Highly Efficient Single-Phase Full-wave FAN Motor Driver

Overview

The FA1220 is a highly efficient Single-Phase Brushless DC FAN motor driver with direct PWM speed control. Many safety features were incorporated to ensure the reliability of motor operation.

The FA1220 is designed with minimal external components to improve reliability.

Package

HTSSOP14

TSSOP20

Application

Variable speed BLDC fan for CPU/VGA cooler, power supplier, game console, etc.

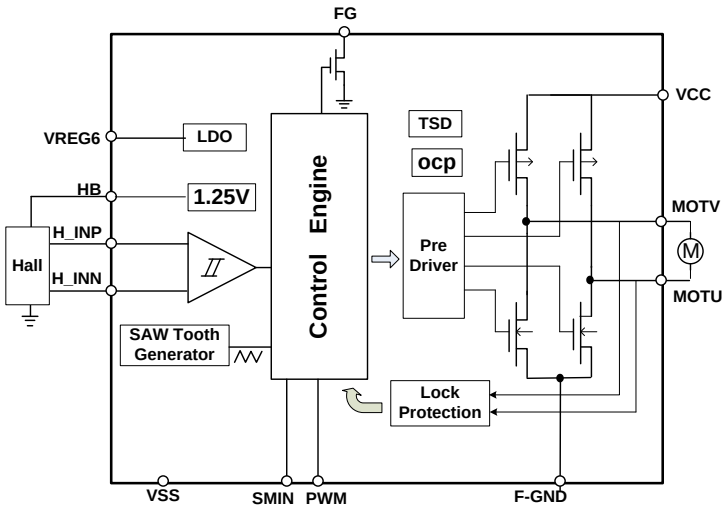
Feature

- Speed Control with direct PWM input
- Soft-Start circuit
- FG output signal
- Built-in Hall bias circuit
- Minimum speed setting
- Soft switch for quiet drive
- Advanced CMOS process and low Rds
- Built-in triangular wave generator, No capacitor need
- Built-in lock protection and automatic recovery circuit, No capacitor need
- Built-in thermal shutdown protection(TSD)
- Built-in over current protection(OCP)
- Built-in under voltage lock out (UVLO)

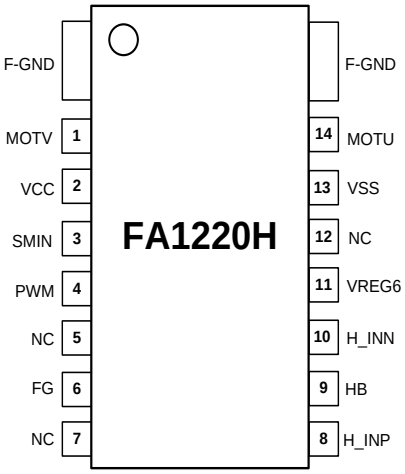
Ordering information

Name	Package	Model Order
FA1220H	HTSSOP14	FA1220H-T(Tube)
		FA1220H-R(Reel)
FA1220T	TSSOP20	FA1220T-T(Tube)
		FA1220T-R(Reel)

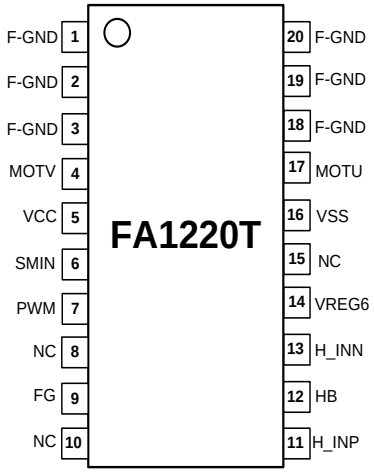
Block Diagram



Pin Configuration (Top view)



HTSSOP14



TSSOP20

Pin Description

FA1220H	FA1220T	PIN Name	Type	Description
PIN NO.	PIN NO.			
1	4	MOTV	O	Motor output
2	5	VCC	Power	Power supply
3	6	SMIN	I	Minimum speed setting
4	7	PWM	I	Direct PWM for speed control
5	8	NC		Not connected
6	9	FG	O	Frequency generator
7	10	NC		Not connected
8	11	H_INP	I	Hall Sensor input, IN+
9	12	HB	O	Hall bias voltage
10	13	H_INN	I	Hall Sensor input, IN-
11	14	VREG6	O	LDO 6V output
12	15	NC		Not connected
13	16	VSS	GND	Control signal ground
14	17	MOTU	O	Motor output
F-GND	1,2,3, 18,19,20	F-GND	O	POWER MOS GND

1. VSS: Control signal ground.
2. F-GND: Power ground and thermal dissipation pad, this pin must be connected together with VSS and ground on board.

Truth Table

PWM	H_INN	H_INP	MOTU	MOTV	FG	Mode
High	H	L	H	L	OFF	Rotation-driver
	L	H	L	H	L	
Low	H	L	OFF	L	OFF	Rotation-regeneration
	L	H	L	OFF	L	
-	H	L	-	-	L	Lock protection
-	L	H	-	-	L	

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable about the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress rating only.

Parameter	Symbol	Condition	Ratings	Unit
Power supply voltage	V_{CC} max		30	V
Output current	I_{OUT} max	Peak current	1.2	A
Logic input pin withstand voltage	V_{logic} max		6.5	V
FG output pin withstand voltage	V_{FG} max		30	V
FG output current	I_{FG} max		10	mA
Power dissipation	Pd max*		1.1	W
Operating temperature	Topr		-40~+90	℃
Storage temperature	Tstg		-55~+150	℃

* Mounted circuit board: 70x70x1.6 mm^3glass epoxy board.

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fortior does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{CC}	Power supply voltage	4.5		28	V
TA	Operating Ambient Temperature	-40		90	℃

Electrical Characteristics(Unless otherwise specified, Ta = 25℃, V_{CC} = 12 V)

Parameter	Symbol	Condition	Ratings			Unit
			Min.	Typ.	Max.	
Power supply current	I_{CC}	Working	-	5	8	mA
Output Block						
Source	Ron (H)	I_O = 0.5A	-	0.7	1.2	Ω
Sink	Ron (L)	I_O = 0.5A	-	0.5	0.8	Ω
Source + sink	Ron (H+L)	I_O = 0.5A	-	1.2	2	Ω
6V Regulator Block						
Regulator voltage	VREG6		5.7	6	6.3	V
Regulator output current	Iv6out(1)	VREG6=6V			10	mA
HB Voltage						
HB voltage	HB	I HB=5mA		1.25		V
Hall input pin						
Hall sensor input sensitivity	VHN	Zero peak value (including offset and hysteresis)		10	20	mV
Analog I/O Section						
Analog Input range			0		6.3	V
PWM						
PWM PIN Frequency	PWM		21K	25K	28K	Hz
SMIN Block						
VPWM High Level Voltage	VPWMH		3.48	3.66	3.84	V
VPWM Low Level Voltage	VPWML		1.71	1.8	1.89	V
FG Output Pin						
FG output pin low-level voltage	VFG	When I_O = 5mA	-	0.1	0.2	V
Thermal Protection Circuit						
Thermal protection circuit operating temperature	TSD	Design target	-	170	-	℃
Temperature hysteresis width	ΔTSD	Design target	-	15	-	℃
Low-Voltage Detection						
Low voltage detection voltage	UVLO			3.5		V

1. This current is output of internal LDO. Please do not exceed the maximum value specified.

Operating and Function Description

1. Speed Control Mode

When the system needs speed control, the FA1220 uses PWM pin by adjusting its duty cycle to controlling the speed.

a. Full Speed Mode

When the duty cycle of PWM is 100%, motor fan will be driven at full speed.

b. Variable Speed Mode

In variable speed mode, the duty cycle of PWM is set to higher than the minimum duty cycle, the minimum duty cycle controlled by SMIN pin and determined by the equation:

$$Minimum\_duty\_cycle = \frac{0.305 * VCC - V_{SMIN}}{(0.305 - 0.15) * \mathrm{VCC}}$$

The duty cycle of PWM increases and the motor fan speed increases consequently.

c. Minimum Speed Mode

In this mode, the duty cycle of PWM is set to lower than the minimum duty cycle, the fan rotates at the lowest speed which is set using SMIN .

Note: SMIN can only be used in 12V application;

2. Lock Protection and Automatic Recovery

When the rotor is blocked, the internal detection circuit will shut down output driver, and then the automatic recovery circuit will try to restart motor in soft-start mode until the blockage is removed. The typical timing diagram is shown as in figure1. Ton is lock detection ON time, Toff is lock detection OFF time. Once the rotor is blocked, the controller will restart the motor with 4 seconds interval and improve system reliability.

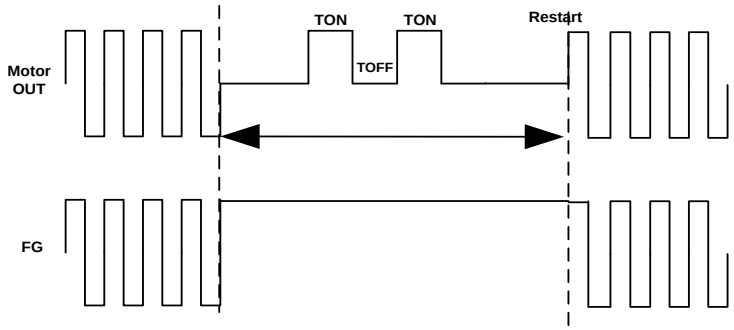


Figure1. Lock protection and automatic recovery time sequence diagram

3. Over Current Protection (OCP)

The over current protection circuit safeguards the internal FETs by monitoring the peak current. Once the current exceeds the over current protection limit, drive will be turned off and then the controller will restart the motor with 4 seconds interval.

4. Under Voltage Lockout (UVLO)

If the voltage on the VREG6 pins falls below 3.5V, all internal circuitry will be disabled and logic will be reset.

5. Thermal Shutdown (TSD)

When the junction temperature of the device reaches the thermal shutdown limit(2) (the thermal shutdown value is shown in Electrical Characteristics table), PWM drive output will be turned off. When the junction temperature cools to the required level, the PWM initiates normal start-up cycle. Thermal shutdown has a hysteresis of approximately 15°C.

6. Soft Switch

Soft Switching function can reduce motor electromagnetic noise by reducing motor commutation torque ripple. The reduction of torque ripple is achieved by changing the motor current smoothly while keeping the current continuous.

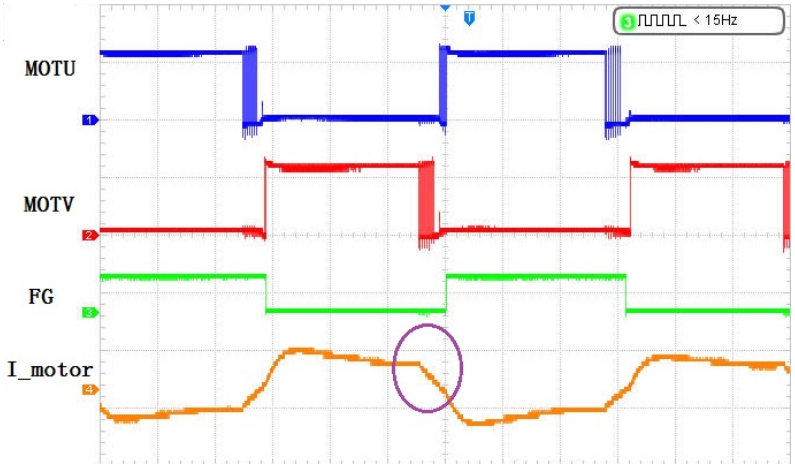


Figure2. The waveform with soft switch function

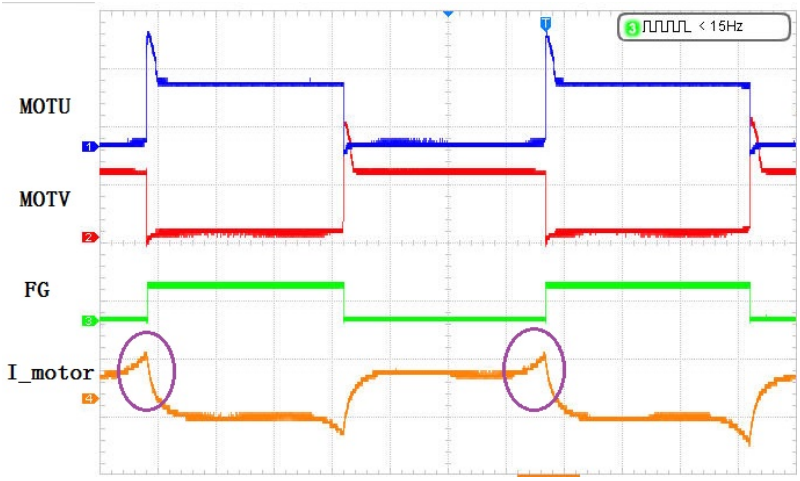


Figure3. The waveform without soft switch function

Figure 2 is the waveform with soft switching function, and figure 3 is the waveform without soft switching function. It can be seen that the motor current of Figure 2 changes smoother in comparison to that in Figure3. And experimentally, motor electromagnetic noise of Figure 2 is measured to be lower than Figure 3.

12V Application Circuit

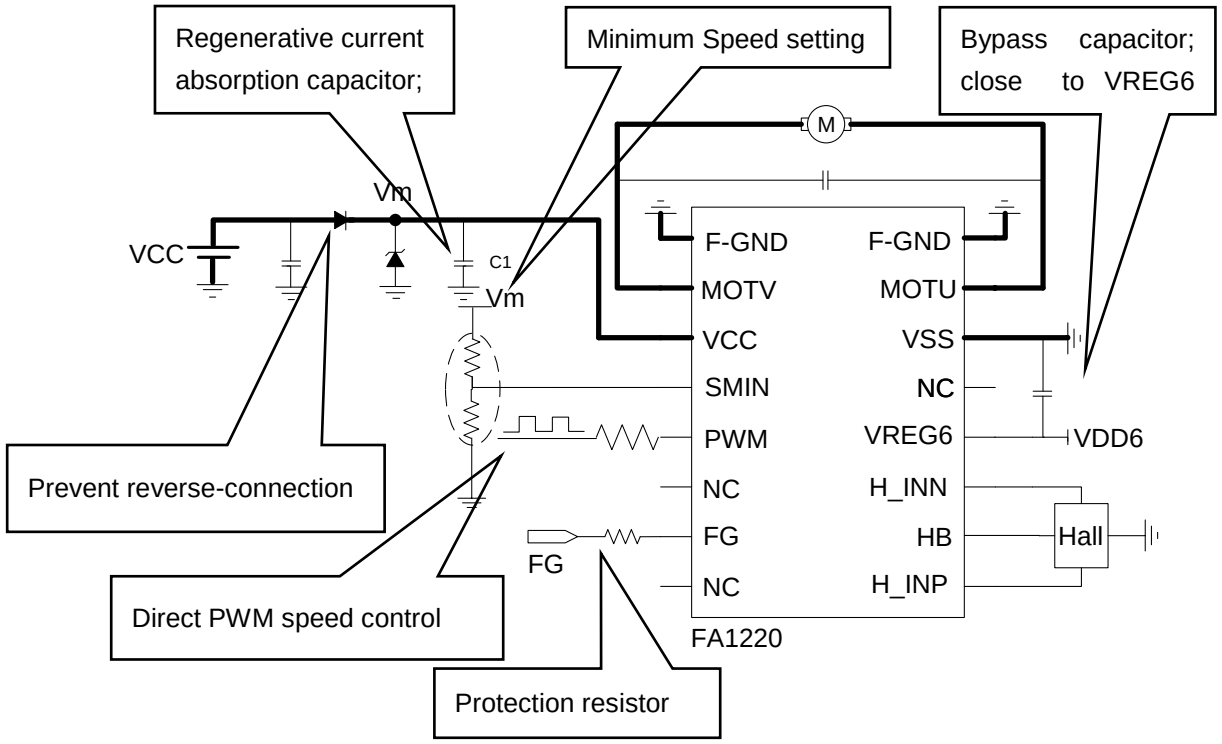


Figure4. 12V application circuit of FA1220

24V Application Circuit

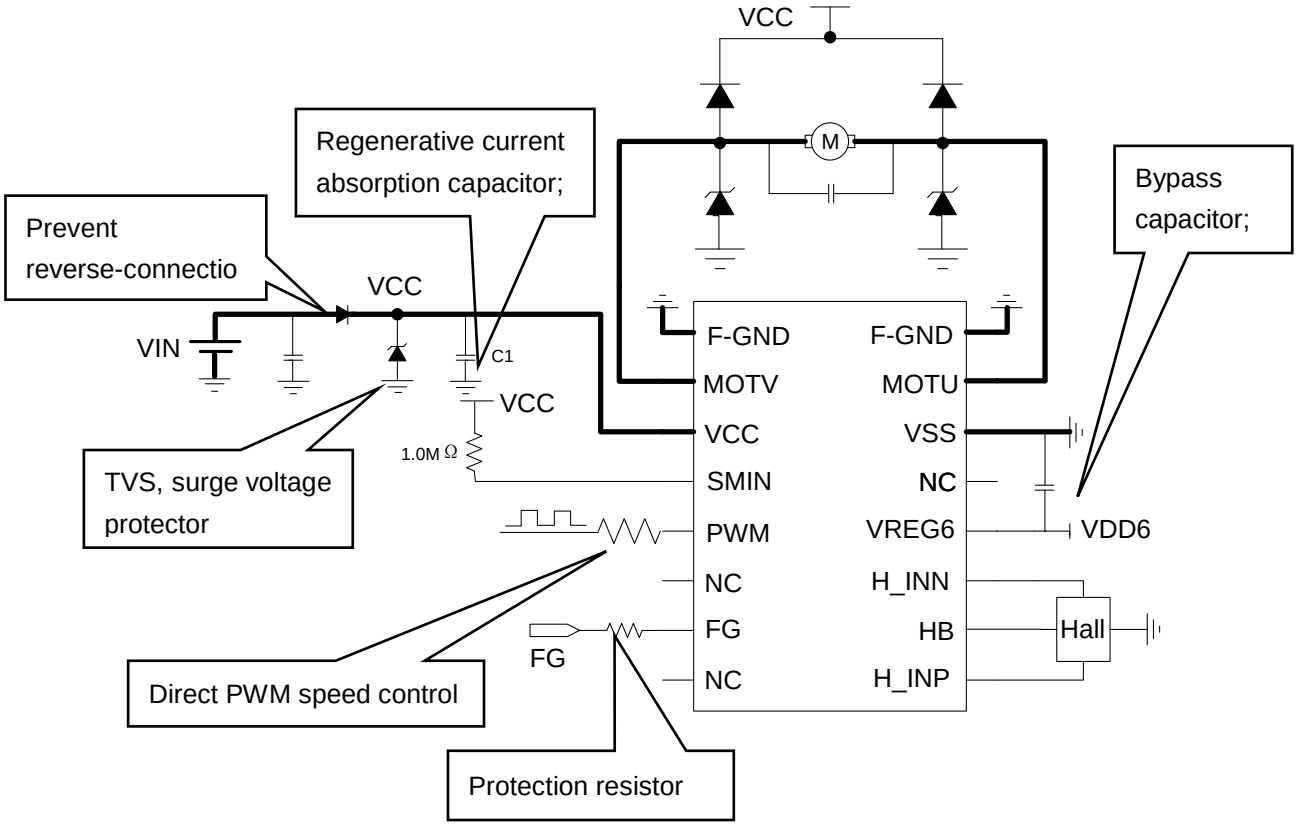


Figure4. 24V application circuit of FA1220

Application notes:

1. Power and ground lines

F-GND and VSS should be connected together on board.

2. Power supply bypass capacitor & TVS zener diodes

The capacitor C1on VCC provides power supply stabilization for both PWM drive and kickback absorption. When a diode is used to prevent destruction of controller IC from reverse connection, please make sure to add capacitor C1 for routing of regenerative current, In order to protect surge voltage damage, please insert a TVS zener diode between GND and VCC.

3. Hall input

The Hall sensor input circuit consists of a comparator with hysteresis of 20mV. Hall sensor input level with at least three times of this hysteresis, i.e. at least 60mVp-p is recommended.

4. FG output

This is an open collector output, the pin must be left open if unused. FG output is used to reflect rotation count, which corresponds to the phase switching. When lock protection , it will be zero all the time.

5. HB pin

This pin provides constant-voltage output of 1.25V for hall effect sensor biasing.

6. SMIN pin

This pin is used to set minimum speed by adjusting external resistors.

SMIM can only be used in 12V application. If 24V application, please connect 1M ohm resistor to VCC.

7. Motor capacitor

Insert a capacitor between the MOTU and MOTV pin if the noise is a problem.

8. Motor terminal schottky diode

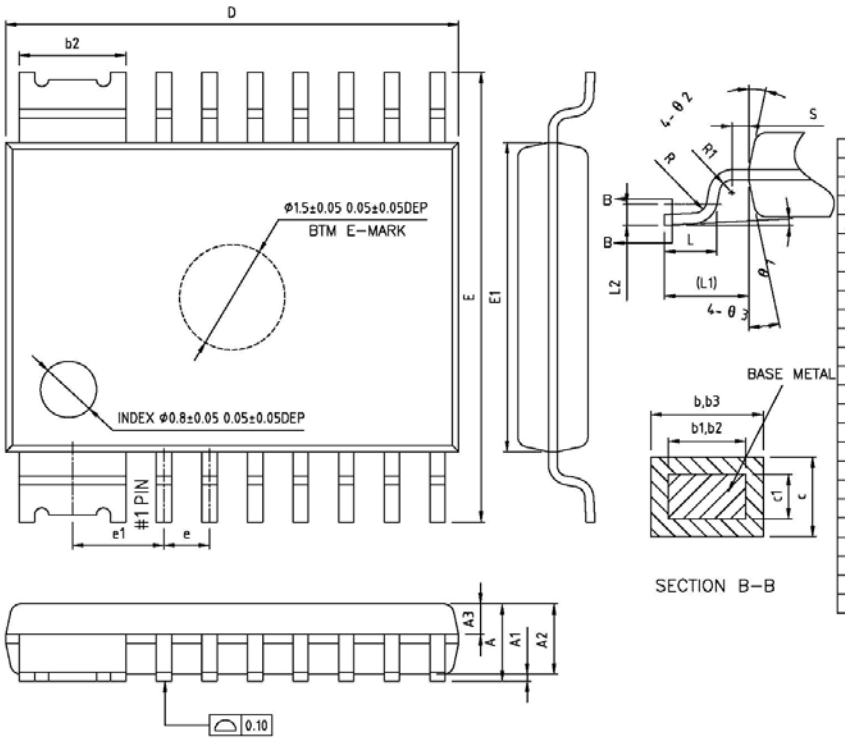
Please insert schottky diode between the motor terminal and VCC for bigger current.

9. Motor terminal zener diode

Please insert zener diode between the motor terminal and VSS for routing of regenerative current

Package Information

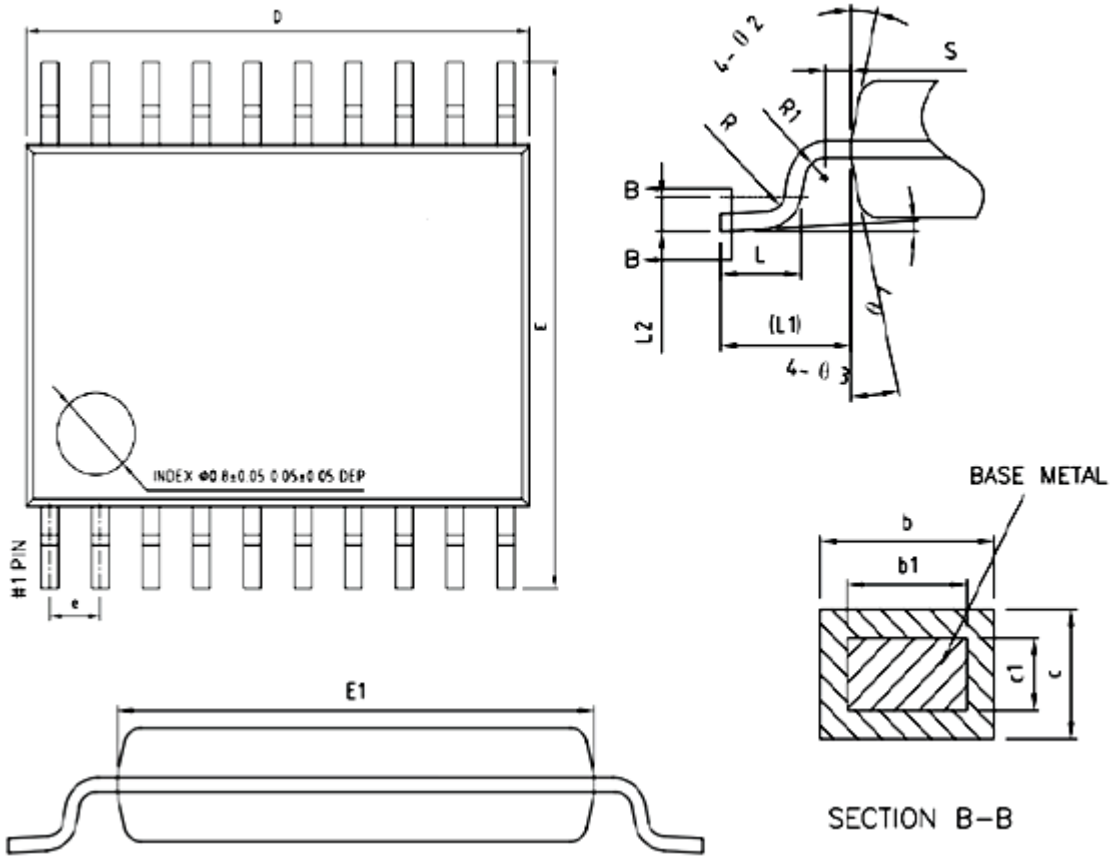
HTSSOP14



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	–	–	1.20
A1	0.05	–	0.20
A2	0.90	1.00	1.05
A3	0.34	0.44	0.54
b	0.20	–	0.28
b1	0.20	0.22	0.24
b2	1.47	1.52	1.57
b3	1.48	–	1.61
c	0.10	–	0.19
c1	0.10	0.13	0.15
D	6.35	6.45	6.55
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65BSC		
e1	1.30BSC		
L	0.45	0.60	0.75
L1	1.00REF		
L2	0.25BSC		
R	0.09	–	–
R1	0.09	–	–
S	0.20	–	–
θ1	0°	–	8°
θ2	10°	12°	14°
θ3	10°	12°	14°

TSSOP-20



	MIN	NOM	MAX
A	—	—	1.20
A1	0.05	—	0.15
A2	0.80	1.00	1.05
b	0.19	—	0.30
b1	0.19	0.22	0.25
c	0.09	—	0.20
c1	0.09	—	0.16
D	6.40	6.50	6.60
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65BSC		
L	0.45	0.60	0.75
L1	1.00BSC		

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