Battery Charging and Chemistry Detection with the MSP430

Neal Brenner
MSP430 FAE North America
Texas Instruments

Agenda

- Battery Charging Basics
- Li-Ion Charging
- NiMH Charging
- Chemistry Detection
- Hardware and Software Overview
- Demo

Battery Chemistries

Chemistry	Alkaline	Ni-Cad	NiMH	Li-Ion
Rechargeable	No	Yes	Yes	Yes
Memory Effect	N/A	Large	Small	None
Self Discharge	Medium	High	High	Low
Current Output	Medium	High	High	Low
Capacity	Low	Low	Medium	High
Cost	Low	Low	Medium	High

- **Li-Ion is potentially dangerous to charge**
- **Ni-Cad is very environmentally unfriendly**

Battery Charging Basics

- **Battery Capacity is expressed in mAh**
- **Charge rate is expressed in terms of C**
- **C = Battery Capacity / 1 hour**
- **Example: 2500mAh battery**
  - C = 2.5A
  - 2C = 5A
  - C/2 = 1.25A
  - C/10 = 250mA
  - Etc.
- **A battery charged at 1C should charge in ~1 hour, at C/2 in ~2 hours**

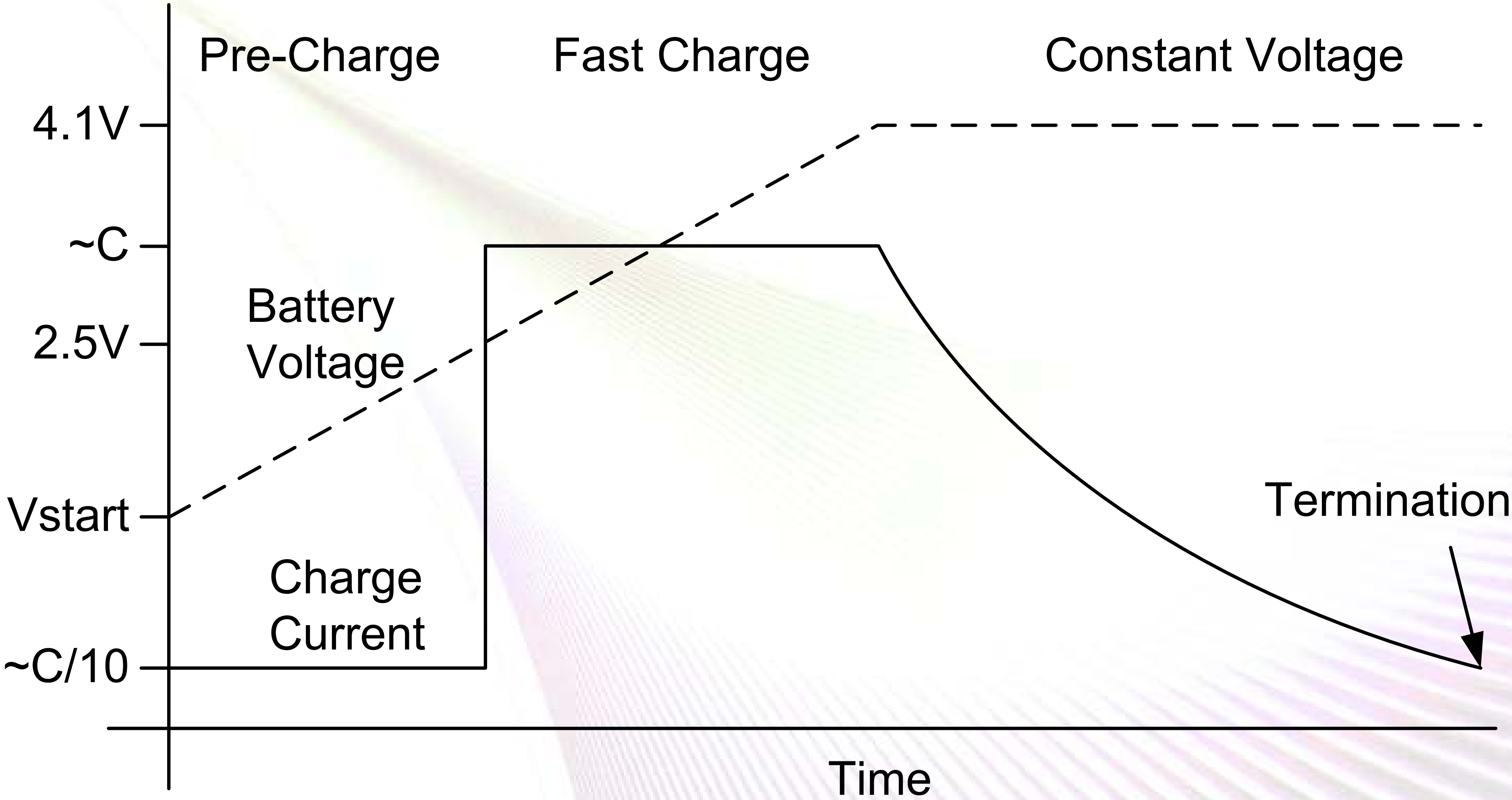
Agenda

- Battery Charging Basics
- Li-Ion Charging
- NiMH Charging
- Chemistry Detection
- Hardware and Software Overview
- Demo

Li-Ion Charging Stages

- **Pre-Charge (Conditioning)**
  - If battery voltage < 2.5V
  - Constant current of C/10
- **Fast Charge**
  - Constant current of 1C
  - While battery voltage in between 2.5V and 4.1V
- **Constant Voltage Charge**
  - Constant voltage at 4.1V
- **Termination**
  - When current drops below C/10

Li-Ion Charging



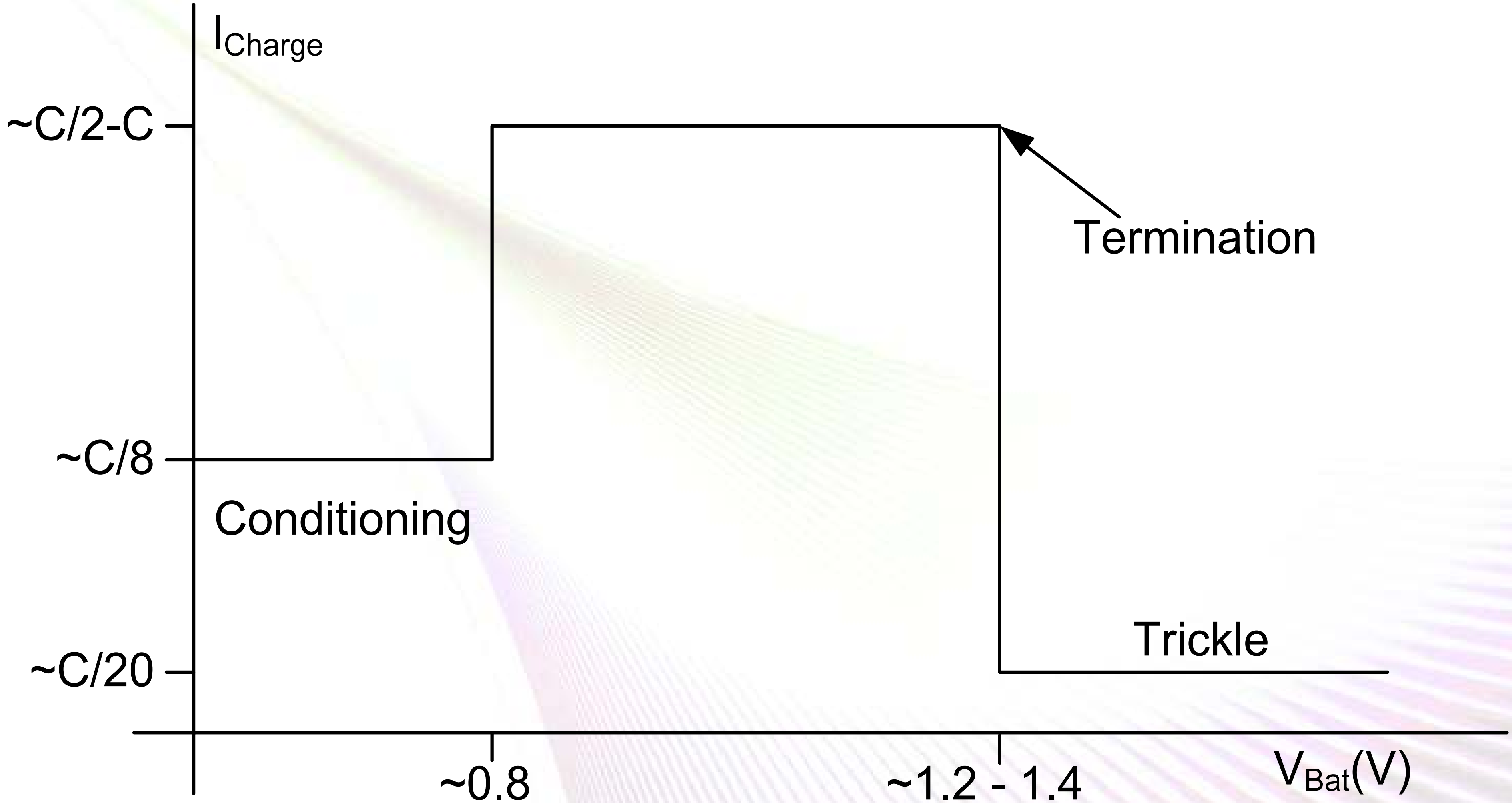
Agenda

- Battery Charging Basics
- Li-Ion Charging
- NiMH Charging
- Chemistry Detection
- Hardware and Software Overview
- Demo

NiMH Charging Stages

- **Pre-Charge (Conditioning)**
  - If battery voltage < 0.9V
  - Constant Current of C/10
- **Charge**
  - Constant current of C/2 - 1C
  - When battery voltage > 0.9V
- **Termination**
  - 3 different methods
- **Trickle Charge**
  - After termination constant current of C/20 to maintain charge

NiMH Charging



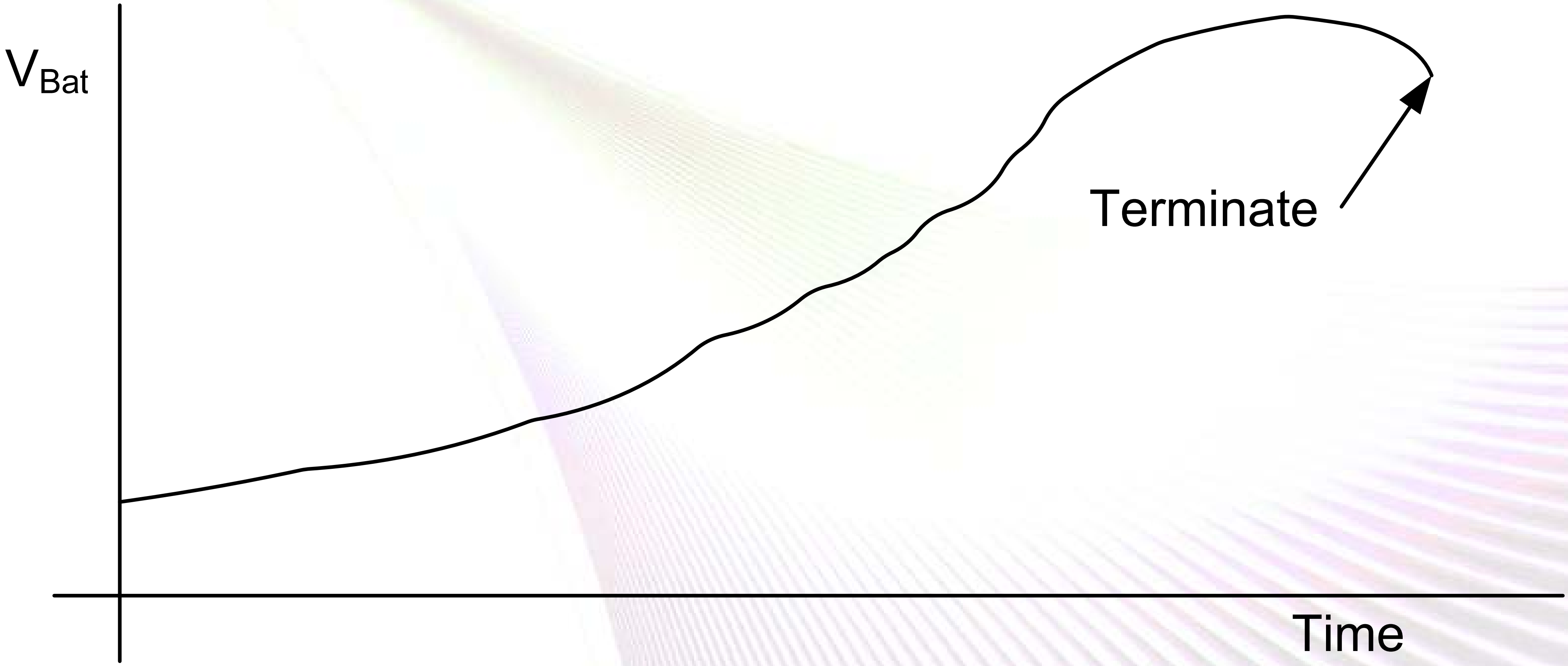
NiMH Charge Termination

- **3 Methods**
  - $-\Delta V/\Delta t$ (primary)
  - $\Delta T/\Delta t$ (secondary)
  - Timer (secondary)
- **Use all 3 for robust charge termination**

- **$\Delta T/\Delta t$**
  - Look for sharp increase in battery temperature over ambient or absolute safety temperature
- **Timer**
  - Set timer for appropriate charge time + 10% to 20% (to account for inefficiencies)
  - Example: if charging at C/2, set timer for 2 hours + 12 to 24 minutes

-ΔV/Δt Termination

- **Look for battery voltage dip**



Agenda

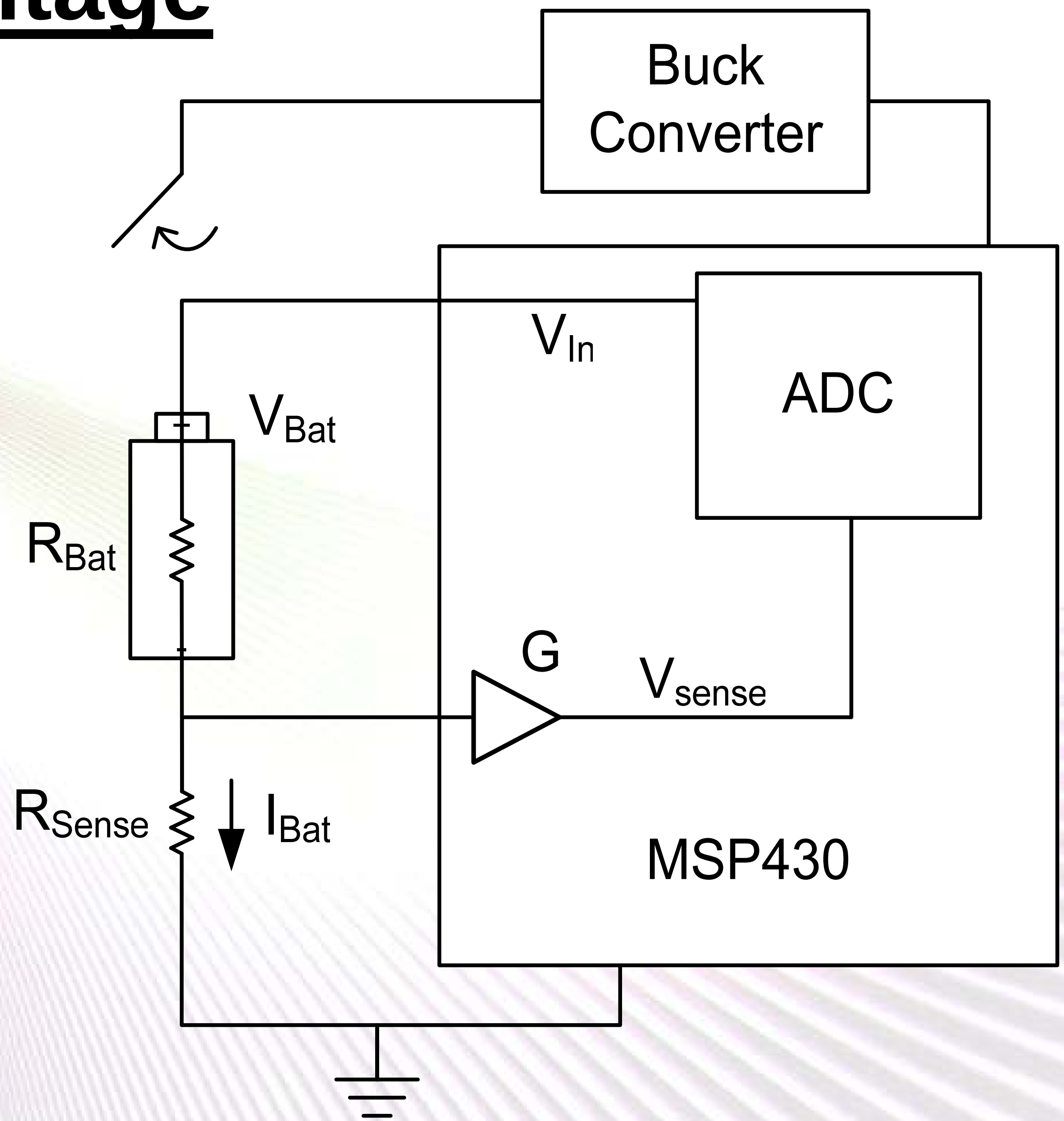
- Battery Charging Basics
- Li-Ion Charging
- NiMH Charging
- Chemistry Detection
- Hardware and Software Overview
- Demo

About Chemistries Detection

- **Different battery chemistries have different internal impedances**
- **These impedances change over temperature, charge state, and life of the battery**
- **Goal: only charge the battery if it is definitely a NiMH (or NiCad)**
- *Never* **attempt to charge different chemistries (Alkaline, Lithium, etc.)**
- **NiMH has lowest impedance of all AA battery chemistries**
- **Impedance =** $R_{Bat} = \dfrac{V_{Bat(Closed)} - V_{Bat(Open)}}{I_{Bat(Closed)}}$

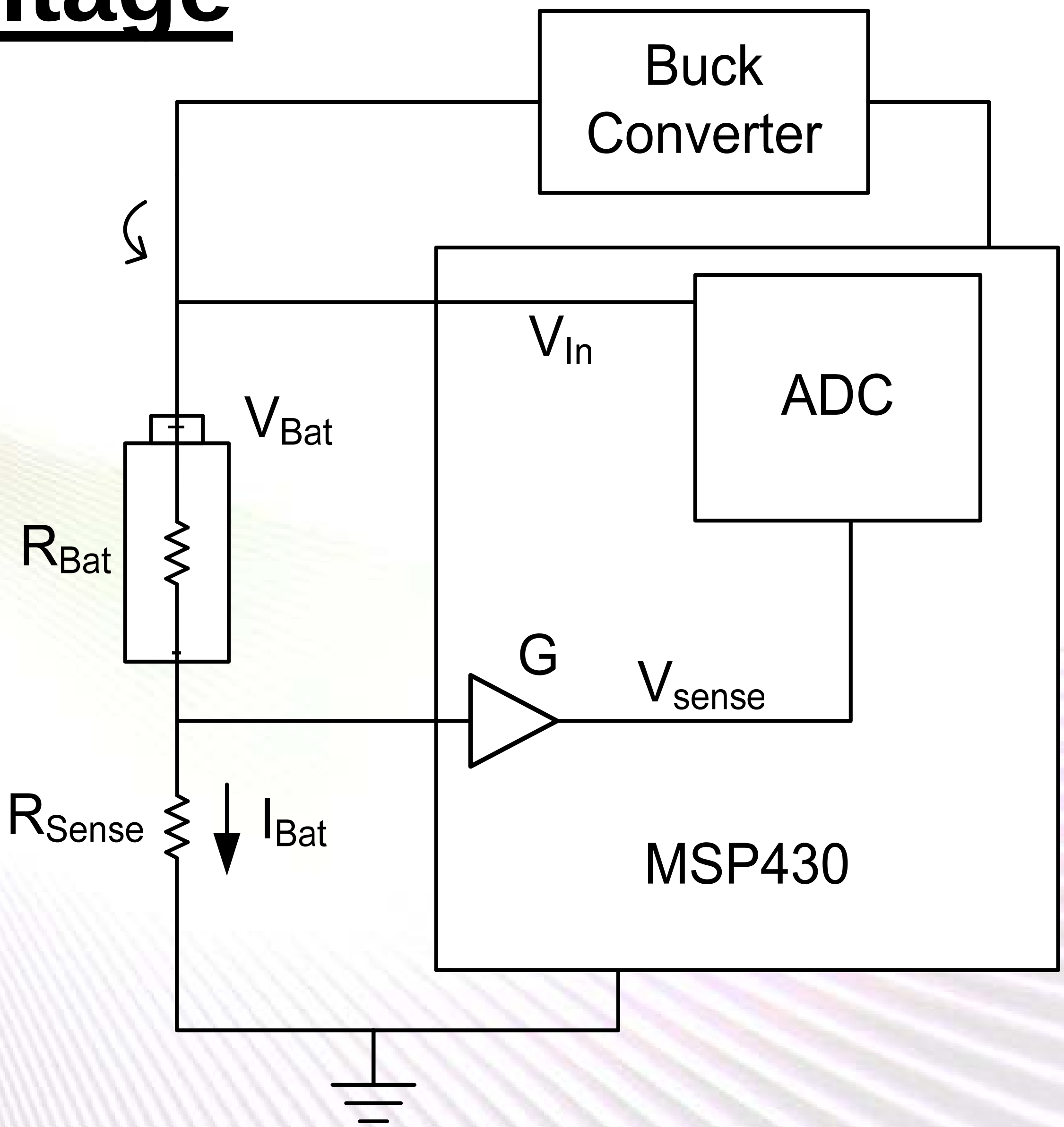
Open Loop Voltage

- I_{Bat} = 0mA
- V_{sense} = 0V
- $V_{Bat} = V_{In}$



Closed Loop Voltage

- $I_{Bat} < 150mA$
- $V_{sense} = G \cdot I_{Bat} \cdot R_{Sense}$
- $V_{Bat} = V_{In} - (I_{Bat} \cdot R_{Sense})$



Impedance Calculation

- $V_{Bat(Closed)} = V_{In} - (V_{sense} / G)$
- $I_{Bat(Closed)} = V_{sense} / (G \cdot R_{Sense})$
- $R_{Bat} = \dfrac{V_{Bat(Closed)} - V_{Bat(Open)}}{I_{Bat(Closed)}}$

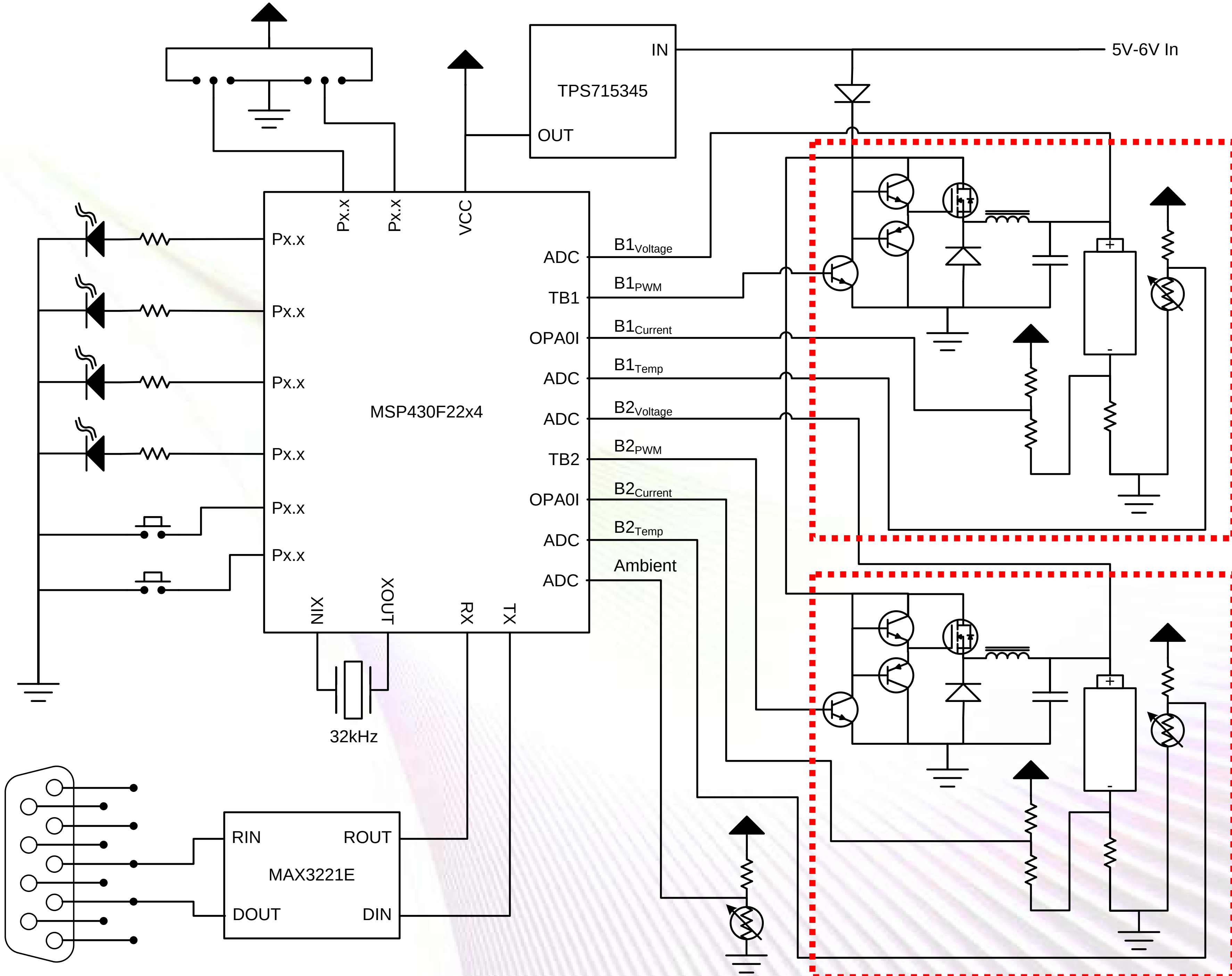
How to Identify a NiMH AA Battery

- **We use the battery's impedance calculation along with its open circuit voltage (estimate of its charge state) to determine whether it is a NiMH battery**
- **This method will sometimes fail to identify very old NIMH batteries correctly**
  - Impedance increases over the life of a battery
- **Conditioning charge of 150mA for some time often allows NiMH to recover to low impedance**
- **Example Impedance cutoffs for AA batteries**

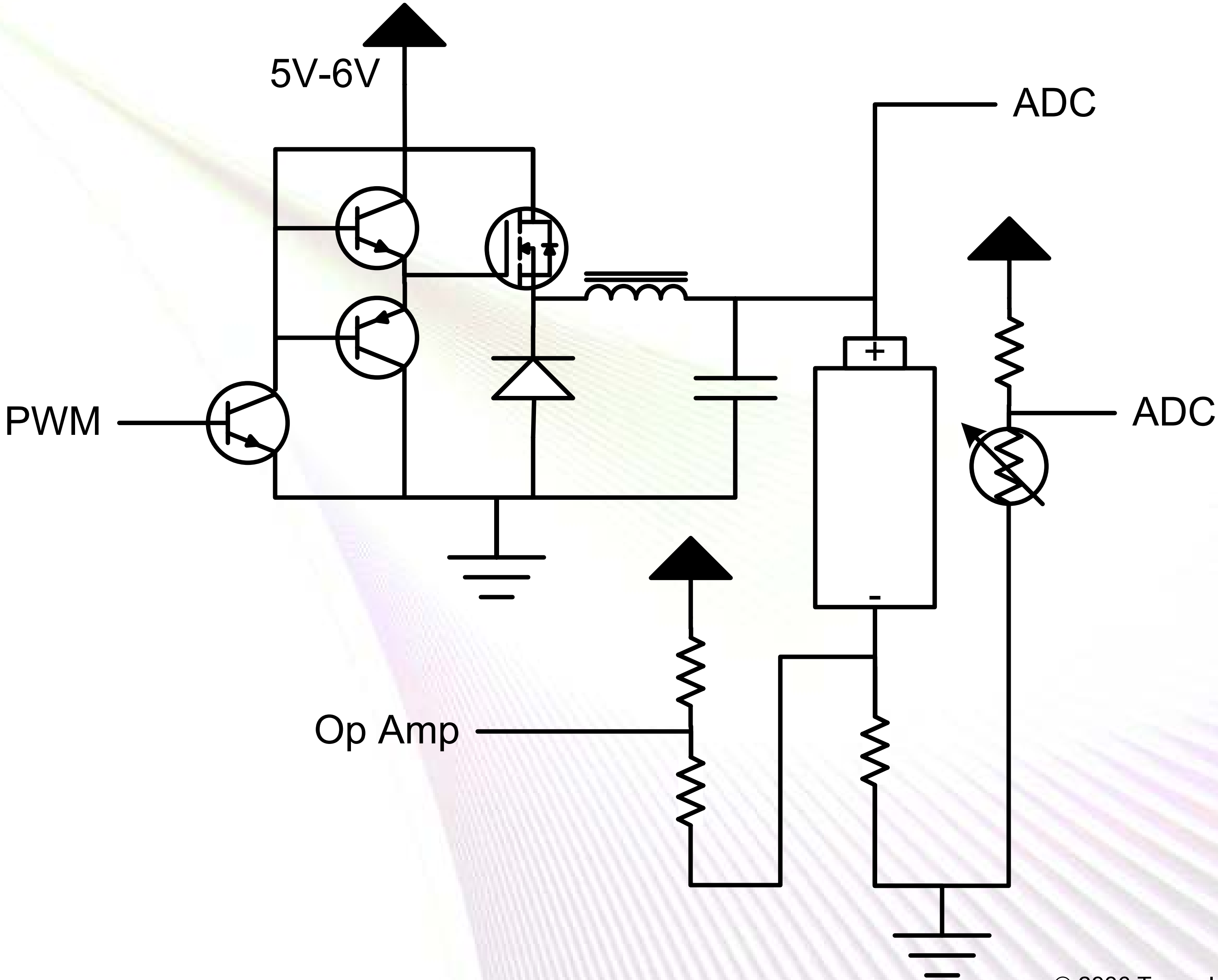
Voltage	1.5V	1.2V	0.9V
Cutoff Impedance	100mOhm	150mOhm	200mOhm

Agenda

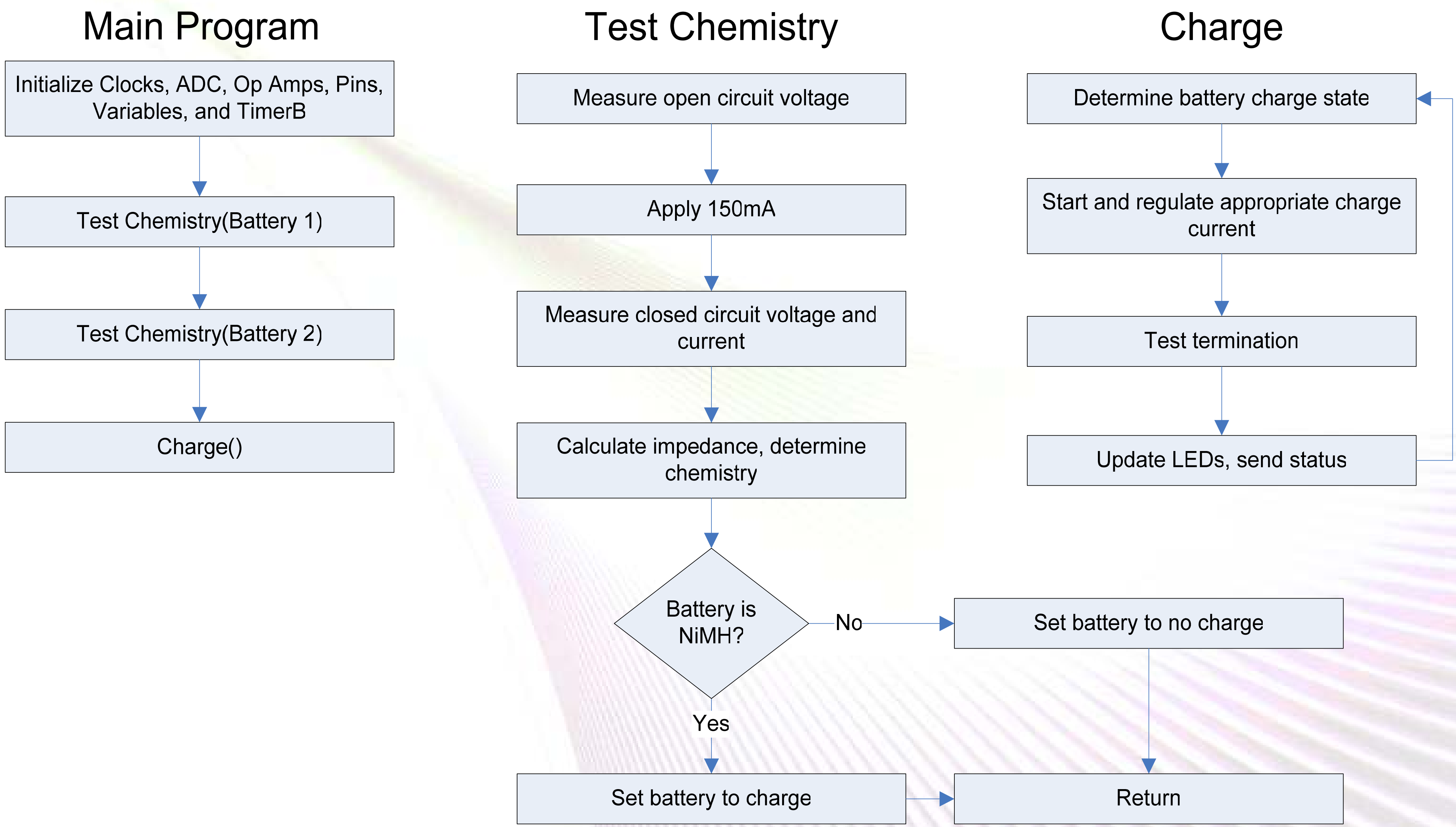
- Battery Charging Basics
- Li-Ion Charging
- NiMH Charging
- Chemistry Detection
- Hardware and Software Overview
- Demo


TPS715345
IN
OUT
5V-6V In
MSP430F22x4
Px.x
Px.x
VCC
Px.x
Px.x
Px.x
Px.x
Px.x
Px.x
ADC
TB1
OPA0I
ADC
ADC
TB2
OPA0I
ADC
ADC
B1Voltage
B1PWM
B1Current
B1Temp
B2Voltage
B2PWM
B2Current
B2Temp
Ambient
XIN
XOUT
RX
TX
32kHz
RIN
ROUT
MAX3221E
DOUT
DIN

Battery Charge Circuitry



Software Overview



Agenda

- Battery Charging Basics
- Li-Ion Charging
- NiMH Charging
- Chemistry Detection
- Hardware and Software Overview
- Demo

Demo

- Impedance Demo
- NiMH Charging Demo

Summary

- Li-Ion and NiMH batteries can be charged using the analog and digital control capabilities of the MSP430
- Non-Rechargeable batteries can be detected by measuring their open circuit voltage and impedance

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
RFID	www.ti-rfid.com	Telephony	www.ti.com/telephony
Low Power Wireless	www.ti.com/lpw	Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265