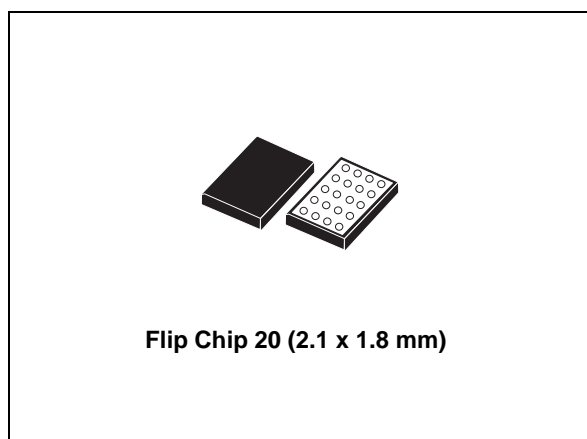


## 800 mA 2.5 MHz, high efficiency dual mode buck-boost DC-DC converter

Datasheet - production data



### Features

- Operating input voltage range from 2.3 V to 5.5 V
- $\pm 2\%$  output voltage tolerance over process and temperature variations
- Bypass power save function
- Selectable output voltage with dedicated VSEL pin
- Very fast line and load transients
- 2.5 MHz switching frequency
- Power save mode (PS) at light load
- Typical efficiency higher than 90%
- 50  $\mu$ A max. quiescent current
- Flip Chip 20 bumps 0.4 mm pitch 2.1 x 1.8 mm

### Applications

- Memory card supply
- Cellular phones

### Description

The STBB2 is a fixed frequency, high efficiency, buck-boost DC-DC converter able to provide output voltages from 1.2 V to 4.5 V starting from input voltage of 2.3 V to 5.5 V. The device can operate with input voltages higher than, equal to, or lower than the output voltage making the product suitable for single Li-Ion, multi-cell alkaline or NiMH applications where the output voltage is within the battery voltage range. The low- $R_{DS(on)}$  N-channel and P-channel MOSFET switches are integrated and contribute to achieving high efficiency. The MODE pin allows selection between auto mode and forced PWM mode, therefore benefiting from either lower power consumption or best dynamic performance. The bypass function allows battery power saving. In this operating mode the high-side switches are turned on so that the output voltage is equal to the input voltage; in this condition the current consumption is reduced to a maximum of 5  $\mu$ A. The device includes also soft-start control, thermal shutdown, and current limit. The STBB2 is packaged in Flip Chip 20 bumps with 0.4 mm pitch.

**Table 1. Device summary**

| Order codes | Markings | Packaging     | Output voltages |
|-------------|----------|---------------|-----------------|
| STBB2JAD-R  | BB2      | Tape and reel | Adjustable      |
| STBB2J29-R  | B229     | Tape and reel | 2.9 V / 3.4 V   |
| STBB2J33-R  | B230     | Tape and reel | 3.0 V / 3.3 V   |

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# 1 Application schematic

Figure 1. Application schematic for fixed version

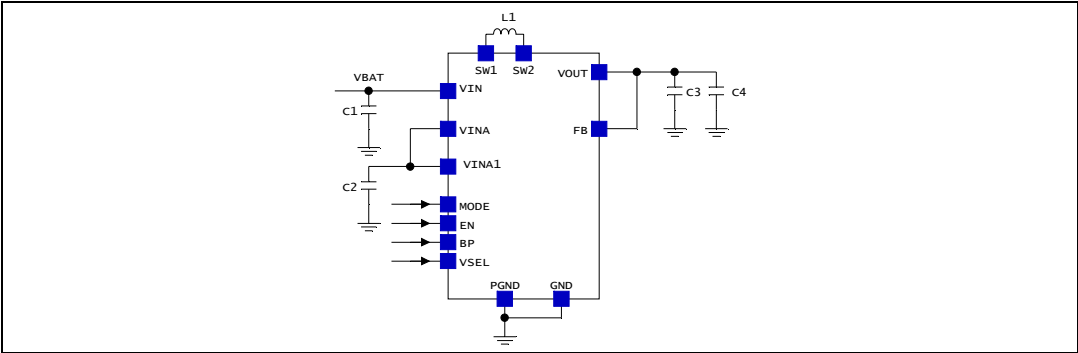


Figure 2. Application schematic for adjustable version

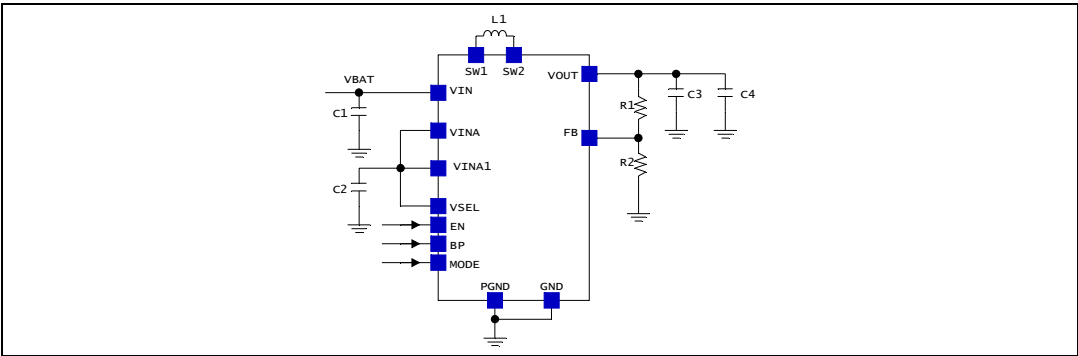


Table 2. Typical external components

| Component        | Manufacturer   | Part number     | Value  | Size               |
|------------------|--|-----------------|--------|--------------------|
| C1               | Murata   | GRM188R60J106M  | 10 μF  | 0603               |
|                  | TDK-EPC  | C1608X5R0J106M  |        |                    |
| C2               | Murata   | GRM188R61C105K  | 1 μF   | 0603               |
| C3, C4           | Murata   | GRM188R60J106M  | 10 μF  | 0603               |
|                  | TDK-EPC  | C1608X5R0J106M  |        |                    |
| L <sup>(1)</sup> | Murata   | LQH3NPN1R0NM0   | 1.0 μH | 3 x 3 x 1.4 mm     |
|                  | Coilcraft  | LPS3015-102ML   |        | 3.0 x 3.0 x 1.5 mm |
|                  | TDK-EPC  | VLS252010ET1R0N |        | 2.5 x 2 x 1 mm     |
| R1               | Depending on the output voltage, 0 Ω for fixed output version      |                 |        |                    |
| R2               | Depending on the output voltage, not used for fixed output version |                 |        |                    |

1. Inductor used for the maximum power capability. Optimized choice can be done according to the application conditions (see [Section 8](#)).

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

## 2 Block diagram

Figure 3. Block diagram adjustable

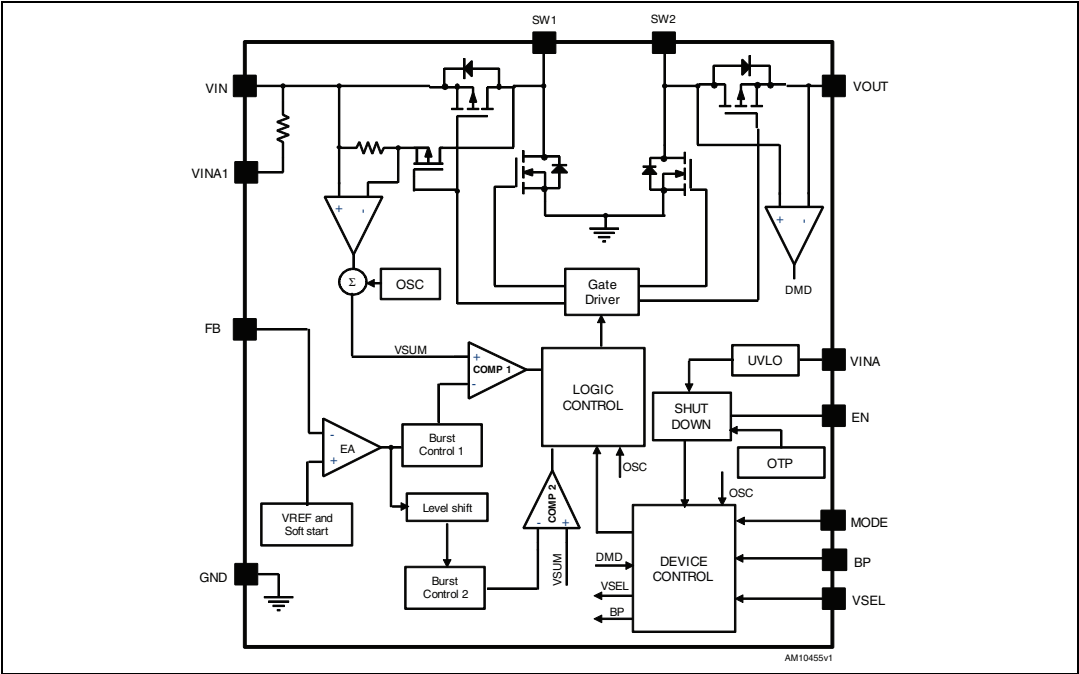
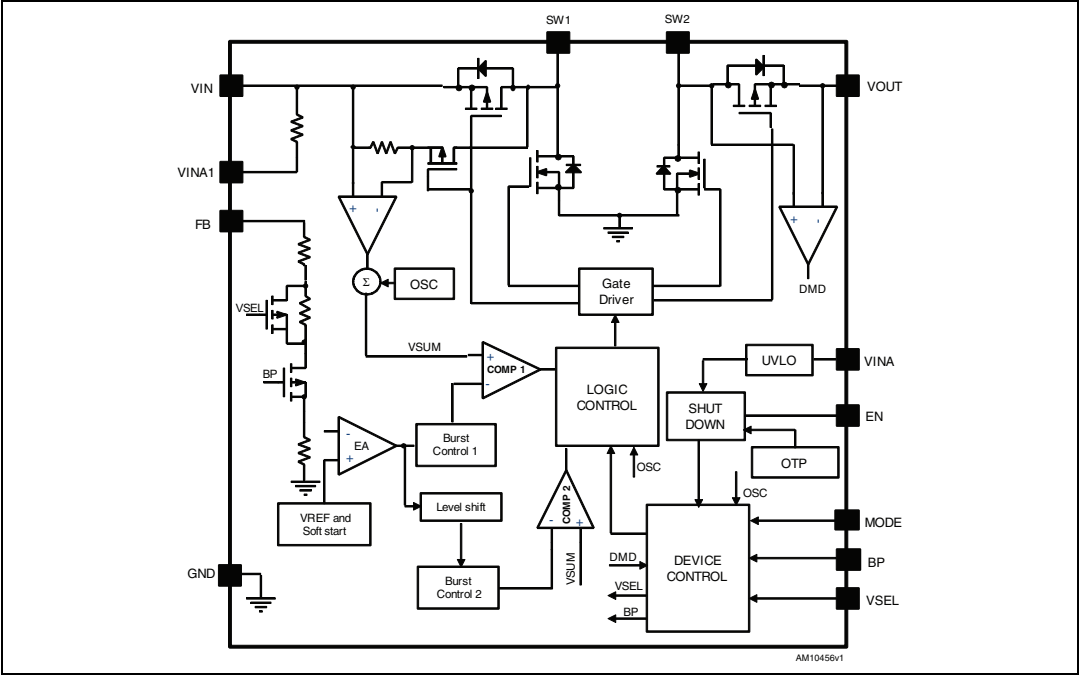


Figure 4. Block diagram fixed



### 3 Absolute maximum ratings

**Table 3. Absolute maximum ratings**

| Symbol             | Parameter                              | Value       | Unit |
|--------------------|--|-------------|------|
| VIN, VINA, VINA1   | Supply voltage                         | -0.3 to 7.0 | V    |
| SW1, SW2           | Switching nodes                        | -0.3 to 7.0 | V    |
| VOUT               | Output voltage                         | -0.3 to 7.0 | V    |
| MODE, EN, BP, VSEL | Logic pins                             | -0.3 to 7.0 | V    |
| FB                 | Feedback pin                           | -0.3 to 6.0 | V    |
| ESD                | Human body model                       | ± 2000      | V    |
|                    | Charged device model                   | ± 500       |      |
| T <sub>AMB</sub>   | Operating ambient temperature          | -40 to 85   | °C   |
| T <sub>J</sub>     | Maximum operating junction temperature | 150         | °C   |
| T <sub>STG</sub>   | 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 4. Thermal data**

| Symbol            | Parameter                           | Value             | Unit |
|-------------------|-------------------------------------|-------------------|------|
| R <sub>thJA</sub> | Thermal resistance junction-ambient | 80 <sup>(1)</sup> | °C/W |

1. PCB condition: JEDEC standard 2s2P(4-layer).

## 4 Pin configuration

Figure 5. Pin connections (top view)

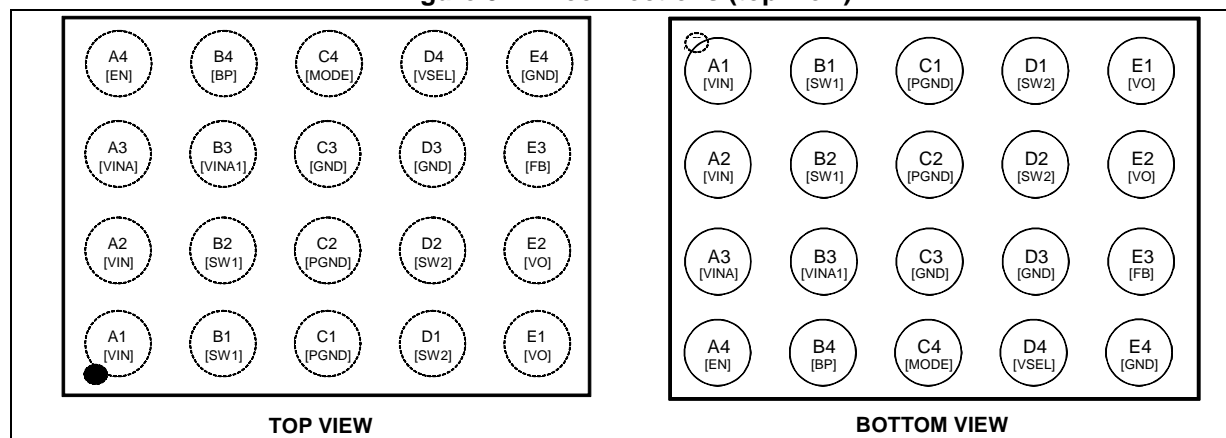


Table 5. Pin description

| Pin name | Pin n°     | Description   |
|----------|------------|---|
| VOUT     | E1, E2     | Output voltage  |
| SW2      | D1, D2     | Switch pin - internal switches C and D are connected to this pin. Connect inductor between SW1 to SW2   |
| PGND     | C1, C2     | Power ground  |
| SW1      | B1, B2     | Switch Pin - internal switches A and B are connected to this pin. Connect inductor between SW1 and SW2  |
| EN       | A4         | Enable pin. Connect this pin to GND or a voltage lower than 0.4 V to shut down the IC. A voltage higher than 1.2 V is required to enable the IC. Do not leave this pin floating.  |
| MODE     | C4         | When in normal operation, the MODE pin selects between auto mode and forced PWM mode. If the MODE pin is low, the STBB2 automatically switches between pulse-skipping and standard PWM according to the load level. If the MODE pin is pulled high, the STBB2 works always in PWM mode. Do not leave this pin floating. |
| VINA     | A3         | Supply voltage for control stage.   |
| VINA1    | B3         | A 100 $\Omega$ resistor is internally connected between VIN and VINA1. Connecting a 1 $\mu$ F capacitor between VINA1 and GND, an input filter is realized suitable to provide a clean supply to VINA.  |
| VIN      | A1, A2     | Power input voltage. Connect a ceramic bypass capacitor (10 $\mu$ F min.) between this pin and PGND   |
| GND      | C3, D3, E4 | Signal ground   |
| FB       | E3         | Feedback voltage. For the fixed version this pin must be connected to $V_{OUT}$ .   |
| BP       | B4         | Bypass mode selection.<br>When EN is high, connecting this pin to a voltage higher than 1.2 V, the device works in bypass mode. A voltage lower than 0.4 V is required to disable bypass mode. In bypass mode VIN is shorted to $V_{OUT}$ through the internal switches. Do not leave this pin floating.                |
| VSEL     | D4         | Selection of output voltage for fixed versions (0 $V_{OUT}$ = 2.9 V / 1 $V_{OUT}$ = 3.4 V), (0 $V_{OUT}$ = 3.0 V / 1 $V_{OUT}$ = 3.3 V).<br>This feature is not present in the adjustable version where the VSEL pin must be connected to VINA. Do not leave this pin floating.   |

## 5 Electrical characteristics

- 40 °C < T<sub>A</sub> < 85 °C, V<sub>IN</sub> = 3.6 V; V<sub>OUT</sub> = 3.4 V, V<sub>EN</sub> = V<sub>IN</sub>, V<sub>BP</sub> = 0 V; typical values are at T<sub>A</sub> = 25 °C, unless otherwise specified.

**Table 6. Electrical characteristics**

| Symbol                 | Parameter   | Test conditions  | Min. | Typ. | Max. | Unit |
|------------------------|---|--|------|------|------|------|
| <b>General section</b> |   |  |      |      |      |      |
| V <sub>IN</sub>        | Operating power input voltage range                               |  | 2.3  |      | 5.5  | V    |
| I <sub>q</sub>         | Shutdown mode   | V <sub>EN</sub> = 0 V  |      | 0.5  | 2    | μA   |
|                        | Pulse-skipping  | I <sub>OUT</sub> = 0 A, V <sub>MODE</sub> = 0  |      | 35   | 50   | μA   |
|                        | PWM mode  | I <sub>OUT</sub> = 0 A, V <sub>MODE</sub> = V <sub>IN</sub>  |      | 8    | 10   | mA   |
|                        | Bypass mode   | V <sub>BP</sub> = V <sub>IN</sub> ; I <sub>OUT</sub> = 0 A;<br>V <sub>MODE</sub> = 0, V <sub>IN</sub> = 2.3 to 5.5 V                           |      | 5    | 10   | μA   |
| V <sub>UVLO</sub>      | Undervoltage lockout threshold                                    | V <sub>IN</sub> rising; V <sub>MODE</sub> = V <sub>IN</sub> ;<br>I <sub>OUT</sub> = 100 mA   |      | 1.6  | 2.2  | V    |
|                        |   | V <sub>IN</sub> falling; V <sub>MODE</sub> = V <sub>IN</sub> ;<br>I <sub>OUT</sub> = 100 mA  |      | 1.5  | 2    |      |
| f <sub>SW</sub>        | Switching frequency   |  | 2    | 2.5  | 3    | MHz  |
| I <sub>OUT</sub>       | Continuous output current <sup>(1)</sup>                          | 2.5 V ≤ V <sub>IN</sub> ≤ 5.5 V  | 800  |      |      | mA   |
| I <sub>PK</sub>        | Switch current limitation   |  | 2.3  | 2.5  | 2.7  | A    |
| I <sub>PS-PWM</sub>    | PS to PWM transition  |  |      | 300  |      | mA   |
|                        | PWM to PS transition  |  |      | 280  |      |      |
| h                      | Efficiency<br>(V <sub>IN</sub> = 3.6 V; V <sub>OUT</sub> = 3.4 V) | I <sub>OUT</sub> = 10 mA (PS mode)   |      | 85   |      | %    |
|                        |   | I <sub>OUT</sub> = 50 mA (PS mode)   |      | 90   |      |      |
|                        |   | I <sub>OUT</sub> = 150 mA (PWM)  |      | 90   |      |      |
|                        |   | I <sub>OUT</sub> = 250 mA (PWM)  |      | 91   |      |      |
|                        |   | I <sub>OUT</sub> = 500 mA (PWM)  |      | 92   |      |      |
|                        |   | I <sub>OUT</sub> = 800 mA (PWM)  |      | 92   |      |      |
| T <sub>ON</sub>        | Turn-on time <sup>(2)</sup>                                       | V <sub>EN</sub> from low to high;<br>I <sub>OUT</sub> = 10 mA  |      | 260  | 300  | μs   |
| T <sub>SHDN</sub>      | Thermal shutdown  |  |      | 150  |      | °C   |
|                        | Hysteresis  |  |      | 20   |      | °C   |
| <b>Output voltage</b>  |   |  |      |      |      |      |
| V <sub>OUT</sub>       | Output voltage range  |  | 1.2  |      | 4.5  | V    |
| %V <sub>OUT</sub>      | Output voltage accuracy in PWM mode                               | V <sub>IN</sub> = 2.5 to 5.5 V,<br>V <sub>MODE</sub> = V <sub>IN</sub> V <sub>SEL</sub> = GND/V <sub>IN</sub>                                  | -1.5 |      | +1.5 | %    |
|                        | Output voltage accuracy in power save mode                        | V <sub>IN</sub> = 2.5 to 5.5 V, V <sub>MODE</sub> = GND<br>V <sub>SEL</sub> = GND/V <sub>IN</sub> suitable output current to keep PS operation | -3   |      | +3   | %    |

Table 6. Electrical characteristics (continued)

| Symbol                | Parameter  | Test conditions                           | Min. | Typ.      | Max. | Unit       |
|-----------------------|--|---|------|-----------|------|------------|
| $V_{FB}$              | Feedback voltage accuracy                          | Adj version                               | 493  | 500       | 507  | mV         |
| $\%V_{OUT}$           | Maximum load regulation                            | $I_{LOAD}$ = from 10 mA to 800 mA         |      | $\pm 0.5$ |      | %          |
| $V_{OPP-PS}$          | Peak-to-peak ripple in PS mode                     | $I_{OUT}$ = 100 mA                        |      | 100       |      | mV         |
| $I_{LKFB}$            | FB pin leakage current                             | $V_{FB}$ = 5.5 V                          |      |           | 9    | $\mu A$    |
| <b>Logic inputs</b>   |  |   |      |           |      |            |
| $V_{IL}$              | Low-level input voltage (EN, MODE, BP, VSEL pins)  |   |      |           | 0.4  | V          |
| $V_{IH}$              | High-level input voltage (EN, MODE, BP, VSEL pins) |   | 1.2  |           |      | V          |
| $I_{LK-I}$            | Input leakage current (EN, MODE, BP, VSEL pins)    | $V_{EN}=V_{MODE}=V_{BP}=V_{SEL}$ = 5.5 V  |      | 0.01      | 1    | $\mu A$    |
| <b>Power switches</b> |  |   |      |           |      |            |
| $R_{DS(on)}$          | P-channel on-resistance                            |   |      | 130       | 350  | m $\Omega$ |
|                       | N-channel on-resistance                            |   |      | 130       | 350  | m $\Omega$ |
| $I_{LKG-P}$           | P-channel leakage current                          | $V_{IN} = V_{OUT} = 5.5$ V; $V_{EN} = 0$  |      |           | 1    | $\mu A$    |
| $I_{LKG-N}$           | N-channel leakage current                          | $V_{SW1} = V_{SW2} = 5.5$ V; $V_{EN} = 0$ |      |           | 1    | $\mu A$    |

1. Not tested in production. This value is guaranteed by correlation with  $r_{ds\_on}$ , peak current limit and operating input voltage.

2. Not tested in production.



## 6 Typical performance characteristics

Table 7. Table of graphs

|                        |  |           |
|------------------------|--|-----------|
| Maximum output current | vs. input voltage  | Figure 5  |
| Efficiency             | vs. output current (power save enabled, $V_{IN} = 2.5\text{ V}$ , $3.6\text{ V}$ , $4.5\text{ V}/V_{OUT} = 3.4\text{ V}$ )   | Figure 6  |
|                        | vs. output current (power save disabled, $V_{OUT} = 2.5\text{ V}$ , $3.6\text{ V}$ , $4.5\text{ V}/V_{OUT} = 3.4\text{ V}$ ) | Figure 7  |
|                        | vs. output current (power save enabled, $V_{IN} = 2.5\text{ V}$ , $3.6\text{ V}$ , $4.5\text{ V}/V_{OUT} = 2.9\text{ V}$ )   | Figure 8  |
|                        | vs. output current (power save disabled, $V_{OUT} = 2.5\text{ V}$ , $3.6\text{ V}$ , $4.5\text{ V}/V_{OUT} = 2.9\text{ V}$ ) | Figure 9  |
|                        | vs. input voltage power save enabled, $V_{OUT} = 3.4\text{ V}$ , $I_{OUT} = (10; 50; 150; 500; 800\text{ mA})$               | Figure 10 |
|                        | vs. input voltage power save disabled, $V_{OUT} = 3.4\text{ V}$ , $I_{OUT} = (10; 500; 1000; 2000\text{ mA})$                | Figure 12 |
|                        | vs. output current (PWM/Auto mode)   | Figure 13 |
| Waveforms              | Load transient response $V_{IN} < V_{OUT}$   | Figure 14 |
|                        | Load transient response $V_{IN} > V_{OUT}$   | Figure 15 |
|                        | Line transient response ( $V_{OUT} = 3.3\text{ V}$ , $I_{OUT} = 1500\text{ mA}$ )  | Figure 16 |
|                        | Startup after enable ( $V_{OUT} = 3.3\text{ V}$ , $V_{IN} = 2.3\text{ V}$ , $I_{OUT} = 300\text{ mA}$ )                      | Figure 17 |
|                        | Startup after enable ( $V_{OUT} = 3.3\text{ V}$ , $V_{IN} = 4.2\text{ V}$ , $I_{OUT} = 300\text{ mA}$ )                      | Figure 18 |

Figure 6. Maximum output current vs. input voltage

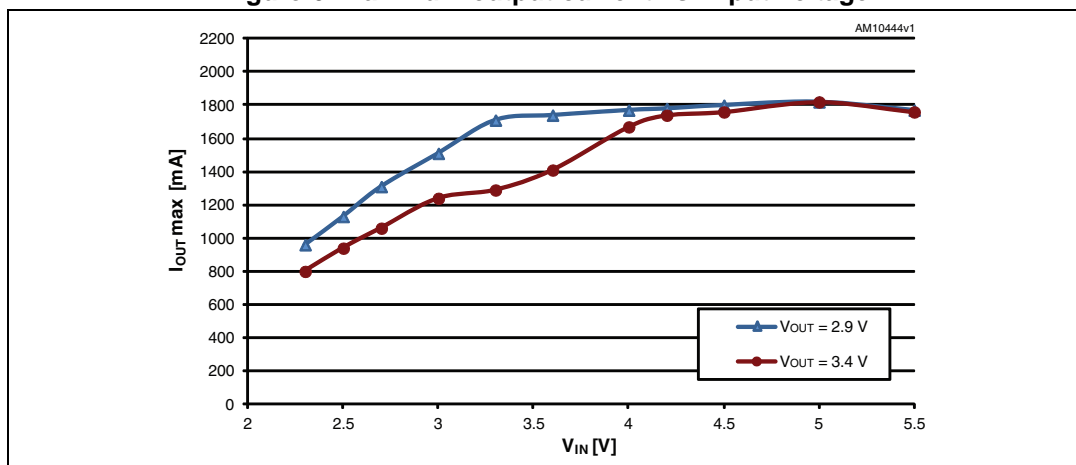


Figure 7. Efficiency vs. output current (power save mode enabled  $V_{OUT} = 3.4\text{ V}$ )

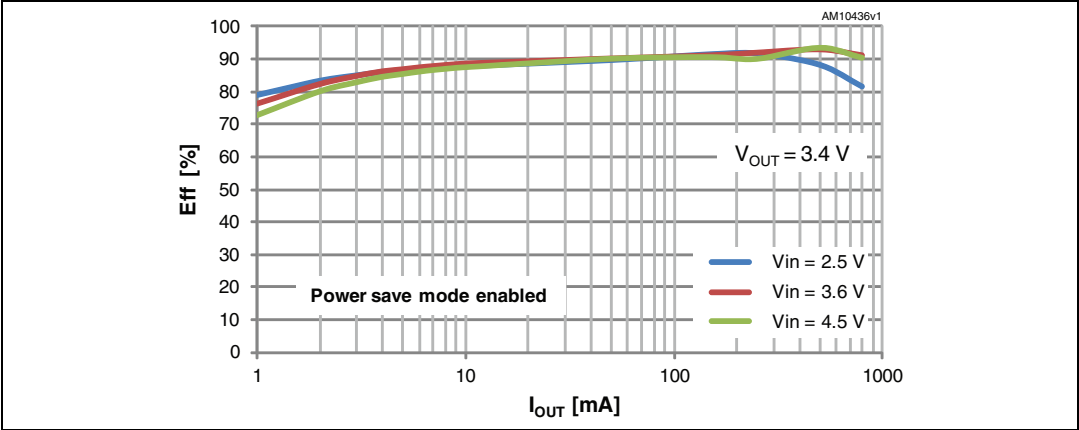


Figure 8. Efficiency vs. output current (power save mode disabled  $V_{OUT} = 3.4\text{ V}$ )

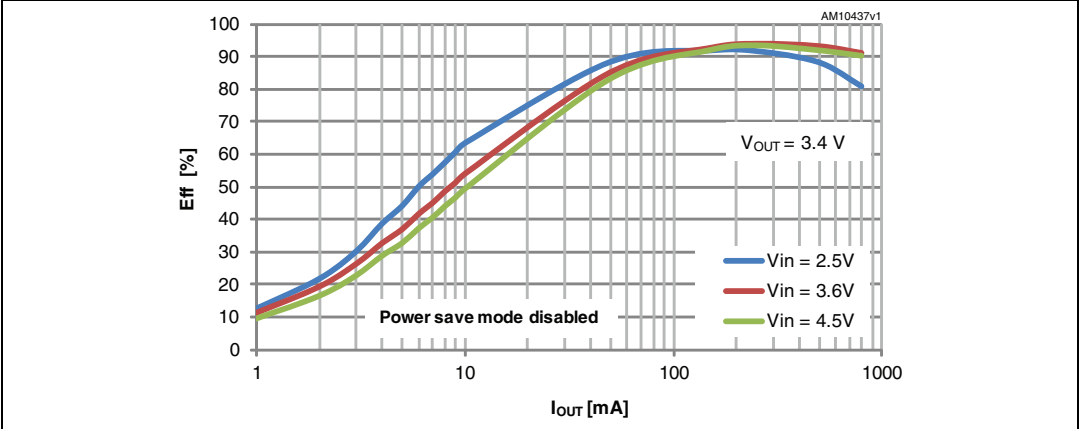


Figure 9. Efficiency vs. output current (power save mode enabled  $V_{OUT} = 2.9\text{ V}$ )

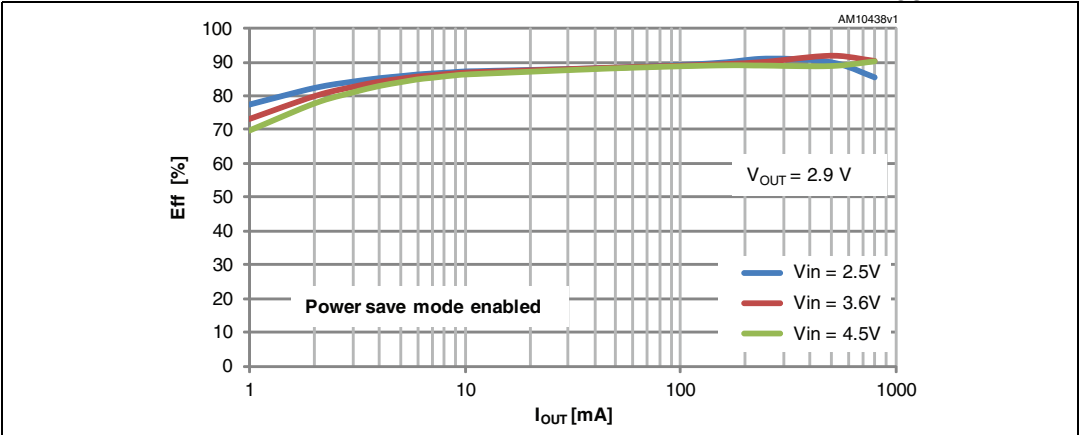


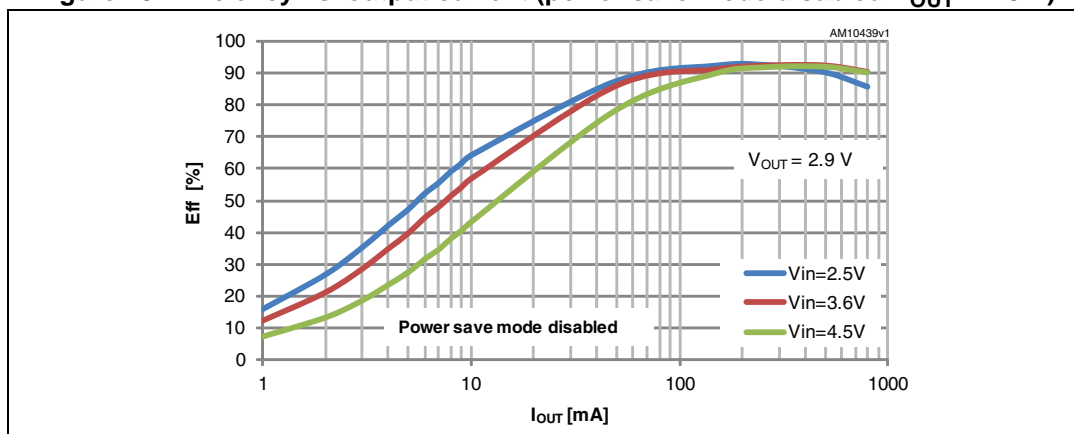
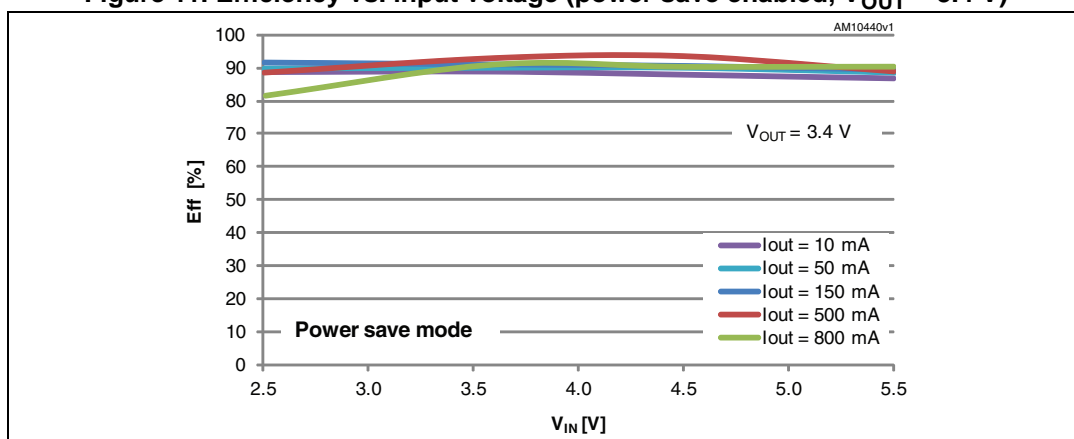
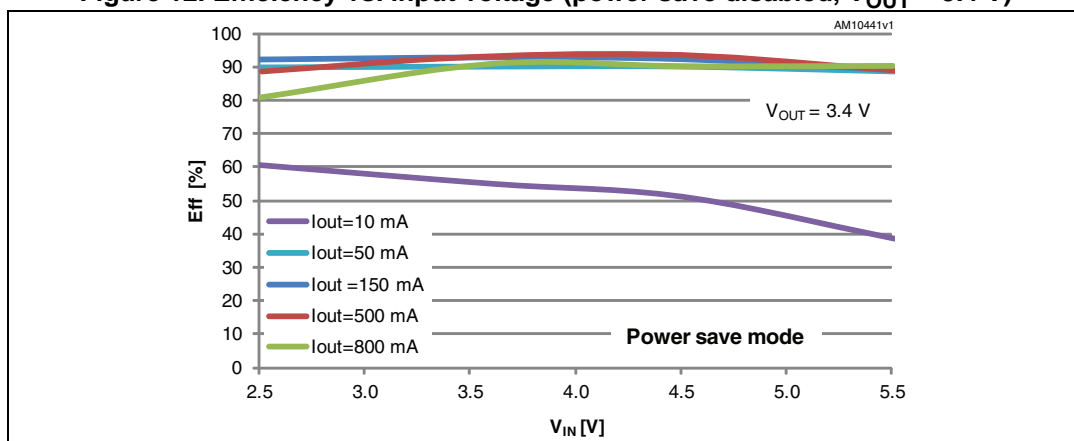
Figure 10. Efficiency vs. output current (power save mode disabled  $V_{OUT} = 2.9\text{ V}$ )Figure 11. Efficiency vs. input voltage (power save enabled,  $V_{OUT} = 3.4\text{ V}$ )Figure 12. Efficiency vs. input voltage (power save disabled,  $V_{OUT} = 3.4\text{ V}$ )

Figure 13. Efficiency vs. output current (PWM / auto mode)

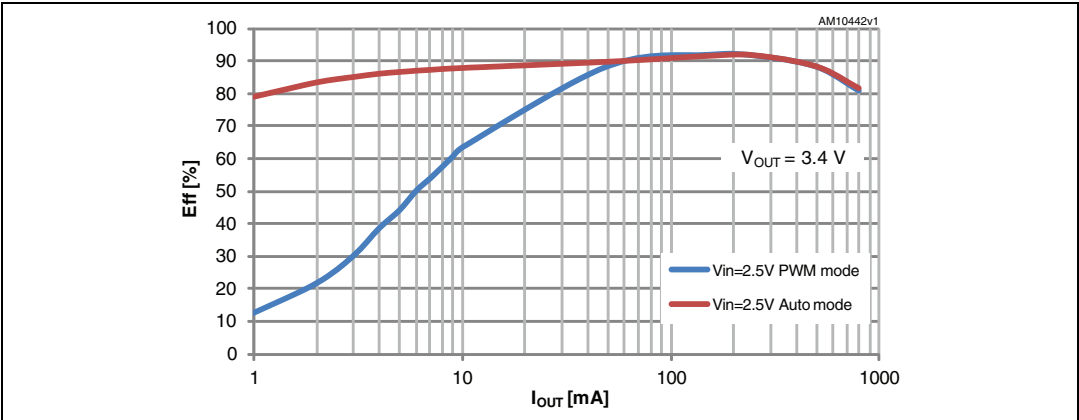


Figure 14.  $V_{IN} = 2.4\text{ V}$ ,  $V_{OUT} = 3.4\text{ V}$ ,  $I_{OUT}$  = from 80 mA to 630 mA

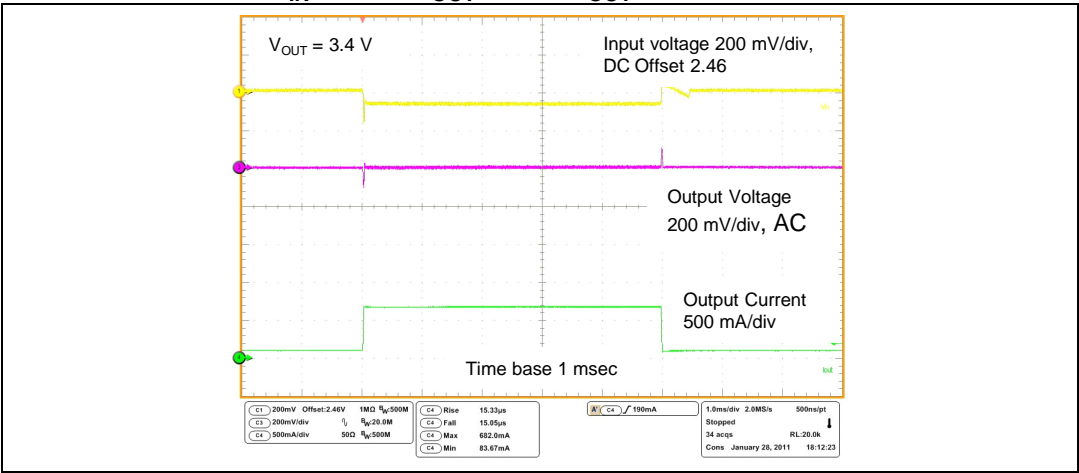


Figure 15.  $V_{IN} = 4.2\text{ V}$ ,  $V_{OUT} = 3.4\text{ V}$ ,  $I_{OUT}$  = from 80 mA to 1100 mA

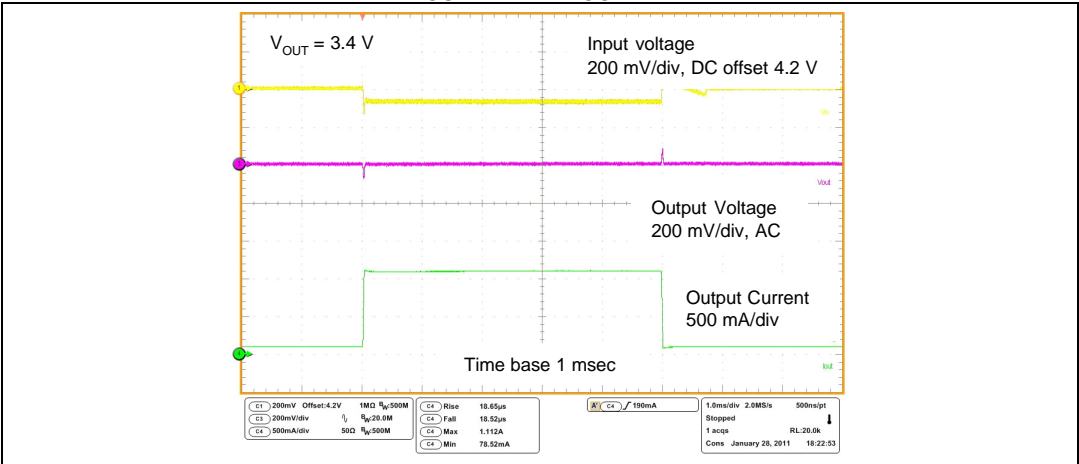
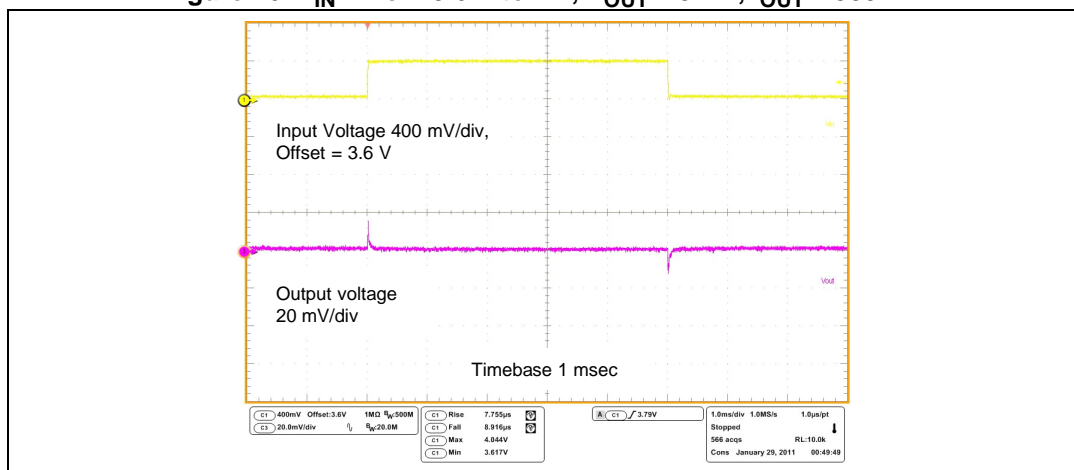
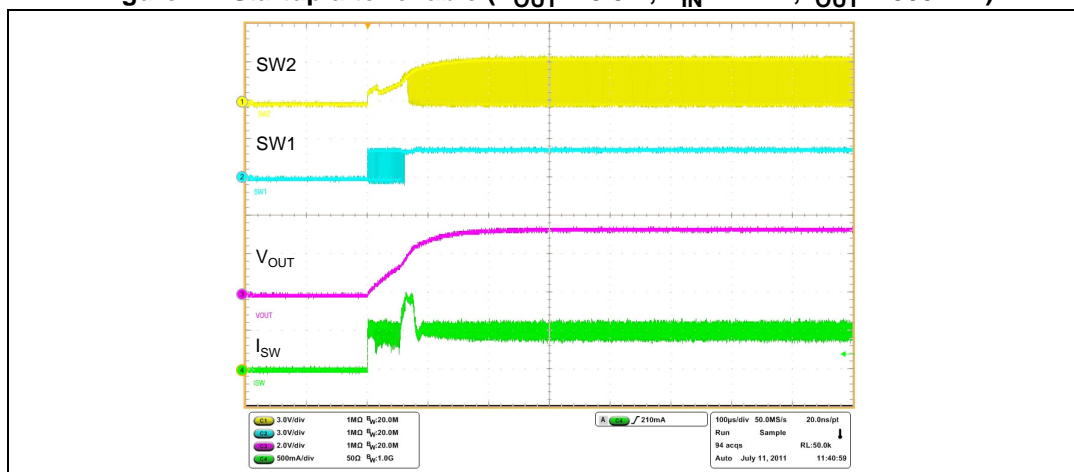
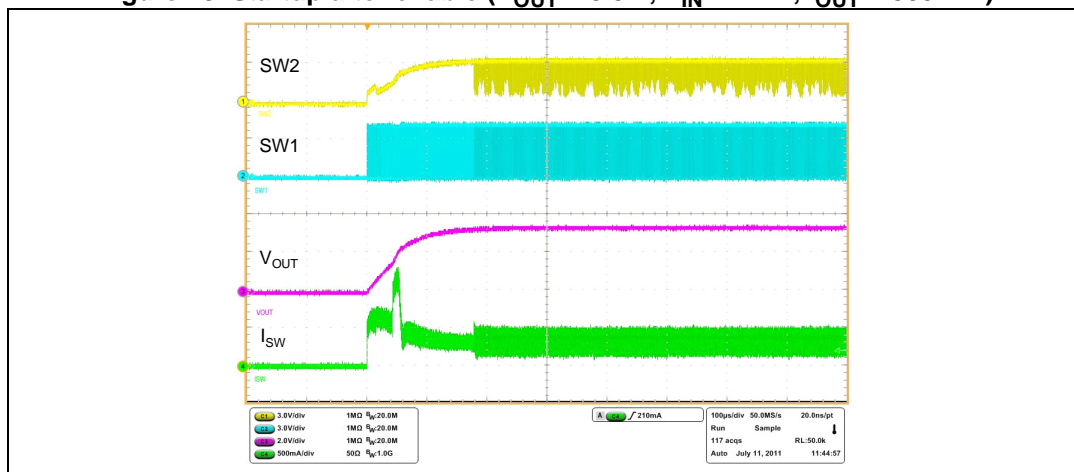


Figure 16.  $V_{IN}$  = from 3.6 V to 4 V,  $V_{OUT}$  = 3.4 V,  $I_{OUT}$  = 300 mAFigure 17. Startup after enable ( $V_{OUT}$  = 3.3 V,  $V_{IN}$  = 2.4 V,  $I_{OUT}$  = 300 mA)Figure 18. Startup after enable ( $V_{OUT}$  = 3.3 V,  $V_{IN}$  = 4.2 V,  $I_{OUT}$  = 300 mA)

## 7 General description

The STBB2 is a high efficiency dual mode buck-boost switch mode converter. Thanks to the 4 internal switches, 2 P-channels and 2 N-channels, it is able to deliver a well-regulated output voltage using a variable input voltage which can be higher than, equal to, or lower than the desired output voltage. This solves most of the power supply problems that circuit designers face when dealing with battery powered equipment.

The controller uses an average current mode technique in order to obtain good stability in all possible conditions of input voltage, output voltage and output current. In addition, the peak inductor current is monitored to avoid saturation of the coil.

The STBB2 can work in two different modes: PWM mode or power save mode. In the first case the device operates with a fixed oscillator frequency in all line/load conditions. This is the suitable condition to obtain the maximum dynamic performance. In the second case the device operates in burst mode allowing a drastic reduction of power consumption.

Top-class line and load transients are achieved thanks to a feed-forward technique and due to the innovative control method specifically designed to optimize the performances in the buck-boost region where input voltage is very close to the output voltage.

The STBB2 is self-protected from short-circuit and overtemperature. Undervoltage lockout and soft-start guarantee proper operation during startup.

Input voltage and ground connections are split into power and signal pins. This allows reduction of internal disturbances when the 4 internal switches are working. The switch bridge is connected between the  $V_{IN}$  and PGND pins while all logic blocks are connected between  $V_{INA}$  and GND.

### 7.1 Dual mode operation

The STBB2 works at fixed frequency pulse width modulation (PWM) or in power save mode (PS) according to the different operating conditions. If the MODE pin is pulled high the device works only at fixed frequency pulse width modulation (PWM) even at light or no load. In this condition, the STBB2 provides the best dynamic performance. If the MODE pin is logic low, the STBB2 operation changes according to the average input current handled by the device. At low average current the STBB2 enters into PS mode allowing very low power consumption and therefore obtaining very good efficiency event at light load. When the average current increases, the device automatically switches to fixed switching frequency mode in order to deliver the power needed by the load. In PS mode the STBB2 implements a burst mode operation: if the output voltage increases above its nominal value the device stops switching; as soon the  $V_{OUT}$  falls below the nominal value the device restarts switching.

### 7.2 Enable pin

The device turns on when the EN pin is pulled high. If the EN pin is low the device goes into shutdown mode and all the internal blocks are turned off. In shutdown mode the load is electrically disconnected from the input to avoid unwanted current leakage from the input to the load and the current drawn from the battery is lower than 1  $\mu A$  in the whole temperature range.

## 7.3 Bypass operation

In bypass mode the output is connected directly to the battery by the two P-channels and the inductor. The bypass function has been implemented in order to save energy when the application is in idle mode. At light load condition it is possible to put the device into bypass mode to reduce the current drained from the battery. In bypass mode the quiescent current is around 5  $\mu\text{A}$ . Without bypass function, the buck-boost would work in pulse-skipping mode with around 50  $\mu\text{A}$  of current consumption. The device can be placed in bypass mode by the BYP pin.

Table 8. Bypass and enable matrix

| EN | BP | MODE | Status    |
|----|----|------|-----------|
| 0  | 0  | 0    | Shutdown  |
| 0  | 0  | 1    | Shutdown  |
| 0  | 1  | 0    | Shutdown  |
| 0  | 1  | 1    | Shutdown  |
| 1  | 0  | 0    | Auto mode |
| 1  | 0  | 1    | PWM mode  |
| 1  | 1  | 0    | Bypass    |
| 1  | 1  | 1    | Bypass    |

## 7.4 VSEL pin operation

For the fixed output voltage version the FB pin must be connected to the  $V_{\text{OUT}}$  pin. Only the fixed output voltage versions have two different output voltages programmed internally which are selected by programming high or low at VSEL. The higher output voltage is selected by programming VSEL high and the lower output voltage is selected by programming VSEL low. This feature is not present in the adjustable version, where the VSEL pin must be connected to  $V_{\text{INA}}$ .

Table 9. Output selection

| P/N       | $V_{\text{SEL}}$ | $V_{\text{OUT}}$ |
|-----------|------------------|------------------|
| STBB2J-29 | Low              | 2.9 V            |
|           | High             | 3.4 V            |
| STBB2J-33 | Low              | 3.0 V            |
|           | High             | 3.3 V            |

## 7.5 Protection features

### 7.5.1 Soft-start and short-circuit

After the EN pin is pulled high, the device initiates the startup phase. The average current limit is set to 400 mA at the beginning and is gradually increased while the output voltage

increases. As soon as the output voltage reaches 1.0 V, the average current limit is set to its nominal value.

This method allows for a current limit proportional to the output voltage. If there is a short in the  $V_{OUT}$  pin, the output current does not exceed 400 mA. This process is not handled by a timer so the device is also able to start up even with large capacitive loads.

### 7.5.2 Undervoltage lockout

The undervoltage lockout function prevents improper operation of the STBB2 when the input voltage is not high enough. When the input voltage is below the VUVLO threshold, the device is in shutdown mode. The hysteresis of 100 mV prevents unstable operation when the input voltage is close to the UVLO threshold.

### 7.5.3 Overtemperature protection

An internal temperature sensor continuously monitors the IC junction temperature. If the IC temperature exceeds 150 °C (typ.), the device stops operating. As soon as the temperature falls below 130 °C (typ.), normal operation is restored.



## 8 Application information

## 8.1 Programming the output voltage

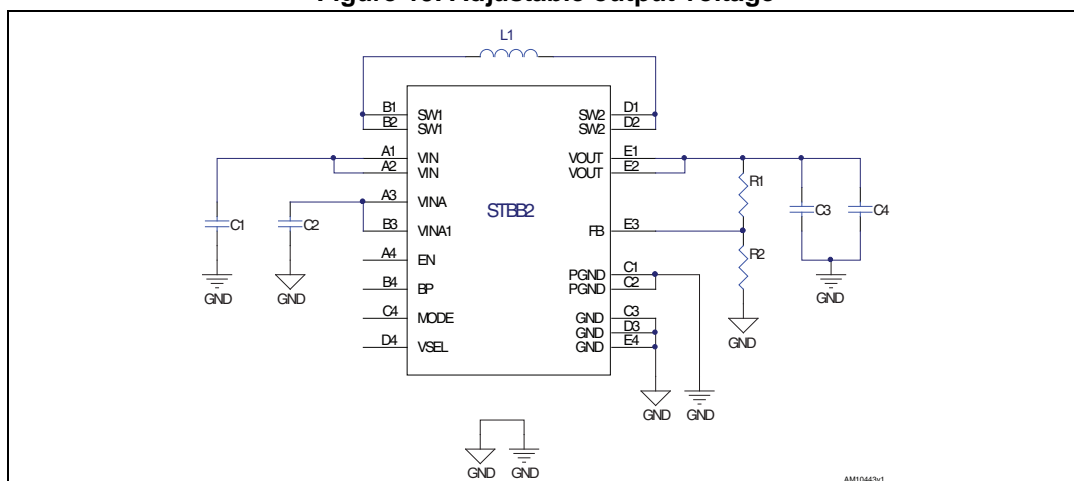
The STBB2 is available in two versions: fixed output voltage (STBB2-xx) and adjustable output voltage (STBB2-x).

In the first case the device integrates the resistor divider needed to set the correct output voltage and the FB pin must be connected directly to  $V_{OUT}$ . Only for the fixed version is it possible to select two different output voltages programmed internally by the VSEL pin. For the adjustable version the VSEL pin must be connected to  $V_{IN}$ . The resistor divider must be connected between  $V_{OUT}$  and GND and the middle point of the divider must be connected to FB as shown in [Figure 19](#).

### Equation 1

$$R1 = R2 \times \left( \frac{V_{OUT}}{V_{FB}} - 1 \right)$$

### Figure 19. Adjustable output voltage



A suggested value for  $R_2$  is 100 k $\Omega$ . To reduce the power consumption a maximum value of 500 k $\Omega$  can be used.

## 8.2 Inductor selection

The inductor is the key passive component for switching converters. With a buck-boost device, the inductor selection must take into consideration the following two conditions in which the converter works:

- as buck at the maximum operative input voltage of the application
- as a boost at the minimum operative input voltage of the application.

Two critical inductance values are then obtained according to the following formulas:

### Equation 2

$$L_{\text{MIN-BUCK}} = \frac{V_{\text{OUT}} \times (V_{\text{IN\_MAX}} - V_{\text{OUT}})}{V_{\text{IN\_MAX}} \times f_s \times \Delta I_L}$$

**Equation 3**

$$L_{\text{MIN-BOOST}} = \frac{V_{\text{IN\_MIN}} \times (V_{\text{OUT}} - V_{\text{IN\_MIN}})}{V_{\text{OUT}} \times f_s \times \Delta I_L}$$

where  $f_s$  is the minimum value of the switching frequency and  $\Delta I_L$  is the peak-to-peak inductor ripple current. As a rule of thumb, the peak-to-peak ripple can be set at 10% or 20% of the output current.

The minimum inductor value for the application is the higher between [Equation 2](#) and [Equation 3](#). In addition to the inductance value, also the maximum current which the inductor can handle must be calculated in order to avoid saturation.

**Equation 4**

$$I_{\text{PEAK-BUCK}} = (I_{\text{OUT}} / \eta) + \frac{V_{\text{OUT}} \times (V_{\text{IN\_MAX}} - V_{\text{OUT}})}{2 \times V_{\text{IN\_MAX}} \times f_s \times L}$$

**Equation 5**

$$I_{\text{PEAK-BOOST}} = \frac{V_{\text{OUT}} \times I_{\text{OUT}}}{\eta \times V_{\text{IN\_MIN}}} + \frac{V_{\text{IN\_MIN}} \times (V_{\text{OUT}} - V_{\text{IN\_MIN}})}{2 \times V_{\text{OUT}} \times f_s \times L}$$

where  $\eta$  is the estimated efficiency. The maximum of the two values above must be considered when selecting the inductor.

## 8.3 Input and output capacitor selection

It is recommended to use ceramic capacitors with low ESR as input and output capacitors in order to filter any disturbance present in the input line and to obtain stable operation.

Minimum values of 10  $\mu\text{F}$  for both capacitors are needed to achieve good behavior of the device. The input capacitor must be placed as close as possible to the device.

## 8.4 Layout guidelines

Due to the high switching frequency and peak current, the layout is an important design step for all switching power supplies. If the layout is not done carefully, important parameters such as efficiency and output voltage ripple may be compromised.

Short and wide traces must be implemented for main current and for power ground paths. The input capacitor must be placed as close as possible to the device pins as well as the inductor and output capacitor.

The feedback pin (FB) is a high impedance node, so the interference can be minimized by placing the routing of the feedback node as far as possible from the high current paths. A common ground node minimizes ground noise.

## 8.5 Demonstration board

Figure 20. Assembly layer

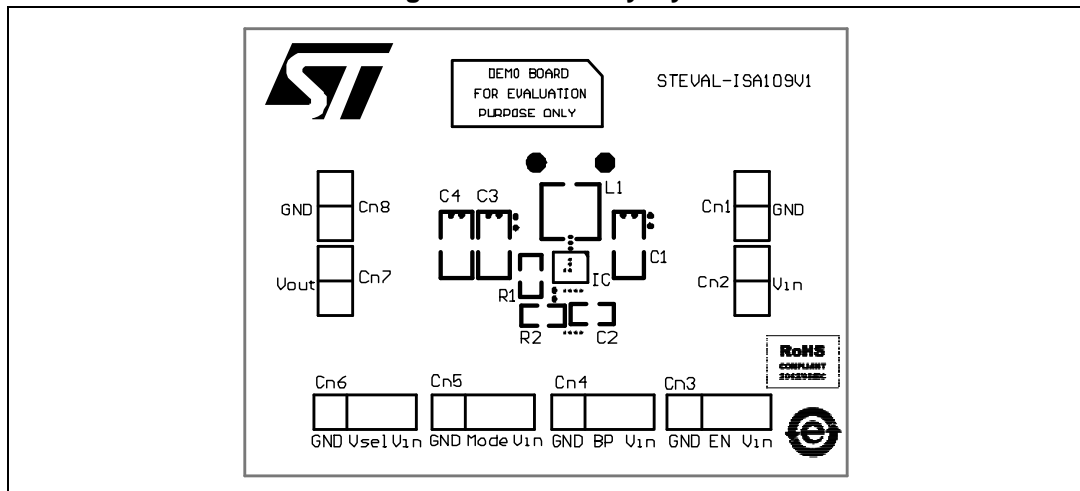


Figure 21. Top layer

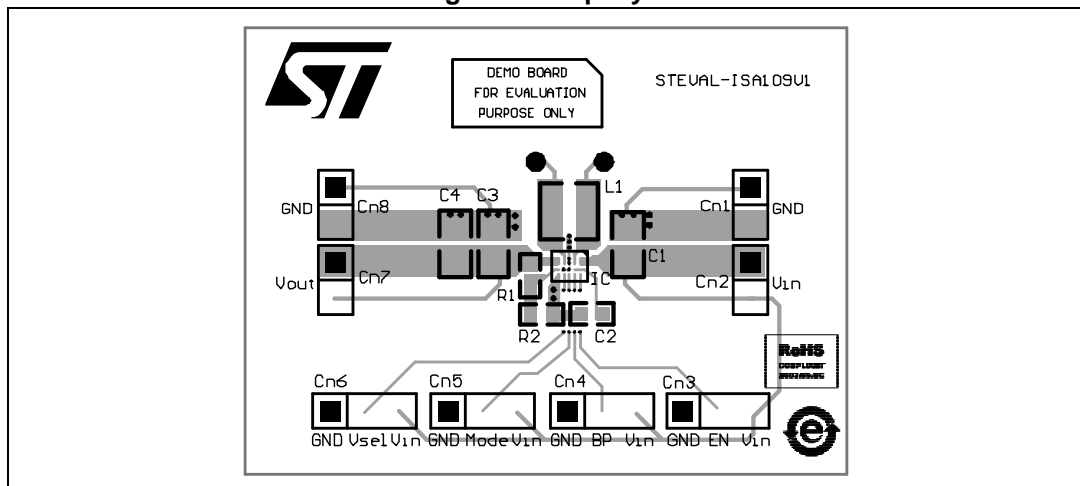
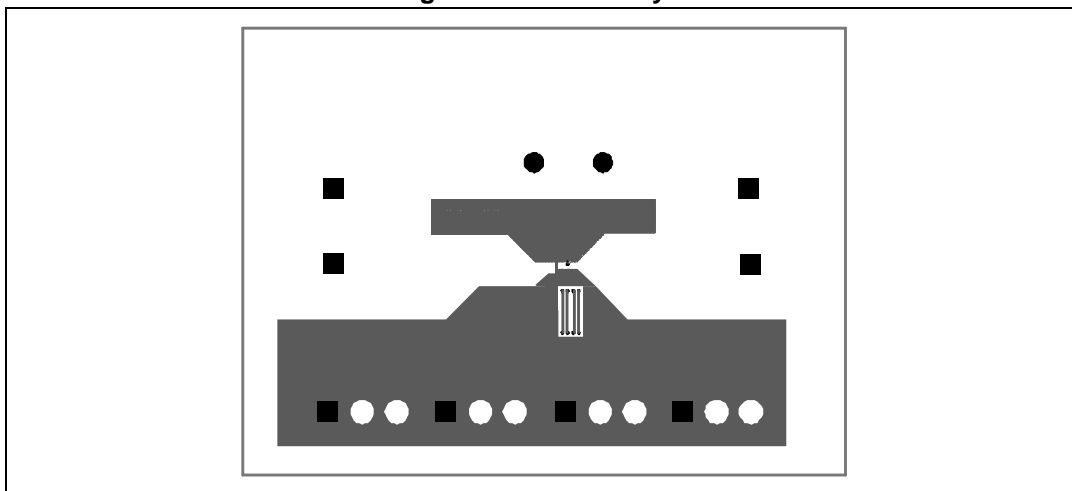


Figure 22. Bottom layer



## 8.6 Thermal consideration

To enhance the thermal performance it is recommended to improve the power dissipation capability of the PCB design by traces that are as wide as possible. The maximum recommended junction temperature ( $T_J$ ) of the devices is 125 °C. The junction ambient thermal resistance of this 20-pin WLCSP package is 80 °C/W, if all pins are soldered.

To the maximum ambient temperature  $T_A = 85$  °C the maximum power dissipated inside the package is given by:

### Equation 6

$$P_{DISS\_MAX} = (T_{JMAX} - T_{AMAX}) / R_{JA} = (125 - 85) / 80 = 500 \text{ mW}$$

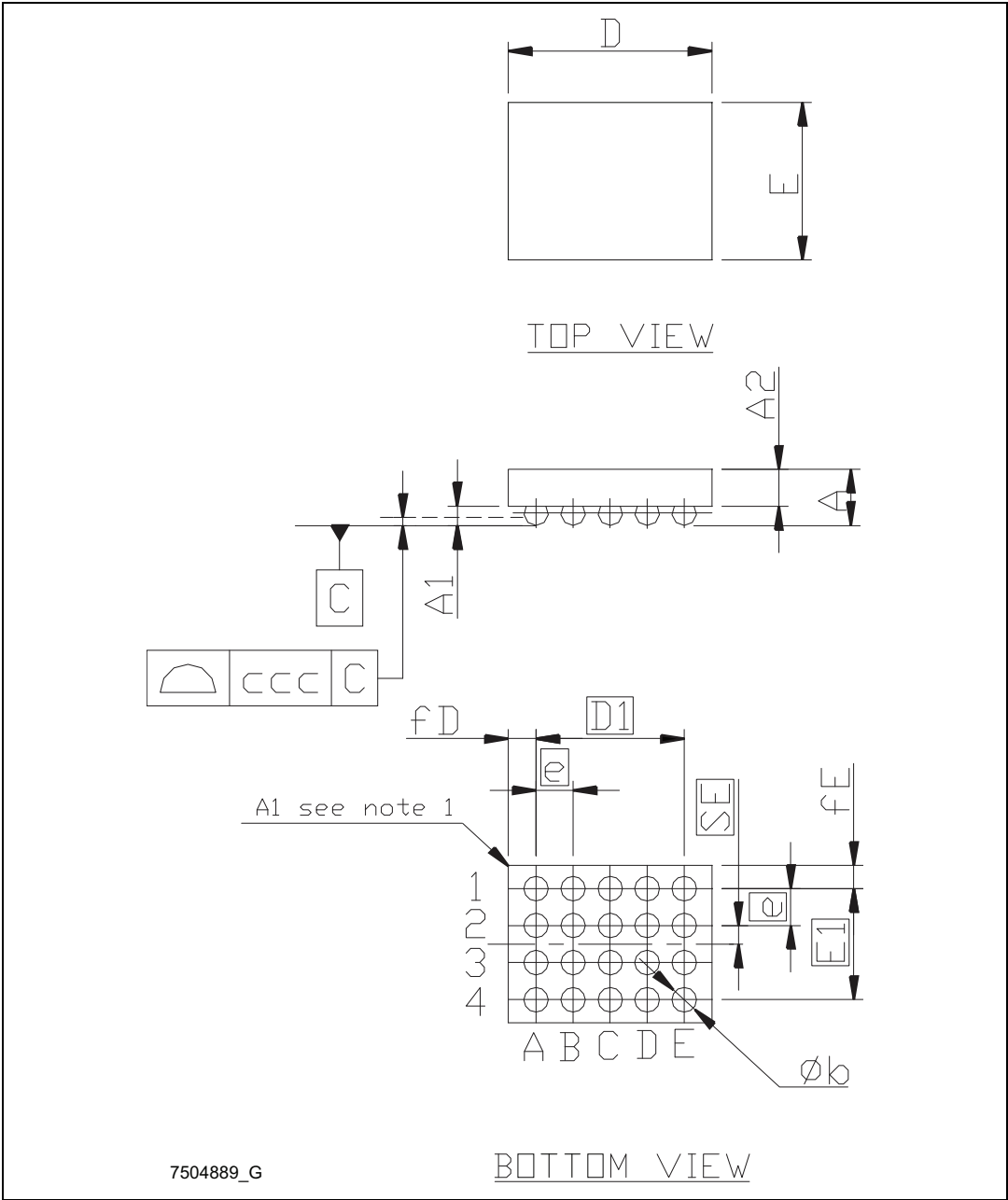
## 9 Package mechanical data

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](http://www.st.com). ECOPACK is an ST trademark.

**Table 10. Flip Chip 20 (2.1 x 1.8 mm) mechanical data**

| Dim. | mm.   |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 0.52  | 0.56  | 0.60  |
| A1   | 0.17  | 0.20  | 0.23  |
| A2   | 0.35  | 0.36  | 0.37  |
| b    | 0.23  | 0.25  | 0.29  |
| D    | 2.033 | 2.053 | 2.083 |
| D1   |       | 1.6   |       |
| E    | 1.701 | 1.731 | 1.761 |
| E1   |       | 1.2   |       |
| e    |       | 0.4   |       |
| fD   |       | 0.2   |       |
| fE   |       | 0.227 |       |
| SE   |       | 0.266 |       |
| ccc  |       | 0.075 |       |

Figure 23. Flip Chip 20 (2.1 x 1.8 mm) package dimensions



## 10 Revision history

Table 11. Document revision history

| Date        | Revision | Changes   |
|-------------|----------|---|
| 27-Jan-2012 | 1        | First release.  |
| 27-Mar-2012 | 2        | Datasheet promoted from preliminary data to production data.<br>Removed: order code STBB2J28-R <a href="#">Table 1 on page 1</a> .                                  |
| 09-May-2012 | 3        | Modified: marking BB2 <a href="#">Table 1 on page 1</a> , description pin B4 and D4 <a href="#">Table 5 on page 6</a> .   |
| 26-Jul-2012 | 4        | Modified: C2 value <a href="#">Table 2 on page 3</a> .<br>Updated: <a href="#">Figure 20</a> , <a href="#">Figure 21</a> and <a href="#">Figure 22 on page 20</a> . |
| 19-Sep-2012 | 5        | Modified: <a href="#">Figure 2 on page 3</a> .  |
| 06-Mar-2013 | 6        | Added: new order code STBB2J33-R <a href="#">Table 1 on page 1</a> .  |

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