

英飞凌家电生态圈
<赋能课堂>

Washing machine motor control reference design

IPC ISD SYS (Xi'an)
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Since 2011 working at Infineon as a system design engineer, mainly responsible for motor applications, software and tools development. Now have some smart home projects based on Sensors and IoT.

A reference designs, which helps to design washing machines efficient, flexible and at smaller form factors



Name:

REF-MHA1KIM5PSOC4

OPN:

REFMHA1KIM5PSOC4TOBO1

Dimensions:

125 x 115 x 80 mm



This reference design

- › features optimized efficiency and high reliability
- › provides software flexibility for customers writing their own code to develop differentiating feature sets
- › shows how to reduce form-factor by higher integration

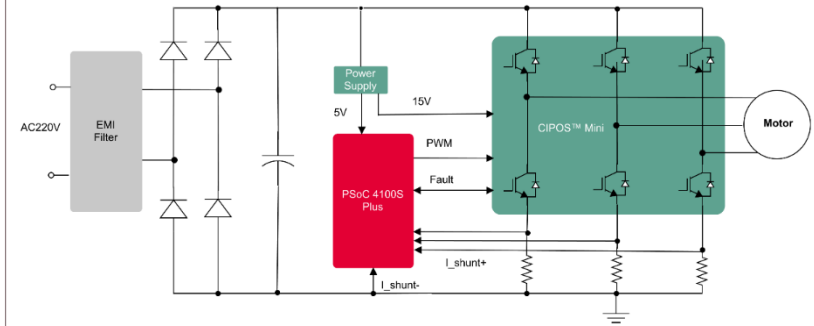
A reference designs, which helps to design washing machines efficient, flexible and at smaller form factors



Overview

1. Small and cost effective single layer PCB
2. CIPOS™ Mini IPM & rectifier bridge for 3 Φ motors
3. PSoC 4100S Plus for system and motor control
4. 160...265 V_{AC} input incl EMI filter and relay
5. Debug interface to connect Segger J-Link probe
6. Isolated UART communication with host

Block Diagram



Target application

> Washing machine



Key featured products

- > **CIPOS™ Mini 600 V, 10 A three-phase IPM**, IKCM10H60GA with TRENCHSTOP™ IGBT, antiparallel diodes and SOI gate drivers
- > **PSoC 4100S Plus**, CY8C4146AZI-S443, embedded controller based on 32-bit Arm Cortex-M0+ CPU

PSoC 4100S Plus provides the interfaces and development environment for designing own differentiating motor control solutions



Flexible MCU and software design environment for own developments

PSoC 4100S Plus,
Programmable
System on-Chip
CY8C4146AZI-S443

CIPOS™ Mini 600 V, 10 A
three-phase IPM,
(Control Integrated POver
System)
IKCM10H60GA

- › 48 MHz Arm® Cortex® -M0+ CPU with up to 128 KB flash and up to 16 KB SRAM
- › External power supply range from 1.8 V ~ 5.5 V with internal regulator active.
- › Two op amps with reconfigurable high-drive, external and high-bandwidth internal drive, and comparator modes and ADC input buffering capability
- › Eight 16-bit timer/counter/pulse-width modulator (TCPWM) blocks
- › Smart I/O Block and Up to 38 GPIOs, 48-pin TQFP package
- › Washing machine reference design developed using PSoC® Creator™ Integrated Design Environment (IDE) for code development and IAR live-watch for online-debugging



IAR
SYSTEMS



PSoC® CREATOR™ 4.4
DUAL-CORE APPLICATION
DEVELOPMENT MADE EASY

The **CIPOS™ Mini IPM** saves board space while not compromising efficiency and thermal



Inverter, anti parallel diodes and SOI gate drivers integrated into a single module

PSoC 4100S Plus,
Programmable
System on-Chip
CY8C4146AZI-S443

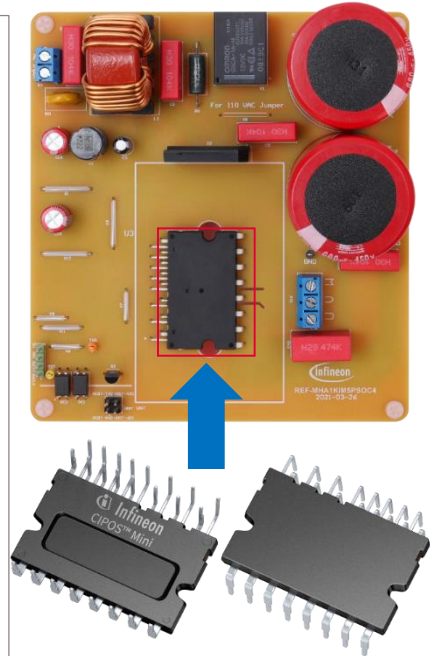
CIPOS™ Mini 600 V, 10 A
three-phase IPM,
(Control Integrated POWER
System)
IKCM10H60GA

Inverter

- › 600 V, 10 A 3-phase TRENCHSTOP™ IGBT incl. anti parallel diodes integrated with optimized SOI gate driver for excellent power density
- › designed for AC and PMSM motors in high switching frequency (~15kHz) drives, such as washing machines with low turn-off switching loss

Package

- › Compact, UL certified package (Dual-in-line transfer molded package)
- › Designed for power applications, which need good thermal conduction and electrical isolation



System level integrating for a complete advantage washing machine solution



Combining Infineon's products to a complete washing machine solution



Suitable peripherals for BLDC motor control processor

- › Two Operational Amplifiers: leg shunt for current feedback sample
- › One low-power comparator: Overcurrent protection (Gate-kill)

CIPOS™ Mini Intelligent Power Module (IPM)

- › TRENCHSTOP™ IGBT is optimized to high frequency switching application like washing machine, fan, etc.
- › With fully integrated anti parallel diodes and SOI gate driver, simple the layout.

Solution provided for Inverter Sensor-Less Washer

- › System peripherals configuration is using schematic capture
- › Advanced algorithm are provided for washing machine total solution

Cost reduced by omit external OPAMP and Comparator from system level

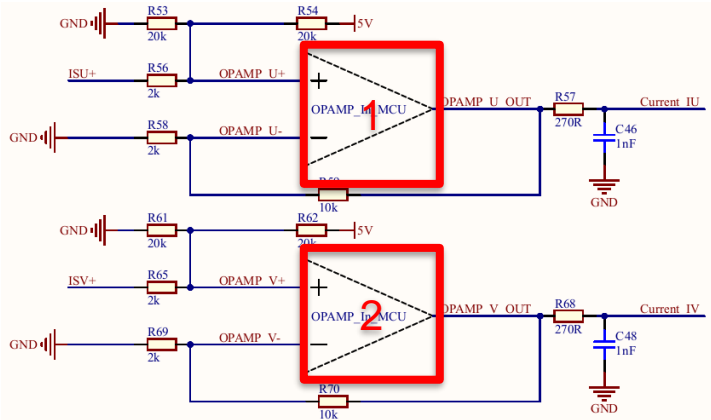
Non-Inverting differential amplifier:

Design tips:

When Current feedback voltage = 0 V, OPAMP Output = 2.5V

Gain = 5

Phase current sensing range = $2.5 / (5 * 0.05) = 10A$

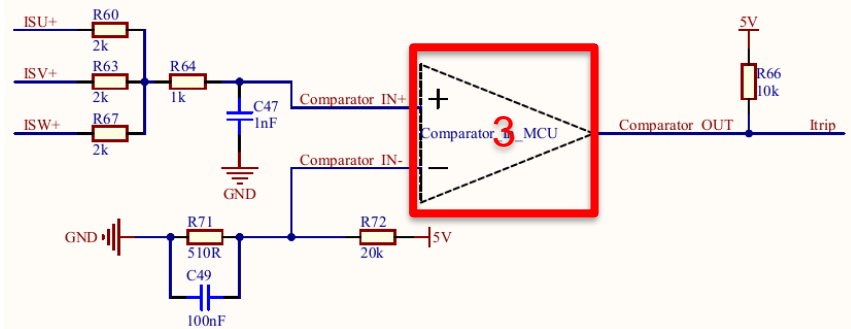


Over-Current protection:

Design tips:

Comparator Standard level = 0.13V

Itrip_level = $(0.13 / 0.05) * 3 = 7.8A$ (Peak)



1

2

3

> Components are PSoC 4100S Plus's configurable peripherals.

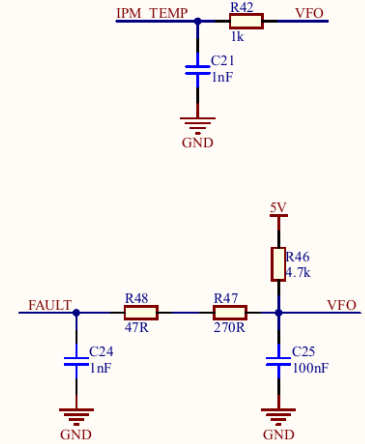
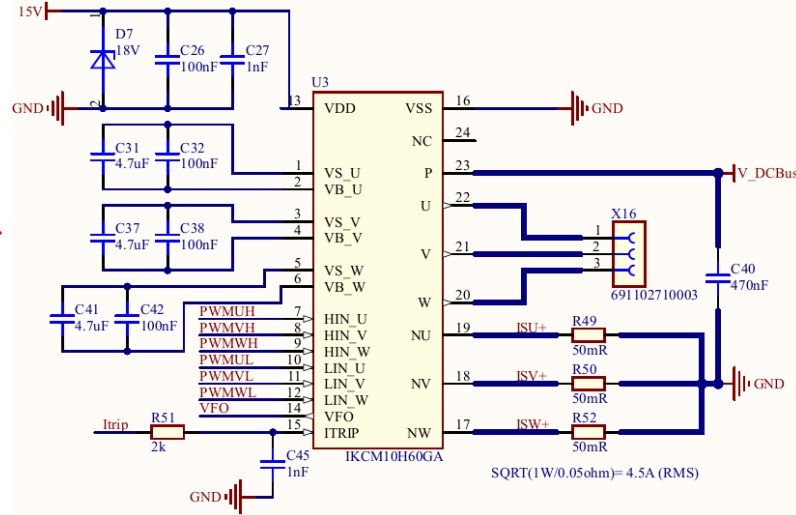
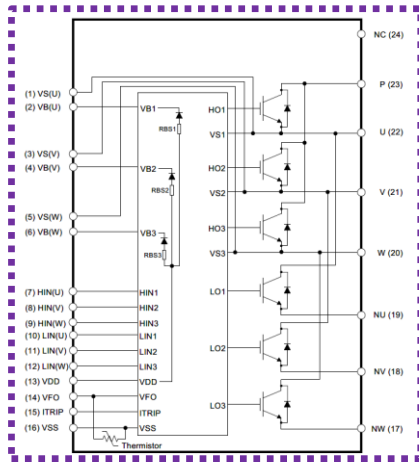
Control Integrated Power System (CIPOS™)



CIPOS™ Mini IPM: IKCM10H60GA in motor system

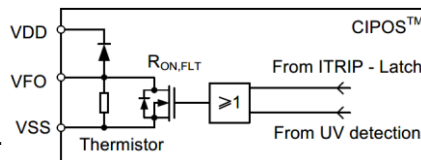
Design tips:

- The ITRIP comparator threshold (typ. 0.47V) is referenced to VSS ground.
- VFO Pull-up register value selected 4.7K. And the NTC temperature is about $T_{\infty} = 120^{\circ}\text{C}$ for PSoC4 Fault signal generated.



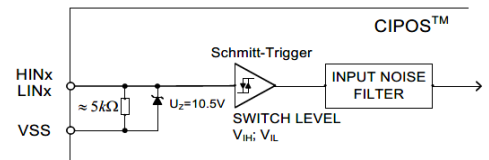
✓ VFO Pin: (multi-function pin)

A pull-up resistor is externally required. This value needs to consider shutdown temperature level by system requirement.



✓ PWM Pins:

There is about 5KΩ pull-down resistor internal.



Board layout overview

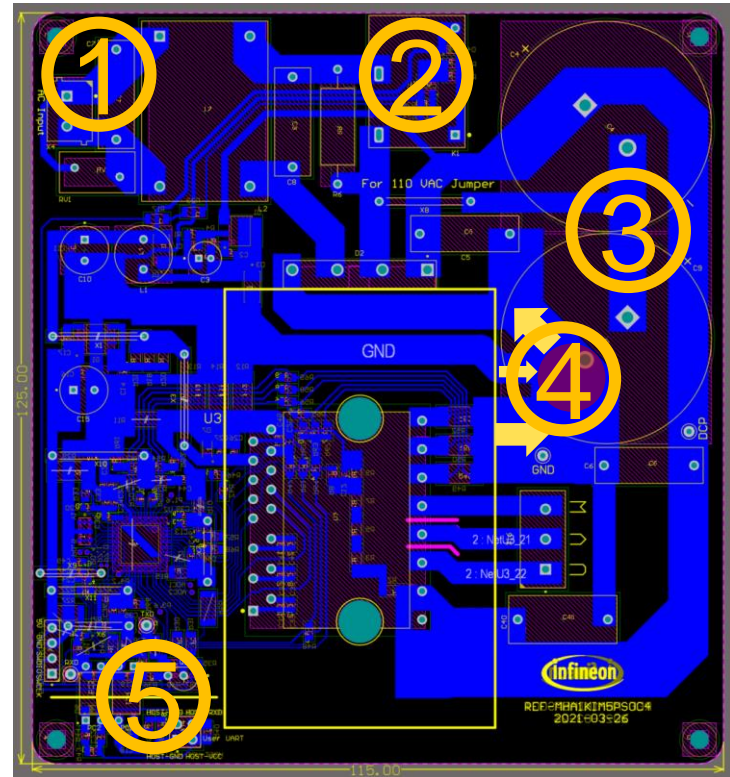
1. Single layer PCB

2. PSoC4 GPIO for relay control

3. Two aluminum electrolytic capacitors in series

4. Single point grounding connection

5. Isolated User UART interface



System Configuration provides hardware/software co-design environment



The screenshot displays the System Configuration software interface for a project named 'TopDesign.cysch'. The main workspace is divided into several functional blocks:

- ADC Trigger:** Contains a 'PWM D' block connected to 'ADC_TRI' and a 'Bus_Clock' input.
- PWM Drive:** Features three 'PWM' blocks (A, B, C) each with 'PWM_UPDATE' and 'Bus_Clock' inputs, and various output pins like 'PVMMAH', 'PVMAL', 'PVMBH', 'PVMBL', 'PVMCH', and 'PVMCL'.
- Current Sampling:** Includes an 'ADC SAR Seq' block with 'ADC_SAR_Seq' and 'DMA Ch' inputs, and two 'Opamp' blocks (A and B) with 'OP_U_Pos', 'OP_U_Neg', 'OP_V_Pos', and 'OP_V_Neg' inputs.
- Other Pins:** Lists various pins such as RELAY, LED, P4_2, P0_5, P7_1, P1_6, P0_4, P3_6, and P7_0.
- Clocks:** Shows a 'Clock_PWM' block connected to 'Bus_Clock'.
- Over Current Protection:** Contains an 'LPComp' block with 'Cprt_VPos' and 'Cprt_VNeg' inputs, and a 'FAULT Pins' block.

Three large blue circles with numbers 1, 2, and 3 are overlaid on the diagram to highlight specific areas:

- 1:** Points to the 'ADC Trigger' block.
- 2:** Points to the 'PWM Drive' block.
- 3:** Points to the 'Current Sampling' block.

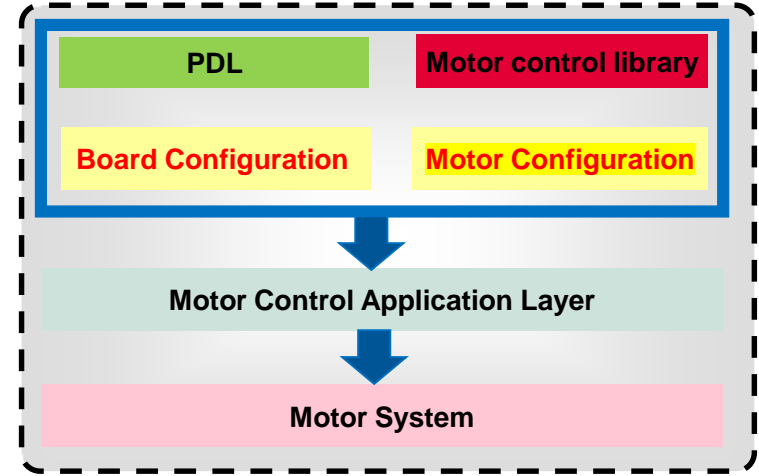
The interface also includes a 'Component Catalog' on the right side, listing various components like ADC, Opamp, and DMA. The bottom status bar shows 'Page 1' and 'Output Show output from: All'.

Advanced algorithm can be provided as a washing machine total solution

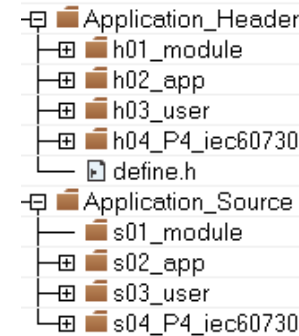


Partly of solution key features:

- 1. High frequency injection estimate rotor initial position
- 2. Direct close loop startup function to decrease startup power cost
- 3. Voltage feedback speed brake down on BLDC motor
- 4. Energy consumption speed brake down on DD motor
- 5. Motor resistor check & motor temperature protect
- 6. precision OOB and Weight function
- 7. Wide range speed adjust: 1hz to 350hz
- 8. Class B and UL certification



Motor Control Firmware Structure



Motor Control File Structure



Part of your life. Part of tomorrow.