



# TEA1721AT

**HV start-up flyback controller with integrated MOSFET for 5 W applications, 430 Hz burst frequency**

Rev. 2.1 — 7 June 2012

Product data sheet

## 1. Product profile

### 1.1 General description

The TEA1721 is a small and low cost module Switched Mode Power Supply (SMPS) controller IC for low power applications (up to 5 W) and operates directly from the rectified universal mains input. The device includes a high voltage power switch (700 V) and has been optimized for flyback converter topologies to provide high-efficiency over the entire load range with ultra-low power consumption in the no-load condition. It provides a circuit for start-up directly from the rectified mains voltage without any external bleeder circuits.

The converter operates as a regulated voltage source from no-load up to the maximum output current and operates as current source that delivers the maximum current over a broad output voltage range. Using the TEA1721, a low power converter can be built at minimum cost and with the minimum number of external components.

The controller regulates the output voltage with primary-side sensing which eliminates the need for an additional secondary feedback circuitry and simplifies the design. At higher power levels, a frequency and current control mode is used. It operates with Burst mode control at low power levels and no-load condition. The burst mode minimizes audible noise and provides an energy saver state which reduces the power consumption in no-load condition. The Burst mode frequency of 430 Hz enables no-load power consumption below < 10 mW at high mains input.

### 1.2 Features and benefits

Power features:

- Low power SMPS controller with integrated power switch designed for applications up to 5 W
- 700 V high voltage power switch for global mains operation
- Primary sensing for control of the output voltage without optocoupler and secondary feedback circuitry
- Minimizes audible noise in all operation modes
- USB battery charging and Energy Star 2.0 compliant
- Jitter function for reduced EMI



Green features:

- Enables no-load power consumption below < 10 mW
- Very low supply current in no-load condition with energy saver mode
- Incorporates a high voltage start-up circuit with zero current consumption under normal switching operation
- Available in halogen-free and Restriction of Hazardous Substances (RoHS) SO7 package

Protective functions:

- OverVoltage Protection (OVP) on Feedback control (FB) pin with auto-restart
- UnderVoltage LockOut (UVLO) protection on IC supply pin
- OverTemperature Protection (OTP)
- Soft-start by reduced peak current for zero and low output voltage
- Demagnetization protection for guaranteed discontinuous conduction mode operation
- Open and short-circuit protection of the Feedback control (FB) pin
- Short-circuit protection of the charger output

### 1.3 Applications

- Battery chargers for cellular phones and other low power adapters up to 5 W
- Standby supply for TV and desktop PC
- Power supply for white goods applications

### 1.4 Quick reference data

Table 1. Quick reference data

| Symbol                                     | Parameter                        | Conditions                                                     | Min | Typ  | Max | Unit     |
|--------------------------------------------|----------------------------------|----------------------------------------------------------------|-----|------|-----|----------|
| <b>Power switch (Pin: DRAIN)</b>           |                                  |                                                                |     |      |     |          |
| $R_{DSon}$                                 | drain-source on-state resistance | $I_{ds} = 30 \text{ mA}$ ; $T_j = 25 \text{ }^{\circ}\text{C}$ | 13  | 15.5 | 17  | $\Omega$ |
| <b>Oscillator (Pins: DRAIN and SOURCE)</b> |                                  |                                                                |     |      |     |          |
| $f_{burst}$                                | burst frequency                  | burst frequency in CVB mode, without jitter                    | 390 | 430  | 470 | Hz       |
| $f_{osc-high}$                             | oscillator frequency High        | maximum switching frequency in CV and CC mode, without jitter  | 48  | 50.5 | 53  | kHz      |
| <b>Supply (Pin: VCC)</b>                   |                                  |                                                                |     |      |     |          |
| $V_{CC(startup)}$                          | start-up supply voltage          |                                                                | 15  | 17   | 19  | V        |
| $V_{CC(stop)}$                             | stop supply voltage              | undervoltage lockout of IC                                     | 7.5 | 8.5  | 9.5 | V        |

2. Ordering information

Table 2. Ordering information

| Type number  | Package |                                                           | Version   |
|--------------|---------|-----------------------------------------------------------|-----------|
|              | Name    | Description                                               |           |
| TEA1721AT/N1 | SO7     | plastic small outline package; 7 leads; body width 3.9 mm | SOT1175-1 |

3. Block diagram

3.1 Block diagram

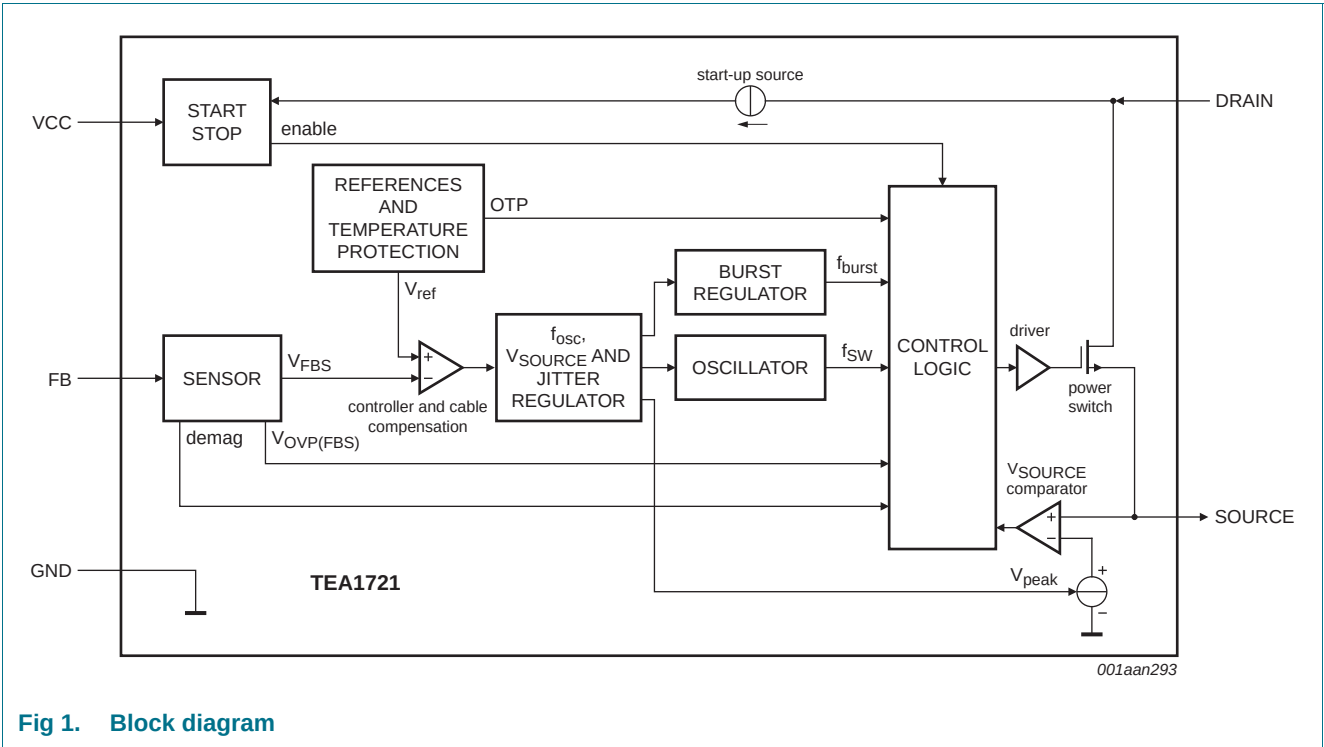


Fig 1. Block diagram

## 4. Pinning information

### 4.1 Pinning

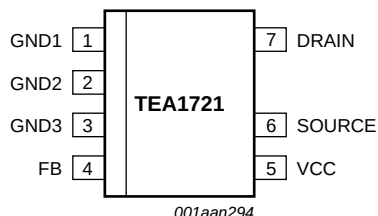


Fig 2. Pinning top view

### 4.2 Pin description

| Pin | Pin name | I/O type | Pin description                    |
|-----|----------|----------|------------------------------------|
| 1   | GND1     |          | ground                             |
| 2   | GND2     |          | ground                             |
| 3   | GND3     |          | ground                             |
| 4   | FB       | I        | feedback input for voltage sensing |
| 5   | VCC      | I        | supply input                       |
| 6   | SOURCE   | O        | source for power switch            |
| 7   | DRAIN    | I        | drain of power switch              |
| -   | -        |          | high voltage spacer                |

## 5. Functional description

### 5.1 Start-up

The TEA1721 starts up by charging the VCC capacitor until the  $V_{CC(start)}$  level. The charging current flows from the high voltage DRAIN pin via an internal start-up current source to the VCC pin.

Once the start level has been reached the start-up current source is switched off. During switching operation, the start-up current source remains current-less and has zero bleeder loss.

### 5.2 Primary sensing

The FB input senses the reflected secondary voltage on the primary side. The FB input has a sample and hold function that samples the FB voltage on the secondary stroke to control the output voltage.

The sampled  $V_{FBS}$  voltage is the input for the TEA1721's control loop and defines the operating mode.

### 5.3 Operating modes

The TEA1721 operates in three modes, one of which is active at the time. The three modes in order of decreasing load impedance are:

- CVB: Constant Voltage with Burst mode
- CV: Constant Voltage mode
- CC: Constant Current mode

The converter acts as a voltage source in CVB and CV modes.

The converter acts as a current source in CC mode.

#### 5.3.1 Constant Voltage with Burst mode (CVB)

At low power, the TEA1721 operates in Burst mode.

Burst mode operates with a  $V_{SOURCE} = 100$  mV, a switching frequency of 22.5 kHz and burst duty-cycle regulation by sensing the FB voltage.

The TEA1721 features an energy save function that puts the main part of the analogue blocks in a sleep mode with low supply current in burst mode. The burst mode enables the energy save mode in the non-switching part of the burst. The IC switches to the nominal supply just before new burst starts.

Transition from burst mode to CV mode happens at 100 % burst duty cycle: a burst completely filled with 32 pulses. This 100 % pulse train is identical to the lowest power level of the CV mode. The TEA1721 changes directly from burst mode to CV mode if the FB voltage drops below 2.4 V in burst mode.

#### 5.3.2 Constant Voltage mode (CV)

At higher power levels, the TEA1721 operates in CV mode. The output voltage is sensed by the FB pin and the control keeps the output voltage constant over the power range.

CV mode starts at 22.5 kHz switching frequency and  $I_{SOURCE}$  regulation at the  $V_{SOURCE}$  minimum level of 100 mV.

With an increasing power output, the  $V_{SOURCE}$  level and the switching frequency are also increased.

CV mode is exited when the maximum power level is reached. Maximum power occurs at  $I_{SOURCE}$  regulation at the  $V_{SOURCE}$  maximum level of 555 mV and a maximum switching frequency of 50.5 kHz.

### 5.3.3 Constant Current mode (CC)

The CC mode starts at maximum power delivery and keeps the output current constant for decreasing output voltage.

CC mode is enabled when the converter is operating at the maximum switching frequency, with the maximum primary peak current when the FB voltage drops below the regulated level.

CC mode operation controlled is by regulation of the switching frequency from 50.5 kHz down to 22.5 kHz and by  $I_{SOURCE}$  regulation from the maximum  $V_{SOURCE}$  level of 555 mV until level of  $V_{SOURCE}$  is 0.21 V. The  $V_{SOURCE}$  level of 0.21 V equals the level at start-up with zero output voltage and the output capacitor discharged or on a short-circuit of the charger output.

### 5.4 Jitter

The TEA1721 features a jitter function for ElectroMagnetic Interference (EMI) reduction. The switching frequency is 7 % typical for the spread spectrum. The sweep frequency is a low frequency of approximately 200 Hz. To keep the output power constant, the  $V_{SOURCE}$  level is jittered with the opposite polarity. The jitter is active in all operation modes except burst mode.

## 6. Limiting values

**Table 3. Limiting values**

*In accordance with the Absolute Maximum Rating System (IEC 60134).*

| Symbol              | Parameter                       | Conditions                  | Min                       | Max   | Unit |
|---------------------|---------------------------------|-----------------------------|---------------------------|-------|------|
| T <sub>amb</sub>    | ambient temperature             |                             | -40                       | +85   | °C   |
| T <sub>j</sub>      | junction temperature            |                             | -40                       | +150  | °C   |
| T <sub>stg</sub>    | storage temperature             |                             | -55                       | +150  | °C   |
| V <sub>ESD</sub>    | electrostatic discharge voltage | CDM; all pins               | -500                      | +500  | V    |
|                     |                                 | HBM; all pins, except pin 7 | <a href="#">[1]</a> -2000 | +2000 | V    |
|                     |                                 | HBM; pin 7                  | <a href="#">[1]</a> -1000 | +1000 | V    |
| Voltages            |                                 |                             |                           |       |      |
| V <sub>DRAIN</sub>  | voltage on pin DRAIN            |                             | -2                        | +700  | V    |
| V <sub>SOURCE</sub> | voltage on pin SOURCE           |                             | -0.3                      | +5    | V    |
| V <sub>CC</sub>     | voltage on pin VCC              |                             | -0.3                      | +35   | V    |
| V <sub>FB</sub>     | voltage on pin FB               |                             | -20                       | +5    | V    |
| Currents            |                                 |                             |                           |       |      |
| I <sub>DRAIN</sub>  | current on pin DRAIN            |                             | -0.1                      | +0.7  | A    |
| I <sub>SOURCE</sub> | current on pin SOURCE           |                             | -0.7                      | +0.1  | A    |

[1] Human body model: equivalent to discharging a 100 pF capacitor through a 1.5 kΩ series resistor.

## 7. Thermal characteristics

**Table 4. Thermal characteristics**

| Symbol        | Parameter                                   | Conditions                                                                  | Min | Typ | Max | Unit |
|---------------|---------------------------------------------|-----------------------------------------------------------------------------|-----|-----|-----|------|
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | in free air; SO7 package; on open PCB of 2.2 cm X 2.2 cm; 2-layer; 70 μm Cu | -   | 136 | -   | K/W  |
|               |                                             | in free air; SO7 package; on open PCB of 3 cm X 6 cm; 1-layer; 35 μm Cu     | -   | 136 | -   | K/W  |

## 8. Characteristics

**Table 5. Characteristics**

$V_{CC} = 20\text{ V}$ ;  $V_{FB} = 0\text{ V}$ ;  $R_{source} = 1.5\ \Omega$ ;  $T_{j-switch} = 25\text{ }^{\circ}\text{C}$ ;  $T_{j-controller} = 25\text{ }^{\circ}\text{C}$ ; all voltages referenced to GND, positive currents flow into the IC, unless otherwise specified.

| Symbol                                     | Parameter                                                          | Conditions                                                                                     | Min  | Typ  | Max  | Unit               |
|--------------------------------------------|--------------------------------------------------------------------|------------------------------------------------------------------------------------------------|------|------|------|--------------------|
| <b>Supply (Pin: VCC)</b>                   |                                                                    |                                                                                                |      |      |      |                    |
| $I_{CC(startup)0V}$                        | start-up supply current                                            | $V_{CC} = 0\text{ V}$                                                                          | -1.6 | -1.2 | -0.8 | mA                 |
| $I_{CC(startup)17V}$                       | start-up supply current                                            | $V_{CC} = V_{CC(startup)}$                                                                     | -1.6 | -0.7 | -0.2 | mA                 |
| $I_{CC(energysave)}$                       | supply current in energy save                                      | $V_{FB} = 2.8\text{ V}$ , non-switching                                                        | 90   | 130  | 170  | $\mu\text{A}$      |
| $I_{CC(50kHz)}$                            | supply current at 50 kHz                                           | in CC mode                                                                                     | 530  | 750  | 970  | $\mu\text{A}$      |
| $V_{CC(startup)}$                          | start-up supply voltage                                            |                                                                                                | 15   | 17   | 19   | V                  |
| $V_{CC(stop)}$                             | stop supply voltage                                                | undervoltage lockout of IC                                                                     | 7.5  | 8.5  | 9.5  | V                  |
| $T_{otp}$                                  | overtemperature protection threshold temperature on controller die |                                                                                                | 140  | 150  | 160  | $^{\circ}\text{C}$ |
| $T_{otp(hys)}$                             | overtemperature protection temperature hysteresis                  |                                                                                                | -    | 50   | -    | $^{\circ}\text{C}$ |
| <b>Feedback (Pin: FB)</b>                  |                                                                    |                                                                                                |      |      |      |                    |
| $V_{th(ovp)fbck}$                          | feedback overvoltage protection threshold voltage                  |                                                                                                | 3.1  | 3.2  | 3.3  | V                  |
| $V_{ref(fbck)}$                            | feedback reference voltage                                         | in CV ode                                                                                      | 2.5  | 2.55 | 2.6  | V                  |
| $V_{th(fbck)CV}$                           | constant voltage mode feedback threshold voltage                   | in burst mode operation                                                                        | 2.35 | 2.4  | 2.45 | V                  |
| $V_{th(det)demag(fb)}$                     | demagnetization detection voltage level on FB pin                  |                                                                                                | 25   | 50   | 75   | mV                 |
| <b>Oscillator (Pins: DRAIN and SOURCE)</b> |                                                                    |                                                                                                |      |      |      |                    |
| $f_{burst}$                                | burst frequency                                                    | burst frequency in CVB mode, without jitter                                                    | 390  | 430  | 470  | Hz                 |
| $f_{jit}/f_{sw}$                           | jitter frequency to switching frequency ratio                      | in all operation modes except in CVB mode                                                      | 5    | 7    | 9    | %                  |
| $f_{osc-high}$                             | oscillator frequency High                                          | maximum switching frequency in CV and CC mode, without jitter                                  | 48   | 50.5 | 53   | kHz                |
| $f_{osc-low}$                              | oscillator frequency Low                                           | minimum switching frequency in CV and CC mode, without jitter. Switching frequency in CVB mode | 21   | 22.5 | 24   | kHz                |
| $f_{sweep}$                                | jitter sweep frequency                                             | In current source operation                                                                    | 150  | 200  | 250  | Hz                 |
| $\bar{D}_{max}$                            | maximum duty cycle                                                 |                                                                                                | 72   | 75   | 78   | %                  |



**Table 5.** Characteristics ...continued

$V_{CC} = 20\text{ V}$ ;  $V_{FB} = 0\text{ V}$ ;  $R_{source} = 1.5\ \Omega$ ;  $T_{j-switch} = 25\text{ }^{\circ}\text{C}$ ;  $T_{j-controller} = 25\text{ }^{\circ}\text{C}$ ; all voltages referenced to GND, positive currents flow into the IC, unless otherwise specified.

| Symbol                                       | Parameter                                             | Conditions                                                          | Min   | Typ   | Max   | Unit          |
|----------------------------------------------|-------------------------------------------------------|---------------------------------------------------------------------|-------|-------|-------|---------------|
| <b>Power switch (Pin: DRAIN)</b>             |                                                       |                                                                     |       |       |       |               |
| $I_{\text{drain(off)}}$                      | off-state drain current                               | $V_{\text{DRAIN}} = 325\text{ V}$                                   | -     | 1     | -     | $\mu\text{A}$ |
| $R_{\text{DSon}}$                            | drain-source on-state resistance                      | $T_j = 25\text{ }^{\circ}\text{C}$ ; $I_{\text{ds}} = 30\text{ mA}$ | 13    | 15.5  | 17    | $\Omega$      |
| $V_{(\text{BR})\text{DS}}$                   | drain-source breakdown voltage                        |                                                                     | 700   | -     | -     | V             |
| <b>Peak current comparator (Pin: SOURCE)</b> |                                                       |                                                                     |       |       |       |               |
| $t_{\text{PD}}$                              | propagation delay time                                | $dV/dt = 0.2\text{ V}/\mu\text{s}$                                  | -     | 100   | -     | ns            |
| $t_{\text{leb}}$                             | leading edge blanking time                            |                                                                     | 290   | 325   | 360   | ns            |
| $V_{\text{ref-peak-high}}$                   | reference voltage, high peak voltage                  | maximum peak voltage in CV and CC modes, without jitter             | 0.525 | 0.555 | 0.585 | V             |
| $V_{\text{ref-peak-low}}$                    | reference voltage, low peak voltage                   | in CVB mode                                                         | 0.085 | 0.1   | 0.115 | V             |
| $V_{\text{ref-0 V}}$                         | reference voltage at start-up or 0 V feedback voltage | in CC mode with $V_{\text{FBS}} = 0\text{ V}$                       | 0.18  | 0.21  | 0.24  | V             |

9. Package outline

SO7: plastic small outline package; 7 leads; body width 3.9 mm

SOT1175-1

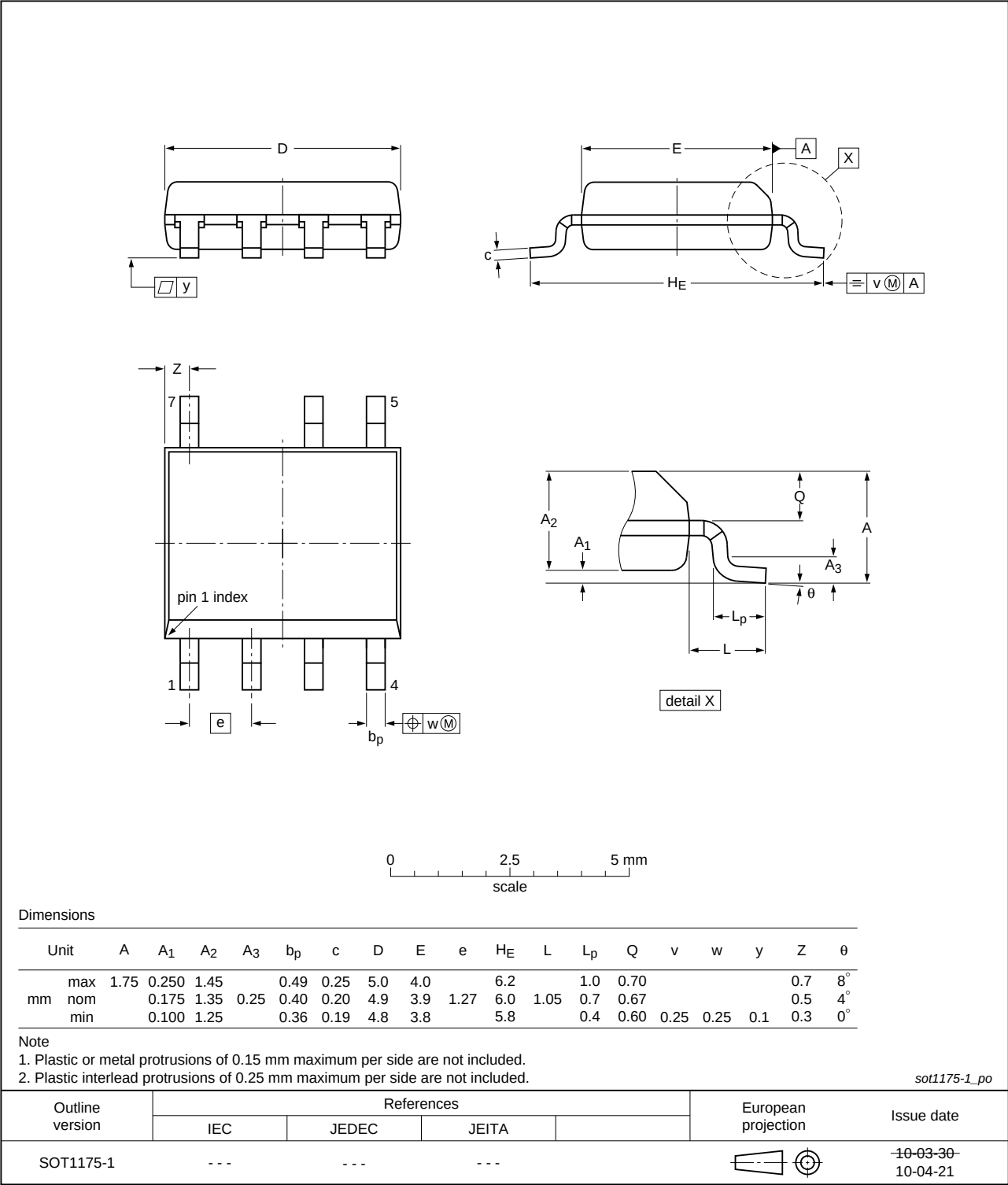


Fig 3. Package outline SOT1175-1 (SO7)

## 10. Revision history

Table 6. Revision history

| Document ID     | Release date                                                                                                                                                                              | Data sheet status      | Change notice | Supersedes    |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|---------------|---------------|
| TEA1721AT v.2.1 | 20120607                                                                                                                                                                                  | Product data sheet     | -             | TEA1721AT v.2 |
| Modifications:  | <ul style="list-style-type: none"><li>• Symbol <math>t_{d(OCF)}</math> changed to <math>t_{PD}</math> in table <a href="#">5 on page 8</a>.</li><li>• Data sheet title changed.</li></ul> |                        |               |               |
| TEA1721AT v.2   | 20120507                                                                                                                                                                                  | Product data sheet     | -             | TEA1721AT v.1 |
| TEA1721AT v.1   | 20120124                                                                                                                                                                                  | Preliminary data sheet | -             | -             |

## 11. Legal information

### 11.1 Data sheet status

| Document status <sup>[1] [2]</sup> | Product status <sup>[3]</sup> | Definition                                                                            |
|------------------------------------|-------------------------------|---------------------------------------------------------------------------------------|
| Objective [short] data sheet       | Development                   | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet     | Qualification                 | This document contains data from the preliminary specification.                       |
| Product [short] data sheet         | Production                    | This document contains the product specification.                                     |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.

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