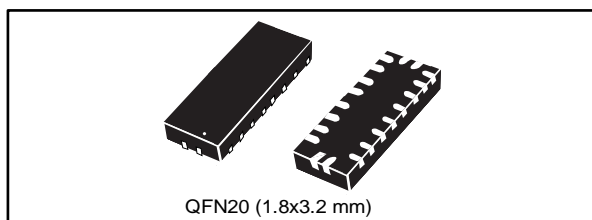


## Low voltage 4-channel constant current LED driver with charge pump

Datasheet - production data



### 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.  $\pm 7\%$  and channel-to-channel mismatch of max.  $\pm 4\%$
- 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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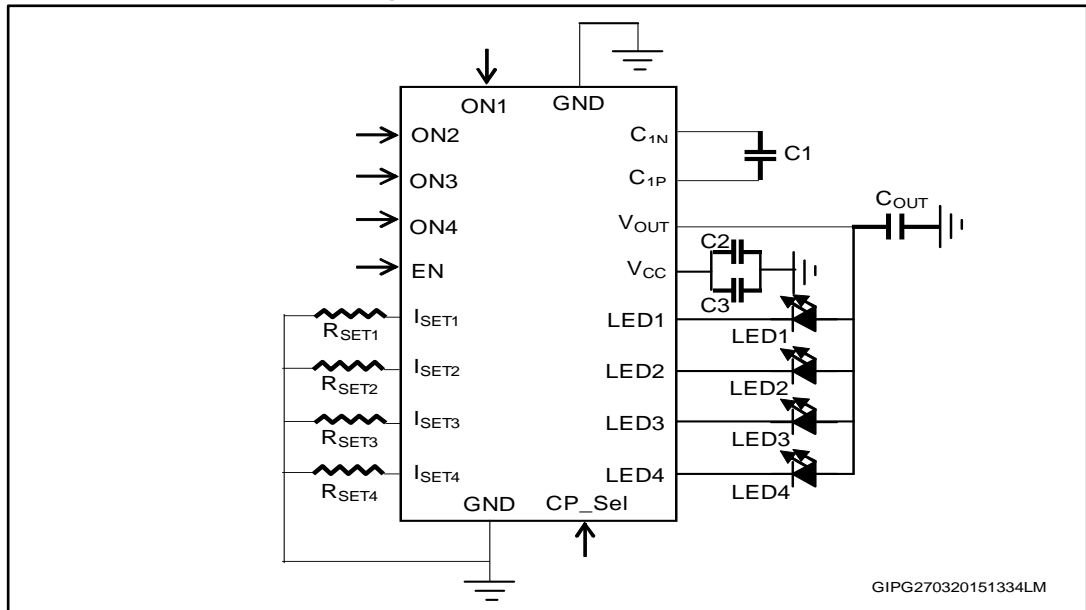
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# 1 Application schematic

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, C<sub>1</sub>, and the output capacitor, C<sub>OUT</sub>, to be placed as close as possible to the pins.

Table 2: Typical external components

Component	Manufacturer	Part number	Value	Size
C <sub>1</sub> , C <sub>OUT</sub>	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 <sub>SET1-4</sub> <sup>(1)</sup>	Tyco	CPF0402B976RE1	976 Ω	0402
LED1-4 <sup>(2)</sup>				

**Notes:**

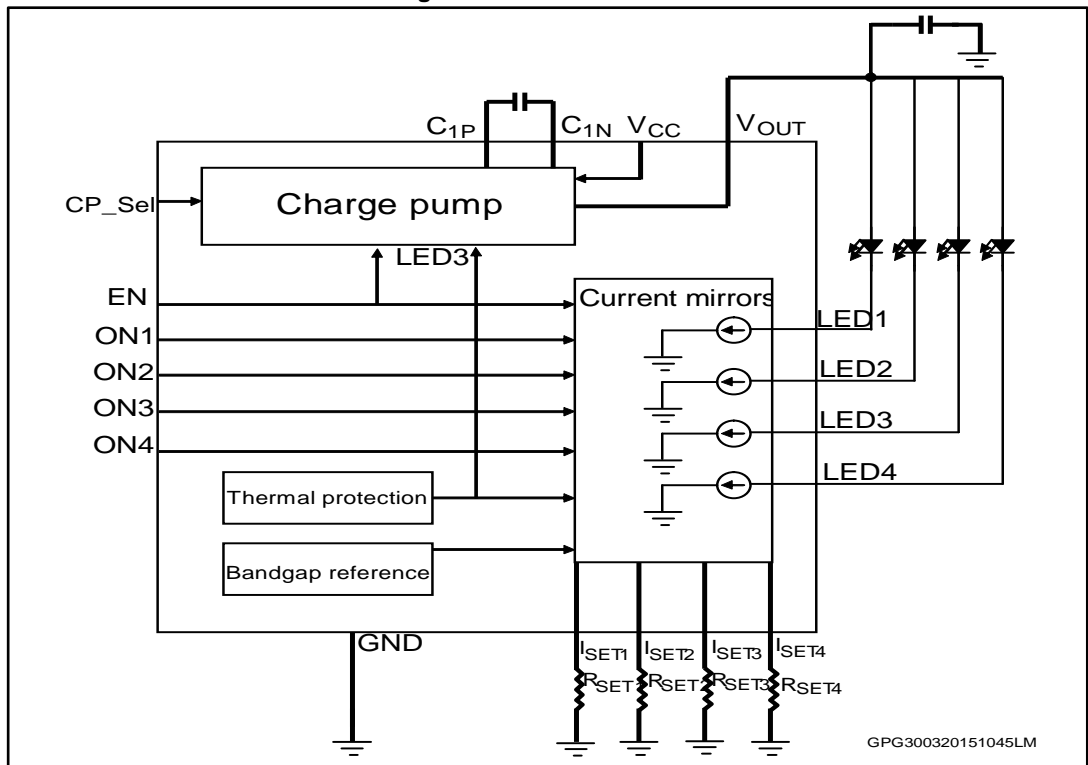
<sup>(1)</sup> 649 Ω to 7.87 kΩ according to the desired output current from each channel.

<sup>(2)</sup> 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)

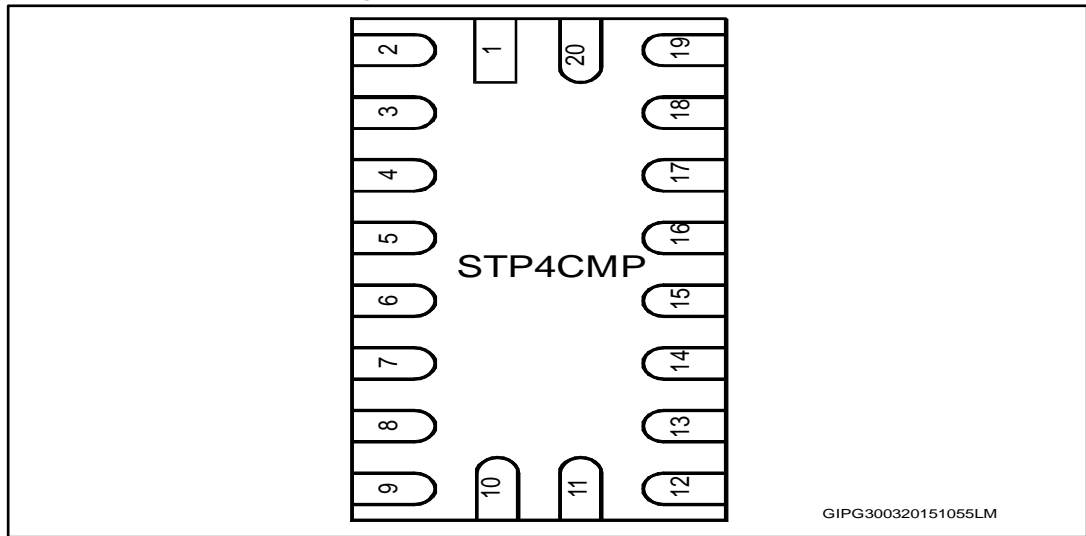


Table 3: Pin description

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 <sub>SET1</sub>	LED1 max. current setting resistor
7	I <sub>SET2</sub>	LED2 max. current setting resistor
8	I <sub>SET3</sub>	LED3 max. current setting resistor
9	I <sub>SET4</sub>	LED4 max. current setting resistor
10	GND	Ground
11	CP_SEL	Charge pump mode selection, 1 = enable 0 = disable
12	LED4	4 <sup>th</sup> LED current sink
13	LED3	3 <sup>rd</sup> LED current sink
14	LED2	2 <sup>nd</sup> LED current sink
15	LED1	1 <sup>st</sup> LED current sink
16	V <sub>CC</sub>	Supply voltage
17	V <sub>OUT</sub>	Charge pump output
18	C <sub>1P</sub>	Positive terminal of charge pump bucket capacitor
19	C <sub>1N</sub>	Negative terminal of charge pump bucket capacitor
20	GND	Ground

### 3 Maximum ratings

**Table 4: Absolute maximum ratings**

Symbol	Parameter	Value	Unit
ON <sub>1-4</sub> , V <sub>CC</sub> , EN, CP_SEL, C <sub>1P</sub> , C <sub>1N</sub>	Supply voltage	- 0.3 to + 6.0	V
VOUT	Output voltage	- 0.3 to + 6.0	V
LED1-4, I <sub>SET1-4</sub>	Current setting	-0.3 to 2	V
ESD	Human body model	±1500	V
	Charged device model	±500	
	Machine model	±200	
T <sub>AMB</sub>	Operating ambient temperature	- 30 to 85	°C
T <sub>J</sub>	Maximum operating junction temperature	+150	°C
T <sub>STG</sub>	Storage temperature	-65 to 150	°C

**Table 5: Recommended operating conditions**

Symbol	Parameter	Min.	Typ.	Max.	Unit
V <sub>CC</sub>	Supply voltage	2.7		5.5	V
T <sub>op</sub>	Operating temperature	-40		85	°C
I <sub>LED</sub>	Current through each LED	2.5		30	mA
T <sub>pwm_ON</sub>	ON time of PWM signal at each ON pin	33			µs
T <sub>pwm_OFF</sub>	OFF time of PWM signal at each ON pin				
V <sub>fw</sub>	LED forward voltage			3.8	V

**Table 6: Thermal data**

Symbol	Parameter	Value	Unit
R <sub>thJA</sub> <sup>(1)</sup>	Thermal resistance junction-ambient	70	°C/W

**Notes:**

<sup>(1)</sup>This parameter corresponds to the PCB board, 4-layer with 1 inch<sup>2</sup> of cooling area.



## 4 Electrical characteristics

$V_{CC} = 3.3\text{ V}$ ,  $V_{EN} = V_{ON1} = V_{ON2} = V_{ON3} = V_{ON4} = V_{CC}$ ,  $V_{CP\_SEL} = V_{CC}$ ,  $R_{SET1} = R_{SET2} = R_{SET3} = R_{SET4} = 649\ \Omega$ ,  $C_1 = 1\ \mu\text{F}$ , typical values are at  $T_A = 25\ ^\circ\text{C}$  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	$2.7\text{ V} \leq V_{CC} < 3.1\text{ V}$ ; $V_{CP\_SEL} = V_{CC}$ ; $I_{OUT} \leq 40\text{ mA}$		5		V
		$V_{CC} > 3.1\text{ V}$ ; $V_{CP\_SEL} = V_{CC}$ ; $I_{OUT} \leq 120\text{ mA}$		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	$R_{setx} = 649\ \Omega$ at $V_{LEDx} = 0.9\text{ V}$ ; $V_{CC} > 3.1\text{ V}$	27.9	30	32.1	mA
		$R_{setx} = 7.87\text{ k}\Omega$ at $V_{LEDx} = 0.9\text{ V}$ ; $V_{CC} \geq 3.1\text{ V}$	2.33	2.5	2.68	mA
$\Delta I_{LED}$	Output current error between each channel	$R_{SET1} = R_{SET2}$ , $R_{SET3} = R_{SET4}$ , $T_A = 25\ ^\circ\text{C}$		$\pm 1$	$\pm 4$	%
$V_{IH}$	High level input voltage		2.0			V
$V_{IL}$	Low level input voltage				0.8	
$I_{CC}$	Supply operating current	$V_{ON1} = V_{ON2} = V_{ON3} = V_{ON4} = \text{GND}$ ; no-load; $V_{CC} = 5.5\text{ V}$ (charge pump disabled); $V_{CP\_SEL} = \text{GND}$ , $R_{SET1} = R_{SET2} = R_{SET3} = R_{SET4} = 7.87\text{ k}\Omega$		3.6		mA
		$V_{ON1} = V_{ON2} = V_{ON3} = V_{ON4} = \text{GND}$ ; no-load; $V_{CC} = 5.5\text{ V}$ (charge pump disabled); $V_{CP\_SEL} = \text{GND}$ , $R_{SET1} = R_{SET2} = R_{SET3} = R_{SET4} = 649\ \Omega$		1.7		
		$V_{ON1} = V_{ON2} = V_{ON3} = V_{ON4} = \text{GND}$ ; no-load; $V_{CC} = 3.3\text{ V}$ (charge pump enabled); $V_{CP\_SEL} = V_{CC}$ , $R_{SET1} = R_{SET2} = R_{SET3} = R_{SET4} = 7.87\text{ k}\Omega$		4.5		
		$V_{ON1} = V_{ON2} = V_{ON3} = V_{ON4} = \text{GND}$ ; no-load; $V_{CC} = 3.3\text{ V}$ (charge pump enabled); $V_{CP\_SEL} = V_{CC}$ , $R_{SET1} = R_{SET2} = R_{SET3} = R_{SET4} = 649\ \Omega$		17.2		
$I_{SHUTDOWN}$	Supply current during power-down	$V_{EN} = V_{ON1} = V_{ON2} = V_{EN} = V_{ON3} = V_{ON4} = V_{CP\_SEL} = 0\text{ V}$			5	$\mu\text{A}$

**Electrical characteristics****STP4CMP**

<b>Symbol</b>	<b>Parameter</b>	<b>Test conditions</b>	<b>Min.</b>	<b>Typ.</b>	<b>Max.</b>	<b>Unit</b>
T <sub>SD</sub>	Thermal shutdown			150		°C
T <sub>HS</sub>	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<sub>SETX</sub> 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<sub>ON</sub>/T<sub>OFF</sub>. 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<sub>SET1</sub>, I<sub>SET2</sub>, I<sub>SET3</sub>, I<sub>SET4</sub> to ground. The relationship between the resistor (R<sub>SET</sub>) and the LED current (I<sub>LED</sub>) is given by the below equation:

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

### 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<sub>CC</sub> and forward voltage of the LEDs used. This allows the connection of V<sub>CC</sub> directly to V<sub>OUT</sub> to drive the external LEDs. At V<sub>CC</sub> 3.1 V, the charge pump maintains regulation at 5 V when the total current drawn from it (on V<sub>OUT</sub> pin) is ≤ 120 mA. At 2.7 ≤ V<sub>CC</sub> < 3.1 V, in order for the charge pump to maintain regulation at 5 V, the total current drawn from it (on V<sub>OUT</sub> 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.  $V_{IN}$ ,  $I_{OUT} = 10\text{ mA}$

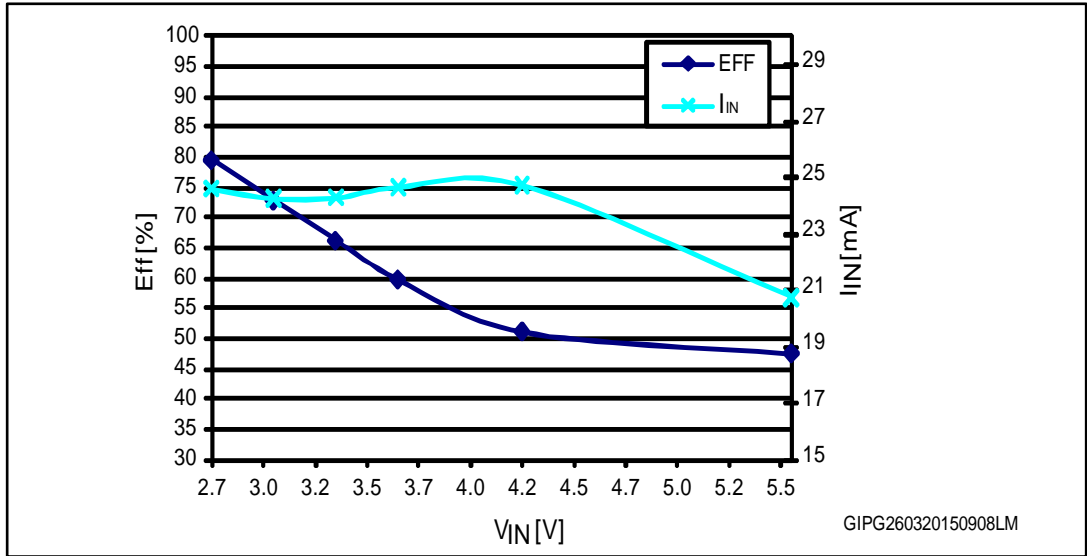


Figure 5: Efficiency vs.  $V_{IN}$ ,  $I_{OUT} = 60\text{ mA}$

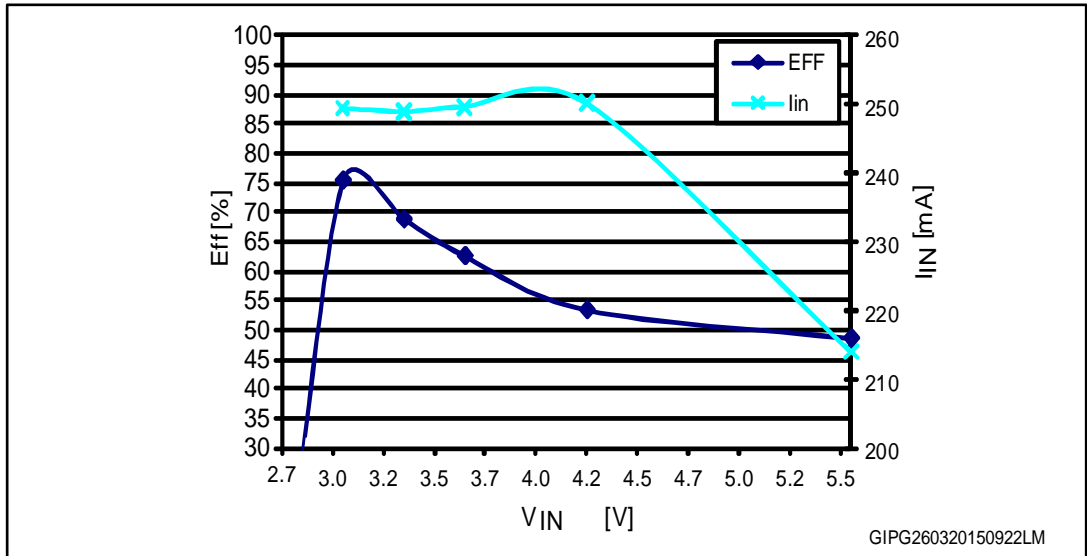


Figure 6:  $V_{OUT}$  vs.  $V_{IN}$

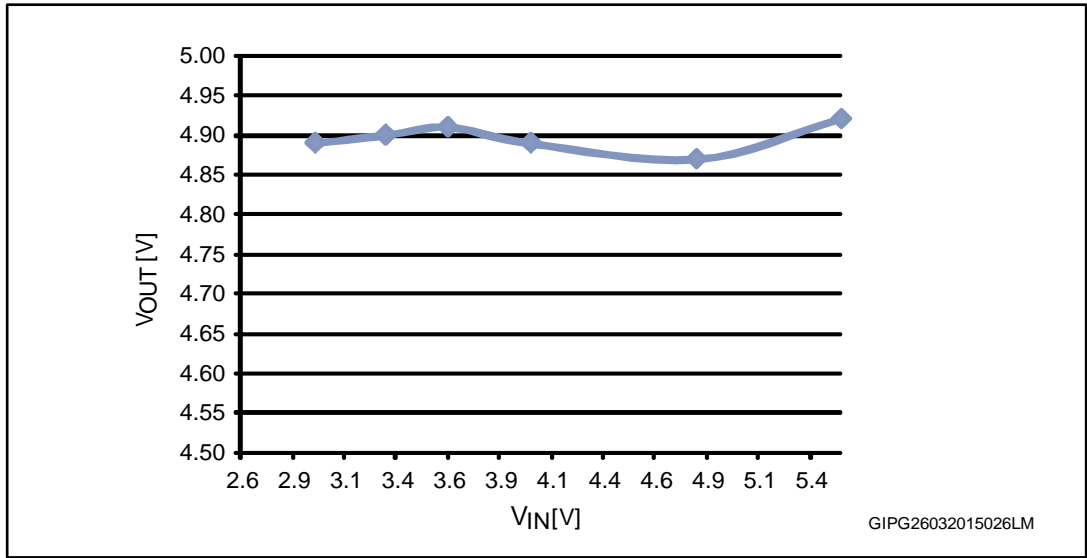


Figure 7: PWM modulation CH1-2

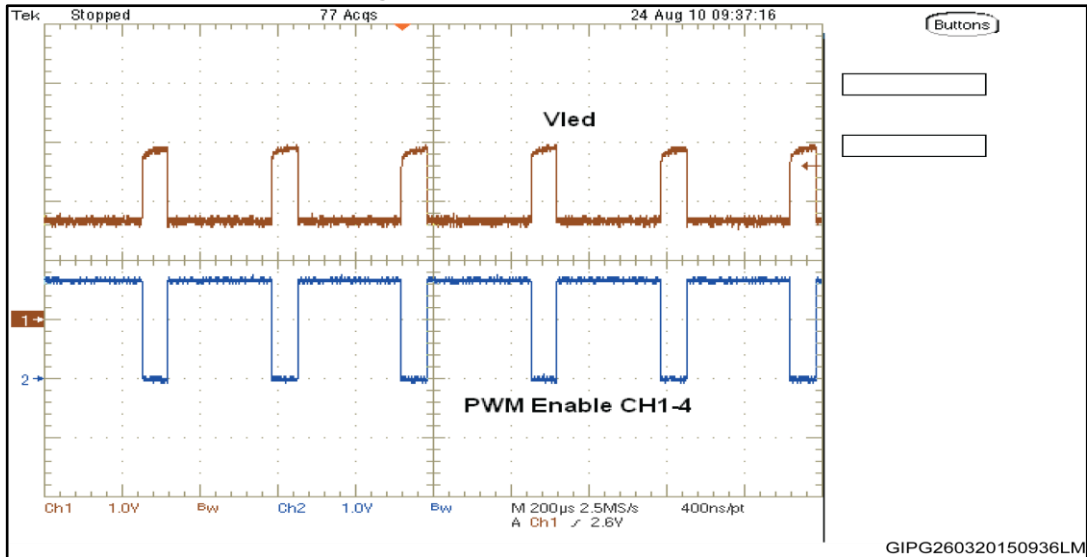
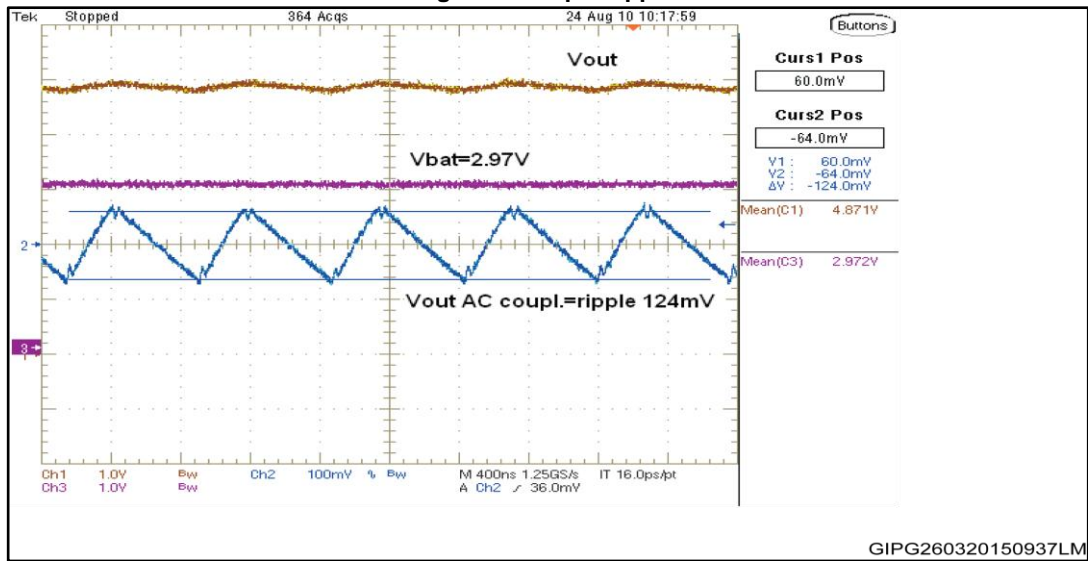


Figure 8: Output ripple



## 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

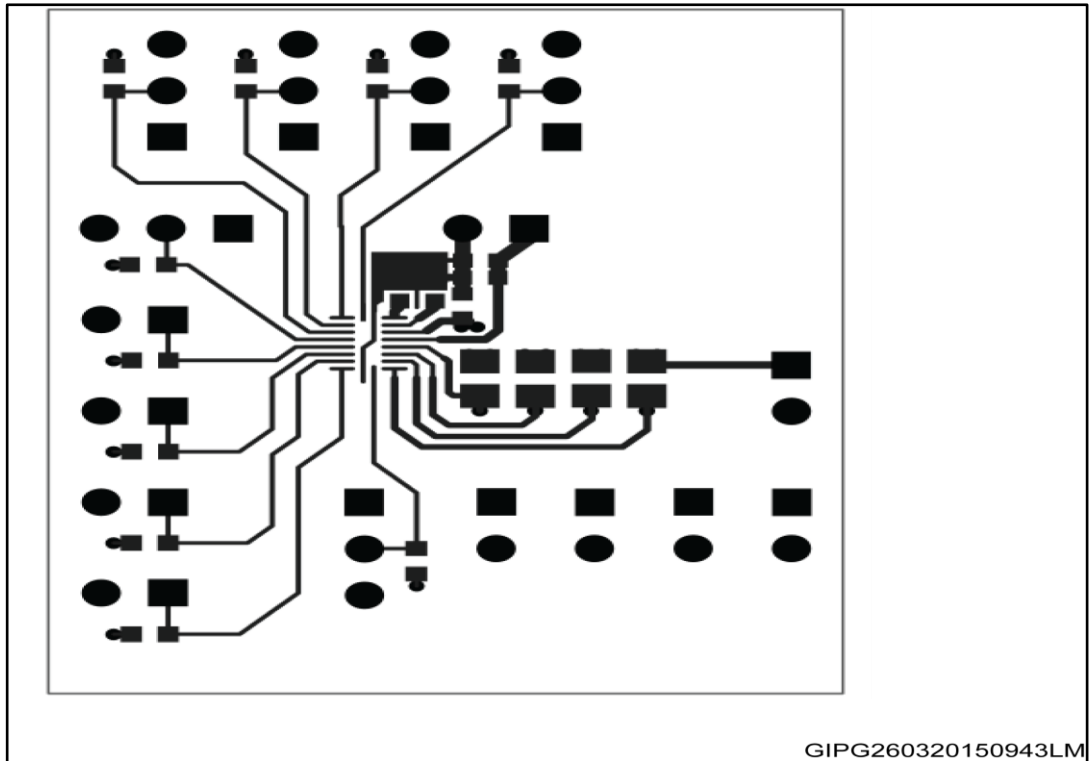


Figure 10: Bottom layer

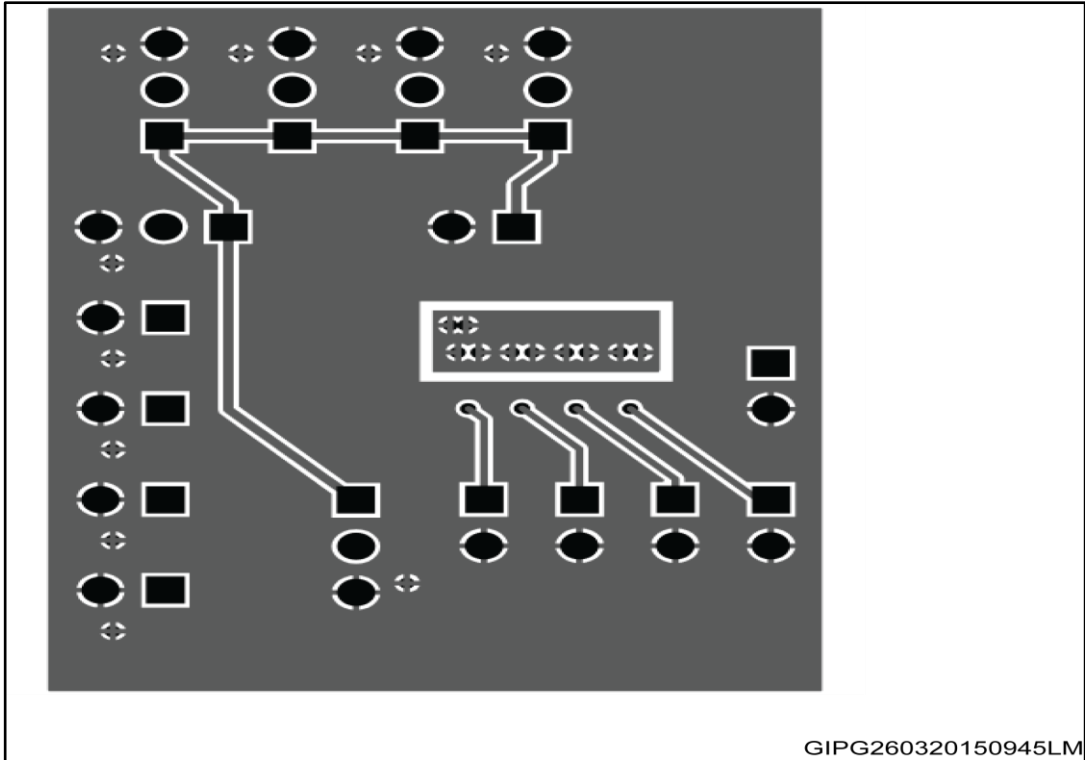
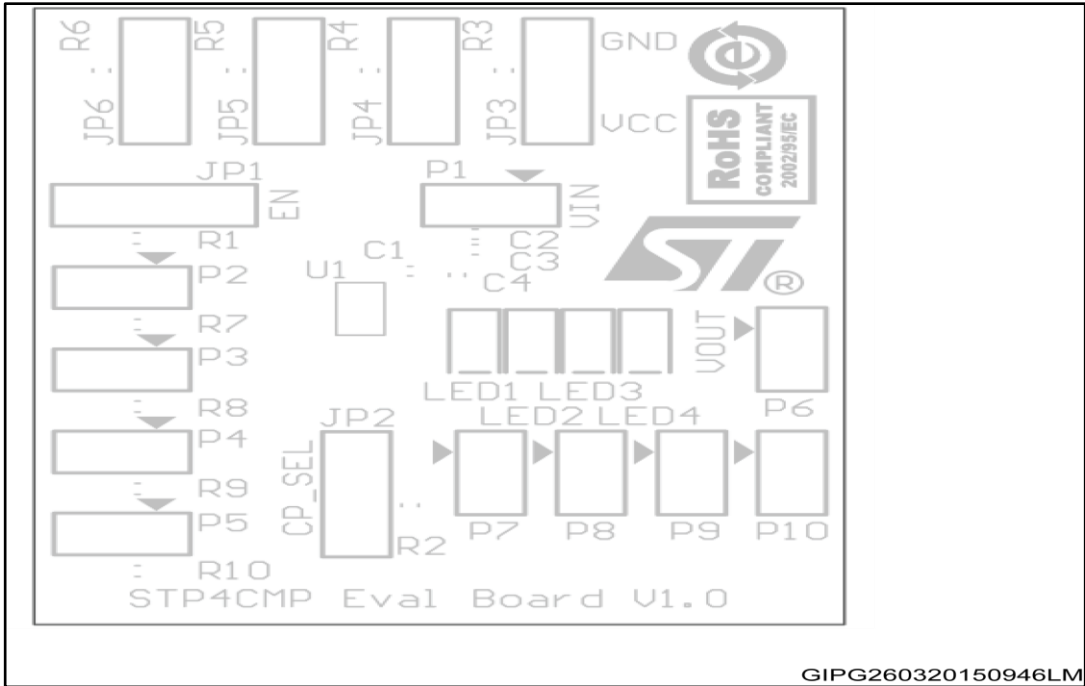


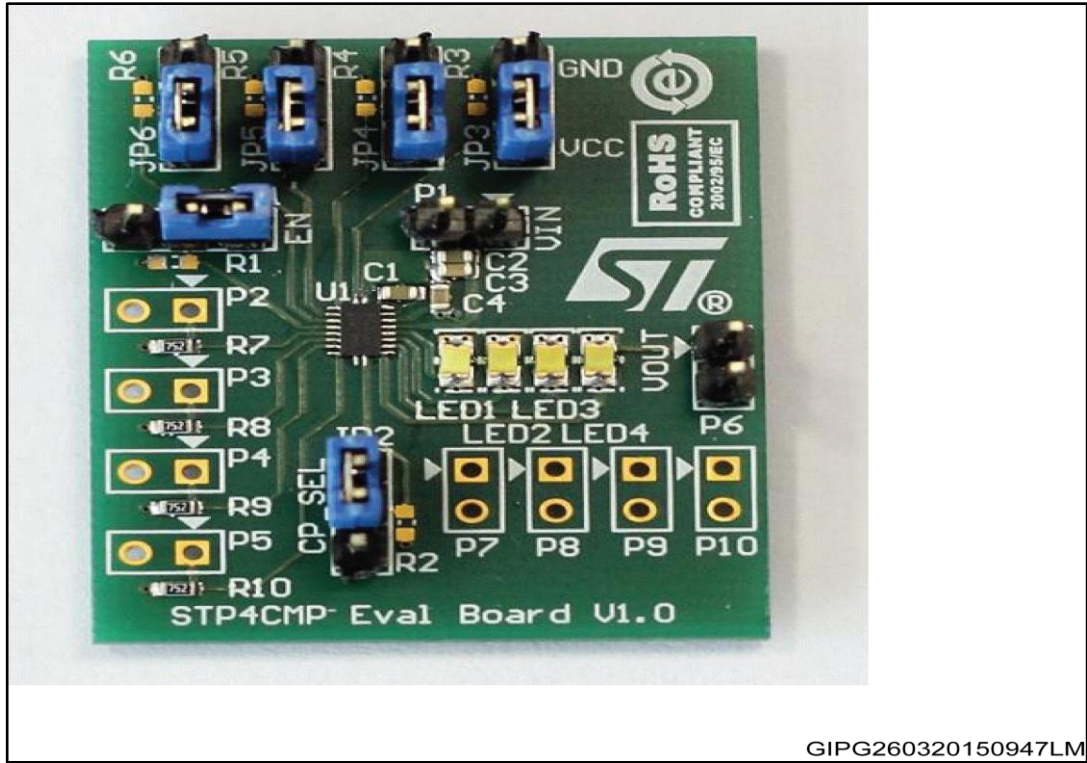
Figure 11: Top overlay





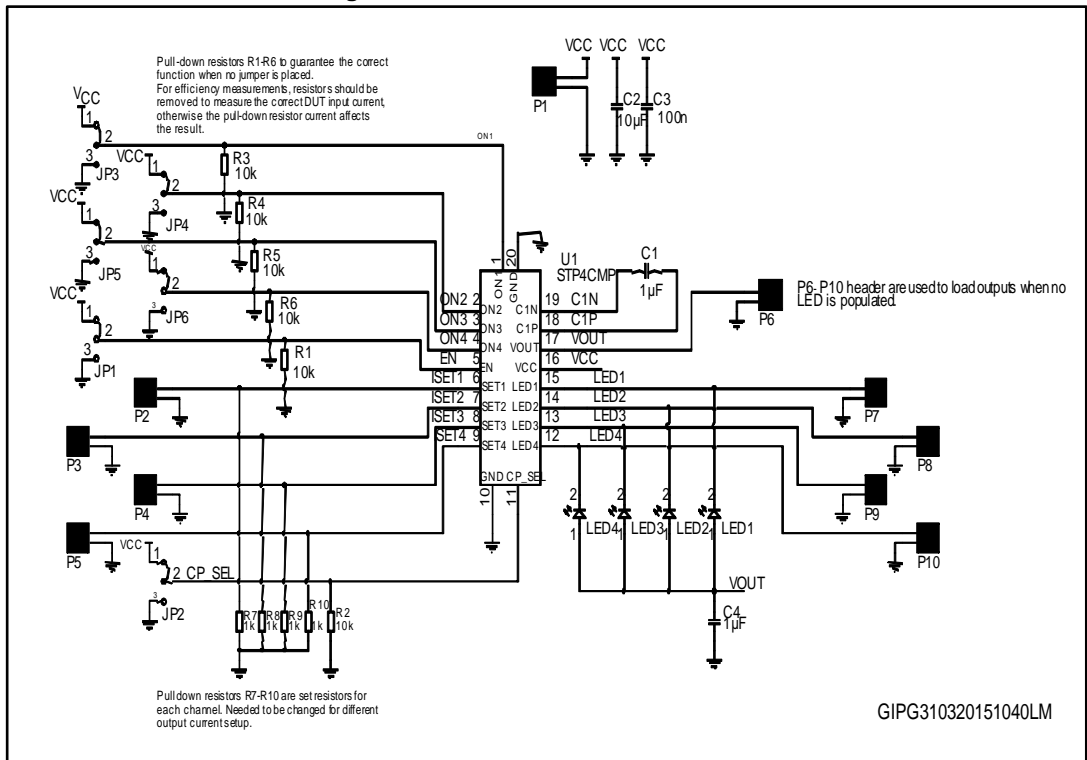
## 7.2 Evaluation board

Figure 12: Evaluation board



GIPG260320150947LM

Figure 13: Evaluation board schematic



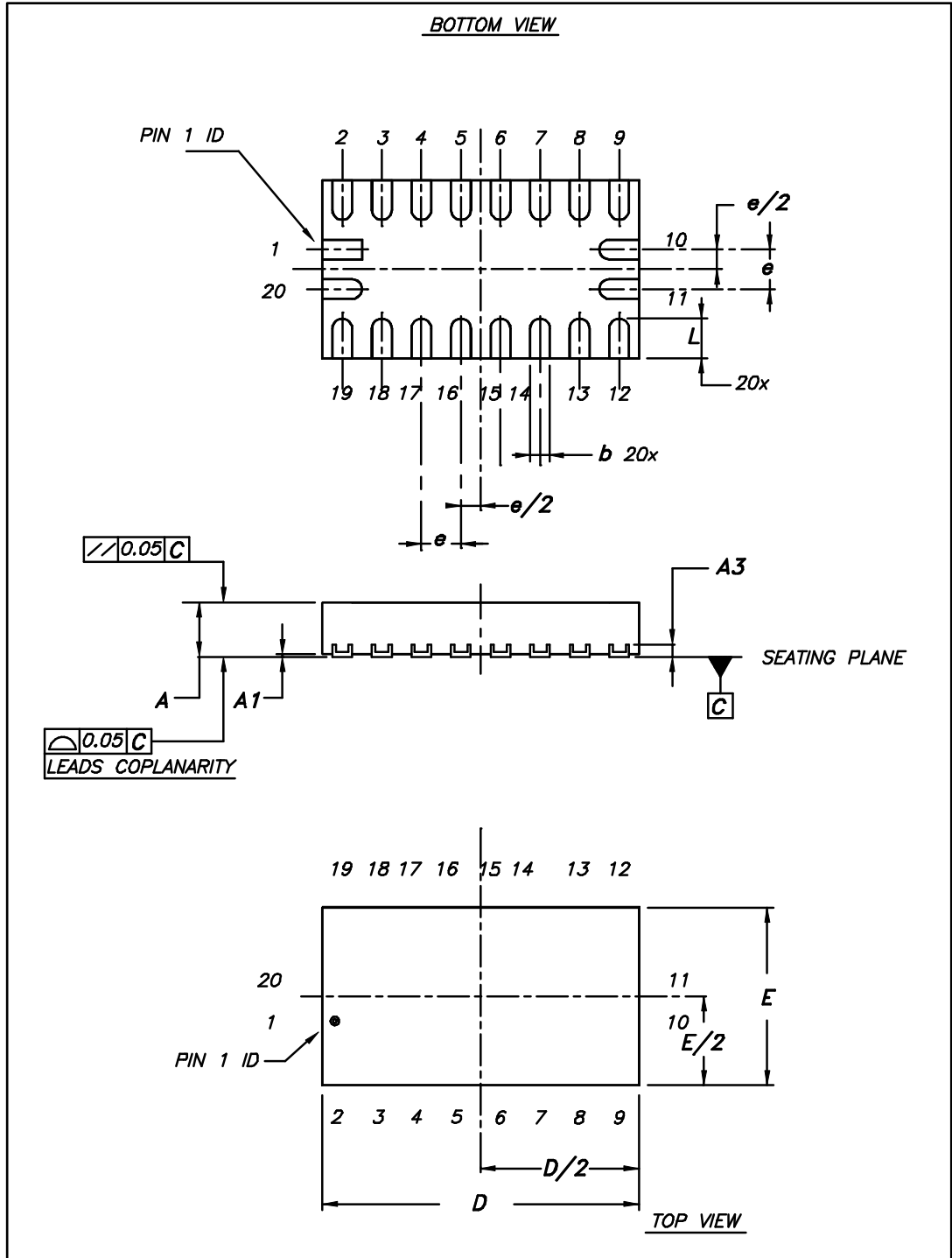
GIPG310320151040LM

## 8 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: [www.st.com](http://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





8.2 Packing information

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

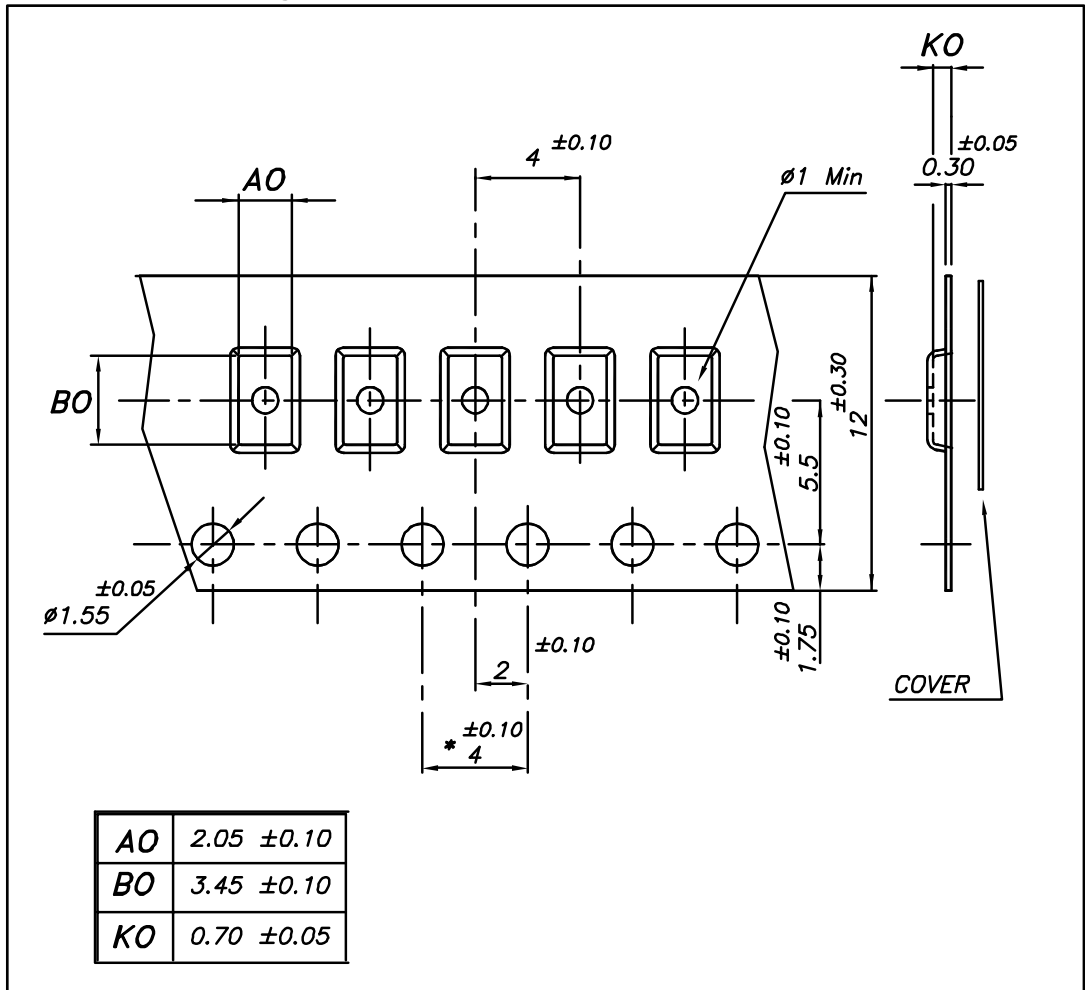
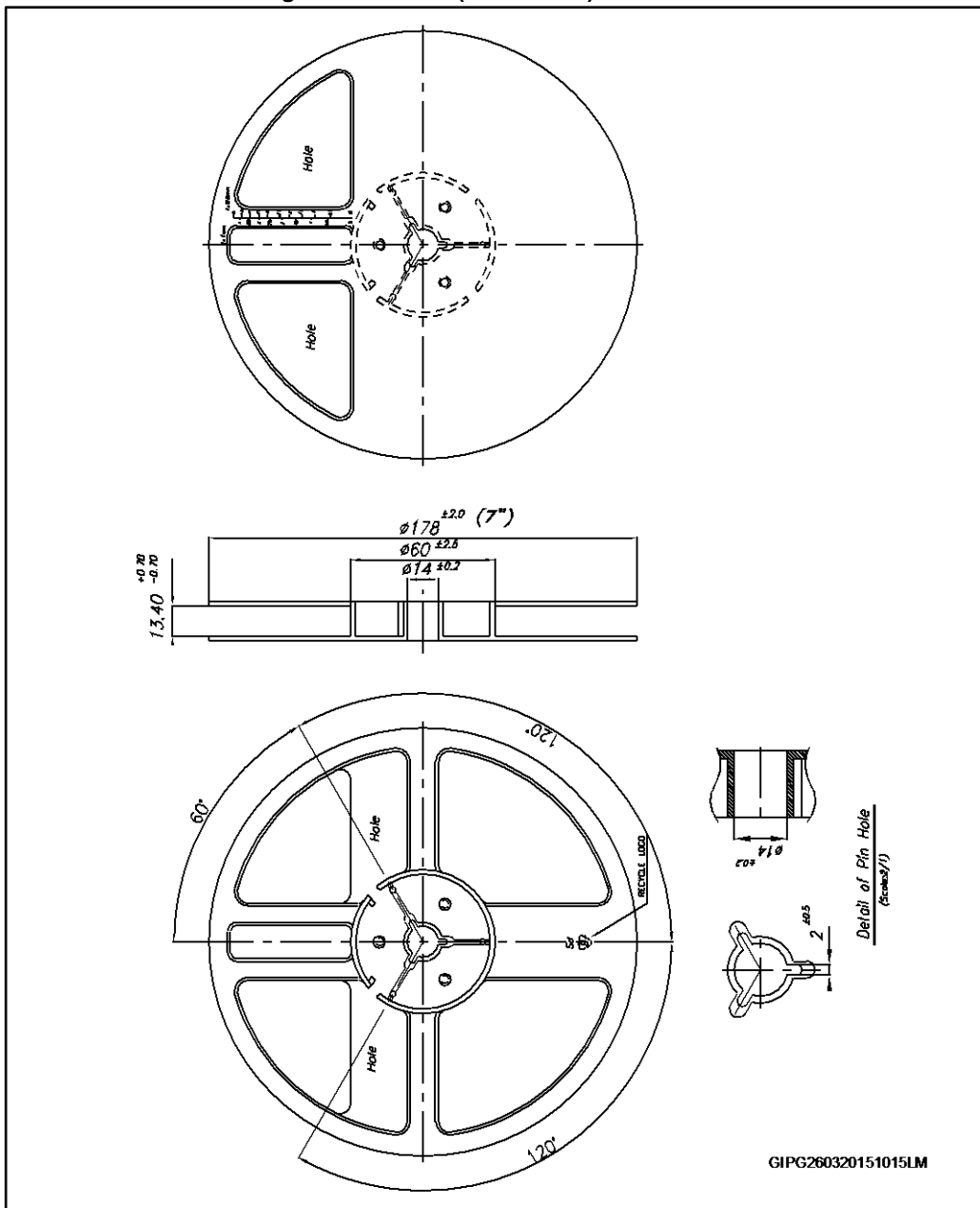


Figure 17: QFN20 (1.8x3.2 mm) reel outline



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.

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