

Reduced Battery Current Using CC112x/CC1175/CC1200 with TPS62730

By Charlotte Stephansen

Keywords

- *Low-Power Battery Applications*
- *Low Duty-Cycle Applications*
- *System Efficiency*
- *Battery Life Time*
- *DC-DC converter*
- *TPS62730*
- *CC1120*
- *CC1121*
- *CC1125*
- *CC1175*
- *CC1200*

1 Introduction

The TPS62730 is a high frequency synchronous step down DC/DC converter optimized for ultra low power wireless applications. The TPS62730 reduces the current drawn from the battery by a high efficient step down voltage conversion. It provides up to 100 mA output current at 2.1 V output voltage. The TPS62730 features a low power bypass mode with typical 30 nA current consumption to support sleep and low power modes of TI's transceiver and SoC solutions. For more information, see the TPS62730 datasheet [1].

This design note shows the advantages of using TPS62730+CC1120 for battery powered applications. All measurements are performed on the CC1120_DCDC_EM_868MHz reference

design [2]. The TPS62730+CC1120 performance is compared to similar measurements performed without voltage conversion.

Measurements show that battery current is reduced by more than 30% in TX at +10 dBm output power and by more than 35% in RX when using the TPS62730+CC1120 compared to using CC1120 without a DC-DC converter.

Section 4.2 discusses modifications to the CC1120_DCDC_EM_868MHz reference design to achieve less than 20 mA battery current in TX at +10 dBm output power.

The results from this design note are also applicable for the CC1121, CC1125, CC1175 (TX part only), and CC1200.

Table of Contents

KEYWORDS.....	1
1 INTRODUCTION.....	1
2 ABBREVIATIONS.....	2
3 FEATURES AND BENEFITS.....	3
4 MEASUREMENTS RESULTS.....	4
4.1 TX PERFORMANCE.....	4
4.1.1 Case 1 and Case 2: +10 dBm Output Power.....	5
4.1.2 Case 3 and Case 4: Maximum Output Power.....	6
4.2 SUB-20 mA CURRENT CONSUMPTION AT +10 DBM OUTPUT POWER.....	7
4.3 RX PERFORMANCE.....	7
5 REFERENCES.....	8
6 GENERAL INFORMATION.....	8
6.1 DOCUMENT HISTORY.....	8
7 APPENDIX –TPS62730 + CC1120 SCHEMATIC.....	9

2 Abbreviations

EM	Evaluation Module
LDO	Low Drop-out Regulator
LP	Low-Pass
LPM	Low Power Mode
LPRF	Low Power RF
MCU	Microcontroller
RF	Radio Frequency
TX	Transmit
RX	Receive

3 Features and Benefits

The CC1120 is designed for operation over a wide supply voltage range; from 2.0 V to 3.6 V. Internally, the CC1120 contains several on-chip linear voltage regulators that generate the supply voltages for the different sub-modules. These LDOs are invisible to the user, and can be viewed as integral parts of the various sub-modules. The input current to and output current from the LDOs is always the same. The efficiency is determined by the ratio between the LDO output and input voltages and energy is lost in the LDO when doing the voltage conversion. To remedy this, an external DC/DC converter can be used to regulate down to ~2.1 V, which can increase the overall efficiency of the system and lower system current consumption.

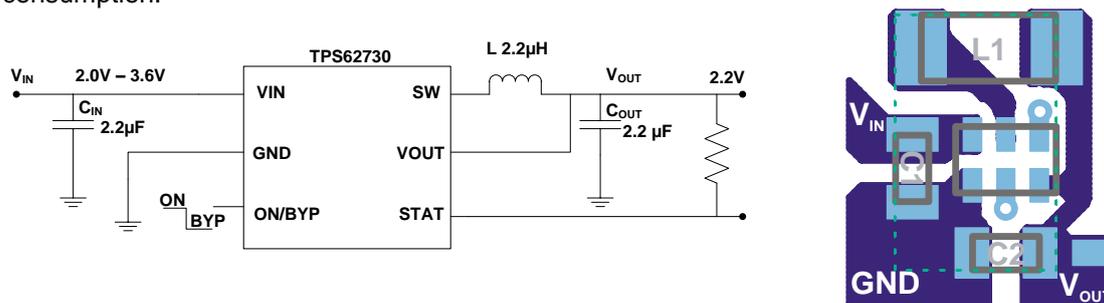


Figure 3.1 TPS62730 Typical Application Circuit and Layout

The TPS62730 requires only two additional components to the design and its recommended PCB layout is very space-efficient as the total area is less than 12 mm². For full schematics and layout recommendations, see the CC1120_DCDC_EM_868MHz reference design [2].

In battery-operated applications, the CC1120 may be powered directly from batteries. During active modes (TX and RX), the battery load usually becomes high due to the high current consumption. High current draw can reduce the battery life time. It may also lead to a small drop in the battery voltage that can cause unexpected and non-desirable RF behavior. The TPS62730 reduces the current consumption drawn from the battery during these high current modes and may thus eliminate undesirable voltage drops. In this way, the TPS62730 may increase the systems life efficiency and battery life time.

The quiescent current of DC-DC solutions normally dictates that they have to be powered down during the lowest power modes (SLEEP) of the transceivers/SoCs. The TPS62730 provides a bypass mode where, when enabled (pulling the ON/BYP pin level to GND, see Figure 3.1), the output capacitor of the TPS62730 converter is connected via an integrated 2.1 Ω (typical) bypass switch to the battery. All other circuits in the TPS62730 are turned off and the internal resistor feedback divider is disconnected. Typical power consumption for the TPS62730 in bypass mode is thus only 30 nA.

When the voltage conversion is enabled (pulling the ON/BYP pin level high, see Figure 3.1), the TPS62730 provides a regulated output voltage consuming typical 25 µA quiescent current. With a switch frequency up to 3 MHz, the TPS62730 features low output ripple voltage and low noise even with a small 2.2 µF output capacitor. This ensures that the RF performance is not degraded due to the noise from the converter.

With pin ON/BYP pulled high, the TPS62730 further features an automatic transition between DC-DC conversion mode and bypass mode to reduce the output ripple voltage to zero. Once the input voltage comes close to the output voltage of the TPS62730 converter, the bypass mode is automatically enabled to prevent the DC-DC converter to operate close to 100% duty cycle operation. This ensures that the system always manages the supply to the CC1120 with maximum efficiency. The automatic transition into bypass mode during DC-DC operation also prevents an increase of output ripple voltage and noise once the DC-DC converter operates close to 100% duty cycle mode.

4 Measurements Results

The measurements results in this design note are for 868 MHz operation and a temperature of 25°C. TPS62730+CC1120 performance has also been tested at 915 MHz and also across the -40°C to +60°C temperature range without any degradation in performance compared to a CC1120 stand-alone solution.

All measurements are performed with “Low Power” mode settings.

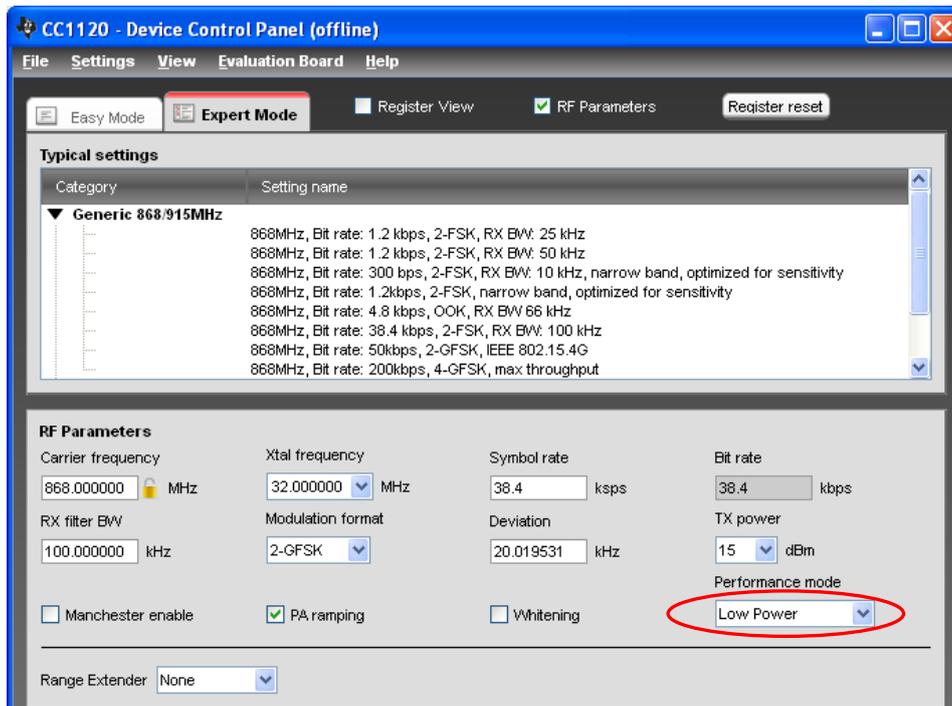


Figure 4.1. SmartRF Studio Showing Low Power Mode Selection

4.1 TX Performance

This section considers four TX test cases

- **Case 1: +10 dBm Output Power TPS62730 + CC1120**
The output power is controlled by the 6 bit value in the CC1120 PA_CFG2[5:0] register. For +10 dBm output power PA_CFG2[5:0] = 0x3A.
- **Case 2: +10 dBm Output Power CC1120**
The TPS62730 is in Bypass Mode and CC1120 is connected directly to the battery. PA_CFG2[5:0] is adjusted for the different battery voltage levels to give a constant +10 dBm output power.
- **Case 3: Maximum Output Power TPS62730 + CC1120**
For maximum output power PA_CFG2[5:0] = 0x3F.
- **Case 4: Maximum Output Power CC1120**
The TPS62730 is in Bypass Mode and CC1120 connected directly to the battery. The output power is set to maximum by configuring PA_CFG2[5:0] = 0x3F.

4.1.1 Case 1 and Case 2: +10 dBm Output Power

Figure 4.2 shows TX current consumption versus battery voltage. At +10 dBm output power and a 3.6 V battery voltage, the current drawn from the battery is 10 mA less when using TPS62730+CC1120 compared to using CC1120 without DC-DC converter. This corresponds to more than 30% reduction in battery current.

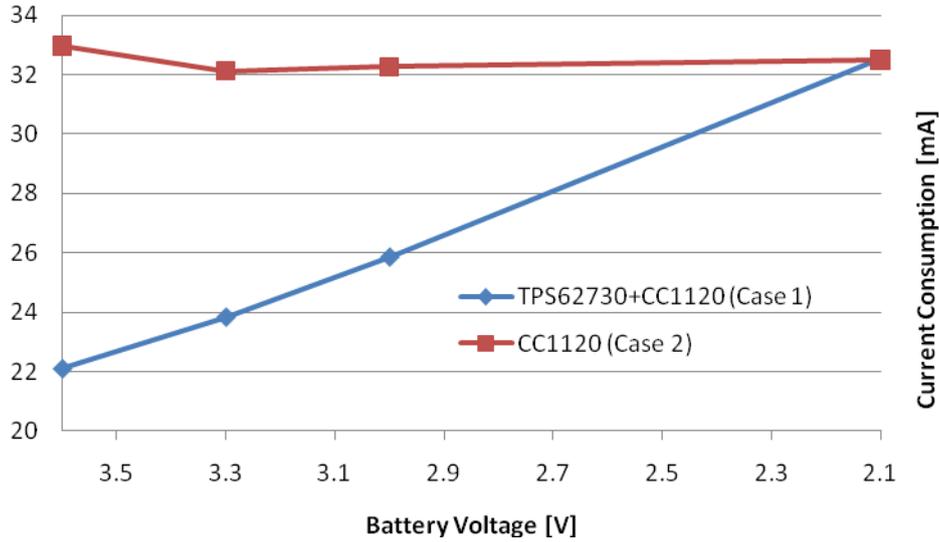


Figure 4.2. Current Consumption vs. Battery Voltage at +10 dBm Output Power

Figure 4.3 shows output power versus battery voltage for the current measurements in Figure 4.2.

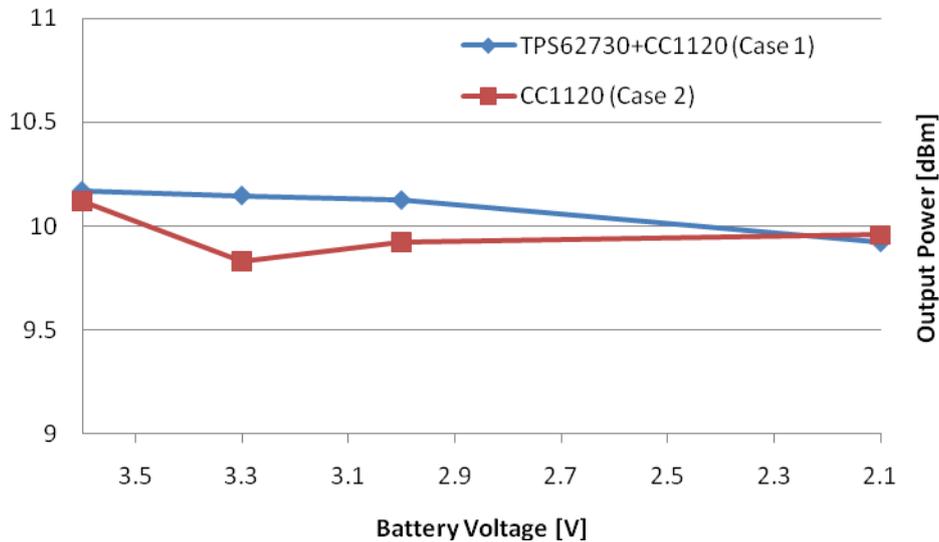


Figure 4.3. +10 dBm Output Power vs. Battery Voltage

4.1.2 Case 3 and Case 4: Maximum Output Power

Figure 4.4 shows TX current consumption versus battery voltage when operating at maximum output power.

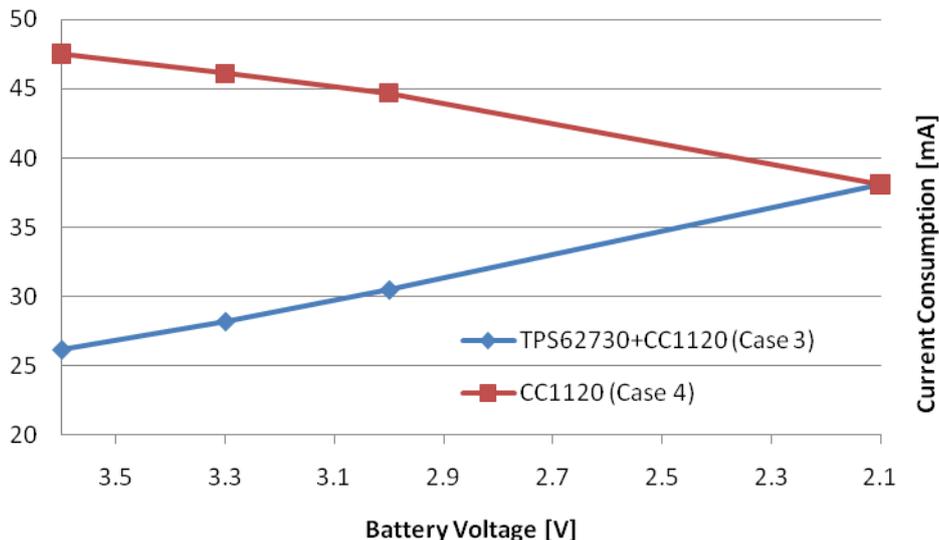


Figure 4.4. Current Consumption vs. Battery Voltage at Maximum Output Power

Figure 4.5 shows output power versus battery voltage. Comparing Case 3 to Case 4 in Figure 4.5, it is seen that the former gives a constant CC1120 output power level over the 3.6 V to 2.1 V battery range. The maximum CC1120 output power with a 3.6 V supply is approximately 3 dB higher for Case 4 compared to Case 3.

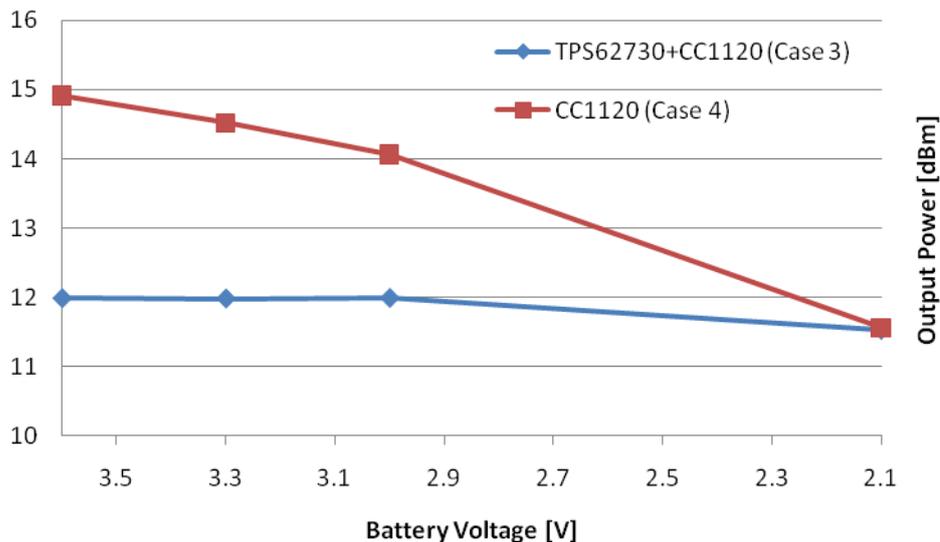


Figure 4.5. Maximum Output Power vs. Battery Voltage

4.2 Sub-20 mA Current Consumption at +10 dBm Output Power

Modifications can be made to the CC1120_DCDC_EM_868MHz reference design to achieve less than 20 mA in TX at +10 dBm output power. With reference to CC1120_DCDC_EM_868MHz reference design [2] and Figure 7.1, the following components in the external low-pass (LP) filter and PA biasing need to be changed/removed:

- R171: 0 ohm
- C173: Not Connected
- L173: 12 nH
- L174: 0 ohm

PA_CFG2[5:0] = 0x39 to achieve +10 dBm output power level. The TX current consumption is then below 20 mA with a 3.6 V battery voltage level. Note that when using this solution, the harmonics will increase slightly due changes to the passive LP filter. The 3rd harmonic has been measured to -38 dBm with this solution; the remaining harmonics are below -44 dBm.

4.3 RX Performance

CC1120 sensitivity has been measured with the TPS62730 in converter mode and also with the TPS62730 in bypass mode. Measurements show that the TPS62730 does not affect the CC1120 sensitivity limit or blocking performance,

Figure 4.6 shows the RX current consumption versus battery voltage level when using the recommended 38.4 kbps LPM setting from SmartRF Studio. At 3.6 V battery voltage the current drawn from the battery is 6 mA less when using TPS62730+CC1120 compared to using CC1120 without DC-DC converter. This corresponds to 35% reduction in battery current.

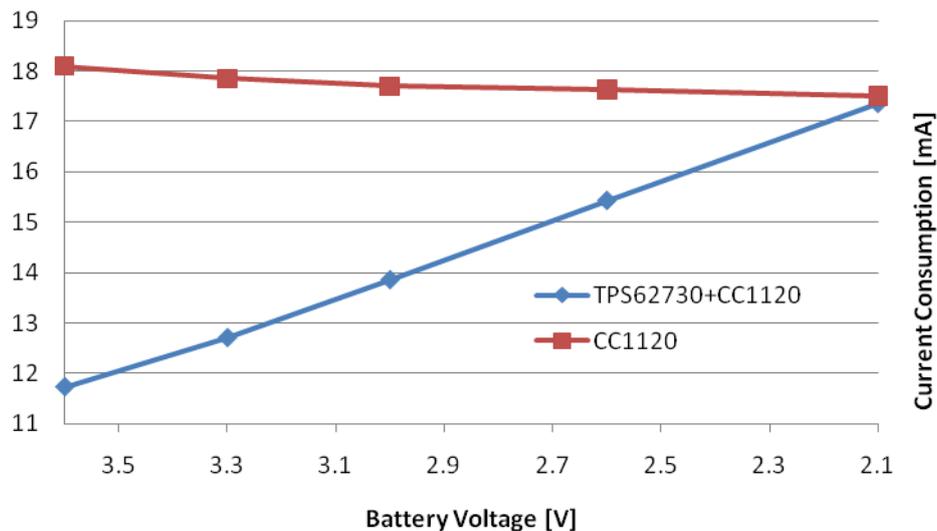


Figure 4.6. RX Current Consumption vs. Battery Voltage, 38.4 kbps GFSK LPM setting, Reception at Sensitivity Limit

Figure 4.6 shows RX *peak* current. Note that a novel RX Sniff Mode feature has been designed for the CC112X/CC1200 family to autonomously sniff for RF activity using an ultra low power algorithm. The CC112X/CC1200 supports very quick start up times and requires very few preamble bits. RX Sniff Mode puts the device into sleep periodically and by setting an appropriate sleep time, the CC112X/CC1200 is able to wake up and receive the packet when it arrives with no performance loss. RX Sniff Mode reduces the *average* current consumption while the receiver is waiting for data.

Using TPS62730+CC1120 together with RX Sniff Mode reduces both the battery peak current and the average current. Refer to CC112x User Guide for more details on RX Sniff Mode [3].

5 References

- [1] TPS62730 Datasheet (SLVSAC3)
- [2] CC1120_DCDC_EM_868_MHz Reference design (SWRR103)
- [3] CC112X/CC1175 Low-Power High Performance Sub-1 GHz RF Transceivers/Transmitter User Guide (SWRU295C)

6 General Information

6.1 Document History

Revision	Date	Description/Changes
SWRA411	2012.09.26	Initial release.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com