

# Distribution Training

„Going for a Greener World with Infineon's Innovative High Performance Solutions“



**Solutions Power steering, fans and pumps**

Automotive Gate Driver ICs

2011

Benno Köppl



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# Agenda

- Low voltage MOS drivers

- Application

- Electric Power Steering

- Application requirements

- TLE7183 / 89

- TLE 7185

- TLE7181 / 82

- HVAC and Engine cooling fan

- Application requirements

- TLE7184

- Fuel pump

- Application requirements

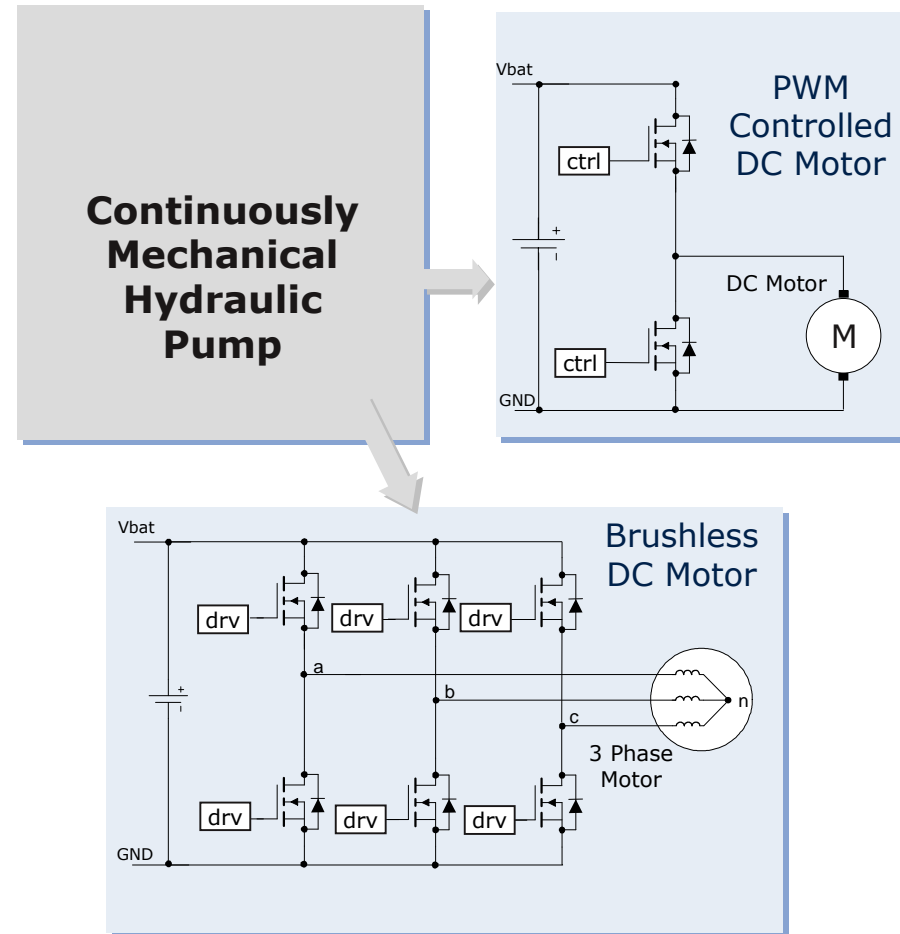
- TLE7185

# Power on Demand Electric Power Steering



- Demand oriented torque controlled electric motor
- Reduced Average Power Consumption down to 50W
- Technologies available

**Total Equivalent Electric  
Power Saving ~ 250 W**



**CO<sub>2</sub>-reduction ~ 5.9 g/km**

# Application requirements Power Steering

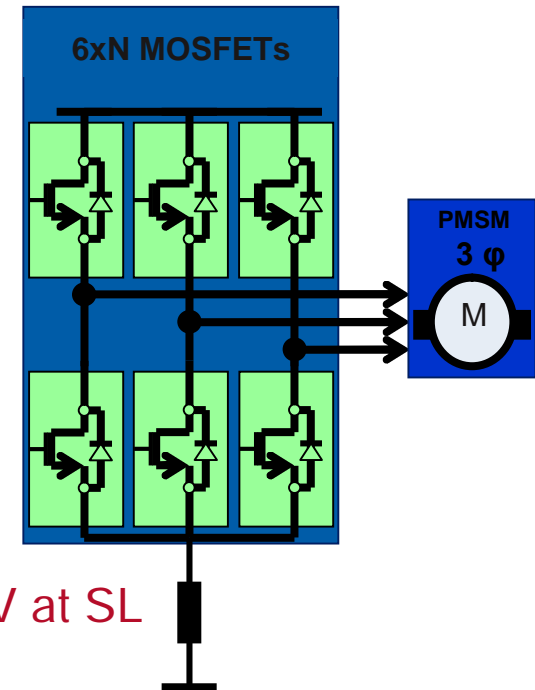
- Basic requirements to power stage
  - 3-phase motor drive
  - Field oriented control
  - up to 200A phase current
  - mostly 12V application
  
- Trends
  - has to work at lower supply voltages
  - only one shunt for current measurement
  - increasing accuracy of current measurement
  - highest efficient usage of motor (0...100% duty cycle)
  - fulfill ASIL D safety requirement in application

## ■ 160A B6-Bridge -> Diver Requirements

- powerful output stage up to 1.5A
- Robust to positive and negative spikes +/-7V at SL
- Separate Source connections 4
- Floating output stages 4



**TLE7183 / 89 / 85**



# Application requirements Power Steering

## ■ Current measurement

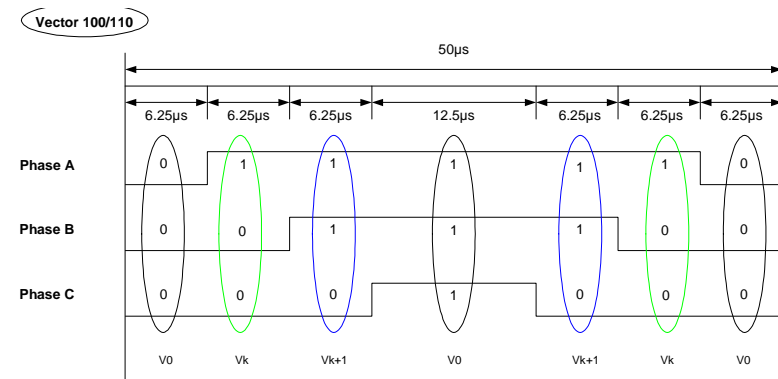
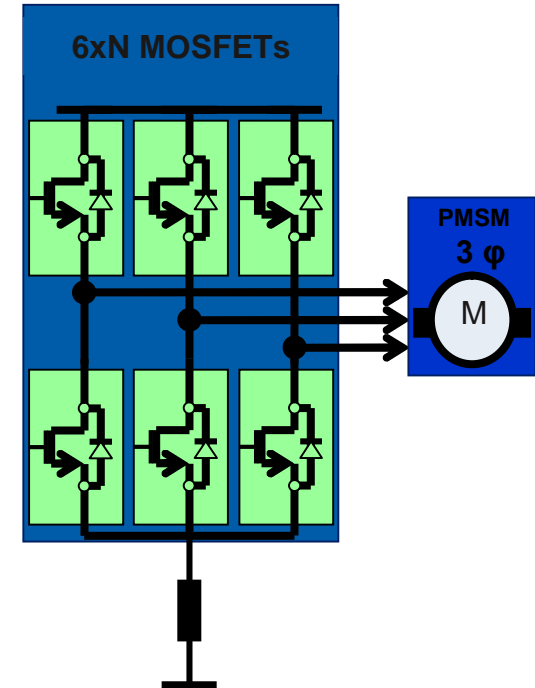
- Only one shunt for cost reasons
- very short time to measure current
- increasing accuracy requirements
- high current in application lead to negative spikes at shunt

## ■ OpAmp requirements

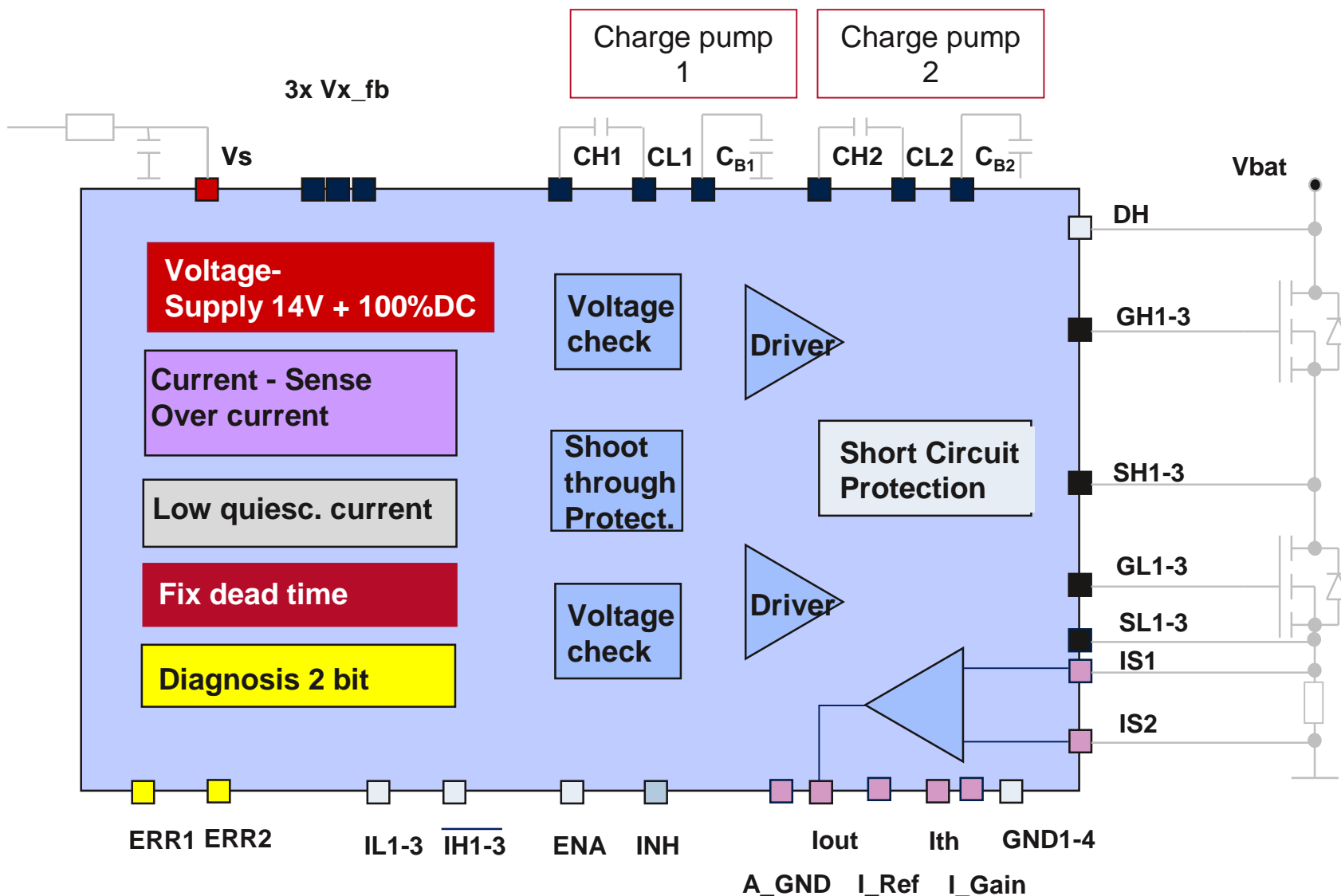
- input range +/-5V spikes 4
- high bandwidth typ. 20 MHz UGBW
- low input offset down to +/- 1.5mV
- high CMRR > 60db minimum



**TLE7183 / 89**

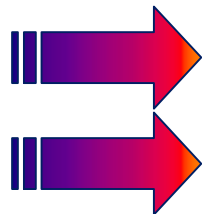
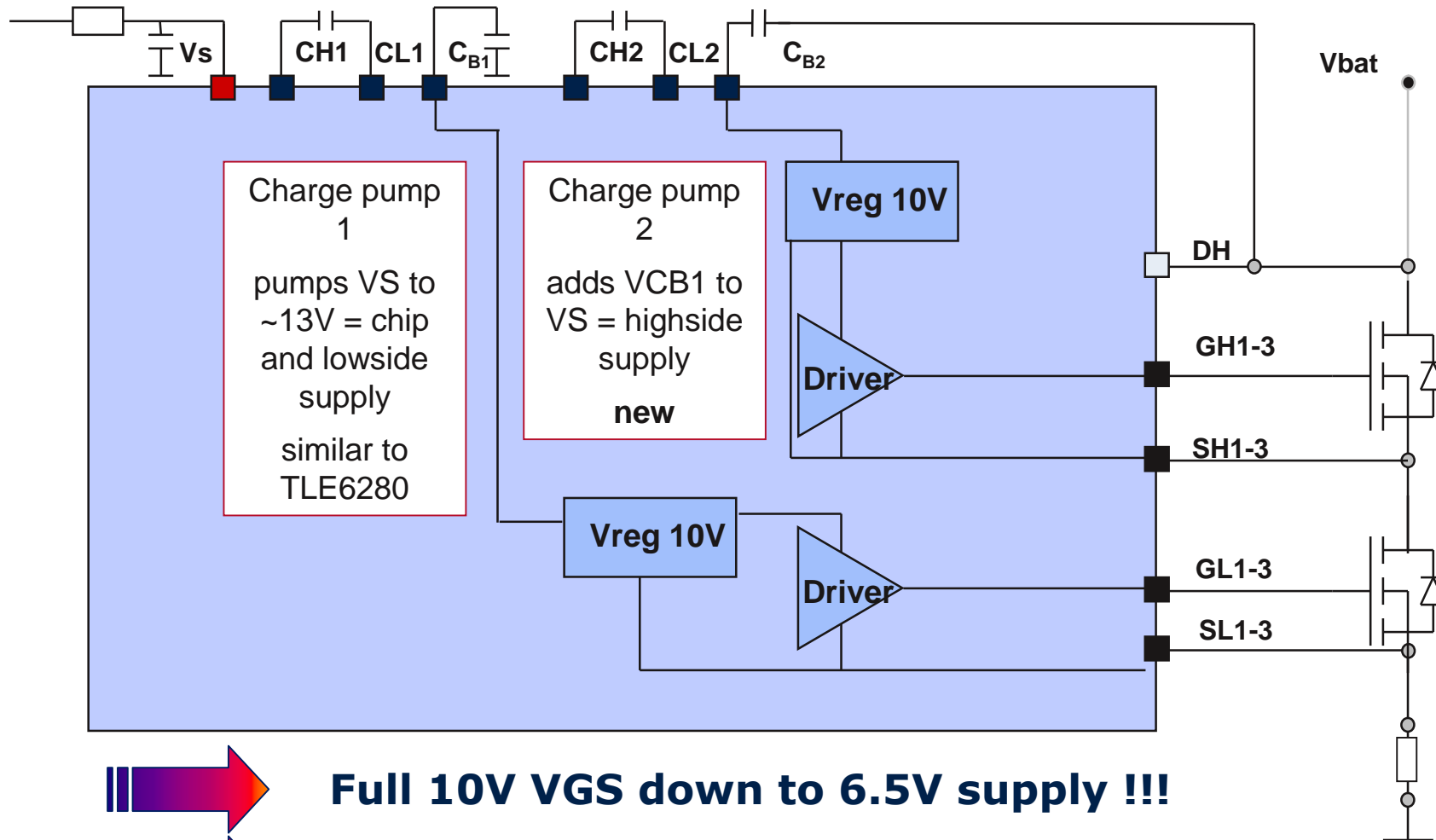


# TLE7183F 3-Phase Driver IC for 12V



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# TLE718xF 3-Phase Driver IC for 12V



**Full 10V VGS down to 6.5V supply !!!**

**0 – 100% without limits**

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# TLE718xF

## Gate voltages at low supply voltages

For internal use only!



### Conditions:

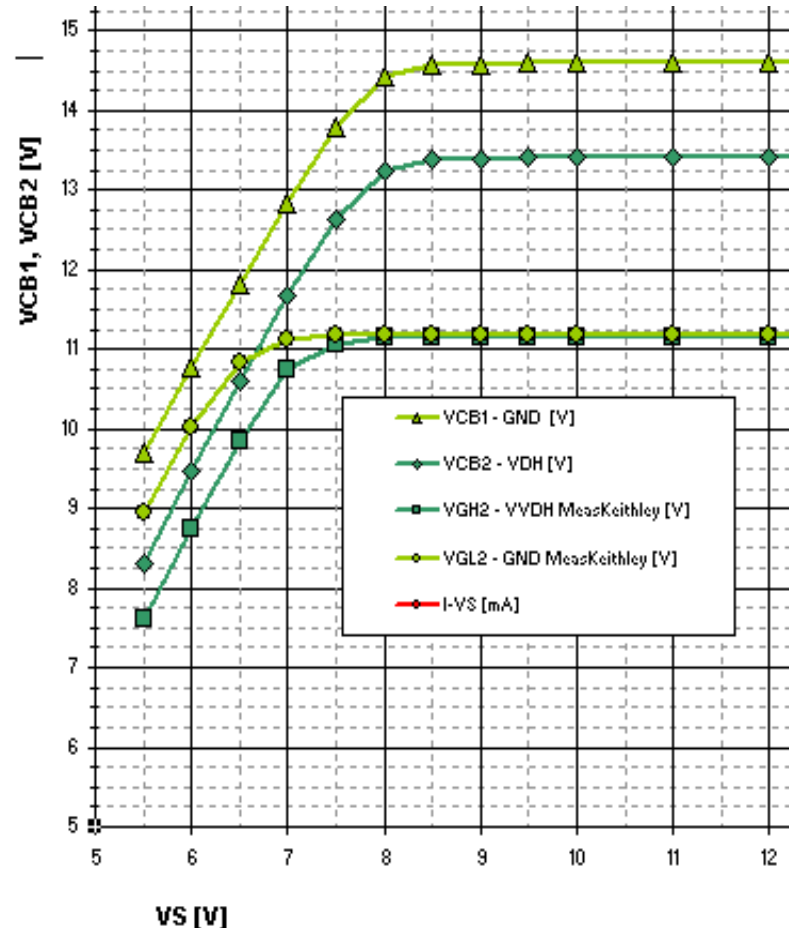
$V_S = 5.5 \dots 12 \text{ V}$

$Q_G = 130 \text{ nC}$

$f = 20 \text{ kHz}$

(Max. UV limit on CB1: 8.3 V)

0...100% duty cycle



full supply voltage reaches motor



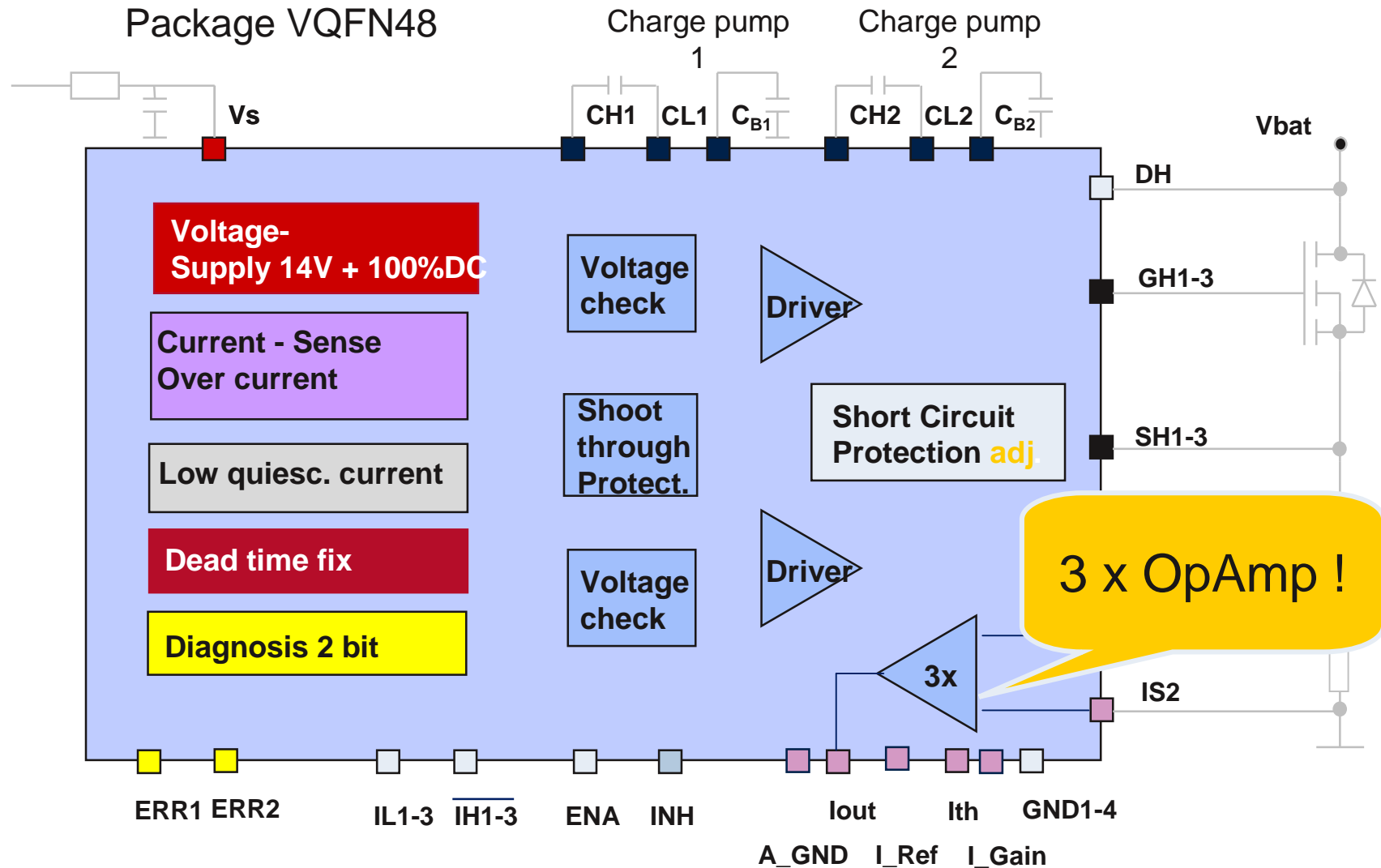
highest efficient usage of motor (costs + space)

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# TLE7189F

## 3-Phase Driver IC for 12V



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## Philosophy

**Add ProSIL features to existing product:  
"sleeping bug is excluded by repeated testing"**

- ⇒ **VCC check (monitors the uC supply)**
- ⇒ **Test function for VCC check**
  
- ⇒ **SC-Detection (monitors short circuit of MOSFET)**
- ⇒ **Test function for SC-Detection at 0A**
  
- ⇒ **High voltage inputs (18V)**
  
- ⇒ **"Common mode failure analysis" (FTA) available, tailored to the FMEA and the FTA of the target system**

# TLE7185

## Simplified 3-phase driver IC



### ■ Features

- B6 MOS Bridge driver
  - ~10 Ohm output stages for MOSFETs up to 100A
  - 0-95% duty cycle (bootstrap principle)
  - Adj. Short circuit detection level 0.3-2V
  - Adj. Dead time
  - Low quiescent current mode 20uA
  - 2 bit diagnostic
  - Separate Source pin for each MOSFET
  - Functional range 5.5 to 33V
- Charge pump to boost the supply voltage
- P-DSO36-Exposed pad allows TA up to 140°C



**Optimized for applications running  
at 5.5V supply**





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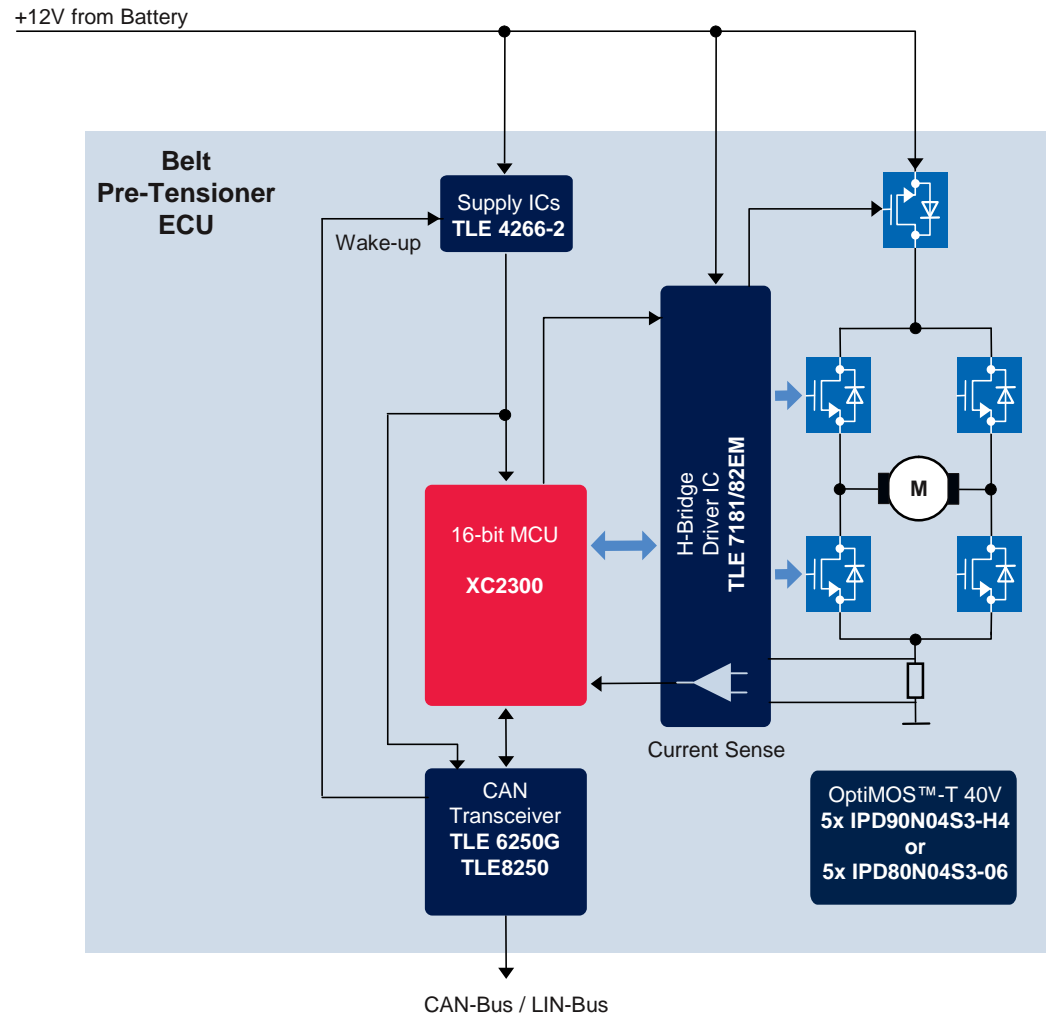
# Bridge Driver ICs -Electric Power Steering Features overview



low cost

features	TLE6280GP	TLE 7183F	TLE 7189F	TLE 7185E
Supply voltage (operation)	8...30V	5.5 ... 28V (CP)	5.5 ... 28V (CP)	5.5 ... 32V (CP)
Duty cycle	0...95% (bootstrap)	0...100% (CP)	0...100% (CP)	0...95% (bootstrap)
Low quiescent mode	No	Yes	Yes	yes
OpAmps	-	1	3	-
Adjustable Dead time	yes	yes	fix	yes
Adjustable short circuit detection level	yes	5 fixed options	yes	yes
SIL 3 features	no	no	yes	no
Used in SIL3 applic.	Yes	Yes	Yes	Yes
Package				

# Electric Power Steering – DC brush Typical ECU Block diagram



 : all products available at ATV

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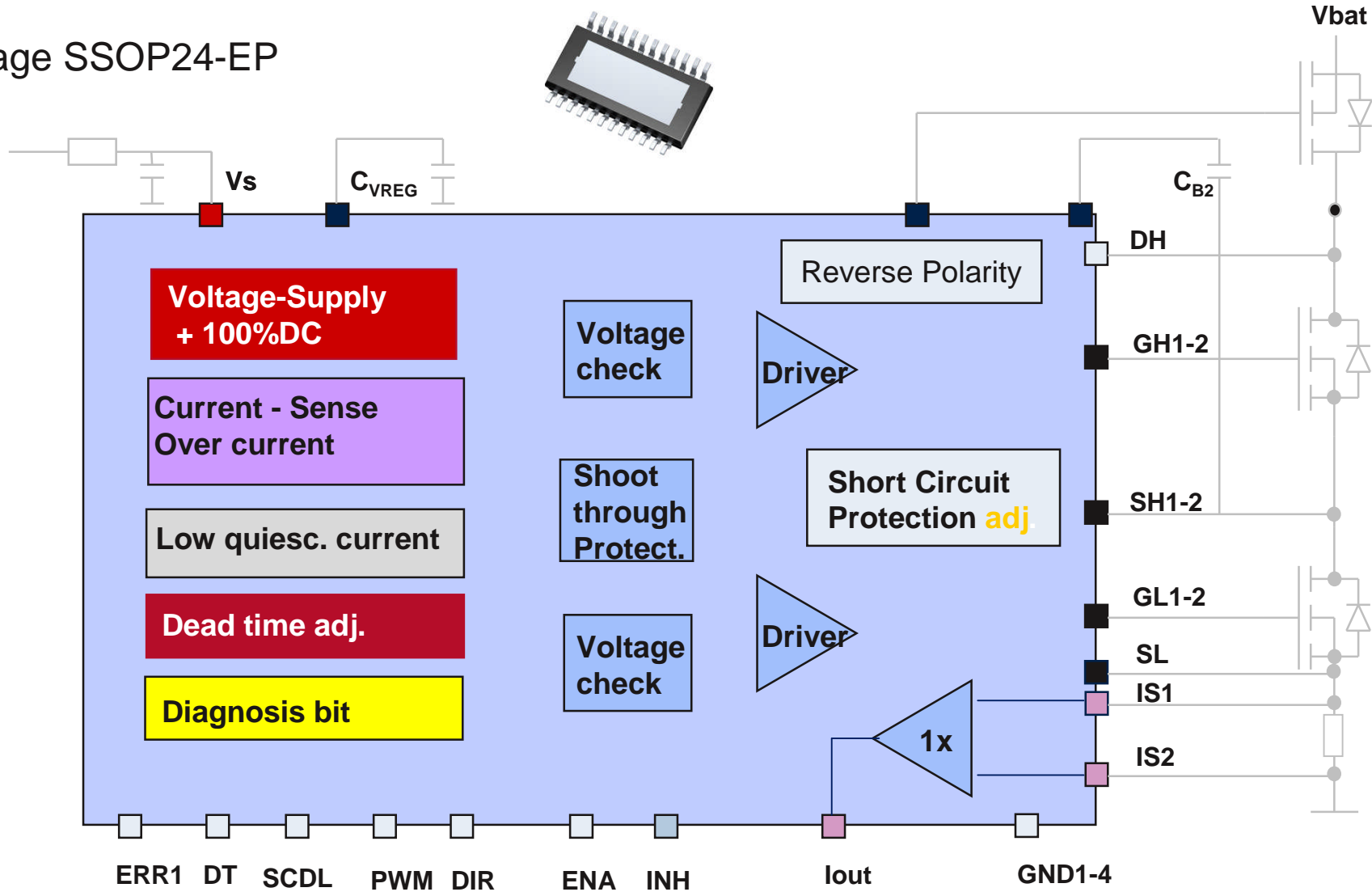
# TLE7182EM

## H-Bridge Driver IC for 12V

In Production



Package SSOP24-EP





# TLE7182EM

## Features



- Output stages of TLE7182EM
  - ~10 Ohm output stages for N-channel MOSFETs
    - Highside stage 0..95%(@20kHz) & 100%
    - Lowside stage 0..100%
  - 4 independent inputs – high flexibility
  - Dead time adjustable
  - Low quiescent current mode  $8\mu\text{A}$   $T_j = 25^\circ\text{C}$ ;
  - supply voltage range: 7.0..34V
- Fast and accurate integrated OPAMP
- Control for reverse polarity MOSFET
- Adj. Short circuit protection
- PG SSOP 24 with exposed pad allows  $T_{\text{ambient}}$  up to  $140^\circ\text{C}$

# Agenda

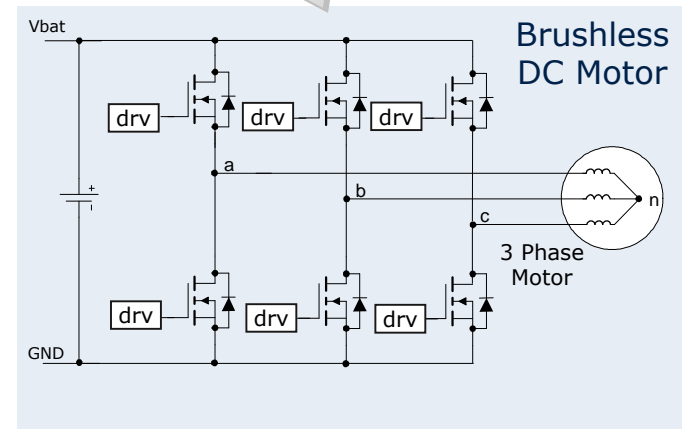
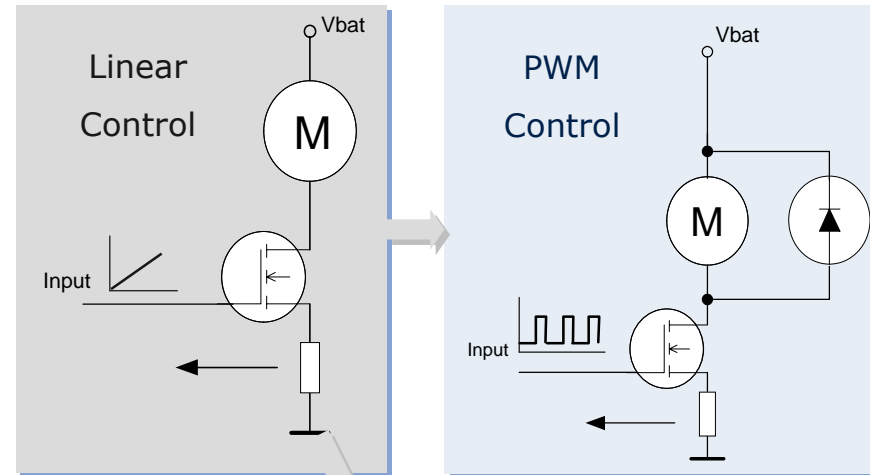
- Low voltage MOS drivers
- Application
  - Electric Power Steering
    - Application requirements
    - TLE7183 / 89
    - TLE 7185
    - TLE7181 / 82
  - HVAC and Engine cooling fan
    - Application requirements
    - TLE7184
  - Fuel pump
    - Application requirements
    - TLE7185

# HVAC System has Huge Saving Potential PWM Controlled Blower Fan



- Blower Control via PWM
- Drastically Reduced Power Losses
- Technologies available

**Total Power Saving ~ 80 W**



**CO<sub>2</sub>-reduction ~ 1.9 g/km**

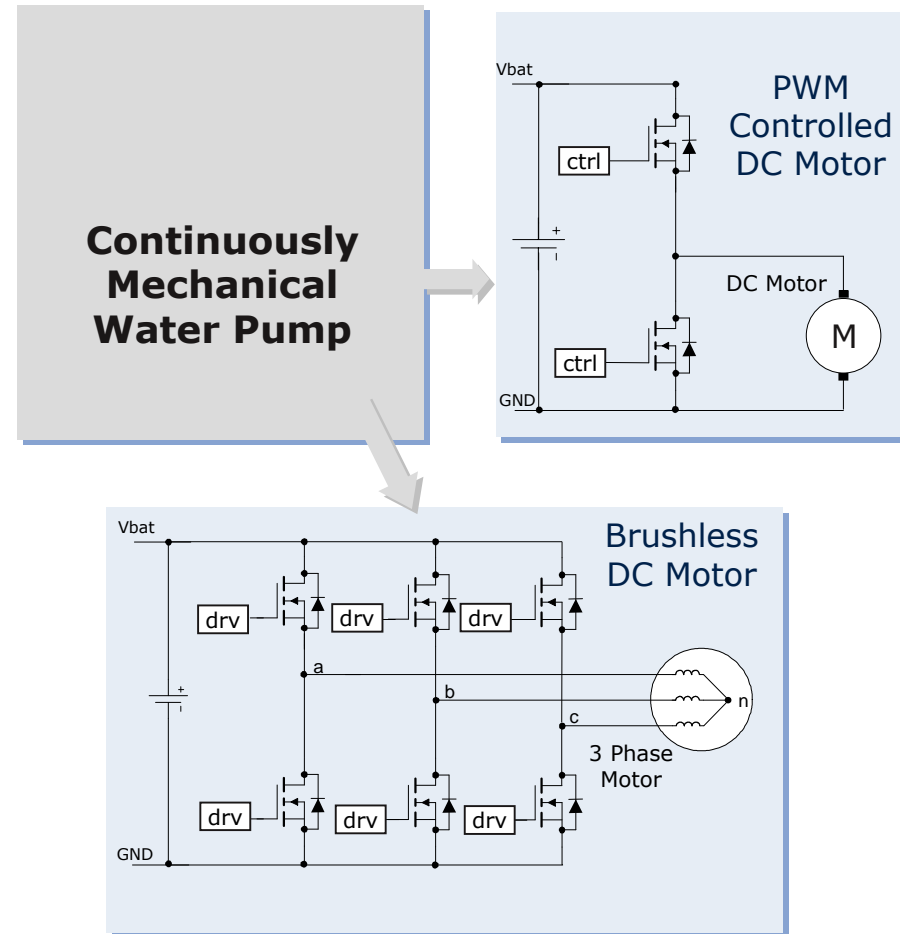
Comparison against linear controlled motor with huge power losses

# Power on Demand PWM Regulated Water Pump



- Electric motor driven and demand controlled by PWM
- Reduced Average Power Consumption down to 15W
- Technologies available

**Total Equivalent Electric Power Saving ~ 300 W**



**CO<sub>2</sub>-reduction ~ 7.1. g/km**

# HVAC

## General statements

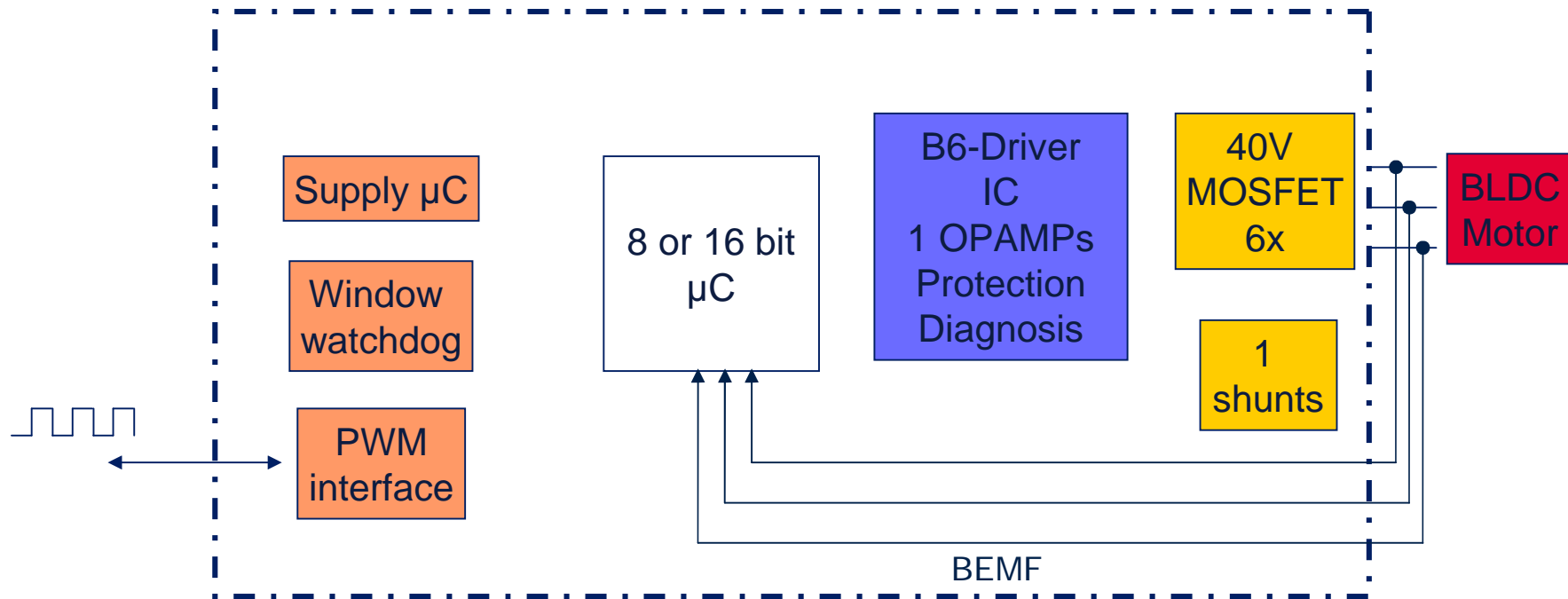


- Main Solution
  - DC Brush motor with linear control -> (Planar MOSFETs)

or

- DC Brush motor with PWM control -> Trench MOSFETs
- Main trend
  - Main trend DC Brush with PWM
  - Trend to BLDC
    - In use 250W....450W for high end cars
    - Silence drives in luxury cars
    - High maintenance costs (>8h workshop)
    - Reduced EMC

# HVAC fan and Engine Cooling Fan General block diagram BLDC



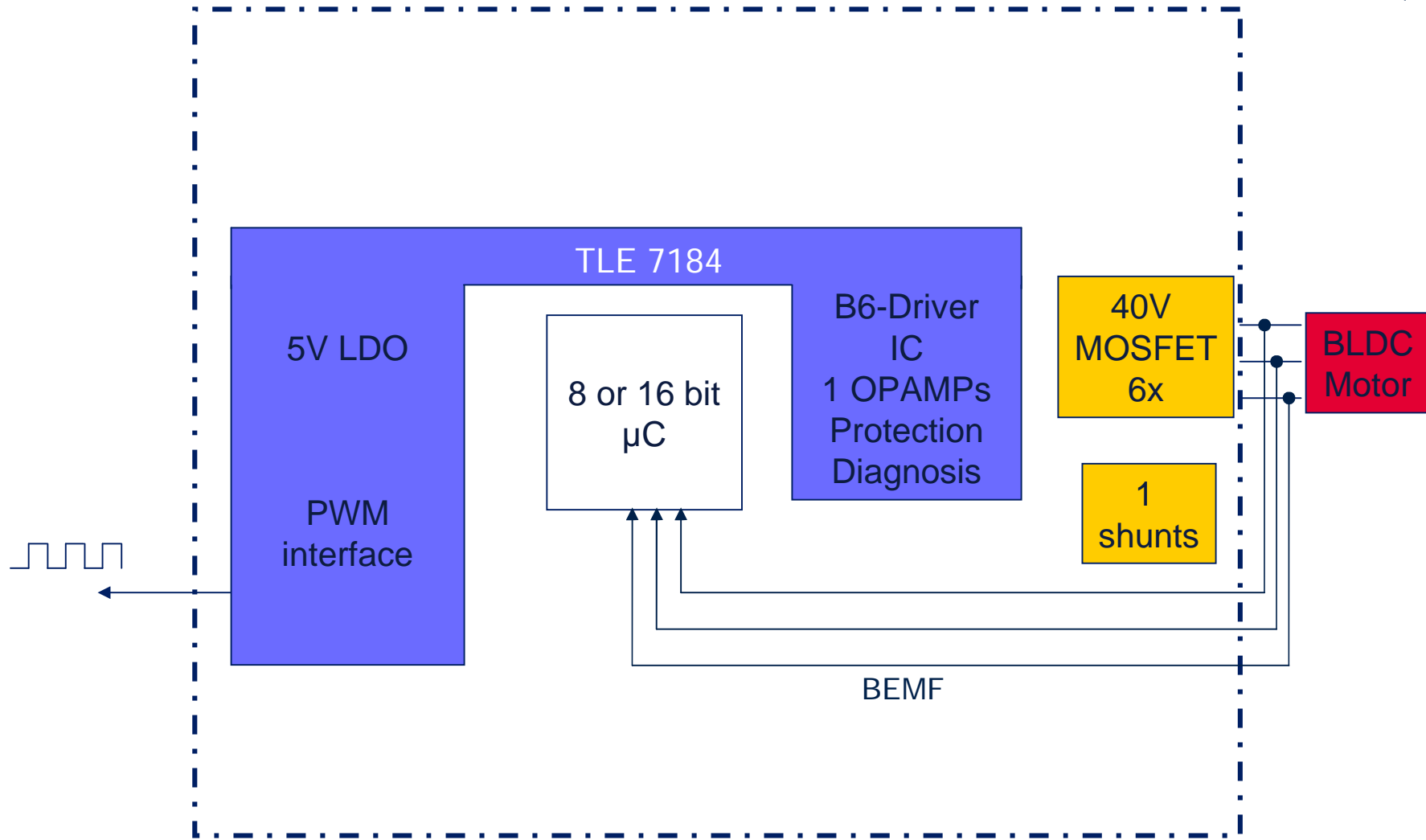
## ■ Variations

- Current sense: 1 phase or none
- Rotor position: 1-3 Hall or BEMF
- Interface: PWM (Majority) or LIN or CAN
- Supply: Dependent on uC – mostly 5V

# BLDC Drive for Fans and pumps TLE7184



In Production



# Application requirements HVAC / Engine cooling fan

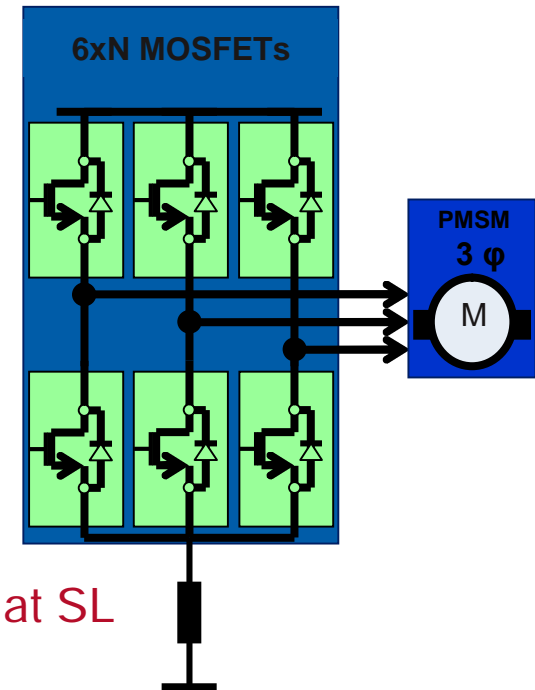


## ■ 50A B6-Bridge -> Diver Requirements

- less powerful output stage 10 Ohm
- Robust to positive and negative spikes +/-7V at SL
- Floating output stages 4
- Moderate Price 4



**TLE7184**





# Application requirements HVAC / Engine cooling fan



## ■ Current measurement

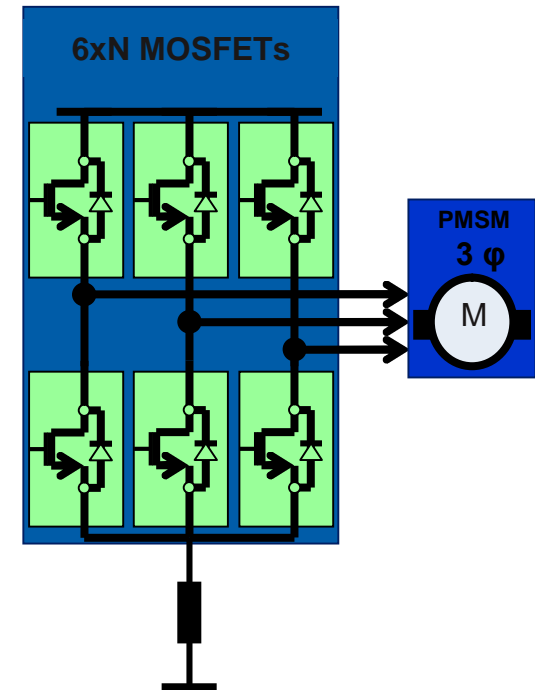
- Only one shunt for cost reasons
- very short time to measure current
- Medium current + low cost power bridge lead to negative spikes at shunt

## ■ OpAmp requirements

- input range +/-5V spikes 4
- high bandwidth typ. 20 MHz UGBW
- low input offset down to +/- 2mV
- high CMRR > 60db minimum



**TLE7183 / 84 / 85**



# Application requirements HVAC / Engine cooling fan



## ■ Low cost approach / less space

- Integration of VREG for uC
- relatively high accuracy for current / temperature measurement

## ■ VDD regulator

- Low drop regulator 4
- support of 8 and 16 uC up to 70mA
- 5V 4
- Sufficient accuracy 2% 5...25mA 3% 5...70mA



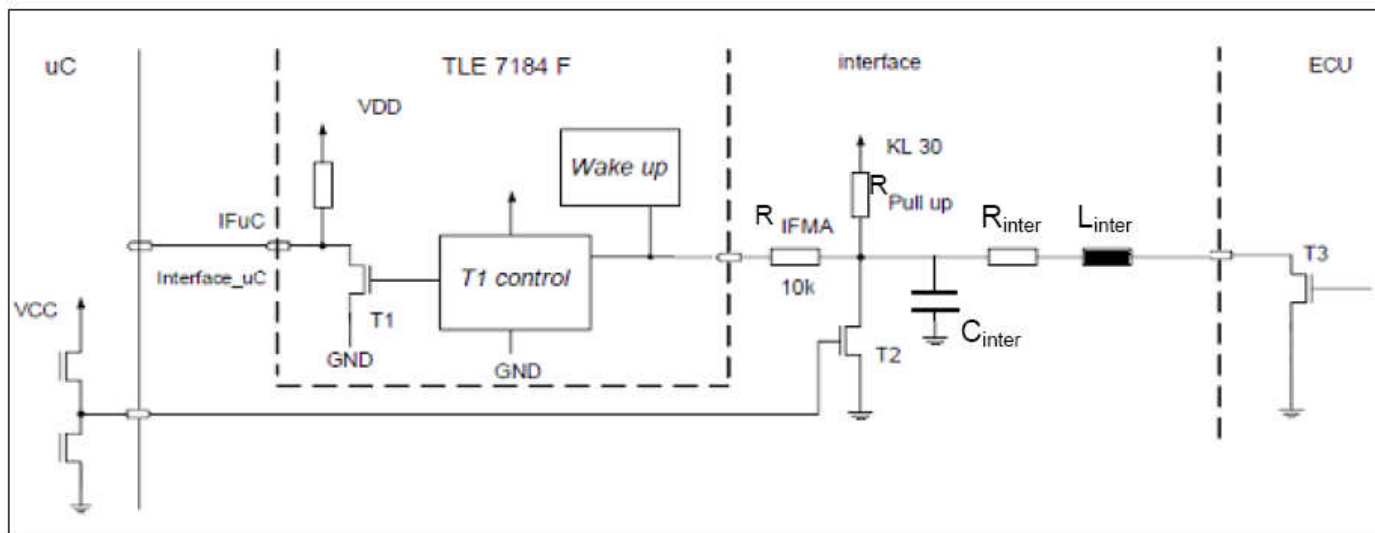
**TLE7184**

# Application requirements HVAC / Engine cooling fan



## ■ Interface

- Low cost interface 400Hz PWM 4
- Capability of 19.2 kbaud flash mode 4



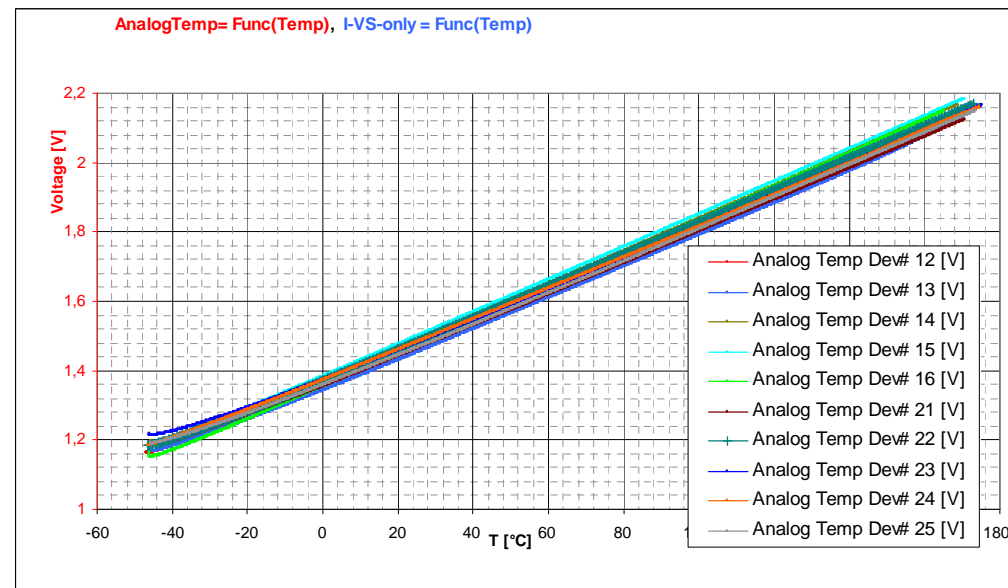
- Switch T2 for bi-directional communication not integrated because
  - bi- directional mode not always needed
  - GND shift requirement of -6V makes external solution cheaper

# Application requirements HVAC / Engine cooling fan



## ■ Temperature Measurement

- Very important in these applications for
  - Control strategy of cooling fan
  - Protection of MOSFETs



## ■ Integration of two sensors

- Analog temperature sense (single point calibration recommended) 4
- Digital over-temp warning 4

## ■ **Optimized logic**

### ■ Allows operation in application controlled by

- only interface (wake up on bus) 4
- only KL15 (wake up on key) 4
- mixed operation 4

### ■ Secures IC against thermal cycling even without interference of any uC

- Dead lock mode 4

### ■ Allows uC controlled after-run 4

# BLDC Drives

## ASSP- Approach TLE7184



- Features
  - B6 MOS Bridge driver
    - ~10 Ohm output stages for MOSFETs up to 100A
    - Works down to 7V
    - OpAmp (UGBW 20Mhz / <1.5mV)
    - 0-94% duty cycle (bootstrap principle)
    - Protection functions
  - 5V 70mA LDO to support 8 and 16bit uCs
  - PWM interface
  - Precise analog and digital temperature sense
  - Specific Logic
  - VDH switch (disconnects circuit from battery – sleep mode)



**Simplified ECU for BLDC Motors**



**Features optimized for HVAC and cooling fan applications**

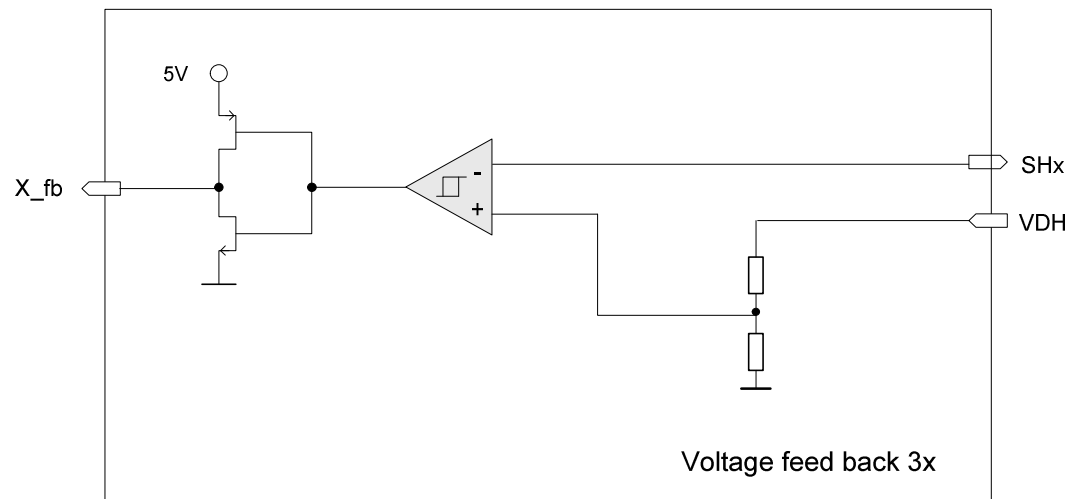
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# BLDC Drives ASSP- Approach TLE7186



- Features
  - same as TLE7186
  - U V W voltage feedback additional






**Simplified Single shunt current sensing**



**Helpful for BEMF Detection**

# Bridge Driver ICs- HVAC / Engine cooling fan Features overview



features	TLE 7183F	TLE 7184F	TLE 7186F
Supply voltage (operation)	5.5 ... 28V (CP)	6 / 7 ... 32V	6 / 7 ... 32V
Duty cycle	0...100% (CP)	0...94% (bootstrap)	0...94% (bootstrap)
Low quiescent mode	Yes	Yes	yes
OpAmps	1	1	1
5V LDO for uC	no	yes	yes
PWM interface	-	yes	yes
VDH switch	-	yes	yes
Dual temperature sense	-	yes	yes
Special logic	-	yes	yes
UVW feedback	-	-	yes
Package			



# Agenda

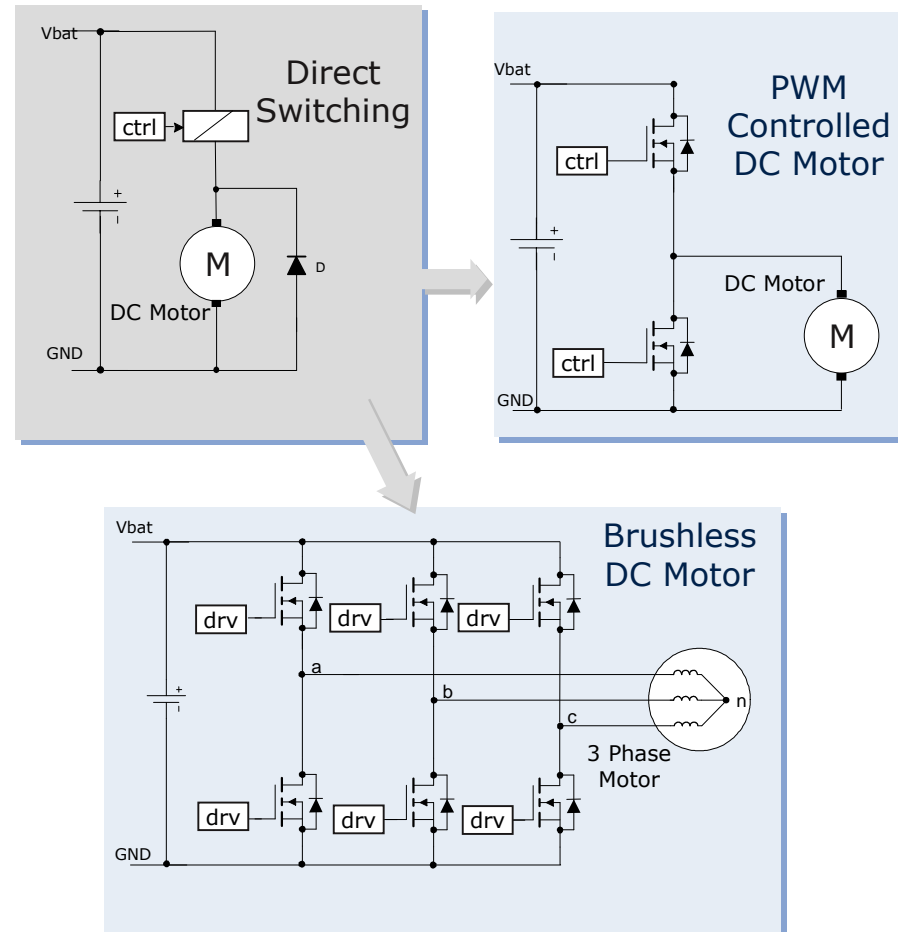
- Low voltage MOS drivers
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- Fuel pump
  - Application requirements
  - TLE7185

# Power on Demand PWM Regulated Fuel Pump



- Electric motor driven and demand controlled by PWM
- Reduced Average Power Consumption up to 40 %
- Technologies available

**Total Power Saving ~ 80 W**



**CO<sub>2</sub>-reduction ~ 1.9 g/km**

# Power on Demand PWM Regulated Fuel Pump



- Has to run at low battery voltages 5,5V and below
- 100 to 250W
- Mainly DC-brush
- Small trend to BLDC

Source : Continental

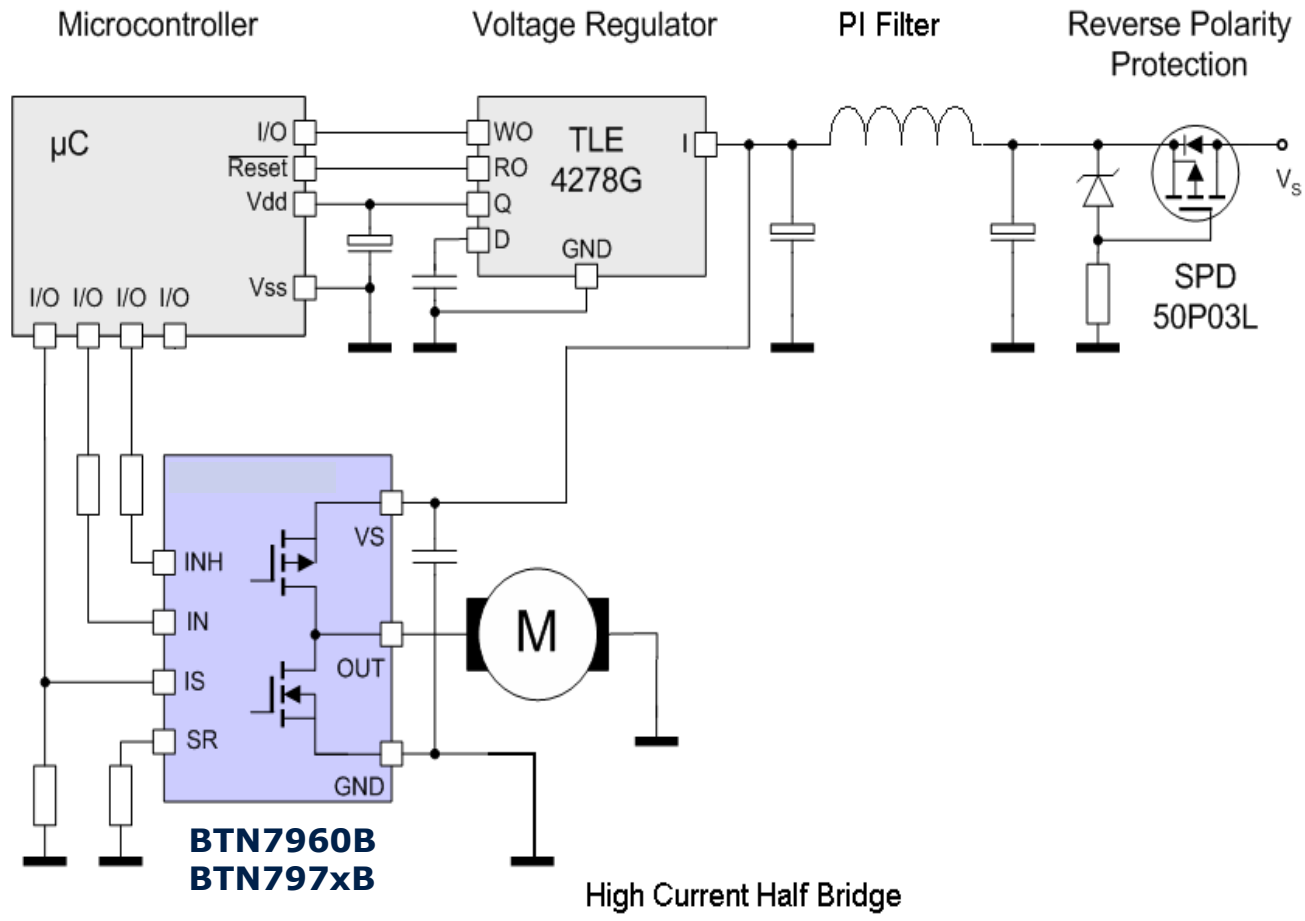
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# NovalithIC Typical halfbridge - Application Circuit



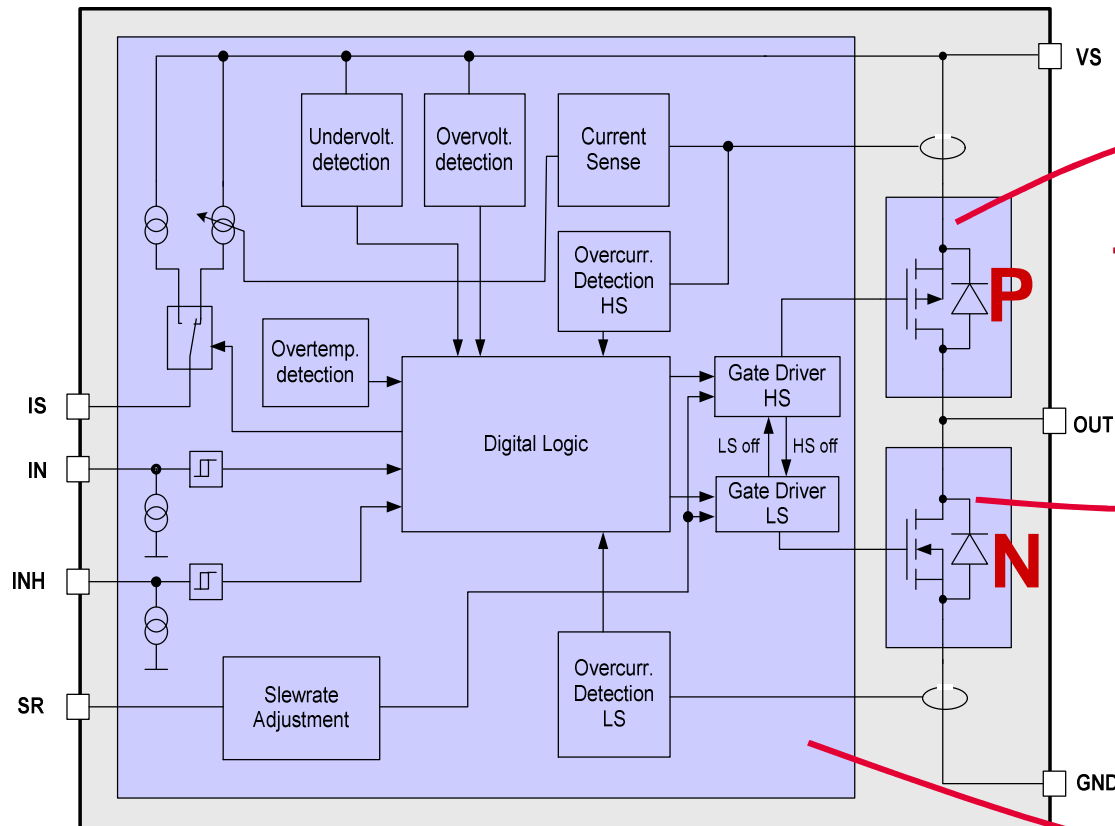
Fuel Pump



# Integrated protected Half Bridge – NovalithIC Concept



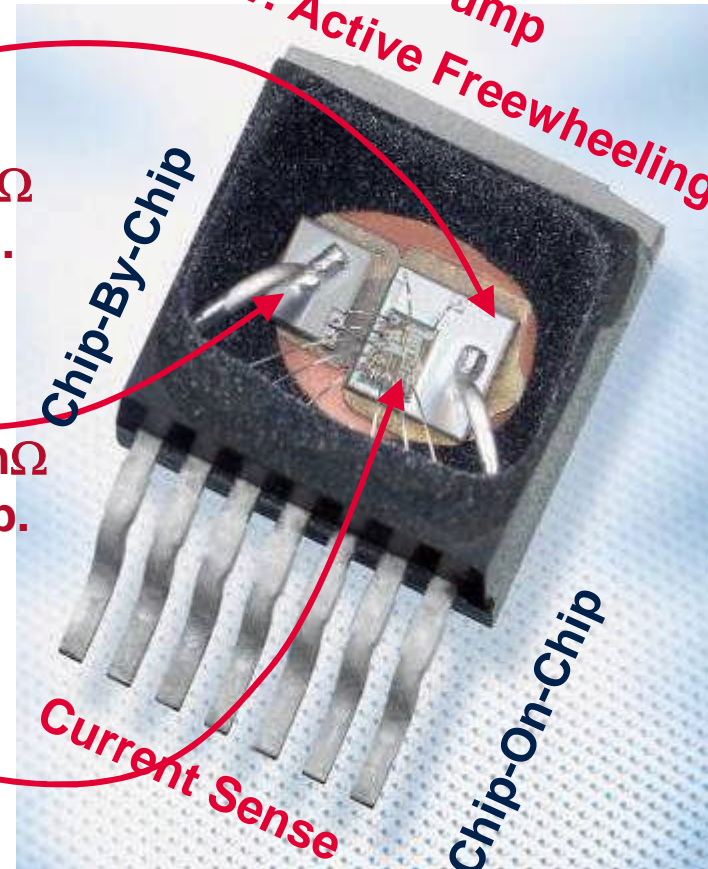
## BTN797xB



**25 kHz PWM w. Active Freewheeling**  
**No Charge Pump**

**7 mΩ typ.**

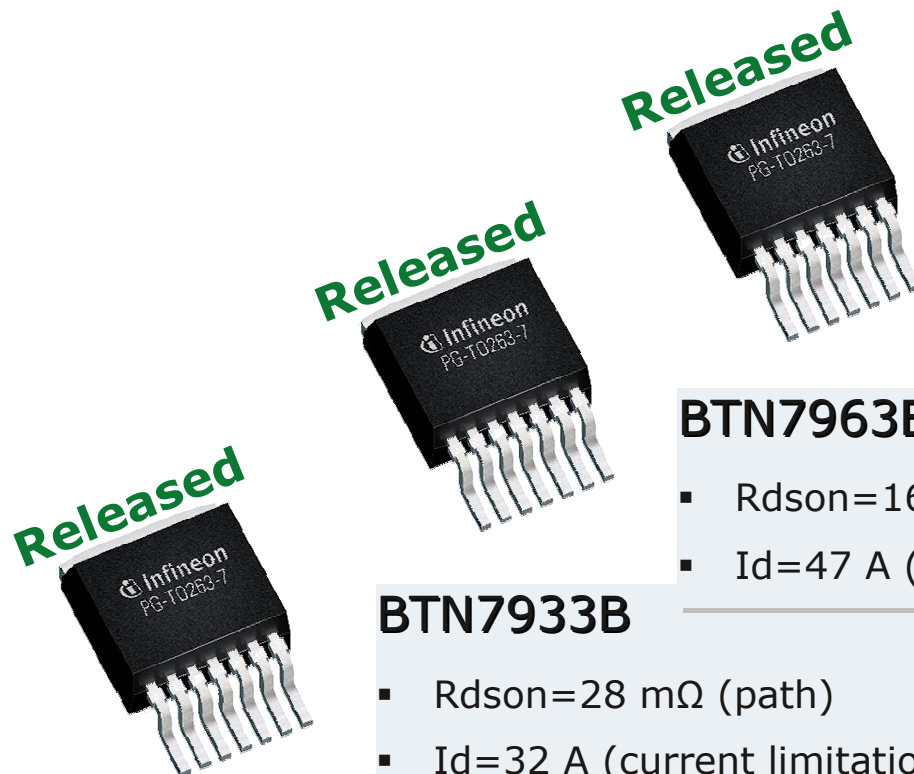
**9 mΩ typ.**



**Current Limitation ~70A typ. / 50A min. (low side)**

# Enhanced *NovalithIC*<sup>TM</sup> family

- 👍 40% reduced switching losses
  - ⇒ Enhanced switching speed for reduced switching losses (rise/fall times down to typ. 600ns)
- 👍 Extended operating voltage range down to 4.5 V
- 👍 Optimized for half-bridge applications
  - ⇒ **“Smart clamping”** in overvoltage



## BTN7973B

- $R_{dson}=16\text{ m}\Omega$  (path)
- $I_d=70\text{ A}$  (current limitation)

## BTN7963B

- $R_{dson}=16\text{ m}\Omega$  (path)
- $I_d=47\text{ A}$  (current limitation)

## BTN7933B

- $R_{dson}=28\text{ m}\Omega$  (path)
- $I_d=32\text{ A}$  (current limitation)

all values  
typ. @ 25°C

# TLE7185

## Simplified 3-phase driver IC



### ■ Features

- B6 MOS Bridge driver
  - ~10 Ohm output stages for MOSFETs up to 100A
  - 0-95% duty cycle (bootstrap principle)
  - Adj. Short circuit detection level 0.3-2V
  - Adj. Dead time
  - Low quiescent current mode 20uA
  - 2 bit diagnostic
  - Separate Source pin for each MOSFET
  - Functional range 5.5 to 33V
- Charge pump to boost the supply voltage
- P-DSO36-Exposed pad allows TA up to 140°C



**Optimized for applications running  
at 5.5V supply**

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