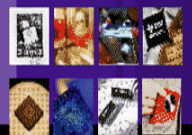




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TI Power Solutions Simplify Design and Speed Time-to-Market

Charles C. Hadsell, Texas Instruments

8th Texas Instruments Developer Conference India
30 Nov - 1 Dec 2005, Bangalore

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Agenda

- ❑ Overview of TI's Power Business
- ❑ Design Tools
- ❑ Design Services
- ❑ Solutions
 - Telecom/Datacom
 - Industrial
 - Consumer



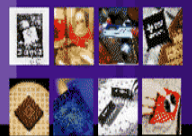
*Did you
know...*

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Introduction to TI Power

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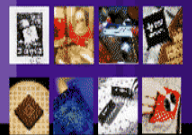
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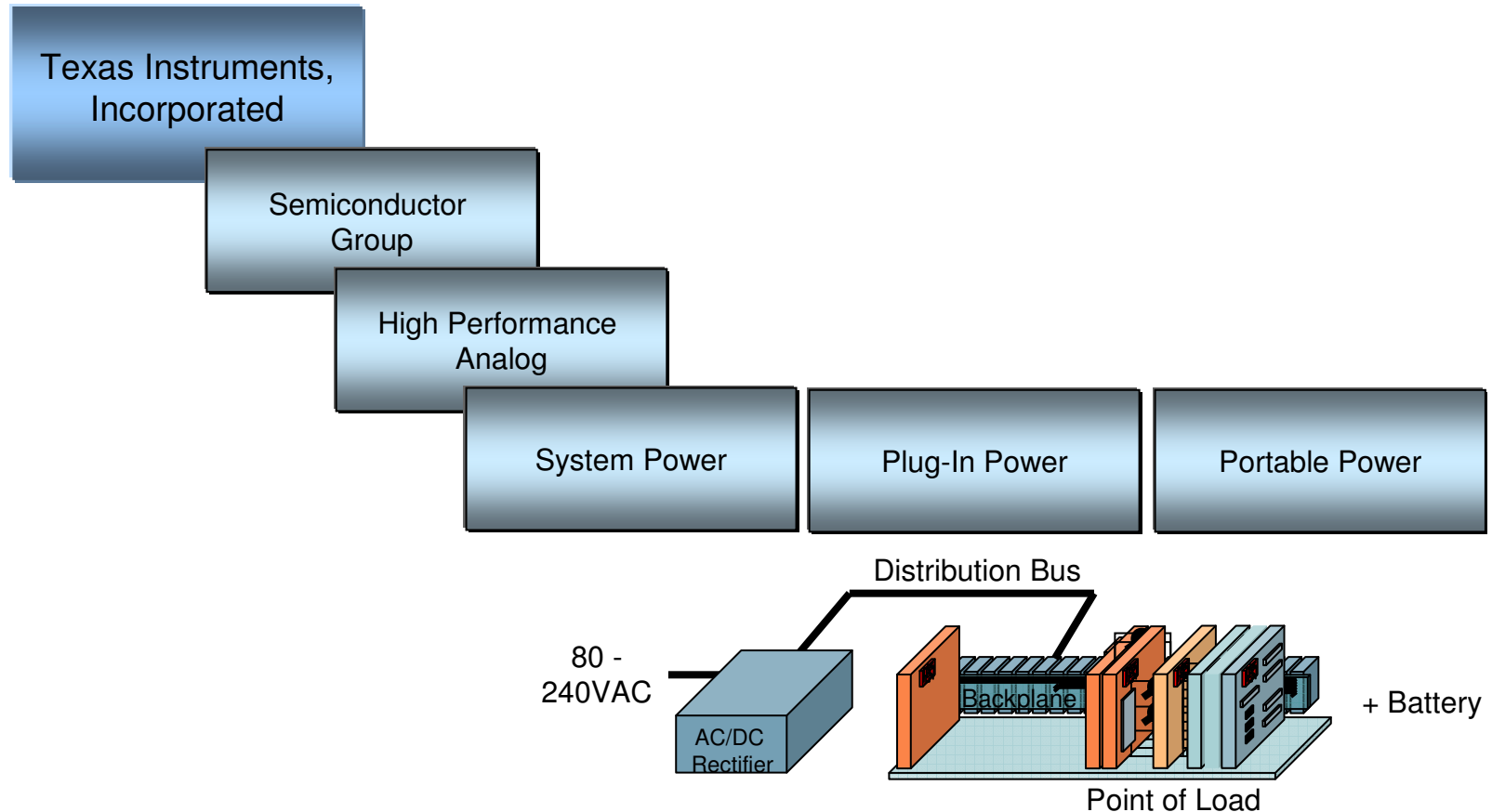
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TI's Power Organization

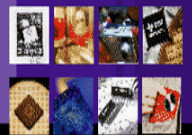




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TI's Power Product Families

Portable Power

- Battery Charge Management
- Battery Fuel Gauges
- Linear Regulators
- Low Power DC/DC Converters
- Supply Voltage Supervisors
- LED Drivers



System Power

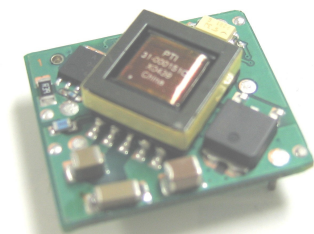
- DC/DC Controllers
- DC/DC Converters
- Charge Pumps
- Hot-Swap Controllers
- PFC + Power Supply Control
- Power-Over-Ethernet
- Digital Power

TI POWER



Plug-In Power

- Non-Isolated Power Modules
- Isolated Power Modules
- Miniature Isolated DC/DC Converters



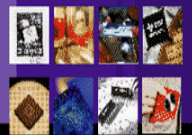
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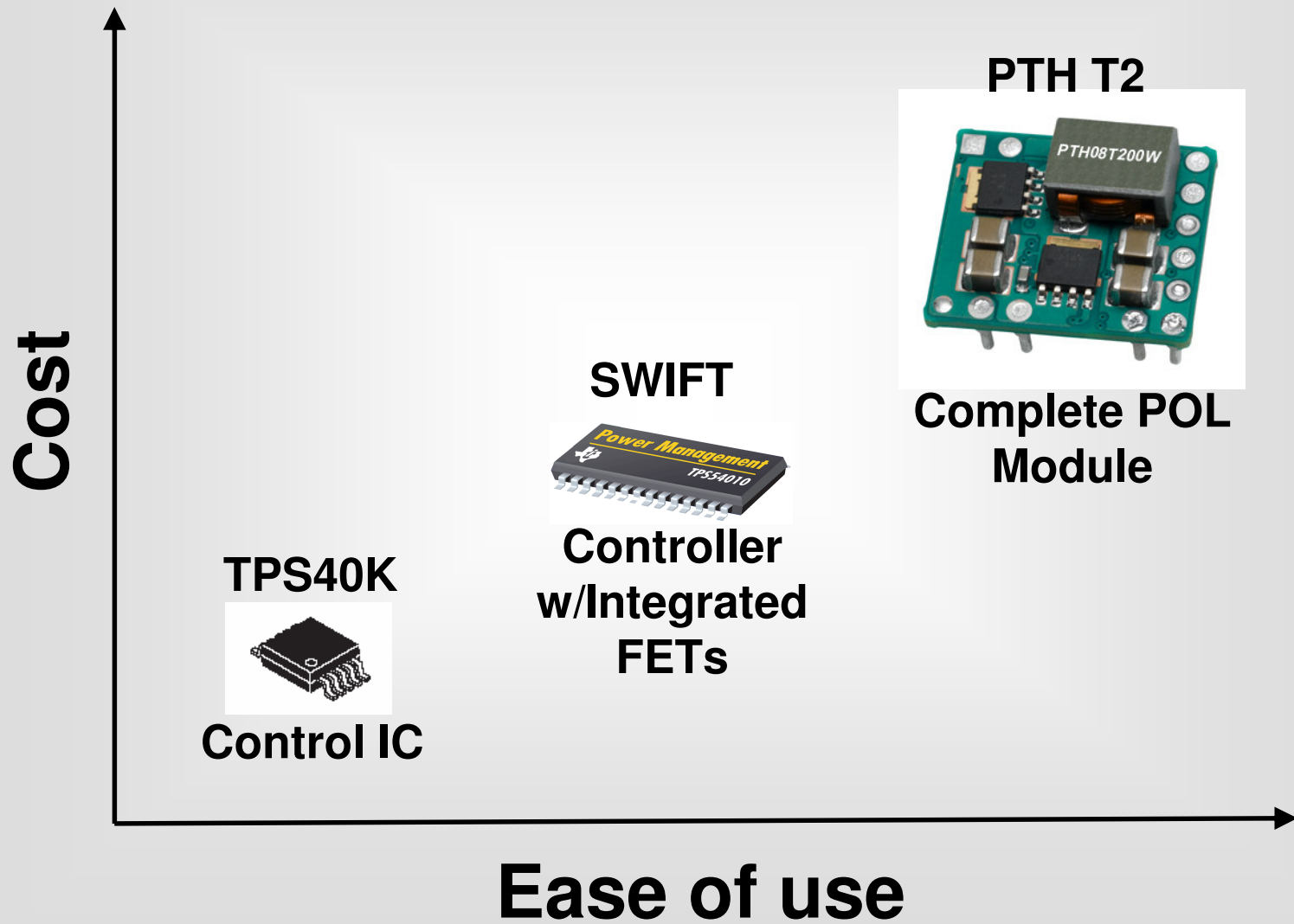
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TI's Non-Isolated Portfolio





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Design Tools

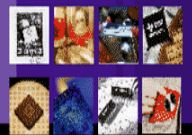
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Finding the Right Device

❑ Power Selector Tool at power.ti.com

*Either Nominal **OR** both Min and Max is Required

device quick search

Input		Output 1	
*Nominal Vin (V)		Vout (V)	Iout (A)
☒ 5		3.3	3
OR		Output 2	
*Min Vin (V)	*Max Vin (V)	Vout (V)	Iout (A)
☐			
☐ Search for isolated solutions		☐ Search for devices with more than two outputs	
		Search	Reset



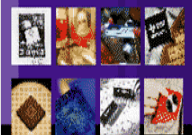
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Results

Linear Regulators

Part Number	Description	Iout (max) (A)	Vin (min) (V)	Vin (max) (V)	Vout
UCC283-3*	Low Power 3 Ampere Low Dropout (LDO) Regulator	3	3.85	9	
TPS75733*	Very Low Dropout (LDO) 3.3 Volt Output 3A LDO With Power Good Output	3	3.45	5.5	

*Please refer to de-rating guidelines in the datasheet to ensure power dissipation limits are not exceeded in your application

[Back to Top](#)

2 of 18 Results

[Show All Results](#)

[Go to Parametric Search](#)

DC/DC Converters (Integrated Switch)

Part Number	Description	Iout (max) (A)	Vin (min) (V)	Vin (max) (V)	Vout
TPS54356	TPS54352/3/4/5/6/7: 4.5-V to 20-V Input, 3-A Output Synchronous PWM Switcher	3		4.5	
TPS54316	Low Input Voltage 3A Synchronous Buck Converter with 3.3V Output	3		4	

[Back to Top](#)

2 of 27 Results

[Show All Results](#)

[Go to Parametric Search](#)

DC/DC Controllers (External Switch)

Part Number	Description	Iout (max) (A)	Vin (min) (V)	Vin (max) (V)	Vout
TL5001	PWM Controller with Wide Input Range	3	3.6	40	
TPS64200	Adjustable, up to 3A, 95% Efficient Step-Down Controller, 20uA, SOT-23	3	1.8	6.5	

[Back to Top](#)

2 of 34 Results

[Show All Results](#)

[Go to Parametric Search](#)

Plug-in Power Modules

Part Number	Description	Sub Family Name	Iout
PTH04070W	3-A, 3.3/5-V Input Adjustable Switching Regulator	Non-Isolated POL	
PTH04000W	3-A, 3.3/5-V Input Adjustable Switching Regulator with Auto-Track Sequencing	Non-Isolated POL	

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Design Software

- ❑ TI offers free software to assist with the design process
 - SWIFT™ for DC/DC Converters
 - TPS40K for DC/DC Controllers
 - TPS62K for low-power DC/DC Converters

- ❑ Available for free download
 - <http://www.ti.com/pol>
 - Product Folders

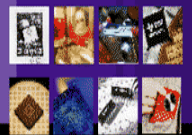


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Software Tools - Schematic Capture

TPS40K Designer 3.0

File Edit Analysis Format Tools Help

Power Management Products

Design Name: Design1

☐ Dual Outputs **ERR**

Vout (V):	1.8
Iout (A):	10
Min Vin (V):	2.40
Max Vin (V):	5.50

Advanced/Optional

Vo Ripple (mVp-p):	36
Soft Start Time (ms):	5
Input Ripple (mVp-p):	360
Iout Limit(A):	13
Min Gain Margin (dB):	10
Min Phase Margin (Deg):	45

Channel Independent Inputs

Design For...

☒ Efficiency ☐ Size

☒ SMD Only ☐ Cer Out Caps

☐ DCM Mode? ☐ PreBias

Sw Freq (kHz):	300
Max Height (mm.):	100
DCM Threshold (A):	NA

Component Deratings: Off

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TEXAS INSTRUMENTS *TPS40K Designer 3.0*

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Software Tools - Analysis

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TPS40K Designer 3.0

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Power Management Products

Design Name: Design1

☐ Dual Outputs **ERR**

Vout (V): 1.8
Iout (A): 10
Min Vin (V): 2.40
Max Vin (V): 5.50

Advanced/Optional

Vo Ripple (mVp-p): 36
Soft Start Time (ms): 5
Input Ripple (mVp-p): 360
Iout Limit(A): 13
Min Gain Margin (dB): 10
Min Phase Margin (Deg): 45

Channel Independent Inputs

Design For...
☒ Efficiency ☐ Size

☒ SMD Only ☐ Cer Out Caps
☐ DCM Mode? ☐ PreBias

Sw Freq (kHz): 300
Max Height (mm.): 100
DCM Threshold (A): NA

Component Deratings: Off

Efficiency (% Full Load)

Analysis

Parameter	Specification	Minimum	Maximum	Units
Input Voltage	2.400	2.250	5.500	Volts
Input Ripple	360	-	342	mVp-p
UVLO	NA	NA	NA	
Output Voltage	1.800	1.754	1.855	Volts
Output Ripple	36	-	26	mVp-p
Transient - VM1	-	-	183	mVp-p
Transient - VM2	-	-	1675	mVp-p
Output Current	10.00	10.00	-	Amps
Inductor Peak to Peak Cur.	-	-	0.949	Amps
Current Limit Threshold	13.00	13.1	36.3	Amps
Frequency	300.0	250.2	349.8	kHz
Slow Start	5	5.4	27.9	ms
Efficiency	-	90.9	-	%
Est PCB Area	-	601.9	-	Sq. mm.
Max Component Height	-	10.0	-	mm.
Gain Margin	-10.0	>-50.2	-	dB
Phase Margin	45	47	-	Deg.

Note: Conditions for transient spikes set in Options (found in the Tools Menu).

100% 11:31 AM 11/21/2005

TEXAS INSTRUMENTS *TPS40K Designer 3.0*

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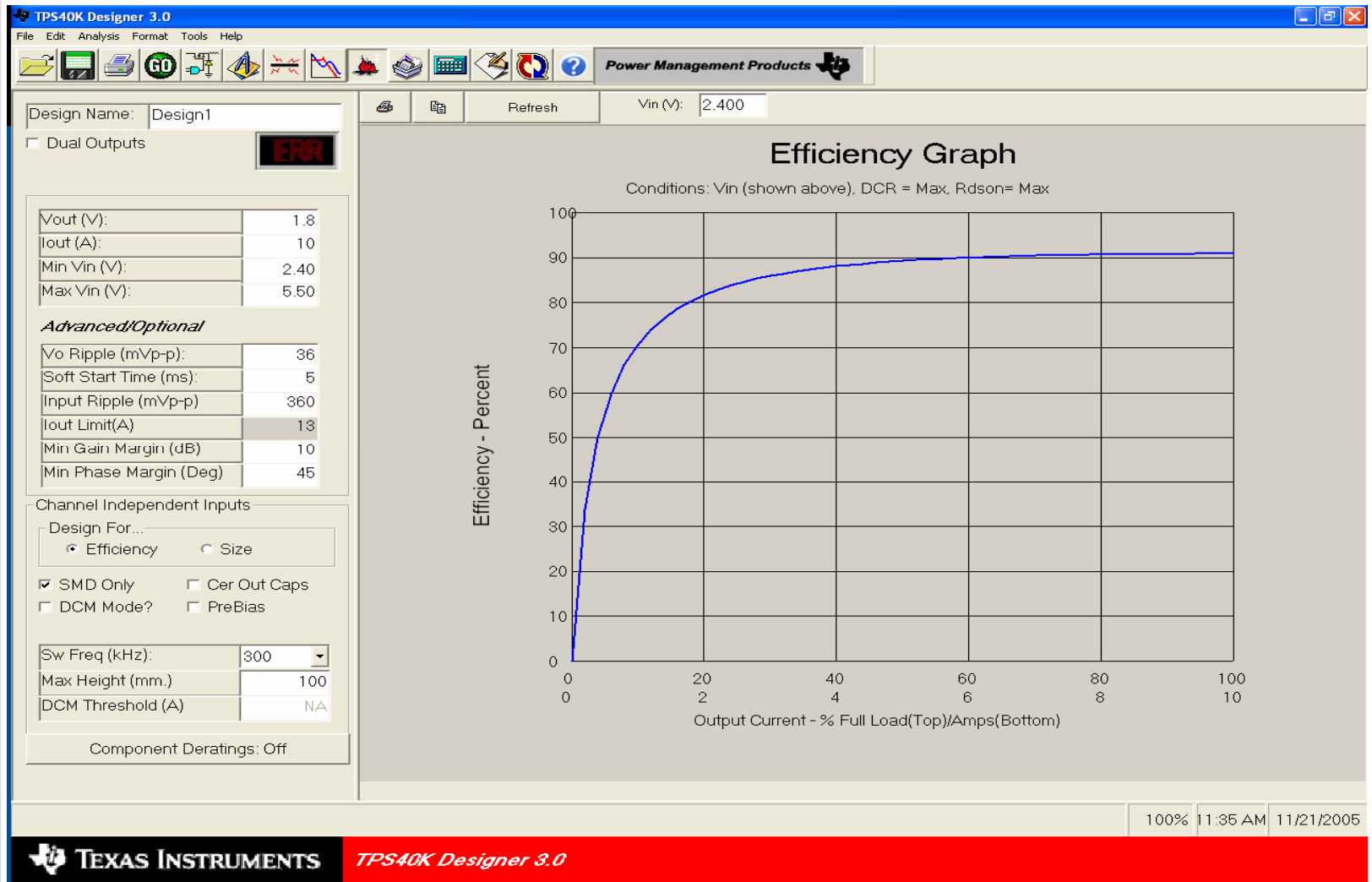


Software Tools - Efficiency

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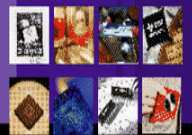
TEXAS INSTRUMENTS



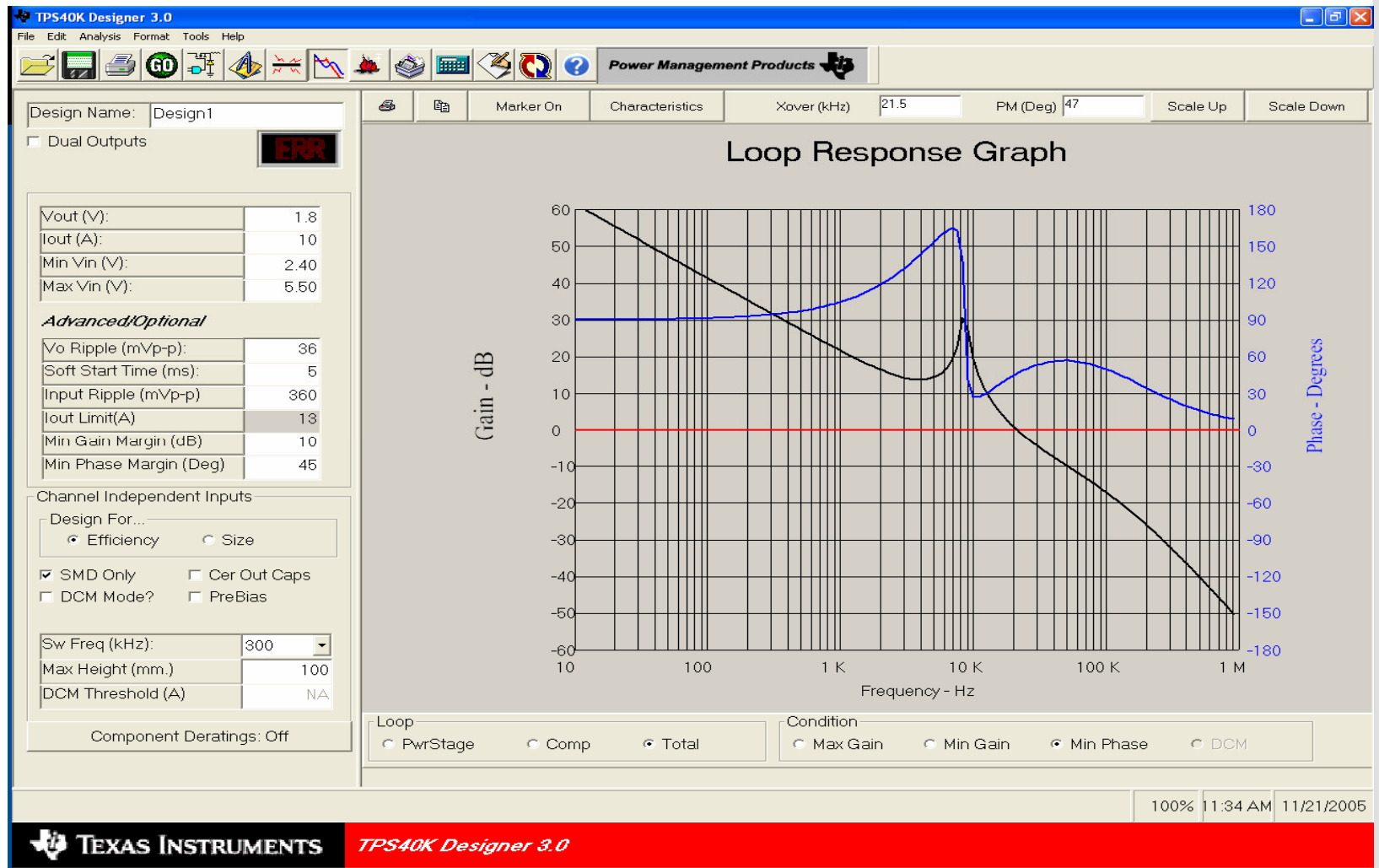
Software Tools - Bode Plot

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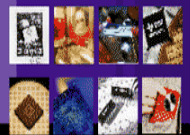


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Software Tools - BOM

TPS40K Designer 3.0

File Edit Analysis Format Tools Help

Design Name: Design1

☐ Dual Outputs

Advanced/Optional

Vout (V):	1.8
Iout (A):	10
Min Vin (V):	2.40
Max Vin (V):	5.50

Vo Ripple (mVp-p): 36
Soft Start Time (ms): 5
Input Ripple (mVp-p): 360
Iout Limit(A): 13
Min Gain Margin (dB): 10
Min Phase Margin (Deg): 45

Channel Independent Inputs

Design For...
☒ Efficiency ☐ Size

☒ SMD Only ☐ Cer Out Caps
☐ DCM Mode? ☐ PreBias

Sw Freq (kHz): 300
Max Height (mm.): 100
DCM Threshold (A): NA

Component Deratings: Off

Bill of Materials

Ref Des	Qty	Part Number	Description	Mfr	Size
C2	3	20TQC22M	Capacitor, POSCAP, 22 uF, 20.0-V, 20%	Sanyo	D2
C3	1	Std	Capacitor, Ceramic, 0.10 uF, 16.0-V, 10%	Std	0603
C5	1	Std	Capacitor, Ceramic, 0.022 uF, 16.0-V, 10%	Std	0603
C6	1	Std	Capacitor, Ceramic, 3300 pF, 16.0-V, 10%	Std	0603
C7	1	Std	Capacitor, Ceramic, 150 pF, 16.0-V, 10%	Std	0603
C8	1	Std	Capacitor, Ceramic, 2200 pF, 16.0-V, 10%	Std	0603
C9	3	C2012X5R0J106M	Capacitor, Ceramic, X5R, 10.0 uF, 6.3-V, 20%	TDK	805
C10	1	Std	Capacitor, Ceramic, 1.0 uF, 6.3-V, 20%	Std	0805
C12	1	Std	Capacitor, Ceramic, 1.0 uF, 16.0-V, 10%	Std	0805
L1	1	HC1-5R1	Inductor, 5.1-uH, 12.79-A, 5-millohms	Coiltronics	HC1
Q1	1	Si7106DN	Transistor,NFET, 20-V, 19.5-A, 0.0062-Ohms	Vishay Silicon	PowerPak
Q2	1	Si7860DP	Transistor,NFET, 30-V, 15.0-A, 0.011-Ohms	Vishay Silicon	Low Therm
R1	1	Std	Resistor, SM, 10.0 kOhms, 1/16-W,1%	Std	0603
R2	1	Std	Resistor, SM, 6.34 kOhms, 1/16-W,1%	Std	0603
R3	1	Std	Resistor, SM, 6.19 kOhms, 1/16-W,1%	Std	0603
R5	1	Std	Resistor, SM, 453 Ohms, 1/16-W,1%	Std	0603
R6	1	Std	Resistor, SM, 7.32 kOhms, 1/16-W,1%	Std	0603
R8	1	Std	Resistor, SM, 1.00 Ohms, 1/16-W,1%	Std	0603
R9	1	Std	Resistor, SM, 1.00 Ohms, 1/16-W,1%	Std	0603
R13	1	Std	Resistor, SM, 3.30 Ohms, 1/16-W,1%	Std	0603

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TEXAS INSTRUMENTS TPS40K Designer 3.0

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Design Services

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Scope of Services Offered

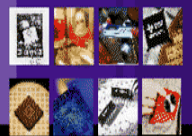
- ❑ TI Warrenville for Modular Power Solutions
 - Schematic proposals
 - Architecture proposals

- ❑ Dallas Team for Discrete Design Services
 - Block diagrams and IC recommendations
 - Paper analysis of design, cost, area
 - Schematics and PWB layouts
 - Prototype boards and test reports



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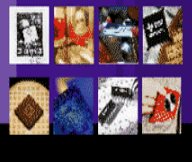
Provide TI Warrenville with...

- ☐ Input Bus Voltage
- ☐ Output Voltages
- ☐ Output Currents
- ☐ Sequencing Needs
- ☐ Other size / efficiency / thermal requirements





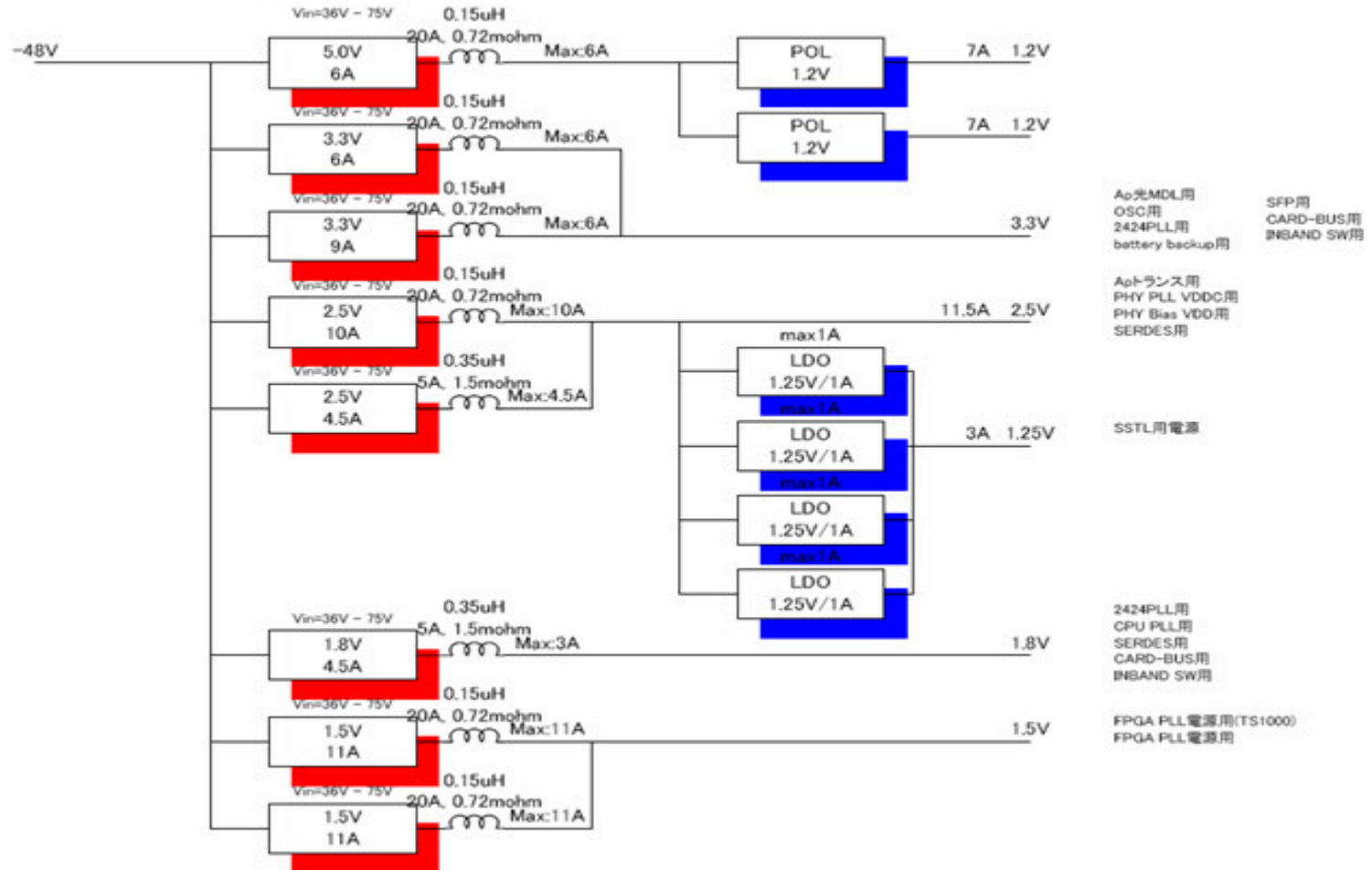
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Or provide us with your current solution...

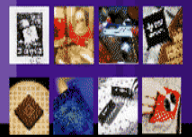
Current Solution





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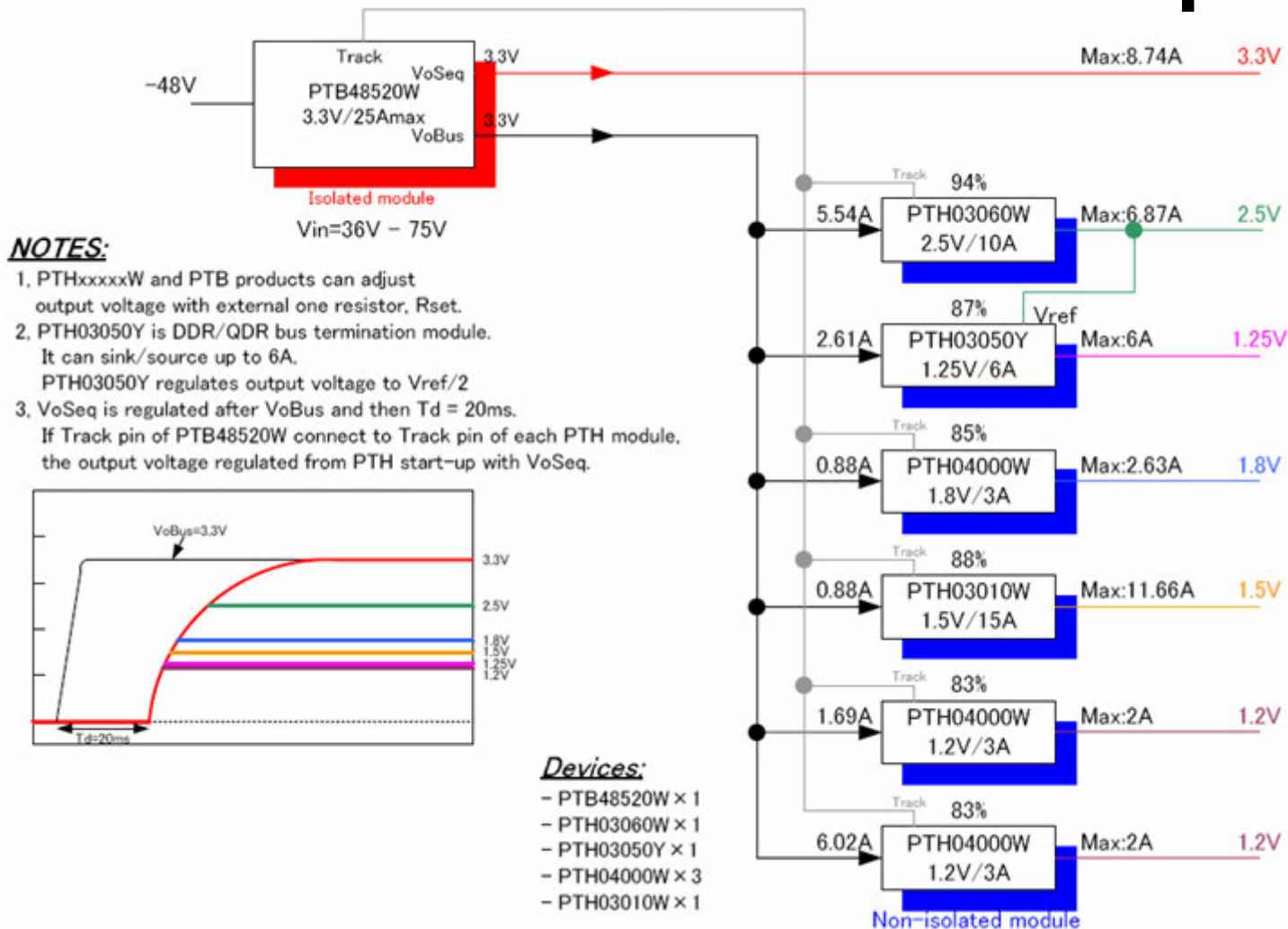
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We'll provide you with a TI Proposal

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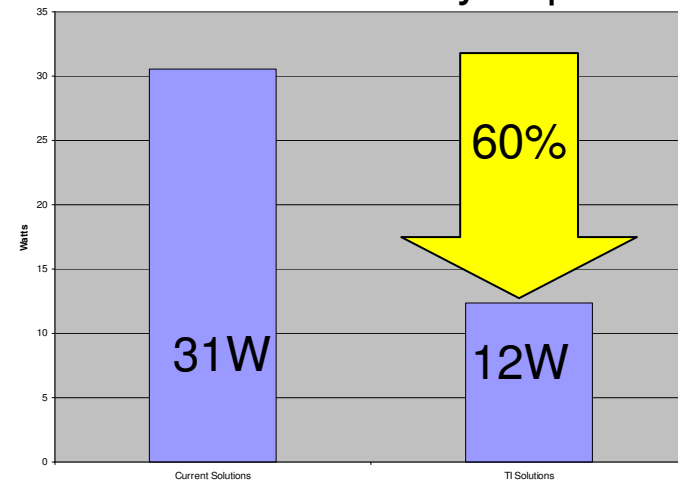


Advantages of the TI Proposal

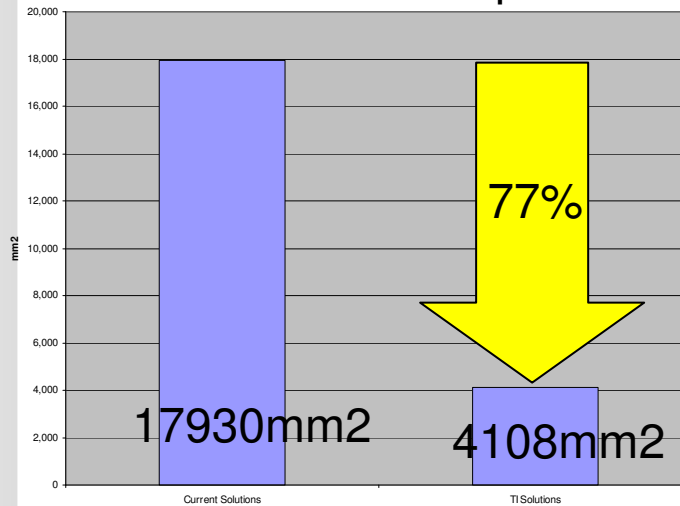
Price Comparison



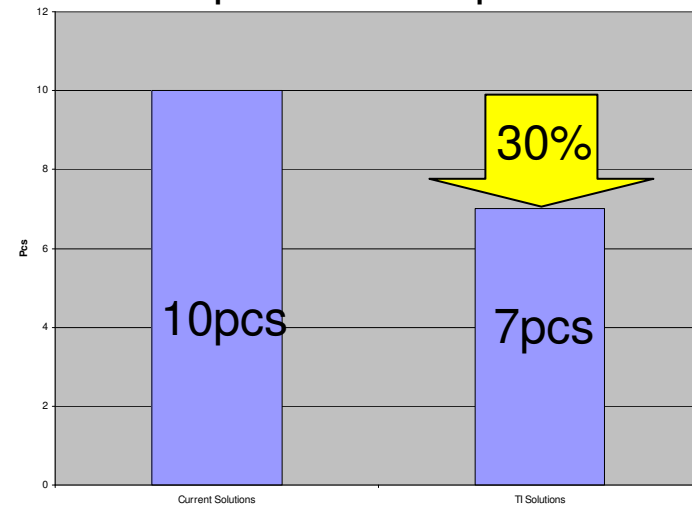
Module Efficiency Impact



Real-estate Comparison



Component Comparison



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Discrete Design Services

- ❑ Team of 15 engineers in Dallas that specialize in discrete power supply design
 - Library of over 1,500 reference designs
- ❑ After a project is accepted:
 - An engineer is assigned to work with the customer to define the specification
 - An electrical schematic is created and reviewed with customer
 - Prototype hardware and a test report are delivered
 - Ongoing layout and debug support available
 - Schedules are driven by complexity, but the typical design takes 2-4 weeks



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To Take Advantage of these Services...

- ❑ Look online at the library of reference designs at power.ti.com
- ❑ Work through your local TI India team
 - TI Warrenville for modular solutions
 - Dallas team for discrete design services



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Solutions

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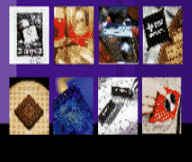
Problems Observed in Datacom/Telecom

- ☐ Compensating for high inrush current
- ☐ Filtering switching frequency noise
- ☐ Sequencing multiple power rails



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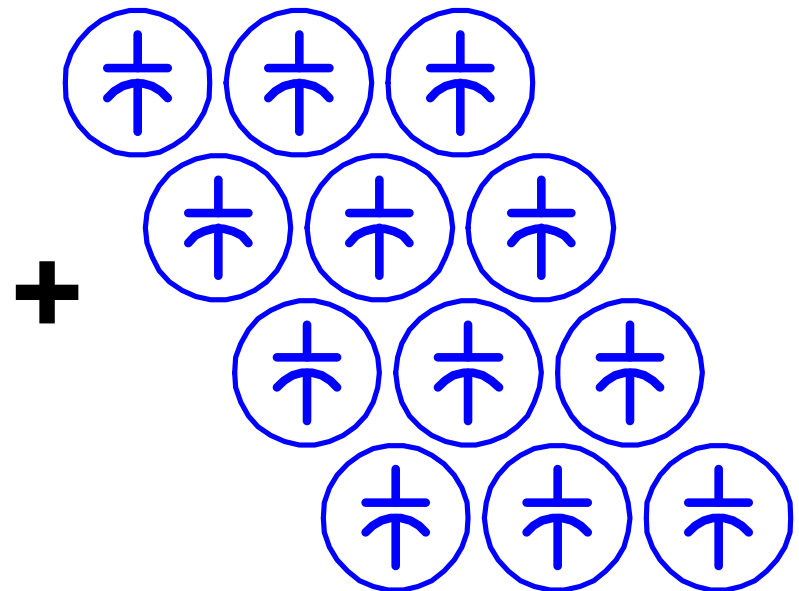
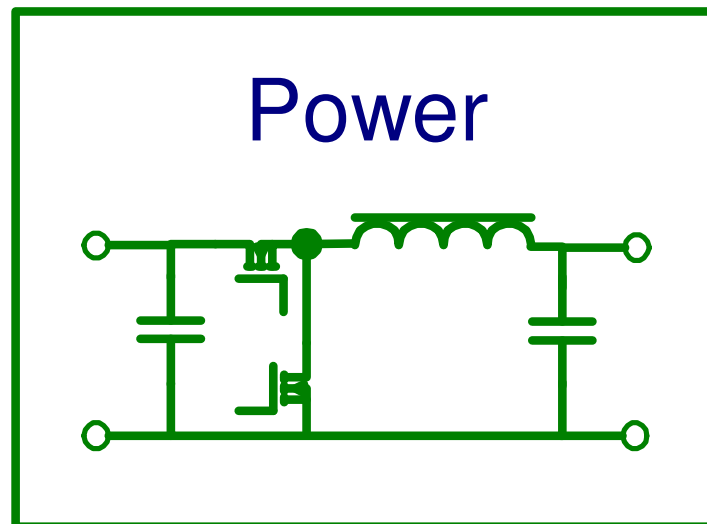
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The Problem... high current demands of digital loads

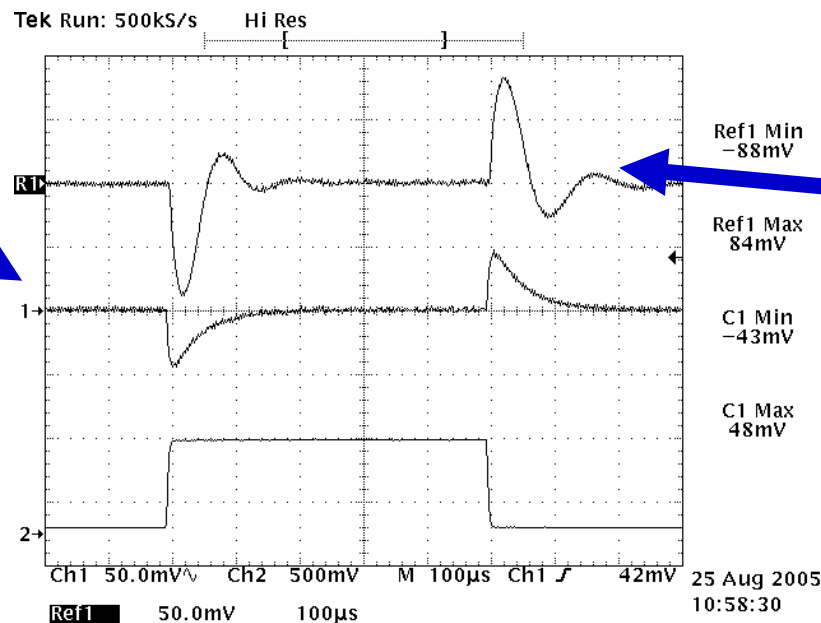
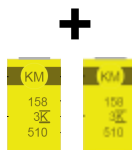
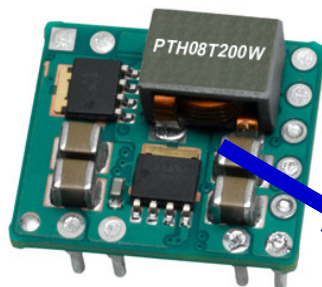
- ❑ High speed digital loads demand large amounts of current on startup
- ❑ Traditional power supplies need a large capacitor bank to handle transients



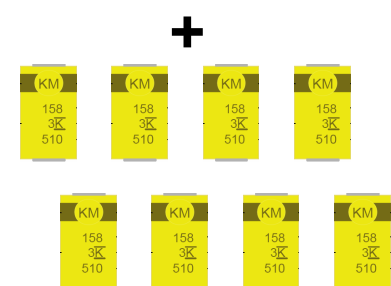
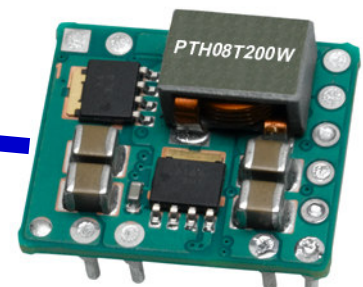
TurboTrans™ Slashes Required Capacitance

- TI's patent-pending TurboTrans™ feature allows the designer to tune the power module to meet transient requirements
 - Stability is increased, transient response is greatly improved, and less output capacitance is needed

TurboTrans



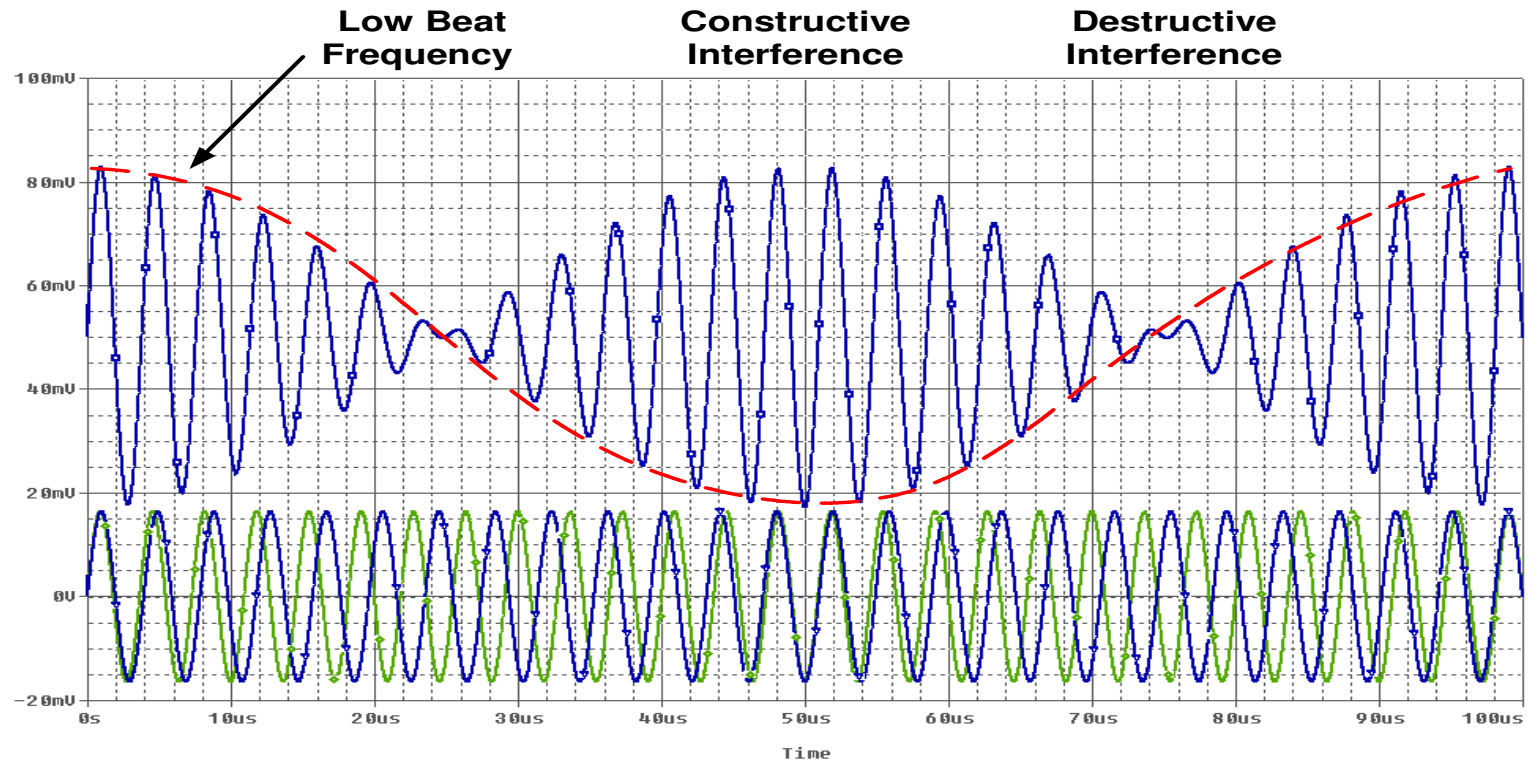
w/o TurboTrans



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The Problem...Beat Frequencies

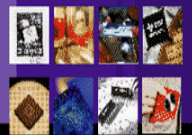
- Two power supplies switching at 300kHz and 290kHz create a 10kHz beat frequency
- This forces the designer to filter 3 different frequencies





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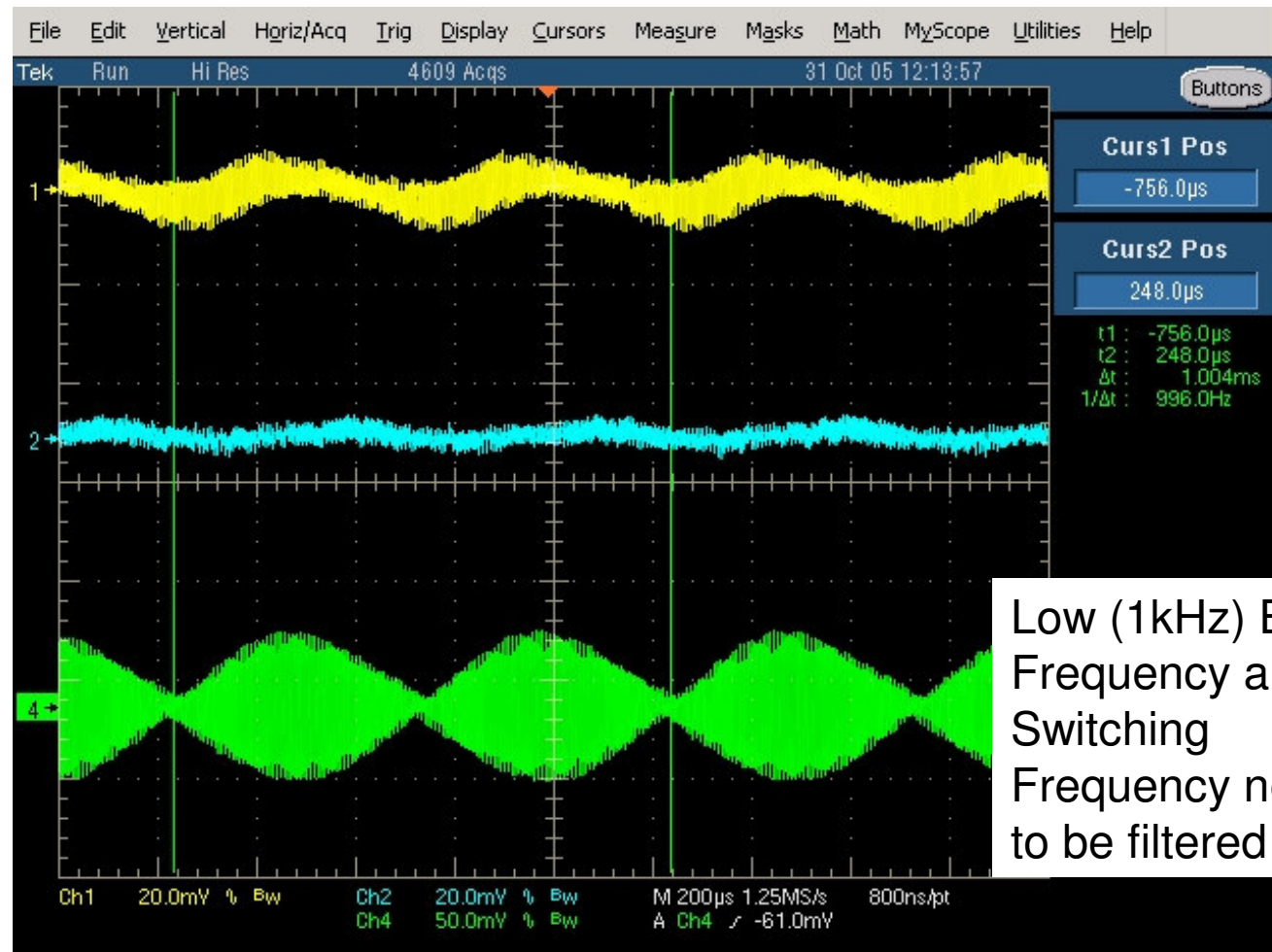
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Non Synchronized T2's

PTH08T2
#1

PTH08T2
#2

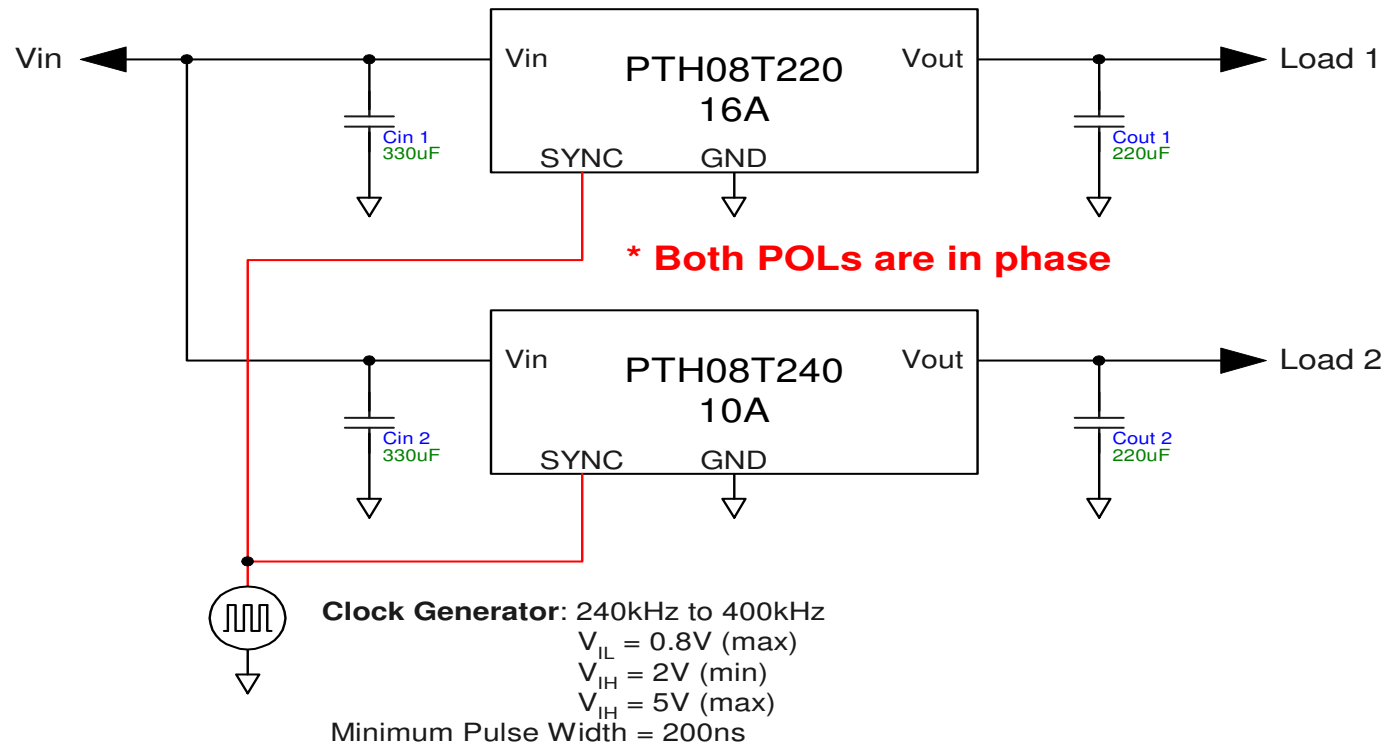
Reflected
Input
Ripple



Low (1kHz) Beat
Frequency and
Switching
Frequency need
to be filtered

Basic *SMART SYNC*

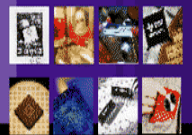
- ❑ SmartSync allows the designer to synchronize multiple T2 power modules
 - Driving the SYNC pin with an external clock generator accomplishes this





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Synchronized T2's

PTH08T2
#1

PTH08T2
#2

Reflected
Input
Ripple



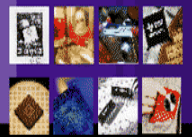
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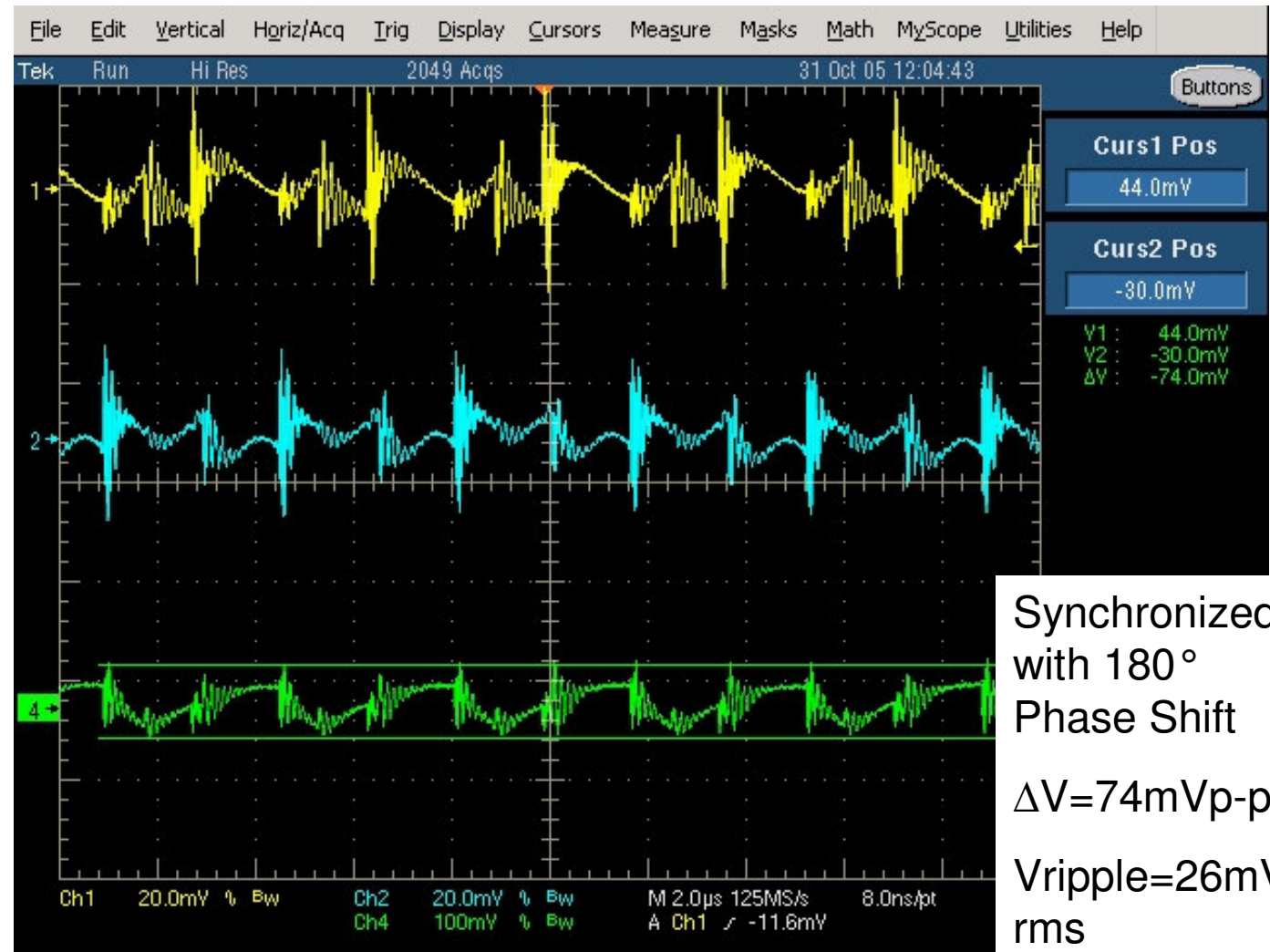
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PTH08T2
#1

PTH08T2
#2

Reflected
Input
Ripple

Synchronized T2's Phase Shifted 180°



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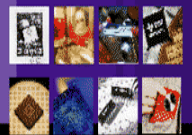
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The Problem... Sequencing multiple voltage rails

- ❑ Complex systems now require several voltage rails to support core, I/O and other voltage needs
 - Many DSP's, FPGA's and ASIC's require special sequencing
- ❑ Sequencing on power-up and power-down can be a difficult design challenge



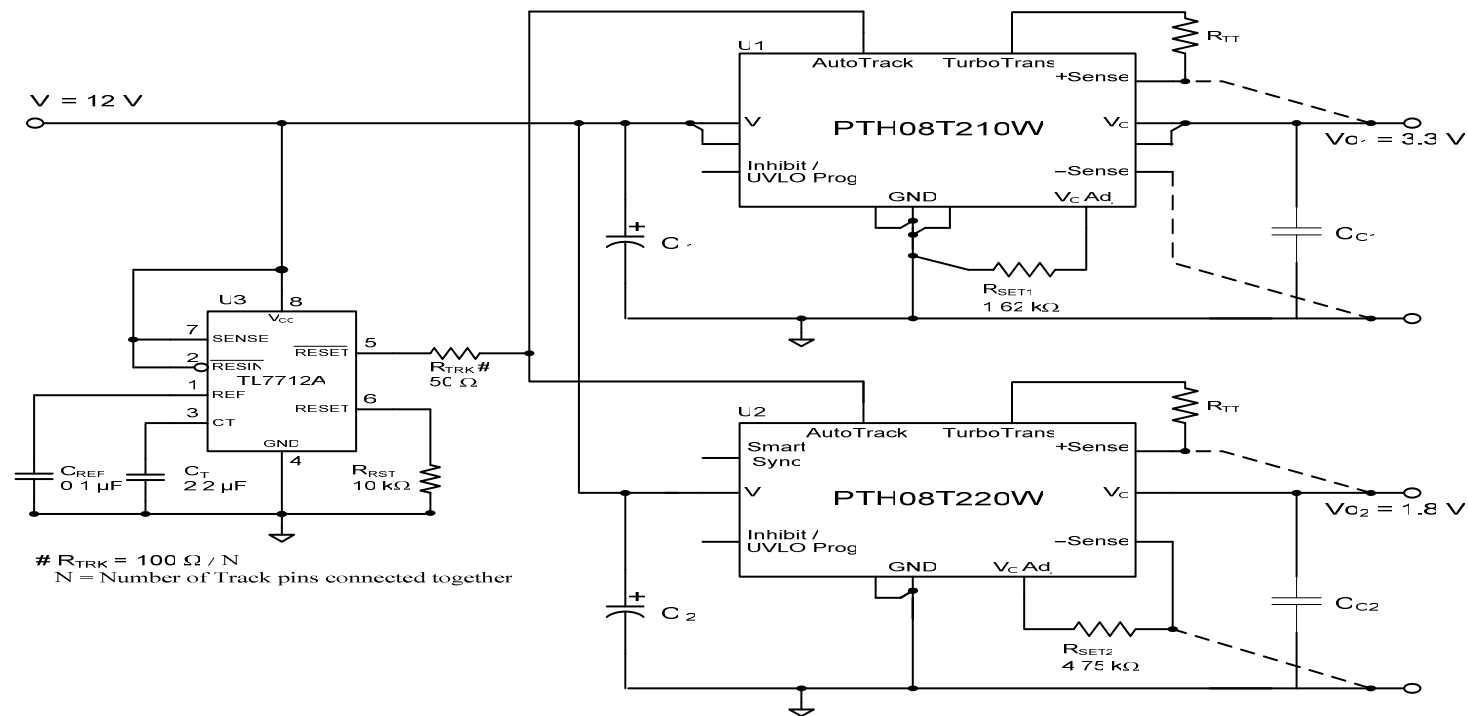
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Simultaneous Sequencing with Auto-Track

- TI developed the Auto-Track feature to simplify sequencing
 - By tying together the auto-track pins, voltages will ramp together

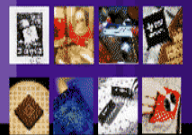




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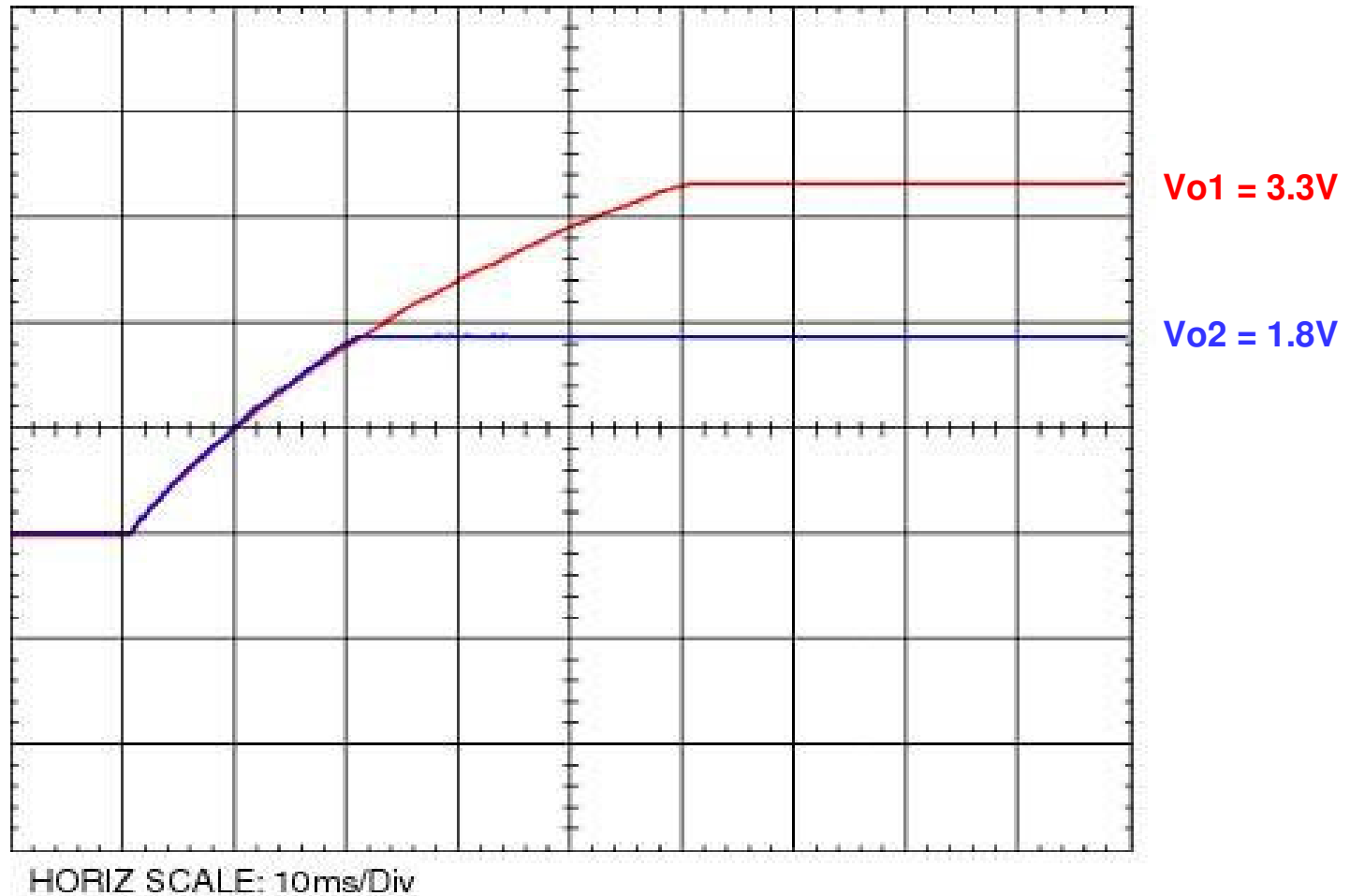
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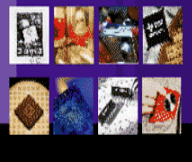
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Simultaneous Auto-Track Sequencing



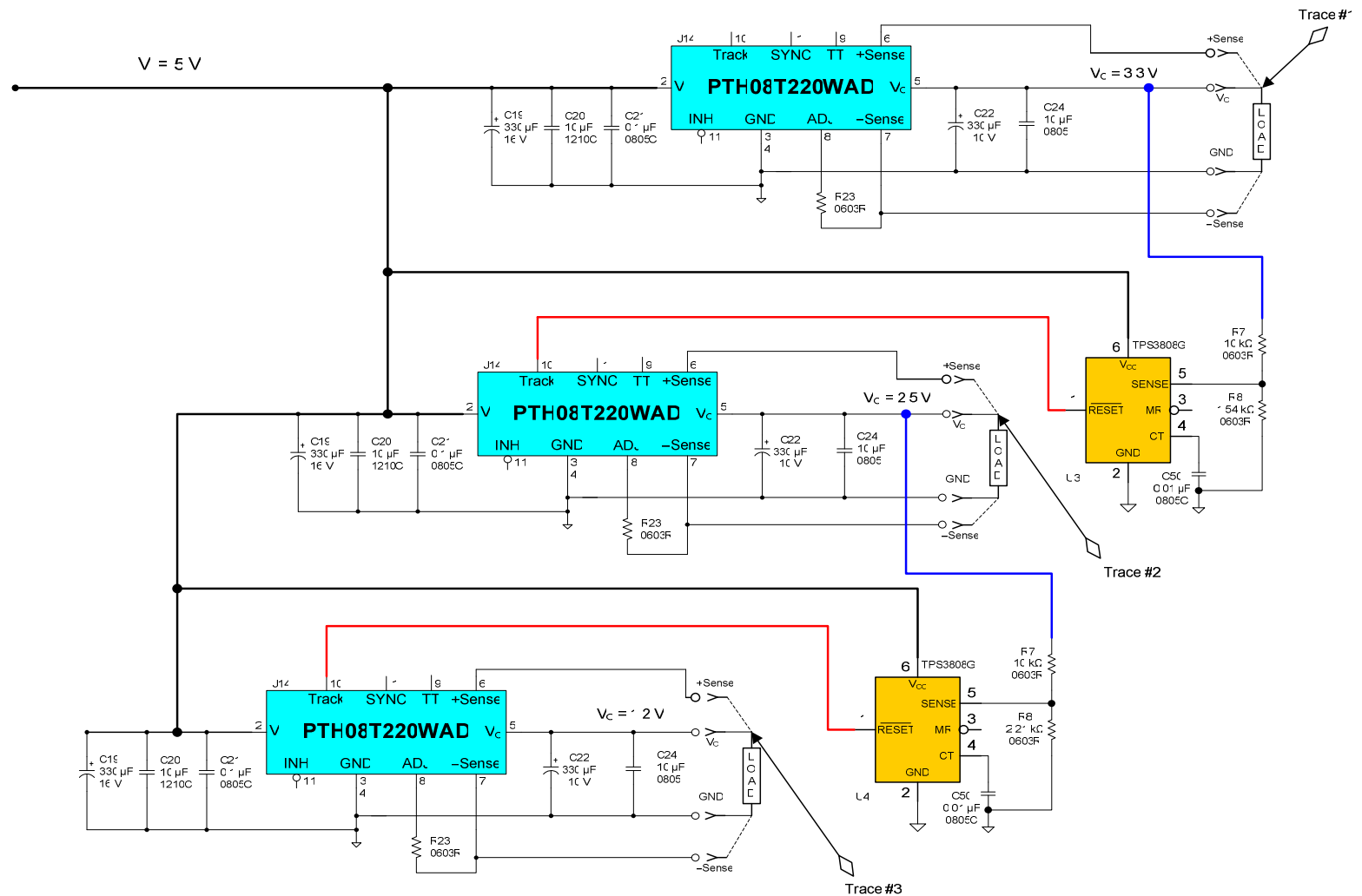


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Sequential Sequencing using AutoTrack™



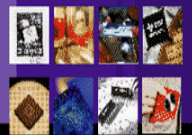
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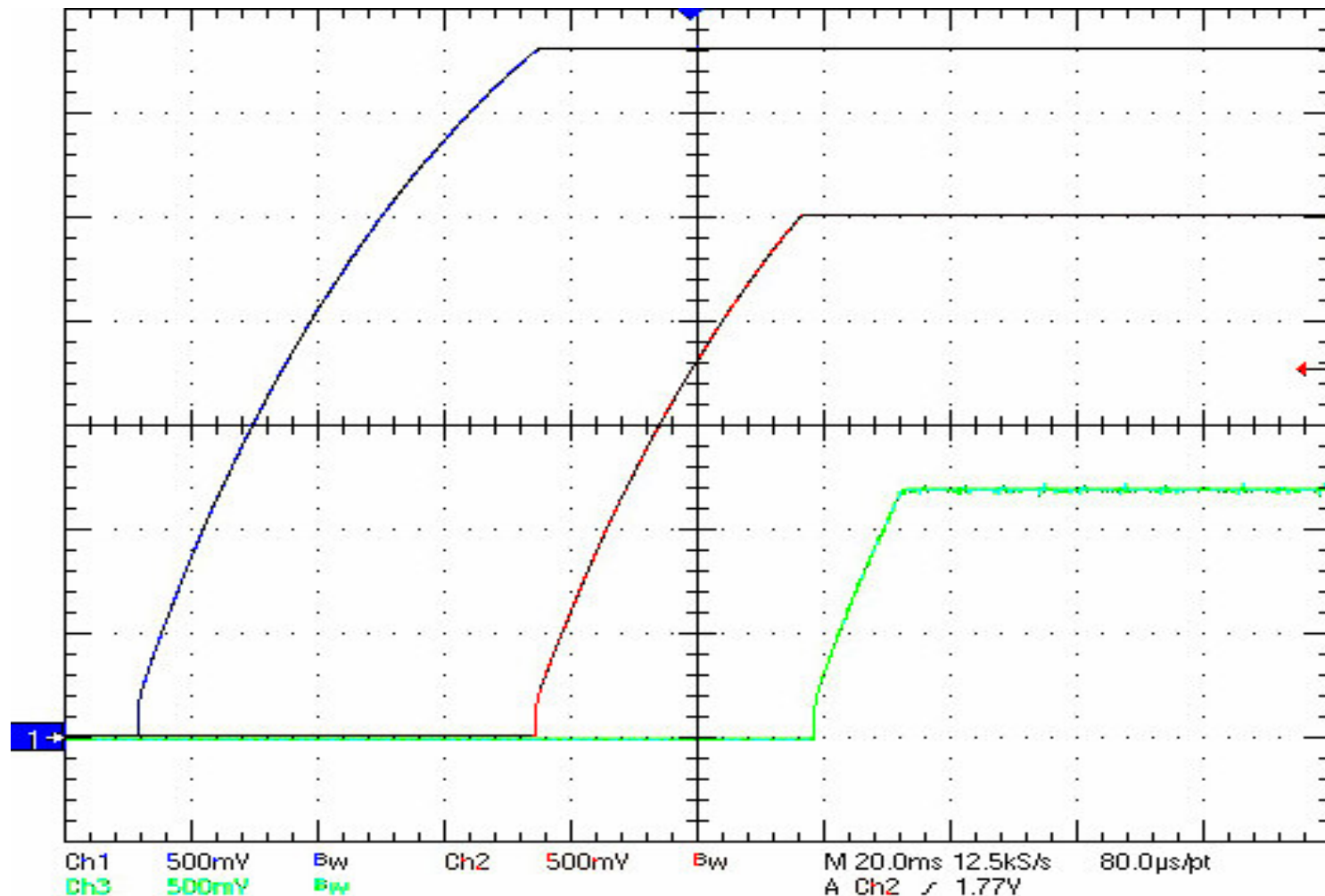
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Problems Observed in Industrial

- ☐ Compensating for loosely regulated bus voltages
- ☐ Minimizing noise



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The Problem.... Loosely regulated input bus voltages

- ❑ Industrial systems typically have unstable bus voltages due to long buses and variations in loading
- ❑ Creates a difficult power design challenge
 - Power supplies have to perform under many different operating conditions



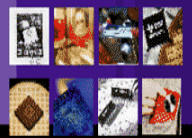
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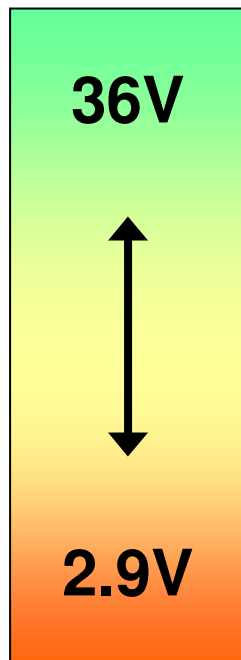
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PTN modules allow a wide input voltage range

Input Voltage Range



PTN78xxxH
12V to 22V
Buck

PTN78xxxW
2.5V to 12.6V
Buck

PTN78xxxA
PTN04050A
-3.0V to -15V
Inverter

PTN04050C
5V to 15V
Boost

Pb-Free & RoHS Compatible

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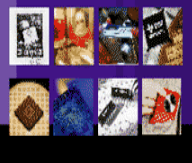
The Problem.... Minimizing noise

- ❑ Industrial systems typically have a lot of noise on the bus
- ❑ Isolating the power supply for analog circuitry is a good method for minimizing noise
 - Discrete isolated designs are difficult
 - Discrete transformers require a lot of board space



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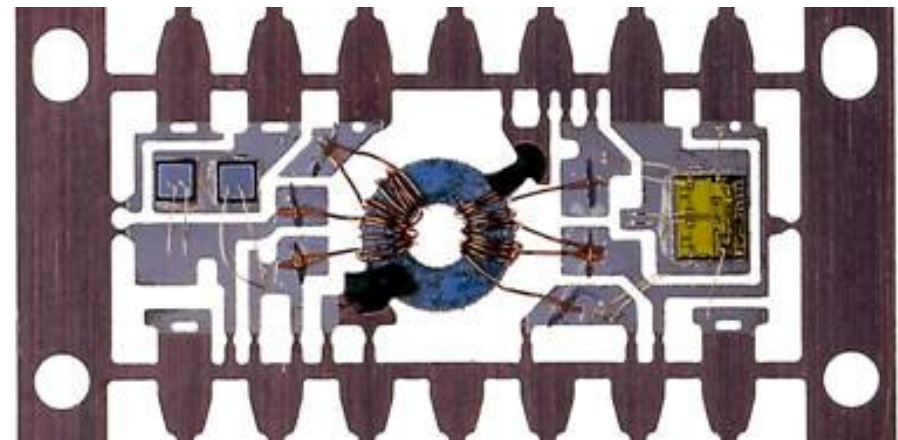
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TI's DCx modules provide isolation in a small package

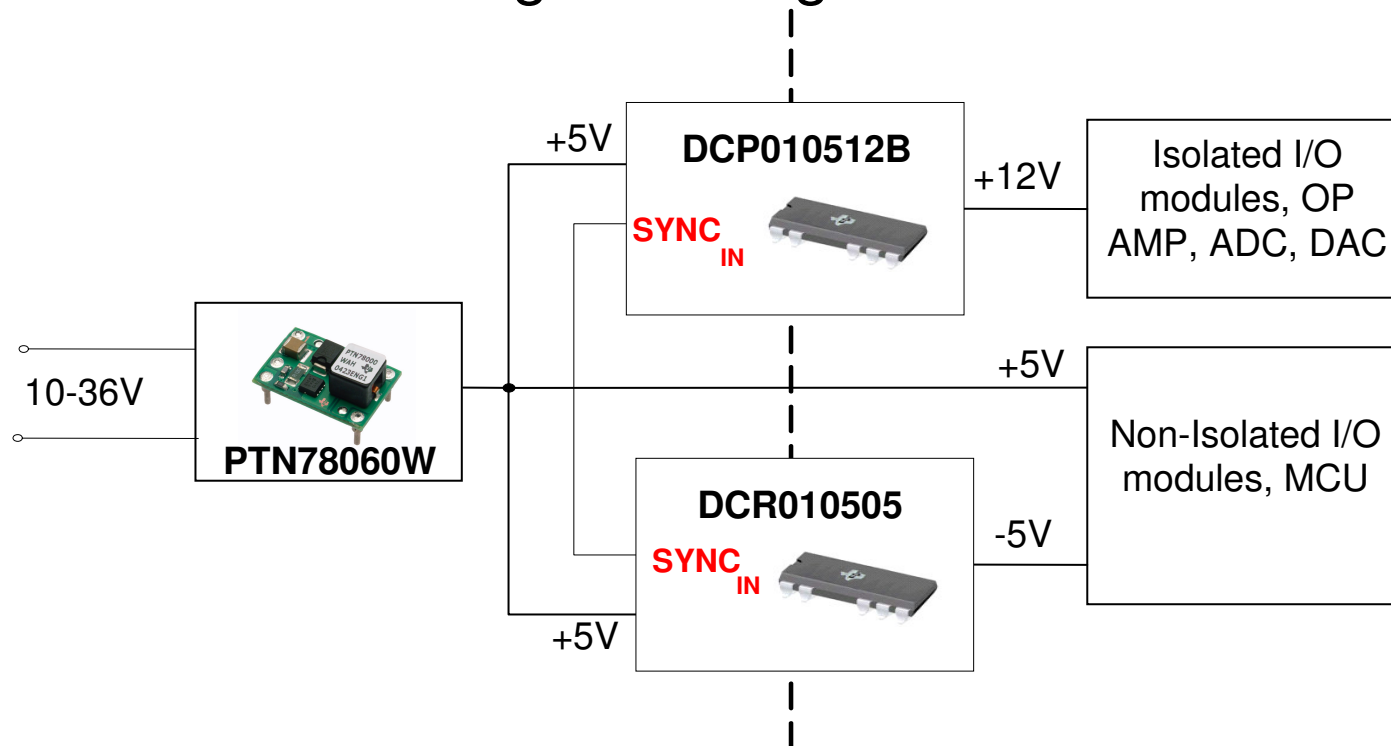
- ❑ TI's 1W and 2W miniature isolated modules provide isolated power for sensitive analog circuitry
 - Designers can now isolate noise and eliminate ground loops without consuming a lot of board space



IC Lead-Frame

Synchronization also helps to minimize noise

- ❑ TI's DCx modules have a synchronization feature that make filtering switching noise much easier

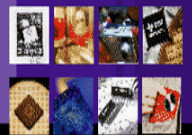




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Problems Observed in Consumer Segments

- ☐ Available board area for power
- ☐ Accurately measuring the remaining charge of a battery



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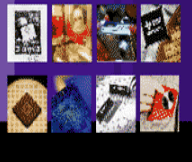
The Problem.... Board space constraints

- ☐ Portable systems are getting smaller and smaller
- ☐ Requires a higher level of integration, smaller package size, and fewer external components



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TI's Drive towards Higher Integration



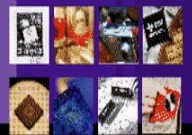
- ❑ Power Control for 10 Voltages
 - 3 DC/DC, 7 LDO's
- ❑ Integrated USB/AC battery charger with Dynamic Power Path management
- ❑ White LED + RGB driver
- ❑ 10-bit, 60uS ADC optimized for battery management



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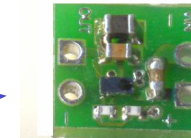
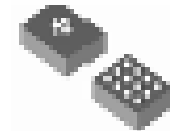
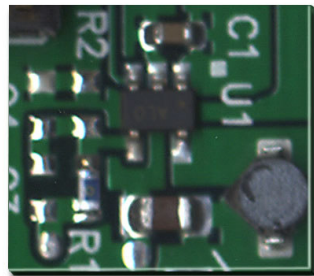
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TI's Drive to a Smaller Overall Solution Size

70% Smaller
Than Previous TI DC/DC Solution



TPS6222x

- 3 x 3 ThinSOT-23
- 1.5 MHz
- 400mA

TPS6230x

5 mm x 5 mm
Total Solution Size

- 2 x 1 Lead-free, 8-pin CSP
- 3-MHz, 1-uH inductor
- 4.7-uF output capacitor
- < 1 mm tall!
- 500mA



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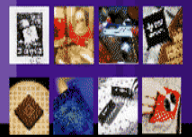
The Problem.... Accurately measuring battery charge

- ❑ Accurately measuring battery charge over the life of the battery and displaying state of charge
- ❑ Requires significant work during development and at production
 - Extensive characterization of each battery model and board-level calibration
 - Capacity learning, typically involving a fully charge/discharge cycle



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Impedance Track™ simplifies battery design

Impedance Track™



- ❑ Exploits the 'Real' potential energy of a battery and 'learns' battery degradation
 - Over 99% accuracy over the life of a battery
- ❑ Provides 'Instant State of Charge'
- ❑ Dynamic modeling algorithm makes designing with batteries easier and faster



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Summary

- ❑ TI's online search allows you to quickly find appropriate power products for your application
- ❑ TI's free design software minimizes risk and simplifies discrete power design
- ❑ Design services help you architect a complete power solution
- ❑ Innovations in our products specifically address application issues in telecom/datacom, industrial and consumer segments



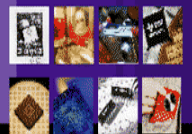
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Thank You

Questions?

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