



۲

#### Ddule Smart Powe or Refric

TM

Power Player - page 10 Automotive Electronies: Part II **Hestromagnetic** Actuator

# Powerful designs. Innovative power solutions.



Non-Isolated DC/DC Power Supply



Viewpoint         Summer Takes Place at the Beach Now         Industry News         Ansoft Seminars         Traction Refurbishment         Fairchild and Changhong         Electric Scooters from Automotive         Renesas joins AUTOSAR         Zetex Achieves Automotive Standard         Tektronix Oscilloscopes for Education         Cover Story         Smart Power Module         Difference         Difference         Tracts in Distributed Power Management         Branchogy ReviewIGBT's and Modules are Good for Vehicle         MarketwatchPower-Management Semiconductor Market Fore         Automotive Electronagnetic Actuator         Marketwatch-Power-Management Semiconductor Market Fore         Automotive Instrument Panels         Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Stores         Discores         Marketware         Pricarding         Marketware         Design Options for Automotive Instrument Panels         New Products         Diversions         Marketware      <	POWErs		
Summer Takes Place at the Beach Now         Industry News         Ansoft Seminars         Traction Refurbishment         Fairchild and Changhong         Electric Scooters from Automotive         Renesas joins AUTOSAR         Zetex Achieves Automotive Standard         Tektronix Oscilloscopes for Education         Cover Story         Smart Power Module         Division Distributed Power Management         Features         Marketwatch         Pachnology Review         IGBT's and Modules are Good for Vehicles         Magnetics         Robust Control of an Electromagnetic Actuator         Marketwatch         Power-Management Semiconductor Market Fores         Automotive Electronics: Part         Tranch MOSFETs Feature Rugged, Efficient switching         Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Part Roll Resense         Marketware         Marketware         Design Options for Automotive Market Fores         Design Options for Automotive Market Soft         Design Options for Automotive Market Soft	Viewpoint		
Industry News         Ansoft Seminars         Traction Refurbishment         Faction Refurbishment         Faction Refurbishment         Faction Refurbishment         Faction Refurbishment         Faction Refurbishment         Faction Refurbishment         Factoric Scooters from Automotive         Renesas joins AUTOSAR         Zetx Achieves Automotive Standard         Tektronix Oscilloscopes for Education <b>Double Double Dible Double Dible Double</b> Tends in Distributed Power Management         Fende in Distributed Power Management Semiconductor Market Fore <b>Attomotive Electronagnetic Actuator</b> Marketwatch – Power-Management Semiconductor Market Fore <b>Attomotive Electronagnetic Actuator</b> Trench MOSFETs Feature Rugged, Efficient switching         Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products <b>Design Options for Automotive Motor Control</b> Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products <b>Design Options for Automotive M</b>	Summer Takes Place	at the Beach Now	
Ansoft Seminars	Industry N	ews	
Traction Refurbishment         Fairchild and Changhong         Electric Scooters from Automotive         Renesas joins AUTOSAR         Zetex Achieves Automotive Standard         Tektronix Oscilloscopes for Education         Cover Story         Smart Power Module         Distributed Power Management         Fendus in Distributed Power Management         Marketwatch         Power-Modules         Marketwatch         Power-Management Semiconductor Market Fore         Automotive Electromagnetic Actuator         Marketwatch         Posingin Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Power Supparation         Lighting up Automotive Instrument Panels         New Products         Parational Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Parational Safety         Design Options for Automotive Motor Control         Marketware         New Products         Mand Alderman         Dr. Uwe Knorr         Dr. Uwe Kno	Ansoft Seminars		
Fairchild and Changhong       Electric Scooters from Automotive         Renesas joins AUTOSAR       Zetex Achieves Automotive Standard         Zetex Achieves Automotive Standard       Tektronix Oscilloscopes for Education         Cover Story       Smart Power Module         Juine Deuter Deuter       Juine Deuter         Juine Deuter Deuter Management       Enconology Review—IGBT's and Modules are Good for Vehicle         Magnetics—Robust Control of an Electromagnetic Actuator       Marketwatch—Power-Management Semiconductor Market Fore         Automotive Electronics: Part       Trench MOSFETs Feature Rugged, Efficient switching       Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control       Off-Board Navigation       Lighting up Automotive Instrument Panels         New Products       Imagement Semiconductor Semicores       Safety Semicores         New Products       Bab Switzerland       Alegro MicroSyse Analog Devices	Traction Refurbishmer	ıt	
Electric Scooters from Automotive         Renessas joins AUTOSAR         Zetex Achieves Automotive Standard         Tektronix Oscilloscopes for Education         Cover Story         Smart Power Module         Difficient Counce         Difficient Curve         Tends in Distributed Power Management         Features         Technology Review—IGBT's and Modules are Good for Vehicle         Magnetics—Robust Control of an Electromagnetic Actuator         Marketwatch—Power-Management Semiconductor Market Fore         Actomotive Electronics: Part         Trench MOSFETs Feature Rugged, Efficient switching         Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Market         Market         Market         Main Alderman         Dr. Uwe Knorr         Dradid Alderman         Dr. Uwe Knorr         Dradid Hendrix         Allego Nicrosyse         Anald Hendrix         Corcent Terch	Fairchild and Changho	ong	
Renesas joins AUTOSAR         Zetex Achieves Automotive Standard         Tektronix Oscilloscopes for Education         COVER Story         Smart Power Module         Difficience         Difficience         Trends in Distributed Power Management         Features         Technology Review         ICB         Automotive Electromagnetic Actuator         Marketwatch         Power Module         Trench MOSFETS Feature Rugged, Efficient switching         Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Eric Carroll         Bob Christy         Mangemein         Diffection	Electric Scooters from	Automotive	
Zetex Achieves Automotive Standard         Tektronix Oscilloscopes for Education         COVER Story         Smart Power Module         Distributed Power Management         Features         Technology Review—IGBT's and Modules are Good for Vehicle         Magnetics—Robust Control of an Electromagnetic Actuator         Marketwatch—Power-Management Semiconductor Market Fore         Automotive Electronics: Part         Trench MOSFETs Feature Rugged, Efficient switching         Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Eric Carroll         Bob Christy         Paul Low         Prover Systemana         Allegro MicroSystemana         Anagenesis         And Alderman         Dr. Uwe Knorr         Tod Hendrix         Artesyn Technolog         Allegro MicroSystemana         Anagenesis	Renesas joins AUTOS	AR	
Tektronix Oscilloscopes for Education         COVER Story         Smart Power Module         Distributed Power Management         Fends in Distributed Power Management         Features         Technology Review—IGBT's and Modules are Good for Vehicle         Magnetics—Robust Control of an Electromagnetic Actuator         Marketwatch—Power-Management Semiconductor Market Fore         Automotive Electronics: Part         Trench MOSFETs Feature Rugged, Efficient switching         Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Eric Carroll         Bo Chrisp         Paul Löser         Analo Devices         Analo Steries         Cover Stores	Zetex Achieves Autom	otive Standard	
Cover Story   Smart Power Module   Discretion   Discretion<	Tektronix Oscilloscope	s for Education	
Smart Power Module   Distributed Power Management   Features   Technology Review—IGBT's and Modules are Good for Vehicle   Magnetics—Robust Control of an Electromagnetic Actuator   Marketwatch—Power-Management Semiconductor Market Fore   Automotive Electronics: Part   Trench MOSFETs Feature Rugged, Efficient switching   Increasing Passenger Car Comfort and Safety   Design Options for Automotive Motor Control   Off-Board Navigation   Lighting up Automotive Instrument Panels   New Products     Power System Ensign Passenger Car Comfort and Safety   Design Options for Automotive Motor Control   Off-Board Navigation   Lighting up Automotive Instrument Panels   New Products     Power System Ensign Passenger Car Comfort and Safety   Design Options for Automotive Motor Control   Off-Board Navigation   Lighting up Automotive Instrument Panels   New Products     Power System Ensign Passenger Car Confort   Market Products	Cover Stor	у	
Trends in Distributed Power Management         Features         Technology Review—IGBT's and Modules are Good for Vehicle         Magnetics—Robust Control of an Electromagnetic Actuator         Marketwatch—Power-Management Semiconductor Market Fore         Automotive Electronics: Part         Trench MOSFETs Feature Rugged, Efficient switching         Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Exercise         Exercise      <	Smart Power Module		
Trends in Distributed Power Management         Features         Technology Review—IGBT's and Modules are Good for Vehicle         Magnetics—Robust Control of an Electromagnetic Actuator         Marketwatch—Power-Management Semiconductor Market Fore         Automotive Electronics: Part         Trench MOSFETs Feature Rugged, Efficient switching         Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Imagement Semiconductor Market Pore         Imagement Semiconductor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Imagement Semiconductor         Imagement Semiconducto	2ก็พี่ส่ง 21กพล		
Features   Technology Review   IGBT's and Modules are Good for Vehicle   Magnetics   Robust Control of an Electromagnetic Actuator   Marketwatch   Power-Management Semiconductor Market Fore   Automotive Electronics: Part   Trench MOSFETs Feature Rugged, Efficient switching   Increasing Passenger Car Comfort and Safety   Design Options for Automotive Motor Control   Off-Board Navigation   Lighting up Automotive Instrument Panels   New Products   Encreasing   Marketwatch   Power Suscence   Design Options for Automotive Instrument Panels   New Products     Barner   Rice Carroll   Bo Christy   Panda Idlerman   Christy   Panda Idlerman   Christy   Manda Idlerman   Christy   Panda Idlerman   Christy   Panda Idlerman   Christy   Panda Idlerman   Christy   Panel Rice Rice   Panel Rice   Panel Rice	Trends in Distributed F	ower Management	Prote
Technology Review—IGBT's and Modules are Good for Vehicle   Magnetics—Robust Control of an Electromagnetic Actuator   Marketwatch—Power-Management Semiconductor Market Fore   Automotive Electronics: Part   Trench MOSFETs Feature Rugged, Efficient switching   Increasing Passenger Car Comfort and Safety   Design Options for Automotive Motor Control   Off-Board Navigation   Lighting up Automotive Instrument Panels   New Products     Power System Enstrument Panels   New Products   Eric Carroll   Bob Christy   Paul Löser   Analog Devices	Features		
Magnetics       Robust Control of an Electromagnetic Actuator         Marketwatch       Power-Management Semiconductor Market Fore         Automotive Electronics: Part         Trench MOSFETs Feature Rugged, Efficient switching         Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Power Systems Design Euro         Member         Representing         Bob Christy         Paul Löser         Analog Devices         Analog Devices         Analog Devices         Analog Devices         Analog Devices	Tachnology Poview	ICPT's and Madulas ar	Cood for Vahiala
Magnetics—Kobdst Control of an Electronicg Park         Marketwatch—Power-Management Semiconductor Market Fore         Automotive Electronics: Part         Trench MOSFETs Feature Rugged, Efficient switching         Increasing Passenger Car Comfort and Safety         Design Options for Automotive Motor Control         Off-Board Navigation         Lighting up Automotive Instrument Panels         New Products         Imagnetics         Design Options for Automotive Instrument Panels         New Products         Imagnetics	Magnetics Robust (	-IGBT s and Modules and	e Good for vehicle
Automotive Electronics: Part   Trench MOSFETs Feature Rugged, Efficient switching   Increasing Passenger Car Comfort and Safety   Design Options for Automotive Motor Control   Off-Board Navigation   Lighting up Automotive Instrument Panels   New Products     Power System Design Europe   Member   Eric Carroll   Bob Christy   Paul Löser   Anagenesis   Ansott   Allegro MicroSystem   Anagenesis   Ansott   Attesprotectore	Marketwatch—Power	-Management Semicond	luctor Market Fore
Trench MOSFETs Feature Rugged, Efficient switching   Increasing Passenger Car Comfort and Safety   Design Options for Automotive Motor Control   Off-Board Navigation   Lighting up Automotive Instrument Panels   New Products     Power Systems Design Euro   Member   Representing   Bob Christy   Paul Löser   Anold Alderman   Dr. Uwe Knorr   Todd Hendrix   Heinz Rüedi   Artesyn Technolog   CT-Concent Tech	Automotive	e Electronic	s: Part
Increasing Passenger Car Comfort and Safety	Trench MOSFETs Fea	ture Rugged, Efficient sv	vitching
Design Options for Automotive Motor Control       Off-Board Navigation         Lighting up Automotive Instrument Panels       New Products         New Products       Image: Control Con	Increasing Passenger	Car Comfort and Safety	
Off-Board Navigation       Lighting up Automotive Instrument Panels         New Products       Image: Comparison of the structure of th	Design Options for Aut	comotive Motor Control .	
Lighting up Automotive Instrument Panels         New Products         Power Systems Design Euro         Member       Representing         Eric Carroll       ABB Switzerland         Bob Christy       Allegro MicroSys         Paul Löser       Analog Devices         Analog Devices       Analog Devices         Analog Devices       Analog Devices         Analog Devices       Analog Devices         Analog Devices       Analog Devices         Ansoft       Artesyn Technolog         Heinz Rüedi       CT-Concent Technolog	Off-Board Navigation		<mark>.</mark>
New Products         Power Systems Design Euro         Member       Representing         Eric Carroll       Bob Christy         Paul Löser       Analog Devices         Anold Alderman       Analog Devices         Dr. Uwe Knorr       Todd Hendrix         Todd Hendrix       Artesyn Technolog         Heinz Rüedi       CT-Concent Technolog	Lighting up Automotive	Instrument Panels	
Power Systems Design Euro         Member         Fric Carroll       ABB Switzerland         Bob Christy       Allegro MicroSys         Paul Löser       Analog Devices         Arnold Alderman       Anagenesis         Dr. Uwe Knorr       Ansoft         Todd Hendrix       Artesyn Technolog         Heinz Rüedi       CT-Concent Tech	New Produ	icts	
Power Systems Design Euro         Member       Representing         Eric Carroll       Bob Christy       ABB Switzerland         Bob Christy       Paul Löser       Analog Devices         Analog Devices       Analog Devices       Analog Devices         Todd Hendrix       Artesyn Technolog       Artesyn Technolog         Heinz Rüedi       CT-Concent Technolog       CT-Concent Technolog			
Nember       Representing         Eric Carroll       ABB Switzerland         Bob Christy       Allegro MicroSys         Paul Löser       Analog Devices         Analog Devices       Anagenesis         Dr. Uwe Knorr       Ansoft         Todd Hendrix       Artesyn Technolog         Heinz Rüedi       CT-Concent Technolog			Common State
Keynologie       Newer Systems Design Euro         Member       Representing         Eric Carroll       ABB Switzerland         Bob Christy       Aallegro MicroSyst         Paul Löser       Analog Devices         Arnold Alderman       Anagenesis         Dr. Uwe Knorr       Ansoft         Todd Hendrix       Artesyn Technolog         Heinz Rüedi       CT-Concent Technolog			20
Member       Representing         Eric Carroll       ABB Switzerland         Bob Christy       Allegro MicroSys         Paul Löser       Analog Devices         Arnold Alderman       Anagenesis         Dr. Uwe Knorr       Ansoft         Todd Hendrix       Artesyn Technolog         Heinz Rüedi       CT-Concept Technolog			15
Nember     Representing       Eric Carroll     ABB Switzerland       Bob Christy     Allegro MicroSyst       Paul Löser     Analog Devices       Arnold Alderman     Anagenesis       Dr. Uwe Knorr     Ansoft       Todd Hendrix     Artesyn Technolo       Heinz Rüedi     CT-Concept Tech		Devues Sucto	
Fric Carroll         ABB Switzerland           Bob Christy         Allegro MicroSys           Paul Löser         Analog Devices           Arnold Alderman         Anagenesis           Dr. Uwe Knorr         Ansoft           Todd Hendrix         Artesyn Technolo           Heinz Rüedi         CT-Concept Tech		Power Syste	Boprosonting
Bob Christy Allegro MicroSys Paul Löser Analog Devices Arnold Alderman Anagenesis Dr. Uwe Knorr Ansoft Todd Hendrix Artesyn Technolo Heinz Rüedi CT-Concept Tech		Eric Carroll	ABB Switzerland
Arnold Alderman Dr. Uwe Knorr Todd Hendrix Heinz Rüedi Artalog Devices Anagenesis Arnold Alderman Anagenesis CT-Concept Tech	. 2501.	Bob Christy	Allegro MicroSys
Dr. Uwe Knorr Ansoft Todd Hendrix Artesyn Technolo Heinz Rüedi CT-Concept Tech	200	Arnold Alderman	Anagenesis
Heinz Rüedi CT-Concept Tech		Dr. Uwe Knorr Todd Hendrix	Ansoft Artesyn Technolo
Dr. Reinhold Bayarar ounoo	18 504	Heinz Rüedi Dr. Reinhold Boyoror	CT-Concept Tech
Chris Rexer Fairchild Semicol		Chris Rexer	Fairchild Semico

Double Factoria

#### The Power Franchise Innovations for your power supply designs.

Fairchild Power Switch (200V, 650V and 800V) PWM plus high voltage MOSEET plus protection - 0.3A - 11.5A peak current capability

#### **Optically Isolated Error Amplifier**

TL431 type reference and optocoupler in one package -2500V - 5000V RMS tolation; 0.5% - 2.0% reference

#### PowerTrench\* 20V - 200V MOSFETs

Optimized for high hequency switching flow Potient and Q<sub>2</sub>) SyncfET' products for high efficiency output rectification Flip Leaded Molded Packages (FUMP) and BGA packages

#### QFET', SuperFET' 60V - 1000V MOSFETs

- Optimized for high frequency and robustness - Fast body diode MOSFETs available

For more information on Fairchild's power supply solutions, visit our website. CONTENTS

2	
4	
	al
4	
4	
6	
	TAIRO
	A A A A A A A A A A A A A A A A A A A
ast22	ENTER PRESE
	SRM for Ref
· · · · · · · 41	
· · · · · · 41 · · · · · · 44 · · · · · · 47	

#### pe Steering Committee Members

#### Member

tems

gies nology

nductor Infineon Technologies

Eric Lidow David Bell Rüdiger Bürkel Paul Greenland Kirk Schwiebert Christophe Basso Dr. Thomas Stockmeier Dr. Martin Schlecht Uwe Mengelkamp Peter Sontheimer

#### Representing

International Rectifier Linear Technology LEM Components National Semiconductor Ohmite On Semiconductor Semikron SynQor **Texas Instruments** Tyco Electronics

## PIII/2 PSystems Design

#### AGS Media Group

Katzbek 17a D-24235 Laboe, Germany Phone: +49 4343 421790 Fax: +49 4343 421789 info@powersystemsdesign.com www.powersystemsdesign.com

#### Editor-in-Chief

Bodo Arlt, Dipl,-Ing Bodo.Arlt@powersystemsdesign.com

#### Publisher

Jim Graham Jim.Graham@powersystemsdesign.com

#### Associate Publisher

Julia Stocks Julia.Stocks@powersystemsdesign.com

#### **Creative Direction & Production**

Evemotive beata@evemotive.com www.eyemotive.com

#### Circulation Management

circulation@powersystemsdesign.com

Advertising Rates, Sizes and Digital File Requirements available at: www.powersystemsdesign.com

Subscription Request available at: www.powersystemsdesign.com/psd/ subsloan.htm

Registration of copyright: January 2004 ISSN number: 1613-6365 Issue print run: 20.000 Printing by: Central - Druck Trost GmbH & Co. Heusenstamm, Germany

AGS Media Group and Power Systems Design Europe magazine assume and hereby disclaim any liability to any person for any loss or damage by errors or omissions in the material contained herein regardless of whether such errors result from negligence, accident or any other cause whatsoever.

Send address changes to: circulation@powersystemsdesign.com Volume 1. Issue

## **Summer Takes Place** at the Beach Now



Europeans received a late good stable weather condition that pushes everybody to the beach.

I am watching the young children building their sandcastles while the tide runs all around them, perhaps some of the kids will be the next generation of engineers. Having wireless LAN may let me work with my laptop direct on the beach. The weather today with wind and water surrounded by nice sunshine in the northern region is like heaven. I am overlooking the Kiel fjord and the beach is only a few steps away with the continuous changing nature of the Baltic waterfront. Europeans have much more interesting views at the beach than our friends in the US. The freedom of "less", "top" or "bottom" or both.

I remember a gentleman I had worked with on a module program who was the packaging director of a US company made a lasting nose impression on the glass at my favorite fish restaurant amazed at the beach scenery. This kind of freedom is only known in Europe.

In this issue, we continue with Part II of our series on Automotive electronics. Part I which appeared in the July/August issue proved to be Power Systems Design Europe's strongest issue editorially and in ad pages since we started the magazine in January, our thanks to the industry for such strong support and confidence in our efforts.

Electronics gives the life and functionality to modern cars. Economic aspects are seen in the spot of rising energy cost. Mainly the fuel price is going up and the mileage is critical. We Europeans say liter per kilometer if we are not on the tunneled island called United Kingdom.

Modern electronics using power switches makes drive by wire possible. That means steering can be put anywhere in the car. Left or right side for the driver and his steering wheel or even on the back seats if it makes sense.

That amount of freedom in electronics allows us the freedom in our designs. Hybrid solutions including fuel cell designs in automotive will be pushed by the legislative. The upcoming restrictions will force us to innovation that helps us to continue with individual transportation. Mass transportation will be good for long distance and in big cities. For all the rest we need freedom and our own automobile

Automotive electronics serves a wide field in modern vehicles. Electronics allows the innovation to more efficient cars for the future. Whether we talk about combustion, electric or hybrid cars. The electronic components makes it happen, that our designs become reality.

Fall is coming along with "Electronica", Power Systems Design Europe's October issue will be distributed to that all important show in Munich. I have been invited to serve as moderator at the podium discussions on power electronics. As engineers we continue to learn all our life. It is a never ending process in our profession that differentiates us from other jobs and professions.

Stop by and see me on the show floor!

Best regards

Bodo Arlt Bodo.Arlt@powersystemsdesign.com

# An easier way to measure currents up to 400A?

Yes, the HAIS series is available just the way vou want it:

- 1. With ref-out mode, access to the zero point, and internal reference voltage:
- 2. Or with the possibility of external reference voltage for the zero current output level:
- 3. Or with integral bus bars for the 50 and 100A models.

#### Put the advantages of the HAIS series to your advantage:

- Current ratings from 50A to 400A for PCB mounting
- Bipolar AC, DC or complex current measurements
- Single 5V power supply
- Open-loop transducer with ASIC technology
- Low power consumption
- Operating temperature range : -40°C to +85°C

LEM NORMA (Austria) Tel. 02236/69152; e-mail: la@lem.com, LEM Belgium (BeNeLux) Tel. 067/550114; e-mail: lbe@lem.com, LEM France Tel. 01/69181750, e-mail: Ifr@lem.com, LEM Deutschland Tel. 06152/9301-0, e-mail: postoffice.ide@lem.com, LEM Italia Tel. 049/8066060, e-mail: Ifr@lem.com, TVLEM (Russia) Tel. 0622/444053, e-mail: Mem@hptmts.tvcom.ru, LEM (Susse) Tel. 022/7061111, e-mail: Isa@lem.com, LEM Components (UK) Tel. 01695/720777, e-mail: luk@lem.com, Beijing LEM Tel. 010/69490470, e-mail: hzh@lem.com, NanaLEM Tel. 042/725-B151, e-mail: nie@lem.com, LEM USA Tel. 800/2365366, e-mail: lus@lem.com www.lem.com



## **Ansoft Seminars**

The GSEM '04: 2004 Global Seminars -Electromechanical Series offers a realistic report on the state of the art in electromechanical design and simulation and presents solutions that address the future demands of electrical, transportation and power electronics and drives industries. Attendees will learn how industry experts use simulation to more efficiently design today's advanced electromechanical features, such as electric-assist

power steering, electric pumps, fans, electromechanical actuators and power-processing elements. For details, go to: www.ansoft.com/gsem04.

Ansoft is a leading developer of high-performance electronic design automation (EDA) software. Engineers use Ansoft software to design state-of-the-art products, such as electromechanical components and systems, hybrid-electric vehicles, drive-by-wire systems, power electronics, wireless products, integrated circuits (ICs) and printed circuit boards (PCBs). Interested parties may submit a 100-word abstract for presentation by emailing gsem04@ansoft.com

Asia and Europe during October and November2004. Please visit: www.ansoft.com/gsem04 for details.

directly to the existing controls and cooling

system with the minimum of modifications

The system operates directly from the 3kVDC

catenery and will facilitate an increase of load

Contact us at wsl.sales@westcode.com or

power from 750kW to 1MW. There are cur-

rently 99 of the Siemens BBC built locos in

by telephone: +44 (0)1249 444525

service requiring this upgrade.

www.ansoft.com

www.westcode.de

## **Traction Refurbishment**

Westcode Semiconductors an IXYS company is awarded a development contract to upgrade the traction package of the Class 8E locomotives by Spoornet (RSA railways). The proposed design uses Westcode's state of the art press-pack IGBT technology to replace the fast thyristor based converters.

The contract is for the design, development and realisation of an upgrade package for the DC propulsion chopper system. This includes replacing existing obsolete reverse conducting thyristor technology with



Westcode's state of the art press-pack IGBT's, gate drivers and associated power electronics. The upgrade package will retrofit into the existing power cubicle and interface

**Fairchild and Changhong** 

Fairchild announced the opening of a joint product development laboratory with Sichuan Changhong Electric Co., Ltd.—one of the largest manufacturers of consumer devices in China. The lab enables the companies to collaborate on product development using Fairchild's leading edge power components. Fairchild's power devices are designed into a broad range of Changhong products including color TVs, LCD TVs, PDP TVs, rear projection TVs, DVDs, set-top boxes and air conditioners. Fairchild and Changhong have established a close relationship over several years. This announcement is an extension of that cooperation. Changhong is known for technical innovation, quality products and significant production capabilities. Fairchild products designed into Changhong consumer devices include Green Mode Fairchild power switches, advanced power MOSFETs, interface switches, diodes, logic devices and rectifiers.

Fairchild's components manage, distribute, convert and minimize power in a broad range of end markets including computing and display, industrial, consumer, communications

and automotive segments. New power products are gaining strong acceptance with customers, including Smart Power Modules for electric motors, air conditioners and inductive heating; Green Mode power switches for battery chargers, televisions, display and PCs; MOSFETs for notebooks, displays and plasma panels; IGBTs for ignition control and induction heating; and power supply controllers for microprocessors.

www.fairchildsemi.de

## **Electric Scooters from Vectrix**

The Parker Automation servo motor-based prototypes are now being road tested in European cities.

Leveraging the efficiency of real-time, highperformance control, Vectrix Corporation has selected the TMS320LF2401A digital signal controller from Texas Instruments for its revolutionary electric motor scooters. By pairing TI's leading digital signal processing (DSP)based motor control technology with a high performance, custom designed brushless servo motor from Parker SBC, part of the

Parker Automation division, the new lightweight Vectrix scooter delivers a level of performance and acceleration typically only found in a 250-cc gasoline-powered motorcycle. Vectrix's scooter achieves this gas-like performance without the polluting emissions typically found in two stroke gas engines. (For more information on the LF2401A digital signal controller, please visit www.ti.com/vectrixpr)

The LF2401A controller is ideal for applications that require the high-performance of TI's leading DSP technology along with the

peripheral integration and ease-of-use typically found in a microcontroller (MCU). TI's DSP-based controller helps Vectrix's scooter motor operate more efficiently and at a higher level of performance than traditional MCUs or analog designs. This increased functionality and efficiency gives Vectrix a valuable edge in developing lightweight, inexpensive solutions for electrically powered transportation that rival gas-powered options and are environmentally friendly.

www.ti.com



#### Power for Your FPGA and DDR Memory Designs

Intersit's switching regulators (PWMs) maintain efficiencies in excess of 90% in your FPGA and DDR memory designs. even when the input and output voltages differ by a large amount and the current requirements range from a few milliamps to 100A. Intersil's regulators are available in several configurations including singlephase, multi-phase, integrated FETs up to 8A and up to 100A with external FETs. www.intersil.com/data/AG

#### World's Only 5-in-1 DDR Chip Set Regulators

The ISL6537ACR and ISL6537BCR supply all of the required voltages along a full range of protection features and high integration in small packages. These controllers offer high performance in an ultra-small 6 x 6mm QFN package. www.intersil.com/ISL6537

#### Single-Chip, 80A Capable, Two-Phase **DC-DC Buck Controller**

Intersit's ISL6563 two-phase PWM controller IC integrates MOSFET drivers in a thermally enhanced 4 X 4mm package to deliver a 30 to 80A. power solution

www.intersil.com/ISL6563

#### Small, Pre-set **Output DC-DC** Converter



www.intersil.com/ISL6410

# Do You Need?

Intersil Power Management Solutions

Each technology generation seems to create a new low voltage requirement; 2.5V, 1.8V, 1.5V, 1.2V, 1.2V, 0.9V and on it goes. Intensil offens a broad portfolio of power management ICs to easily generate the voltages you need.





Device	Regulators PWMs	Regulators Linears	Vin	Package/Pin	# of Output Voltages
SL6521	1	3	5V	SOIC-16	
HIP6021	1	3	5V, 12V	SOIC-28	
HIP60198	2	2	5V, 12V	SOIC-28	4
SL6537 (new)	2	2 + Ref	5V, 12V	QFN-28	
SL6532A	1	2	5V, 12V	QFN-28	2
SL6402/A (new)	2	1	4.5V to 24V	TSSOP-28, QFN-28	3
SL6539 (new)	2	0	5V to 15V	SSOP-28	
SL6227 (new)	2	0	4.5V to 24V	SSOP-28	
SL6444	2	Ref	5V to 24V	SSOP-28	2
SL6530/1	2	Ref	5V	SOIC-24, QFN-32	1.1
SL6528	1	1	3.3V, 5V	SOIC-8	
SL6529	1	1	3.3V to 5V, 12V	SOIC-14, QFN-16	

#### Learn more about this family and get free samples at www.intersil.com/PSDE

Get more technical info on intensi's complete portfolio of High Performance Analog Solutions at www.intersil.com/info intersil Indexed Subject Street, Spinster, Spinster, Angelliers | Converters | Interface | Power Management | Switch/MLIX | Voice Over IP | Military/Space

# How Many Low Voltage Supplies

Multi-output DC-DC Converters from Intersil

#### Over 1 Billion Intersil Power Management ICs Shipped

## **Renesas joins AUTOSAR**

Renesas announced that it has joined AUTOSAR (Automotive Open System Architecture), an industry partnership working to establish standards for software interfaces. and software modules for automobile electronic control systems. Renesas Technology joined as a Premium Member.

In recent years electronic systems have come to be used ever more extensively in automobiles, a trend that is accelerating rap-

idly. Such systems are used for applications including engine control, body control, safety control and information systems. As this process has advanced, the share of the software component in the overall development process for automotive control systems has grown substantially. The need is growing for software standardisation as a means to improve the efficiency of the development process, and thereby enable even more

extensive use of electronic systems in future. Such standardisation would allow previously developed software to be used in new products as well as in microcomputers and microprocessors from different manufacturers.

AUTOSAR was established in July 2003 to promote the standardisation of software for the automobile industry.

www.renesas.com

### Zetex achieves Automotive Standard

Zetex has achieved corporate registration as an ISO/TS16949:2002 certified company, following audits conducted by Underwriters Laboratories Inc. Jointly developed by International Automotive Task Force (IATF) members and the International Standards Organisation (ISO), ISO/TS16949:2002 is recognised as the most comprehensive quality management standard for companies operating in the automotive industry supply chain.

The quality registration strengthens Zetex'

position as a leading supplier of discrete and integrated analog semiconductor devices to automotive system integrators and vehicle manufacturers alike. A broad range of Zetex power management products including IntelliFET smart MOSFETs, current monitors and fan controller ICs are employed in a wide variety of automotive applications.

According to WSTS/Bosch, the global semiconductor demand in the automotive manufacturing sector is expected to rise from \$13.7B in 2003 to \$23.2B in 2008, representing a compound annual growth rate of 11.1%. The research also indicates the growing importance of semiconductors to the sector. As a percentage of the production cost of an average light vehicle, the semiconductor content is forecast to grow from 9.5% in 2004 to over 15% in 2010.

www.zetex.com

## **Tektronix Oscilloscopes for Education**



Tektronix announced that Turkey's first foundation university, Bilkent University, has installed more than 100 Tektronix oscilloscopes into a new laboratory to provide measurement tools for undergraduate student coursework. The Electrical & Electronics Engineering Department of Bilkent University, Ankara, Turkey, attracts a significant portion of the highest performing students in Turkey. The 50-seat modern laboratory was designed to allow students to conduct analogue, digital design, circuit, microprocessor and control experiments. The philosophy employed when

designing and setting up the laboratory was to equip each bench with a computer that controls the oscilloscope and a function/signal generator using leading third-party software. This enables students to learn and employ the concepts of modern experimentation easily and effectively. Internet connections to each bench are also provided, which allows students to prepare and submit lab reports via the network and to use Internet resources while they are in the lab. The framework requires digital storage oscilloscopes that have a computer and printer interface, FFT math and high sampling rate.

www.tektronix.com

#### Power Events

• H2Expo 2004, September 15-17, Hamburg, www.h2exp0.de

• Semi Expo 2004CIS, September 27- 30,

Moscow http://wps2a.semi.org

Automotive EMC 2004, October12, York

Racecourse UK, www.AutoEMC.net

 Power Conversion Design. October12-15. Portsmouth UK, www.ejbloom.com

Ansoft Seminar, October 21, Stuttgart/

Sindelfingen. http://www.ansoft.com/gsem04/

• Electronica 2004, November 9-12, Munich,

• Surface Mount 2004, November 16-18,

Brighton UK www.smartgroup.org

• SPS/IPC/DRIVES 2004, November 23-25,

Nuremberg, www.mesago.de

www.global-electronics.net

• Embedded World 2005, February 22-24

Nuremberg, www.embedded-world.de

**Less Heat = More Battery Life** 



## Switchers Reduce Heat by More Than 10 Times vs an LDO

Linear Technology's family of monolithic synchronous step-down converters provides conversion efficiencies up to 96% in low profile footprints as small as 35mm<sup>2</sup>. Compared to linear regulators, switching converters offer superior power conversion efficiency when generating 1.xV from a single-cell Li-Ion battery. With LDOs, the associated power loss generates heat which equates to a reduction in battery run time. Also, our growing family of buck-boost converters provides the most efficient solution for generating 3.3V from this battery source. Isn't it time you made the switch?

#### VSvnchronous Buck Converter Family

Synchronous	Buck					
Part No.	V <sub>IN</sub> (V)	V <sub>OUT (min)</sub> (V)	I <sub>out</sub> (A)	Frequency	I <sub>Q</sub> (μΑ)	Package
LTC <sup>®</sup> 3405A	2.5 to 5.5	0.8	0.30	1.5MHz	20	ThinSOT™
LTC3404	2.65 to 6.0	0.8	0.60	1.4MHz	10	MSOP-8
LTC3406/B	2.5 to 5.5	0.6	0.60	1.5MHz	20	ThinSOT
LTC3406B-2	2.5 to 5.5	0.6	0.60	2.25MHz	20	ThinSOT
LTC3407	2.5 to 5.5	0.6	0.60 x 2	1.5MHz	40	MSOP-10, DFN
LTC3407-2	2.5 to 5.5	0.6	0.80 x 2	2.25MHz	40	MSOP-10, DFN
LTC3408	2.5 to 5.5	0.3	0.60	1.5MHz	1500	DFN
LTC1877	2.6 to 10.0	0.8	0.60	550kHz	10	MSOP-8
LTC1879	2.6 to 10.0	0.8	1.20	550kHz	15	TSSOP-16
LTC3411	2.6 to 5.5	0.8	1.25	4MHz	60	MSOP-10, DFN
LTC3412	2.65 to 5.5	0.8	2.50	4MHz	62	TSSOP-16E
LTC3414	2.25 to 5.5	0.8	4.00	4MHz	64	TSSOP-20E
Synchronous Buck-Boost						
Part No.	V <sub>IN</sub> (V)	V <sub>OUT</sub> (V)	I <sub>out</sub> (A)	Frequency	I <sub>Q</sub> (μΑ)	Package
LTC3440	2.5 to 5.5	2.5 to 5.5	0.60	2MHz	25	MSOP-10
LTC3441	2.4 to 5.5	2.4 to 5.5	1.20	1MHz	25	DFN
LTC3443	2.4 to 5.5	2.4 to 5.25	1.20	600kHz	28	DFN

Europe Sales Offices: France 33-1-41079555 Italy 39-02 38093656 Germany 49-89-9624550 Sweden 46-8-623-1600 United Kingdom 44-1628-477066 Finland 358-9-88733699 ors: Australia Soanar 61-2-9741-0122 Belgium ACAL 32-0-2-7205983 Finland Tech Data 358-9-88733382 France Arrow Electronique 33-1-49-784978





www.linear.com Tel: 1-408-432-1900



J. LTC. LT and Burst Mode are registered trademarks and ThinSOT. SwitcherCAD and PowerPath are trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

Tekelec Airtronic 33-1-56302425 Germany Insight 49-89-611080 Setron 49-531-80980 Ireland MEMEC 353-61-411842 Israel Avnet Components 972-9-778-0351 Italy Silverstar 39-02-66125-1 Netherlands ACAL 31-0-402502602 Spain Arrow 34-91-304-3040 Turkey Arrow Elektronik 90-216-4645090 (Ext. 238) UK Arrow ctronics 44-1234-791719, Insight Memec 44-1296-330061



# **IGBTs and Modules are good for Vehicles**

Continued improvement in packaging and mounting technology allows for more efficient performance in electric automotive motor drives.

#### Bodo Arlt, Power Systems Design Europe Editor-in-Chief

GBTs are dominating all areas in a voltage range from 200V up to 6500V. The IGBT with it's high current density is the perfect candidate allowing to build a high current switch in a small package at a reasonable price. The IGBT is a MOS gate controlled power switch. Cell structure and manufacturing process are very similar to a MOSFET. The IGBT is the workhorse of modern inverter technology. It is the preferred switch because of short circuit capability, speed and improved saturation voltage.

The drive control using IGBTs technoloav permits sensitive starting, powerful acceleration and finely regulated electric motor braking with energy reclamation. In automotive applications, the demand on the cars' electrical power generation is increasing due to the requirement for more driving comfort, better performance and more features. This while the fuel consumption and emissions must be decreased. Auto makers like Mercedes with its luxury S class have announced to have a hybrid version to gain mileage. The Japanese Toyota with the Lexus Automobiles are pushing the market. Electrical—and Hvbrid Electrical -Vehicles are using already IGBT modules. Their bus voltage is between 200VDC and 400VDC with DC currents up to a few hundred amps.

Synchronous or asynchronous machines are used for automotive applications powered by frequency converters. Power modules with a high switching power density combined with low loss designs. To achieve these tasks we need integrated insulation to the heatsink, low thermal resistance and low stray inductance. The power semiconductors, along with the energy storage device, are the two main components, which determine the functionality, reliability, and cost. To compliment the IGBT performance, modules have to include perfect diodes with soft recovery characteristics.

Both IGBT concepts of Punch Through (PT) and Non Punch Through (NPT) have been improved over the years. Reducing the wafer thickness in the NPT side also the transistor cell structures changed to minimised planar cells or trench cells. Outstanding improvement in the IGBT development has been achieved with the Field Stop IGBT.

Pressure contacts have been successful introduced into modules by ABB and Semikron. These modules are designed to take a PCB containing control and gate drive, which snaps on to the module, and is held in place by rugged hooks. A product resulting out of this area is the SKAI, an optimized system for hybrid and electric vehicles, that fulfils the high demands of the automobile industry. Semikron has been named by General Motors "Supplier of the Year" in recognition of the optimized power electronics system developed for GM fuel cell automobiles.

Optimizing thermal resistance in the module design is the designer's goal. Improvement in silicon switches which minimize switching losses and conduction losses in IGBTs has been achieved. With improved silicon thinning processes, thinner die have become a reality. Thinner die equate to a better thermal response. Module manufactures are moving to more dense packages and higher break down voltages. In the past, the major improvements for efficiency have been made by optimizing the silicon. Now the silicon has reached a point where improvement in connecting and packaging technology contribute a higher amount to the total performance of systems. Wire bonding is being replaced for power packaging by alternate technology like solder or pressure contact.

The IGBT had become the switch of choice. Thank you to Frank Wheatley and his college Dr. Hans Becke at RCA. They got the critical important US patent 4,364,073 that had changed the world of power electronics.

## Probabilities are strictly for the weekend only:

Peter F., head of the development department of a system supplier to the car industry.





## CarPACK

eupec GmbH has brought out new power module solutions concept for car applications such as electrical power steering, starter generators, DC/DC converters, x-by-wire drives and hybrid electrical drives. The modules are characterised by a compact design and have high levels of heat conductivity, electrical strength, power density and current carrying capacity. Other outstanding attributes are a low-inductivity structure and high temperature resistance coupled with a high level of reliability.

An Infineon Technologies Company



## ļ

# Power electronics in motion

eupec GmbH Max-Planck-Straße 5 D-59581 Warstein Tel. +49 (0)29 02 7 64-0 Fax +49 (0)29 02 7 64-1256 info@eupec.com www.eupec.com

## Power Player

# **Trends in Distributed Power Management**

By Paul Greenland, Marketing Director of National Semiconductor's Power Management Products Group

n recent years we have seen a revolution in the distributed power architecture for the rapidly evolving information infrastructure. We start with the introduction of the Intermediate Bus Architecture followed by the advent of digital control and the trend towards the manageability of on-board power.

#### Intermediate Bus Architecture

Roughly five years ago, power management met an inflection point in system design. The forced air cooling budget for racks in telecom and datacom applications had reached a ceiling. The proliferation of DSPs, FPGAs and digital ASICs, driven by the end-customer's insatiable thirst for bandwidth and content, had increased the number and complexity of loads to the point at which the conventional distributed power architecture, using a single isolated multi-output modular DC-DC converter on each card became inefficient. The answer was to separate the isolation, step-down and point-of-load regulation into two distinct stages replacing the single multioutput brick.

This metamorphosis is not without its challenges; each stage has to occupy less than half the volume of the original solution and the series combination has to have higher overall efficiency. Typically the architecture uses a loosely regulated first stage which performs the isolation and step-down function, with a precision second stage at the point of load. The first stage is called the Intermediate Bus Converter (IBC). The IBC is usually regulated against line voltage variation, load regulation is coarse, typically ±10%. Conversely, regulators at the point of load have



tight load regulation, typically <  $\pm$ 1% and are not isolated. The primary distributed bus is -36 V to -72 V dc or +43 V to +53 V dc, for telecom or datacom respectively. The intermediate bus is usually 8 V to 14 V dc.

#### **Digital Power**

Economy, flexibility and reliability are the primary motivations for considering digital control. As process geometries have shrunk, digital implementation can often be achieved in a smaller die area. with lower power consumption than its analog counterpart. Digital control offers the promise of improved noise immunity and sophisticated adaptive onthe-fly control allowing the power supply designer to consider power factor correction and resonant conversion topologies hitherto regarded to be too complex for analog control. The transition to digital control is however, a risky proposition. Notoriously conservative power supply designers who have invested years of hard won experience in analog control have to learn to use a whole new vocabulary and toolset. Up to now digital control has been focused on applications where the time constants in the load system have been long enough to permit real-time calculation of pulse

width, and reference to look up tables. A good example is battery charging with power factor correction, for instance, the "Rectifier" in a telephone exchange.

#### **Power System Manageability**

Complex loads, particularly FPGAs and DSPs require separate supplies for core and I/O. The core processor technology often operates at, or below, one volt, while the I/O is held at a conventional potential by the communication interface standard. Since these sub-circuits are often separated in the IC, by a reverse biased ESD diode, the power rails have to be applied and removed in a particular order, tracking one another to prevent latch-up and potential destruction. Furthermore, sophisticated loads often require "voltage margining" during automatic test procedures and may give an indication of their status and immediate power consumption for energy efficient application. On-board power manageability includes the capability to dynamically configure the power supply to optimize a sensed parameter such as temperature, throttle airflow or improve signal integrity, and to automatically compensate for the sensor's characteristics.

In summary power management is gaining recognition as a true enabling technology, capable of differentiating the performance of the final system. The latest developments in distributed power architectures are prime examples of where timely collaboration with power management semiconductor suppliers can yield sustainable advantage.

#### www.national.com



## SOLVE THE FIELDS. SOLVE THE MECHANICS. SOLVE THE SYSTEM.

With Ansoft EM, you can create virtual prototypes of components, circuits, controls, mechanics, and hydraulics; optimize their performance; deliver them to market fast and under budget.

#### High-performance electromechanical design at the touch of a button.

#### FIND OUT WHAT ANSOFT CAN SOLVE FOR YOU:

UK/EUROPEAN HEADQUARTERS phone: +44 20 8891 6106 email: europe@ansoft.com MUNICH, GERMANY P phone: +49 89 68 08 62 40 pi email: info@ansoft.de ei

PARIS, FRANCE phone: +33 01 39 56 67 99 email: france@ansoft.com ROME, ITALY phone: +39 06591 6845 email: italy@ansoft.com



# **Smart Power Module**

## *Powering the motion*

Inverter technology is the key to cost-effective and efficient motor drives. As a solution, Fairchild has developed a broad range of Smart Power Modules tailored to variable speed drives. SPM series are designed to bring the customers both high performance and lower cost, and to make electronic motor drives efficient, compact, easy and fast to design, rugged and less risky.

By Sung-il Yong and Bum-Seok Suh, Fairchild Semiconductor

oncerns about the environment and energy conservation have resulted in new regulations and recommendations from government agencies throughout the world. Low power drives both in consumer appliance and general industrial applications have shown a rapid growth in recent years, increasing the need for low power modules. SPM (Smart Power Module) has established a dominant position in these application areas with its compactness, functionality, reliability and ease of user interface.

From 1999, when the SPM series was first developed, to the present, Fairchild has manufactured millions of 600V SPM series with the power range of 400W ~3.7kW in consumer appliances and low power general industry applications.

This article will detail the SPM design concept and its implementation of semiconductor (power devices and control ICs) technology, package technology, and system technology mainly through the newly developed SPM3 and SPM5. Benefits of using SPM inverters will also be discussed.

#### SPM Design Concept

The key SPM design concept is to create a low power module with both improved reliability achieved by applying the existing IC and LSI transfer mold packaging technology to the SPM. SPM structure is relatively simple: power chips and the IC chips are directly die bonded on the copper lead frame, the bare ceramic material is attached to the frame, and then molded into epoxy resin. In comparison, the IPM is made of power chips bonded on the metal or the ceramic substrate and the ICs and the passive components assembled on the PCB, which in turn is assembled into a plastic or epoxy resin case and then filled up with silicon gel. The SPM greatly minimizes the number of parts count and material types, optimizing assembly process and overall cost. To the left in figure 1 is SPM3 and to the right is SPM5. Their relative sizes are shown next to a US quarter coin.

The second important design concept is the implementation of a product with smaller size but higher power rating. Of

the low power modules released to date, SPM3 has high power density with a 3A~30A rated product built into a single package outline.

The third design concept is user design flexibility to enable use in a wide range of applications. For example, there are two major flexibility features in the SPM3 series. First is the 3-N terminal structure where the IGBT inverter bridge emitter terminal is separated. In this type of structure, shunt resistance can be used in each 3-N terminal to easily detect inverter phase current. Second is high-side IGBT switching dv/dt control made possible by the insertion of appropriate impedance cell in the SPM. Depending on how the impedance cell is designed, the high-side switching slope can be adjusted so that critical EMI problems may be easily dealt with.



Figure 1. SPM3 and SPM5 compared to a quarter coin.

The 2SD315AI is a 2-channel driver for IGBTs up to 1700V (optionally up to 3300V). Its gate current capability of ±15A is optimized for IGBTs from 200A to 1200A.

The 2SD315AI has been established on the market as an industrial standard for the last four years. The driver has been tried and tested within hundreds of thousands of industrial and traction applications. The calculated MTBF to MIL Hdbk 217F is 10 million hours at 40°C. According to field data, the actual reliability is even higher. The operating temperature is -40°C...+85°C.

The driver is equipped with the awardwinning CONCEPT SCALE driver chipset, consisting of the gate driver ASIC IGD001 and the logic-to-driver interface ASIC LDI001.

#### **Chipset Features**

- Short-circuit protection
- Supply undervoltage lockout
- Direct or half-bridge mode
- Dead-time generation
- High dv/dt immunity up to 100kV/us
- Transformer interface
- Isolated status feedback
- 5V...15V logic signals
- Schmitt-trigger inputs
- Switching frequency DC to >100kHz
- Duty cycle 0...100%
- Delay time typ. 325ns



#### More information: www.IGBT-Driver.com/go/2SD315AI

CT-Concept Technology Ltd. is the technology leader in the domain of intelligent driver components for MOS-gated power semiconductor devices and can look back on more than 15 years of experience.

Key product families include plug-and-play drivers and universal driver cores for mediumand high-voltage IGBTs, application-specific driver boards and integrated driver circuits (ASICs).

By providing leading-edge solutions and expert professional services, CONCEPT is an essential partner to companies that design systems for power conversion and motion. From customspecific integrated circuit expertise to the design of megawatt-converters, CONCEPT provides solutions to the toughest challenges confronting engineers who are pushing power to the limits.

As an ideas factory, we set new standards with respect to gate driving powers up to 15W per channel, short transit times of less than 100ns, plug-and play functionality and unmatched field proven reliability. In recent years we have developed a series of customized products which are unbeatable in terms of today's technological feasibility.

Our success is based on years of experience, our outstanding know-how as well as the will and motivation of our employees to attain optimum levels of performance and quality. For genuine innovations, CONCEPT has won numerous technology competitions and awards, e.g. the "Swiss Technology Award" for exceptional achievements in the sector of research and technology, and the special prize from ABB Switzerland for the best project in power electronics. This underscores the company's leadership in the sector of power electronics.

Driver stage for a gate current up to ±15A per channel, stabilized by large ceramic capacitors

Specially designed transformers for creepage distances of 21mm between inputs and outputs or between the two channels. Insulating materials to UL V-0. Partial discharge test according IEC270.

Isolated DC/DC power supply with 3W per channel



**CT-Concept Technologie AG** Renferstrasse 15 2504 Biel-Bienne Switzerland

Tel +41-32-341 41 01 Fax +41-32-341 71 21

Info@IGBT-Driver.com www.IGBT-Driver.com

Let experts drive your power devices



viding fail-safe operation with direct

connection between the SPM and a

3.3V CPU or DSP. Additional exter-

nal sequence logic is not needed

• Divided negative DC-link terminals

• Very low leakage current due to

Isolation voltage rating of

2500Vrms/min

Features of SPM5:

built-in HVIC

tions

for inverter current sensing applications

ceramic heat-sink and DBC substrate.

• 500V, 0.5A, 1A and 250V 1A rating,

3 - phase MOSFET inverter bridge

High reliability due to fully tested

including control ICs for gate driving

coordination of HVIC and MOSFETs

• Single-grounded power supply and

opto-coupler-less interface due to

resolves the startup and shutdown

sequence constraint between the

control supply and control input pro-

viding fail-safe operation with direct

connection between the SPM and a

3.3V CPU or DSP. Additional exter-

• 3 divided negative DC-link terminals

for inverter current sensing applica-

• Typical switching frequency of 15kHz

• Isolation voltage rating of 1500Vrms/min.

Semiconductor Technology, POWER

The performance upgrade of SPM3,

which consists of 3-phase IGBT inverter

Devices—IGBT, FRD and MOSFET

nal sequence logic is not needed

High-active input signal logic

Figure 2. Block Diagrams of SPM3 and SPM5.

The internal block diagram of the SPM3 is shown in Figure 2 (a) and SPM5 is shown in Figure 2 (b).

SPM3 is a 3-phase IGBT inverter with 3 HVICs, 1 LVIC, 6 IGBTs and 6 FRDs. SPM5 is a 3-phase MOSFET inverter optimally designed for use with low power applications. It has 6 power MOSFETs and 3 half bridge drive ICs built in. The detailed features and integrated functions of SPM3 and SPM5 are as follows.

#### Features of SPM3:

- 600V/3A to 30A rating in one package (with identical mechanical layouts)
- Low-loss efficient IGBTs and FRDs optimized for motor drive applications
- High reliability due to fully tested coordination of HVIC and IGBTs
- 3-phase IGBT inverter bridge including control ICs for gate driving and protection
- High-side: Control circuit under voltage (UV) protection (without fault signal output)
- Low-side: UV and short-circuit (SC) protection through external shunt resistor (with fault signal output)
- Single-grounded power supply and opto-coupler-less interface due to built-in HVIC
- High-active input signal logic resolves the startup and shutdown sequence constraint between the control supply and control input pro-

circuits, is basically the result of technological development of power devices (IGBT and FRD). The fundamental design rule of power devices is the reduction of chip size and the increase of current density. The IGBT applied to SPM was newly developed by Fairchild. Through optimized PT planar IGBT design, it maintains the SOA (Safe Operating Area) suitable for motor control application while dramatically reducing the on-state loss (VCE(SAT) = 1.6V) and turn-off loss (EOFF = 60mJ @25∞C). It also implements smooth switching performance without sacrificing other characteristics. The FRD is a hyperfast diode that has low forward voltage drop (an important factor in inverter applications) along with soft recovery characteristics.

In the 3-phase MOSFET inverter SPM5, the MOSFET's internal body diode is used as a free wheeling diode for the implementation of a more compact structure. The MOSFET used in SPM5 was primarily designed to have an outstanding body diode recovery characteristics as well as the implementation of noise immunity and switching performance for motor control application. By optimizing gate resistance, dV/dt was implemented at below 2kV/ms to suppress the resonance of gate signal and to reduce EMI.

## Semiconductor Technology, Control IC—LVIC, HVIC

In the SPM inverter, the HVIC and LVIC were designed to have only the minimum necessary function suitable for low power inverter drive. The HVIC has a built-in high voltage level shift function that enables the ground referenced PWM signal to be sent directly to the SPM's assigned high side IGBT gate circuit. This built-in function enables opto-coupler-less interface, making it possible to design a very simple system. In addition, with a built-in under-voltage lockout (UVLO) protection function, it interrupts IGBT operation under control supply under-voltage conditions. Because the charge-pump mode, which interlocks to the low-side PWM outside of the SPM, can be used as the highside driving power, it can be driven with

# Tiny, Efficient, Accurate 3-MHz DC/DC; 2 mm x 1 mm

Operating	Chip-Scale	Peak	DC Voltage	Output	Output Voltage
Frequency	Package	Efficiency	Regulation Accuracy	Current	Range (V)
3 MHz	2 mm x 1 mm	93%	-0.5% to 1.3%	500 mA	5.4 to 0.6

With capabilities that far exceed its size, the TPS62300 DC/DC converter provides the industry's smallest solution for 500-mA applications. Its power efficiency prolongs battery life, and its accuracy makes it suitable for low-power processors such as TI's TMS320C5000<sup>™</sup> DSP platform.



"TMS2XESOID feel World Signal Processing and the red liter's banne are madematic of Texas Instruments 18

#### REAL WORLD SIGNAL PROCESSING

High Performance. Analog. Texas Instruments.

For a data sheet, sample and evaluation module, visit www.ti.com/tps62300-e

> TPS62300 Actual Size

> > **Typical Circuit**

5 mm 🙀 5 mm

Ultra-reliable CSP 1-µH inductor 4.7-µF capacitors

ALLER DE LEUA T



a 15V single control supply. This is not necessary to have three isolated voltage sources for the high-side gate drive used in inverter systems that use conventional power modules.

Recent progress in the HVIC technology includes chip downsizing through the introduction of wafer fine process technology, input logic change from the conventional low active to high active permitting direct drive by 3V feed Microcontroller or DSP, low circuit current, increased noise immunity and good performance stability against temperature variation.

#### Package Technology

Since heat dissipation is an important factor limiting the power module's current capability, the heat dissipation characteristics of a package is critical in determining SPM performance. A tradeoff exists between heat dissipation characteristic and isolation characteristic. The key to a good package technology lies in the implementation of outstanding heat dissipation characteristic without compromising the isolation rating.

In SPM3, a technology was developed in which bare ceramic with good heat dissipation characteristics is attached directly to the lead frame. For expansion to a targeted power rating of 20A/30A within a single package, DBC (Direct Bonding Copper) technology was applied. This made it possible to achieve optimum trade-off characteristics while maintaining cost-effectiveness.

In SPM5, special epoxy resin was used with optimized thermal conductivity and insulation characteristic. At the same time, the thickness of the insulation layer, which is also composed of resin, has been carefully optimized to meet the required specification both in terms of insulation level and thermal resistance.

Figure 3 shows cross sections of the SPM3 and SPM5 package. As seen in Figure 3 (a), the lead frame structure was bent to secure the required electrical spacing. In Figure 3(b), the lead frame and the DBC substrate are being directly soldered in the DBC-SPM3.



Figure 3. Cross Sections of SPM3 and SPM5

#### **Inverter System Technology**

The package has been designed to satisfy the basic creepage and clearance spacing related safety regulations (UL, IEC, etc.) required in inverter systems. In SPM3, 3mm creepage and 4mm clearance was secured in all areas where high voltage is applied. In addition, the Cu frame pattern and wire connection have been optimized with the aid of computer simulation for less parasitic inductance, which is favorable to the suppression of voltage surge at high frequency switching operation.

HVIC is sensitive to noise since it is not a complete galvanic isolation structure but is implemented as a level shift latch logic using high voltage LDMOS that passes signals from upper side gate and lower side gate. Consequently, it was designed with sufficient immunity against such possible malfunctions as latch-on, latch-up, and latch-off caused by IGBT switching noise and system

outside noise. Fairchild's SPM design also taken into consideration the possibility of high side malfunction caused by short PWM pulse. Since the low voltage part and the high voltage part are configured onto the same silicon in the HVIC, it cannot operate normally when the electric potential in the high voltage part becomes lower than the ground of the low voltage part. Accordingly, sufficient margin was given to take into account the negative voltage level that could cause such abnormal operation. Soft turn off function was added to secure basic IGBT SOA (Safe Operating Area) under short circuit conditions.

#### Advantage of SPM-inverter Drives and SPM Inverter Engine Platform

SPM3 was designed to have 3A~30A rated products built into a single package outline. Figure 4 shows the junction to case thermal resistance at each current range of the SPM3.



Figure 4. Junction-to-case Thermal Resistance according to Current Rating of SPM3 Line-up.

As seen in the figure, in the 20A and 30A range, intelligent 3-phase IGBT module with high power density (Size vs. Power) was implemented. Accordingly. in the low power range, inverter system designers are able to cover almost the entire range of 0.1KW~2.2KW rating in a single power circuit design using SPM3. Since circuitry and tools can become more standardized, product development and testing process are simplified, significantly reducing development time and cost. Through control board standardization, overall manufacturing cost will be substantially reduced as users are able to simplify materials purchasing and maintain manufacturing consistency.

#### **Noise Reduction**

Small package and low power loss are the primary goals of low power modules. However, in recent years, attempting to reduce power loss through excessively fast switching speed has given rise to various challenges. Excessive switching speed increases the dV/dt, di/dt, and recovery current and creates challenges such as large EMI (Electromagnetic Interference), excessive surge voltage, and high magnitude of motor leakage current. Such problems increase system cost and can even shorten motor life. SPM series solve these problems by adjusting the

switching dV/dt to below 3kV/usec (typical) through advanced gate drive impedance design.

Thanks to very low on-state voltage of the new generation IGBT and low forward voltage of FRD, an optimized switching speed meeting the low EMI requirement has been realized in SPM while keeping the total power loss at a low level equal to or less than other low power modules.

#### **Cost-effective Current Detection**

As sensorless vector control and other increasingly sophisticated control methods are applied to general industrial inverters and even in consumer appliance inverters, there is a growing need to measure inverter phase current. SPM family has a 3-N terminal structure in which IGBT inverter bridge emitter terminal is separated. In this type of structure, inverter phase current can be easily detected simply by using external shunt resistance.

#### **High Reliability**

The wire-to-chip junctions and the chip-to-frame junctions have been enforced in a transfer mold package to make it endure severe thermal stress. In particular, the wire-to-chip junction endurance against steep temperature swing caused by rapid load variation



has been substantially improved. Power cycle results show that SPM is capable of over ten million power cycles at an average chip junction temperature swing of 25∞C. This makes SPM suitable not only for home appliances, which usually work under a relatively constant load, but also for a typical servo operation characterized by frequent and dramatic load changes.

#### Conclusion

Today, SPM has positioned itself as strong inverter solution in low power motor control. With its compact size. optimized performance, high reliability, and low cost, the SPM family is accelerating the inverterization not only of low power industry applications but also of consumer appliances. Fairchild will continue its effort to develop the next generation of SPMs optimized for a wider variety of applications and with higher power rating in mind.

For more information on Fairchild's SPM products, please visit http://www.fairchildsemi.com/offers/dis crete/spm/index.html

# **Robust Control of an** Electromagnetic Actuator

## Accurate control of the moving armature

System identification experiments and robust controller design method are presented in the case of a nonlinear electromagnetic actuator.

By A. Forrai, T. Ueda and T. Yumura, Mitsubishi Electric Corp., Japan

he considered control problem requires accurate control of the moving armature. The small contact velocity, known as: 'soft landing', is a very important consideration because high contact velocities correlate with component wear and noise.

Moreover, soft landing of the armature has to be achieved within a limited time. These two requirements are obviously conflicting. Other control difficulties arise from: the nonlinear characteristics of the actuator, control input saturation, dispersion due to the manufacturing and setting process, etc.

Similar control problem arises in the case of electromagnetic valve actuators in combustion engines, and if the armature is controlled around an operating point (magnetic levitation) there are applications such as: high-speed transportation, magnetic bearings, artificial heart, clean room applications in the semiconductor industry, etc.

Modelling and System Identification

The basic structure of the electromagnetic actuator is presented in Figure 1.

The related mathematical model of the investigated electromagnetic actuator can be written as:

$$u = Ri + \frac{d\Psi}{dt} = Ri + \frac{f\Psi}{fi}\frac{di}{dt} + \frac{f\Psi}{fy}\frac{dy}{dt}$$
 (1)

where u – applied voltage, i – current, R – coil resistance, y – air-gap and Y = Y(i,y) is the magnetic flux, which is current and air-gap dependent.

The equation of motion is given by:

$$m\frac{d^2y}{dt^2} = F_m - F_s \qquad (2)$$

where m is the moving mass, Fs is the spring force and Fm is the magnetic



Figure 1. The electromagnetic actuator.

force computed using the magnetic coenergy (the friction can be neglected).

The control problem can be viewed as a general case of a magnetic levitation problem: the nonlinear system can be linearized around an equilibrium point noted by (i0, y0) using Taylor series expansion. The open-loop transfer function is:

$$P(s) = \frac{\Lambda y(s)}{\Lambda i(s)} = \frac{\beta_1}{i_0(s + \beta_2)(s - \beta_2)}$$
(3)

where b1 and b2 are positive constants and the symbol D suggests small variations around the equilibrium point.

For simplicity let us consider that the armature is controlled around an equilibrium point, then the easiest way to compensate the system nonlinearity is by adding a constant bias current denoted by ib=lb (or a constant bias voltage in case of voltage control configuration ub = Ub=RIb).

A much robust approach is exact linearization of the plant, in this case the bias current equals the equilibrium current:

which is armature position and spring force dependent.

This nonlinear function f can be

$$i_b = i_0 = f(y, F_s)$$
 (4)

obtained by measurements and can be implemented in real-time, however, in the industry preference is given to simple compensation laws.

Therefore, we consider the bias current to be the measured current, which under control asymptotically converges to the equilibrium current.

 $i_h = i \quad with \quad i \blacklozenge \quad i_0 \quad (5)$ 

This approach is called asymptotically exact linearization [2]. From energetic point of view the compensation law covers exactly the Ohmic losses ubib = Ri2, which means that if the system is stabilized around an equilibrium point this nonlinear compensation will not make it unstable. In case of voltage control configuration the compensation law has the form ub = Ri.

The condition of asymptotic convergence i Æ i0 can be assured if the linear control system (around an equilibrium point) is internally stable. Therefore, considering a robust control framework for controller design is essential (robust stability assures internal stability) [3].

The first step in controller design is system identification—a model always must be derived from experimental data. Due to open-loop instability, experimental models for the electromagnetic actuator are obtained through closed-loop experiments only.

Therefore, the first step was to design, through trial and error procedure, a controller, which can stabilize the system, when the nonlinearity has been compensated using asymptotically exact linearization.

The system has been stabilized around different equilibrium positions: y0 = 0.15 mm, y0 = 0.2 mm, y0 = 0.25 mm and  $y_0 = 0.35$  mm.

Closed-loop identification has been performed considering an indirect approach: we assume that the reference signal and the regulator to be known, we identify the closed-loop system from reference input to output, and retrieve from that the open-loop system, making use of the known regulator.

The system is identified on the basis of measured input/output data, using well-known Auto-Regressive eXogenous (ARX) model, when the input signal is the Pseudo-Random Binary Signal (PRBS) [4].

Defining the sample period of the PRBS as Ts and noting with M the maximum length period it can be shown that the frequency range of the PRBS is:

$$\frac{2\pi}{MT_s} \le \omega \le$$

System identification experiments have been performed in two different frequency ranges defined by: 4 rad/sec < wlow < 62 rad/sec, which corresponds to Ts = 0.05 s and 20 rad/sec < whigh < 314 rad/sec, which corresponds to Ts = 0.01 s and around different equilibrium points, when the air-gap was successively 0.15 mm, 0.2 mm, 0.25 mm and 0.35 mm.

librium point y0 = 0.15 mm are presented in Figure 2.a and Figure 2.b where the measured output (solid line 1) is compared with the estimated output (dotted line 2). Basically there is a good



Figure 2. System identification under closed loop.

(6)

$$\leq \frac{2\pi}{2T_s}$$

Experimental results around the equiagreement between the real plant and

derived plant model.

The identified transfer functions (around different equilibrium points and different frequency ranges) are validated in frequency and time domain and the nominal model is chosen using error minimization. The nominal plant is given by:

$$P_{s}(s) = \frac{120}{(s-1.4)(s+300)}$$
 (7)

#### **Robust Controller Design and Experimental Results**

In the aim to assure 'soft landing' of the moving armature a positioning control approach has been considered, when the reference input signal is a ramp.

The block diagram of the proposed robust control system with direct voltage control is presented in Figure 3, where the asymptotically exact linearization (AEL) block already has been descried. Moreover, the linearized plant is modified by rate feedback to improve the disturbance rejection properties against the spring force-the modified plant is noted by G(s).



Figure 3. The control structure.

The controller design specifications are summarized as follows:

- The armature speed denoted by v must be between: 1 mm/s < v < 2mm/s - this will assure 'soft landing' and armature pull-up/release time less than 0.5 seconds:
- The order of the robust controller should be as low as possible;
- The sensitivity function should be minimized as much as possible (its minimization is also limited by the lowest possible gain due to the open-loop instability)

Considering a mixed sensitivity approach the robust performance condition (which assures robust stability and performance) is written as:

#### $|W_{s}(s)S(s)| + |W_{\tau}(s)T(s)| \le 1$ (8)

where S(s) is the sensitivity transfer function, T(s) is the complementary sensitivity transfer function and WS(s) an WT(s) are the performance and robustness weighting functions.

The robustness weighting function WT(s) is derived based on system identification experiments. The multiplicative uncertainty model for the modified plant is given by:

$$\Delta_m(s) = \frac{G(s) - G_n(s)}{G_n(s)}$$
(9)

where Gn(s) is the nominal plant modified by rate feedback. The weighting function WT(s) is made larger than the multiplicative uncertainty at any frequency |Dm(s)| < |WT(s)|.

The performance weighting function WS(s) is chosen by the designer, taking into account that the reference signal is a ramp, for asymptotic tracking the sensitivity transfer function must have at least two zeros at the origin, this means the order of WS(s) transfer function is at least two.

The robust controller is designed systematically according to the robust control theory and a fourth-order controller is obtained (which can be reduced to a third-order controller). The transfer func-



Figure 4. The system response

tion of the controller is discretized using the bilinear Tustin transformation with the sampling time Ts = 0.001 s and is implemented on a TMS 320C40 DSP board. The armature current is sensed using LEM current sensors and the armature position is sensed by infra-red sensors, having operating temperature range up to 85∞C degrees.

In Figure 4 is shown the armature current and position variation under control, when the spring force undergoes variations ±5% according to the manufacturing dispersion. The solid line 1 corresponds to the highest spring force, the dashed line 2 to the nominal spring force and the dotted line 3 to the lowest spring force. In all cases soft landing of the armature is achieved, according to the design specifications.

#### Conclusions

The article focused on system identification experiments and robust controller design applied for an electromagnetic actuator.

The nonlinear system has been linearized using asymptotically exact linearization, which is easy to implement and from passivity based control theory has a nice interpretation—it covers exactly the Ohmic losses.

First, due to open-loop instability system identification experiments have been performed under closed-loop in different frequency ranges and for different equilibrium positions. Next, the robust controller approach has been considered during the controller synthesis. Finally, the designed control system has been implemented on a DSP board and tested experimentally - good

robustness and performance ('soft landing') have been achieved.

The performance could be improved, by considering a linear parameter variant controller synthesis approach, which allows a lower uncertainty bound and higher control bandwidth.

#### References

- 1. A.Forrai. T.Ueda. T.Yumura -Asymptotically Exact Linearization and Robust Control of an Electromagnetic Actuator, Proc. PCIM'04 Conference, Nuremberg, Germany, 2004, Vol. II pp. 788-793. 2. L.Li. T.Shinshi. A.Shimokohbe
- Asymptotically exact linearizations for active magnetic bearing actuators in voltage control configuration. IEEE Trans. on Control Systems Technology, Vol. 11, No. 2, 2003, pp. 185-195.
- 3. J.C.Doyle, B.A.Francis, A.R.Tannenbaum - Feedback control theory. New York, Mcmillan 1992.
- 4. L.Ljung System identification theory for the users. New York, Prentice-Hall 1987.

A. Forrai. T. Ueda and T. Yumura: Mechatronics Department

Advanced Technology R&D Center Mitsubishi Electric Corp., Japan

Tel: +81 6 6497 7759 Fax: +81 6 6497 7725 E-mail: forrai@ieee.org

#### www.mitsubishi.com

# **Power and System Management** for Battery Powered Applications



MLF and MoroLandFrame are trainmarks of Arrikov Technology

# **Power–Management Semiconductor Market** Hits its Stride in 2004

## Sales boosted by robust increases in mobile-PC, automotive markets

With the semiconductor and electronic-equipment markets set for robust growth in 2004, the power-management chip segment also is on its way to a great year.

lobal revenue for all types of power-management semiconductors will reach an estimated \$20.1 billion in 2004, up 24.3 percent from \$16.2 billion in 2003, according to iSuppli Corp. Revenue will grow to \$29.5 billion in 2008, rising at a Compound Annual Growth Rate (CAGR) of 12.7 percent from 2003. However, revenue growth will slow in 2005 and nearly stall in 2006 before beginning another growth cvcle, conforming with electronics and semiconductor industry trends.

iSuppli believes 2004 will represent the peak year for growth in the powermanagement semiconductor realm in the current cycle. This year also will mark the zenith of the present semiconductor cvcle, with worldwide chip revenue rising 24.4 percent in 2004. Electronic equipment sales also will peak this year, rising 10 percent.



Revenue growth in 2004 for powermanagement semiconductors is being aided by high Average Selling Prices (ASPs). Sellers have the upper hand in the power-management area in 2004, and have been able to increase prices. Power-management semiconductors



Figure 1. iSuppli's forecast for power-management semiconductors.

## By Derek Lidow, iSuppli

benefit from broad usage in all electronic segments of electronic equipment. Thus, there is a close correlation between power-management semiconductor sales and end-equipment revenue.

#### **Power Goes Mobile**

However, beyond the general growth of the semiconductor and electronicequipment markets, various product areas are driving increased sales of powermanagement semiconductors this year and further in the future. A major dynamic driving power-management semiconductor sales growth is the increasing number of battery-operated products on the market, such as mobile PCs and wireless handsets, which have more stringent power-management requirements. Beyond mobile products, powermanagement semiconductor sales are being boosted by the proliferation of electronics into new areas that have growing power needs, such as the automotive market.

Notebook PCs will enjoy 29 percent unit growth in 2004, compared to only 6 percent for desktops. Notebook computers have greater power-management requirements. Thus, the migration to notebooks means the PC market will



# ... for Motor Control

Mitsubishi Electric offers a variety of power modules with both IGBT and IPM concept. The unique CSTBT<sup>TM</sup> technology. the 5th generation IGBT chip, is significantly contributing to higher performance in smaller and lighter power equipment.

#### **IGBTs** with

- Excellent short-circuit robustness and reduced gate capacitance
- Excellent thermal resistance and power cycling capability
- . 900A & 1400A/1200V without the need to parallel
- · Single, dual, six- and sevenpacks



semis.info@meg.mee.com - www.mitsubishichips.com

IPMs with

- Optimised EMI performance
- · On-chip temperature sensing
- Dedicated gate drive ICs and full protection logic
- Small compact packages

increase its demand for power-management semiconductors in 2004 and beyond, iSuppli believes.

Meanwhile, sales of power-management semiconductors to the automotive market will rise to an estimated \$2.9 billion in 2004, up 31.7 percent from \$2.2 billion in 2003. Revenues will nearly triple from 2002 to 2008, iSuppli predicts. Automotive power-management semiconductor revenues will grow to \$5.3 billion in 2008, rising at a CAGR of 18.5 percent from \$1.9 billion in 2002.

Sales growth of some power-management components to the automotive market will be boosted by the rising popularity of hybrid vehicles, which are powered by gas and electric engines. Such autos use between \$500 and \$1,000 of power electronics in each vehicle, generating a huge opportunity for component suppliers.

#### **Power-Management Semiconductor** Product Outlook

The fastest-growing major segment of the power-management semiconductor market is power ICs. Within the power IC category, the voltage regulator and reference segment dominates, with more than \$4.3 billion in revenue.

The voltage regulator category consists of three different types of ICs: linear regulators, switching regulators and voltage reference and other devices.

Voltage regulator revenue will rise to \$5.5 billion in 2004, up 26.9 percent from \$4.3 billion in 2003, iSuppli predicts. Revenue will rise at a 17.5 percent CAGR from \$4.3 billion in 2003 to \$9.7 billion in 2008.

In the power discrete area, power transistor revenue will reach \$7.6 billion in 2004, up 26.5 percent from \$6 billion in 2003. Revenue will grow to \$10.5 billion in 2008, rising at a CAGR of 11.8 percent from 2003.

Within the power-discrete segment, power MOSFETs will post a notable performance in 2004, with sales rising to \$4.98 billion for the year, up 30.5 percent from \$3.8 billion in 2003. Power MOSFET revenue will reach \$7.3 billion in 2008, rising at a CAGR of 13.9 percent from \$3.8 billion in 2003.

Figure 2: Top Five Suppliers of Power-Management Semiconductors in 2002 (Revenue in Millions of U.S.



Figure 2. iSuppli's ranking of the topfive suppliers of power-management semiconductors in 2002.

#### **Competitive Developments**

With demand coming from multiple, fragmented markets, and divided evenly between discrete and IC device types, the power-management semiconductor area has no clear dominant supplier.

The names of the top-10 power-management semiconductor suppliers were unchanged from 2001 to 2002. However, there was some changing of chairs among the top competitors. STMicroelectronics solidified its number-one ranking in 2002 on the strength of leadership positions in

both power ICs and power discretes. Fairchild Semiconductor moved up to the number-two rank. up from number three in 2001, also based on a good balance of strength in power ICs and discretes. At the number-three ranking, Texas Instruments moved up one place from the prior year. TI achieved this level without any participation in power discretes, but it leveraged its leadership in power ICs by growing revenue at twice the industry average rate.

International Rectifier, with its strong focus in the power MOSFET area, but with a

much weaker position in power ICs, maintained essentially flat sales in 2002 and slipped from the number-two position in 2001 to the number-four spot for 2002, while the power-management market grew 7 percent.

#### Power Up

Power-management ICs occupy an enviable market position. Their prospects are limited only by the level of sales growth in electronic equipment and the increase in the need for power management in products. With both of these areas set to increase over the next few years, the power-management IC market is in for continued growth over the long term.

Derek Lidow is president and chief executive officer of the market research firm iSuppli Corp., based in El Segundo, Calif. Contact him at

dlidow@isuppli.com

www.iSuppli.com

## APT Introduces..... Standard Power Modules Using the latest Power MOS 7<sup>®</sup> **MOSFETs and IGBTs** SP6 17mm height SP4 17mm height Packages compatible to common outlines in the industry New low profile packages for increased performance PT & NPT IGBTs MOSFETs A variety of configurations available ... Phase Leg, Boost Chopper, Full Bridge, Common Source, Asymetrical, & Many Others DWANCED Phone: 33 55792 1515 Fax: 33 55647 9767

Data Sheets available at www.advancedpower.com



# **Automotive Electronics Driving Technology: Part II**





1. Power Distribution







3. Powertrain







5. Safety & Chassis

# **100V Regulator**



## No R<sub>SENSE</sub><sup>™</sup> & 95% Efficient

The LTC®3703 synchronous DC/DC controller can directly step-down voltages from inputs up to 100V, eliminating the need for additional input voltage protection in telecom and automotive applications. The LTC3703's internal 1Ω gate drivers, 600kHz switching frequency and VDS current sensing provide a highly efficient and compact solution. The device's high bandwidth error amplifier and patented feed forward compensation guarantee very fast transient response to changes in line and load.

Fast Transient Resnonse

#### **Features**

- High Voltage Operation: Up to 100V
- Large 1Ω Synchronous Gate Drivers
- · No Current Sense Resistor Required
- · Step-Up or Step-Down High Efficiency DC/DC Converter

- · Excellent Transient Response and DC Line Regulation
- · Programmable Constant Frequency: 100kHz to 600kHz
- SSOP-16 and SSOP-28 Packages

Europe Sales Offices: France 33-1-41079555 Italy 39-02-38093656 Germany 49-89-9624550 Sweden 46-8-623-1600 United Kingdom 44-1628-477066 Finland 358-9-88733699 Distributors: Australia Soanar 61-2-9741-0122 Belgium ACAL 32-0-2-7205983 Finland Tech Data 358-9-88733382 France Arrow Electronique 33-1-49-784978

	Fast Iran	sient Response	VInfo & Online Store
V <sub>OUT</sub> SOmV/QIV	/n		www.linear.com Tel: 1-408-432-1900
V <sub>IN</sub> 201/01/ 24/01/ 24/01/			SufficientsD Durunnal
	V <sub>DUT</sub> = 12V I <sub>LOAD</sub> = 1A 25V TO 60V V <sub>IN</sub> STEP	20,15/DW	D, DC and D are registered traden ThirtSOT, Bot Swap, SwitcherCAD an trademarks of Linear Technology Corp.
			Tekelec Airtronic 33-1-56302425 Germany Insigh



## inear.com 408-432-1900



and LT are registered trademarks and Hot Swap, SwitcherCAD and No R<sub>SENSE</sub> are Its of Linear Technology Corporation

ronic 33-1-56302425 Germany Insight 49-89-611080, Setron 49-531-80980 Ireland MEMEC 353-61-411842 Israel nents 972-9-778-0351 Italy Silverstar 39-02-66125-1 Netherlands ACAL 31-0-402502602 Spain Arrow 34-91-304-3040 Turkey Arrow Elektronik 90-216-4645090 (Ext. 238) UK Arrow Electronics 44-1234-791719, Insight Memec 44-1296-330061

# **Trench MOSFETs Feature Rugged**, **Efficient Switching**

## *The right device for automotive electronics*

The Q101 specification defines the minimum stress test-driven requirements and references test conditions for qualification of discrete semiconductors (transistors and diodes) for the automotive environment

By Anthony Murray, International Rectifier

ntegrated starter alternators, synchronous rectifier alternators, electrical power steering systems, and brush and brushless dc motor drives employ power semiconductor switches to control turn-on, turn-off, speed and direction of travel. These power semiconductor switches must operate reliably in the harsh automotive environment, regardless of noise transients and voltage variations. Meeting this need is a new Trench HEXFET (MOSFET) family. To ensure reliability, all members of this Trench MOSFET family are tested according to the AEC Q-101 specification that guides electronic component selection and testing for the automotive environment.

Trench MOSFETs employs the same schematic configuration of the older planar MOSFETs, as shown in Figure 1. The new Trench MOSFETs offer significant advantages over the older generation Trench MOSFETs and also some improvements over the older planar MOSFET technology. To understand the new Trench MOSFET improvements,



Figure 1Trench MOSFET schematic.

we have to investigate several parameters critical to the performance of power semiconductors employed in automotive applications:

- Blocking voltage (BV<sub>DSS</sub>)
- Maximum avalanche energy (E<sub>AR</sub>)
- On-resistance (R<sub>DS(ON)</sub>) Maximum junction temperature
- $(T_{J(max)})$ • Continuous drain current (I<sub>D</sub>)
- Safe operating area (SOA)
- Gate charge (Q<sub>G</sub>)

AUTOMOTIVE ELECTRONICS: PART II



Blocking voltage is the maximum voltage that can be applied to the MOSFET. When driving an inductive load, such as a motor, this includes the applied voltage plus any inductively induced voltage. With inductive loads, the voltage across the MOSFET can actually be twice the applied voltage. Blocking voltage ratings of International Rectifier's new Trench MOSFET family are 30V. 40V. 55V. 75V and 100V.

The automotive environment can produce repetitive high voltage transients caused by fast current changes, such as starting the engine, which may force MOSFETs into an avalanche condition. There are two possible failure modes caused by the avalanche condition that can destroy a MOSFET. The most destructive is "bipolar latching" that occurs if the device current causes a voltage drop across its internal device resistance, resulting in transistor action and latching of the parasitic bipolar structure of the MOSFET. A second failure mode is thermal, which occurs if the avalanche condition raises the device





Figure 3. Normalized on-resistance vs. temperature for

maximum rating.

the IRF2804 Trench MOSFET.

Figure 2. Maximum avalanche energy vs. temperature for the IRF2804 rated at 40V  $\mathsf{BV}_{\mathsf{DSS}}.$ 

temperature above its maximum junction temperature.

The new Trench HEXFET technology offers an avalanche capability comparable to industry-leading planar technology and up to twice that of some currently available trench products. To ensure satisfactory performance, all the devices in this automotive-oriented family are fully characterized for repetitive avalanche energy ( $E_{AR}$ ) up to their maximum junction temperature,  $T_{J(max)}$ . The higher the  $E_{AR}$ , the more rugged the device. Figure 2 shows the maximum avalanche energy vs. temperature for the IRF2804 rated at 40V BV<sub>DSS</sub>.

Trench technology provides the desirable characteristics of high avalanche capability and low on-resistance, or  $R_{DS(ON)}$ . On-resistance consists of the resistance of the MOSFET die plus its lead resistance, which is a function of the package that is employed. The new automotive-specific, Trench HEXFET power MOSFET technology provides 15% lower device on-resistance per unit area than existing benchmark technologies. And, the new Trench technology allows 10% lower on-resistance temperature coefficient. On-resistance is tem-

perature dependent, as seen in Figure 3, which plots normalized on-resistance vs. temperature for the IRF2804 with  $I_D$  = 75A and  $V_{GS}$  = 10V ( $V_{GS}$  is gate-to-source voltage).

On-resistance is important because it determines the power loss and heating of the power semiconductor. The lower the R<sub>DS(ON)</sub> the lower the device power loss and the cooler it will operate. This is particularly important in automotive applications where the nominal operating temperatures usually exceed 125°C. Low on-resistance drastically reduces heat-sinking requirements in many applications, which lowers parts count and assembly costs. In many applications, the low on-resistance also eliminates the need to parallel MOSFETs for low on-resistance, which leads to improved reliability and lower overall system cost than previous MOSFET generations.

Maximum junction temperature is a function of the electrical characteristics of the device itself, as well as the package employed. Package thermal properties determine its ability to extract heat from the die. The junction-to-ambient (RqJA) thermal resistance of the device

is a measure of its ability to extract heat. The lower the thermal resistance, the more efficient the package is in eliminating heat. In some cases, a heat sink may be required to maintain the device junction temperature below its

Continuous drain current establishes the ability of the MOSFET to drive a specific load. This value can be limited by the MOSFET's package. When operated in the pulsed mode, the MOSFET's drain current can be several times its continuous rating. In the pulsed mode the pulse width and duty cycle determine safe drain current and device power dissipation.

Safe operating area is exactly what the name implies. The maximum safe operating area depends on the drain current and VDS (drain-to-source voltage). Figure 4 shows the maximum safe operating area for the IRF2804.

Gate charge affects the highest reliable switching frequency of the MOS-FET. The lower the gate charge, the higher the frequency. Operation at higher frequencies allows use of lower value, smaller size capacitors and

# Automatic Display Brightness Low Cost. Easy.



Approximates human eye spectral response

- · Accurate/repeatable output current vs. light
- Voltage scalable
- Integrated high gain photo current amplifiers
- · Complementary current outputs
- Temperature stable
- 8-pin MSOP package

#### www.Microsemi.com

© 2004 Microsemi Corporation. All trademarks are of Microsemi Corporation

## LX1970 <sup>™</sup> Visible Light Sensor

Simplicity is the key to Microsemi's new LX1970 Visible Light Sensor.

Designing with it is easy. You need no optical filters, and as few as a single resistor to build a complete ambient light-sensing function.

It's easy for users as well, responding to light just like the human eye. It's not fooled by ultraviolet or infra-red signals. Set the LX1970 sensor once and a display will remain at an eye-comfort level thereafter.

Dawn to midnight, indoors and out.

It's a simple solution that can extend battery operation in portable products and component life in stationary applications.

Visit our website for all the LX1970's technical information: www.Microsemi.com.







Figure 4. Safe operating area for the IRF2804 Trench MOSFET.

Figure 5. Typical gate charge vs gate-to-source voltage for the IRF2804 Trench MOSFET



Figure 6. MOSFET cross-sections: a TrenchFET: b Planar MOSFET.

inductors, which can be significant factors in system cost. A low gate charge also makes it easier to drive the MOS-FET, however, automotive engineers sometimes need to trade-off switching frequency with Electromagnetic Interference (EMI) considerations, which follow very strict guidelines in the automotive envoirnment. The new devices exhibit lower gate charge than existing planar technologies. Gate charge is a function of  $V_{GS}$ ,  $I_D$ , and  $V_{DS}$ , as shown in Figure 5.

#### **AEC Q-101**

The Automotive Electronics Council (AEC) consists of two committees that establish the requirements for the Q-101 specification: the Quality Systems and the Component Technical committees. Today, the committees includes repre-

sentatives from the sustaining members DaimlerChrysler, Delphi Delco Electronics Systems, Visteon Automotive Systems and other associate members. The Component Technical committee establishes standards for reliable, high quality electronic components. Components meeting these specifications are suitable for use in the harsh automotive environment without additional component-level qualification testing.

The Q101 specification defines the minimum stress test-driven requirements and references test conditions for qualification of discrete semiconductors (transistors and diodes) for the automotive environment. It does not relieve suppliers of the responsibility to meet their internal qualification program.

**Planar MOSFETs vs Trench MOSFETs** 

From it very inception, planar MOS-FET on-resistance depended on its cell density, that is, the number of cells/mm3. However, there is an upper bound on cell density that limits the lowest value of on-resistance possible.

The Trench MOSFET structure vertically redirects the current flow in the device's channel in a direct path between the topside source and the backside drain contact. Figure 6(a) and 6(b) show the vertical Trench and horizontal planar MOSFET cross-sections, respectively. The TrenchFET configuration avoids the parasitic series-JFET problem inherent in planar DMOS devices. Process refinements have yielded devices with steadily increasing density and lower on-resistance. TrenchFET devices have achieved onresistance less than 1mW for a 25mm2 silicon die, exclusive of lead resistance.

IR response management is: Mike Wigg, International Rectifier Co Ltd,

European Regional Centre, 439/445 Godstone Road, Whyteleafe, Surrey. CR3 0BL Tel; +44 (0)20 8645 8003 Fax; +44 (0)20 8645 8077

e-mail: mwigg1@irf.com

#### www.irf.com

## **APEC. 2005**

March 6-10, 2005 Austin Hilton Austin, TX

# **Call for Papers!**



# THE PREMIER GLOBAL EVENT IN POWER **ELECTRONICS**

- Deadline for Abstract and Digest-August 9, 2004
- Acceptance Notification-October 18th, 2004
- Papers due-December 13, 2004

Visit the conference web site below for paper submission details

# www.apec-conf.org

SPONSORED BY









# **Increasing Passenger Car Comfort and Safety**

## LIN-Bus controlled smart-power chips to control exterior mirrors

A Smart-Power Chip with a Microcontroller-core, embedded in a mechatronic mirror concept solves this problem with only three leads needed to the door module, including: power supply, ground and LIN-Bus.

By Alberto Coen, STMicroelectronics

n the ever increasing need to support safety and comfort in passenger cars, more features are being added to external mirrors. In addition to mirror adjustment and defrosting, which are today standard, electrochromatic controlled dimming, turn indicators, the door's outside (puddle) lights, the folding in of the mirror, and the storing of the mirror position are also become standard in automobiles. The multiple new actuator and sensor functions however result in a significant cost increase, driving up wiring expenses to the door module.

#### Development trends in the area of exterior mirrors

There have already been different tentative approaches in the area of a mechatronic solutions, without giving up the concept of a central control module. Figure 1 shows some examples of solutions with the resulting effect on the count of the internal connecting leads. This shows the significant reduction in leads achieved by the mechatronic approach.

The mirror has the highest lead count and hence offers the greatest savings



Figure 1. A Actuator driver inside a separate module

- B Window winder combined with door module
- C Keyboard combined with door module
- D Actuator drivers dedicated to actuators (mechatronic)

potential for the mechatronic approach. Experience shows that features that today command an additional price, are tomorrow's standard equipment. This means where today 5 leads are sufficient to provide the standard mirror

adjustment and heating, up to 19 leads will be necessary, which can easily become a problem as the hollow spindle of the mirror joint has a limited capacity. Figure 2 shows a typical case for the maximum level of mirror equipment, as



Figure 2. Driving functions for a high end mirror showing significant level of harness complexity.



Figure 3. Mirror driver designated as UD13.

well as the effect upon the central door module which naturally also bears the load of multiple options.

#### **Development target- mechatronics**

The limited space available in the mir-

ror housing allows only very compactly built electronics, which in the end eliminates a multichip concept with several packages. The way out of this dilemma is the mechatronic mirror concept, in which all signals and actuator functions

#### AUTOMOTIVE ELECTRONICS: PART II

are already pre-processed within the mirror and only one bus connection and the two supply leads are present. For the target monolithic solution, a 0.6µ BCD (Bipolar Cmos Dmos) technology was selected, which also allows the integration of an "embedded controller", whose architecture is specified according to the ST 7 family from STMicroelectronics. This technology was chosen because it allows the possibility of integrating the power and the digital parts in the same piece of silicon.

The integrated controller monitors and controls all sensors and actuators. All actuator drivers have such a layout that the SMD power package HIQUAD64 can be used without additional cooling, allowing maximum flexibility of mounting. Below, Figure 3 shows the block diagram of the mirror driver designated as UD13.

Table 1 shows the function and loading profile of the mirror actuators. The given values are largely representative for all mirror types and manufacturers.

#### Control of the mirror motors

The UD13 contains four half-bridges for the control of the motors for the mirror adjustment as well as the folding in of the mirror. Each half bridge is separately controllable from the controller so that simultaneous operation is also possible. The central half bridge, and also the half bridge branch for the fold in motor offers a 200mOhm per transistor (25°C) and is hence capable of driving all known motors with very low power dissipation. In order to safe the otherwise normally used mechanical end switches, the central half bridge allows a bi-directional current measurement with which the blocking of the motor can be detected. The current level can be read out from the controller over the ADC.

#### Consideration of the power dissipation

The mirror driver U13 has a total of nine actuator drivers as well as a voltage regulator and the position sensor supply. All drivers in active operation generate a power dissipation, which in total (taking into account the package, ambient temperature and heat removal

Function	Load	Load Behaviour	Voltage	Peak Current	Working Current	Typical Operating Time
EC-Control	Chemical Substance	Capacitive & Resistive	01,5V 6 Bit DAC	150/350 mA	75 /150 mA	Continuous
Heating	Resistance	Copper Lead or PTC	Vbatt	2,5 A	2,5 A (R) 1,5 A (PTC)	Continuous
Side Indicator	5/10W Lamp	PTC	Vbatt	5A	0,4/0,8A	Continuous (2 Hz PWM)
Exterior Lamp	10W Lamp	PTC	Vbatt	5 A 10 ms	0,8A	up to 30s
Fold in	DC-Motor	Resistive- Inductive	V batt	3 A	0,8A	up to 10s
Central Half Bridge	DC-Motor	Resistive- Inductive	V batt	3 A	0,8A	up to 10s
Adjustment	DC-Motor	Resistive- Inductive	Vbatt	500 mA	250 mA	up to 10s
Mirror Memory	Potentiometer	Resistance 1 kOhm	5V	5 mA	5 mA	Software dependant

Table 1. Function and loading profile of the mirror actuators.



Figure 4. Maximum expected power dissipation for simultaneous operation of several actuators.

possibilities) may not exceed a specific limit. This limit was set at 1.5 watts to provide the supplier who has to assemble the device in the board with maximum flexibility in his mounting and wiring needs. It also must be considered that not all actuators must work simultaneously. A scenario has therefore been worked out that shows which actuators are given priority under which circumstances. Whether less important actuators are blocked for a short period by targeted activation of specific functions

is an exclusive decision of the system developer implemented by means of the software. For this purpose the chip informs the controller of the current junction temperature. If the thermal reserves are sufficiently high, which is usually the case, there are no resulting limitations. Should, through particular operating conditions, a higher power dissipation briefly occur, this will still have no effect as the thermal impedance of the HIQUAD64 package and is still better than 15°C/W after one minute.

The following bar diagram in below Figure 4, shows the maximum expected power dissipation for simultaneous operation of several actuators. It represents, for each actuator:

- which should be activated with priority
- which further actuators may also be activated
- which can be shut off for a specific time

As an example, the turn indicator is chosen. Should this function be activated and the chip temperature is in a limit range, it is no problem to shortly turn off the mirror heating as its thermal time constant completely bridges this interruption.

#### Considerations for chip technology

UD13 is designed in BCD5. What makes this technology uniquely important is that the signal section density reaches a level where it is economically feasible to integrate an 8-bit microcomputer core and peripheral circuits on a single smart power chip. A circuit like this is much more than a micro with some high power I/Os. Because it is based on a 40V technology, a BCD5 chip can operate directly from a 40V supply, deliver several Amperes output



mechanics and electronics Mechatronics combines application and system relevant functions: actuators, sensors, data handling and control, into a single functional and mechanical unit. The objective of mechatronics is to increase quality and combine it with improved functionality and reduced costs. It requires a simultaneous and unprejudiced design process, evaluation of all technologies,

Figure 5. PC-board of mechatronic mirror. Smart power chip is in center position.

current (limited only by the package) and function at a junction temperature up to 150 Celsius, which is the point where on-chip protection intervenes. UD13 includes a voltage regulator, line interface, power actuators, a micro (core and peripherals) and memories (RAM/EPROM).



Figure 6. Housing shell for motors and PC-board

The technology chosen for the mirror driver chip is a "Mixed Signal + Power Process" solution, which is designated as BCD5 at STMicroelectronics. It offers a comprehensive spectrum of components from analog to digital functions including program memory and power drivers.

The UD013 concept is tightly linked to the mechatronic concept. Mechatronics was born with the goal to combine





**HVIC IGBT Diode - Power controlled** 

materials and processes and a willingness to build new production structures from the separated production lines of today.

www.stm.com

www.hitachi-eu.com/pdd



# Get your own copy of stems Desian

# your trade journal for the power engineer!



Sign up today online at www.powersystemsdesign.com

# **Automotive & Industrial Applications**

High Performance Analog Solutions from Linear Technology

## **High Input Voltage Monolithic Switcher Provides Continuous** 5V from a 4V to 60V Input Using a Single Inductor

lectronic systems must perform under very stringent power requirements in automotive systems. These include load-dump, cold-crank, very low power consumption at light loads and low-noise operation. Additionally, footprints must be very compact and thermally efficient. Linear Technology has developed an entire family of products targeted specifically to meet these demanding requirements.

"Cold Crank" is a

condition that occurs when

the car's engine is

subjected to cold/freezing

temperatures for a period

of time. The engine oil gets

very viscous and requires

the starter motor to deliver

more torque, in turn

demanding more current

from the battery. This large

current load can pull the

battery/primary bus volt-

age as low as 4V. Upon

ignition, it typically returns

to a nominal 13.8V. The

problem arises when certain

subsystems require a

constant well regulated 5V

output throughout this

cold-crank condition. These

applications include Engine Control Units (ECU), environmental and emergency system microprocessors which are critical to the car's reliable performance. Traditionally, these requirements were fulfilled by a dual inductor SEPIC (Single Ended Primary Inductor Coupling) DC/DC converter. The disadvantages of a SEPIC topology include a dual inductor configuration

(1a) Step-Down (VIN > VOUT)





Figure 1. The LT3433 Merges the Elements of Step-Up and Step-Down DC/DC Converters







(1c) Step-Up/Step-Down (VIN > VOUT or VIN < VOUT)

which is both costly and physically large and efficiencies in the low 70% range.

Linear Technology's LT®3433 is a high voltage monolithic DC/DC converter that incorporates two switch elements, allowing for a unique topology that accommodates both step-up and step-down conversion using a single inductor.

> The LT3433 uses a 200kHz constant frequency, current mode architecture and operates with input voltages from 4V to 60V. An internal 1% accurate voltage reference allows programming of precision output voltages up to 20V using an external resistor divider. Burst Mode<sup>®</sup> operation improves efficiencies during light-load conditions, reducing the device's quiescent current to 100µA during no-load conditions. A soft-start feature reduces output overshoot and inrush currents during start-up. Both current limit foldback and frequency foldback are employed to control inductor current runaway during start-up and short-circuit conditions.

#### **Automotive & Industrial Applications**

The LT3433 is available in a 16-pin TSSOP exposed pad package which provides a small footprint and excellent thermal characteristics. When the converter input voltage is significantly higher than the output voltage, the LT3433 operates as a modified buck converter using a boosted-drive high side switch. If the converter input voltage becomes close enough to the output voltage to require a duty cycle greater than 75% in buck mode, the LT3433 automatically enables a second switch. This second switch pulls the output side of the switched inductor to ground during the "switch on" time, creating a bridged switching configuration.

During bridged switching, the LT3433 merges the elements of buck and boost DC/DC converters as shown in Figure 1. In the simplest terms, a buck DC/DC converter switches the  $V_{IN}$  side of the inductor, while a boost converter switches the V<sub>OUT</sub> side of the inductor. Combining the elements of both topologies achieves both step-up and step-down functionality using a single inductor, so voltage



Figure 3. 4V to 60V Input to 5V Conversion Efficiency



Figure 2. 4V to 60V input to 5V DC/DC Converter

conversion can continue when V<sub>IN</sub> approaches or is less than  $V_{OUT}$ .

#### 4V to 60V Input to 5V Output **DC/DC Automotive Converter**

A 4V to 60V input to 5V output DC/DC converter is shown in Figure 2. This converter is well suited for 12V automotive battery applications, maintaining output voltage regulation with battery line voltages from 4V coldcrank through 60V load dump. The threshold for bridged mode operation is about 8V, so the converter will normally operate in buck mode. During buck operation, this converter can provide load currents up to 350mA with input voltages up to 60V. Operating with a nominal 13.8V input, the LT3433 accommodates loads of 400mA and produces efficiencies up to 82% (Figure 3). When the input voltage drops below 8V, the converter switches into bridged operation to maintain output voltage regulation. Because the LT3433 switch current limit is fixed, converter load capability is reduced while operating in bridged

mode. With an input of 4V, the converter accommodates loads up to 125mA. Not only does the LT3433 converter operate across a large range of DC input voltages, but it also maintains tight output regulation during input transients. When subjected to a 1ms 13.8V to 4V input transition to simulate a cold-crank condition, regulation is maintained to 1% with a 125mA load.

#### Conclusion

The LT3433 simplifies ultrawide input range DC/DC voltage conversion, enabling simple and inexpensive solutions to a variety of design problems. Automatic transitioning between buck and bridged modes of operation provides seamless output regulation for wide input voltage ranges and input voltage transients. The use of a small footprint TSSOP package, a single inductor and few external components reduces board space requirements, increases efficiency and improves thermal performance.

#### www.linear.com

## **Dual High Efficiency White LED Drivers with Integrated** Schottkys Drive Up to 20 LEDs from a 3mm x 3mm DFN

he LT3466 is a dual, full function, step-up DC/DC converter specifically designed to drive up to 20 white LEDs from a wide input voltage range. Its high efficiency, current mode and fixed frequency operation ensure uniform LED brightness. low noise and maximum battery life. On-chip schottky

diodes

eliminate

both the added cost

and space require-

ments of external

diodes. Its two inde-

pendent converters

are capable of driv-

ing asymmetric

LED strings (up to

10 in series per

converter) from an

input voltage of

2.7V to 24V, deliv-

#### HIGHI IGHTS

- · Drives up to 20 white LEDs from a 3.6V Supply
- Up to 81% Efficiency
- Independent Dimming and Shutdown Control
- 3mm x 3mm **DFN-10 Package**

ering efficiencies up to 81%. Its 3mm x 3mm DFN package and tiny externals provide a very compact footprint for space-constrained applications.

The LT3466 switching frequency can be set between 200kHz and 2MHz via a single resistor, enabling the designer to minimize solution footprint and maximize efficiency. Because the LT3466 utilizes a constant frequency

architecture, noise is minimized, eliminating interference with any onboard RF circuitry. Its 2.7V to 24V input voltage range enables the device to operate in applications visible from Li-Ionpowered handheld devices to automotive backlighting. Also, the LT3466 acts as a constant current source. It delivers the same current to each white LED regardless of fluctuations in the LED's forward voltage drop which vary with temperature, manufacturing tolerances and age, ensuring uniform LED brightness. Although on the same chip, the

### Low Supply Currents for "Always-On" Systems

th the adoption of new navigation, security and always-on power systems in automobiles, there is an everincreasing demand on the battery even when the ignition is turned off. Collectively, several hundreds of milliamps of supply current required to

maintain standby power to always-on processors could completely drain a battery in a matter of weeks. For example, after an extended business trip, a high-end luxury automobile would be unable to crank over the engine. Quiescent currents need to be drastically reduced in order to preserve



www.powersystemsdesign.com



Figure 4. Dual Full Function White LED Step-Up Converter with Built-In Schottky Diodes

independent step-up converters are capable of driving asymmetric LED strings with independent dimming and shutdown control of each string. Additional features include internal softstart/inrush current limiting and open LED protection. The combination of the LT3466's high efficiency, versatility, low noise and extremely small "total solution" footprint make it ideal for a variety of backlighting applications that require many white LEDs in a tiny form factor. 🎵

battery life without greatly increasing the size or complexity of the electronic systems. Until recently, the requirement of high input voltage capability and low quiescent currents were mutually exclusive parameters for a DC/DC converter. A car's high voltage step-down converters require 2mA to

150

125 (m) 100

50

25

0

10

#### **Automotive & Industrial Applications**



Figure 5. LT3434 Efficiency vs Load Current

INPUT VOLTAGE (V) Figure 6. LT3434 Supply Current vs Input Voltage

20

30

40

50

60



(I<sub>sw</sub>) monolithic buck switching regulator that accepts input voltages from 3.3V to 60V and can deliver output currents as high as 2.5A to output voltages as low as 1.25V. This wide input range makes it ideal for automotive applications which are subjected to 60V transients. Additionally, its Burst Mode operation reduces "light load" supply current to less than 100µA, making it ideal for always-on systems. Current mode topology is used for fast transient response and good loop stability.

The LT3434 is a constant frequency, current mode buck converter. It includes an internal clock and two feedback loops that control the duty cycle of the power switch. In addition to the normal error amplifier, there is a current sense amplifier that monitors switch current on a cycle-bycycle basis. A switch cycle starts with an oscillator pulse which sets an RS latch to turn the switch on.

When switch current reaches a level set by the current comparator, the latch is reset and the switch turns off. Output voltage control is obtained by using the output of the error amplifier to set the switch current trip point. This technique means that the error amplifier commands current to be delivered to the output rather than voltage. A voltage fed system will have low phase shift up to the resonant frequency of the inductor and output capacitor (LC), then an abrupt 180° shift will occur. The current fed system will have 90° phase shift at a much lower frequency, but will not have the additional 90° shift until well beyond the LC resonant frequency. This makes it much easier to frequency compensate the feedback loop and also gives much quicker transient response.

Most of the LT3434 circuitry operates from an internal 2.4V bias line. The bias regulator normally draws power from the  $V_{IN}$  pin. If the BIAS pin is

connected to an external voltage higher than 3V, bias power will be drawn from the external source (typically the regulated output voltage) improving efficiency (Figure 5). High switch efficiency is attained by using the BOOST pin to provide a voltage to the switch driver which is higher than the input voltage, allowing the switch to be saturated. This boosted voltage is generated with an external capacitor and diode.

 $V_{OUT} = 3.3V$ 

To further optimize efficiency, the LT3434 automatically switches to Burst Mode operation in light load situations. In Burst Mode operation, all circuitry associated with controlling the output switch is shut down reducing the input supply current to less than 100µA (Figure 6). The LT3434 contains a power good flag with a programmable threshold and delay time. A logic-level low on the  $\overline{\text{SHDN}}$  pin disables the LT3434 and reduces input supply current to less than 1µA. The LT3434 provides a high voltage, high current and compact solution with less than 100µA quiescent current for always-on automotive systems.

Note: LT, LTC, 🖍 and Burst Mode are registered trademarks of Linear Technology Corporation





# **Design Options for Automotive Motor** Controls

## Monolithic IC design for lower current applications

The choices that motor control designers have for the power control portion of brush dc motors have never been better. Brush dc motors are the predominant motor technology in vehicles. With a high-end vehicle having 60 or more motors, a one-size fits all approach does not work.

#### By Francoise Vareilhias and Lonne Mays, Freescale

ith the ability to integrate more efficient power MOSFETs with extensive control circuitry within a sophisticated power integrated circuit (IC) process, such as Freescale's SMARTMOS process, and more efficient power packages with sufficient pinouts for a variety of inputs and outputs, today's IC designers can simplify the motor control system-level design for many different automotive applications.

Issues for the control portion include protection, diagnostics and communications. Issues for the power switching devices include on-resistance, thermal impedance, and power dissipation. The right technology for a specific fractional horsepower motor depends on the motor, desired features, and the network, if appropriate, in which the motor operates.

#### Multiple Output High-side and Lowside Switches

For lower current applications several power MOSFETs and the control circuitry can be integrated into a single integrated circuit (IC) to control motors and

other loads. For example, the MC33880 is an eight-output hardware configurable high-side and/or low-side switch with 8bit serial input control. Two of the outputs (IN5 and IN6) may be controlled directly by a microprocessor for pulse width modulated (PWM) applications. The circuit controls various inductive loads such as motors or solenoids or incandescent loads by directly interfacing with a microcontroller. Monitoring and protection features include very low



Figure 1a. Two low-side switched (single direction) motors could be small fan motors in a seat cooling and heating distribution system.



standby currents, cascade fault reporting, output-specific diagnostics, and independent shutdown of output. Figure 1 shows two simplified application circuits for the 8-output switch where the outputs control motors, solenoids and lamps.

The circuit is designed to operate between typical automotive voltage extremes of 5.5 V minimum to 24.5 V maximum. It has output voltage clamp

Figure 1b. The reversible motor could be a power antenna or a headlamp wiper or headlamp aiming motor.

of +45 V (typical) for the low-side drive and -20 V (typical) for the high-side drive) during inductive switching.

Fault protection circuitry includes: independent overtemperature protection, short circuit detection and current limit with automatic retry, internal reverse battery protection on VPWR. In addition, loss of ground or supply voltage will not energize the loads or damage the IC. The 8-Bit (4-pin) serial peripheral interface (SPI) that connects the 8 output switches to an MCU for control and fault reporting is 3.3 V/ 5.0 V compatible.

Each of the eight MOSFETs has an typical on-resistance of 0.55 ohms at 25°C and each output is current limited (0.8 A to 2.0 A) to drive incandescent lamps. The circuit draws a maximum 5.0 µA standby current at 13 V up to 95°C. Since, the on-resistance of the MOSFETs have an inherent positive temperature coefficient, all outputs can be tied together providing balanced current sharing.

Packaging for the eight-output hardware configurable high-side/low-side switch is either a 28- or 32-pin plastic package providing thermal capability of 94∞C/W or 70∞C/W, respectively. The 32-pin SOIC has pins 8, 9, 24, and 25 grounded for improved thermal performance.

#### **Dual High-side Switch with External** Low-side FETs

For higher current applications where the dc motor must operate in both forward and reverse direction, a four MOS-FET H-bridge with lower on-resistance is required. One common partitioning scheme integrates only the upper legs of the H-bridge, the high side switches, into the IC with the control circuitry.

For example, the MC33486 integrates two 15 milliohm N-channel power MOSFETs with their associated control circuitry and additional circuitry for controlling the external low-side switches. The dual high side switch for H-bridge (DHSB) is designed to monitor the two low side switches for H-bridge control of an automotive DC-motor. It can be directly interfaced with a microcontroller for control and diagnostic functions, is



Figure 2. A dual high-side switch for automotive motor control applications, such as the MC33486 uses two external MOSFETs to complete the Hbridge motor control configuration.

PWM capable from DC to 30 KHz and has a self-adjusted switching speed for minimizing electromagnetic emission.

Each of the 2 high-side switches is protected against short to ground and load shorts, and has over temperature detection with hysteresis. Circuitry includes a current recopy feature for the high-side switches to monitor the load current. The control circuitry also has an overvoltage detector which turns off the bridge and protects the load in case of the battery voltage exceeding 28V. The low side control circuitry drives the 2 external low-side switches in the Hbridge and provides short circuit protection. This circuitry, in combination with the high-side protection, fully protects the H-bridge from shorted loads, shorts to battery voltage and shorts to ground.

THE DHSB offers a very low quiescent current in standby mode and can control 10 Amps nominal DC current and handle up to 35 Amps maximum peak current. The device is designed to operate from 8 to 28V but can withstand DC voltages from -0.3V to 40V. It incorporates overvoltage detection and switches off when the battery voltage exceeds 28V.

Both the internal high-side switches and the external low-side switches are protected from overcurrent and are designed for operating junction temperatures from - 40∞C to 150∞C. The standby mode, implemented by the Wake pin, reduces the standby current to less than



Figure 3. Current recopy in high-side switch for current sensing. The external resistor is not in series with the high current path, so it does not contribute to power losses.

10 A. A common diagnostic output (St) provides status for both channels.

Packaging for the dual high-side switch is a 20-pin HSOP with 5∞C/W thermal resistance, junction to ambient. This measurement is made with the DHSB mounted on dual-side printed circuit board with 70 m copper thickness and 10cm2 copper heat sink (2.5 cm2 on top side and 7.5 cm2 on the bottom side). The junction-to-case thermal resistance is 2∞C/W.

One of the important design aspects of integrated dual MOSFETs is the use of a current recopy feature that provides a current mirror with the ratio of 1/3700 of the high side output current. This eliminates the additional losses that typically occur when a low value series resistor is placed in the high current path to the motor to determine the current level. However, as shown in Figure 3, it still requires an external resistor connected to the Cur R pin of the mirror MOSFET and then tied to an MCU A/D input for analog voltage measurement. The Cur R pin is internally clamped (Vclst) to protect the MCU A/D input. If a ground shift occurs between the MCU and the DHSS, the amplifier will adapt its output to maintain the same current copy. The shift has to be between +/- 1V.

#### **Monolithic H-Bridge**

All of the H-bridge MOSFETs and the control circuitry can be integrated into a single package with a monolithic IC for lower current applications. For example,



Figure 4. The monolithic H-Bridge MC33887, considerably reduces the number of external components to provide forward and reverse control for a brush dc motor. This simplified application only shows 2 additional passive components.



Figure 5. Internal block diagram of the MC33887, a monolithic H-Bridge with a Sleep Mode feature.

the MC33887 is a monolithic H-bridge designed for fractional horsepower DCmotor and bi-directional thrust solenoid control. The application circuit in Figure 4 shows the monolithic H-bridge controlling a DC motor, such as a power door

	8-Output	Dual High Side	Monolithic
Feature	Switch	Switch	H-Bridge
On-resistance (each switch, max)	850 m_	15 m_	120m_(typ)
Nominal current	0.4A	10A	5A
Max current	2A	35A	7A
Individual temperature sensing	yes	HS only	yes
Over current detection	yes	yes	yes
Over voltage detection	yes	yes	yes
Fault status	yes	yes	yes
PWM control	2 outputs	<30 kHz	<10 kHz
Package (highest pin count)	32 (70°C/W)	N/A	20 (5°CAV)
Package (lowest pin count)	28 (94°C/W)	20 (5°C/W)	54 (12°C/W)

Table 1. Summary of key features.

lock. The IC has a sleep-mode feature and incorporates internal control logic, charge pump, gate drive, and four 150milliohm (typical) MOSFETs. It is able to control continuous inductive DC load currents of 6.0 A.

Referring to Figure 5, the output loads can be PWM controlled at frequencies up to 10 kHz through the internal logic and gate drive circuitry. An output current monitoring circuit. similar to the approach shown in Figure 3 but fully contained within the chip, provides a proportional (1/375th) feedback current output for the microcontroller to monitor the output current and provide closed-loop control.

The fault status output indicates undervoltage, overcurrent, and overtemperature conditions. Two independent inputs provide polarity control of the two half-bridge totem-pole outputs for forward and reverse operation for the motor. An enable (EN) pin is used to place the circuit in a power-conserving sleep mode reducing the current draw (in standby) of 20 mA max to less than 50 A.

Other operational features of the monolithic H-bridge include: speed. torque, dynamic breaking, and closedloop control. The amount of integration provided by the circuitry requires only 7 additional components (6 capacitors and 1 resistor) in the typical application.

Packaging for the fully integrated H-bridge and its associated junction to board thermal resistance can be a 20-pin HSOP (5∞C/W), 44-pin QFN (18∞C/W) or 54-pin SO-EP (12∞C/W).

A summary that compares key features, including packaging aspects, of the three different architectures that have been presented is shown in Table 1. Fault protection and diagnostics are essential features of these types of devices, although how they are implemented can varv.

The motors controls that have been presented were either directly connected to the MCU (MC33887 and MC33486) or used a serial peripheral interface (MC33880). Requirements to connect to CAN and LIN buses are becoming common in more recent motor control applications.

#### **Choose Wisely**

While the choice of motor controls is ultimately up to the system design engineer, based on the analysis that goes into designing a motor control IC, the IC supplier can provide assistance that avoids choosing an IC that may not be the best choice for a particular application. Evaluations of the performance of the IC during the development and qualification phases can involve evaluating a variety of motors and applications. In some cases, however, the motor control circuitry could have been specifically designed with only one intended application and the data sheet simply suggests additional applications.

Application concerns such as amount of heatsinking, electromagnetic interference and availability of a reference design are typically discussion points with marketing or application engineers. Additional data not found in the data sheet that is available to support a customer's design approach is frequently a part of the IC qualification package. These are just of few of the additional options available to make future automotive motor control applications easier, guicker and more trouble-free.

# **Off-Board Navigation**

## Bringing low cost navigation to the motorist

Only optimised power consumption together with power management on chip and systems level allows applications like this one. If we play in the automotive world the luxury accessories can only be efficient if they don't reduce the economic aspects.

#### By Stuart Cording, National Semiconductor

f given the choice, I am sure that evervone would take the option of having a GPS navigation system in their vehicle. The amount of time when travelling that can be saved, and the quantity of frustration when lost that can be relieved can be considered too valuable to be turned down. But, unfortunately, the price tag that this level of comfort commands is just too much for most people. Even the latest range of software and GPS add-ons for the various PDA platforms have still not brought quality navigation aids to the masses. So for now, at least, we must rely on our sense of direction, the support of a fellow passenger with whatever maps are to hand and the quality of the local signs to navigate our way through the unknown.

If we look at the design of a typical built-in or aftermarket GPS Navigation System (Figure 1), we can see the building blocks are made up from several costly components. Firstly there is the processor, which is typically of a 32-bit type allowing the complex routing algorithms to be calculated quickly and efficiently to provide a quality user experience. Next comes a colour display to shows the map of the current location, and possibly a touch screen for user input. A GPS module is of course a must, as is the storage medium for holding the database of maps, locations and points of interest. One large cost which is not shown here is the license fee for the map itself which is the reason why new CD-ROMs for these systems are

so costly, and why most motorists do not bother to keep their system up to date. The navigation system in it's current form has more or less remained the same since it was first designed, but with data being available readily from the internet these days, a GSM module would also provide the perfect way to enhance the features of the systems to provide accurate traffic information, points-of-interest, hotel booking features and more. Unfortunately, the cost of doing so remains prohibitive

Ideally, if one of these systems is built into the car. the user could just use their own mobile phone fitted into a cradle to provide that data link. Unfortunately, adding a cradle for a GSM mobile phone is also too complicated for the mass market due to the large number of different and ever changing connectors used by the different phone manufacturers. The RDS system used by car radios can

provide traffic data for use by navigation systems, but these are always limited to systems that are embedded into the cars dashboard.

In order to bring navigation systems to the broad market, both as an option when purchasing a new car and as a product for the aftermarket, the cost of the system needs to be brought down considerably. It needs to based on a low-cost microcontroller, whilst bringing the user a broad range of valuable services such as traffic-avoidance routing and traffic-flow updates during the journey. The display of a colour map can removed, as it is not really required, and replaced with high quality verbal direction commands and text based directions from a simple and value for money monochrome type display. And we can also do away with the local CD-ROM or Flash memory map information and instead use a remote server to calculate



Figure1. Aftermarket GPS Navigation System

the routing for us, using the latest mapping information and a knowledge of road usage according to time of day, allowing users access to the most optimal route. Such a hardware platform is shown in Figure 2. Here we can see that, rather than integrating a GSM module to provide the required data link to the internet, and the associated problems of trying to implement a way of the user using a SIM card for call billing, a Bluetooth interface has been added using the LMX5252 radio. Bluetooth provides GPS Navigation System developers with the most cost effective, shortest time to market and most interoperable solution to this low cost GPS System.

By making use of the Dial-Up Networking Profile (DUNP) of Bluetooth, a GPS Navigation System can use any available local Bluetooth enabled mobile phone to access internet based traffic information. The web-based traffic information could be provided through partnerships with automobile associations that already provide such information

(e.g. ADAC in Germany) or through web-sites that are created specifically for the purpose by the hardware manufacturer (see Figure 3). Due to the guaranteed interoperability of the Bluetooth protocol and profiles, the GPS system developer can leave it up to the end consumer to choose how the navigation system will access the internet based traffic information by choosing an appropriate Bluetooth enabled mobile phone and GSM service provider.

National Semiconductors CP3000 family of Connectivity Processors form the perfect platform to Bluetooth enable any current GPS system in such a manner, be it embedded into a car dashboard, or a handheld system. These devices also provide many additional connectivity interfaces that give additional flexibility or provide a means to develop the product further with time. In addition the large addressing capability of the processor can provide ample off-chip memory for immediate storage of downloaded data and traffic information databases.

## Looking for More Low Cost, Energy Efficient **Solutions for Appliance Control Power?**

We've expanded our LinkSwitch-TN off-line power conversion IC family to give you even more design options!

#### **Key Features:**

- Lowest cost non-isolated buck or buck-boost converter solution for linear/passive dropper replacement
- Tight tolerances for low cost. high volume manufacturing
- Short circuit, open loop, & thermal overload protection
- No-load power consumption <80 mW



LinkSwitch-TN data sheet, Design Guide (AN-37), Design Accelerator Kit (DAK-48A), & PI Expert\*\* design software now available at:

www.powerint.com

www.powersystemsdesign.com

The CP3000 Connectivity Processors are driven by the powerful, third generation CR16C CompactRISC processor core – a 16-bit RISC like processor. Because of its delicate blend of RISC instructions, keeping code size small, and CISC type instructions, allowing non-interruptible bit manipulation. push/pop and load/store instructions, the CR16C is quite capable of supporting the Bluetooth interface, including profiles, and handling complex applications in small amounts of memory. The ability to store and retrieve up to 8 internal core registers to and from the stack quickly using a single instruction makes RTOS's easier to port, and ensures fast and effective context switches. The three-stage pipeline performs the fetch, decode and execution of instructions, allowing a peak throughput of one instruction per clock cycle. Despite being a 16-bit architecture, with mostly 16-bit general-purpose registers, it can also be seen that the internal data path of the core is 32 bits wide. This allows 32-bit data to be loaded into the four





Figure 2. Complex Info input.

general-purpose core registers that are 32 bits wide, enhancing the cores performance when using relocatable code. With the efficient Index Addressing mode, a mixture of memory types can be used to expand the generous 256kbytes of on-chip flash memory and 10kbytes of on-chip SRAM. The on-chip flash memory also supports single cycle read accesses at system clock frequencies of up to 24MHz.

The CAN interface of the CP3000 communications processor is suitable



Figure 3. The full Advantage of System Design.

for navigation systems built into the dashboard of a car. This would allow automotive manufacturers to integrate the GPS system through the CP3BT onto a CAN bus to share data and issue and accept control requests. Additionally, the system could use dashboard displays and control buttons already within the vehicle as its humanmachine interface (HMI). The alternative interface for aftermarket GPS systems is the USB interface. This would give consumers the flexibility to connect the GPS system to a laptop or desktop PC,

which commonly have USB but no Bluetooth interface at present, whilst still being able to make use of the Bluetooth capability of their mobile phone for traffic information whilst on the move. The audio from the system could also be rerouted through to the audio system that already resides in the vehicle, temporarily muting the radio as it does so.

Because of Bluetooth's high level of flexibility, support of many different connections with many types of electronic products, and the guaranteed interoperability of the protocol, it has to be the interface of choice to extend the capabilities of navigation systems. The CP3000 family of connectivity processors is available to make that choice easier.

www.national.com/appomfp/cp3000



WHEN YOU'RE LOOKING TO BUILD SAFETY, RELIABILITY AND VALUE

into your product, the Raychem Circuit Protection Databook is the only resource you'll ever need. In it you'll find an unrivaled portfolio of overtemperature, overcurrent, and overvoltage solutions including SBar thyriator surge protectors, RCV racial-leaded metal oxide variators, and telecom fuses, as well as the entire family of PolyGwitch resettable devices that have been built into billions of electronic products.

in 1980, Raychem pioneered the development of PPTC (Polymer Positive Temperature Coefficient) resettable device technology



Raychem Circuit Protection remains dedicated to simplifying and improving electrical systems across a spectrum of markets, including telecommunications, computing, portable electronics, consumer electronics, automotive, and industrial

We take great pride in our ability to deliver world-class customer service. comply with globally recognized quality standards, and provide local



engineering support while remaining cost competitive. If you don't already have the workd's most comprehensive book on circuit protection (or just want to make sure you own the most recent version), order your free copy by calling +32 16 351 321 or by visiting us at ww.cpdatabook.com/order

tyco | Electronics

# **Lighting up Automotive Instrument Panels**

## Wide range of features requested from switching regulators

Depending on where the electronic system operates on the automotive power bus, it is frequently required to perform under very stringent power requirements. These include load-dump, cold-crank, very low power consumption at light loads, and low-noise operation. Additionally, solution footprints are generally required to be very compact and thermally efficient.

#### By Tony Armstrong, Linear Technology Corporation

ver the past decade, the electronics content in automobiles has made quantum leaps in both the quantities and sophistication of electronic control, telematics and entertainment systems. With the recent introduction of electric and electric/hybrid vehicles, the electronics content extends even further into propulsion systems. On one end of the automotive spectrum, many historically mechanical systems such as throttle control, braking, and suspension control are now being both controlled and optimized by electronic systems. On the other end, entertainment and wireless navigation are fast becoming standard equipment on nonluxury automobiles.

Wide operating voltage requirements coupled with large transient voltages and large temperature excursions combine to make life tough on electronic systems. What's more, the performance requirements continue to become even tougher. Multiple supply voltages are required for different portions of the system. A typical Navigation system can have six or more different supplies including 8V, 5V, 3.3V, 2.5V, 1.8V, and 1.5V. At the same time, as the number of components increases, the space available continues to shrink. Therefore, efficiency becomes more critical because of the space limitations and

www.powersystemsdesign.com

temperature requirements. At low output voltages and even with moderate current levels, above a few hundred milliamps, it is no longer practical to simply use a linear regulator to generate these system voltages. As a result, over the last several years, primarily due to thermal constraints, switching regulators have been replacing linear regulators. The benefits of a switcher, including the increased efficiency and smaller footprint, outweigh the additional complexity and EMI considerations.

Virtually all luxury automobiles come with in-dash audio, visual and navigational systems, along with the traditional instrument panel. All of these systems need some kind of backlighting to allow for readability in all kinds of ambient light conditions. White LEDs are now commonly used to provide backlighting. In these applications, the white LEDs must be powered by a constant current to guarantee consistent light intensity and uniform brightness. Figure 1 shows the LT3466 powering 50 (two banks of 25) white LEDs from a 12V input supply. The circuit is configured as a voltage tripler to produce output voltages in excess of 90V. This allows a string of 25 LEDs to be connected at each output, resulting in constant current and uniform brightness.

46

AUTOMOTIVE ELECTRONICS: PART II



The device is configured to operate at a 2MHz switching frequency by the choice of the 20.5kW resistor. This ensures that the radiated switching noise falls outside the AM radio band. High switching frequency also allows the use of low-profile inductors and surface mount capacitors. Furthermore, in this application the LT3466 delivers 2.4W output power with 83% efficiency. The thermally enhanced 3mm x 3mm DFN packaging (with exposed pad) of theLT3466 enables it to drive as many as 50 white LEDs from a 12V input supply. For optimum performance the inductors can be powered directly from the battery, whereas the LT3466 should be driven from an existing 3.3V rail.

The LT3466 has two independent, but identical, step-up converters capable of driving asymmetrical LED strings. The step-up converters are designed to drive the series connected LEDs with a constant current, thus ensuring uniform brightness and eliminating the need for ballast resistors. It also incorporates internal 44V power switches and Schottky diodes. Switch current limit is guaranteed to be greater than 320mA over the full operating temperature range. A low, 200mV, high accuracy (±4%) reference voltage is provided to program the LED current.



Figure 1. 50 white LEDs powered by 12V input using low profile surface-mount components.

The step-up converters use a current mode topology to provide excellent line and load transient response. Internal feedback loop compensation of the LT3466 allows the use of small ceramic capacitors on the output. The built-in over-voltage protection circuit clamps the output to either converter to 42V if the LED string connected to that output fails open-circuited. Internal soft start is provided for

each step-up converter during start-up.

The switching frequency of the LT3466 can be programmed over a 200kHz to 2MHz range by means of a single resistor from the RT pin to ground. Its 2.7V to 24V input voltage range makes it ideal for a wide range of applications. The device features independent shutdown and dimming control of two LED string. The

current in each LED string can be shut off by pulling the respective control (CTRL1 or CTRL2) pin voltage below 50mV. Dimming of each LED string is achieved by applying a DC voltage to its respective control pin. When both CTRL1 and CTRL2 pin voltages are pulled below 50mV, the devices enters total shutdown.

The LT3466 is a dual white LED driver with integrated switches. Schottky diodes and a space saving 3mm x 3mm DFN package. The wide operating voltage range and high frequency capability of the LT3466 enables it to meet the backlighting needs for automotive instrument panels and car radio displays. Features like the internal soft start, open LED protection and internal loop compensation reduce the number of external components, thus reducing the overall cost and size of the white LED driver circuit.

tarmstrong@linear.com

www.linear.com



E-mail: dsp-sales@danfoss.com + Homepage: www.danfoss.com/siliconpower

5V Eighth-Brick DC/DC Converters at 92%



Artesyn Technologies has launched two new 5V single output eighth-brick DC/DC converters which provide industry-leading conversion efficiencies of 92%. The new converters are available with current ratings of 10 and 15A now, and 20A in the near future. enabling designers to choose the most cost-effective model for their particular application.

Both converters feature a wide input voltage range of 36 to 75VDC and generate a single 5V isolated output, adjustable over the range 4 to 5.5V via a single external resistor. The converters feature remote sense and remote on/off facilities as standard, and have a typical start-up time of 10ms when driving a resistive load. Synchronous rectification and advanced processor control of both primary and secondary-side circuitry maximise efficiency and transient response.

Artesyn's 5V eighth-brick converters are designed for operation over an ambient temperature range of -40 to +85\_C without a heatsink. Their ultra low profile construction minimises air-

Engineering The Difference The biggest innovation is to meet your expectations The new NCS sensors are designed from a new technology, it's an ABB innovation

NCS is a completely flexible product thanks to:

A new ABB technology: 100% electronic	• Re
Elexible usage	w
<ul> <li>A high measurement range (up to 50kA)</li> </ul>	• A (
An output choice (Current or Voltage)	EN
<ul> <li>A mechanical and electronic concept which allows the possibility of adding functions in the future</li> </ul>	• Th
<ul> <li>A compact size compared to existing products</li> </ul>	ABE

A88 Entrelec - Control Division - 10, rae Ampère - F60685 Chassieu - Fax : + 33 (0)4 72 22 19 69 Email :sensors.sales@frabb.com Brain Power.

flow disruption and makes them suitable for both convection cooled and forced air environments. The converters feature under-voltage lockout, as well as non-latching over-voltage protection, and are also protected against short-circuit and over-temperature conditions, with automatic recovery. The converters carry a full set of international safety approvals, including EN60950 VDE and UL/cUL60950.

www.artesyn.com



ac respect of the environment: designed under ISO 14001

B, the real innovator in current sensing!



## **Off-Line IC Family for Efficient Power Supplies**

Power Integrations announced today the expansion of TinySwitch-II, the company's widely used low power family of off-line switcher ICs. The two new device family members, TNY263 and TNY265, extend the cost effectiveness of the highly integrated, energy efficient, low power IC family.

The TNY263 offers a lower-cost, lower power solution compared to TNY264 for universal input adapters up to 3.7 W or up to 7.5 W for 230 V input open frame designs. The TNY265 pro-

vides a cost optimum solution for power levels that fall in between the capabilities of existing TNY264 and TNY266 by addressing universal input adapters up to 5.5 W or up to 11 W for 230 V input open frame supplies.

The TinySwitch-II family integrates a 700 V Power MOSFET, an oscillator with simple on/off control, and current limit and thermal protection circuitry onto a single CMOS chip. Other built-in features include auto-restart for short circuit and open loop fault protection, frequency

jittering for low EMI filtering cost, programmable line under-voltage detection. and circuitry to eliminate audible transformer noise. Key parameters are designed with very tight tolerances and negligible temperature variation. The internal switching frequency of 132 kHz reduces transformer size, allowing the use of low cost EF12.6 or EE13 cores.

www.powerint.com/greenroom

www.powerint.com

### **DIP24 DC-DC Converter**



Advanced Power Conversion PLC announces a further enhancement to its

broad range of DC-DC converters with the new APC-PEN series.

Providing 2.5 W to 6 W of output power in a low profile DIP24 case, the range offers a working temperature between -40°C and +85°C without derating.

Offered in single or dual output versions,

inputs include: 9-18, 18-36, and 36-72 V DC wide input 2:1. For applications requiring a very wide operating voltage range wide input 4:1 versions are available with 9-36 and 18-72 VDC.

A very compact and versatile package the APC-PEN series is similar to the APC-TG range but modified to match industry common pinning. The converters can be supplied in either non conductive black plastic or Nickel Coated Copper

and efficiency is up to 81%. Additional features of the range include six sided shielding, isolation of 1500 VDC and the modules are short circuit protected with continuous, automatic restart. Outputs options include: 3.3, 5, 9, 12, 15 and 18 V DC single outputs as well as dual outputs with : +/- 3.3, 5, 9, 12, 15 and 18 V.

www.linear.com



## 2.25MHz Dual 800mA Synchronous Step-Down DC/DC Converter



Linear Technology announces the LTC3407-2, a dual output, high efficiency, 2.25 MHz synchronous buck

regulator that delivers up to 800mA of continuous output current from two separate channels. Using a constant frequency and current mode architecture. the LTC3407-2 operates from an input voltage range of 2.5V to 5.5V making it ideal for single cell Li-Ion. multi-cell alkaline or NiMH applications. The

LTC3407-2 can generate two independent output voltages as low as

0.6V, enabling it to power the latest

Power MOSFET

Advanced Power Technology

Europe announced the addition of

1000V and 1200V MOSFET mod-

ules to the existing product range

single switch, Buck, Boost, Dual

common source, phase leg and full bridge configurations. Current ratings range from 13A to 160Amps. Single switch, phase leg and

full bridge configurations utilize MOSFETs with high speed

intrinsic diodes (FREDFET) for improved diode recovery charac-

teristics and better dV/dt capabili-

ty. High current single switch mod-

ules, with and without a combina-

tion of series and parallel diodes,

The low profile SP4 and SP6

modules exhibit minimum internal

1000V and 1200V MOSFETs and FREDFETs allows operating in hard switching mode in the range

www.advancedpower.com

www.powersystemsdesign.com

parasitic resistance and inductance offering high frequency operation capability. The use of the latest generation PowerMOS 7

utilize AIN substrates for best

thermal characteristics.

of 100 kHz to 200 kHz.

in SP4 and SP6 packages. These modules are offered in

**Modules** 

generation of low voltage DSPs and microcontrollers. Its 2.25 MHz switching frequency of keeps switching noise out of critical AM and xDSL frequency bands and allows the use of tiny, low cost ceramic capacitors and inductors less than 1.2mm in height. The LTC3407-2 is the most compact synchronous step-down solution available

3mm DFN packages.



products, talk to Hitachi.

Isn't it time you switched to Hitachi?



**HVIC IGBT Diode - Power controlled** 

Power Systems Design Europe September 2004

for dual output voltage rails, with its tinv externals and MSOP-10 and 3mm x

The LTC3407-2 uses internal switches with an RDS(ON) of only 0.35 Ohms to deliver efficiencies as high as 95%. It utilizes low dropout 100% duty cycle operation for output voltages up to VIN, further extending battery run-time. No load quiescent current is only 40uA (both channels) and <1uA in shutdown, ensuring optimal battery life.

www.linear.com

Call us now on +44 (0)1628 585000 or email us on pdd@hitachi-eu.com

www.hitachi-eu.com/pdd



## **MOSFET Technology Reduces Miller Charge by 35-40%**



Fairchild announces its advanced-performance PowerTrench(r) MOSFET process technology that

yields exceptionally low values for Miller Charge (Qgd), RDS(on), total gate charge (Qg), and improves gate-drain charge to gate-source charge (Qgd:Qgs) ratio-enhancements that result in superior switching performance and thermal efficiencies when used in synchronous buck applications. The benefits of low Qgd are decreased switching losses

and reduced "dead time" for improved regulation. A favorable Qgd:Qgs ratio offers immunity against false gate triggering that result in shoot-through currents between switching MOSFETs when employed as a synchronous rectifier. Low RDS(on) is critical in minimizing conduction losses and low Qg reduces the power consumed to turn the MOSFET on and off each cycle. Two 30V MOSFETs from Fairchild, the FDS6294 and FDS7288N3, exhibit the benefits of this

improved fast-switching technology. With its very low Qgd, the new FDS6294 provides excellent performance in highfrequency, narrow duty cycle switching applications. The extremely low Miller

Charge (Qgd) value of 3nC (typical) of the FDS6294 minimizes this transition time, and in conjunction with a low RDS(on) of 11.3m??max, allows the device to offer superior performance to existing solutions. The FDS6294 is available in an SO-8 package. For more information about these products go to:

- http://www.fairchildsemi.com/pf/FD/ FDS6294.html
- http://www.fairchildsemi.com/pf/FD/ FDS7288N3.html.

www.fairchildsemi.com

## Second–Generation IBIS2SPICE Converter

Intusoft announced the release of its second-generation IBIS-to-SPICE model conversion software. The enhanced program (IBIS2SPICE Converter) offers more power and ease of use than Intusoft's former version released in 1998. The new version supports all 14 IBIS model types, and converts IBIS models up to and including version 3.2.

The converter now uses an updated modeling template, which produces SPICE models that exhibit remarkable accuracy with Intusoft's IsSpice4 simulation kernel. SPICE models are generat-

ed for Input, Output, I/O, 3-state, Open-Source, Open-Drain and other I/O structures. Further, the SPICE models can be easily added to the part browser inside Intusoft's ICAP/4 "SpiceNet" design entry system, an integral part of the analog, mixed-signal and mixed-system design automation tool suite.

IBIS2SPICE Converter will be included free of charge with the following software packages: Test Designer, ICAP/4 Professional, ICAP/4Windows Power Deluxe, ICAP/4Windows RF Deluxe and ICAP/4Windows, in Intusoft's upcoming

ICAP/4 software release in Q3 of 2004. For Intusoft customers currently on maintenance with any of the above packages, IBIS2SPICE Converter can be downloaded at no charge from the technical support page at: http://www.intusoft.com/support.htm. For all others, a former version is available at no cost from: http://www.intusoft.com/utilities.htm.

www.intusoft.com

		Companies in th	Companies in this issue	
Company	Page	Company	Page	
ABB Lyon	49	Fairchild	1,4,12,52	
ABB Switzerland	1	Freescale		
Allegro MicroSystems	1	Hitachi		
Analog Devices	1	International Rectifier	C4	
Anagenesis	1	International Rectifier		
Ansoft	11	Intersil		
Ansoft	1,4	Intersil		
APEC	31	Intusoft		
Advanced Power Technology	24	iSuppli		
Asvanced Power Technology	51	LEM		
Artesyn Technologies	1,49	Linear Technology7,	26,37,38,39,40	
CT-Concept Technology	13	Linear Technology	1,47,51	
Danfoss	48	Mircel	<b>21</b>	
eupec	9	Microsemi		
eupec	1	Mitsubishi		
Electronica	C3	National Semiconductor	1,10,44	
Fairchild	C2	Ohmite		

#### Companies in this issue

9	Company	Page
	Ohmite	1
	On Semiconductor	1
	Power Systems Design Europe	36
	Power Integrations	45
	Power Integrations	50
	Raychem Circuit Protection, Unit	of
	Tyco Electronics	46
	Renesas	6
	Semikron	1,6
	SynQor	1
	STMicroelectronics	32
	Tektronix	6
	Texas Instruments	15
	Texas Instruments	4
	Tyco Electronics	1
	Westcode	4
	Zetex	6

## **Fit for electronics** New Munich Trade Fair Centre, November 9–12, 2004

## electronica 2004

21st International Trade Fair for Components and Assemblies in Electronics

## a)Ufi

Organizer: Messe München GmbH Messegelände, 81823 München, Germany Hotline: (+49.89) 949-11458 E-mail: info@electronica.de

BEING FIT FOR BUSINESS means more just than having a well-trained body. The mind, know-how and optimum innovative performance are indispensable if you want to stay on the ball with investments. The most important trade fair for components, systems and applications gives you a future-oriented training platform in every discipline. So start your fitness program now at electronica.de or at the global-electronics.net portal and enjoy working out at an advance-sale discount.

Success is based on industry fitness. With over 3,000 exhibitors, electronica will make you fit for the industry.





www.global-electronics.net

# GRAB THE WHEEL AND DRIVE YOUR DESIGNS

Transition to Power Electronics With Confidence



for more information call +44(0)20 8645 8015 or visit us at http://auto.irf.com/cp2z Drive your next generation vehicle designs with International Rectifier's innovative power management solutions, designed for the harshest of automotive environments. Whether you are new to electronically driven automotive design or not, International Rectifier can assist and guide you through the transition from electro-mechanical to electronically driven automotive systems with confidence.

At International Rectifier, we have combined over 50 years of experience with our broad range of patented semiconductor technology, software expertise, and applications know-how to bring you the next generation in power management solutions.

Leaders in the automotive industry look to us for our wide array of application-specific solutions, from superior silicon to complete sub-systems, for both 14V and 42V.

#### Leading-Edge Applications

- · Electric Power Steering (EPS)
- Active Integrated Rectifier Regulator (AIRR)
- · Integrated Starter Alternator (ISA)
- · Variable Speed Engine Cooling
- · Active Suspension
- Climate Control (HVAC)

As your next design challenge rounds the bend, look to International Rectifier to help you transition to electronically driven automotive with confidence.

# International

THE POWER MANAGEMENT LEADER