

# UBA3070

## LED backlight driver IC

Rev. 3 — 9 December 2010

Product data sheet

### 1. General description

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The UBA3070 driver IC is the first member of a first generation of power-efficient LED backlight driver ICs. Highly efficient, flexible and reliable LED drivers can easily be designed using the UBA3070 control IC.

### 2. Features and benefits

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- Switch-mode buck controller that drives strings of LEDs up to 600 V power-efficiently
- Controller with power-efficient Boundary Conduction Mode (BCM) operation:
  - ◆ Virtually no reverse recovery losses in freewheel diode
  - ◆ Zero Current Switching (ZCS) at switch, switch-on
  - ◆ Zero voltage or valley switching at switch, switch-on
  - ◆ Minimal required inductance value and size
- Suitable for direct Pulse Width Modulation (PWM) dimming
- Fast transient response through cycle-by-cycle current control, thereby:
  - ◆ Preventing over or undershoots in the Light Emitting Diode (LED) current
  - ◆ Enabling efficient PWM dimming by quickly turning the converter on and off and thus removing the need for extra dimming switches and high-side drivers
- Single controlled input voltage required for all UBA3070 driven LED strings in RGB or white backlighting units
- No binning on LED forward voltage required
- Protections:
  - ◆ UnderVoltage LockOut (UVLO)
  - ◆ Leading Edge Blanking (LEB)
  - ◆ OverCurrent Protection (OCP)
  - ◆ OverTemperature Protection (OTP)
- Low cost LED driver solution:
  - ◆ No fast-switching Schottky diode required due to ZCS
  - ◆ No dimming switch or high-side driver required for PWM dimming
  - ◆ Operates with smaller inductor than a comparable fixed-frequency Continuous Conduction Mode (CCM) controller

### 3. Applications

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- The UBA3070 is suitable for high voltage LED lighting application:
  - ◆ LED backlighting in LCD televisions and monitors
  - ◆ General lighting applications
- The UBA3070 application is most efficient when driving long LED strings



### 4. Ordering information

Table 1. Ordering information

Type number	Package		Version
	Name	Description	
UBA3070T	SO8	plastic small outline package; 8 leads; body width 3.9 mm	SOT96-1

### 5. Block diagram

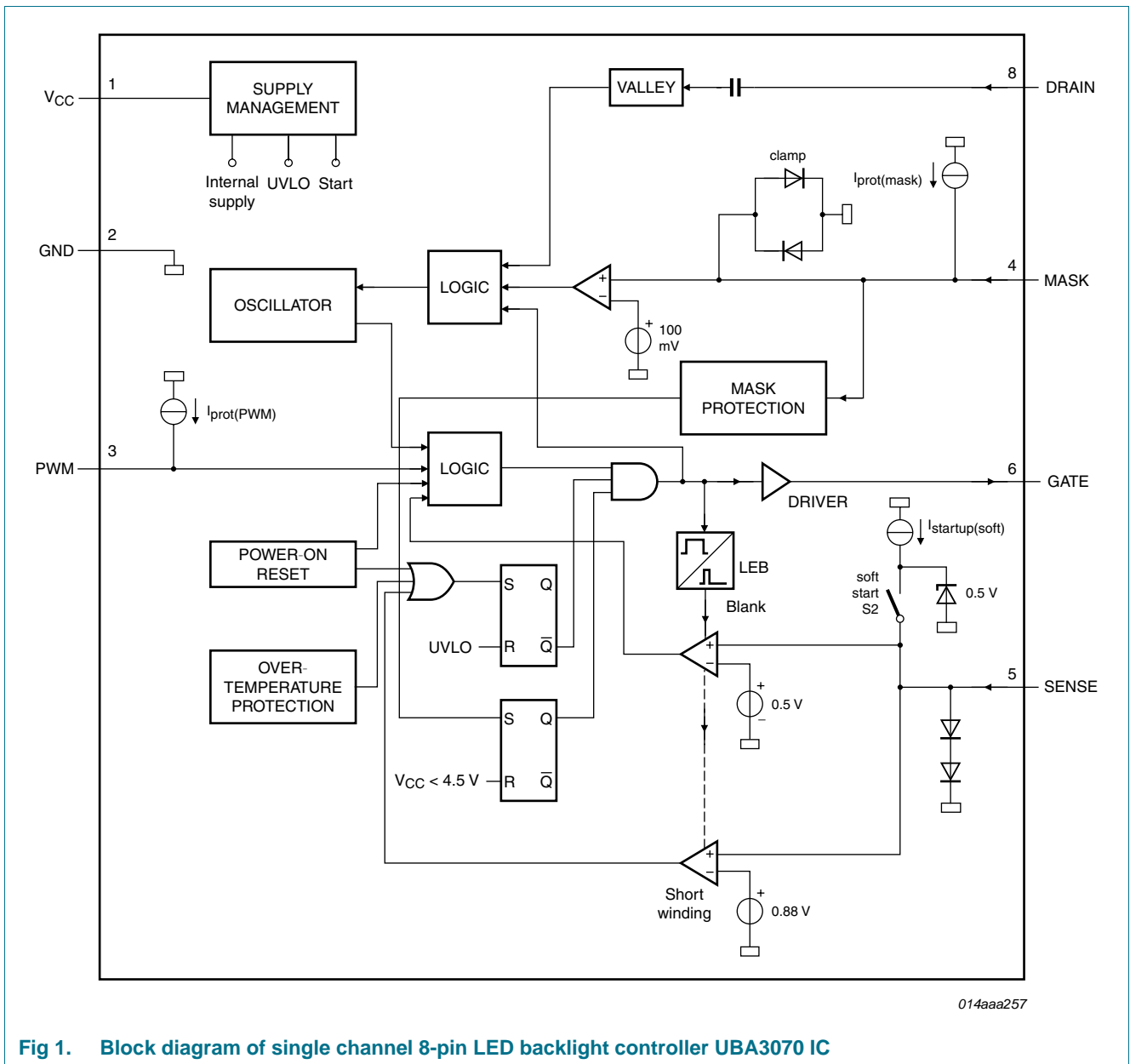


Fig 1. Block diagram of single channel 8-pin LED backlight controller UBA3070 IC

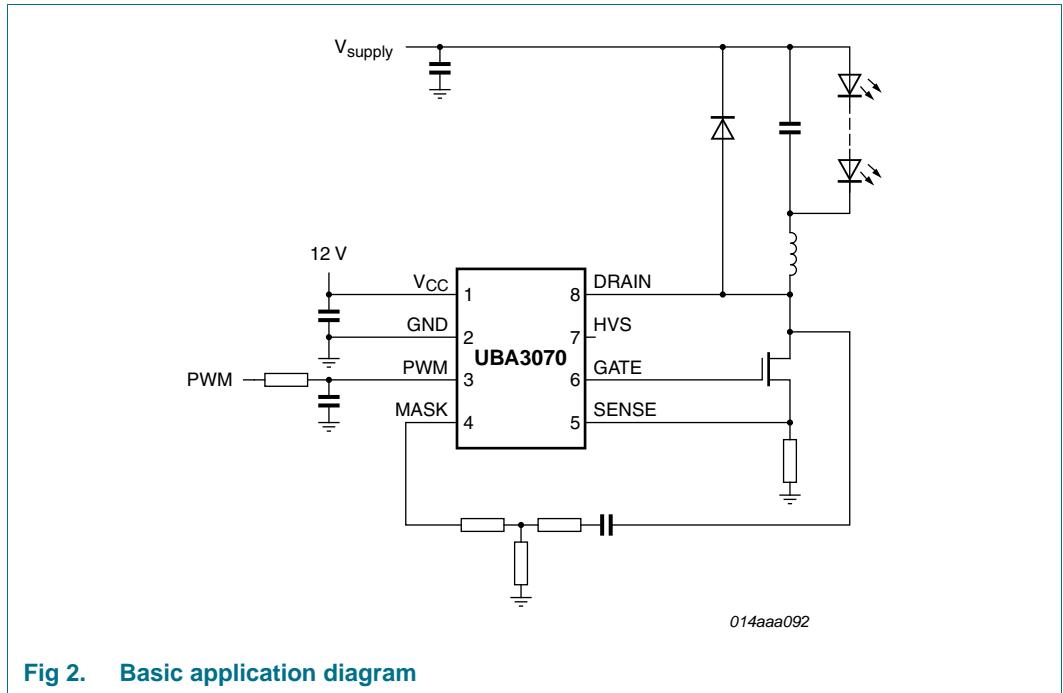


Fig 2. Basic application diagram

## 6. Pinning information

### 6.1 Pinning

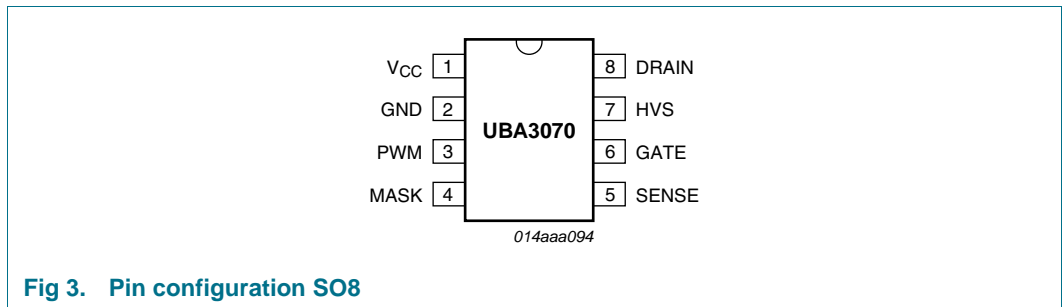


Fig 3. Pin configuration SO8

### 6.2 Pin description

Table 2. Pin description

Symbol	Pin S08	Description
V <sub>CC</sub>	1	supply voltage
GND	2	ground
PWM	3	PWM input voltage
MASK	4	masking input voltage
SENSE	5	resistor programmable current sense input
GATE	6	gate driver output
HVS	7	high voltage safety spacer: not connected
DRAIN	8	drain of external MOSFET switch: input for valley sensing

## 7. Functional description

The UBA3070 is a monolithic driver IC for controlling the current through LED strings e.g. 45 green/blue/white LEDs connected in series making the UBA3070 IC especially suitable as an LED driver.

The driver stage enables optimal performance for series connected LED strings in 0D, 1D and 2D segmented Backlight Units (BLUs). Since the UBA3070 drives an external power device, it can be used for all kinds of BLU designs ranging from high-power to low-power LEDs, and high-voltage to low-voltage LED strings. Therefore, the UBA3070 is an excellent driver solution for all types of LEDs and LCD screen sizes. Combining the UBA3070 with suitable power devices means the quantity of drivers can be minimized by optimizing the quantity of series LEDs.

Each driver stage consists of a buck converter operating in BCM with its peak level determined by an external sense resistor. Since the peak and zero levels are fixed by design, the converter behaves as a current source. This gives an average LED current throughput that is half the peak value of that through the inductor. The ripple current through the LEDs can be selected by connecting an external capacitor in parallel with the LEDs.

### 7.1 Supply management and UVLO

As long as  $V_{CC}$  is below the  $V_{CC(\text{startup})}$  level of typically 10 V, the supply current remains below 600  $\mu\text{A}$ . The UBA3070 IC activates the converter as soon as the voltage on the  $V_{CC}$  pin passes the  $V_{CC(\text{startup})}$  level. When the voltage on  $V_{CC}$  pin drops below the UVLO voltage typically 8.7 V the UBA3070 IC stops switching.

### 7.2 Current control and PWM

If the PWM input is HIGH ( $> 2\text{ V}$ ) the converter is disabled and does not switch and, LED current remains at zero. When the PWM input pin is LOW ( $< 0.5\text{ V}$ ) the converter is enabled and operates as follows.

The external Field-Effect Transistor (FET) is turned on and current in the inductor begins to build up. During the charging phase of the inductor the current is sensed across an external sense resistor. The internal driver turns off the external FET on detecting a voltage level of 0.52 V at the SENSE pin. The inductor now starts to freewheel its current through the external diode and starts discharging.

Following the discharge period the switch node rings. On detection of a valley or zero voltage on the switch node the internal driver turns on the external FET. As the FET is at zero current and minimal voltage, this results in minimal power losses and ElectroMagnetic Interference (EMI). The conversion cycle is repeated as described above, until the PWM input signal is driven high to disable the converter and steers the LED current to zero.

If the PWM pin is open circuit or not connected, a fault condition is assumed and the converter stops switching. Operation restarts as soon as the fault condition is removed.

### 7.3 Masking and valley switching

The MASK pin ensures that switch-on of the converter is at a valley during ringing and not at a peak during freewheeling of the inductor. If the voltage level at the MASK pin is above 100 mV, then switch-on of the switching FET is prevented. If the voltage level is below 100 mV, then switch-on prevention of the FET is released and at the moment of valley detection the FET is turned on. The signal for the MASK pin can be derived from the signal at the switch node as shown in [Figure 2](#). The current flowing into the MASK pin must be lower than the typical stop current of 60  $\mu$ A.

If the MASK pin is open circuit or not connected, a fault condition is assumed and the converter stops operating immediately. Operation restarts as soon as the fault condition is removed.

### 7.4 Conversion frequency

The maximum conversion frequency of the UBA3070 is limited to 175 kHz. However, due to production spread, the maximum conversion frequency of an individual UBA3070 sample can be as low as 145 kHz. Therefore, an inductance value must be selected so that the applications conversion frequency always remains below 145 kHz after taking into account variations due to the supply voltage, LED string voltage and component spread. There is no limitation for the minimum conversion frequency.

### 7.5 Minimum on-time

The LEB time, typically 370 ns is a fixed delay that determines the minimum on-time of the controller. The LEB time prevents the MOSFET switch from switching off unintentionally (due to coupling to the sense node) directly after the start of a conversion cycle.

### 7.6 OverCurrent Protection (OCP)

As the converter acts as a current source it is self-protected from overcurrent by an extra level of protection, i.e. a second trip level of typically 0.88 V applied to the short-winding/sense node as shown in [Figure 1](#). This second trip level is designed to protect the converter against short-circuits in external components e.g. in the diodes, inductors, capacitors and/or LEDs. If a short-circuit is detected the converter stops switching.

### 7.7 OverTemperature Protection (OTP)

OTP is provided in the UBA3070 IC and functions as follows. When the junction temperature exceeds the thermal shutdown temperature of typically 140 °C the converter stops switching.

### 7.8 Driver

The driver circuit to the gate of the power FET has a current sourcing capability of approximately 135 mA and a current sinking capability of 560 mA. This capability means the FET operates more efficiently with fast switch-on and switch-off cycles. A low driver source current has been chosen to limit the  $\Delta V/\Delta t$  at switch-on thereby reducing EMI and voltage spikes across  $R_{sense}$ .

## 8. Limiting values

**Table 3. Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134).<sup>[1]</sup>

Symbol	Parameter	Conditions	Min	Max	Unit <sup>[1]</sup>	
<b>Voltages</b>						
V <sub>CC</sub>	supply voltage	current limited	-0.4	+20	V	
V <sub>PWM</sub>	voltage on pin PWM		-0.4	+5	V	
V <sub>MASK</sub>	voltage on pin MASK	current limited	-0.4	-	V	
V <sub>SENSE</sub>	voltage on pin SENSE	current limited	-0.4	-	V	
V <sub>DRAIN</sub>	voltage on pin DRAIN		-0.4	+650	V	
<b>Currents</b>						
I <sub>PWM</sub>	current on pin PWM		-	5	mA	
I <sub>MASK</sub>	current on pin MASK		-250	+250	μA	
I <sub>SENSE</sub>	current on pin SENSE		-1	+10	mA	
I <sub>GATE</sub>	current on pin GATE	d < 10 %	-0.8	+2	A	
I <sub>DRAIN</sub>	current on pin DRAIN		-	5	mA	
<b>General</b>						
P <sub>tot</sub>	total power dissipation	T <sub>amb</sub> < 70 °C	-	0.5	W	
T <sub>stg</sub>	storage temperature		-55	+150	°C	
T <sub>j</sub>	junction temperature		-40	+145	°C	
<b>ESD</b>						
V <sub>ESD</sub>	electrostatic discharge voltage		-	-	-	
		all pins except pins DRAIN and V <sub>CC</sub> ; HBM class 1	<sup>[2]</sup>	-	2000	V
		pins DRAIN and V <sub>CC</sub> ; HBM class 1	<sup>[2]</sup>	-	1500	V
	any pin; MM	<sup>[3]</sup>	-	200	V	

[1] All voltages are measured with respect to ground; positive currents flow into the UBA3070 IC. The V<sub>CC</sub> pin may not be current driven. The voltage ratings are valid provided other ratings are not violated. The current ratings are valid provided the maximum power rating is not violated.

[2] Human Body Model (HBM): equivalent to discharging a 100 pF capacitor through a 1.5 kΩ resistor.

[3] Machine Model (MM): equivalent to discharging a 200 pF capacitor through a 0.75 μH coil and a 10 Ω resistor.

## 9. Thermal characteristics

**Table 4. Thermal characteristics**

Symbol	Parameter	Conditions	Typ	Unit
R <sub>th(j-a)</sub>	thermal resistance from junction to ambient	in free air	150	K/W

## 10. Characteristics

**Table 5. Characteristics**

$T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $V_{CC} = 15\text{ V}$ ; all voltages are measured with respect to ground; currents are positive when flowing into the UBA3070 IC; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{BR}$	breakdown voltage		650	-	-	V
<b>Supply voltage management (<math>V_{CC}</math> pin)</b>						
$V_{CC(\text{startup})}$	start-up supply voltage		9.3	10	10.6	V
$V_{CC(\text{UVLO})}$	undervoltage lockout supply voltage		8.1	8.7	9.3	V
$V_{CC(\text{hys})}$	hysteresis of supply voltage	$V_{CC(\text{startup})} - V_{CC(\text{UVLO})}$	1.0	1.3	1.6	V
$I_{CC(\text{oper})}$	operating supply current	no load on GATE pin	1.1	1.3	1.5	mA
$I_{CC(\text{startup})}$	start-up supply current	$V_{CC} < V_{CC(\text{startup})}$	-	-	600	$\mu\text{A}$
$I_{CC(\text{prot})}$	protection supply current	$V_{CC} > V_{CC(\text{UVLO})}$	-	0.85	-	mA
<b>Masking management (MASK pin)</b>						
$V_{th(\text{MASK})}$	threshold voltage on pin MASK		50	100	150	mV
$V_{\text{clamp}(\text{neg})(\text{MASK})}$	negative clamp voltage on pin MASK	$I_{\text{MASK}} = -150\text{ }\mu\text{A}$	-0.5	-0.25	-0.05	V
$V_{\text{clamp}(\text{pos})(\text{MASK})}$	positive clamp voltage on pin MASK	$I_{\text{MASK}} = 250\text{ }\mu\text{A}$	0.5	0.7	0.9	V
$I_{\text{stop}(\text{pos})(\text{MASK})}$	positive stop current on pin MASK		54	60	66	$\mu\text{A}$
$t_{\text{sup}(\text{xfrm}_r\text{ring})}$	transformer ringing suppression time	start secondary stroke	1.1	1.5	1.9	$\mu\text{s}$
$I_{\text{prot}(\text{MASK})}$	protection current on pin MASK	$V_{\text{MASK}} = 50\text{ mV}$	-50 <sup>[1]</sup>	-	-10	nA
<b>Oscillator</b>						
$f_{\text{osc}(\text{high})}$	high oscillator frequency	$V_{\text{PWM}}$ is LOW	145	175	205	kHz
<b>PWM duty cycle control (PWM pin)</b>						
$V_{IL(\text{en})\text{ILED}(\text{PWM})}$	LED current enable LOW-level input voltage on pin PWM		<sup>[2]</sup> -	-	0.5	V
$V_{IH(\text{dis})\text{ILED}(\text{PWM})}$	LED current disable HIGH-level input voltage on pin PWM		<sup>[2]</sup> 2.0	-	-	V
$I_{\text{prot}(\text{PWM})}$	protection current on pin PWM	$V_{\text{PWM}} = 1.5\text{ V}$	-1.0 <sup>[1]</sup>	-0.8	-0.5	$\mu\text{A}$
<b>Valley switch (DRAIN pin)</b>						
$(\Delta V/\Delta t)_{\text{vrec}}$	valley recognition voltage change with time		-85	-	+85	V/ $\mu\text{s}$
$t_{\text{d}(\text{vrec-swon})}$	valley recognition to switch-on delay time		-	150 <sup>[1]</sup>	-	ns
<b>OCP (SENSE pin)</b>						
$V_{\text{sense}(\text{max})}$	maximum sense voltage	$\Delta V/\Delta t = 0.1\text{ V}/\mu\text{s}$	0.48	0.52	0.56	V
$t_{\text{PD}}$	propagation delay	$\Delta V/\Delta t = 0.5\text{ V}/\mu\text{s}$	-	140	185	ns
$V_{\text{swp}}$	short-winding protection voltage		0.83	0.88	0.95	V
$t_{\text{leb}}$	leading edge blanking time		300	370	440	ns
$I_{\text{startup}(\text{soft})}$	soft startup current	$R_{\text{sense}} < 0.5\text{ V}$	45	60	75	$\mu\text{A}$

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

$T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $V_{CC} = 15\text{ V}$ ; all voltages are measured with respect to ground; currents are positive when flowing into the UBA3070 IC; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Driver (GATE pin)</b>						
$I_{source}$	source current	$V_{CC} = 9.5\text{ V}$ ; $V_{GATE} = 2\text{ V}$	-	-135	-	mA
$I_{sink}$	sink current	$V_{CC} = 9.5\text{ V}$ ; $V_{GATE} = 2\text{ V}$	-	240	-	mA
		$V_{CC} = 9.5\text{ V}$ ; $V_{GATE} = 9.5\text{ V}$	-	560	-	mA
$V_{o(max)}$	maximum output voltage	$V_{CC} > 12\text{ V}$	-	11.5	12	V
<b>OTP</b>						
$T_{pl(max)}$	maximum protection level temperature		130	140	150	$^{\circ}\text{C}$
$T_{pl(hys)}$	protection level hysteresis temperature		-	8	-	$^{\circ}\text{C}$

[1] Guaranteed by design.

[2] When the voltage at the PWM pin is between 0.5 V to 2.0 V the peak current and the frequency is reduced.



### 11. Package outline

SO8: plastic small outline package; 8 leads; body width 3.9 mm

SOT96-1

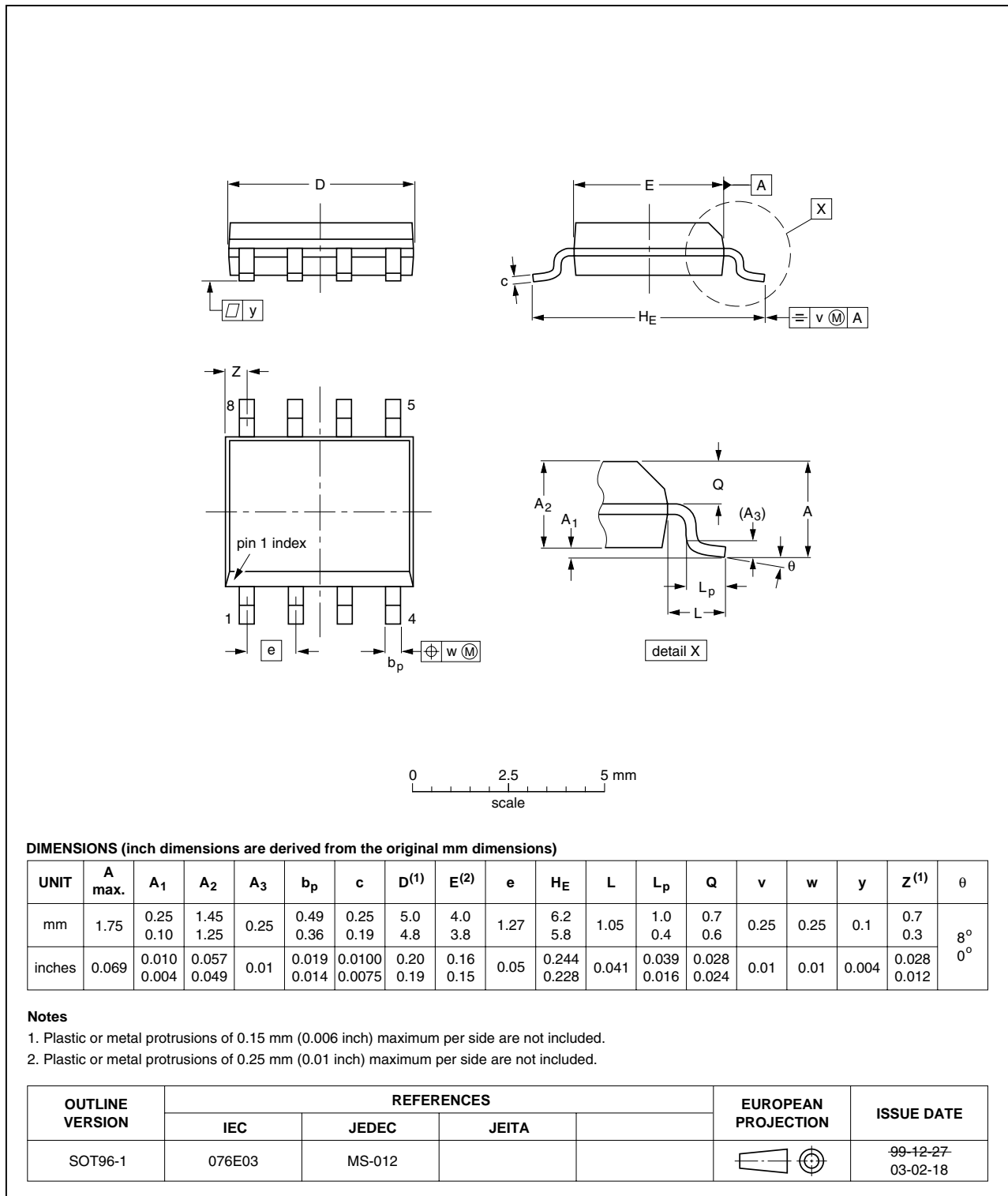


Fig 4. Package outline SOT96-1 (SO8)

## 12. Abbreviations

Table 6. Abbreviations

Acronym	Description
BCM	Boundary Conduction Mode
BLU	Backlight Unit
CCM	Continuous Conduction Mode
EMI	ElectroMagnetic Interference
FET	Field-Effect Transistor
HBM	Human Body Model
IC	Integrated Circuit
LCD	Liquid Crystal Display
LEB	Leading Edge Blanking
LED	Light Emitting Diode
MM	Machine Model
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
OCP	OverCurrent Protection
OTP	OverTemperature Protection
PWM	Pulse Width Modulation
RGB	Red/Green/Blue
UVLO	UnderVoltage LockOut
ZCS	Zero Current Switching

## 13. References

- [1] **UM10400** — UBA3070 V1.2 demo board

## 14. Revision history

Table 7. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
UBA3070 v.3	20101209	Product data sheet	-	UBA3070 v.2
Modifications:	• Minor updates.			
UBA3070 v.2	20080212	Product data sheet	-	UBA3070 v.1
Modifications:	• The minimum value for junction temperature has been updated in <a href="#">Table 3</a> .			
UBA3070 v.1	20080605	Product data sheet	-	-

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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.
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Product [short] data sheet	Production	This document contains the product specification.

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