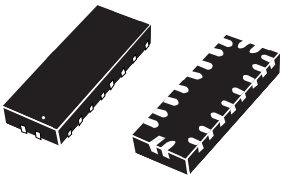
STP4CMP

Low voltage 4-channel constant current LED driver with charge pump

Datasheet - production data



QFN20 (1.8x3.2 mm)

Features

- Operating voltage range: V_{CC} 2.7 V to 5.5 V
- Full RGB function support
- 4-channel LED driver with individual ON/OFF control directly from input pins
- Individually programmable output current for the 4 channels through 4 external resistors with a max. capability of 30 mA
- Absolute output current accuracy of max. ±7% and channel-to-channel mismatch of max. ±4%
- Selectable charge pump enable/disable
- Thermal protection
- Small QFN20 (1.8x3.2 mm) package

Applications

- Mobile phone display backlighting
- RGB LED indicator driver

Description

The STP4CMP is a charge-pump-based 4-channel LED driver designed for RGB illumination or LCD display backlighting. The STP4CMP works off a battery with an input voltage between 2.7 V and 5.5 V. The device generates regulated current sinks with high absolute and channel-to-channel accuracy to drive up to 4 LEDs. It can support LEDs with forward voltage as high as 3.8 V. The current sink for each channel can be set with 4 individual external resistors. Each channel is controlled independently. The PWM control can be applied directly to the 4 EN (enable) pins to provide brightness control. When enabled, the charge pump, which uses a small ceramic bucket capacitor between C_{1P} and C_{1N}, operates to regulate the V_{OUT} with a clamping voltage at typ. 5 V. The tiny QFN20 (1.8x3.2 mm) package allows the device to be also used for applications with space limitations.

Table 1: Device summary

Oder code	Package	Packing
STP4CMPQTR	QFN20 (1.8x3.2 mm)	Tape and reel

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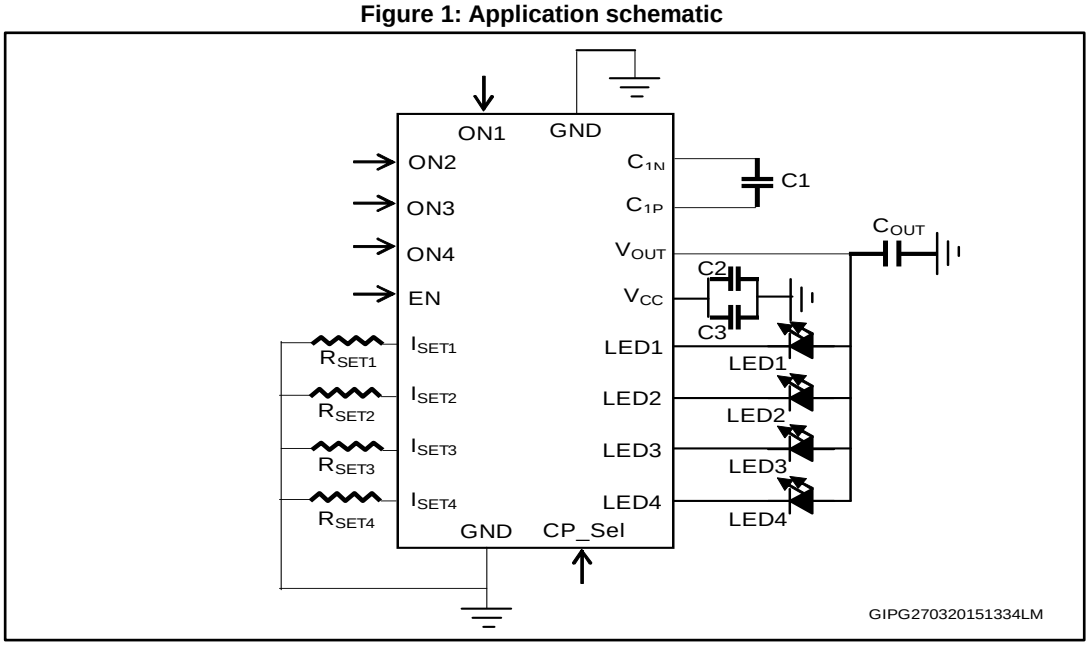
1 Application schematic

Figure 1: Application schematic



The above figure shows the typical application diagram with the external components. To ensure an optimal charge pump performance, it is highly recommended that the bucket capacitor, C1, and the output capacitor, C_{OUT}, to be placed as close as possible to the pins.

Table 2: Typical external components

Component	Manufacturer	Part number	Value	Size
C_1,C_{OUT}	Murata	GRM155R61A105KE15D	1 µF/10 V	0402
	TDK	C1005X5R1A105MT		
C2	Murata	GRM188R60J106ME84	10 µF/6.3 V	0603
	TDK	C1608X5R0J106MT		
C3	Murata	GRM155R60J104KA01D	100 nF	0402
	TDK	C1005X5R1C104KT		
R_{SET1-4} (1)	Tyco	CPF0402B976RE1	976 Ω	0402
LED1-4 (2)				

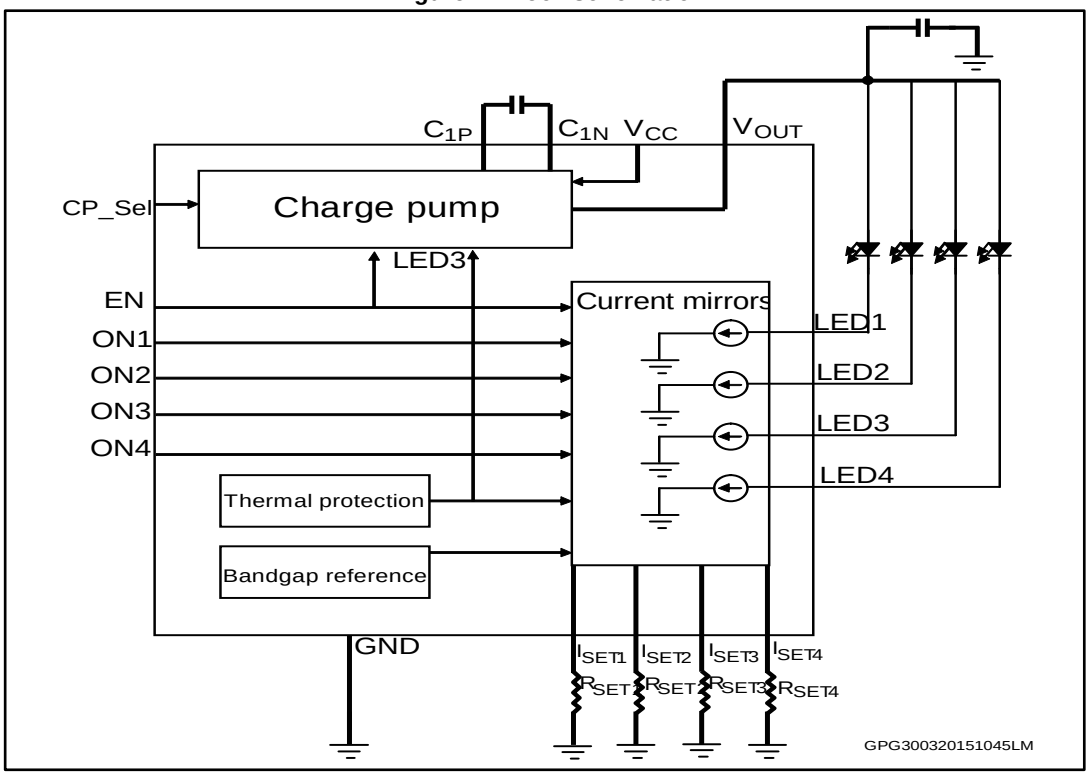
Notes:

(1)649 Ω to 7.87 kΩ according to the desired output current from each channel.

(2)Forward voltage typ. 3.8 V.

All the above components refer to a typical application. Operation of the device is not limited to the choice of these external components.

Figure 2: Block schematic



2 Pin configuration

Figure 3: Pin connections (top view)

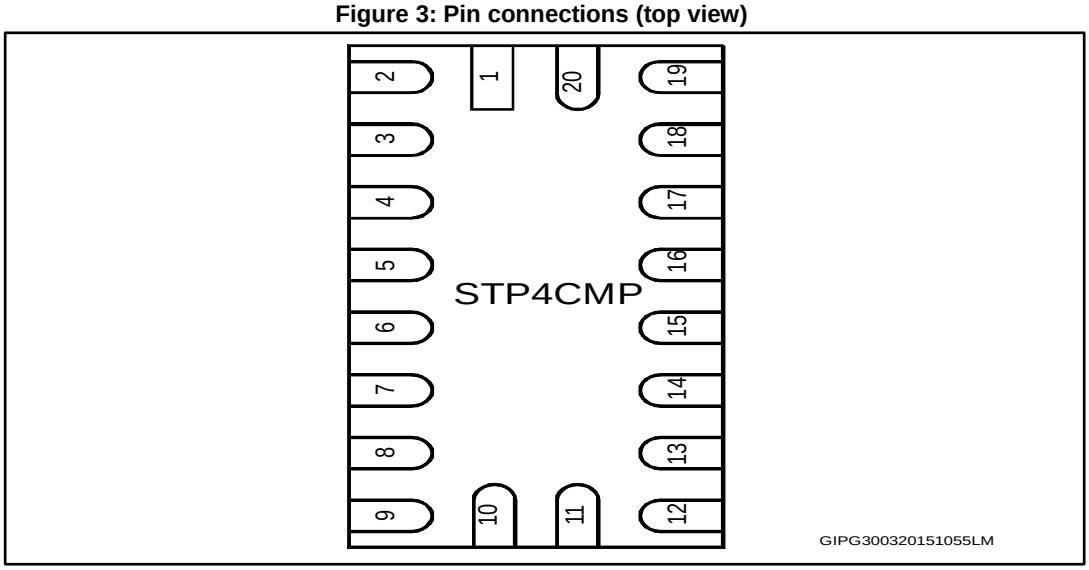


Table 3: Pin description

Pin	Symbol	Description
1	ON1	LED1 enable
2	ON2	LED2 enable
3	ON3	LED3 enable
4	ON4	LED4 enable
5	EN	Chip enable
6	I_{SET1}	LED1 max. current setting resistor
7	I_{SET2}	LED2 max. current setting resistor
8	I_{SET3}	LED3 max. current setting resistor
9	I_{SET4}	LED4 max. current setting resistor
10	GND	Ground
11	CP_SEL	Charge pump mode selection, 1 = enable 0 = disable
12	LED4	4^{th} LED current sink
13	LED3	3^{rd} LED current sink
14	LED2	2^{nd} LED current sink
15	LED1	1^{st} LED current sink
16	V_{CC}	Supply voltage
17	V_{OUT}	Charge pump output
18	C_{1P}	Positive terminal of charge pump bucket capacitor
19	C_{1N}	Negative terminal of charge pump bucket capacitor
20	GND	Ground

3 Maximum ratings

Table 4: Absolute maximum ratings

Symbol	Parameter	Value	Unit
ON_{1-4}, V_{CC}, EN, CP_SEL, C_{1P}, C_{1N}	Supply voltage	- 0.3 to + 6.0	V
VOUT	Output voltage	- 0.3 to + 6.0	V
LED1-4, I_{SET1-4}	Current setting	-0.3 to 2	V
ESD	Human body model	±1500	V
	Charged device model	±500	
	Machine model	±200	
T_{AMB}	Operating ambient temperature	- 30 to 85	°C
T_J	Maximum operating junction temperature	+150	°C
T_{STG}	Storage temperature	-65 to 150	°C

Table 5: Recommended operating conditions

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{CC}	Supply voltage	2.7		5.5	V
T_{op}	Operating temperature	-40		85	°C
I_{LED}	Current through each LED	2.5		30	mA
$T_{pwm_}$ON	ON time of PWM signal at each ON pin	33			µs
$T_{pwm_}$OFF	OFF time of PWM signal at each ON pin				
V_{fw}	LED forward voltage			3.8	V

Table 6: Thermal data

Symbol	Parameter	Value	Unit
R_{thJA} (1)	Thermal resistance junction-ambient	70	°C/W

Notes:

(1)This parameter corresponds to the PCB board, 4-layer with 1 $inch^2$ of cooling area.

4 Electrical characteristics

V_{CC} = 3.3 V, V_{EN} = V_{ON1} = V_{ON2} = V_{ON3} = V_{ON4} = V_{CC}, V_{CP_SEL} = V_{CC}, R_{SET1} = R_{SET2} = R_{SET3} = R_{SET4} = 649 Ω, C_1 = 1 µF, typical values are at T_A = 25 °C unless otherwise specified.

Table 7: Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{CC}	Supply voltage		2.7		5.5	V
V_{cp_clamp}	Charge pump clamp voltage	2.7 V ≤ V_{CC} < 3.1 V; V_{CP_SEL} = V_{CC}; I_{OUT} ≤ 40 mA		5		V
		V_{CC} > 3.1 V; V_{CP_SEL} = V_{CC}; I_{OUT} ≤ 120 mA		5		
T_{cp_start}	Charge pump start-up time	From CP_SEL low to high transition to CP reaches steady-state 5 V			10	ms
$I_{LED1,2,3,4}$	LED sink current for each channel	R_{setx} = 649 Ω at V_{LEDx}= 0.9 V; V_{CC} > 3.1 V	27.9	30	32.1	mA
		R_{setx} = 7.87 kΩ at V_{LEDx}= 0.9 V; V_{CC} ≥ 3.1 V	2.33	2.5	2.68	mA
ΔI_{LED}	Output current error between each channel	R_{SET1} = R_{SET2}, R_{SET3} = R_{SET4}, T_A = 25 °C		±1	±4	%
V_{IH}	High level input voltage		2.0			V
V_{IL}	Low level input voltage				0.8	
I_{CC}	Supply operating current	V_{ON1} = V_{ON2} = V_{ON3} = V_{ON4} = GND; no-load; V_{CC} = 5.5 V (charge pump disabled); V_{CP_SEL} = GND, R_{SET1} = R_{SET2} = R_{SET3} = R_{SET4} = 7.87 kΩ		3.6		mA
		V_{ON1} = V_{ON2} = V_{ON3} = V_{ON4} = GND; no-load; V_{CC} = 5.5 V (charge pump disabled); V_{CP_SEL} = GND, R_{SET1} = R_{SET2} = R_{SET3} = R_{SET4}= 649 Ω		1.7		
		V_{ON1} = V_{ON2} = V_{ON3} = V_{ON4} = GND; no-load; V_{CC} = 3.3 V (charge pump enabled); V_{CP_SEL} = V_{CC}, R_{SET1} = R_{SET2} = R_{SET3} = R_{SET4}= 7.87 kΩ		4.5		
		V_{ON1} = V_{ON2} = V_{ON3} = V_{ON4} = GND; no-load; V_{CC} = 3.3 V (charge pump enabled); V_{CP_SEL} = V_{CC}, R_{SET1} = R_{SET2} = R_{SET3} = R_{SET4} = 649 Ω		17.2		
$I_{SHUTDOWN}$	Supply current during power-down	V_{EN} = V_{ON1} = V_{ON2} = V_{EN} = V_{ON3} = V_{ON4} =V_{CP_SEL} = 0 V			5	µA

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
T_{SD}	Thermal shutdown			150		°C
T_{HS}	Thermal shutdown hysteresis			15		°C

5 Detailed description

The STP4CMP is a charge-pump-based 4-channel LED driver designed for RGB illumination or LCD display backlighting, using constant current topology. Each of the 4 channels can be controlled independently. When ONx is pulled high, a constant current is sunk into the LEDx pin when one LED is connected. This constant current is defined or programmed by the value of the resistor on the I_{SETX} pin.

5.1 Enable pin

The active high enable input pin is used to shut down the whole device. When this pin is pulled low, the device goes into shutdown mode with 5 µA max. current consumption only. An internal pulled down of 300 kΩ is present on this pin.

5.2 LED turn-on pin (ONx)

When the EN pin is pulled high, the STP4CMP provides the flexibility to control ON/OFF on the 4 channels independently through the 4 active high ON pins. To control the brightness of each LED channel, it is possible to drive the selected ON pin with a PWM signal with a frequency up to min. 33 µs T_{ON}/T_{OFF}. An internal pull-down of 300 kΩ is present on these pins.

5.3 Programmable output current

The LED currents on the 4 channels are programmed individually through a resistor connected from I_{SET1}, I_{SET2}, I_{SET3}, I_{SET4} to ground. The relationship between the resistor (R_{SET}) and the LED current (I_{LED}) is given by the below equation:

$R_{SET}= 16x(1.22/I_{LED})$

5.4 Charge pump

The STP4CMP charge pump can be disabled or enabled according to the CP_SEL pin. When enabled (CP_SEL is high), the charge pump provides a clamping voltage of typ. 5.0 V to ensure enough headroom to drive the LEDs. An internal pull-down of 300 kΩ is present on this pin. The charge pump can be disabled by pulling low the CP_SEL pin, based on the V_{CC} and forward voltage of the LEDs used. This allows the connection of V_{CC} directly to V_{OUT} to drive the external LEDs. At V_{CC} 3.1 V, the charge pump maintains regulation at 5 V when the total current drawn from it (on V_{OUT} pin) is ≤ 120 mA. At 2.7 ≤ V_{CC} < 3.1 V, in order for the charge pump to maintain regulation at 5 V, the total current drawn from it (on V_{OUT} pin) must be lowered to ≤ 40 mA.

5.5 Thermal protection

The thermal protection circuit ensures the device shutdown when it is overheated (for example, due to an output short-circuit) to typ. 150 °C. The device resumes normal operation when the temperature drops by 15 °C from the thermal shutdown threshold.

6 Typical performance characteristics

Figure 4: Efficiency vs. V_{IN}, I_{OUT} = 10 mA

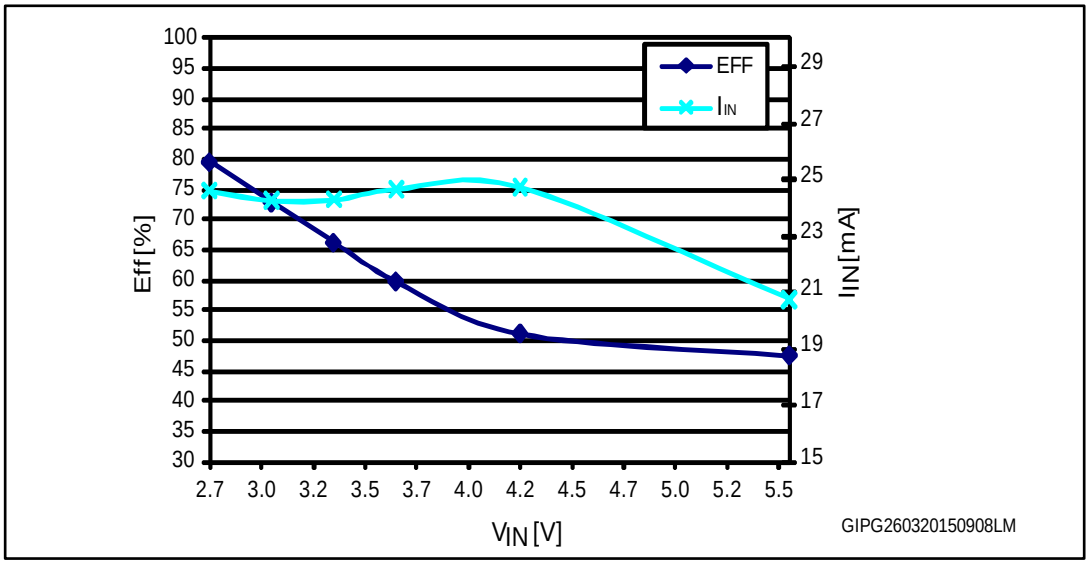


Figure 5: Efficiency vs. V_{IN}, I_{OUT} = 60 mA

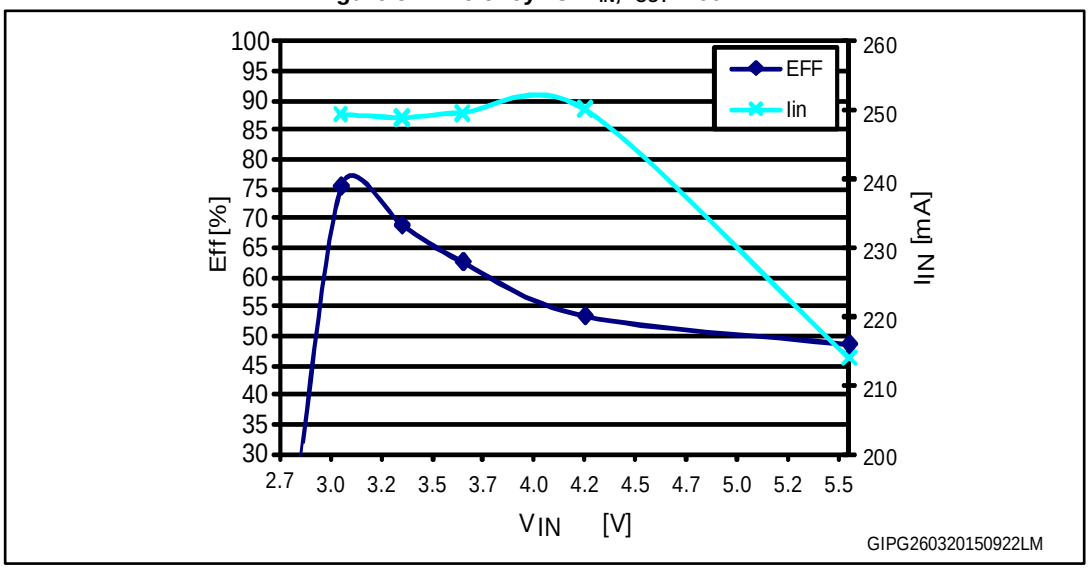


Figure 6: V_{OUT} vs. V_{IN}

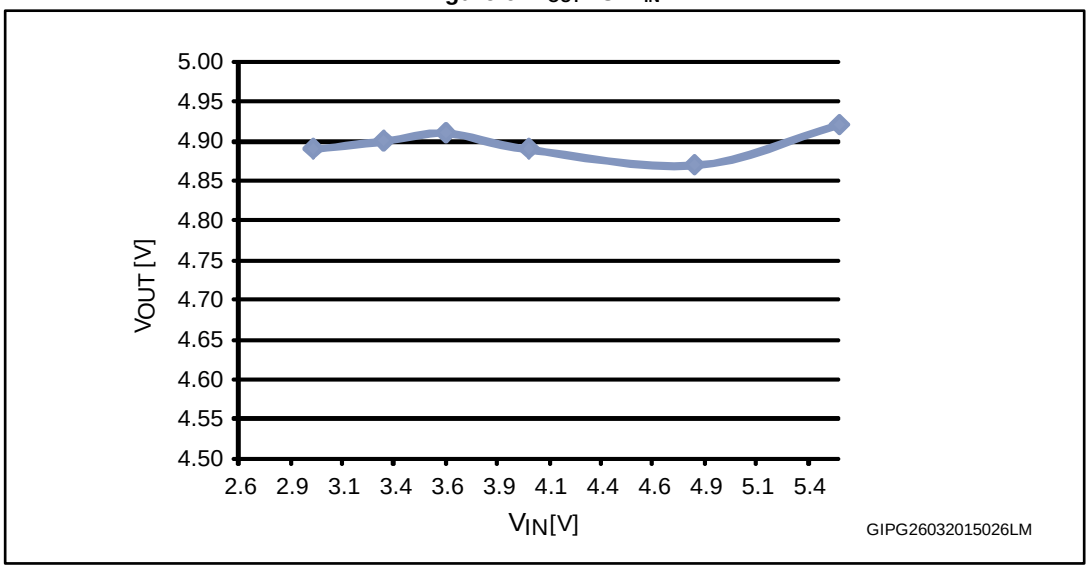


Figure 7: PWM modulation CH1-2

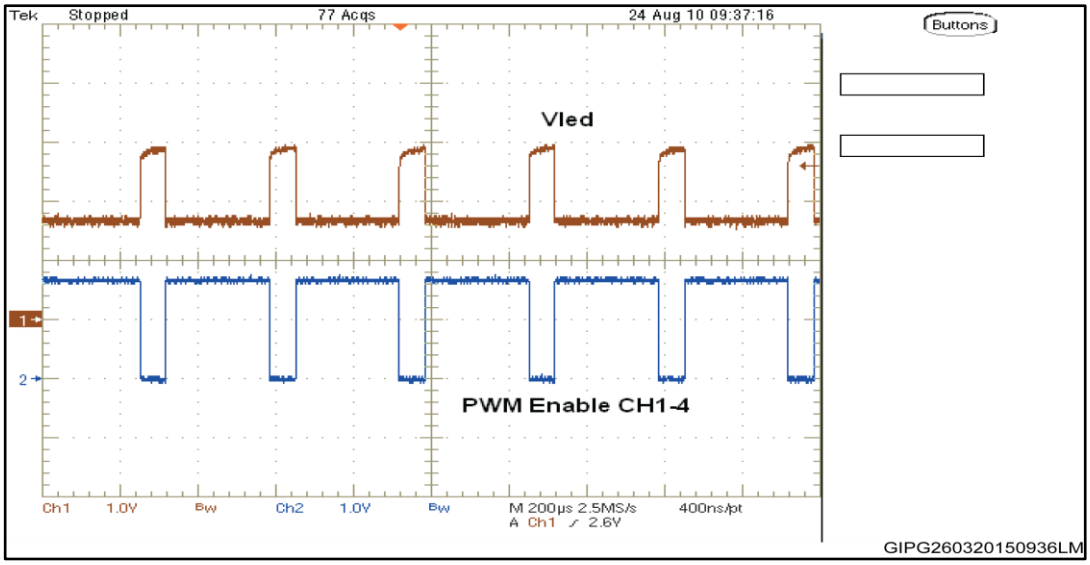
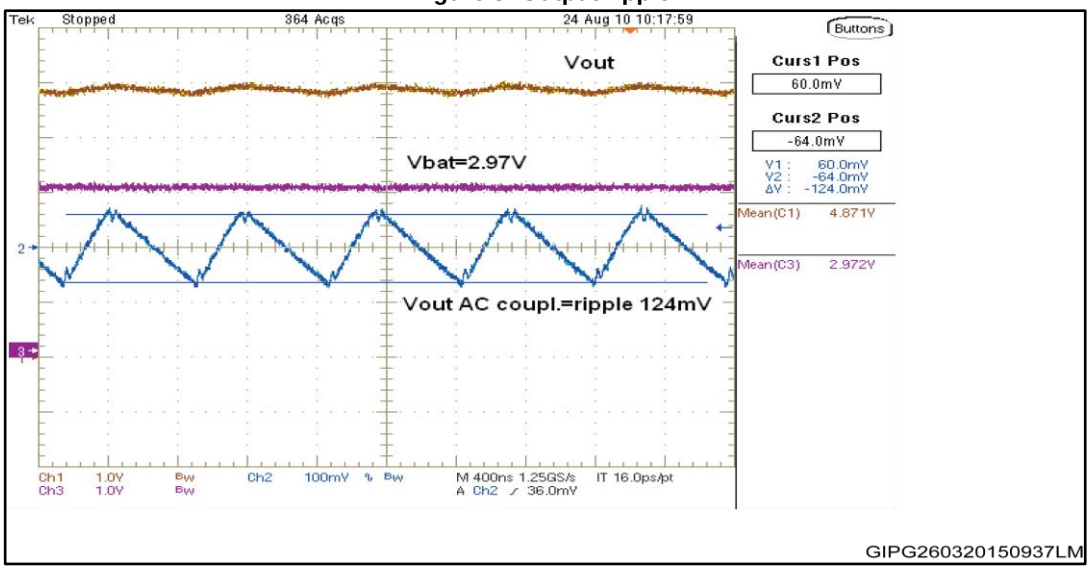


Figure 8: Output ripple



7 PCB layout

7.1 Recommended

The STP4CMP is a charge pump power device so it requires a proper PCB layout in order to obtain the necessary stability and optimize line/load regulation and output voltage ripple. Input, output, and boost capacitors must be as close as possible to their relative pins.

Figure 9: Top layer

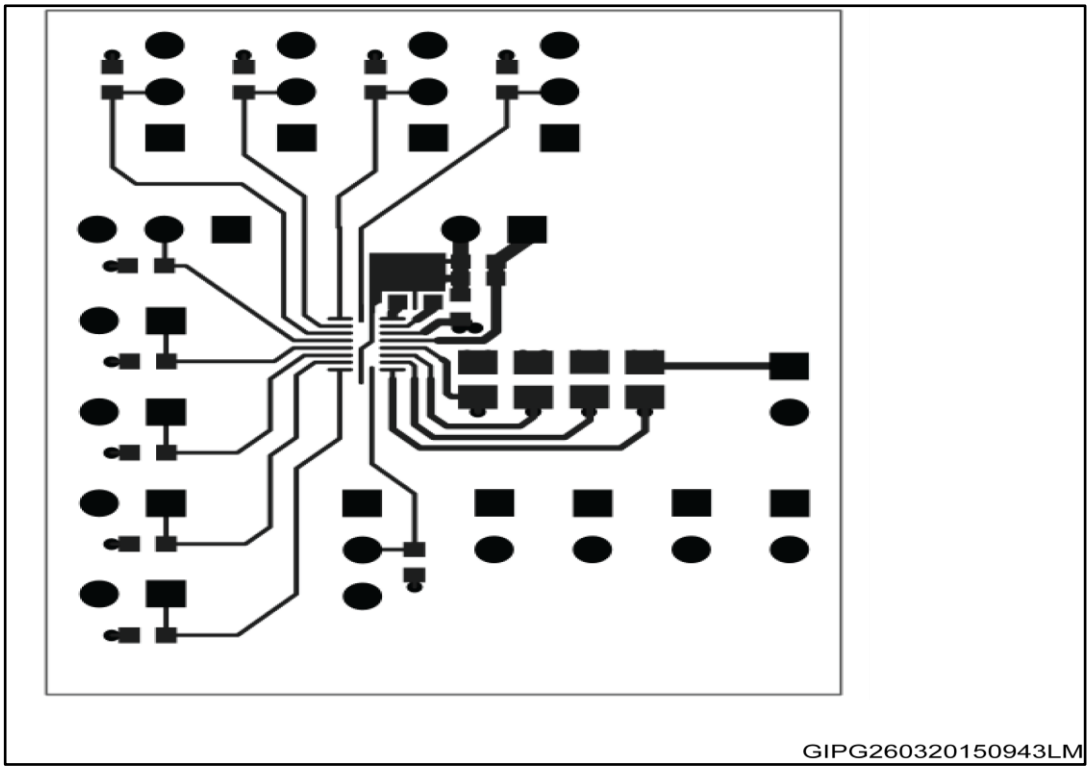


Figure 10: Bottom layer

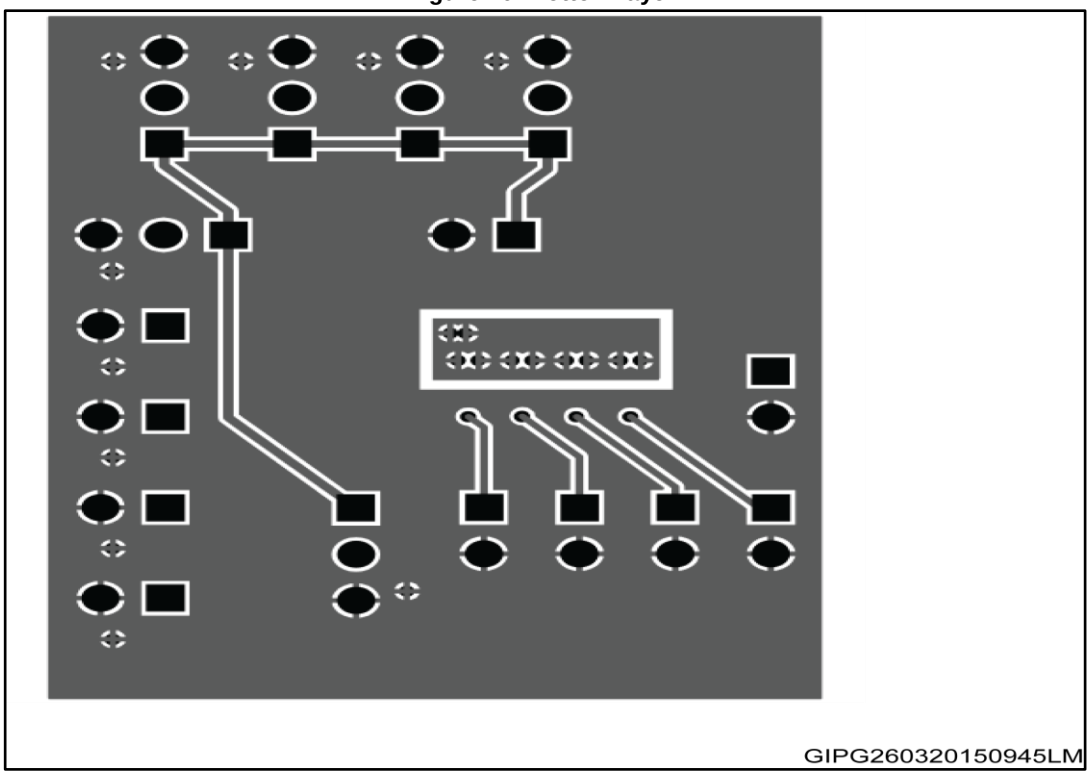
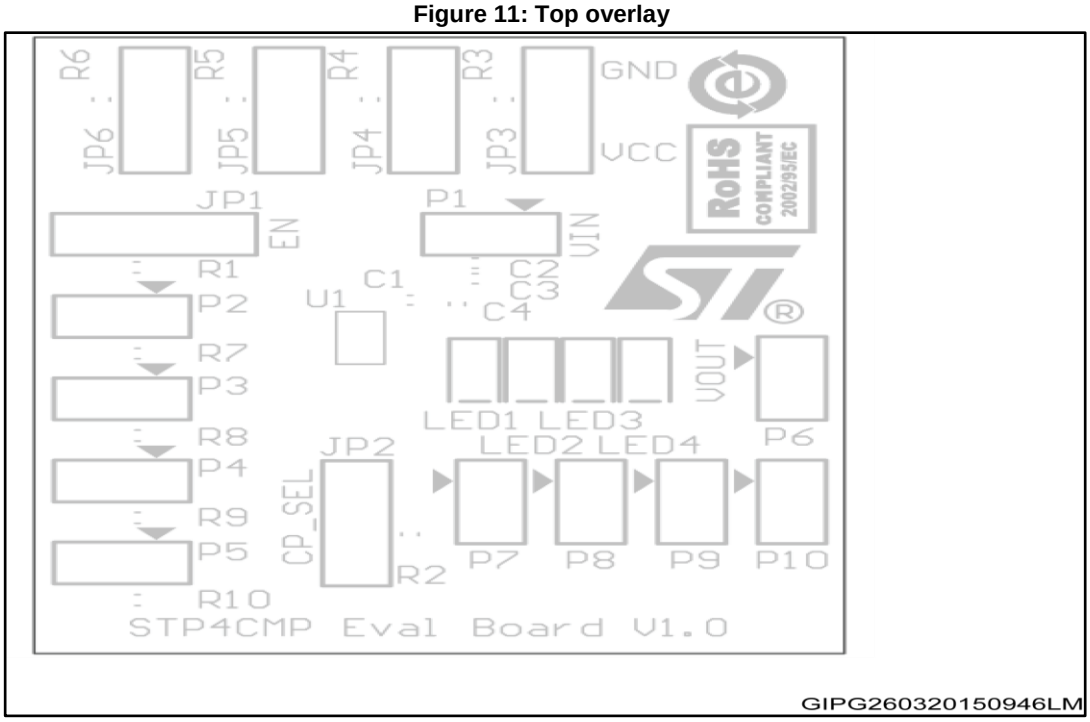


Figure 11: Top overlay



7.2 Evaluation board

Figure 12: Evaluation board

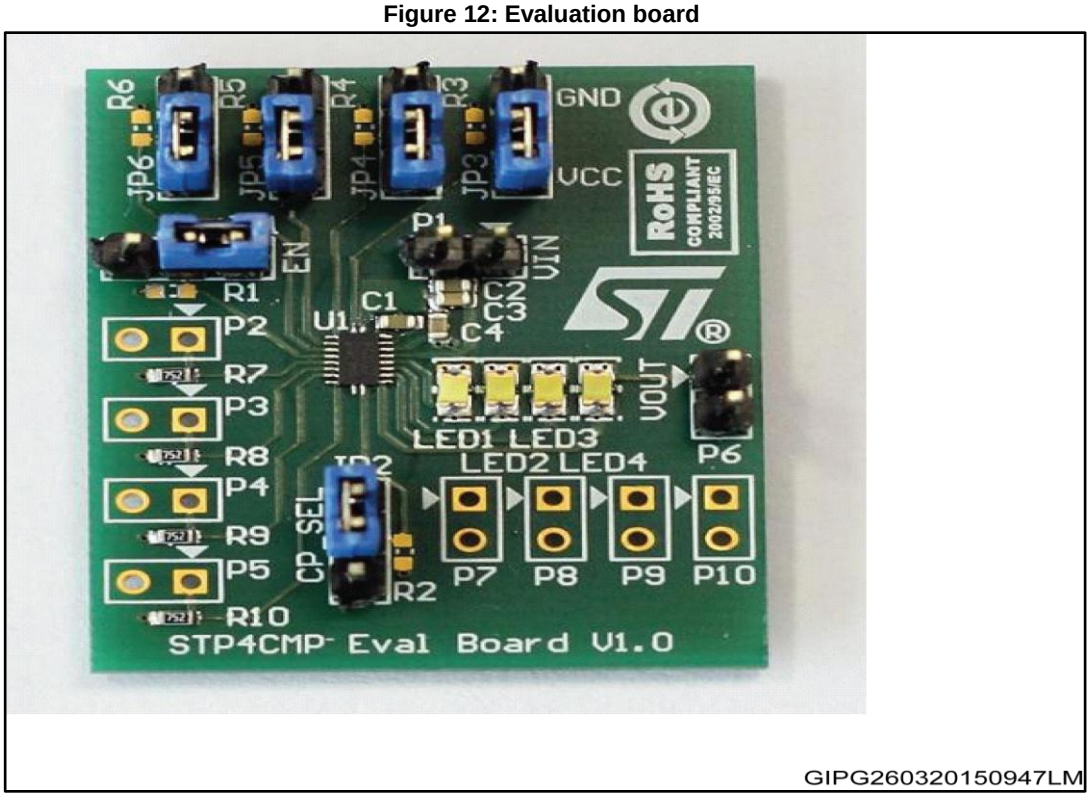
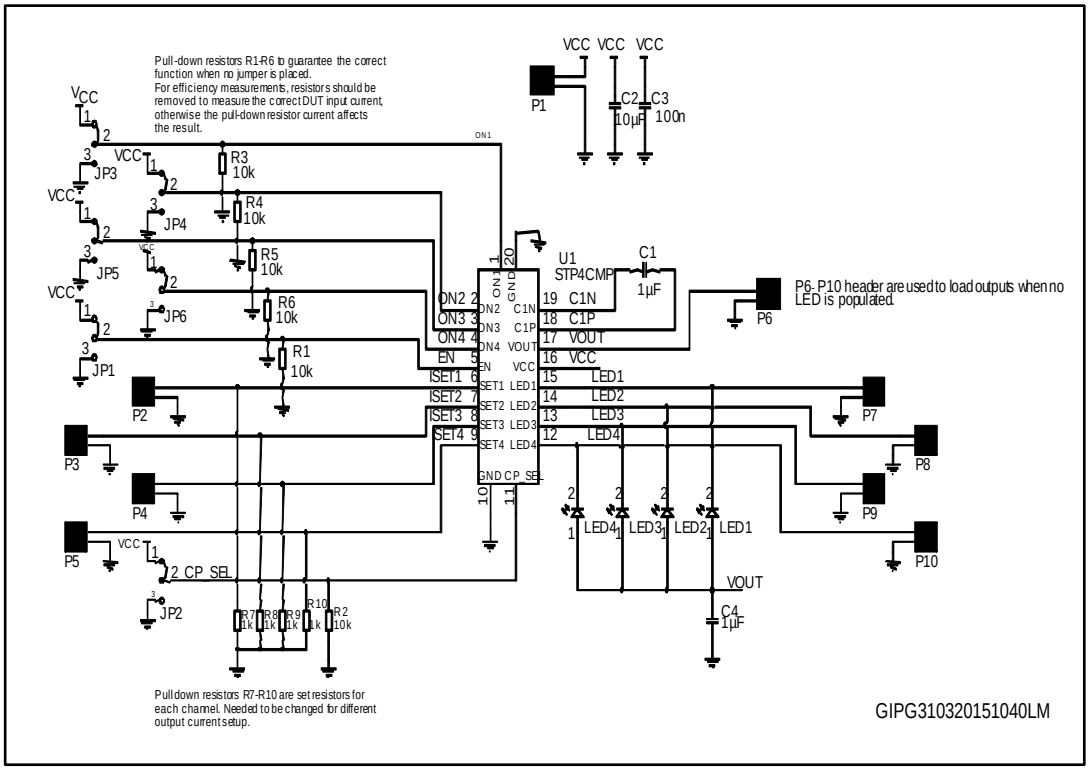


Figure 13: Evaluation board schematic



8 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

8.1 QFN20 (1.8x3.2 mm) package information

Figure 14: QFN20 (1.8x3.2 mm) package outline

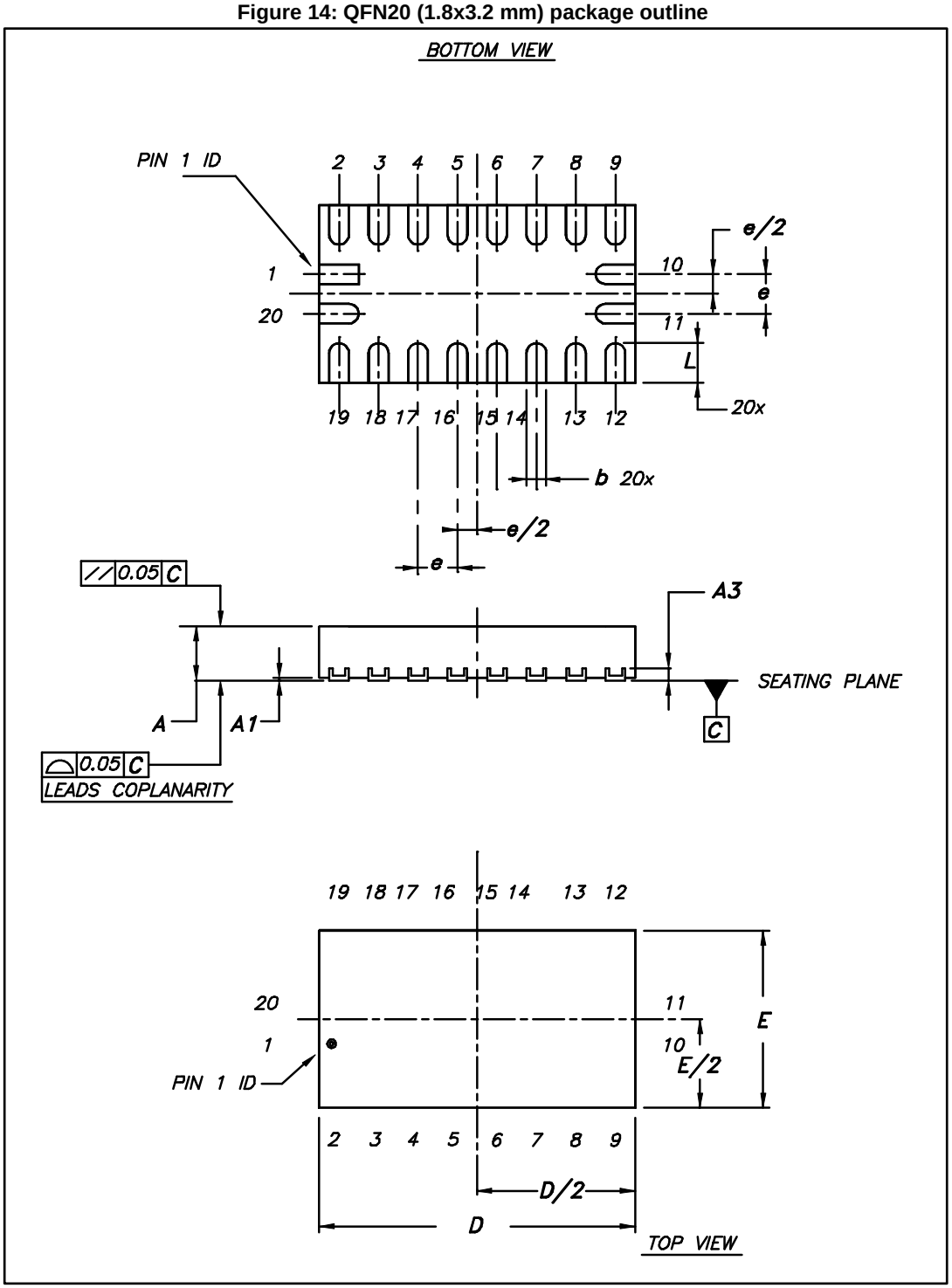
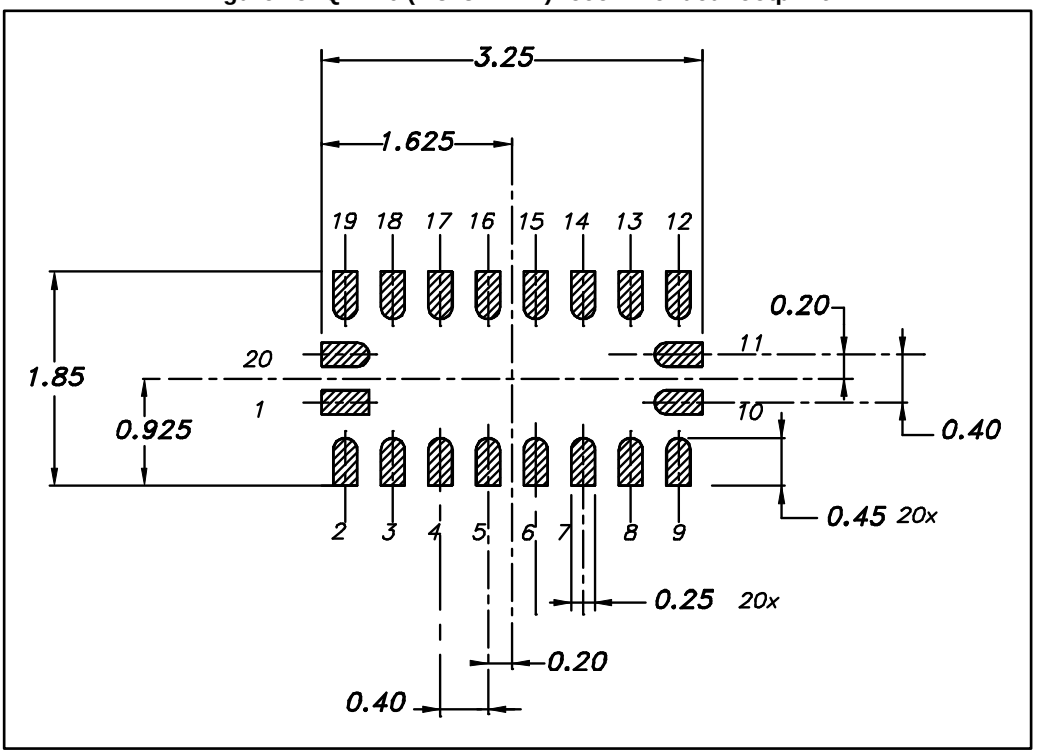


Table 8: QFN20 (1.8x3.2 mm) package mechanical data

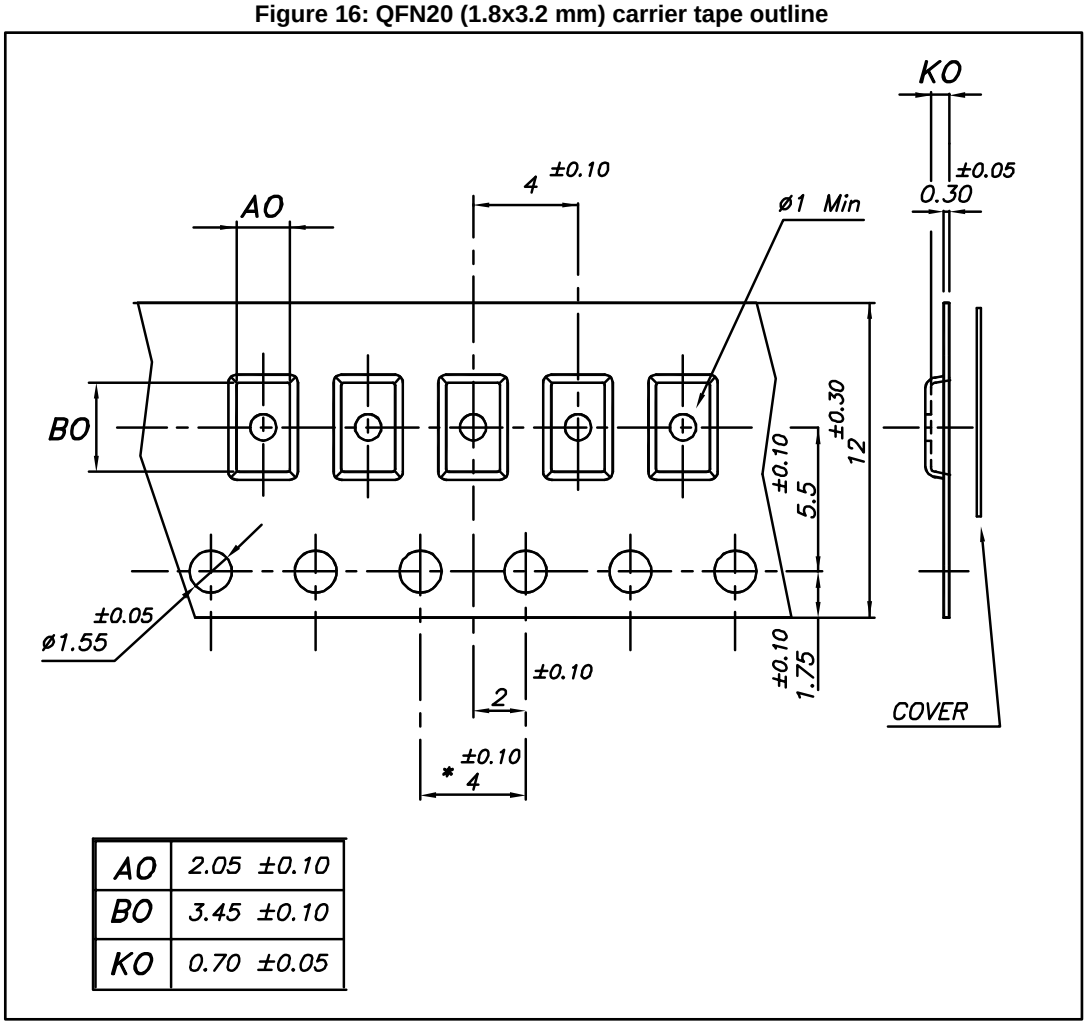
Dim.	mm		
	Min.	Typ.	Max.
A	0.45	0.50	0.55
A1	0	0.02	0.05
A3		0.127	
b	0.15	0.20	0.25
D	3.15	3.20	3.25
E	1.75	1.80	1.85
e		0.40	
L	0.35	0.40	0.45

Figure 15: QFN20 (1.8x3.2 mm) recommended footprint



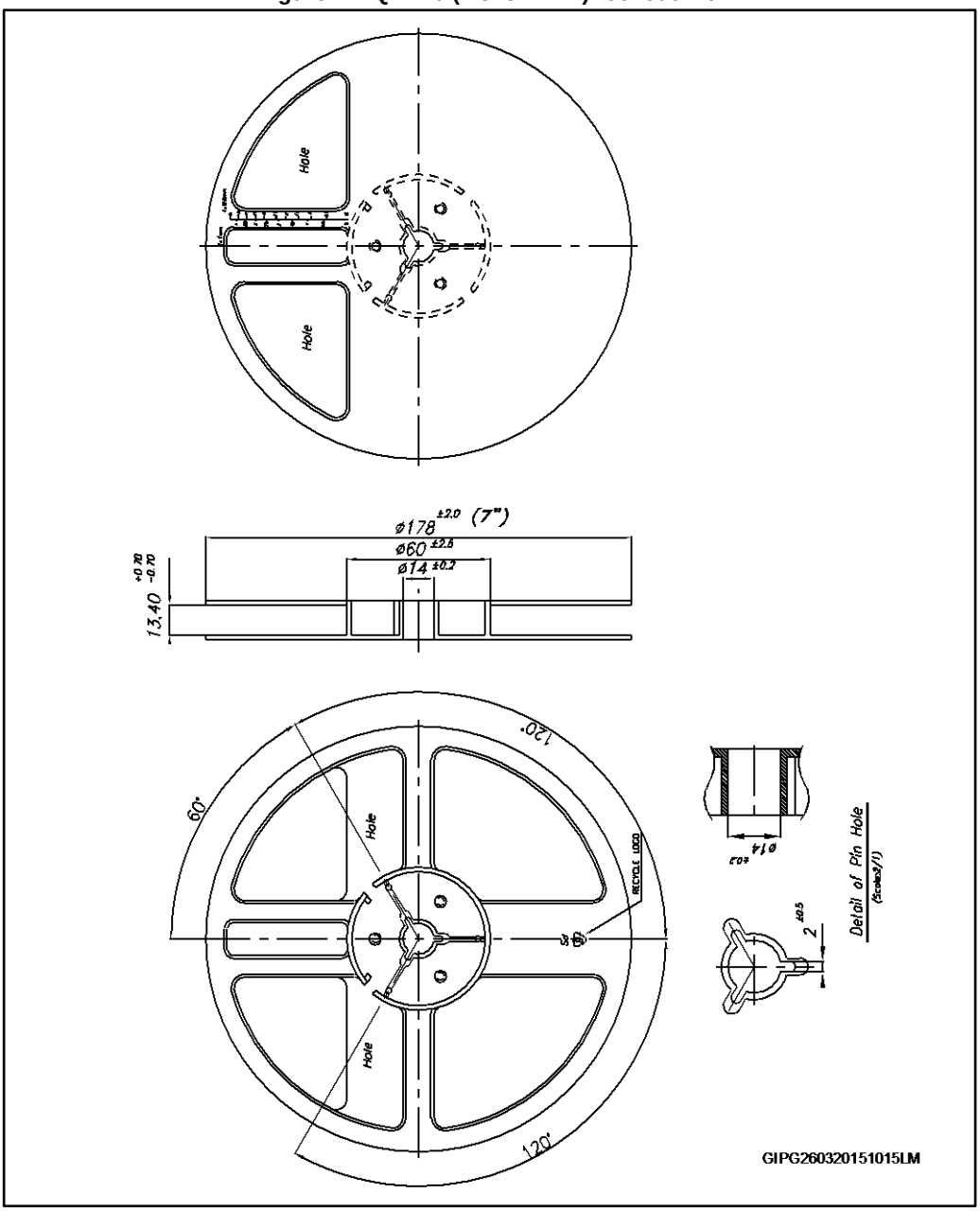
8.2 Packing information

Figure 16: QFN20 (1.8x3.2 mm) carrier tape outline



AO	2.05 ±0.10
BO	3.45 ±0.10
KO	0.70 ±0.05

Figure 17: QFN20 (1.8x3.2 mm) reel outline



Drawing is not in scale and dimensions are in mm

9 Revision history

Table 9: Document revision history

Date	Revision	Changes
09-Jun-2009	1	Initial release.
24-Jan-2012	2	Document status promoted from preliminary data to datasheet. Added section 7.
09-Apr-2015	3	Updated features.