



STP4CMP

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

Features

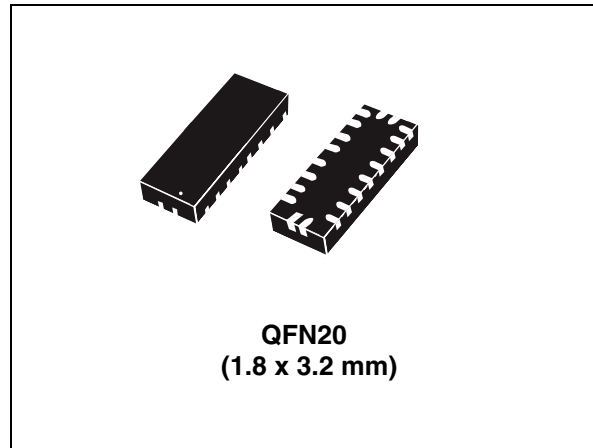
- Operating voltage range: $V_{CC}(\text{opr}) = 2.7\text{ V}$ to 5.5 V
- Full RGB function support
- 4-channel LED driver with individual ON/OFF control directly from input pins
- Individual programmable output current for the 4 channels through 4 external resistors with a max. capability of 30 mA
- 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 (1.8 x 3.2 mm) package

Applications

- Mobile phone display backlighting
- RGB LED indicator drivers

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 - 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 C1P and C1N, operates to regulate the V_{OUT} with a clamping voltage at typ. 5 V . The tiny QFN20 (1.8 x 3.2 mm) package allows the device to be also used for applications with space limitation.

Table 1. Device summary

Order code	Package	Packaging
STP4CMPQTR	QFN20	Tape and reel

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1 Schematic

Figure 1. Application schematic

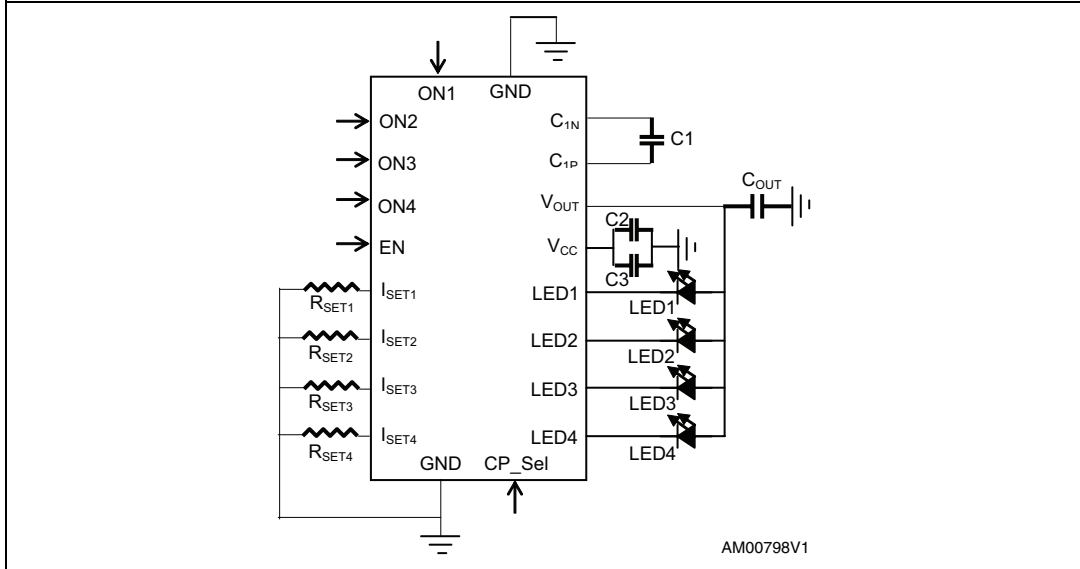


Figure 1 shows the typical application diagram with the external components. To ensure an optimal charge pump performance, it is highly recommended that the bucket capacitor, C1, and the output capacitor, C_{OUT}, to be placed as close as possible to the pins.

Table 2. Typical external components

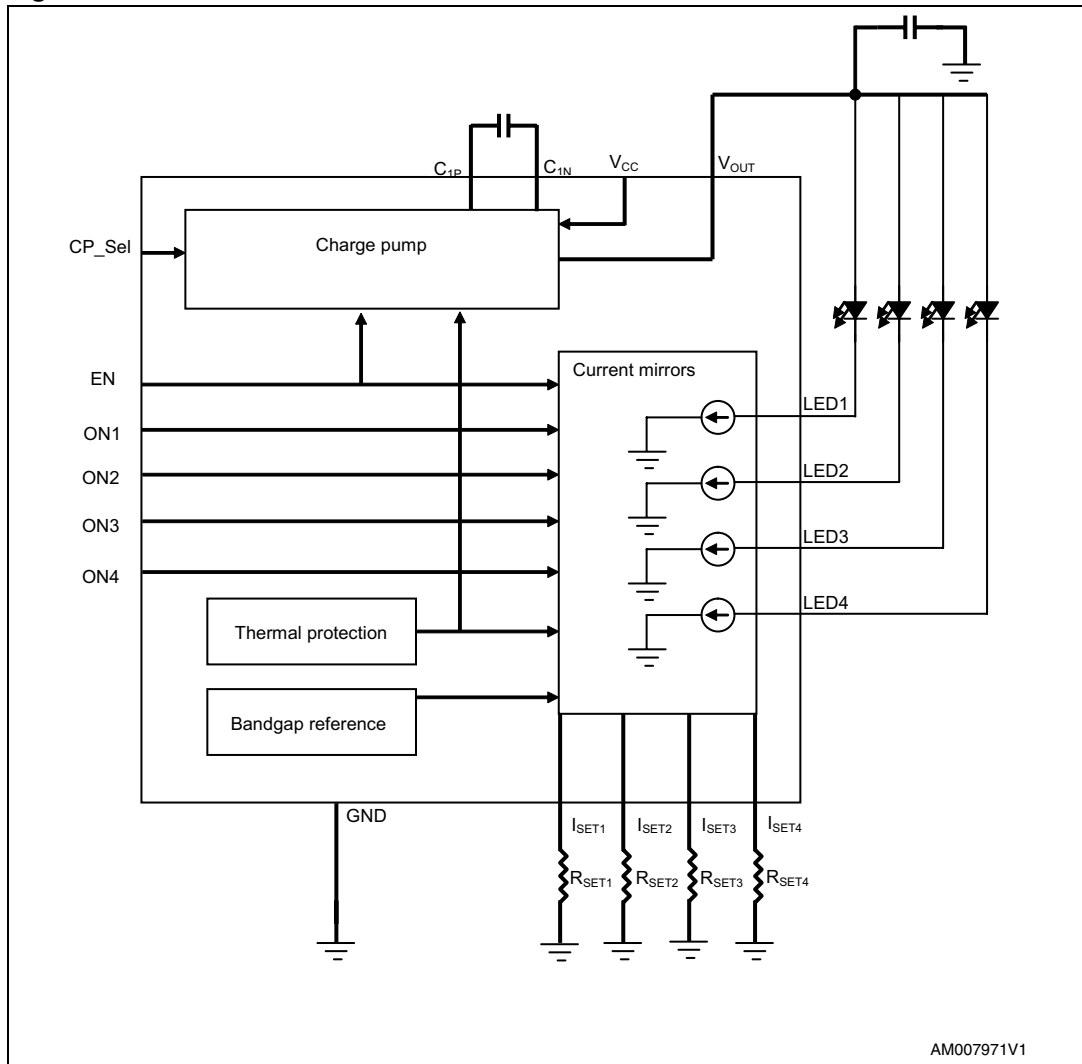
Component	Manufacturer	Part number	Value	Size
C1- C _{OUT}	MURATA	GRM155R61A105KE15D	1 μF / 10 V	0402
	TDK	C1005X5R1A105MT		
C2	MURATA	GRM188R60J106ME84	10 μF / 6.3 V	0603
	TDK	C1608X5R0J106MT		
C3	MURATA	GRM155R60J104KA01D	100 nF	0402
	TDK	C1005X5R1C104KT		
R _{SET1-4} ⁽¹⁾	Tyco	CPF0402B976RE1	976 Ω	0402
LED1-4 ⁽²⁾				

1. R_{SET1-4}: 649 Ω - 7.87 kΩ according to the desired output current from each channel.

2. LED1-4: typ. forward voltage of 3.8 V.

Note: 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



AM007971V1

2 Pin configuration

Figure 3. Pin connection (top through view)

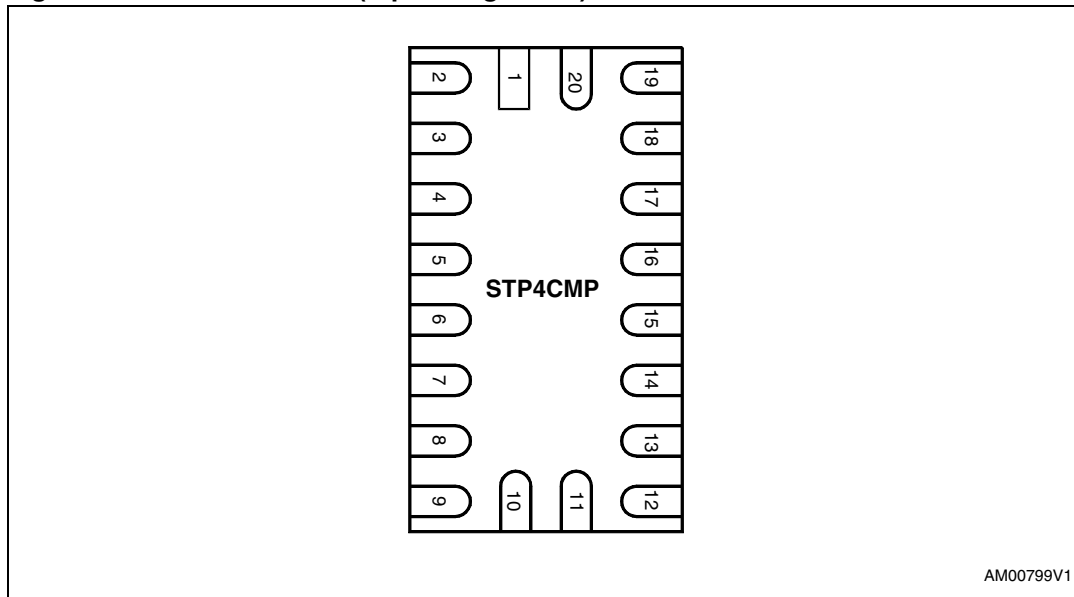


Table 3. Pin description

Pin number	Symbol	Name and function
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

Table 3. Pin description (continued)

Pin number	Symbol	Name and function
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	V
V _{OUT}	Output voltage	- 0.3 to +6	V
LED ₁₋₄ ; ISET ₁₋₄	Current setting	- 0.3 V to 2	V
ESD	Machine model	± 200	V
	Human body model (MIL STD_883)	±1500	
	Charged device model	± 500	
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

Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied.

Table 5. Recommended operating conditions

Symbol	Parameter	Value			Unit
		Min.	Typ.	Max.	
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	33	-		µs
V _{fw}	LED forward voltage		-	3.8	V

Table 6. Thermal data

Symbol	Parameter	Value	Unit
R _{thJA} ⁽¹⁾	Junction to ambient thermal resistance	70	°C/W

1. This parameter corresponds to the PCB board, 4-layers with 1inch² of cooling area.

4 Electrical characteristics

$V_{CC}=3.3V$, $V_{EN}=V_{ON1}=V_{ON2}=V_{ON3}=V_{ON4}=V_{CC}$, $V_{CP_SEL}=V_{CC}$, $R_{SET1}=R_{SET2}=R_{SET3}=R_{SET4}=649\ \Omega$, $C1=1\ \mu F$, typical values are at $T_A=25^\circ C$, unless otherwise specified.

Table 7. Electrical characteristics

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_{CC}	Supply voltage		2.7		5.5	V
V_{cp_clamp}	Charge pump clamp voltage	$2.7\ V \leq V_{CC} < 3.1\ V$; $V_{CP_sel} = V_{CC}$; $I_{OUT} \leq 40\ mA$		5		V
		$V_{CC} > 3.1\ V$; $V_{CP_sel} = V_{CC}$; $I_{OUT} \leq 120\ mA$		5		
T_{cp_start}	Charge pump startup time	From CP_sel low to high transition to CP reaches steady-state at 5 V			10	ms
$I_{LED1,2,3,4}$	LED sink current for each channel	$R_{setx} = 649\ \Omega$ at $V_{LEDx}=0.9\ V$; $V_{CC} > 3.1\ V$	27.9	30	32.1	mA
		$R_{setx} = 7.87\ k\Omega$ at $V_{LEDx} = 0.9\ V$; $V_{CC} \geq 3.1\ V$	2.33	2.5	2.68	mA
ΔI_{LED}	Output current error between each channel	$R_{set1}=R_{set2}=R_{set3}=R_{set4}$ $T_A = 25\ ^\circ C$		± 1	± 4	%
V_{IH}	High level input voltage		2.0			V
V_{IL}	Low level input voltage				0.8	V
I_{CC}	Supply operating current	$V_{ON1}=V_{ON2}=V_{ON3}=V_{ON4}=GND$; no load; $V_{CC}=5.5\ V$ (charge pump disabled); $V_{CP_SEL}=GND$, $R_{set1}=R_{set2}=R_{set3}=R_{set4}=7.87\ k\Omega$		3.6		mA
		$V_{ON1}=V_{ON2}=V_{ON3}=V_{ON4}=GND$; no load; $V_{CC}=5.5\ V$ (charge pump disabled); $V_{CP_SEL}=GND$, $R_{set1}=R_{set2}=R_{set3}=R_{set4}=649\ \Omega$		1.7		
		$V_{ON1}=V_{ON2}=V_{ON3}=V_{ON4}=GND$; no load; $V_{CC}=3.3\ V$ (charge pump disabled); $V_{CP_SEL}=V_{CC}$; $R_{set1}=R_{set2}=7.87\ k\Omega$		4.5		
		$V_{ON1}=V_{ON2}=V_{ON3}=V_{ON4}=GND$; no load; $V_{CC}=3.3\ V$ (charge pump disabled); $V_{CP_SEL}=V_{CC}$; $R_{set1}=R_{set2}=R_{set3}=R_{set4}=649\ \Omega$		17.2		

Table 7. Electrical characteristics (continued)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$I_{SHUTDOWN}$	Supply current during power-down	$V_{EN}=V_{ON1}=V_{ON2}=V_{ON3}=V_{ON4}=V_{CP_SEL}=0\text{ V}$			5	μA
T_{SD}	Thermal shutdown			150		$^{\circ}\text{C}$
T_{HS}	Thermal shutdown hysteresis			15		$^{\circ}\text{C}$

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 a LED is connected. This constant current is defined or programmed by the value of the resistor at I_{SETX} pin.

5.1 Enable pin (EN)

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

5.2 LED turn-on pin (ONx)

When the EN pin is pulled high, the STP4CMP provides the flexibility to control the turning-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 a minimum T_{ON}/T_{OFF} of 33 µs. An internal pull-down of 300 kΩ is present at these pins.

5.3 Programmable output current

The LED currents at 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 governed by this equation:

Equation 1

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

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 at 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 is able to maintain regulation at 5 V when the total current drawn from it (at 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 (at V_{OUT} pin) must be lowered to ≤ 40 mA.

5.5 Thermal protection

The thermal protection circuit ensures 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. Eff. vs. V_{IN} , $I_{OUT} = 10\text{ mA}$

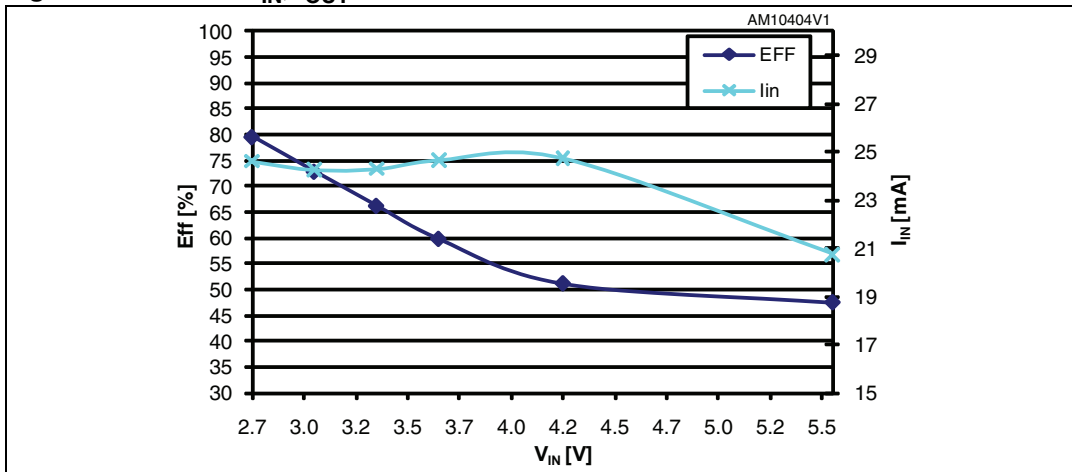


Figure 5. Eff. vs. V_{IN} , $I_{OUT} = 60\text{ mA}$

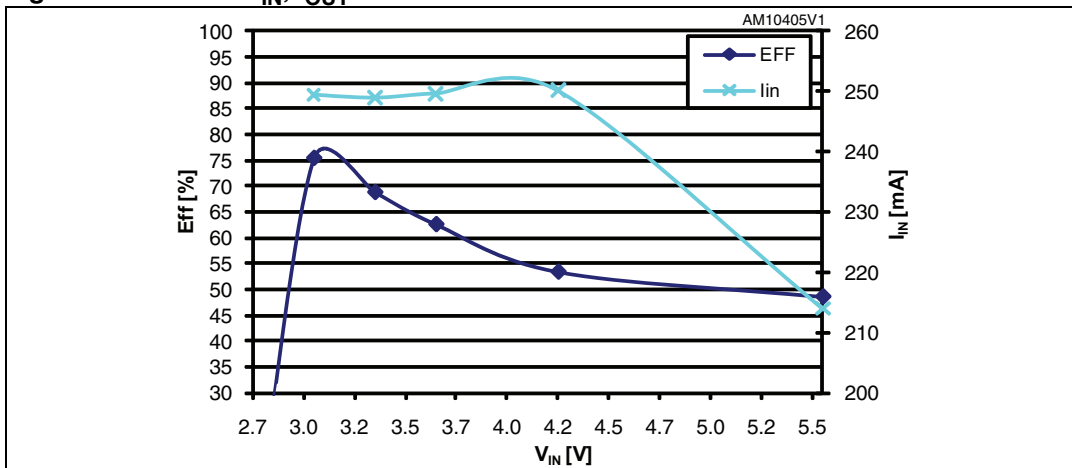


Figure 6. V_{OUT} vs. V_{IN}

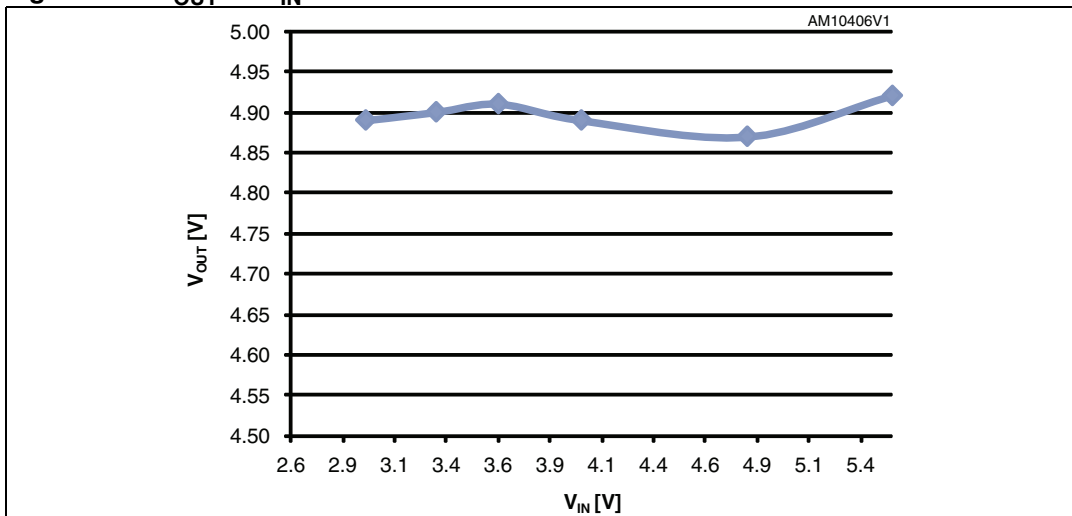


Figure 7. PWM modulation CH1-2

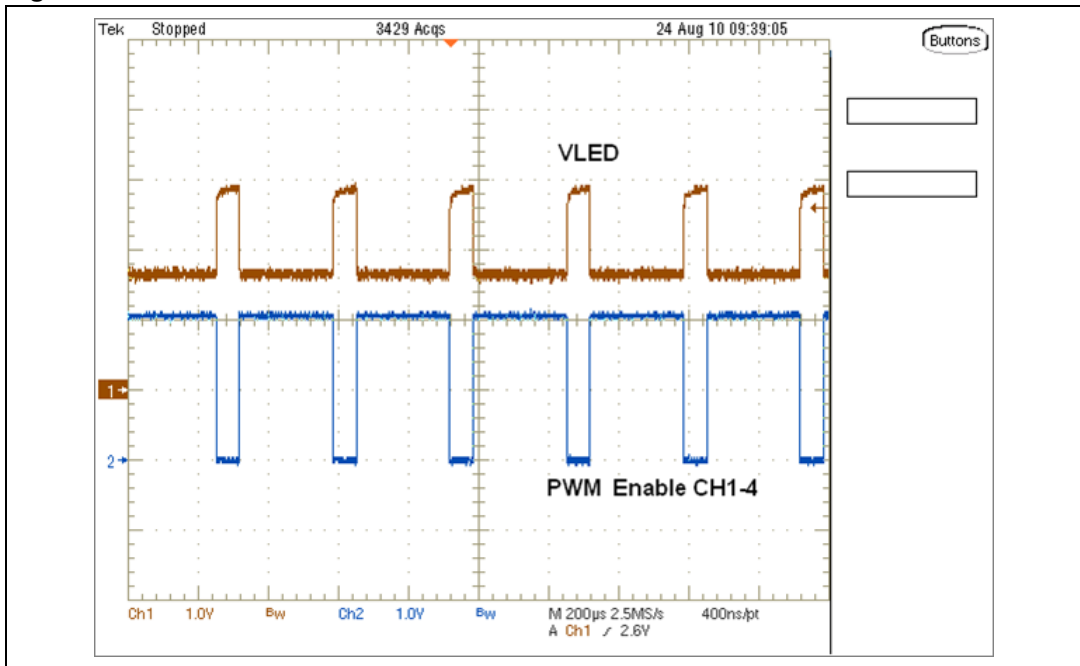
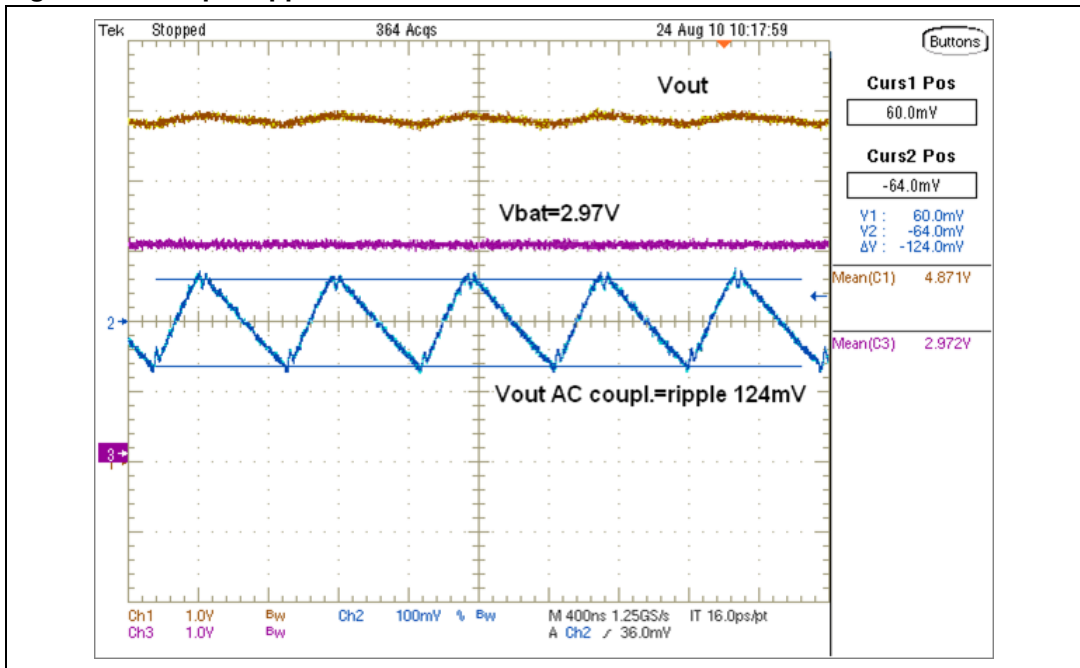


Figure 8. Output ripple



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

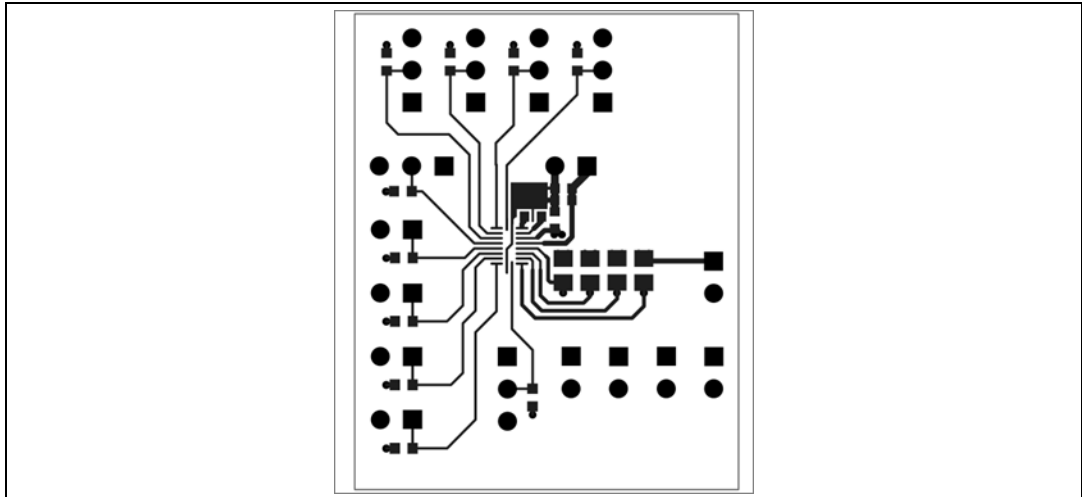


Figure 10. Bottom layer

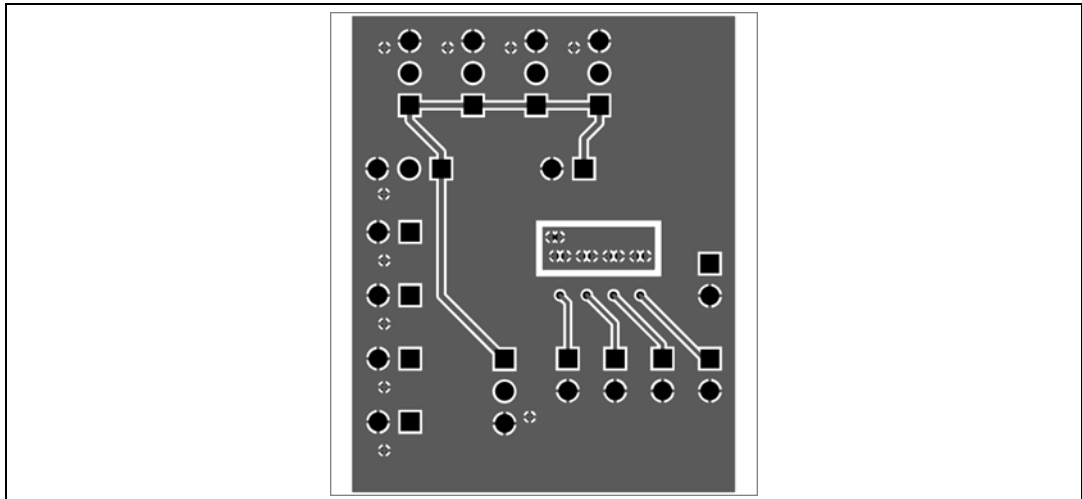
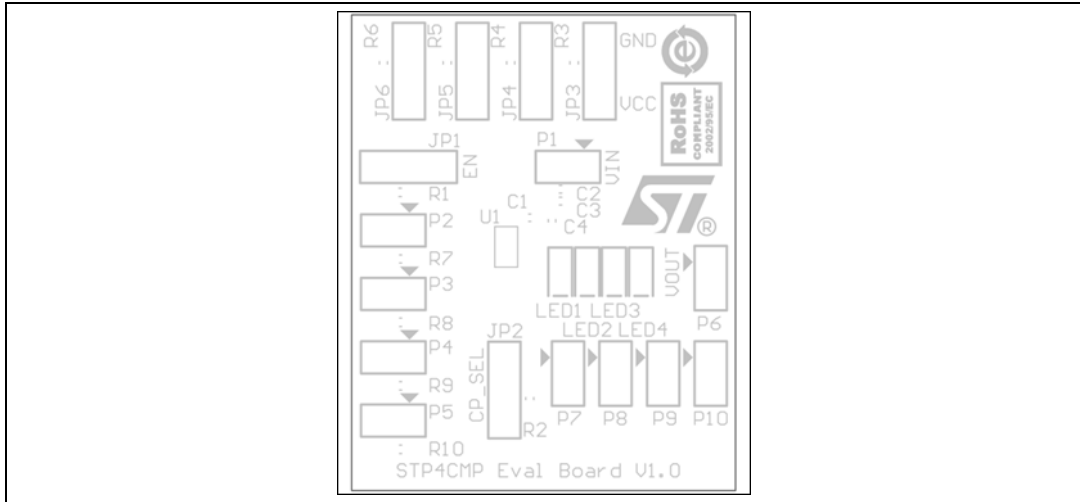
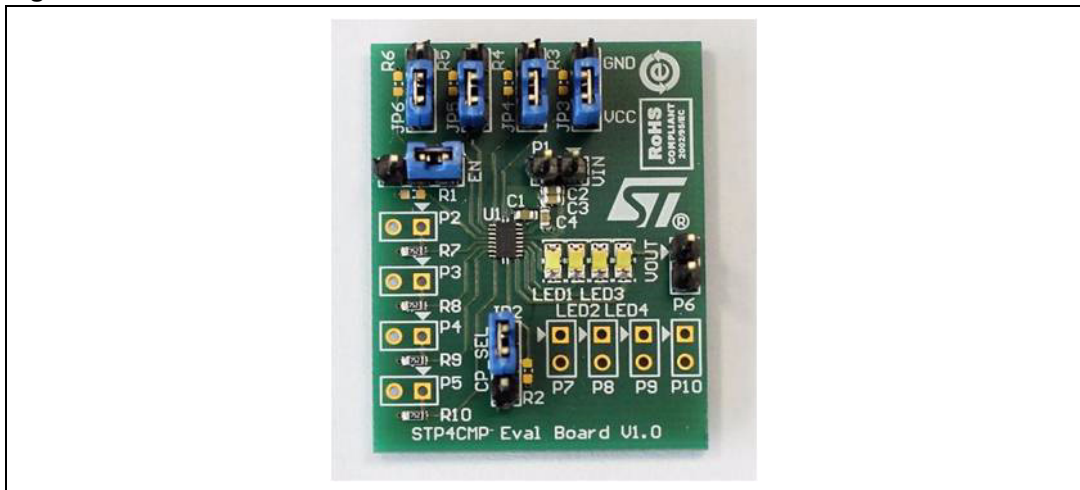


Figure 11. Top overlay



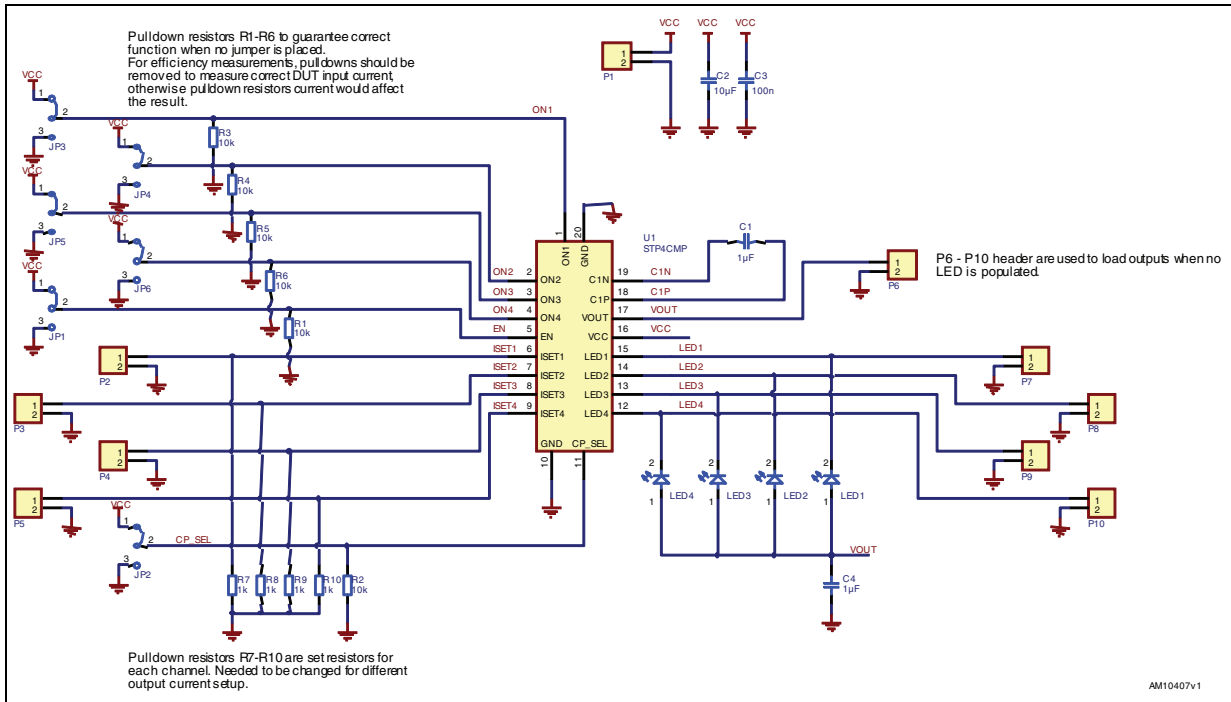
7.2 Demonstration board

Figure 12. Demonstration board



7.3 Demonstration board schematic

Figure 13. Demonstration board schematic



8 Package mechanical data

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.

Figure 14. Package outline for QFN20 (1.8 x 3.2 x 0.5 mm) - pitch 0.4 mm

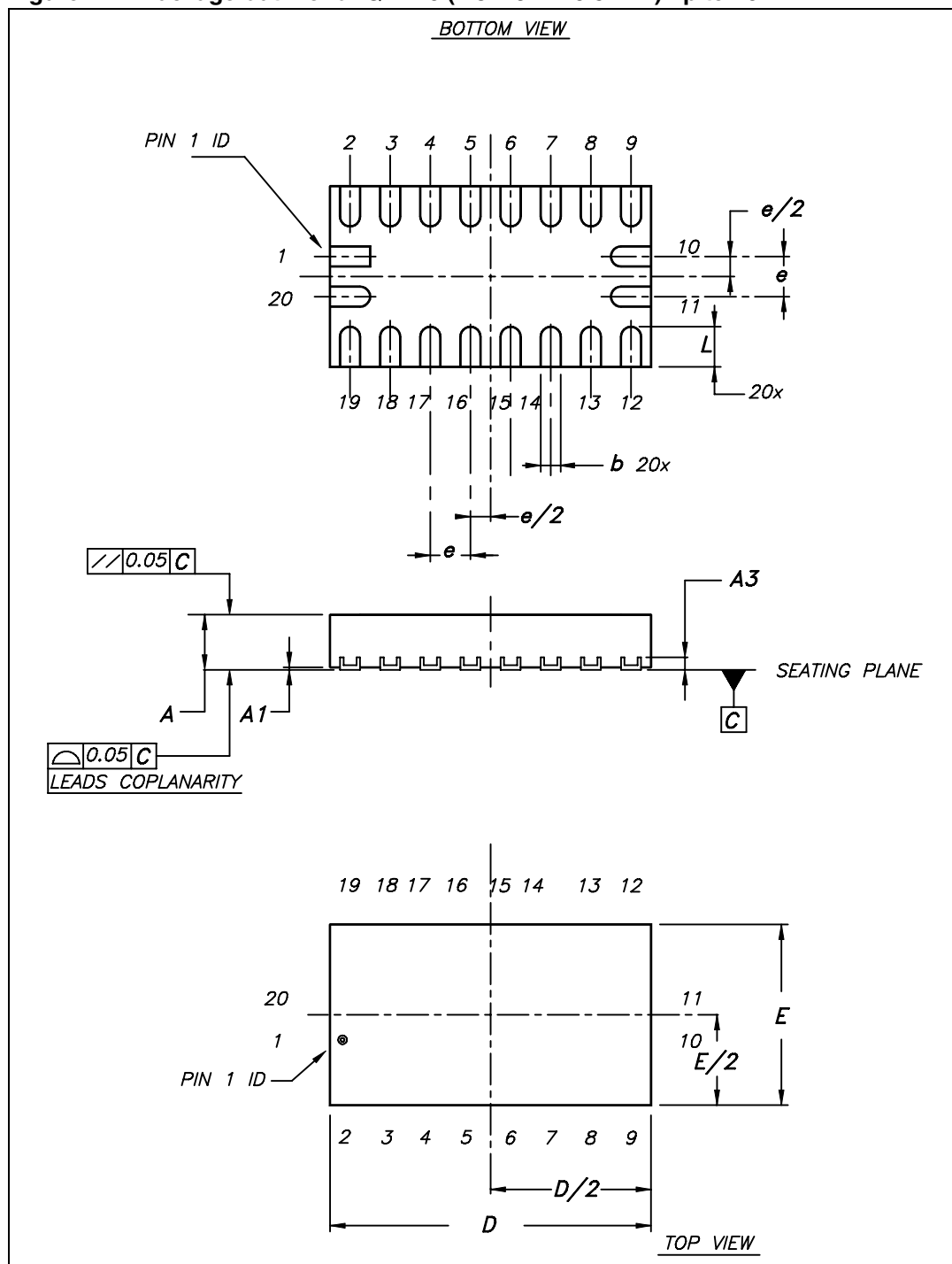
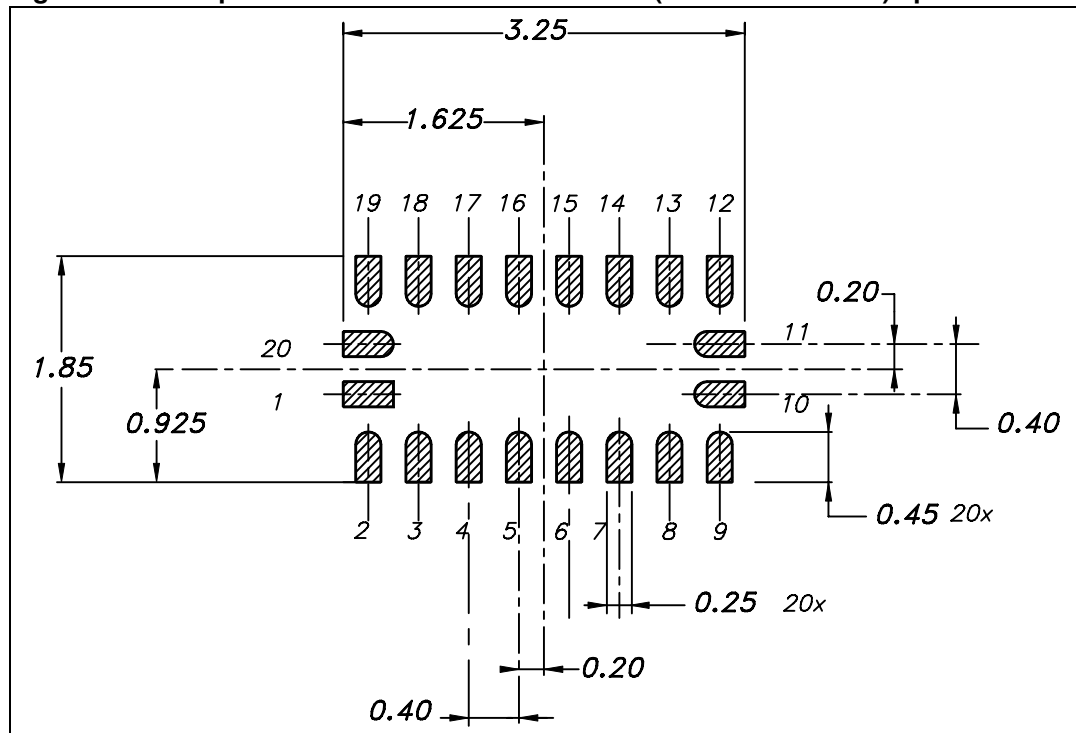


Table 8. Mechanical data for QFN20 (1.8 x 3.2 x 0.5 mm) - pitch 0.4 mm

Symbol	Millimeters		
	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. Footprint recommendations for QFN20 (1.8 x 3.2 x 0.5 mm) - pitch 0.4 mm



- 1. Drawing not to scale.
- 2. Dimensions are in millimeters.

Figure 16. Carrier tape for QFN20 (1.8 x 3.2 x 0.5 mm) - pitch 0.4 mm

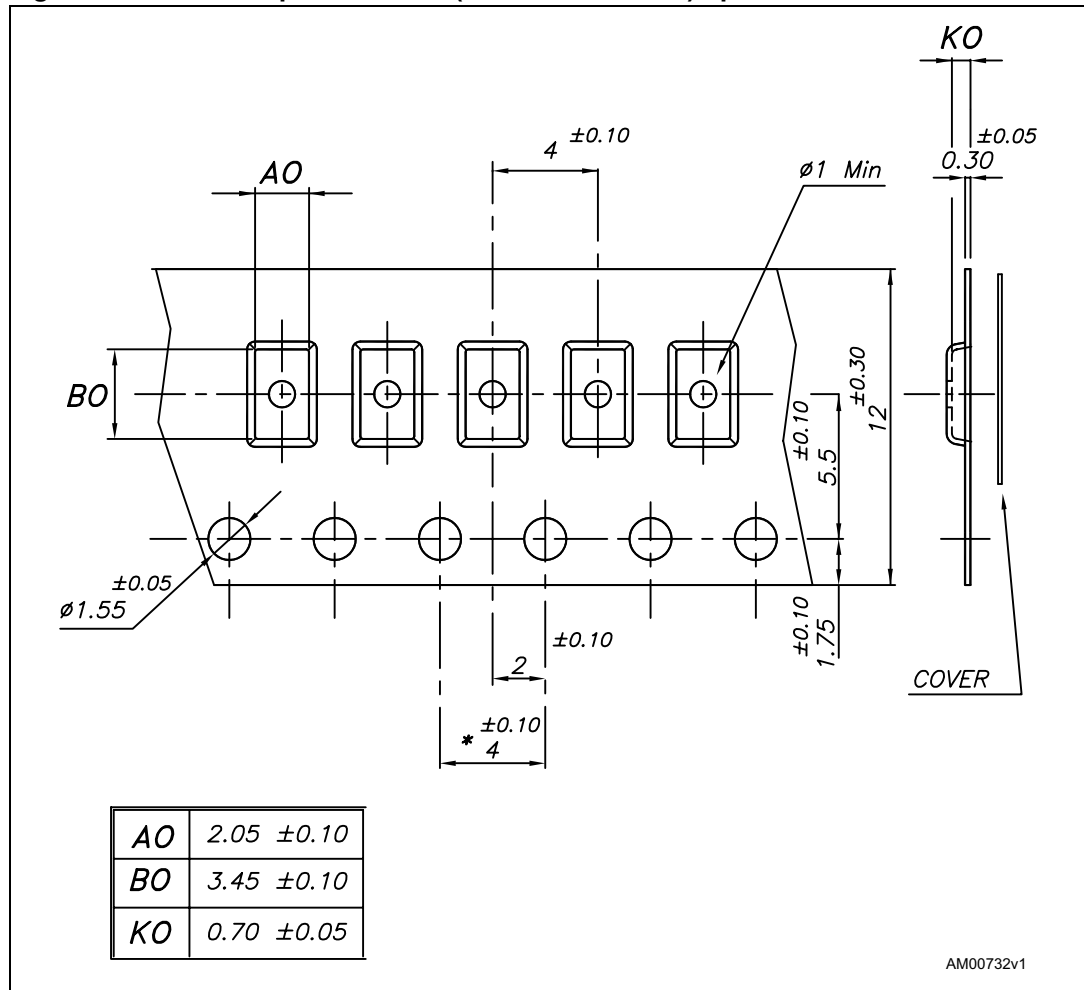
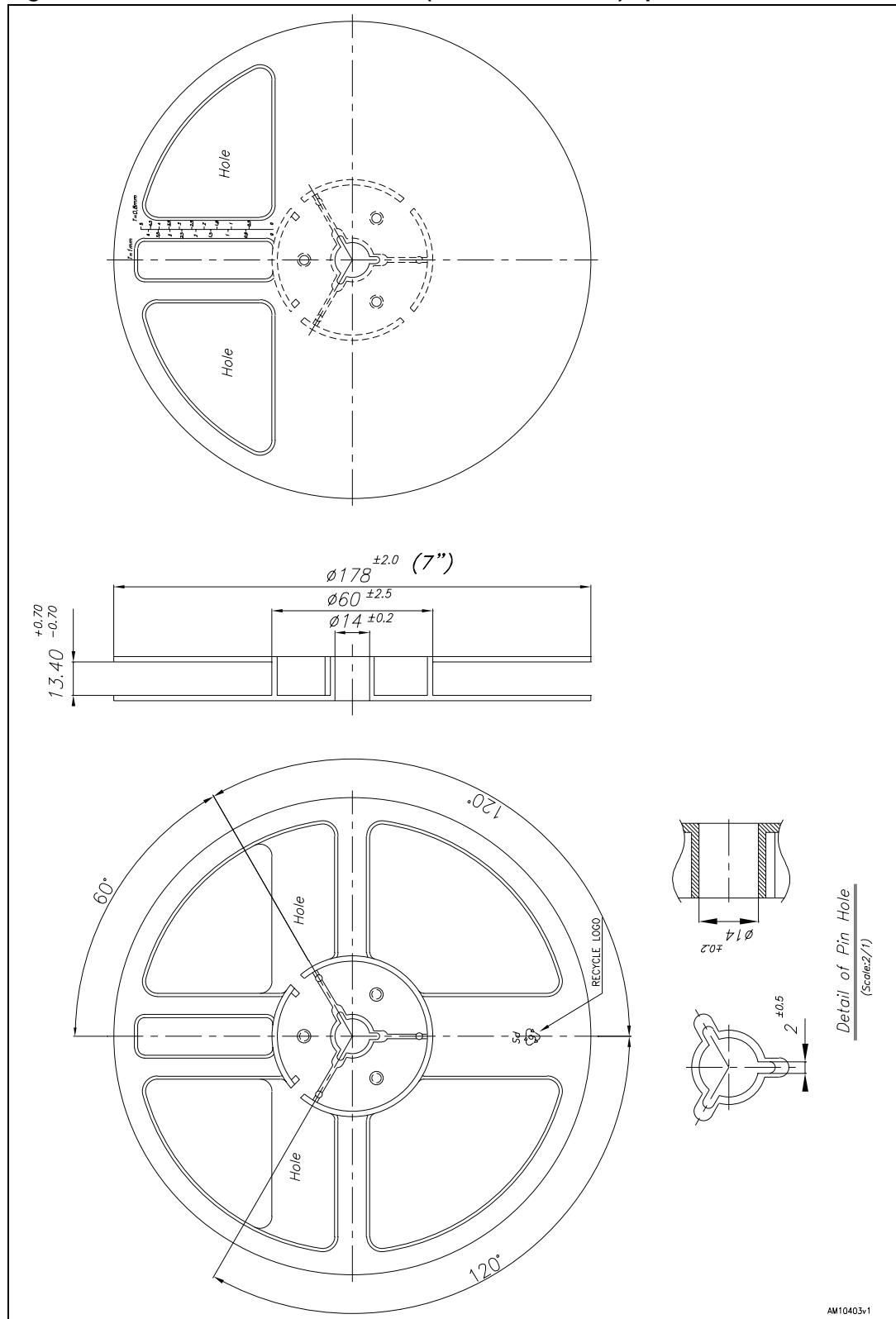


Figure 17. Reel information for QFN20 (1.8 x 3.2 x 0.5 mm) - pitch 0.4 mm



1. Drawing not to scale.
2. Dimensions are in millimeters

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 on page 14 .

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