FEATURES

- Wide Supply Voltage Range: 1.8 V to 3.6 V
- Ultralow Power Consumption
  - CPU Active Mode: 200 µA/MHz at 2.2 V
  - Standby Mode (LPM3): 0.7 µA
  - Off Mode (LPM4): 0.1 µA
  - Power-Down Mode: 60 nA
- Microcontroller System and Peripherals
  - 16-Bit RISC Architecture, 125-ns Instruction Cycle Time
  - Wake-Up From Standby Mode in <6 µs
  - Basic Clock Module Configurations
    - Single External Resistor
    - 32-kHz Crystal
    - High-Frequency Crystal
    - Resonator
    - External Clock Source
  - 16-Bit Timer_A With Three Capture/Compare Registers
  - 10-Bit 200-kps Analog-to-Digital (A/D) Converter With Internal Reference, Sample-and-Hold, and Autoscan
  - 8KB + 256B Flash Memory
  - 256B RAM
  - 133-Byte EEPROM
  - Serial Onboard Programming, No External Programming Voltage Needed
  - Programmable Code Protection by Security Fuse
  - 80-Bit DST80 Security Authentication Coprocessor
  - 17 I/O Ports
- Low-Frequency (LF) Immobilizer Interface
  - Integrated Batteryless Immobilizer Interface
  - Half Duplex (HDX) Immobilizer Communication Achieves up to 4-in (10-cm) Read Range
  - Special Selective Addressing Mode Allows Reliable Learn-In Sequence
  - 80-Bit Authentication Key Length
  - Up to 8-kbit/s LF Uplink Data Rate
  - 5/-3-Byte Challenge/Response Algorithm
  - Fast Authentication Within 42 ms
  - Fast Mutual Authentication Within 65 ms
  - 133-Byte EEPROM
    - 91-Byte Free Available EEPROM User Memory
    - 32-Bit Unique Serial Number
    - High EEPROM Security and Flexibility
    - Write-Only Authentication Keys
    - Pages Are Irreversibly Lockable and Protectable
    - Protected Pages Programmable Only Through Mutual Authentication
    - Battery Check and Charge Functions
    - Each User Page is Lockable
    - Resonant Frequency: 134.2 kHz
    - Integrated Resonant Frequency Trimming
- Low-Frequency 3D Wakeup Receiver
  - Highest Communication Range of More Than Three Meters
    - High Input Sensitivity: 4.2 mVpp (Typ)
    - High Q System
  - Integrated Resonant Circuit Trimming Compensates for Component Offsets
  - Received Signal Strength Indicator (RSSI) Output for Each Channel
  - Resonant Circuit Usable as Clock Reference for Microcontroller (134.2 kHz)
  - Frequency Range: 120 kHz to 140 kHz
  - Ultra-Low Standby Current: 3.9 µA (Typ) With All Three Channels Active for Wake Pattern Detection
  - Interface to up to Three External Antennas
  - Two Different Programmable Wake Patterns
  - Selectable Wake Pattern Length: 0, 4, 8 or 16 Bits
  - Two Separate Adjustable Wake-Up Levels
  - Digital Channel Sensitivity Adjustment for Each Antenna

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DESCRIPTION

The Controller Remote Access Identification Device (CRAID) combines three functions in one device:

- Low-power 16-bit microcontroller based on the MSP430F1232 core
- 3D wakeup receiver
- DST80 immobilizer interface

With these three functions, it is ideally suited for state-of-the-art passive entry and passive start applications. The low-power microcontroller MSP430™ core offers a 16-bit RISC architecture, 8KB program memory, and 17 user-accessible I/O ports. The 3D low-frequency (LF) wakeup receiver offers high sensitivity to receive LF signals between 120 kHz and 140 kHz and has several other features such as RSSI measurement and bidirectional LF signaling.

The embedded DST80 immobilizer interface offers a high level of security through its hardware encryption coprocessor and can also handle mutual authentication schemes. The immobilizer interface operates without battery support. Power management features include battery charge and check as well as a battery backup function allowing operation of all functions (including the microcontroller) with low or even no battery as long as there is sufficient energy from the LF field.

The passive entry device manages the immobilizer communication, push-button interaction, and LF wake reception. The special high-Q design achieves communication ranges up to 3 m for the passive entry link with outstanding low standby current on the receiver side. The front end offers flexible configuration of two different wake patterns lengths of 0, 4, 8, or 16 bits. Each channel can be adjusted in sensitivity and resonance frequency, which results in reproducible system designs. By sensing the pressing of a push button, the device wakes up and controls an external UHF transmitter or transceiver. Security keys and rolling codes can be stored in the integrated EEPROM memory. This memory is accessible over the LF interface without support from the battery in the keyfob. The passive entry device offers a special battery backup mode to operate the microcontroller without battery support. The external resonant circuit with an LF coil and a resonant capacitor can be trimmed to the correct resonant frequency with the integrated trimming capability, eliminating part tolerances.

Ordering Information

<table>
<thead>
<tr>
<th>T_A</th>
<th>PACKAGE(R)</th>
<th>ORDERABLE PART NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>−40°C to 85°C</td>
<td>TSSOP – DBT</td>
<td>TMS37F128D3IDBTRG4</td>
</tr>
</tbody>
</table>

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.
Figure 1. Application Diagram
Figure 2. Application Schematic
### Operating Characteristics

<table>
<thead>
<tr>
<th>Part Number</th>
<th>TMS37F128D3IDBTRG4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Features</strong></td>
<td>Immobilizer plus microcontroller with integrated power management</td>
</tr>
<tr>
<td>DST80 authentication logic</td>
<td>80-bit key length, 5-byte challenge, 3-byte signature</td>
</tr>
<tr>
<td>DST80 authentication time</td>
<td>Mutual authentication: 65 ms, Fast authentication: 42 ms</td>
</tr>
<tr>
<td>Microcontroller</td>
<td>16-bit RISC ultra-low power based on MSP430F1232 core</td>
</tr>
<tr>
<td>Supply voltage (VBAT)</td>
<td>1.8 V to 3.6 V</td>
</tr>
<tr>
<td>Active current consumption</td>
<td>300 μA (typ) (V&lt;sub&gt;CC&lt;/sub&gt; = 2.2 V, f&lt;sub&gt;osc&lt;/sub&gt; = 1 MHz, microcontroller active)</td>
</tr>
<tr>
<td>Standby current consumption</td>
<td>3.9 μA (typ) (three channels wake pattern active, microcontroller in LPM4, V&lt;sub&gt;CC&lt;/sub&gt; = 3 V, T&lt;sub&gt;A&lt;/sub&gt; = 25°C)</td>
</tr>
<tr>
<td><strong>Transponder</strong></td>
<td></td>
</tr>
<tr>
<td>Transmission Principle</td>
<td>HDX (half-duplex telegram protocol)</td>
</tr>
<tr>
<td>Operating Frequency</td>
<td>134.2 kHz</td>
</tr>
<tr>
<td>Security</td>
<td>Challenge/response, mutual authentication</td>
</tr>
<tr>
<td>Downlink</td>
<td>100% AM, PPM Bit coding with 2 kbit/s (typ)</td>
</tr>
<tr>
<td>Uplink</td>
<td>FSK modulation with 7.9 kbit/s (typ)</td>
</tr>
<tr>
<td>EEPROM memory</td>
<td>133 bytes</td>
</tr>
<tr>
<td>Battery charge</td>
<td>Integrated battery charge functionality</td>
</tr>
<tr>
<td>Key learn-in</td>
<td>Special selective addressing to provide secure learn-in procedure</td>
</tr>
<tr>
<td><strong>3D Wakeup Receiver</strong></td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>4.2 mV&lt;sub&gt;pp&lt;/sub&gt; (typ), 2.7 mV&lt;sub&gt;pp&lt;/sub&gt; (min), 5.1 mV&lt;sub&gt;pp&lt;/sub&gt; (max) (V&lt;sub&gt;CC&lt;/sub&gt; = 2.8 V, T&lt;sub&gt;A&lt;/sub&gt; = 25°C)</td>
</tr>
<tr>
<td>Sensitivity tuning</td>
<td>Separate for each channel</td>
</tr>
<tr>
<td>Operating frequency</td>
<td>120 kHz to 140 kHz</td>
</tr>
<tr>
<td>Resonant frequency trimming</td>
<td>Separate for each channel</td>
</tr>
<tr>
<td>Wake pattern</td>
<td>Two independent wake patterns with selectable length: 0, 4, 8 or 16 bits</td>
</tr>
<tr>
<td><strong>Microcontroller</strong></td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td>8KB program memory, 256-byte RAM</td>
</tr>
<tr>
<td>User data flash memory</td>
<td>256-byte information memory</td>
</tr>
<tr>
<td>Flash program and erase endurance</td>
<td>100 000 cycles (typ) (T&lt;sub&gt;A&lt;/sub&gt; = 25°C)</td>
</tr>
<tr>
<td>Flash data retention</td>
<td>10 years (min) (T&lt;sub&gt;A&lt;/sub&gt; = 25°C)</td>
</tr>
<tr>
<td>Program, erase, read supply voltage</td>
<td>2.7 V (min)</td>
</tr>
<tr>
<td>I/O ports</td>
<td>17</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-40°C to 85°C</td>
</tr>
<tr>
<td>Package</td>
<td>44-pin TSSOP (DBT)</td>
</tr>
</tbody>
</table>
## Packaging Information

<table>
<thead>
<tr>
<th>Orderable Device</th>
<th>Status (1)</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>Package Qty</th>
<th>Eco Plan (2)</th>
<th>Lead/Ball Finish (6)</th>
<th>MSL Peak Temp (3)</th>
<th>Op Temp (°C)</th>
<th>Device Marking (4/5)</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMS37F128D3IDBTRG4</td>
<td>ACTIVE</td>
<td>TSSOP</td>
<td>DBT</td>
<td>44</td>
<td>2000</td>
<td>Green (RoHS &amp; no Sb/Br)</td>
<td>CU NIPDAU</td>
<td>Level-2-260C-1 YEAR</td>
<td></td>
<td>37F128D3</td>
<td></td>
</tr>
</tbody>
</table>

(1) The marketing status values are defined as follows:
- **ACTIVE**: Product device recommended for new designs.
- **LIFEBUY**: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
- **NRND**: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
- **PREVIEW**: Device has been announced but is not in production. Samples may or may not be available.
- **OBSOLETE**: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check [http://www.ti.com/productcontent](http://www.ti.com/productcontent) for the latest availability information and additional product content details.

- **TBD**: The Pb-Free/Green conversion plan has not been defined.

- **Pb-Free (RoHS)**: TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

- **Pb-Free (RoHS Exempt)**: This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

- **Green (RoHS & no Sb/Br)**: TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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