

## Multiple multifunction voltage regulator for car radio

### Features

- 5 regulators:
  - 10 V (350 mA)
  - 8.5 V (175 mA)
  - 5 V (350 mA)
  - 5 V (250 mA)
  - 8 V/10 V (1 A)
- All regulators are low dropout
- 3 high side drivers:
  - 2 A (HSD1)
  - 0.45 A (HSD2 and HSD3)
- No external charge pump capacitors are required
- Standby mode controlled by 3 input pins:
  - Enable for Reg2 and Reg3
  - I<sup>2</sup>C bus for Reg1, Reg4, Reg5, Hsd1, Hsd2, Hsd3
- Individual thermal shutdown
- Independent current limiting
- Short circuit protection
- Load dump protection and overvoltage shutdown
- ESD protected



### Description

The L5954 is an integration of three high side drivers and five regulators developed to provide the power for an audio system.

The outputs of the IC are controlled via the I<sup>2</sup>C bus and the Enable input.

External protection must be provided for reverse battery protection.

**Table 1. Device summary**

| Order code | Package     | Packing |
|------------|-------------|---------|
| L5954      | Multiwatt15 | Tube    |

# Contents

|          |                                           |           |
|----------|-------------------------------------------|-----------|
| <b>1</b> | <b>Block and pins connection diagrams</b> | <b>5</b>  |
| <b>2</b> | <b>Electrical specifications</b>          | <b>6</b>  |
| 2.1      | Absolute maximum ratings                  | 6         |
| 2.2      | Thermal data                              | 6         |
| 2.3      | Electrical characteristics                | 6         |
| <b>3</b> | <b>Functional description</b>             | <b>10</b> |
| 3.1      | Protection                                | 10        |
| 3.1.1    | Thermal shutdown                          | 10        |
| 3.1.2    | Current limiting                          | 10        |
| 3.1.3    | Short circuit                             | 10        |
| 3.1.4    | Overvoltage                               | 11        |
| 3.1.5    | Write mode                                | 11        |
| 3.1.6    | Chip address byte                         | 12        |
| 3.1.7    | Data byte                                 | 12        |
| <b>4</b> | <b>Package information</b>                | <b>13</b> |
| <b>5</b> | <b>Revision history</b>                   | <b>14</b> |

List of tables

Table 1. Device summary . . . . . 1

Table 2. Absolute maximum ratings . . . . . 6

Table 3. Thermal data . . . . . 6

Table 4. Electrical characteristics . . . . . 6

Table 5. Document revision history . . . . . 14

Obsolete Product(s) - Obsolete Product(s)

## List of figures

|           |                                                                        |    |
|-----------|------------------------------------------------------------------------|----|
| Figure 1. | Block diagram . . . . .                                                | 5  |
| Figure 2. | Pins connection (top view) . . . . .                                   | 5  |
| Figure 3. | Definition of timing on the I2C bus. . . . .                           | 11 |
| Figure 4. | Typical application circuit. . . . .                                   | 11 |
| Figure 5. | Multiwatt15 (vertical) mechanical data and package dimensions. . . . . | 13 |

Obsolete Product(s) - Obsolete Product(s)

# 1 Block and pins connection diagrams

Figure 1. Block diagram

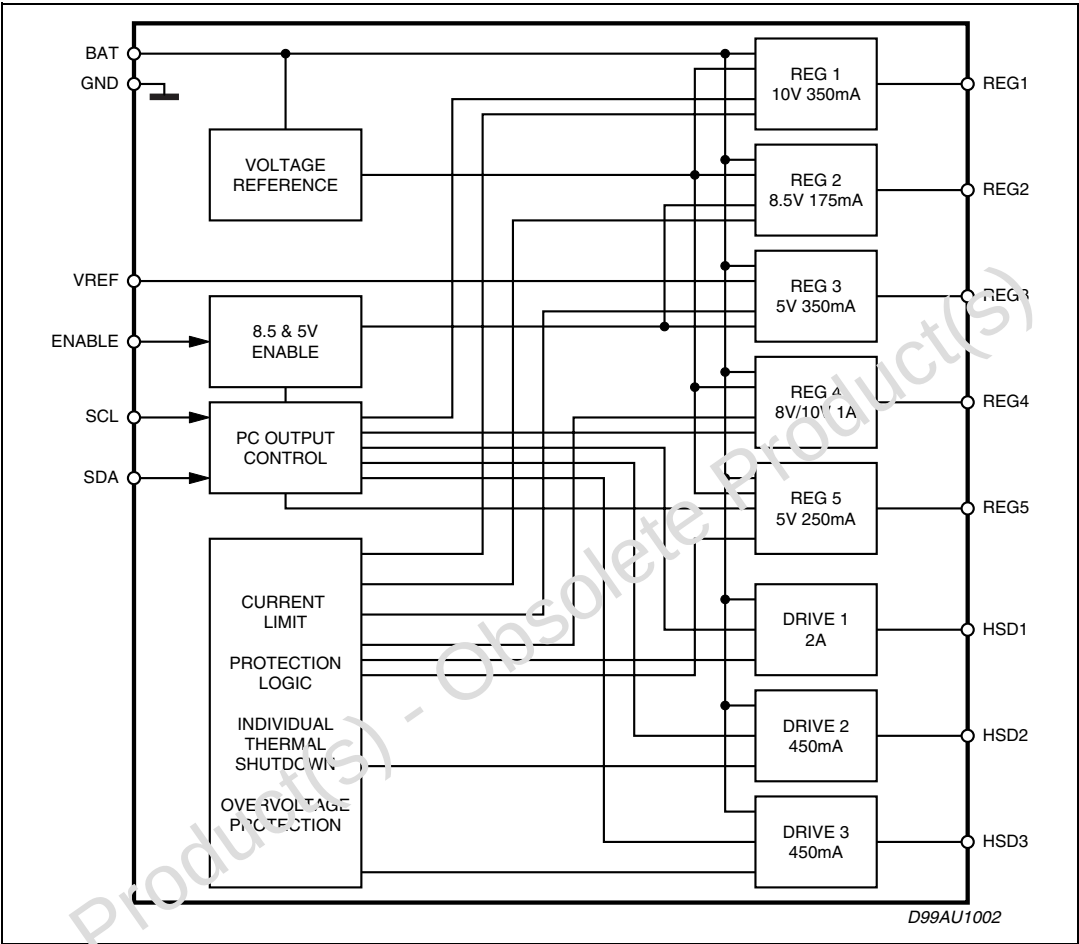
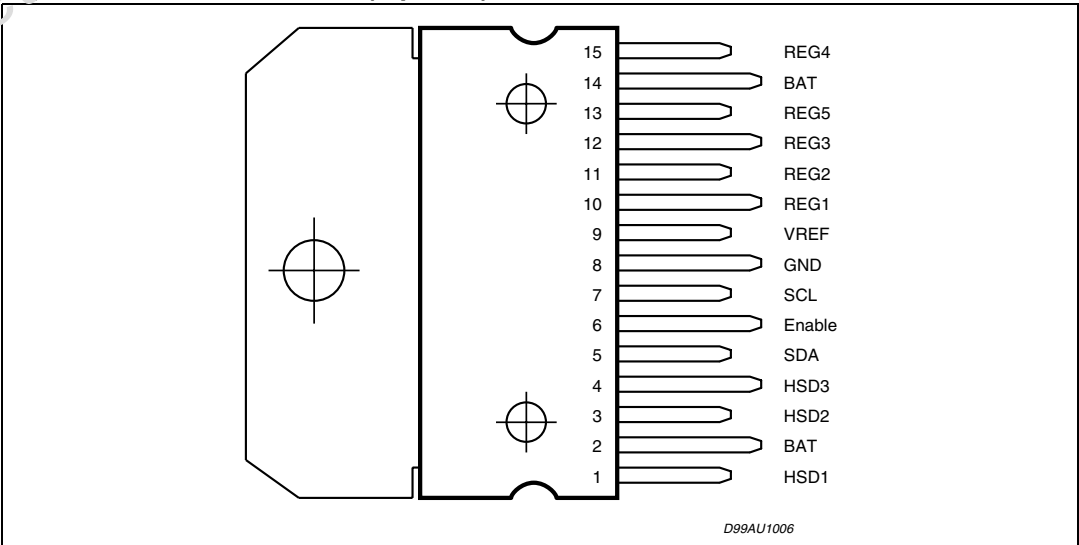


Figure 2. Pins connection (top view)



## 2 Electrical specifications

### 2.1 Absolute maximum ratings

**Table 2. Absolute maximum ratings**

| Symbol    | Parameter                                                               | Value        | Unit |
|-----------|-------------------------------------------------------------------------|--------------|------|
| $V_S$     | DC operating supply voltage                                             | -0.6 to 26.5 | V    |
| $V_S$     | Transient supply overvoltages, rise time = 10 ms<br>delay time = 115 ms | 34           | V    |
| $V_{in}$  | Input voltages (EN, SDA, SCL)                                           | -0.6 to 9    | V    |
| $V_{out}$ | Output control voltage                                                  | -0.6 to 6.0  | V    |
| $T_{op}$  | Operating temperature range                                             | -40 to 85    | °C   |
| $T_{stg}$ | Storage temperature range                                               | 40 to 150    | °C   |

### 2.2 Thermal data

**Table 3. Thermal data**

| Symbol           | Parameter                           | Value | Unit |
|------------------|-------------------------------------|-------|------|
| $R_{th\ j-case}$ | thermal resistance junction-to-case | 2     | °C/W |

### 2.3 Electrical characteristics

Refer to the application circuit,  $V_S = 14.4\text{ V}$ ;  $T_{amb} = 25\text{ °C}$ ; unless otherwise specified.

**Table 4. Electrical characteristics**

| Symbol                            | Parameter                 | Test Condition                                                                                                                                                                                                                          | Min. | Typ. | Max. | Unit |
|-----------------------------------|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $I_{q,ST-PV}$                     | Standby quiescent current | All outputs off, $V_{BAT} = 14\text{ V}$                                                                                                                                                                                                | -    | -    | 2    | μA   |
| $I_q$                             | Maximum quiescent current | $V_{BAT} = 14\text{ V}$ , $I_{REG1} = 350\text{ mA}$ ,<br>$I_{REG2} = 175\text{ mA}$ , $I_{REG3} = 350\text{ mA}$ ,<br>$I_{REG4} = 1\text{ A}$ , $I_{REG5} = 250\text{ mA}$ ,<br>$I_{HSD1} = 2\text{ A}$ , $I_{HSD2,3} = 450\text{ mA}$ | -    | -    | 150  | mA   |
| $I_{EN}$                          | Enable input current      | $V_{BAT} = 14\text{ V}$ , Enable $\geq 2\text{ V}$<br>$V_{BAT} = 14\text{ V}$ , Enable $\geq 0.8\text{ V}$                                                                                                                              | -10  | -    | 10   | μA   |
| $V_{IL}$ , $V_{IH}$               | Enable threshold voltage  | $V_{BAT} = 14\text{ V}$ , $V_{IL}$<br>$V_{BAT} = 14\text{ V}$ , $V_{IH}$                                                                                                                                                                | 2    | -    | 0.8  | V    |
| <b>10 V / 350 mA Reg 1 output</b> |                           |                                                                                                                                                                                                                                         |      |      |      |      |
| $V_{REG1}$                        | Output voltage            | $I_{REG1} = 350\text{ mA}$<br>$11\text{ V} \leq V_{CC} \leq 16\text{ V}$                                                                                                                                                                | 9.50 | 10   | 10.5 | V    |

Table 4. Electrical characteristics (continued)

| Symbol                             | Parameter                                                                  | Test Condition                                                                                                       | Min. | Typ. | Max.       | Unit     |
|------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|------|------|------------|----------|
| $\Delta V_{line}$                  | Line regulation                                                            | $11\text{ V} \leq V_{CC} \leq 26\text{ V}$<br>(Measure $\Delta V_{REG1}$ across $V_{CC}$ range)                      | -    | -    | 55         | mV       |
| $\Delta V_{load}$                  | Load regulation                                                            | $5\text{ mA} \leq I_{REG1} \leq 350\text{ mA}$                                                                       | -    | -    | 55         | mV       |
| $V_{DROPOUT}$                      | Dropout voltage (measure $V_{BAT}$ $V_{REG1}$ when $V_{REG1}$ drops 0.1 V) | (Measure $V_{BAT}$ $V_{REG1}$ when $V_{REG1}$ drops 0.1 V)<br>$I_{REG1} = 350\text{ mA}$<br>$I_{REG1} = 5\text{ mA}$ | -    | -    | 900<br>300 | mV<br>mV |
| $I_{lim1}$                         | Current limit                                                              | -                                                                                                                    | 0.51 | -    | 1.1        | A        |
| SVR                                | Ripple rejection                                                           | $f_o = 1\text{ kHz}$ , $V_{BAT} = 14\text{ V}$<br>with 1Vpp AC<br>$I_{REG1} = 175\text{ mA}$                         | 50   | -    | -          | dB       |
| <b>8.5 V / 175 mA Reg 2 output</b> |                                                                            |                                                                                                                      |      |      |            |          |
| $V_{REG2}$                         | Output voltage                                                             | $I_{REG2} = 175\text{ mA}$<br>$9.5\text{ V} \leq V_{BAT} \leq 16\text{ V}$                                           | 8.0  | 8.5  | 9.0        | V        |
| $\Delta V_{line}$                  | Line regulation                                                            | $9.5\text{ V} \leq V_{BAT} \leq 26\text{ V}$<br>(Measure $\Delta V_{REG2}$ across $V_{BAT}$ Range)                   | -    | -    | 50         | mV       |
| $\Delta V_{load}$                  | Load regulation                                                            | $5\text{ mA} \leq I_{REG2} \leq 175\text{ mA}$                                                                       | -    | -    | 50         | mV       |
| $V_{DROPOUT}$                      | Dropout voltage                                                            | (Measure $V_{BAT}$ $V_{REG2}$ when $V_{REG2}$ drops 0.1 V)<br>$I_{REG2} = 175\text{ mA}$<br>$I_{REG2} = 5\text{ mA}$ | -    | -    | 900<br>300 | mV<br>mV |
| $I_{lim2}$                         | Current limit                                                              | -                                                                                                                    | 280  | -    | 525        | mA       |
| SVR                                | Ripple rejection                                                           | $f_o = 1\text{ kHz}$ , $V_{BAT} = 14\text{ V}$<br>with 1 Vpp AC<br>$I_{REG2} = 100\text{ mA}$                        | 50   | -    | -          | dB       |
| <b>5 V / 150 mA Reg 3 output</b>   |                                                                            |                                                                                                                      |      |      |            |          |
| $V_{REG3}$                         | Voltage offset from $V_{REF}$                                              | -                                                                                                                    | -    | 10   | 40         | mV       |
| $\Delta V_{line}$                  | Line regulation                                                            | $7\text{ V} \leq V_{BAT} \leq 26\text{ V}$<br>(Measure $\Delta V_{REG3}$ across $V_{BAT}$ range)                     | -    | -    | 50         | mV       |
| $\Delta V_{load}$                  | Load regulation                                                            | $5\text{ mA} \leq I_{REG3} \leq 350\text{ mA}$                                                                       | -    | -    | 100        | mV       |
| $V_{DROPOUT}$                      | Dropout voltage (Measure $V_{BAT}$ $V_{REG3}$ when $V_{REG3}$ drops 0.1V)  | (Measure $V_{BAT}$ $V_{REG3}$ when $V_{REG3}$ drops 0.1 V)<br>$I_{REG3} = 175\text{ mA}$<br>$I_{REG3} = 5\text{ mA}$ | -    | -    | 950<br>600 | mV<br>mV |
| $I_{lim3}$                         | Current limit                                                              | -                                                                                                                    | 0.5  | -    | 1          | A        |
| SVR                                | Ripple rejection                                                           | $f_o = 1\text{ kHz}$ , $V_{BAT} = 14\text{ V}$<br>with 1 Vpp AC, $I_{REG3} = 175\text{ mA}$                          | 50   | -    | -          | dB       |

Table 4. Electrical characteristics (continued)

| Symbol                         | Parameter                 | Test Condition                                                                                                       | Min.        | Typ.    | Max.        | Unit          |
|--------------------------------|---------------------------|----------------------------------------------------------------------------------------------------------------------|-------------|---------|-------------|---------------|
| <b>8/10 V/1 A Reg 4 output</b> |                           |                                                                                                                      |             |         |             |               |
| $V_{REG4}$                     | Output voltage            | $I_{REG4} = 1\text{ A}$<br>$b5 = 0$<br>$b5 = 1$                                                                      | 7.6<br>9.50 | 8<br>10 | 8.4<br>10.5 | V<br>V        |
| $\Delta V_{line}$              | Line regulation           | $11\text{ V} \leq V_{BAT} \leq 26\text{ V}$ , $b5 = 1$<br>(Measure $\Delta V_{REG2}$ across $V_{BAT}$ Range)         | -           | -       | 50          | mV            |
| $\Delta V_{load}$              | Load regulation           | $5\text{ mA} \leq I_{REG4} \leq 1\text{ A}$                                                                          | -           | -       | 150         | mV            |
| $V_{DROPOUT}$                  | Dropout voltage           | (Measure $V_{BAT}$ $V_{REG2}$ when $V_{REG2}$ drops 0.1 V)<br>$I_{REG4} = 1\text{ A}$<br>$I_{REG4} = 5\text{ mA}$    | -           | -       | 930<br>600  | mV<br>mV      |
| $I_{lim4}$                     | Current limit             | -                                                                                                                    | 1.3         | -       | 2.4         | A             |
| SVR                            | Ripple rejection          | $f_o = 1\text{ kHz}$ , $V_{BAT} = 14\text{ V}$<br>with 1 Vpp AC, $I_{REG4} = 500\text{ mA}$                          | 50          | -       | -           | dB            |
| <b>5 V/250 mA Reg 5 output</b> |                           |                                                                                                                      |             |         |             |               |
| $V_{REG5}$                     | Output voltage            | $I_{REG5} = 250\text{ mA}$                                                                                           | 4.6         | 5       | 5.4         | V             |
| $\Delta V_{line}$              | Line regulation           | $7\text{ V} \leq V_{BAT} \leq 26\text{ V}$<br>(Measure $\Delta V_{REG5}$ across $V_{BAT}$ Range)                     | -           | -       | 40          | mV            |
| $\Delta V_{load}$              | Load regulation           | $5\text{ mA} \leq I_{REG5} \leq 250\text{ mA}$                                                                       | -           | -       | 100         | mV            |
| $V_{DROPOUT}$                  | Dropout voltage           | (Measure $V_{BAT}$ $V_{REG5}$ when $V_{REG5}$ drops 0.1 V)<br>$I_{REG5} = 250\text{ mA}$<br>$I_{REG5} = 5\text{ mA}$ | -           | -       | 1.6<br>1.2  | V<br>V        |
| $I_{lim5}$                     | Current limit             | -                                                                                                                    | 320         | -       | 700         | mA            |
| SVR                            | Ripple rejection          | $f_o = 1\text{ kHz}$ , $V_{BAT} = 14\text{ V}$<br>with 1Vpp AC, $I_{REG5} = 125\text{ mA}$                           | 50          | -       | -           | dB            |
| <b>2 A HSD1</b>                |                           |                                                                                                                      |             |         |             |               |
| $V_{sat}$                      | Output saturation voltage | $I_{HSD1} = 1\text{ A}$ continuous time operation                                                                    | -           | -       | 0.5         | V             |
| $I_{leak1}$                    | Output leakage current    | All driver outputs are off                                                                                           | -50         | -       | 50          | $\mu\text{A}$ |
| $I_{lim}$                      | Current limiting          | $R_{HSD1} = 0.5\ \Omega$                                                                                             | 2.4         | -       | 4           | A             |



Table 4. Electrical characteristics (continued)

| Symbol                                    | Parameter                 | Test Condition                                            | Min. | Typ. | Max.       | Unit          |
|-------------------------------------------|---------------------------|-----------------------------------------------------------|------|------|------------|---------------|
| <b>0.45A HSD2 and HSD3</b>                |                           |                                                           |      |      |            |               |
| $V_{sat}$                                 | Output saturation voltage | $I_{HSD2,3} = 300\text{ mA}$<br>Continuous time operation | -    | -    | 0.6        | V             |
| $I_{leak2,3}$                             | Output leakage current    | All driver outputs are off                                | -50  | -    | 50         | $\mu\text{A}$ |
| $I_{lim}$                                 | Current limiting          | $R_{HSD2,3} = 0.5\ \Omega$                                | 0.56 | -    | 1          | A             |
| <b>Characteristics for I<sup>2</sup>C</b> |                           |                                                           |      |      |            |               |
| $V_{IL}$                                  | Low level input voltage   | -                                                         | -    | -    | 1.5        | V             |
| $V_{IH}$                                  | High level input voltage  | -                                                         | 3    | -    | -          | V             |
| $V_{HYS}$                                 | Input hysteresis          | -                                                         | 0.2  | -    | -          | V             |
| $V_{OL1}$<br>$V_{OL2}$                    | Low level output          | Sink current = 3 mA<br>Sink current = 6 mA                | -    | -    | 0.4<br>0.6 | V             |
| $I_I$                                     | Input current             | $0.4\text{ V} \leq V_I \leq 0.9\text{ V}_{DDmax}$         | -10  | -    | 10         | $\mu\text{A}$ |
| $f_{SCL}$                                 | SCL clock frequency       | -                                                         | -    | -    | 400        | kHz           |

### 3 Functional description

The three high side drivers are a 2.0 A output (HSD1), and two 450 mA outputs (HSD2 and 3). The five regulator outputs are a 10 V at 350 mA (REG1), an 8.5 V at 175 mA (REG2), a 5 V at 350 mA (REG3), an 8 V/1.0 V at 1 A (REG4), and 5 V at 250 mA (REG5). The regulators are low dropout. The regulators will operate with output capacitors with ESR of 0.1  $\Omega$  to 5  $\Omega$ .

REG3 is referenced from the VREF input not the internal bandgap. This is done to minimize the voltage offset between individual 5 V supplies.

The REG2 and REG3 outputs are turned on and off with the Enable input, a '1' turns the outputs on and a '0' turns them off. When Enable is "1", the other outputs can be independently controlled via the I<sup>2</sup>C bus. When a given regulator is turned off it must be guaranteed to be lower than 0.2 V. The output voltage of REG4 is selected via bit 5 of the I<sup>2</sup>C data byte: 8 V is the output voltage if bit5 = '0' while 10 V is the output voltage when bit5 = '1'. When all outputs are turned off the total current draw must be minimized. I<sup>2</sup>C will run at a clock speed range of 100 kHz to 400 kHz. This device should be capable of operating at any frequency within this range.

#### 3.1 Protection

The L5954 can survive under the following conditions: shorting the outputs to BAT and GND, loss of BAT, loss of IC GND, double battery, ESD, 34V load dump. L5954 will not handle a reverse battery condition. External components must be implemented for reverse battery protection.

##### 3.1.1 Thermal shutdown

REG1, REG2, REG3, REG4, REG5 outputs shutdown at 160 °C and return to normal operation at 130 °C. The HSD2 and HSD3 shutdown at 160 °C and return to normal operation at 130 °C. The HSD1 will go into thermal shutdown at 170 °C and returns to operation at 120 °C.

##### 3.1.2 Current limiting

Each voltage regulator will contain its own current protection.

##### 3.1.3 Short circuit

If the outputs are short circuited, the IC will go into current limiting and eventually the thermal shutdown will kick in. Current limiting will not disable the outputs.

### 3.1.4 Overvoltage

The IC will not operate if the BAT voltage reaches 27 V typ. or above.

Figure 3. Definition of timing on the I<sup>2</sup>C bus.

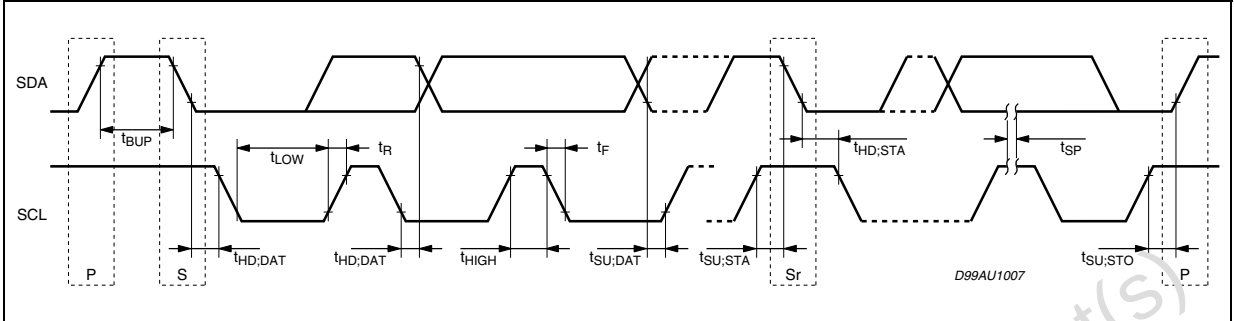
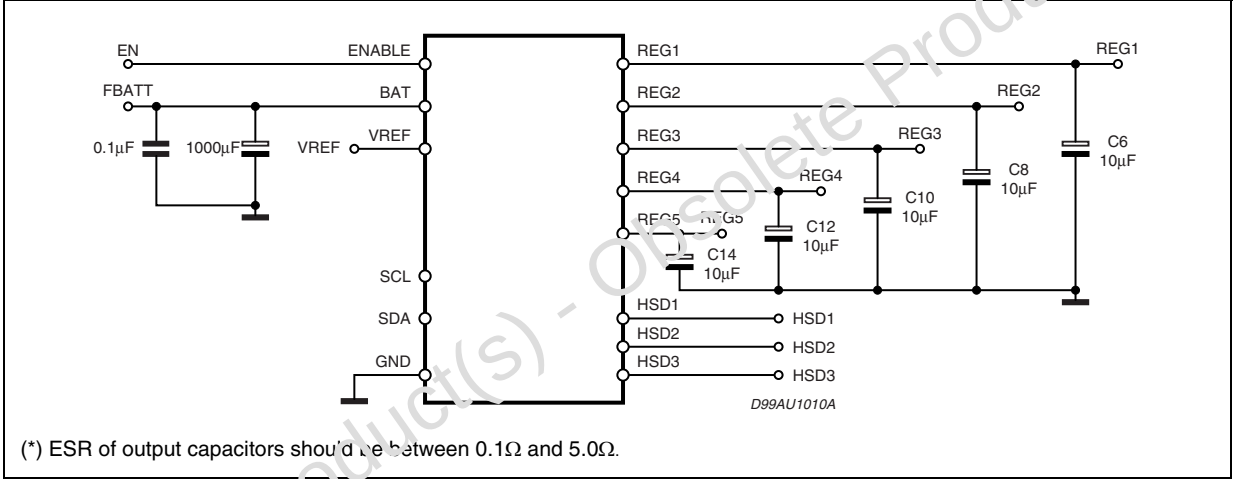
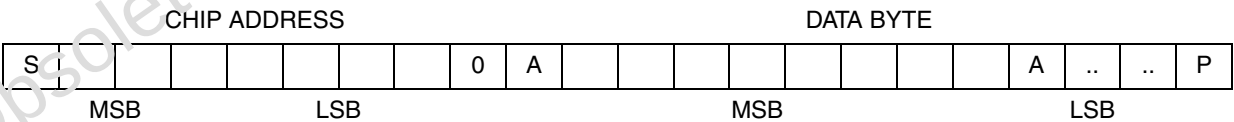


Figure 4. Typical application circuit.



(\*) ESR of output capacitors should be between 0.1Ω and 5.0Ω.

### 3.1.5 Write mode



S = START condition - SDA goes from high to low while SCL is high

A = Acknowledge - the device being written to, pulls down on data line (SDA) during the acknowledge clock pulse.

P = STOP condition - SDA goes from low to high while SCL is high.

### 3.1.6 Chip address byte

| Chip address |    |    |    |    |    |    | Read/write |
|--------------|----|----|----|----|----|----|------------|
| A7           | A6 | A5 | A4 | A3 | A2 | A1 | A0         |
| 0            | 0  | 0  | 1  | 0  | 0  | 0  | 0          |

### 3.1.7 Data byte

| Data byte |    |        |      |      |      |      |      |
|-----------|----|--------|------|------|------|------|------|
| REG1      |    | R4 10V | REG4 | REG5 | HSD1 | HSD2 | HSD3 |
| b7        | b6 | b5     | b4   | b3   | b2   | b1   | b0   |
|           | X  |        |      |      |      |      |      |

Default mode is 0000 0000 which corresponds to all outputs being off, low power mode.

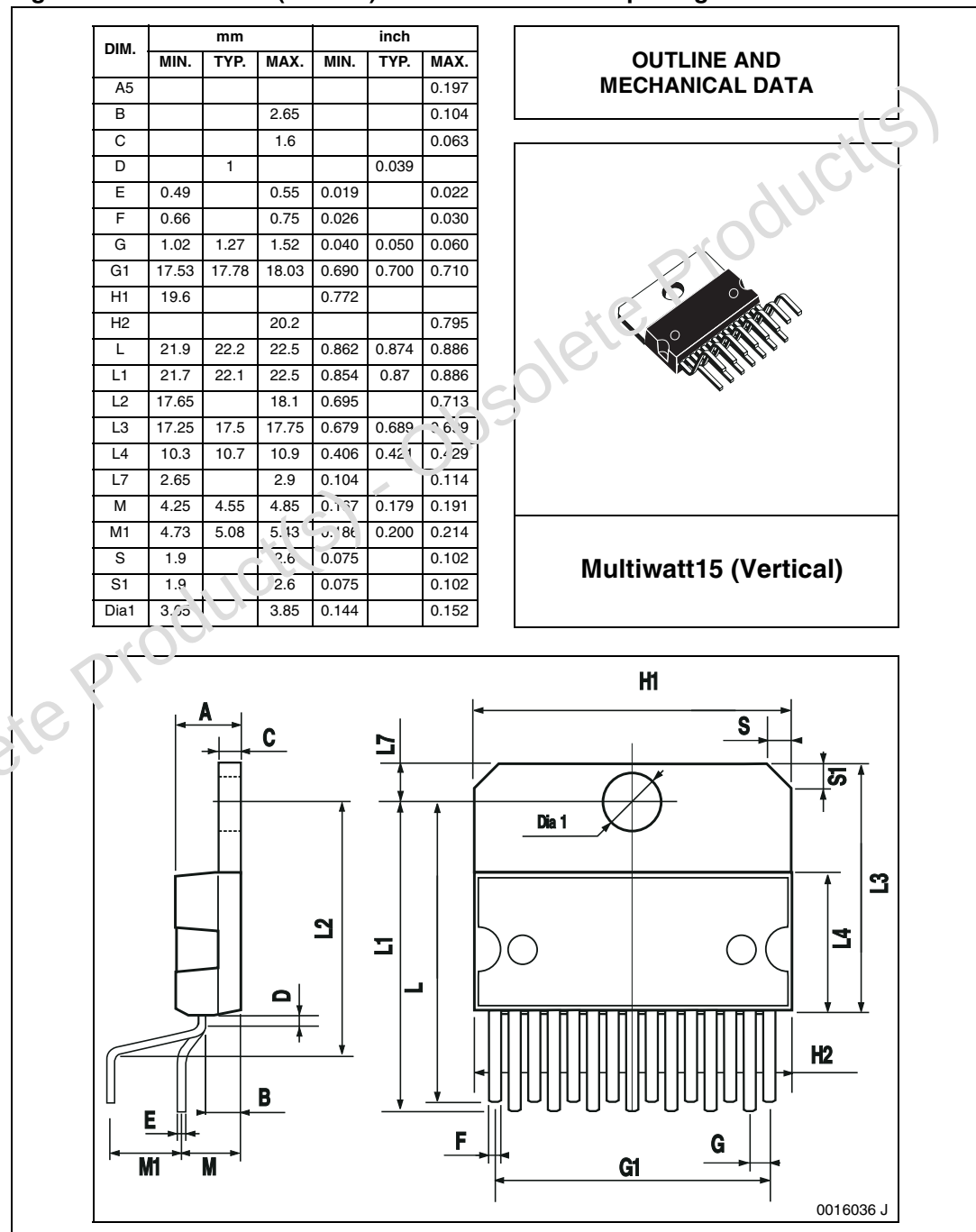
Bit 5 Controls the output voltage of REG4. A '0' corresponds to 8 V and a '1' corresponds to 10 V.

## 4 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](http://www.st.com).

ECOPACK® is an ST trademark.

**Figure 5. Multiwatt15 (vertical) mechanical data and package dimensions**



## 5 Revision history

**Table 5. Document revision history**

| Date        | Revision | Changes          |
|-------------|----------|------------------|
| 09-Jul-2010 | 1        | Initial release. |

Obsolete Product(s) - Obsolete Product(s)

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