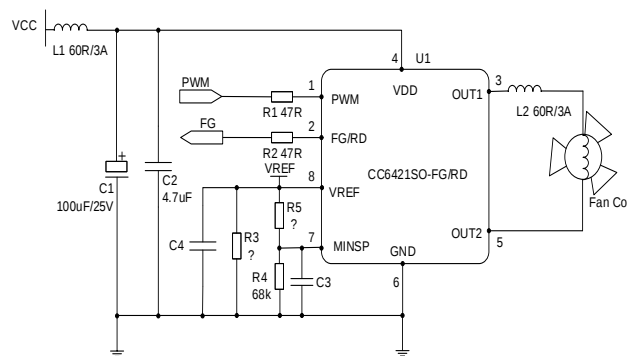


Figure 2

Note: increasing the L1 & L2 of magnetic beads is beneficial to meet the EMI radiation requirements. In order to avoid saturation of the magnetic bead current, the higher the rated current is, the better. It is recommended to 3-5 times the working current.

Application information

Setting of speed control curve

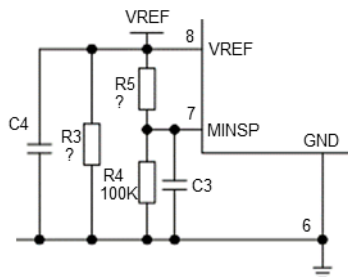


Figure 3

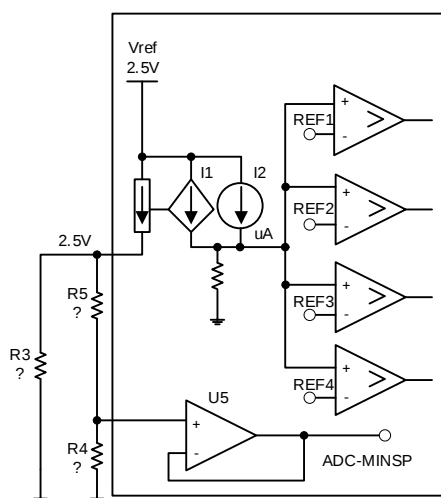


Figure 4

Fig. 3 and Fig. 4 show the block diagram of CC6421 VREF and MINSP to adjust the rotational speed curve.

1. Use only the lowest rotational speed scenario

In the scenario of only using the lowest rotational speed, R3 is suspended without welding, and the sum of resistance (R5 + R4) must be greater than 100kΩ. It is recommended to fix R4 at 100kΩ, unless R5 can be modified as appropriate when the standard resistance value cannot be selected.

CC6421 can be configured with external resistors R5 and R4. The chip determines the minimum rotational speed of the fan by sampling the voltage on the 7-pin (MINSP). The lower the voltage on the 7-pin, the smaller the minimum speed; vice versa.

When R5 is open circuit, the voltage on MINSP is 0V, and there is no function of minimum rotational speed; when R5 is short circuited, the voltage on MINSP is 2.5V, and the fan will always operate at full speed and is not controlled by

PWM signal.

The minimum rotational speed configuration accuracy is 32level, that is, the setting resolution of the minimum rotational speed is about 0%, 3%, 6% Scenarios where only the speed slope is used.

2. Use only speed slope scenarios

By setting the load resistance R3 on the VREF Pin, the output current of the reference can be changed. The current mirror source of the internal 1:1 will generate a voltage on the base resistance. This voltage will be compared with the four internal reference voltages REF1 ~ 4, and will output 4 digital signals of the slope of the speed. (Table 1)

$R_{VREF} (K\Omega)$	$I_{REF} (\mu A)$	PWM DCin while RPM=0
$\infty \sim 14.7 K\Omega$	0 ~ 170	0%
14.7 KΩ ~ 6.46 KΩ	170 ~ 387	10%
6.46 KΩ ~ 3.04 KΩ	387 ~ 820	20%
3.04 KΩ ~ 0.82 KΩ	820 ~ 3000	30%

Table 1

By setting different load resistance, the rotational speed of low PWM input can be lower, which can meet the requirements of different rotational speed curves.

3. Scenarios where the minimum rotational speed and rotational speed slope are used simultaneously

The rotational speed curve in Figure 5 is an example. For a specific rotational speed curve, the requirements are as follows:

- 1) The maximum speed is 3000rpm,
- 2) When the duty cycle is 60%, the speed is required to be below 2000 rpm,
- 3) When the duty cycle is 40%, the speed is required to reach 1000 rpm.

At this time, in order to meet the requirements of condition II, we must select [curve d], set the PWM duty cycle at starting speed to 30%, and select R3 = 2.2k. However, when the duty cycle is 40%, the rotational speed is lower than 1000 rpm, and the minimum rotational speed needs to be set to 33%. R4 is fixed at 100k and R5 is about 200k.

Application information

Note: the minimum rotational speed is only positively related to the voltage of 7-pin MINSP, not in proportion. It is often necessary to readjust the resistance value of R5 according to the actual rotational speed.

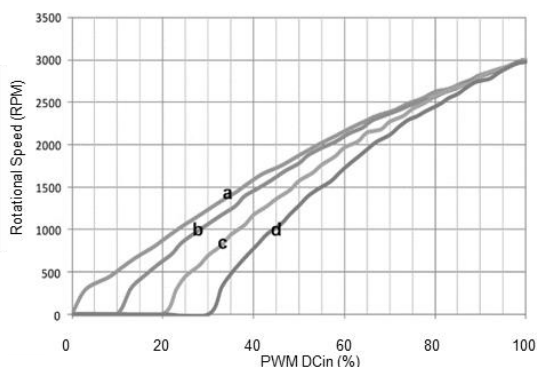


Figure 5

Analog-regulating speed

CC6421 can not only recognize digital speed regulation through PWM Pin, but also analog speed regulation through voltage on MINSP Pin. The effective voltage range is 0-2.5V. (Figure 6)

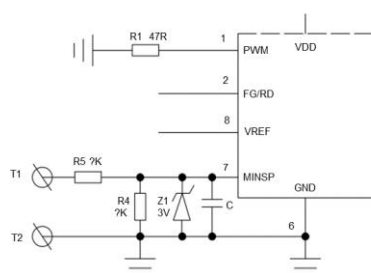


Figure 6

When PWM is forced to the ground, the fan speed is only controlled by the voltage on the 7-pin (MINSP).

When using the MINSP function, it is recommended to increase the capacitance. When the MINSP function is not used, grounding is recommended. When the speed regulating voltage range is 0 ~ 2.5V, R4 is suspended. When the voltage range of the speed regulation exceeds 2.5V, the voltage must be attenuated to the maximum voltage range that the 7-pin can bear through R5 and R4, and some design redundancy should be reserved. When the starting voltage is not 0V in the speed regulating voltage range, such as 1-5V, a suitable diode or

voltage stabilizing diode is connected in series between T1 and R5 to reduce the voltage. Then, the ratio of R5 to R4 is set, and the maximum value of partial voltage is set at 2.5V.

Start-up & Restart of Locked-rotor Characteristics

CC6421 has intelligent soft start function. Soft start can eliminate the peak current during motor starting and improve the system reliability. In the start-up state, the duty cycle of the output signal increases from 25% to 50% by 5% every 100ms. the maximum starting time is 0.5 s. in this stage, it is not controlled by external PWM and MINSP voltage.

During the start-up state, CC6421 detects the magnetic field strength of the environment and makes adaptive gain adjustment. When the start-up cycle is over, the rotation speed detection circuit will detect whether the fan reaches the specified speed; if the threshold is reached, it will enter the sine wave working state after the adaptive adjustment is completed. If the speed is not reached, restart again until the speed reaches the threshold to ensure the reliable start of the fan.

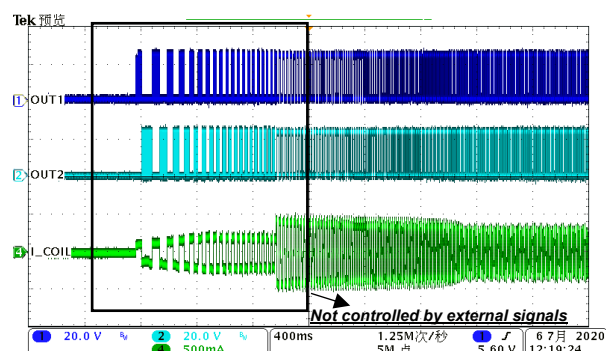
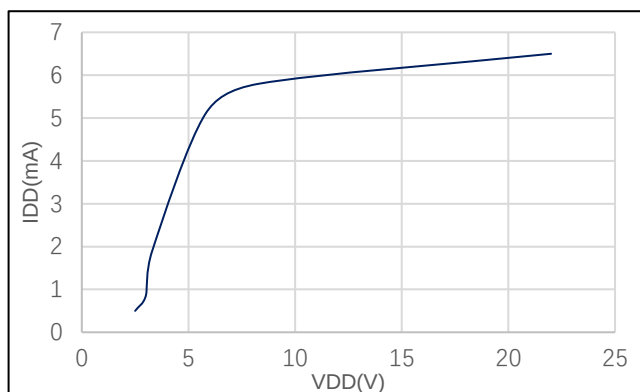
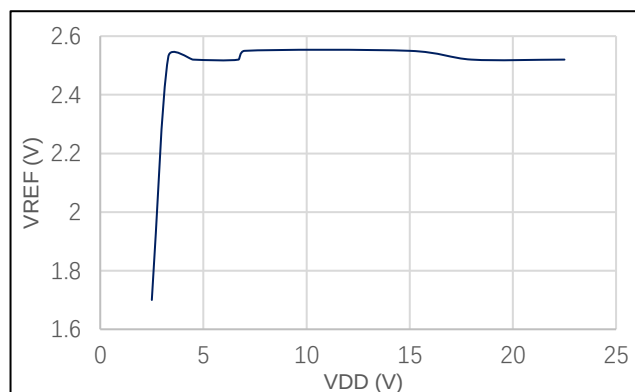


Figure 7 Output voltage & coil current wave at startup

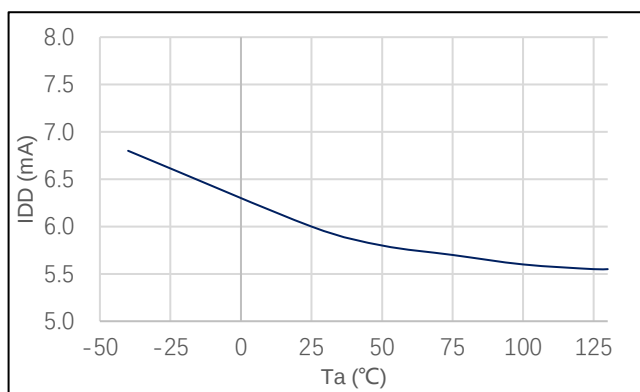
Curve & waveform



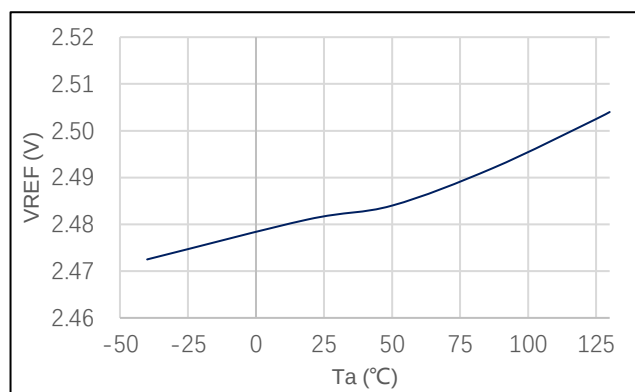
IDD (mA) vs. VDD (V)



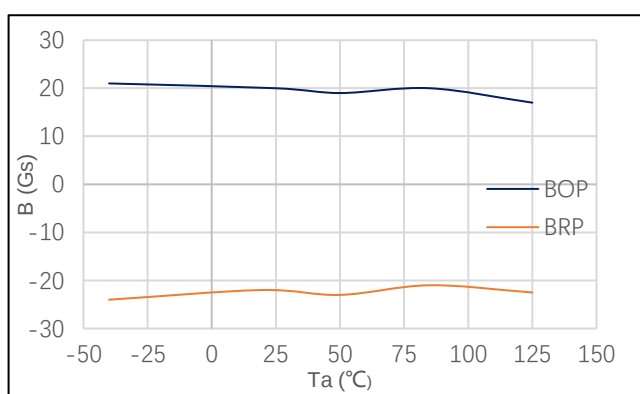
VREF (V) vs. VDD (V)



IDD (mA) vs. Ta (°C)

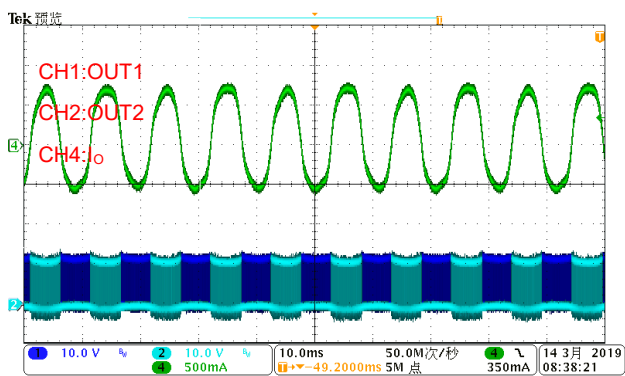


VREF (V) vs. Ta (°C)

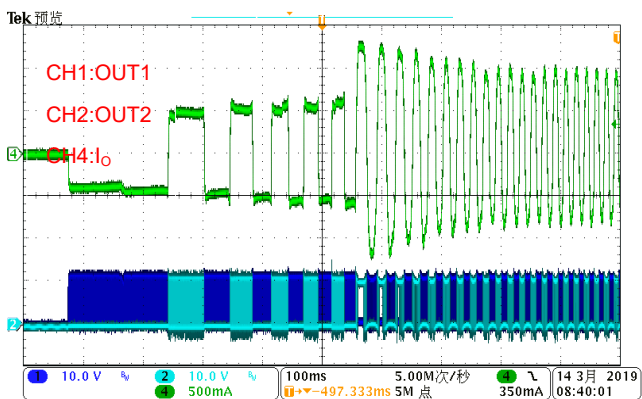


B (Gs) vs. Ta (°C)

Curve & waveform



Output sine current wave & voltage wave



Soft start output current & voltage

Power Dissipation & Maximum Output Current

The power dissipation is determined by the following equation (Note: K is the recommended coefficient):

$$P_{D(MAX)} = (T_J - T_A) / \theta_J \times K$$

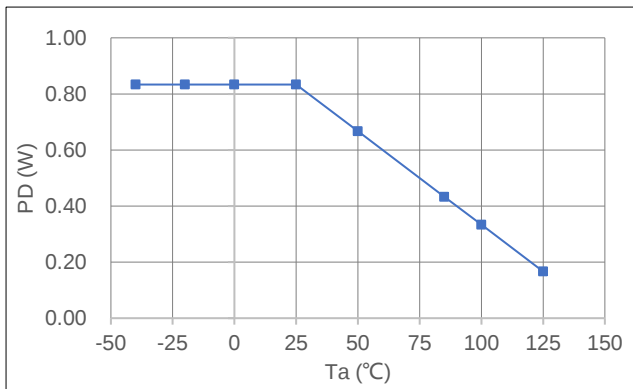
While normal operation, the power dissipated in CC6421:

$$P = I_{CONT}^2 \times R_{DS(ON)} + V_{DD} \times I_{DD}$$

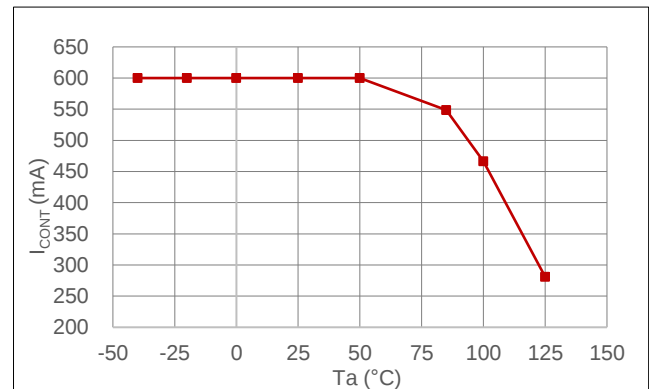
The maximum output current I_{MAX} :

$$I_{MAX} = \sqrt{(P_{D(MAX)} - V_{DD} \times I_{DD}) / R_{DS(ON)}}$$

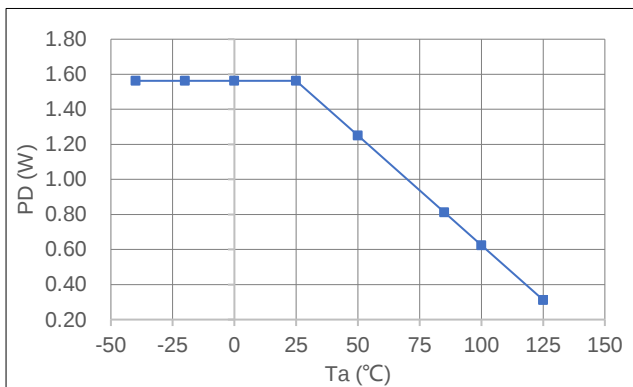
The PD curve and the output current curve



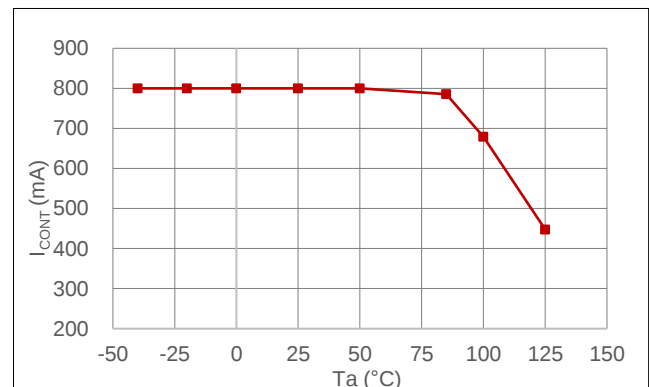
$P_{D(MAX)}$ vs. Temp. (SOP8)



$I_{CONT(MAX)}$ vs. Temp. (SOP8)



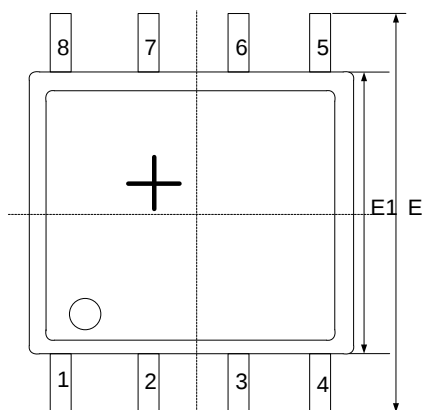
$P_{D(MAX)}$ vs. Temp. (DFN8)



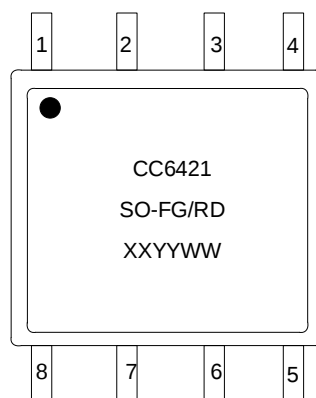
$I_{CONT(MAX)}$ vs. Temp. (DFN8)

Package Information

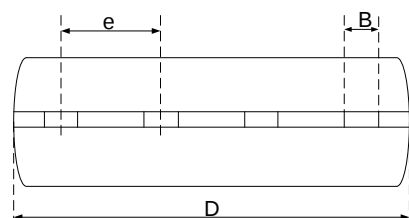
1) SOP8



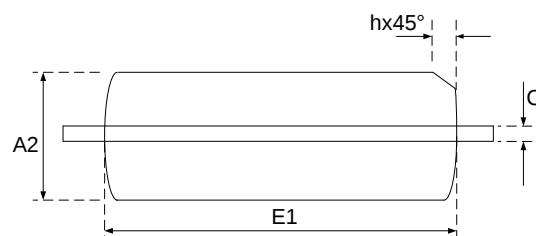
TOP VIEW



BOTTOM VIEW

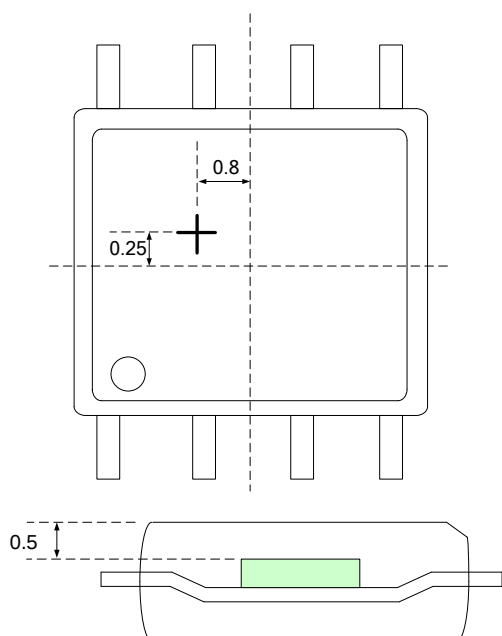


SIDE VIEW



END VIEW

HALL PLATE POSITION



BOTTOM

SYMBOL	DIMENSION (millimeter)		
	MIN	TYP	MAX
A2	1.4	-	1.6
B	0.35	0.4	0.49
c	0.20	0.25	0.30
D	4.8	4.93	5.0
E1	3.80	3.94	4.00
e	1.27BSC		
E	5.84	6.00	6.20
h	0.25	0.33	0.41

Note:

1. All dimensions are millimeters

Marking:

1'st line: CC6421 – product name

2'nd line: SO-FG/RD -- Type

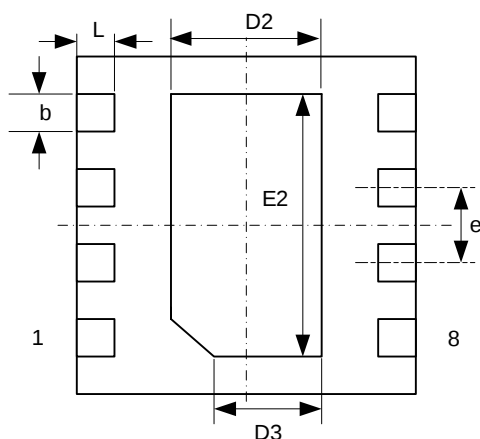
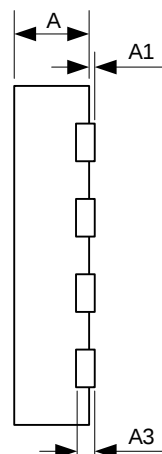
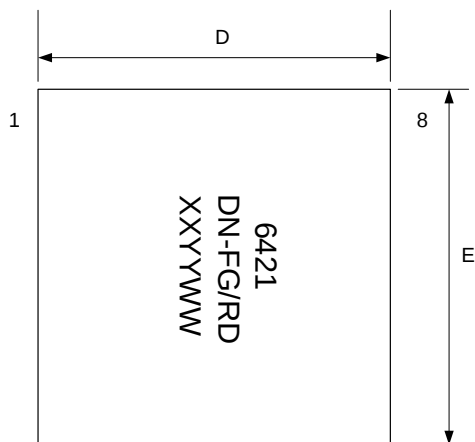
3'rd line: XXYYWW

XX – code

YY – last 2 digits of year

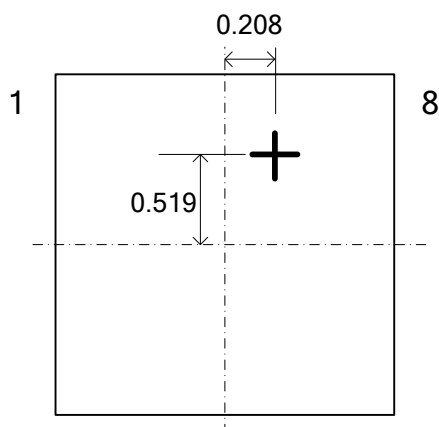
WW – week

2) DFN8 3*3



SYMBOL	DIMENSION (millimeter)		
	MIN	TYP	MAX
A	0.70	0.75	0.80
A1	-	-	0.05
A3	0.203 REF		
b	0.23	0.28	0.33
D	2.90	3.00	3.10
E	2.90	3.00	3.10
D2	1.40	1.50	1.60
D3	-	1.15	-
E2	2.20	2.30	2.40
e	0.65 TYP		
L	0.25	0.30	0.35

HALL PLATE POSITION



Note:

1. All dimensions are millimeters

Marking:

1'st line: CC6421 – product name

2'nd line: SO-FG/RD -- Type

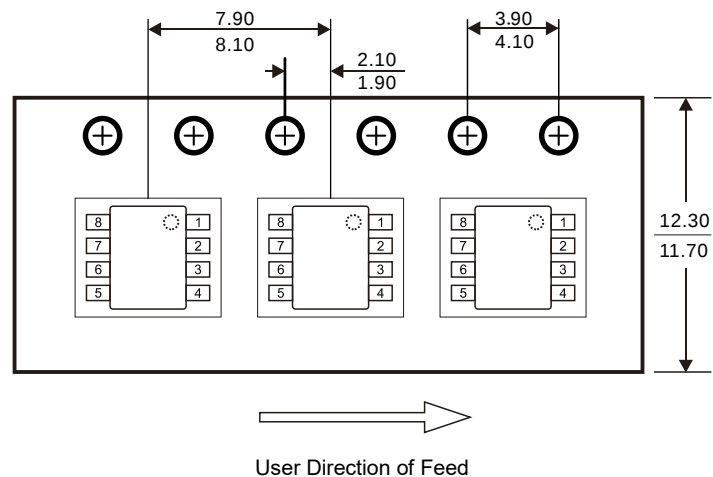
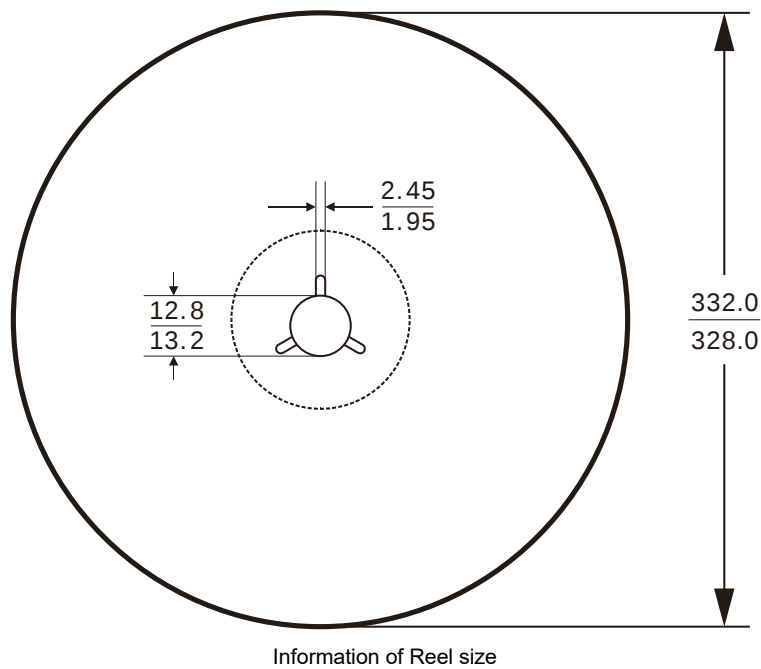
3'rd line: XXXYYWW

XX – code

YY – last 2 digits of year

WW – week

Packaging & Tape reel



Note: The space between the front and back of each tape is 50 ± 2 grids

CrossChip

CrossChip Microsystems Inc. was founded in 2013, is a high-tech enterprise, engaged in integrated circuit design and sales. The company has strong technical strength, has more than 40 patents, mainly used in Hall sensor signal processing, with the following product lines:

- ✓ High precision linear Hall sensor
- ✓ All kinds of Hall switches
- ✓ Single phase motor drive
- ✓ Single chip current sensor
- ✓ AMR Magnetoresistance sensor

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