

# TLE6363 – Picking the Right Components

## Multifunctional Voltage Regulator and Watchdog

Z8F52274258

## Application Note

Rev. 1.01, 2015-04-16

Automotive Power

## Table of Contents

	<b>Table of Contents</b> .....	<b>2</b>
<b>1</b>	<b>Abstract</b> .....	<b>3</b>
<b>2</b>	<b>Introduction</b> .....	<b>4</b>
<b>3</b>	<b>General</b> .....	<b>5</b>
<b>4</b>	<b>Product Description</b> .....	<b>6</b>
4.1	TLE6363 Feature List .....	6
4.2	Block Diagram and Short Description .....	6
<b>5</b>	<b>Application Information</b> .....	<b>8</b>
5.1	Application Circuit .....	8
5.1.1	Input Diodes .....	9
5.1.2	Boost Converter Components .....	9
5.1.2.1	Boost Output Voltage Adjust .....	9
5.1.2.2	Boost Inductance ( $L_{BO}$ ) .....	9
5.1.2.3	Boost Capacitance ( $C_{BO}$ ) .....	10
5.1.2.4	Freewheeling Diode / Catch Diode ( $D_{BO}$ ) .....	10
5.1.3	Buck Converter Components .....	10
5.1.3.1	Buck Inductance ( $L_{BU}$ ) Selection .....	10
5.1.3.2	Buck Output Capacitor ( $C_{BU}$ ) .....	11
5.1.3.3	Freewheeling Diode / Catch Diode ( $D_{BU}$ ) .....	11
5.1.3.4	Bootstrap Capacitor ( $C_{BOT}$ ) .....	11
<b>6</b>	<b>Layout Recommendations</b> .....	<b>12</b>
<b>7</b>	<b>Conclusion</b> .....	<b>13</b>
7.1	Other Infineon Parts .....	13
<b>8</b>	<b>Revision History</b> .....	<b>14</b>

---

**Abstract**

## **1 Abstract**

The TLE6363, a switching converter with integrated power stages for Boost and Buck topologies, is optimized for use in automotive applications. It allows simple and cost effective construction of small control unit power supplies and can bridge short term failures of the battery voltage.

This Application Note provides information on the right choice of external components, for correct PCB design and describes the application boards available.

---

**Introduction**

## **2 Introduction**

The on-board network in a modern automobile has a large number of appliances and loads. Rapid changes in load lead to large voltage variations. For example the 12 V battery voltage drops for about 100 ms below 5V while the starter converts a lot of energy during cranking.

Therefore, conventional voltage control units, composed of linear voltage regulators, cannot maintain a continuous 5 V supply to a microcontroller as example. A simple solution for such cases is a power supply for a wide range of input voltages with the capability of buffering a specific amount of energy. This involves switched concepts which have a far higher efficiency level than linear controllers. This helps improve the overall level of efficiency and reduce fuel consumption. In addition the package construction is simpler due to less heat dissipation.

Increase of computing power of electronic control units has raised the power consumption of controllers with decreasing core feed voltage. This trend favors the use of DC/DC converters, even though they are more expensive than conventional voltage regulators, more difficult to apply and generate more electromagnetic interference. Because of the high demand for computing power in applications of power train and safety using a DC/DC converters is already worthwhile. More applications will follow.

---

**General**

### **3 General**

#### **Application field**

There is a very wide variety of possible applications for the TLE6363. It was specifically developed to supply restraint ECUs (electronic control units). Because of its characteristics it can be used for any small or medium size control unit, however.

---

**Product Description**

## **4 Product Description**

This chapter describes the characteristics of the TLE6363 relevant to the user.

For more detailed information on the device please refer to the TLE6363 data sheet.

### **4.1 TLE6363 Feature List**

- Adjustable Step-up converter
- 5 V Step down converter
- Undervoltage Reset generator with appropriate timing
- Digital Window Watchdog for micro controller supervision
- System Enable Output
- Overtemperature Shutdown
- Wide Supply voltage operation range
- Low current consumption
- Ambient operation temperature range - 40 °C to 125 °C
- Very small P-DSO-14 SMD package

### **4.2 Block Diagram and Short Description**

As shown in [Figure 1](#) the device incorporates a boost controller with integrated low side switch, a cascaded buck controller with integrated power stage and additional blocks for supervision of the micro controller like undervoltage reset generator and window watchdog functionality.

The device was designed with the intention that the Boost converter output acts as supply for the chip itself, as well as for the Buck converter and for additional circuitry in case the battery line is cut. Of course the Boost and the Buck converter could be operated independently from each other as well by supplying both from the battery line.

Both switching converters operate according to the voltage mode control with integrated peak current protection. The output voltage of the Boost converter is adjustable up to 30 V. The Buck converter's output voltage is fixed to 5 V. The switching frequency of those converters is adjustable over a wide frequency range by an external resistor.

In case of undervoltage condition at the Buck converter output a reset to the micro controller is initiated. At power up the Reset Output is switched to high after expiration of the delay time. In addition to the reset generator a window watchdog is included. The window watchdog requires periodic triggering pulses in order not to initiate a periodical reset to the micro controller.

Product Description

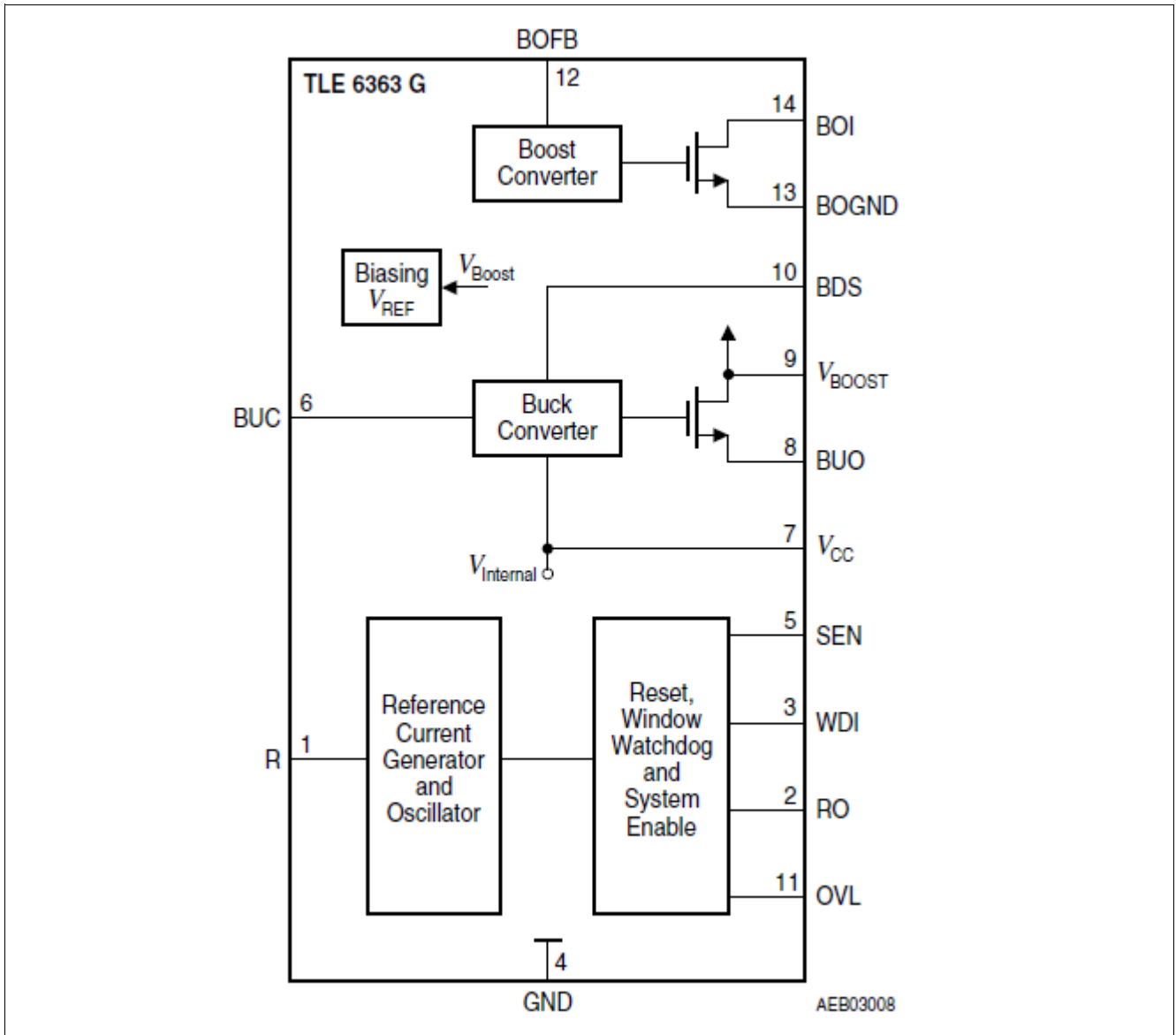


Figure 1 TLE6363 Internal Block Diagram





## Application Information

### 5.1.1 Input Diodes

Diode  $D_1$  provides reverse polarity protection for the TLE6363 application circuit.  $D_2$  avoids high current through the inductance at startup and during short circuit condition at the Boost output.

As long as Boost voltage does not reach battery voltage level, the Boost converter is not able to control the current flowing through the Boost inductance. Therefore it is strongly recommended to use  $D_2$  as inrush current protection and short circuit protection.

### 5.1.2 Boost Converter Components

Inductance, low ohmic, saturation current, catch diode, output capacitance.

#### 5.1.2.1 Boost Output Voltage Adjust

The resistors  $R_{BO1}$  and  $R_{BO2}$  determine the output voltage of the Boost converter  $V_{BOOST}$ :

(5.1)

$$V_{BOOST} = \frac{(R_{BO1} + R_{BO2}) \cdot 2,7}{R_{BO2}}$$

The limiting factor in selecting the output voltage is the maximum duty cycle limitation to 90% of the Boost control loop, the maximum allowed Boost voltage of 30 V and loss of the switching system.

#### 5.1.2.2 Boost Inductance ( $L_{BO}$ )

The principle of operation of the Boost converter is to store energy in the inductance and to transfer this energy to the output to achieve higher voltage at the output than fed into the regulator. The TLE6363 Boost regulator is designed for an inductance value of 100  $\mu$ H. The ripple current in the inductance is calculated as follows:

(5.2)

$$\Delta I = \frac{(V_{BOOST} - V_{BAT}) \cdot V_{BAT}}{f_{SW} \cdot V_{BOOST} \cdot L}$$

The inductance must be chosen according to the maximum current which can occur during the switching operation. According to the data sheet the peak current value of the Boost converter current can be as high as 1.8 A in worst case. This means the minimum saturation current for the inductance is 1.8 A. In case load current through the inductance is significantly lower, the inductance can be chosen to match lower saturation current. During power up phase the inductance must withstand a maximum peak current of 1.8 A.

*Note: Without diode  $D_2$  the Boost converter cannot control the current through the inductance during start-up, nor in short circuit condition at the Boost output. In this case the current through the inductance is determined by the input voltage, by the forward voltages of the diodes  $D_1$  and  $D_{BO}$  and by the resistive components from battery to GND (resistive part of the inductance, ESR of output capacitors etc.). Values of 10 A and above can occur.*

## Application Information

### 5.1.2.3 Boost Capacitance ( $C_{BO}$ )

Due to the nature of boost converters the output capacitance is not charged continuously but in pulses. The voltage ripple occurring at the output of a boost converter can be calculated to:

$$V_{\text{Ripple,Boost}} = \left( \frac{I_{\text{Load}}}{1-D} + \frac{\Delta I}{2} \right) \cdot \text{ESR} + (1-D) \cdot \frac{I_{\text{Load}}}{f_{\text{SW}} \cdot C_{\text{BO}}} \quad \left| \quad D = 1 - \frac{V_{\text{BAT}}}{V_{\text{BOOST}}} \right. \quad (5.3)$$

In order to lower the ESR of a complete output capacitance, network ceramic capacitors in parallel to tantalum or foil capacitors can be used.

### 5.1.2.4 Freewheeling Diode / Catch Diode ( $D_{BO}$ )

The diode clamps the boost voltage and avoids discharging of the Boost output. For low forward conduction loss Schottky diodes are recommended. When considering EME ultra fast recovery diodes can be used in order to enable soft switching.

## 5.1.3 Buck Converter Components

**Figure 2** shows a typical choice of external components for the buck converter.

### 5.1.3.1 Buck Inductance ( $L_{BU}$ ) Selection

Along with input voltage, output voltage and the switching frequency, the inductance value determines the current ripple which occurs during normal operation of the step down converter. This current ripple is important for the overall ripple at the output of the switching converter.

As a rule of thumb this current ripple  $\Delta I$  is chosen between 10% and 50% of the load current.

(5.4)

$$L = \frac{(V_{\text{BOOST}} - V_{\text{CC}}) \cdot V_{\text{CC}}}{f_{\text{SW}} \cdot V_{\text{BOOST}} \cdot \Delta I}$$

The minimum value required for stable operation of the step down converter in the TLE6363 application is 220  $\mu\text{H}$ . The current ripple calculates to:

(5.5)

$$\Delta I = \frac{(V_{\text{BOOST}} - V_{\text{CC}}) \cdot V_{\text{CC}}}{f_{\text{SW}} \cdot V_{\text{BOOST}} \cdot L}$$

When picking the inductance of a particular supplier (Epcos, Coilcraft etc.) the saturation current must be considered. With a maximum peak current limit of the Buck converter of 1.2 A an inductance with a minimum saturation current of 1.2 A has to be chosen.

## Application Information

In applications with much lower output current required at  $V_{CC}$  an inductance with lower saturation current can be chosen as well. During inrush phase at power on or in short circuit condition at the Buck converter output the current through the inductance will be according to the peak current limit 1.2 A. The inductance must withstand that current in order not to be destroyed.

### 5.1.3.2 Buck Output Capacitor ( $C_{BU}$ )

The output capacitance effects to the minimum achievable voltage ripple at the output of the buck converter. In continuous conduction mode the ripple of the output voltage equals:

(5.6)

$$V_{\text{Ripple}} = \Delta I \cdot \left( R_{\text{ESRCBU}} + \frac{1}{8 \cdot f_{\text{SW}} \cdot C_{\text{BU}}} \right)$$

From the formula it is recognized that the ESR has a big influence on the total ripple at the output, so ceramic types or low ESR tantalum capacitors are recommended for the application. A parallel circuit of different types of output capacitors as indicated in the application circuit can decrease the overall ESR as well. The minimum output capacitance required for stable operation is around 100  $\mu\text{F}$ .

### 5.1.3.3 Freewheeling Diode / Catch Diode ( $D_{BU}$ )

For lowest power loss in the freewheeling path Schottky diodes are recommended. With those types the reverse recovery charge is neglectable and a fast handover from freewheeling to forward conduction mode is possible. The diodes must be chosen according to the adjusted Boost voltage in the application (blocking voltage). A fast recovery diode with recovery times in the range of 30 ns can be used to smoothen switching (EME).

### 5.1.3.4 Bootstrap Capacitor ( $C_{BOT}$ )

This capacitance is used to enable the switching of the internal Buck-DMOS transistor, i.e. to achieve a gate voltage above source voltage.

The voltage at the Bootstrap capacitor does not exceed 10 V. A ceramic type capacitor with a voltage class of 16 V is sufficient.

By using the Bootstrap principle 100% duty cycle operation of the Buck converter is not possible, the minimum input voltage for the buck converter is 8 V.

## **6 Layout Recommendations**

Layouting should start with placing the power components and TLE6363. Next the ceramic capacitors to block out high-frequency components should be placed. Make sure to arranged the ceramic capacitors right next to the associated switching elements.

All signal lines where high frequency components occur, i.e. paths between Boost inductance, Boost DMOS, Boost clamping diode and Boost output capacitor or Buck DMOS output, catch diode and Buck converter inductance should be as short as possible with lowest possible inductance. This means that thin signal lines must be avoided.

The critical small signal components include the blocking capacitor on the IC feed voltage connection  $V_{BOOST}$ , the compensation circuit at Pin BUC, the resistors for programming the oscillator frequency at Pin R and the boost feedback circuit. All these components must be placed close to the IC. The ground connections of these components should be joined in a star configuration at one point where possible.

Use of a multilayer PCB is recommended, ideally a 4-layer PCB, with a dedicated ground layer. All ground contacts will be connected to this using vias. A further layer is used as the conductor layer that can be divided up into nodes in accordance with the voltage level of the input voltage and of the buck voltage. At these nodes the signals are fed and picked up, respectively.

The connection surfaces of the power components must lie to the component side. These should be arranged for low capacitance, i.e. forming little area because of rapid voltage changes at the nodes Boost-Input BOI and Buck-Output BUO.

Sufficient copper surface for cooling must be applied to the “cold ends” (nodes without high slew rate) of the diodes and inductors.

The critical nodes with high slew rate are best connected via short connections to wide conductor tracks in order to keep parasitic inductances low.

Conductor width to power elements must suit the current concerned.

The buck output capacitor must be connected as close as possible to the buck inductor on one side and as close as possible to the buck diode ground connection on the other side. This optimizes regulation behavior, in particular the output impedance of the regulator.

The ground points of the boost capacitor, of the buck capacitor and of the buck diode should lie within maximum 10 mm from each other.

---

**Conclusion**

## **7 Conclusion**

The TLE6363 was developed as a standard component at low price with optimized feature set and has gained successful market acceptance. The TLE6363 provides a combination of standard functions that can be used in many applications. Since the product was developed for harsh automotive environment it can be used easily in industrial applications and in consumer applications. In particular the wide range of temperatures is an advantage here. In combination with buck regulators and analog post regulators as they are known, very low-cost multivoltage control unit power packs can be built.

The most important benefits are:

- Wide input voltage range
- Small footprint package (little PCB space requirement)
- Simple application circuit
- Good price-performance ratio

### **7.1 Other Infineon Parts**

Infineon offers a number of switching regulators from a simple stand alone DC/DC converter up to a multi voltage 32-bit micro controller supply. The switching converter family is TLE63xx.

For post regulation Infineon offers a wide range of linear regulators or tracking regulators of the TLE42xx Series.

Visit us: [www.infineon.com](http://www.infineon.com)

---

**Revision History**

## **8 Revision History**

<b>Revision</b>	<b>Date</b>	<b>Changes</b>
1.01	2015-04-16	Infineon Style Guide update. Editorial changes.
1.0	2003-05-02	Application Note created.

#### Trademarks of Infineon Technologies AG

AURIX™, C166™, CanPAK™, CIPOS™, CIPURSE™, CoolGaN™, CoolMOS™, CoolSET™, CoolSiC™, CORECONTROL™, CROSSAVE™, DAVE™, DI-POL™, DrBLADE™, EasyPIM™, EconoBRIDGE™, EconoDUAL™, EconoPACK™, EconoPIM™, EiceDRIVER™, eupec™, FCOS™, HITFET™, HybridPACK™, ISOFACE™, IsoPACK™, i-Wafer™, MIPAQ™, ModSTACK™, my-d™, NovalithIC™, OmniTune™, OPTIGA™, OptiMOS™, ORIGA™, POWERCODE™, PRIMARION™, PrimePACK™, PrimeSTACK™, PROFET™, PRO-SIL™, RASIC™, REAL3™, ReverSave™, SatRIC™, SIEGET™, SIPMOS™, SmartLEWIS™, SOLID FLASH™, SPOC™, TEMPFET™, thinQ!™, TRENCHSTOP™, TriCore™.

#### Other Trademarks

Advance Design System™ (ADS) of Agilent Technologies, AMBA™, ARM™, MULTI-ICE™, KEIL™, PRIMECELL™, REALVIEW™, THUMB™, µVision™ of ARM Limited, UK. ANSI™ of American National Standards Institute. AUTOSAR™ of AUTOSAR development partnership. Bluetooth™ of Bluetooth SIG Inc. CAT-iq™ of DECT Forum. COLOSSUS™, FirstGPS™ of Trimble Navigation Ltd. EMV™ of EMVCo, LLC (Visa Holdings Inc.). EPCOS™ of Epcos AG. FLEXGO™ of Microsoft Corporation. HYPERTERMINAL™ of Hilgraeve Incorporated. MCS™ of Intel Corp. IEC™ of Commission Electrotechnique Internationale. IrDA™ of Infrared Data Association Corporation. ISO™ of INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. MATLAB™ of MathWorks, Inc. MAXIM™ of Maxim Integrated Products, Inc. MICROTEC™, NUCLEUS™ of Mentor Graphics Corporation. MIPI™ of MIPI Alliance, Inc. MIPS™ of MIPS Technologies, Inc., USA. muRata™ of MURATA MANUFACTURING CO., MICROWAVE OFFICE™ (MWO) of Applied Wave Research Inc., OmniVision™ of OmniVision Technologies, Inc. Openwave™ of Openwave Systems Inc. RED HAT™ of Red Hat, Inc. RFMD™ of RF Micro Devices, Inc. SIRIUS™ of Sirius Satellite Radio Inc. SOLARIS™ of Sun Microsystems, Inc. SPANSION™ of Spansion LLC Ltd. Symbian™ of Symbian Software Limited. TAIYO YUDEN™ of Taiyo Yuden Co. TEAKLITE™ of CEVA, Inc. TEKTRONIX™ of Tektronix Inc. TOKO™ of TOKO KABUSHIKI KAISHA TA. UNIX™ of X/Open Company Limited. VERILOG™, PALLADIUM™ of Cadence Design Systems, Inc. VLYNQ™ of Texas Instruments Incorporated. VXWORKS™, WIND RIVER™ of WIND RIVER SYSTEMS, INC. ZETEX™ of Diodes Zetex Limited.

Trademarks Update 2014-07-17

[www.infineon.com](http://www.infineon.com)

**Edition 2015-04-16**

**Published by**

**Infineon Technologies AG**

**81726 Munich, Germany**

**© 2014 Infineon Technologies AG.**

**All Rights Reserved.**

**Do you have a question about any aspect of this document?**

**Email: [erratum@infineon.com](mailto:erratum@infineon.com)**

**Document reference**

**Doc\_Number**

#### Legal Disclaimer

THE INFORMATION GIVEN IN THIS APPLICATION NOTE (INCLUDING BUT NOT LIMITED TO CONTENTS OF REFERENCED WEBSITES) IS GIVEN AS A HINT FOR THE IMPLEMENTATION OF THE INFINEON TECHNOLOGIES COMPONENT ONLY AND SHALL NOT BE REGARDED AS ANY DESCRIPTION OR WARRANTY OF A CERTAIN FUNCTIONALITY, CONDITION OR QUALITY OF THE INFINEON TECHNOLOGIES COMPONENT. THE RECIPIENT OF THIS APPLICATION NOTE MUST VERIFY ANY FUNCTION DESCRIBED HEREIN IN THE REAL APPLICATION. INFINEON TECHNOLOGIES HEREBY DISCLAIMS ANY AND ALL WARRANTIES AND LIABILITIES OF ANY KIND (INCLUDING WITHOUT LIMITATION WARRANTIES OF NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS OF ANY THIRD PARTY) WITH RESPECT TO ANY AND ALL INFORMATION GIVEN IN THIS APPLICATION NOTE.

#### Information

For further information on technology, delivery terms and conditions and prices, please contact the nearest Infineon Technologies Office ([www.infineon.com](http://www.infineon.com)).

#### Warnings

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office. Infineon Technologies components may be used in life-support devices or systems only with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.