TI Solutions for Cold Chain

Daniel Mar: Product Marketing Temperature Sensors
Ali Anwar: Product Marketing MSP430
Agenda

• What is Cold Chain?

• TI Solutions for Cold Chain
  o Temperature sensors
  o Humidity sensors
  o Optical sensors
  o MSP430 FRAM

• TI Reference Designs for Cold Chain
  o Ultralow Power Multi-sensor Data Logger with NFC Interface Reference Design (TIDA-00524)
  o Humidity & Temp Sensor Node for Star Networks Enabling 10+ Year Coin Cell Battery Life Ref Design (TIDA-00374)
  o Humidity & Temp. Sensing Node for Sub-1 GHz Star Networks Enabling 10+ Year Coin Cell Battery Life (TIDA-00484)
  o Dynamic Field-Powered NFC Reference Design for Data Logging, Access Control, and Security Applications (TIDA-00217)
What is Cold Chain?
What is Cold Chain?

Cold chain management includes all of the means used to ensure a constant temperature for a product that is not heat stable from the time it is manufactured or farmed until the time it is used.

**Industries Involved:**
- Food
- Retail
- Medical: (hospitals, transplants, blood)
- Pharmaceutical
- Refrigeration
- Transportation (air, ship, truck, train)
- Fleet Management
- Warehousing
- Packaging

**Examples Cold Chains?**
Cold Chain Facts

$167B was spent on Food Storage and Transportation (2015) -> $235B by 2020

Wastage:
43 Billion Pounds of Food are thrown out annually by US grocery stores (10% of the food supply)

Safety:
48 Million People get sick annually in the use due to foodborne illness
- 128,000 are hospitalized
- 3000 die

Beyond Food:
In a Department of Health and Human Services study, 76% of the providers had stored vaccines at incorrect temperatures for at least 5 hours during the two-week period measured.
Market Drivers

• Increasing Safety Regulations
  – 40 Countries with GDP (Good Distribution Policies)
    • FDA Food Safety Modernization Act (FSMA)
    • EU Commission
    • World Health Organization

• Liability
  – Determining liability should a shipment have a temperature excursion

• Costs
  – Better tracking allows for cheaper transportation methods
    (Air -> Truck / Ship)

• Reduce Carbon Foot Print
  – Reduce Air Freight
Types of Equipment

• **Indicators**
  - Single Event: excursion outside temp/time window
  - Typically disposable
  - Either chemical or electronic

• **Electronic Data Loggers** (disposable, reusable, fixed infrastructure)
  - Temperature, Humidity, Light, Vibration data is stored
  - Real Time Options (Zigbee, Wifi, Cellular, Satellite)
  - Data loggers w/ or w/o integrated sensors
    - Wired and wireless communication between Data Logger and sensors
Common Terms

• **GDP (Good Distribution Practices)**: Government or Corporate guidelines for the proper distribution of medicinal products for human use. GDP is a quality warranty system, which includes requirements for purchase, receiving, storage and export of drugs intended for human consumption.

• **HACCP (Hazard Analysis, Critical Control Point)**: Systematic approach to safety but preventing hazards. See ISO 22000 FSMS 2005 for HACCP

• **NIST Traceability**: The National Institute of Standards and Technology maintains the U.S. national standards for temperature. Traceability can be defined as an unbroken record of documentation ("documentation traceability") or an unbroken chain of measurements and associated uncertainties ("metrological traceability").

• **EN12830**: EU Standard for Temperature-measuring instruments, Temperature measurement, Temperature, Refrigerating plant, Cold storage, Vehicles, Freight transport, Food products, FrozENfoods, Ice cream, Working range, Recording instruments (measurement), Data recording, Chart records.

• **FSMA**: Food Safety Modernization Act. US Law passed in 2011. It aims to ensure the U.S. food supply is safe by shifting the focus from responding to contamination to preventing it.
TI Temperature Sensors Solutions for Cold Chain
TI offers complete monitoring solution for the Cold Chain applications
TI Temperature Sensor for Cold Chain
TI Temp Sensor vs Thermistor

**Advantages of an IC Temp sensor**

**Simplicity:**
- No additional circuitry required
- Better PSRR & Noise Immunity
- Easier to layout
- No curve fitting or lookup table
- Eliminate polling for over / under temp detection

**Wide range of interfaces**
- Analog, I2C, SPI, 1-wire, UART, Pulse Counter
- Cabled / Probe interfaces

**Accuracy:**
- Accuracy is guaranteed (zero calibration needed)
- Analog outputs are linear
- Little to no self heating

**Power**
- Digital Interface options down to 4.8uW
- Built-in low power modes
- Programmable wake->sample->sleep>repeat mode

**Cost**
- Can be very competitively priced compared to total thermistor solution (thermistor + components & calibration)

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**Thermistor**

![Thermistor Circuit Diagram]

**IC Sensor**

35°C

![IC Sensor Output Voltage vs Temperature Graph]
# Featured Local Temperature Sensors

<table>
<thead>
<tr>
<th></th>
<th>TMP112</th>
<th>TMP75C</th>
<th>TMP275</th>
<th>LMT70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>I2C w/Alert</td>
<td>Analog</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Range</td>
<td>1.4V to 3.6V</td>
<td>2.5V to 5.5V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I2C Addresses Available</td>
<td>8</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-20°C to +90°C</td>
<td>0.5°C max</td>
<td>1.0°C max</td>
<td>0.5°C max</td>
<td>0.2°C max</td>
</tr>
<tr>
<td>0°C to +65°C</td>
<td>0.5°C max</td>
<td>2.0°C max</td>
<td>0.5°C max</td>
<td></td>
</tr>
<tr>
<td>-20°C to +85°C</td>
<td>3.0°C max</td>
<td>3.0°C max</td>
<td>1.0°C max</td>
<td></td>
</tr>
<tr>
<td>-40°C to +125°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-55°C to 150°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution</td>
<td>12-Bit</td>
<td></td>
<td></td>
<td>-5.18 mV/°C</td>
</tr>
<tr>
<td>Quiescent Current (max)</td>
<td>10 uA</td>
<td>85uA</td>
<td>12uA</td>
<td></td>
</tr>
<tr>
<td>Shutdown Current</td>
<td>1uA</td>
<td>3uA</td>
<td>50nA</td>
<td></td>
</tr>
<tr>
<td>Package Footprint</td>
<td>SO T-563 1.6 x 1.6mm</td>
<td>SO-8 (3.0mm x 4.9mm) MSOP-8 (4.9mm x 6.0mm)</td>
<td>WCSP 0.8x0.8mm</td>
<td></td>
</tr>
</tbody>
</table>
Probes

Traditional Method: Thermistors
- 2 wire
- Star topology
- Requires Calibration & Non-Linear
- Sensitive to environmental factors

TI Advantage: LMT01
- 2 Wires- mechanically compatible
- Digital - Pulse Counter Interface
- Noise Immunity
- Guaranteed +/-0.5°C Accuracy
- Insensitive to humidity and shock

\[
Temp = \left( \frac{NP_{40\%}}{256} \right) \times 256°C - 50°C
\]
Multi-Location Thermal Monitoring

Traditional Method: Thermistors
- 2 Wires for every location
- Complicated Assembly
- Calibration
- Non-Linear

TI Advantage: TMP107
- 3 Wires (PWR, GND, Comm)
- Daisy Chain Topology
  - Saves copper
  - Faster installation
- Guaranteed +/-0.4°C Accuracy
- Auto Addressing
Host sends initial address to the first device in the chain. Device stores this address in EEPROM. The first device acknowledges the host. It increments the address and passes along, which is stored by the second device. The second device acknowledges the host. It increments the address and passes along, which is stored by the third device. This process continues until the last device acknowledges the host. Bus times out and the chain is back to the forward buffer. All devices know their position on the bus for further reads and writes.

- ½ Duplex UART interface
- Auto addressing based upon location in the chain
- Non-volatile memory is available to store address and programming
TI Humidity Sensors Solutions for Cold Chain
TI – Humidity sensor package option
HDC1010 – HDC1080

• TI Humidity sensor family are based on integrated sensor and dedicate Analog Front End
• HDC family is fully calibrated in TI fab and temperature compensated

  • HDC is available in two packages
    – WLCSP-8 package
    – WSON-6 plastic package
HDC1010
Humidity & Temperature Sensor

Features

- Relative Humidity Range: 0% to 100%
- Humidity Accuracy: ±2%
- Typical Drift: < 0.5%/yr
- Supply Current (Measuring): 180uA
- Avg Supply Current (@1sps): 1.3uA
- Temperature Accuracy: ±0.2ºC (typ)
- Temperature Range (Operating): -20ºC to +85ºC
- Operating Voltage: 2.7V to 5.5V
- Package: 8 pin WLCSP (1.59mm x 2.04mm)

Applications

- HVAC
- White goods (dryer, fridge, microwave, dishwasher)
- Printers
- Handheld Meters
- Camera Defog
- Smart Thermostats and Room Monitors
- Medical Devices

Benefits

- Completely integrated humidity and temperature IC provides guaranteed performance
- Fully calibrated sensor enables quick time-to-market
- Very low power consumption
- Small package size supports compact designs
HDC1080
Humidity & Temperature Sensor

Features

- Relative Humidity Range: 0% to 100%
- Humidity Accuracy: ±2%
- Typical Drift: < 0.5%/yr
- Supply Current (Measuring): 180uA
- Avg Supply Current (@1sps): 1.3uA
- Temperature Accuracy: ±0.2°C (typ)
- Temperature Range (Operating): -20°C to +85°C
- Operating Voltage: 2.7V to 5.5V
- Package
  - 6 pin PWSON (3.0mm x 3.0mm)

Benefits

- Completely integrated humidity and temperature IC provides guaranteed performance
- Fully calibrated sensor enables quick time-to-market
- Very low power consumption
- Small package size supports compact designs

Applications

- HVAC
- White goods (dryer, fridge, microwave, dishwasher)
- Printers
- Handheld Meters
- Camera Defog
- Smart Thermostats and Room Monitors
- Medical Devices
Tools to Win – HDC design resources
EVMs, Reference Designs, App Notes

EVMs
HDC1010EVM - HDC1080EVM

- Evaluate HDC1010 - HDC1080 Humidity and temperature sensor
- User friendly OneGUI interface
- Powered by USB

Application Notes/ Training
- HDC1xxx application note
- HDC1010EVM - HDC1080EVM user guide
- Wireless Sensor Node

TI Designs
TIDA-00374 Humidity & Temp Sensor Node for Star Networks Enabling 10+ Year Coin Cell battery life

- Use of Nano-Power System Timer to Duty-Cycle the System Results in 10+ Year Battery Life from CR2032 Coin Cell
- Configurable System Wakeup Interval
- Extremely Low Off-State Current (183 nA for 59.97 seconds)
- Ultra Low On-State Current Due to Low Active Processor and Radio Transmit Currents (4.04 mA for 30 ms)
- ±2% Relative Humidity Accuracy
- ±0.2°C Temperature Accuracy

TIDA-00488 Humidity & Temp Sensor Node for Sub-1GHz Star Networks Enabling 10+ Year Coin Cell battery life

- Use of Nano-Power System Timer to Duty-Cycle the System Results in 10+ Year Battery Life from CR2032 Coin Cell
- Configurable System Wakeup Interval
- Extremely Low Off-State Current (270 nA for 59.97 seconds)
- Ultra-Low On-State Current Due to Low Active Processor and Radio Transmit Currents (3.376 mA for 30 ms)
- ±2% Relative Humidity Accuracy
- ±0.2°C Temperature Accuracy

TIDA-00524 Ultralow Power Multi-sensor Data Logger with NFC Interface Reference Design

- 5 Year Battery Life on a CR-2032 coin cell
- RF430 NFC Dynamic Tag Type 4B Compliant Communication
- NFC configuration and data read back
- Multiple Sensor Options
  - Temperature (TMP112)
  - Ambient Light (OPT3001)
  - Humidity + Temperature (HDC1000)
- Up to 64KB of non-volatile FRAM memory
- Data is Date/Time stamped using RTC

TIDC-CC2650STK-SENSORTAG

- Support for 10 low-power sensors, including ambient light, digital microphone, magnetic sensor, humidity, pressure, accelerometer, gyroscope, magnetometer, object temperature and ambient temperature
- Ultra-low power, with years of battery life from a single coin cell battery and enabling battery-less applications through the high-performance ARM® Cortex®-M3 CC2650 wireless MCU
- Cloud connectivity lets you access and control your SensorTag kit from anywhere
- Multi-standard support enables ZigBee or 6LoWPAN through a simple firmware upgrade

Texas Instruments
TI Optical Sensors Solutions for Cold Chain
Optical Sensors

TI’s Ambient Light

OPT3001: Precision Human Eye Matching
Features:
>99% IR Rejection
23-Bit Effective Resolution
0.01 Lux to 83K Lux
2.5μA (max) Quiescent Current
2.0 x 2.0mm
MSP430 Microcontrollers

- TI MCU Overview
- MSP430 FRAM Advantages
- TI MCU Solutions for Cold Chain
## Industry-Leading MCU Portfolio

### Low-Power MCUs
- More than 500 low-power MCUs
- Industry’s lowest power MCU
- The world’s only embedded FRAM MCU family
- Combines smart analog with low system power to fit any power budget
- Broad range of applications include smart grid, wearables, sensors and cold chain

### Performance MCUs
- More than 275 high-performance MCUs
- Specialize in control loop and functional safety applications
- Includes support for functional safety standards like IEC61508 and ISO 26262
- Broad range of applications include motor control, industrial drives, digital power, functional safety and transportation

### Wireless MCUs
- Support for more than 14 wireless connectivity technologies – focus on ease of use and low power
- Enable faster IoT designs to connect everything
- Broad range of applications include building automation, wearables, sensors and smart grid

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TI Confidential – NDA Restrictions
TI’s Low-Power Microcontroller Solutions

16-bit MSP430 MCUs
- The industry leader in ultra-low-power, rich peripherals and analog integration.
- World’s only portfolio of ultra-low-power embedded FRAM MCUs.
- Growing portfolio of more than 500 low-power MCUs

32-bit MSP432 MCUs
- Industry’s lowest power ARM® Cortex®-M4F MCUs. Period.
- High performance MCUs without sacrificing power consumption.
- Sampling 256KB today.

SimpleLink Wireless MCUs
- Focus on ease of use and low power.
- Support for more than 14 Bluetooth Smart, Sub-1 GHz, 6LoWPAN, ZigBee and more.
- Portfolio includes SimpleLink Wi-Fi and new ultra-low power platform.
MSP430 FRAM Advantages
New Design Challenges

Application Energy
Designers adding functionality with a reduced or equivalent energy budget

Debugging
Designers spend 75+ percent of their time figuring out where power is “leaking” in their system

Complexity
Embedded software is becoming more complex, increasing memory requirements, energy budget and time to market

Future Development
Designers depend on a scalable portfolio to leverage hardware and software investments in future projects
Introducing the FRAM Advantage

Low power and fast writes
- Because you spend so much time in standby, current consumption as low as 350 nA
- When your application wakes up, 100μA/MHz active mode current for efficient operation
- Write quicker to save power; 13 KB in milliseconds, not seconds

Smart designs and cost saving
- Adjust to changing memory requirements with flexible non-volatile FRAM; store your application, data or both
- Restore your system state after power failure with two lines of code and no backup power source
- Update your system over the air with on-the-fly, bit level data writes and no buffering or pre-erase required

Reliability and robustness
- Log data continuously with $10^{15}$ write endurance and proven 10 year data retention at 85°C
- Prevent unauthorized memory and data communication access with IP encapsulation and hardware AES
- Diminish data loss with undetectable soft error rates and other inherent security advantages of FRAM
## All-in-one: FRAM Delivers Max Benefits

<table>
<thead>
<tr>
<th>Specifications</th>
<th>FRAM</th>
<th>SRAM</th>
<th>EEPROM</th>
<th>Flash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-volatile</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Retains data w/o power</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write speed</td>
<td>10ms</td>
<td>&lt;10ms</td>
<td>2 secs</td>
<td>1 sec</td>
</tr>
<tr>
<td>(13 KB)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average active Power [μA/MHz]</td>
<td>100</td>
<td>&lt;60</td>
<td>50,000+</td>
<td>230</td>
</tr>
<tr>
<td>16 bit word access by the CPU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write endurance</td>
<td>10↑15</td>
<td>Unlimited</td>
<td>100,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Soft Errors</td>
<td>Below Measurable Limits</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bit-wise programmable</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Unified Memory</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Flexible code and data partitioning</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Customers can learn more at: [www.ti.com/fram](http://www.ti.com/fram)
MSP430 Roadmap
Sensing & Measurement portfolio

MSP430

CapTIvate

F6xx
Up to 25 MHz
Up to 512KB Flash

FG6626
Up to 20 MHz
Up to 128KB Flash

FR698x
Up to 16 MHz
Up to 128KB FRAM

F4xx
Up to 16 MHz
Up to 120KB Flash

FR41xx
Up to 16 MHz
Up to 16KB FRAM

FR697x
Up to 16 MHz
Up to 64KB FRAM

F5xx
Up to 25 MHz
Up to 512KB Flash

FR59xx
Up to 16 MHz
Up to 128KB FRAM

F1x/2x
Up to 8/16 MHz
Up to 60/120KB Flash

FR20xx
Up to 16 MHz
Up to 16KB FRAM

FR57xx
Up to 24 MHz
Up to 16KB FRAM

G2xx
Up to 16 MHz
Up to 56KB Flash

i20xx
Up to 16 MHz
Up to 32KB Flash

FR231x
Up to 4KB FRAM
Smart Analog Combo

FR211x
Up to 4KB FRAM
Sys man, power seq

Non-LCD

FR26xx
Up to 16KB FRAM
CapTIvate IP

ES: 4Q 2015
CS: 2Q 2016
RTM: 1Q17

FR211x
Up to 4KB FRAM
Sys man, power seq

FR599X
Up to 256KB FRAM
Nano FRAM, LEA

CapTIvate IP

Texas Instruments
Asset Tracking – MSP430FR5969
- Integrated Low-power RTC
  - Wake-up at precise intervals and pull information
- Over-the-air System Updates
  - Write data on-the-fly: no buffering & no pre-erase
- 64kB of Non-volatile FRAM
  - Log data quickly and over extended periods of time
Electronic Labels – MSP430FR5869

- Low-power system management
  - Only wakeup when needed
- Fast Non-volatile Writes for Screen Refresh
  - Update displays quickly
- Unified Memory
  - Reduce MCU cost when industry standard Flash to RAM ratios are not ideal
TIDesign for Cold Chain Applications
get ahead of competition with TI complete reference solutions
Ultralow Power Multi-sensor Data Logger with NFC Interface Reference Design (TIDA-00524)
For Cold Chain Management

Solution Features
- MSP430 FRAM has unified memory, low power writes, faster writes, high endurance, security, etc.
- RF430 NFC Dynamic Tag Type 4B Communication
- Multiple Sensor Options & Configurations
  - Temp (TMP112)**
  - Temp + Humidity (HDC1000)
  - Ambient Light (OPT3001)
- 5 Year battery life

Solution Benefits
- Encrypted Memory
- NFC:
  - Transform Smartphone in portable data log reader
  - Potential for hermetically sealed enclosures
  - Retrieve data log even when battery is dead
- Mix / Match sensors to achieve the desired power/price point.

System Level View

Resources
- Check out TIDA-00524 [here](#)
- Check out video [here](#)
- Order EVM [here](#)
- Download Datasheet [here](#)
Hardware

Footprint: 55mm x 40mm
Design Features

- Communicates with NFC enabled phone using existing Reader/Writer applications (phone must support Reader/Writer mode)
- “Over the air” Configuration
- Data is Date/Time stamped using RTC
- CR-2032 Battery life of >5 Years
- Read Data stored in FRAM even when battery is depleted (RF energy harvesting)
Configuration Options

- **Control Commands**
  - ST – Start Measurements
  - SP – Stop Measurements
  - CD – Clear Measurement Data
  - RE – Reset all configurations, measurement data, and Date/Time

- **Configuration Commands**
  - MO x – Set Mode (Temp, Light, Temp+Light, Humidity + Temp)
  - TI hh:mm:ss – Set Time
  - DA mm/dd/yy – Set Date
  - PI xxx – Set Polling Interval (minimum: 1 min)

Command list is displayed when reading data logger.
Dynamic Field-Powered NFC Reference Design for Data Logging, Access Control, and Security Applications

**TI Designs Number: TIDA-00217**

### Solution Features
- RF430CL330H dynamic NFC transponder enables static tag emulation
- NFC type 4B compliant
- NFC/RFID protocol handled in ROM code
- Wireless sensor interface
- Low power: NFC reader provides transmission power
- Uses either field or bus power

### Solution Benefits
- User can receive updated information from a field unit including part authentication, sensing data, data logging, or security applications
- NFC devices in most modern cellphones
- Small size allows tags to be embedded in wrist straps, bracelets, key cards, etc.
- Battery-less sensor interface

### Tools & Resources
- TIDA-00217 Tools Folder
- User Guide
- Video
- Device Datasheets:
  - RF430CL330H
  - MSP430FR5969
  - TMP103
  - TPD1E10B06
Humidity & Temp. Sensing Node for 2.4-GHz Star Networks Enabling 10+ Year Coin Cell Battery Life

**Ti Designs Number: TIDA-00374**

### Solution Features
- Configurable System Wakeup Interval
- Extremely low off-state current (183 nA for 59.97 s)
- Ultra low on-state current due to low active processor and radio transmit currents (4.04 mA for 30 ms)
- ±3% Relative Humidity Accuracy
- ±0.2°C Temperature Accuracy
- Multi-standard 2.4 GHz radio

### Solution Benefits
- Use of Nano-Power System Timer to Duty-Cycle the System Results in 10+ year battery life from CR2032 coin cell
- Small, integrated solution size due to the integrated sensor and radio SoC

### Tools & Resources
- **TIDA-00374 Tools Folder**
- **User Guide**
- **Device Datasheets:**
  - HDC1000
  - TPL5110
  - TS5A3160
  - CC2650
Humidity & Temp. Sensing Node for Sub-1 GHz Star Networks Enabling 10+ Year Coin Cell Battery Life

**TI Designs Number: TIDA-00484**

### Solution Features
- Configurable System Wakeup Interval
- Extremely low off-state current (270 nA for 59.97 s)
- Ultra low on-state current due to low active processor and radio transmit currents (3.376 mA for 30 ms)
- Extended transmit range due to Sub-1 GHz radio
- ±3% Relative Humidity Accuracy
- ±0.2°C Temperature Accuracy

### Solution Benefits
- Use of Nano-Power System Timer to Duty-Cycle the System Results in 10+ year battery life from CR2032 coin cell
- Small, integrated solution size due to the integrated sensor and radio SoC

### Tools & Resources
- **TIDA-00484 Tools Folder**
- **User Guide**
- **Device Datasheets:**
  - HDC1000
  - TPL5111
  - TPS22860
  - TPS61291
  - CC1310

![Diagram of the solution components](image-url)
Your one stop shop for Cold Chain

- Sensors (Temperature, humidity, light, and more…)
- Low power microprocessors
- Non-Volatile FRAM memory
- Broad range of RF technologies
- More (power, ADCs, protection, isolation…)

- Accelerate your projects with TI Designs
Thank You!