

Low power motor control board featuring **SLIMMTM NANO STGIPN3H60** and MCU **STM32F100C6T6**

Industrial & Multi-Market Competence Center
& Power Transistor Division

STEVAL-IHM036V1 evaluation board



I&MMCC & PTD
Daniel Kohout
November 14, 2011

Target Applications



- General purpose 3-phase inverter for 3-phase permanent magnet synchronous motors with vector field oriented control for output power up to 100W.
- Inverter for high efficiency circulating water pump for heating systems in single-family houses
- High efficiency drain pump for home appliance white goods, like dishwashers and washers
- High efficiency and reliable solution for small power transfer pumps for waste sludge – sewerage plants in single-family houses, waste piping
- High efficiency transfer pumps for outlet condensation water
- High efficiency exactor hoods and blowers for gas furnace application
- Compressor drives for fridges

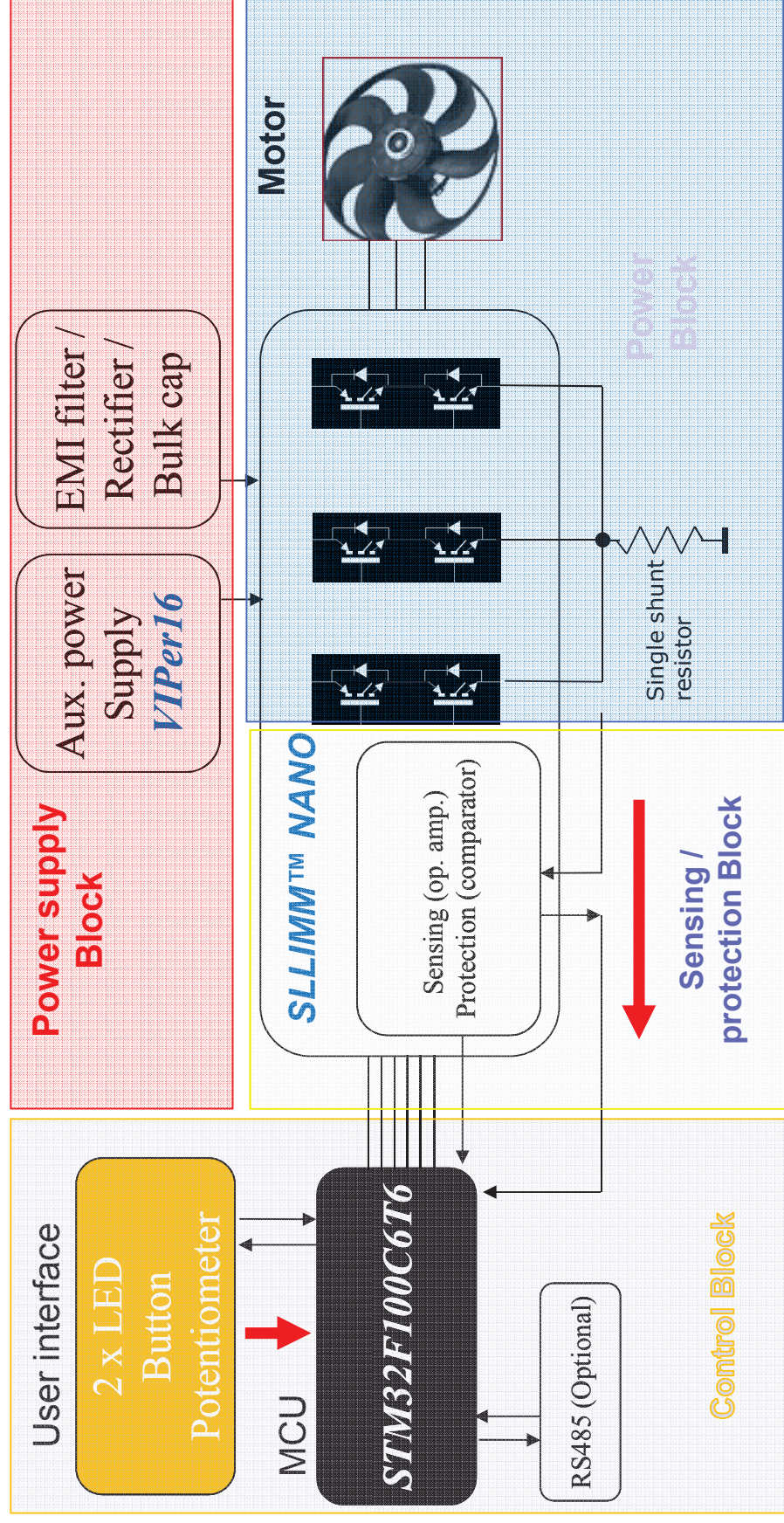


Marketing positioning



- **STEVAL-IHM036V1 evaluation board:**
 - The goal of the **STEVAL-IHM036V1 demonstration board** is to present an design consisting in a **3-phase inverter bridge** based on 600V, 3A small loss intelligent molded module STGIPN3H60 and STM32F100C6T6 MCU.
 - The SLLIMMTM NANO itself consist of short-circuit rugged IGBT's and wide range of auxiliary functions like under voltage lockout and smart shut-down.
 - The system has been **designed to for a field oriented control** (FOC).

System Architecture



Main Features



- **STEVAL-IHM036V1 main features:**
 - Using IGBT **SLLIMM™ NANO STGIPN3H60** in NDIP-26L molded package
 - **Maximum output power** for applied motor **up to 100 W**
 - Single phase power supply: 195VAC to 265VAC, or direct DC line up to +400VDC
 - Input in-rush current limiter controlled by NTC resistor
 - **Based on** STMicroelectronics's ARM™ Cortex-M3 core-based **STM32F100C6T6** microcontroller
 - Single shunt resistor current sensing method
 - Possibility to modify the board by adding RS-485 bus
 - EN55014 (CISPR 14), IEC 61000-4-5 and IEC61000-4-4 compliant
 - Compact and safe design

ST components used in the application



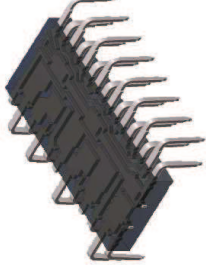
- STEVAL-IHM036V1 bill of material includes:
 - 1 x IGBT SLLIMM™ NANO **STGIPN3H60**
 - 1 x MCU **STM32F100C6T6** microcontroller
 - 1 x PWM SMPS smart driver **VIPer16LD**
 - 1 x Linear regulator L78L33CV
 - 2 x High efficiency power rectifier STTH1L06U
 - 2 x Small signal schottky diode BAT48JFILM
 - 1 x Bus driver ST485EB (N.A.)

Why STGIPN3H60 SLLIMM™ NANO



- Why STGIPN3H60:

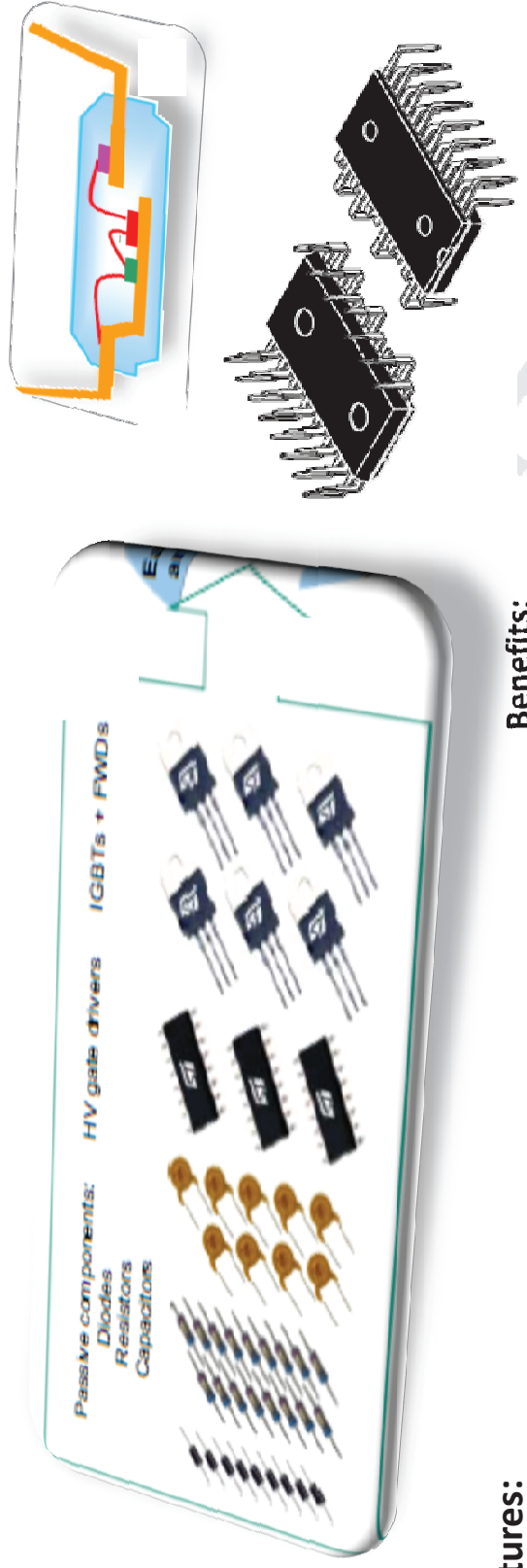
- 600 V, 3A 3-phase IGBT inverter bridge including control ICs for gate driving and freewheeling diodes
- Internal bootstrap diode
- Interlocking function
- Optimized for low electromagnetic interference
- $V_{CE_{SAT}}$ negative temperature coefficient
- Short-circuit rugged IGBT
- Under-voltage lockout
- Fully isolated package
- Smart shut down function
- Op-amps for advanced current sensing
- Comparators for fault protection against over temperature and over current



- A good alternative to promote:

- STGIPN3H60 A - The same IGBT's, no extra feature available (Op.Amp., comparator)

SLLIMMTM-nano for low power motor control up 100W



Main features:

- 600 V 3-phase IGBT inverter bridge including control ICs for gate driving and ultra - soft fast recovery freewheeling diodes
- Dead time and interlocking function
- Internal bootstrap diode
- 3.3V, 5V and 15V CMOS/TTL compatible inputs
- Smart shutdown function
- Integrated comparator for fault protection against over current and short-circuit
- Integrated Op-amp for advanced current sensing

Benefits:

- Improved design time,
- Reduced manufacturing efforts,
- Increased reliability and quality level.
- Maximized efficiency, reduced EMI and noise
- Higher level of protection and lower propagation delay time.
- Small form factor (PCB space reduction)

Why VIPer16L



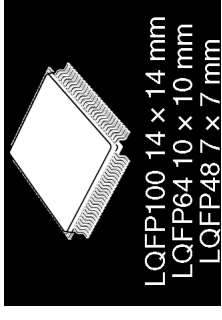
- Why VIPer16L:
 - 800 V avalanche rugged power section
 - Relative simple design
 - Operating frequency 60kHz
 - Hysteretic thermal shutdown
 - Limiting current with adjustable set point
- A good alternative to promote:
 - VIPer06 - When less power is required
 - VIPer26 - When higher power is required ($> 200 \text{ mA}$)



Why STM32F100C6T6



- Why STM32F100C6T6 :
 - Low & medium-density value line, advanced ARM-based 32-bit MCU
 - LQFP48 7 × 7 mm package
 - Core: ARM 32-bit Cortex™-M3 CPU
 - 2.0 to 3.6 V application supply and I/Os
 - 32 Kbytes of Flash memory
 - Temperature range from -40 to 85°C
- A good alternative to promote:
 - STM32F100x8 or STM32F100xB, if larger Flash memory is requested



For Sales and Marketing



STEVAL-IHM036V1

Low power motor control board STEVAL-IHM036V1 featuring SLLIMM™
STGIPN3H60 and MCU STM32F100C6T6

Targeted to dishwasher, washer and dryer drain pumps, fridge

compressors, extractor hood fans and heating recirculation pumps

Single phase connection – input supply voltage from 195VAC to 265VAC

Possibility to use single supply or dual supply mode

For dual supply mode DC supply input from 18VDC to 400VDC

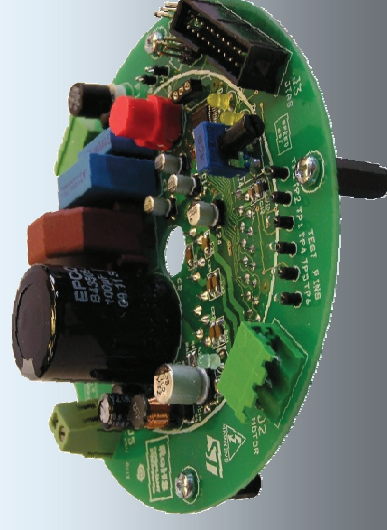
Complete motor control platform for output power up to 100W

Compliance with EN55014, IEC 61000-4-5 and IEC 61000-4-4

Over-temperature and over-current hardware protection

Possibility to modify the board with RS-485 interface

Single shunt current reading configuration



 **EVALUATION BOARD**
www.st.com/evalboards



Ordering code: **STEVAL-IHM036V1**

User Manual: **UM1483**

On Stock by end of **Q4/2011** (prototypes available now)

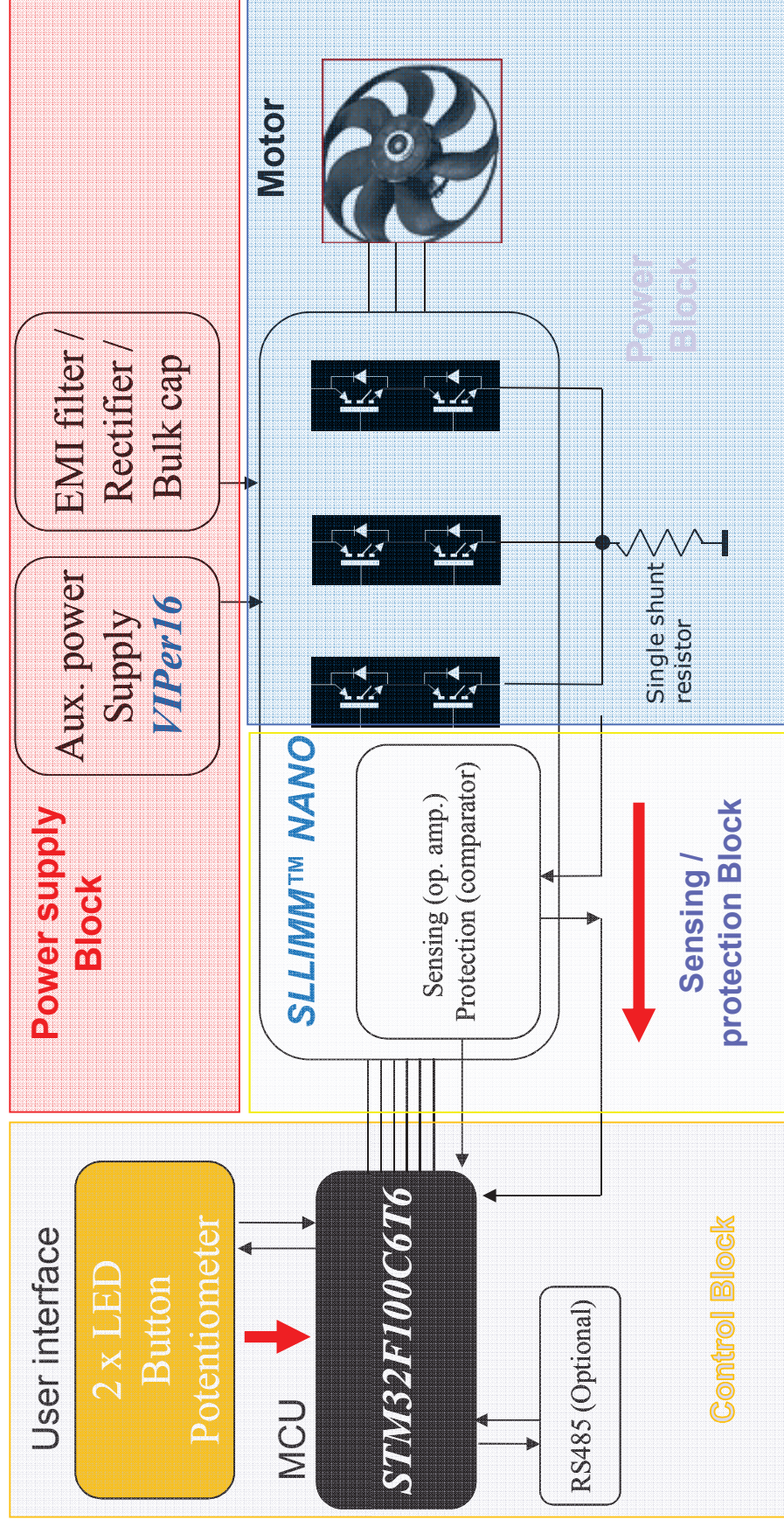
STMicroelectronics

The STEVAL-IHM036V1 evaluation board



Technical Part

System Architecture

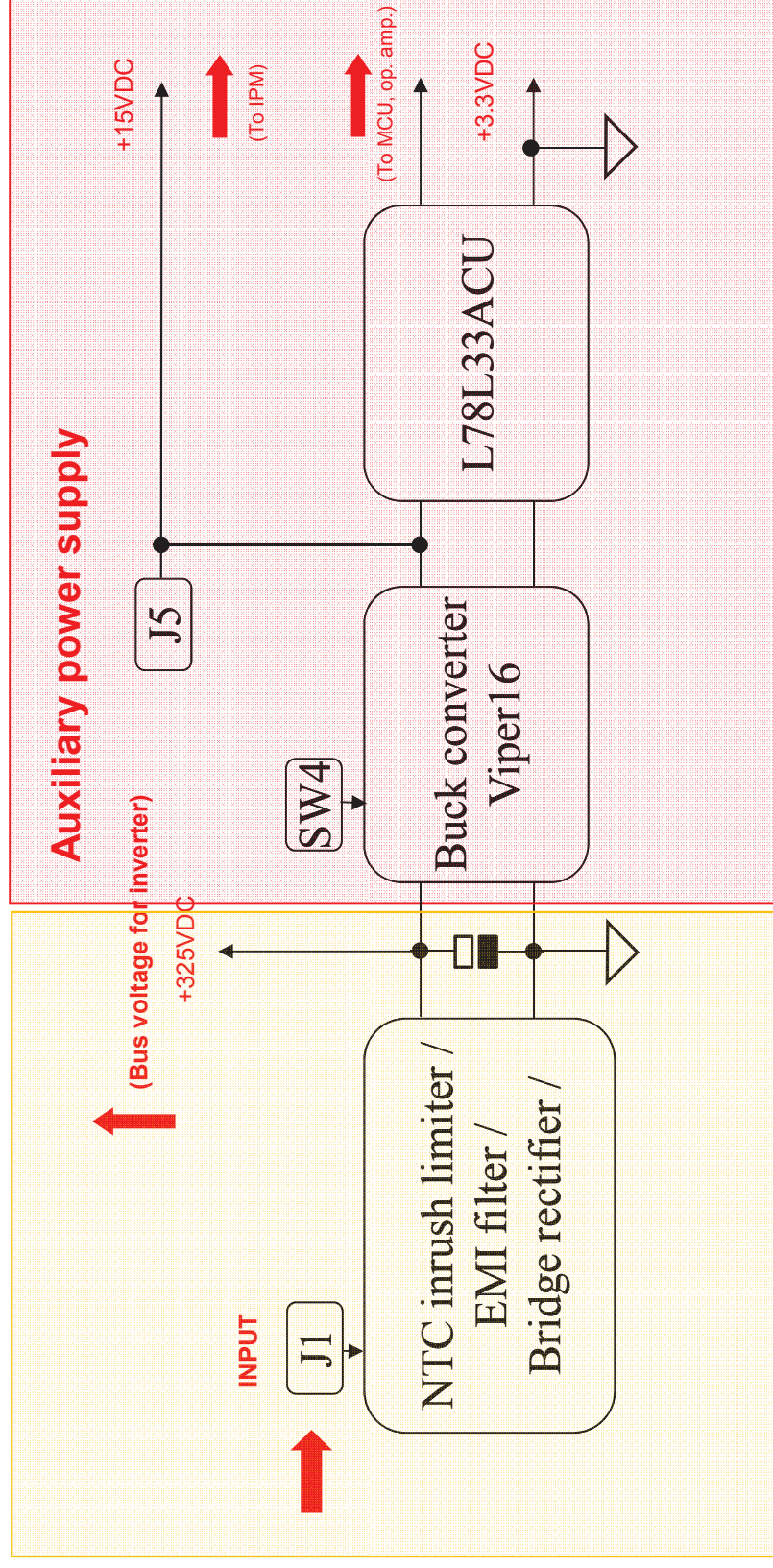


System Architecture



- **Control block:**
 - Accept user commands, motor drive configuration parameters
 - provide appropriate digital signals to perform the proper motor driving strategy
 - Could be updated with driver ST485EB for RS485 BUS
- **Power block:**
 - performs a power conversion from DC bus in to the motor
 - three-phase inverter topology
 - based on SLLIMM™ STGIPN3H60
- **Sensing / protection:**
 - Single shunt topology
 - PMSM with using of FOC itself is conceived for sinusoidal shaped back-EMF
 - Fully using advantage of the SLLIMM™
- **Power supply block:**
 - Single phase connecting - supply voltage 195VAC to 265VAC or direct DC line up to +400VDC

System Architecture - Supply Block



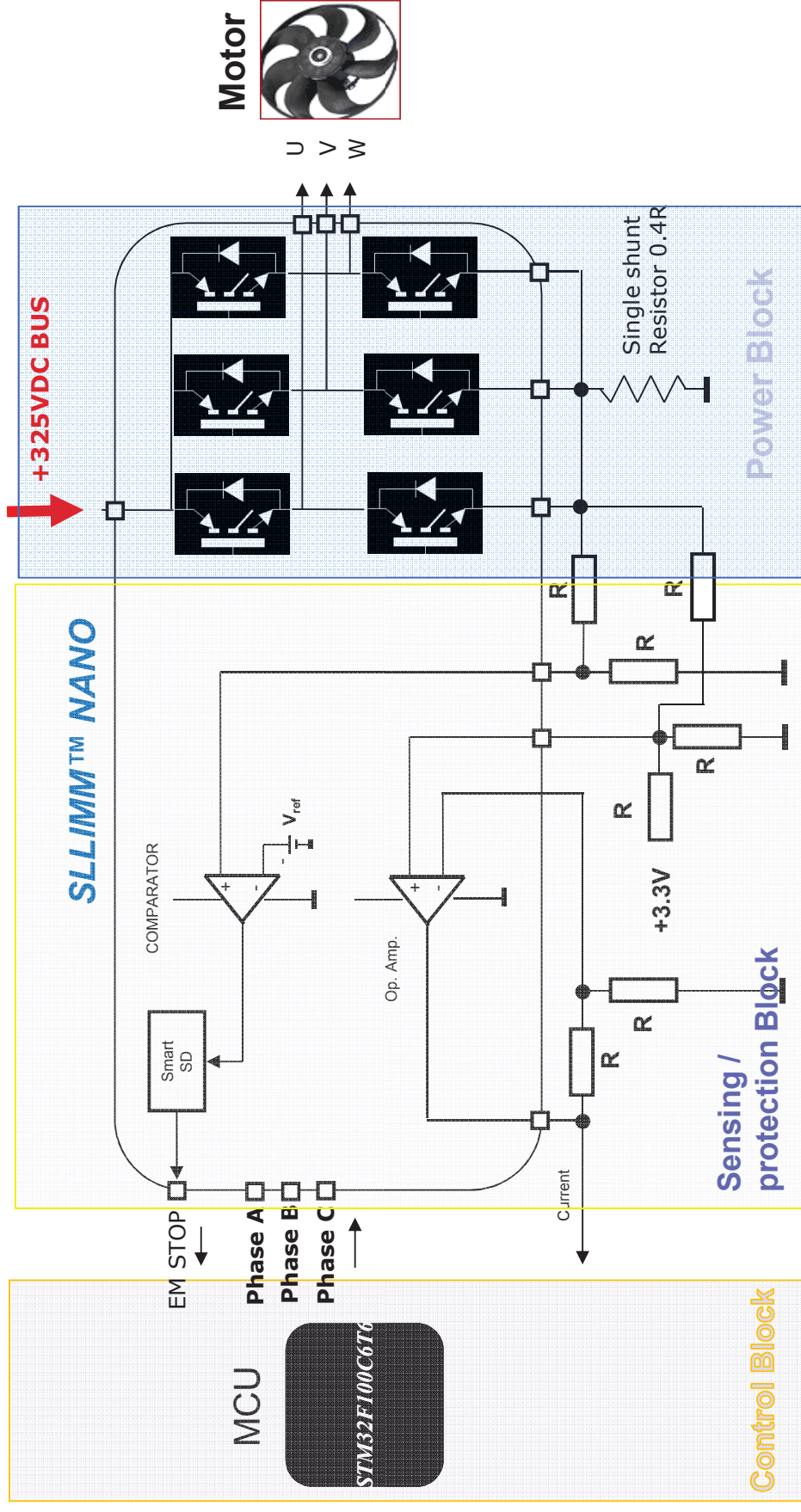
System Architecture - Supply Block



- Includes rectifier bridge
- In-rush current limiter – NTC resistor
- Complete EMI filter based on CM choke, X2 and Y2 capacitors
- EN55014, IEC61000-4-4 and IEC61000 4-5 compliant
- Auxiliary power supply based on Viper16L in buck converter topology
- Working frequency: 60 kHz
- Single phase power supply: 195VAC to 265VAC or direct DC line up to +400VDC



System Architecture - Power / Sensing Block

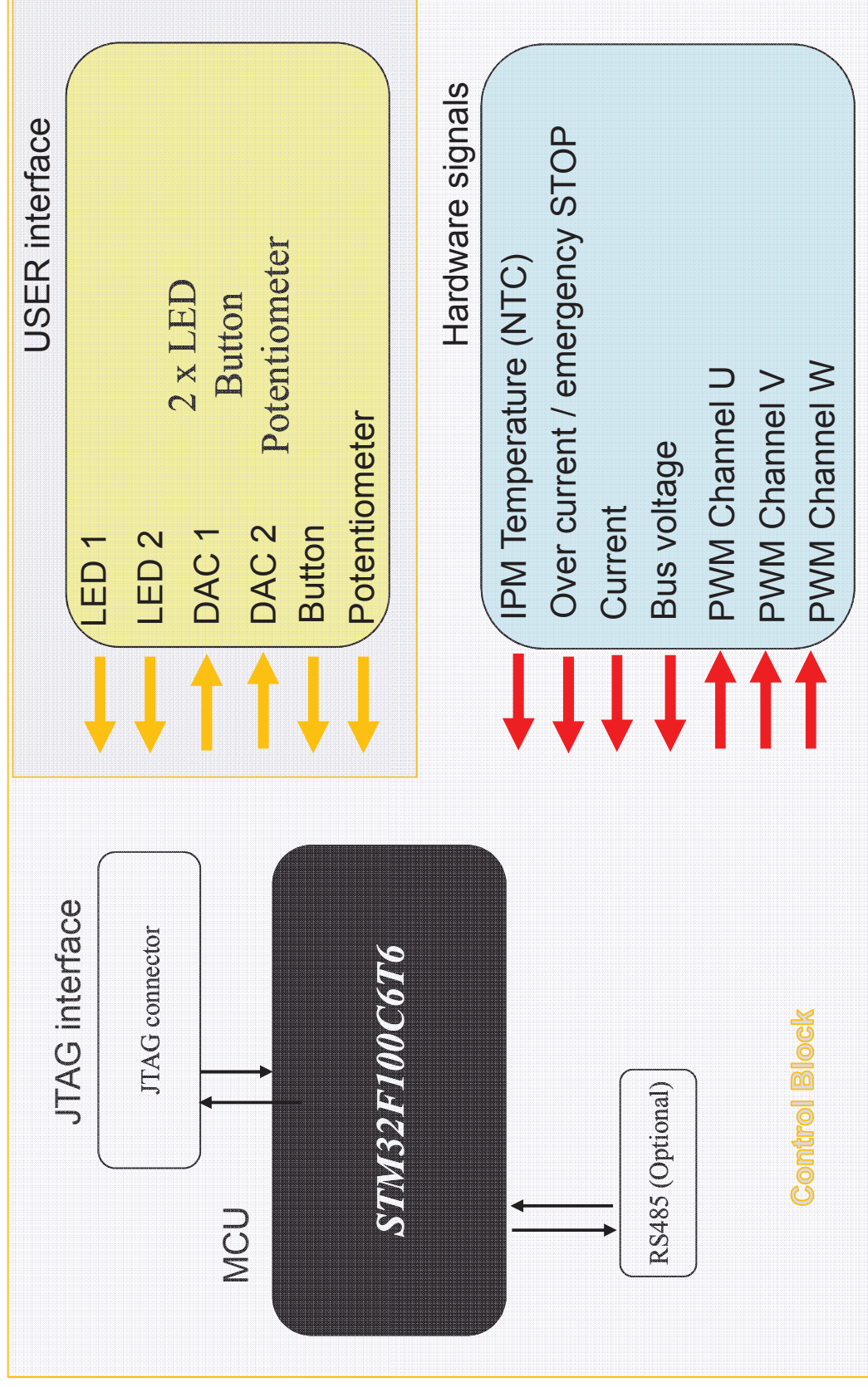




System Architecture - Power / Sensing Block

- Based on SLLIMM™ STGIPN3H60
- Designed for current up to 3A
- Integrated drivers dice L6390
- FOC with single shunt current reading for vector control method
- Fully using integrated features of the SLLIMM™ :
 - Using integrated comparator for over-current protection
 - Direct connection to shut down function of the IPM
 - Advanced current sensing with integrated Op-Amp
 - Adjustable gain of operational amplifier with external resistor network

System Architecture – Control block



System Architecture – Control block



- Based on STM32F100C6T6
- Generated PWM signals for SLLIMM™
- User interface: LED, buttons, potentiometer, DAC
- JTAG interface
- Possibility to modify the board by adding RS485 serial interface
- Sensing various signal with ADC channels
- External 8 MHz crystal
- +3.3V supply voltage



Control block – PMSM FOC library v3.0

- The STM32 PMSM FOC Library v3.0 is a:
 - Motor Control Software Development Kit
 - To be used with STM32F103xx or STM32F100xx
 - For 3-phase Permanent Magnet Synchronous Motors
- Library main features:
 - Single/Dual simultaneous vector control (FOC)
 - Sensor / Sensorless
 - Energy efficient, quiet, motor drive
 - Outstanding dynamic performances, speed range
 - Full customization through GUI
 - Wide range of hardware support, system configurations, addressing applications from Home Appliances to Factory Automation

Control block - ST Motor Control Workbench (STMCWB)



ST Motor Control Workbench, in this version, is a PC code generator tool that reduces the designer effort and time in the firmware development for all the ST Motor control FW library (starting from STM32 PMSM FOC FW library 3.0). The user through a graphical user interface (GUI) generate the parameter header files which configures the library according the application needs.

Tools – Software part



■ Download:

- STM32 FOC PMSM SDK v 3.0 firmware library zip file
 - http://www.st.com/internet/com/SOFTWARE_RESOURCES/SW_COMPONENT/FIRMWARE/stm32_pmsm_foc_motorcontrol_fwlib.zip
- ST MC Workbench v 1.0.2 zip file
 - http://www.st.com/internet/com/SOFTWARE_RESOURCES/TOOL/CONFIGURATION_UTILITY/motorcontrol_workbench.zip

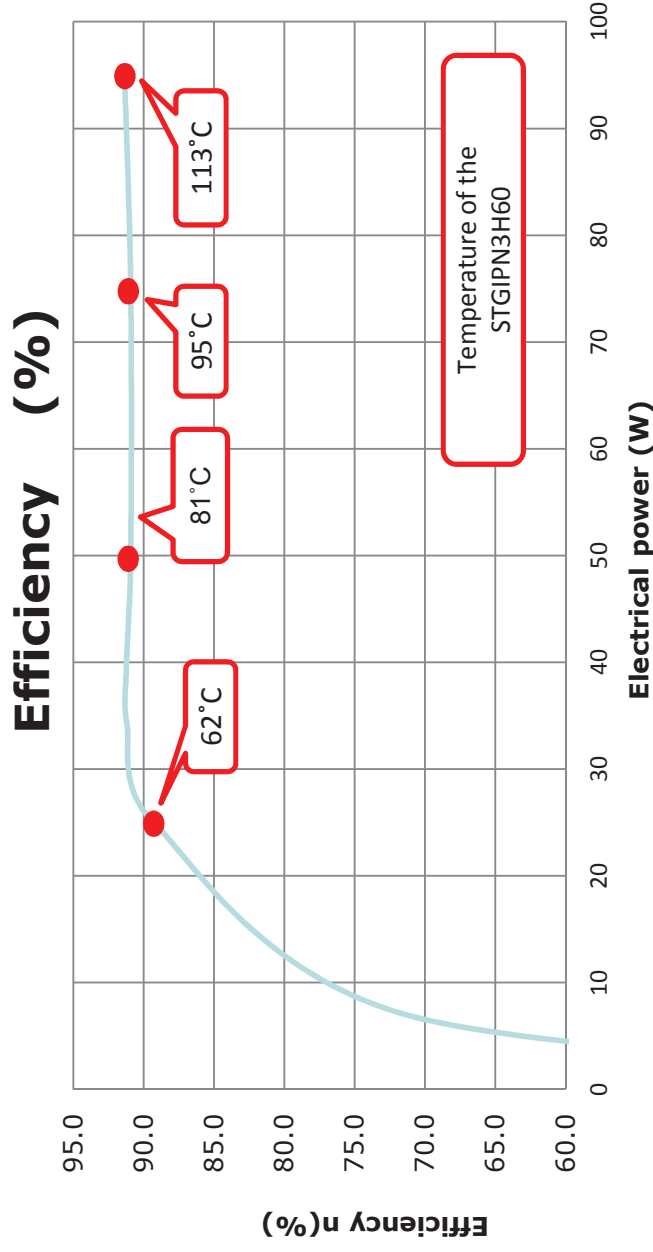
■ Consult:

- TN0516 “Overview of the STM32F103xx/STM32F100xx PMSM single/dual FOC SDK V3.0”
 - http://www.st.com/internet/com/TECHNICAL_RESOURCES/TECHNICAL_LITERATURE/TECHNICAL_NOTE/DM00026481.pdf
- UM1052 “STM32F103 or STM32F100 PMSM single/dual FOC SDK V 3.0”
 - http://www.st.com/internet/com/TECHNICAL_RESOURCES/TECHNICAL_LITERATURE/USER_MANUAL/CD00298474.pdf
- UM1053 “Advanced development Guide for STM32F103 or STM32F100 PMSM single/dual FOC library”
 - http://www.st.com/internet/com/TECHNICAL_RESOURCES/TECHNICAL_LITERATURE/USER_MANUAL/CD00298482.pdf

STEVAL-IHM036V1 parameters - efficiency



- Efficiency measurement:
 - Overall efficiency of the whole demonstration board is above 90% (test conditions- 230VAC, PWM 16kHz, T_{amb} 25°C)
 - Consumption with no motor commutation (STNBY) ~0.6W





STGIPN3H60 vs. Main Competitor FOC @ 16kHz

- SINUSOIDAL FOC CONTROL – SINGLE SHUNT – 3200 RPM (160Hz) – 16kHz – [STGIPN3H60](#)

Ta	Electrical Pout	25W	50W (*)	75W (*)	95(*)
25°C		61°C	80°C	96°C	120°C
50°C		87°C	109°C	123°C @ 65W	-
75°C		116°C	122°C @ 35W	-	-

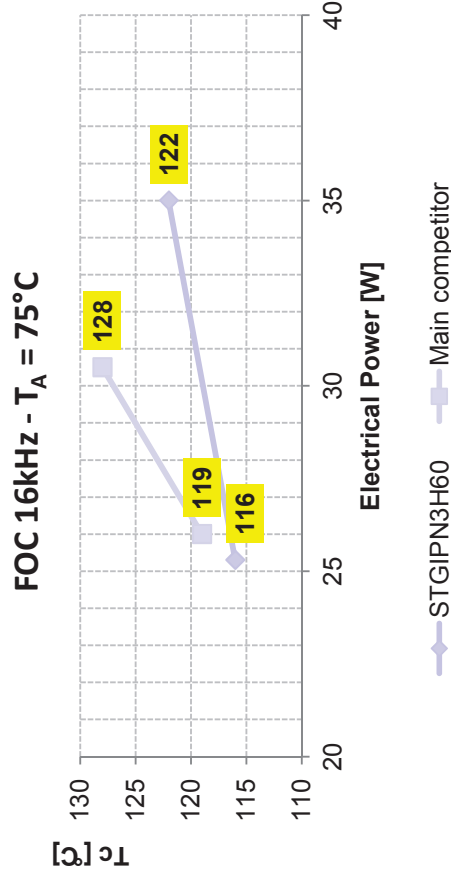
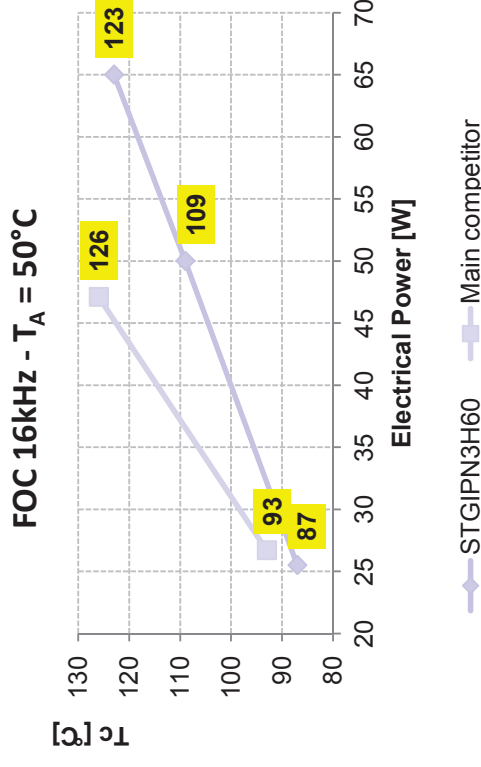
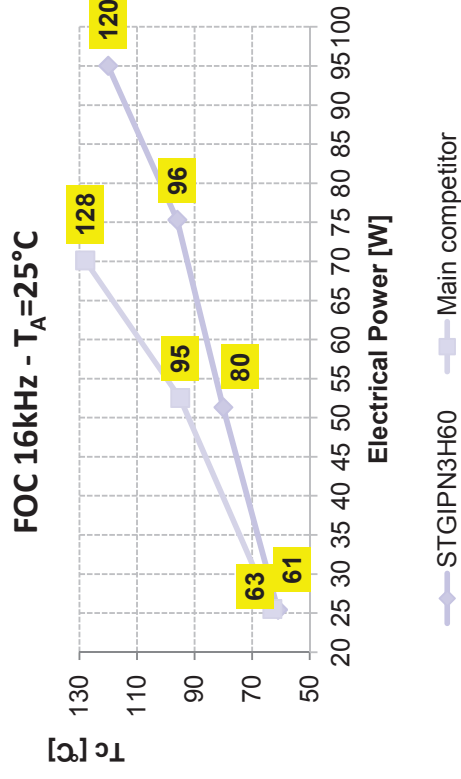
(*) or the maximum power according to a case temperature of 125°C

- SINUSOIDAL FOC CONTROL – SINGLE SHUNT – 3200 RPM (160Hz) – 16kHz – [Main Competitor](#)

Ta	Electrical Pout	25W	50W (*)	75W (*)
25°C		63°C	95°C	133°C @ 70W
50°C		93°C	126°C @ 47W	-
75°C		119°C	128°C @ 30W	-

(*) or the maximum power according to a case temperature of 125°C

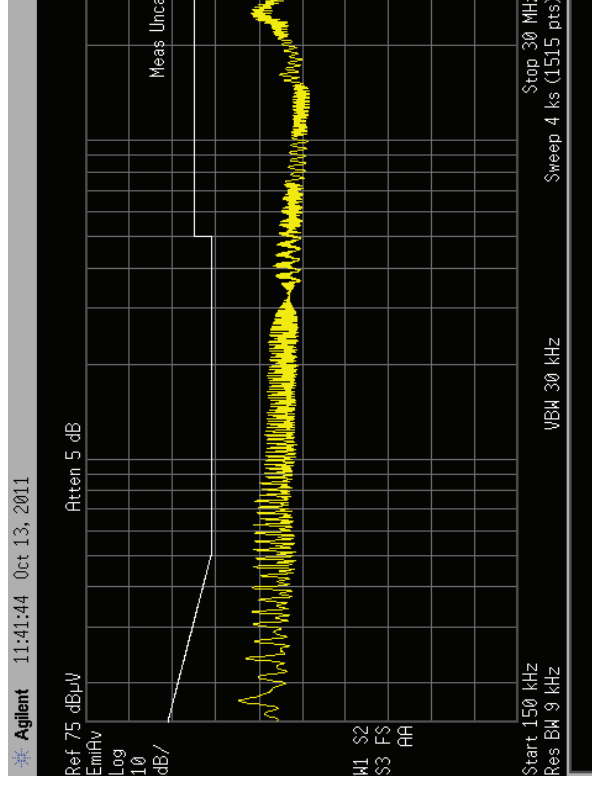
STGIPN3H60 vs. Main Competitor FOC @ 16kHz



STEVAL-IHM036V1 parameters – compliance with EN55014 (CISPR14-1)



- The STEVAL-IHM036V1 evaluation board was tested to be compliant with conducted radio disturbances according to CISPR14 specification, for frequency range from 150kHz to 30MHz
 - Frequency range 150kHz – 30MHz
 - Detector average; detector quasi peak
 - Measured on power supply lines (AC line: L and N)



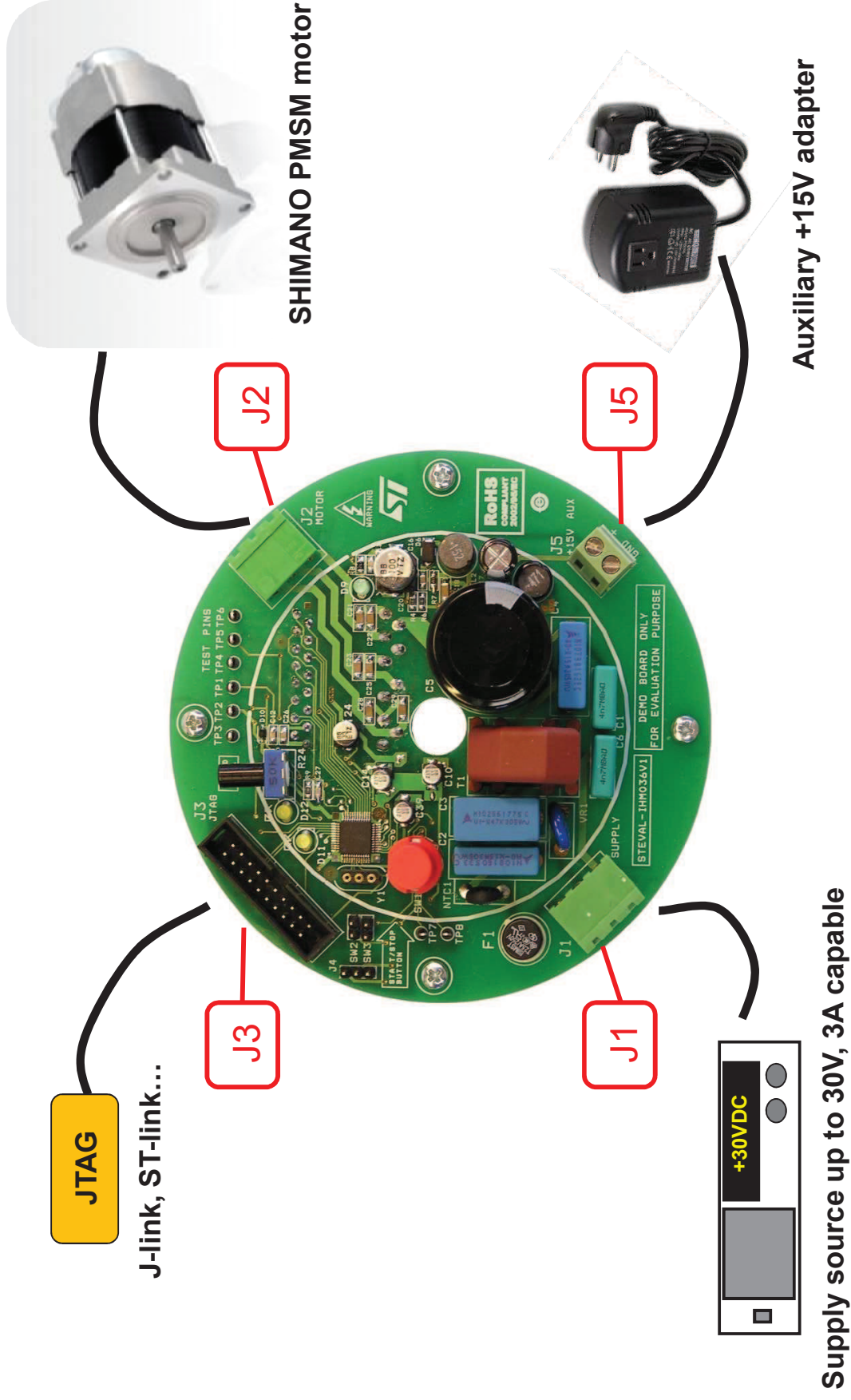
STEVAl-IHM036V1 parameters – compliance with IEC61000-4-4 and IEC61000-4-5



- The board was tested to be compliant with **IEC61000-4-4 burst immunity**:
 - Burst duration 15ms +/- 20% at 5kHz
 - Burst period 300ms +/- 20%
 - Polarity positive/negative
 - Applied to power supply lines (AC line: L and N)
 - Passed 2kV with criteria A (no damage, no influence)

- The board was tested to be compliant with **IEC61000-4-5 surge immunity**:
 - Polarity positive/negative
 - Duration time 10 events; repetition time 30s
 - Phase angle 0°, 90°, 180°, 270° for each test condition
 - Common mode – applied among to AC line and PE earth
 - Differential mode – applied to AC line (L and N)
 - Passed 2kV line to line and 2kV line to earth

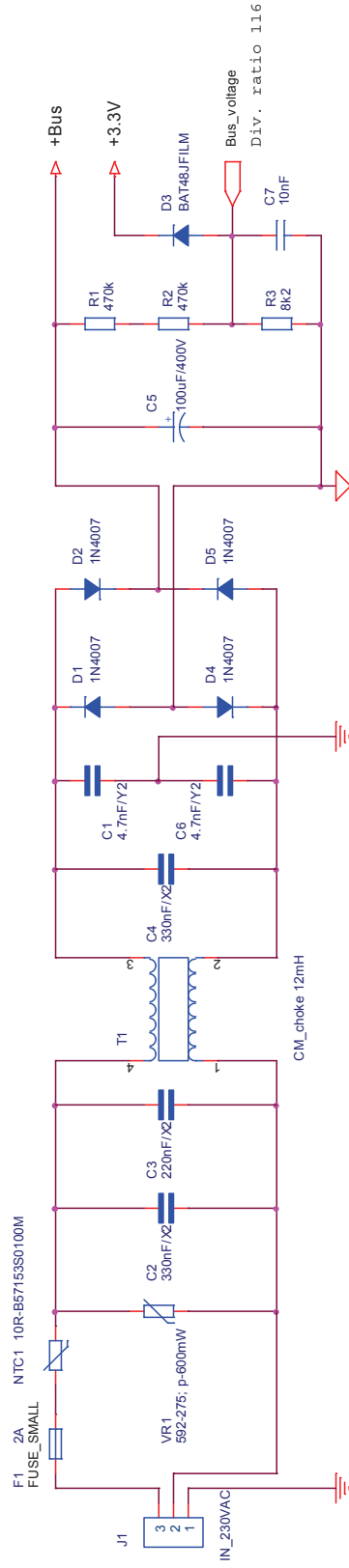
How to connect STEVAL-IHM036V1



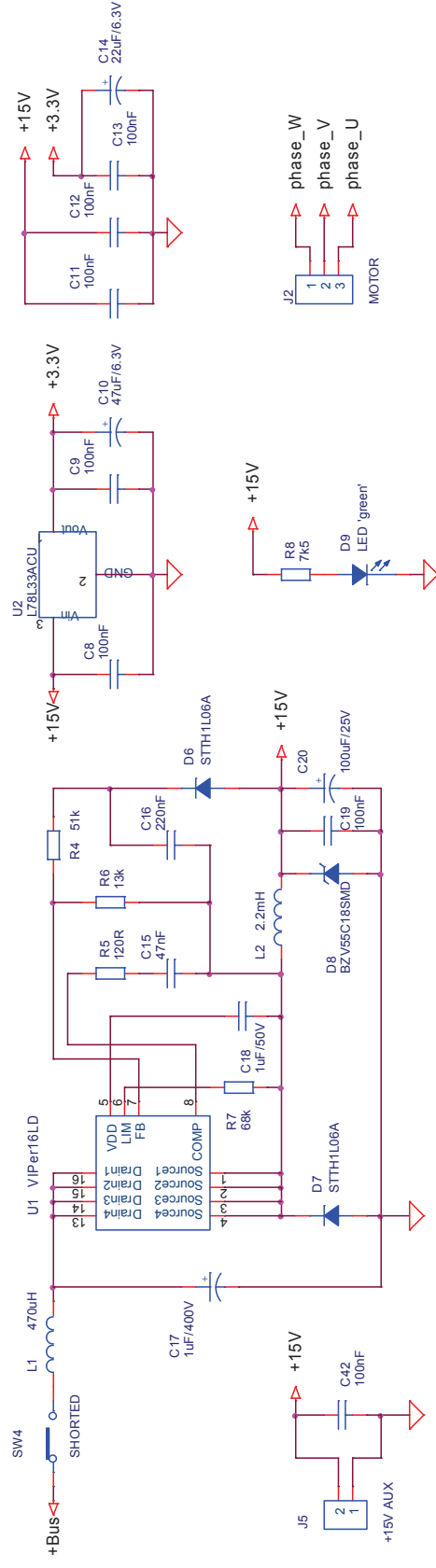
Schematic /1



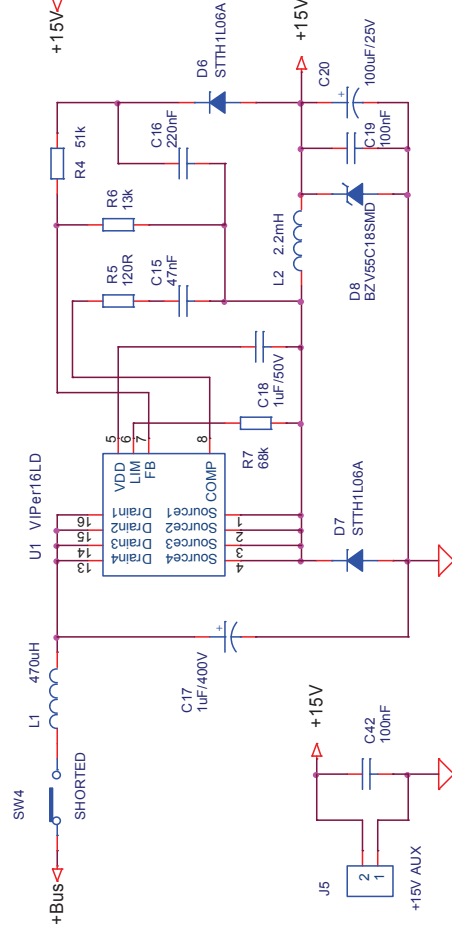
INPUT PART WITH RECTIFIER



+3.3V LINEAR



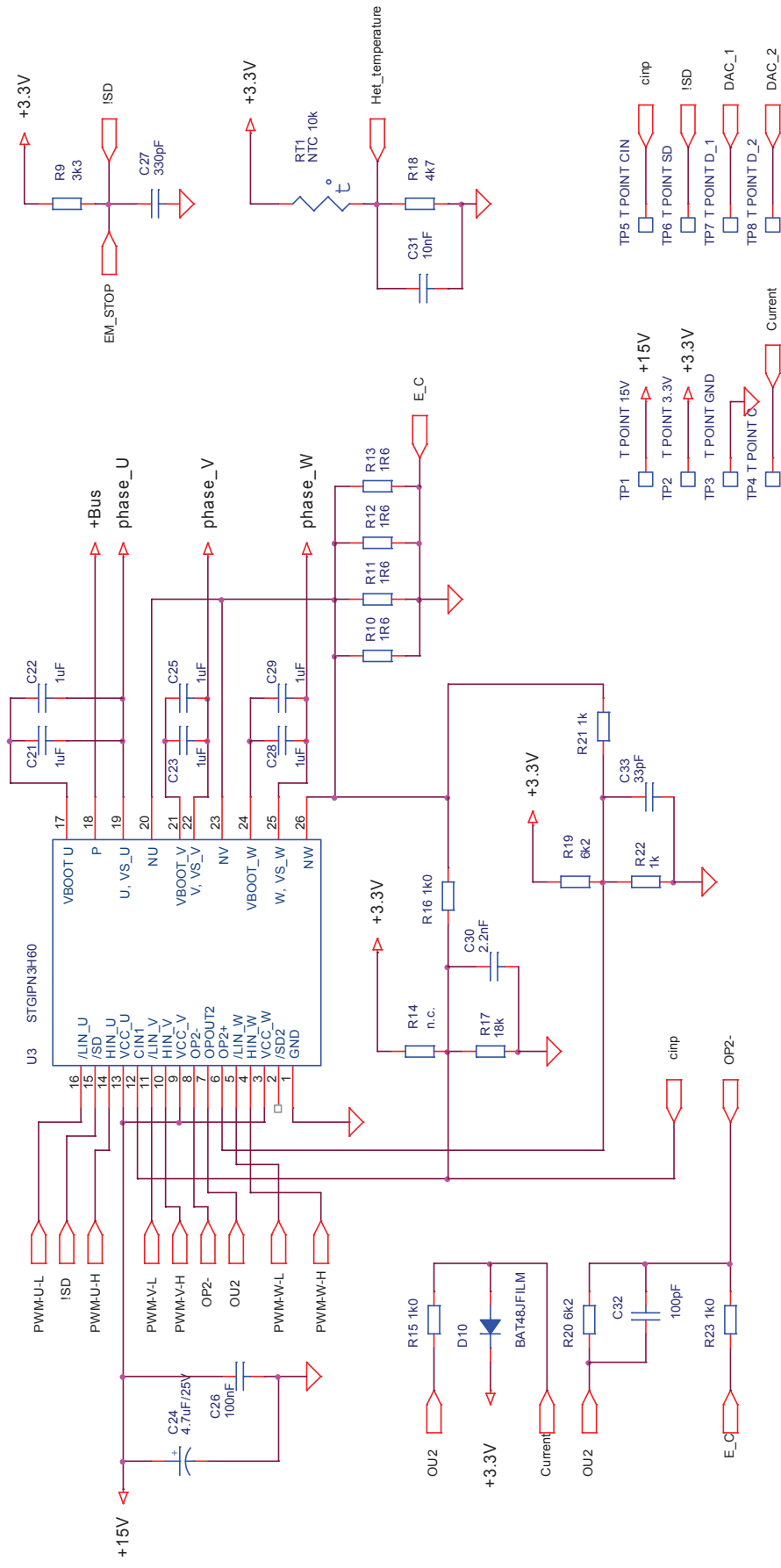
BUCK CONVERTER



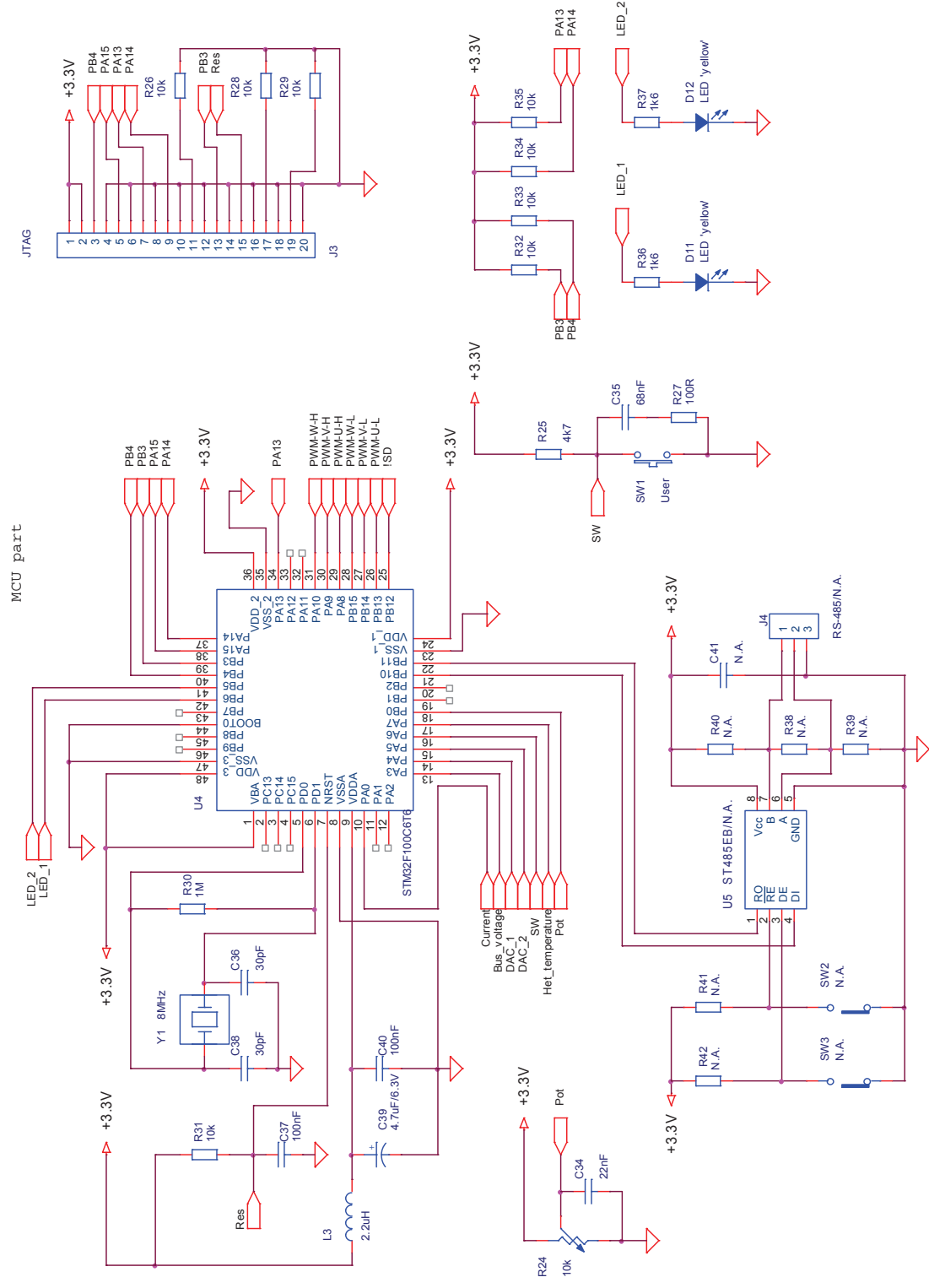
Schematic /2



POWER INVERTER PART



Schematic /3



Tools

- **Datasheets of available components:**
 - STGIPN3H60 IPM
http://www.st.com/internet/com/TECHNICAL_RESOURCES/TECHNICAL_LITERATURE/DATASHEET/DM00032611.pdf
 - VIPer16
http://www.st.com/internet/com/TECHNICAL_RESOURCES/TECHNICAL_LITERATURE/DATASHEET/CD00218828.pdf
 - STM32F100C6T6
http://www.st.com/internet/com/TECHNICAL_RESOURCES/TECHNICAL_LITERATURE/DATASHEET/CD00251732.pdf
- **User manual UM:1483**
Low power motor control board
STEVAL-IHM036V1 featuring
SLLIMM™ STGIPN3H60 and
MCU STM32F100C6T6





UM1483
User manual

Small power motor control board STEVAL-IHM036V1 featuring SLLIMM™ STGIPN3H60 and MCU STM32F100C6T6

1 Introduction

This document describes a small power motor control board STEVAL-IHM036V1 featuring SLLIMM™ IPM036V1, the demonstration board is an ALUOL™ interface that integrates a 3-phase waveform for driving three phase permanent magnet synchronous motor (PMSM) with field oriented control (FOC) up to 100W without sensors. The used controller belongs to STMicroelectronics 48V™ Controller embedded in a high density STM32F101 family.

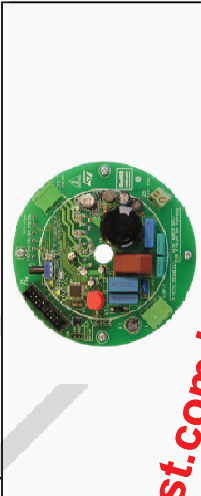
The motor is a permanent magnet synchronous motor (PMSM) with 2.2kW power and 850rpm speed. The motor is controlled by a 3-phase inverter with 3-phase IGBTs in a 2.5L package. The IGBT power module integrated a power IGBT switches with free-wheeling diodes together with the high voltage gate drivers. Thanks to this integrated inverter, the system has been designed to be a reliable and non-rad design.

Such information shows a CB stage, occupation, assembly cost together with high reliability coming from such design simplicity.

The board is designed to be compatible with single-phase mains for European range of supply voltage 230VAC (-15% to +15%), at a responded DC supply voltage. The board includes a power supply stage with VIPer16™ in a black configuration to generate +15V supply voltage required by the application.

This document is associated with the release of the demonstration board STEVAL-IHM036V1 (see Figure 1 below).

Figure 1: STEVAL-IHM036V1



On **st.com** by end of **January 2012**

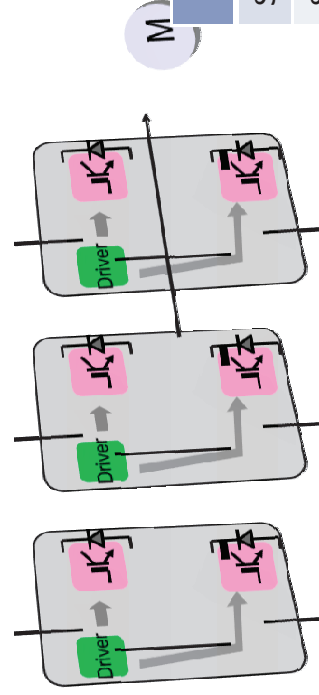
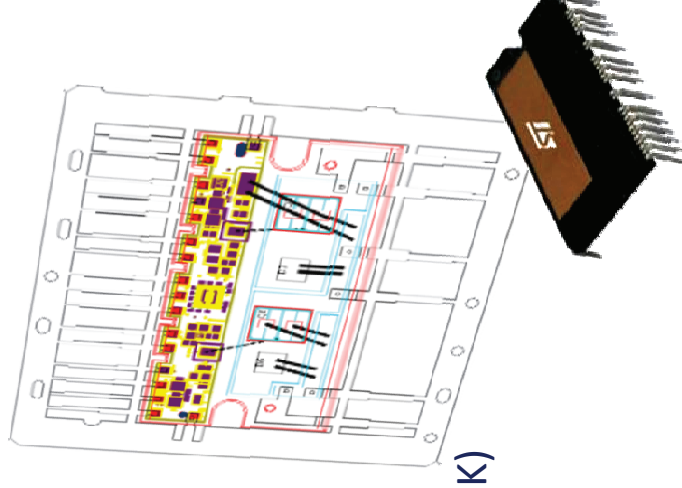
Order 2011
Data for general audience
This is preliminary information about a new product early development. Some features may change without any notice.
121

NEWS!!! SLIMM SINGLE LEG Modular half bridge



NEWS!!!!!!! 2012
Samples available

1. It includes several innovative features:
 - Modular and expandable solution
 - Better Thermal behavior than a six-pack solution
 - Improved board layout
 - Several “smart” functions embedded
 - Silicon options offered for both PFC (W) and Motor Control (K)



PN	BV _{CES} @ 25°C	I _c @ 25°C	Features	NTC	Package
STGIPS35K60L1	600 V	35 A	L6390 based	Y	SDIP 22L
STGIPS40W60L1	600 V	40 A	L6390 based	Y	SDIP 22L



SLIMM SINGLE LEG Features

L6390 Driver available features	35A 600V
Pkg Size [mm]	49.6*24.5*5.4
DBC substrate	yes
Voltage [V]	600
Current @ Tc=25°C [A]	35
Rth (max) [°C/W]	1.25
Embedded Thermal Resistor (NTC)	Yes
Integrated Bootstrap diode	Yes
Smart shutdown function	Yes
SD function	Yes
Op-amps for Advanced current sensing	Yes (3 pins)
Comparator for fault protection	Yes
3.3/5V input interface compatibility	Yes
Interlocking Function	Yes
Under Voltage lockout (on Vcc and Vboot)	yes

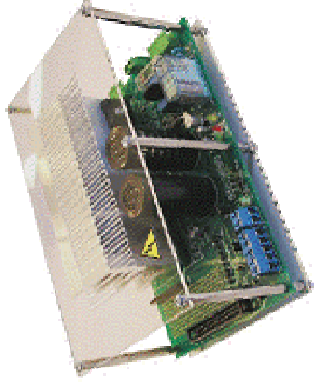
Integrated bootstrap diodes mean:
component cost saving easy layout

Thanks to Smart Shutdown function, ST HV gate driver can turn off the IPM in a faster (T:200ns) and safer way during abnormal state (Over Current or Over Temperature)

SD function available for an efficient connection with micro-controller

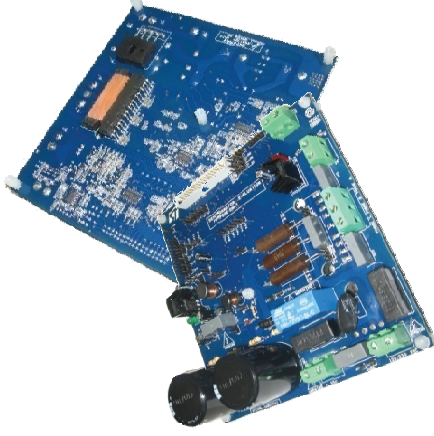
Integrated interlocking function can avoid any malfunctioning coming from overlapped input signals

SLIMM Motor Control Evaluation Board



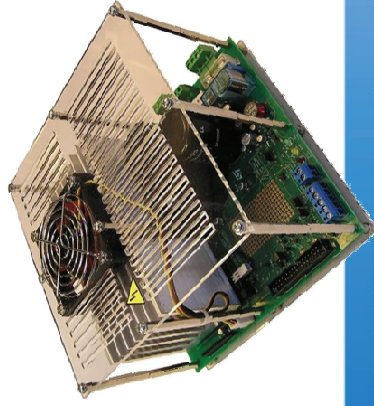
STEVAL-IHM025V1

- 1 x IGBT IPM STGIPL14K60
- 1 x PWM SMPS smart driver VIPer16LD
- 1 x IGBT power switch STGP10NC60KD



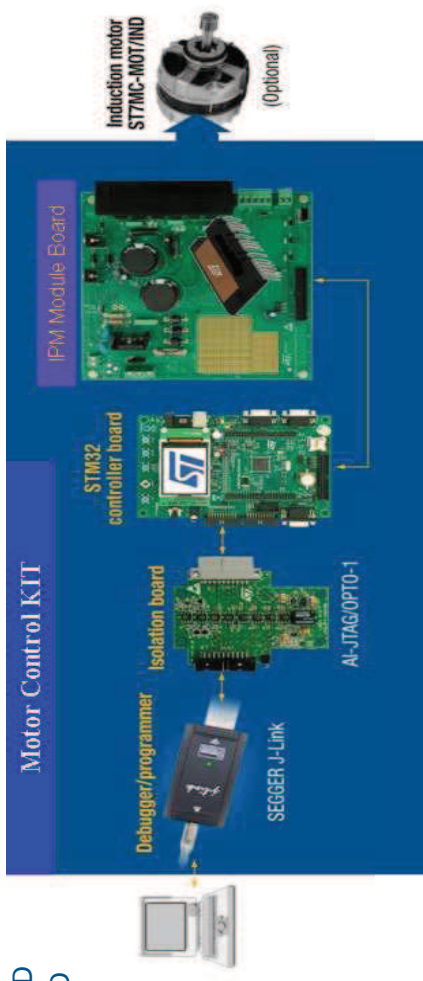
STEVAL-IHM027V1

- 1 x IGBT IPM STGIPS10K60A
- 1 x buck converter based on Viper16
- 1 x IGBT power switch STGP10NC60KD



STEVAL-IHM028V1

- 1 x IGBT IPM STGIPS20K60
- 1 x PWM SMPS smart driver VIPer26LD
- 1 x IGBT power switch STGW35NB60SD



- Three-phase power stage with shunt-based current reading
- Complete source files software libraries for 3-PH Induction and PMSM motors provided

1KW Power Inverter STGIPL14K60



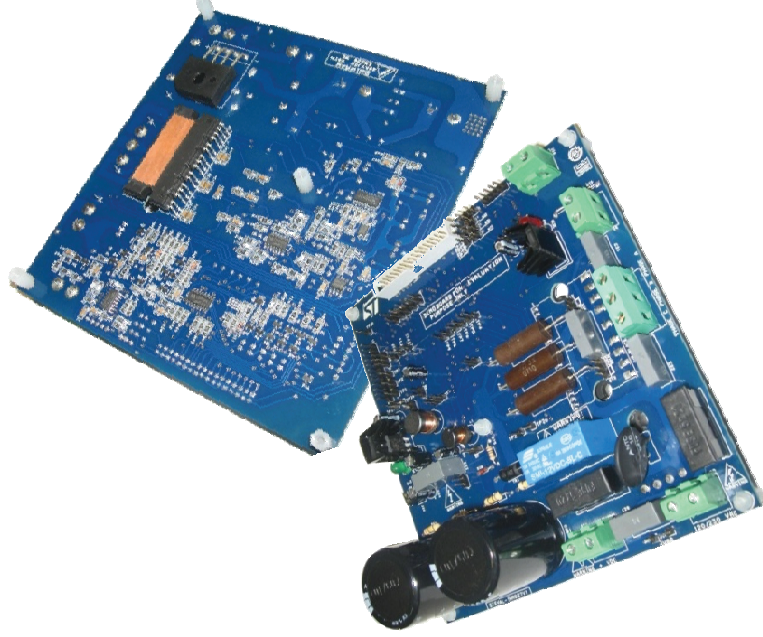
- Single phase connecting - supply voltage from 125VDC to 400VDC
- Possibility to use PMAC motors, 3-phase asynchronous motors, bi-phase AC motors or BLDC motors
- Input in-rush limiter with by-passing relay
- Brake switch with over-voltage comparator
- Hall sensor or encoder input feature, tachometer input feature
- Over-temperature and over-current hardware protection
- Compact and safety design

- 1 x IGBT IPM **STGIPL14K60**
- 1 x PWM SMPS smart driver **VIPer16LD**
- 1 x IGBT power switch **STGP10NC60KD**

Ordering code: STEVAL-IHM025V1

Evaluation boards available at: <http://www.st.com/evalboards>

1KW Power Inverter STGIPS10K60A



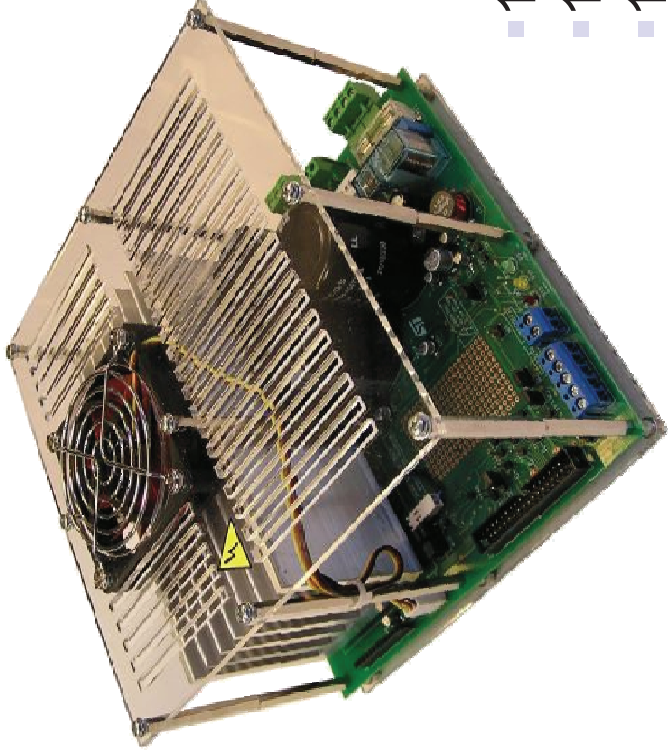
- Single phase connecting - supply voltage from 125VDC to 350VDC
- Motor control connector for interface with STM3210B-EVAL board
- Possibility to use induction motor or PMSM motors up to 1000 W
- Regenerative brake control feature
- Input inrush limitation with bypassing relay
- HallEncoder inputs
- Possibility to connect BEMF daughter board for sensor-less six-step control of BLDC motors
- Tachometer input
- Compact and safety design

- 1 x IGBT IPM STGIPS10K60A
- 1 x buck converter based on Viper16

Ordering code: STEVAL-IHM027V1

Evaluation boards available at: <http://www.st.com/evalboards>

2 KW Power Inverter STGIPS20K60



- HV supply mode -voltage 90VAC to 285VAC or direct DC line 125VDC to 400VDC
 - Input voltage range extended to +400V to be compliant with PFC
 - Input inrush limiter with bypassing relay
 - Brake feature with over-voltage comparator
 - Single or three shunt resistors current sensing method
 - Hall sensor or encoder input feature
 - Tachometer input feature
 - Over-temperature and over-current hardware protection
 - Active fan with automatic over-temperature switching
 - Relative compact and safety design
- 1 x IGBT IPM **STGIPS20K60**
 - 1 x PWM SMPS smart driver **VIPer26LD**
 - 1 x IGBT power switch **STGW35NB60SD**

Ordering code: STEVAL-IHM028V1

Evaluation boards available at: <http://www.st.com/evalboards>