HYDRA-X FOC Head

Power Application Controllers™

PAC5220 Expansion - HYDRA-X FOC Head User's Guide

www.active-semi.com

CONTENTS

OVERVIEW

Active-Semi's HYDRA-X FOC Head is an expansion board for the Hydra-X20/23 Body board, providing a complete motor solution. Although developed to control tri-phase Brushless DC (BLDC) motors or Permanent Magnet Synchronous Machines (PMSM), the module can be utilized to drive other motor topologies including, but not limited to, brushed DC motors or tri phase steppers.

The HYDRA-X FOC Head has been designed to accommodate a robust power stage made of six surface mount power MOSFETs rated at 30V and a maximum of 50A. For higher voltage applications, the surface mount FETs can be interchanged. The module contains all of the passive components required to properly polarize and protect the switch elements.

This module was designed taking into consideration two FOC control methodologies: Hall Sensor FOC and sensorless FOC. A connector is provided to connect hall sensor signals. In parallel to these connections, the board provides three SENSE resistors utilized to measure phase currents which the FOC algorithm employs during commutation. All that is required from the user is to download the pertinent firmware into the Hydra-X20/23 Body board, and establish the respective motor connections.

Other resources made available to prospective developers are a potentiometer which could be used to control motor speed, two push buttons, and a series of connectors which could be used to add external switches. A placeholder for a thermistor was designed into the system allowing developers to add their own version of a thermal protection directly interfaced at the FET block.

Active-Semi's HYDRA-X FOC Head kit consists of the following:

- HYDRA-X FOC Head module
- HYDRA-X FOC Head User's Guide
- Schematics, BOM and Layout Drawings

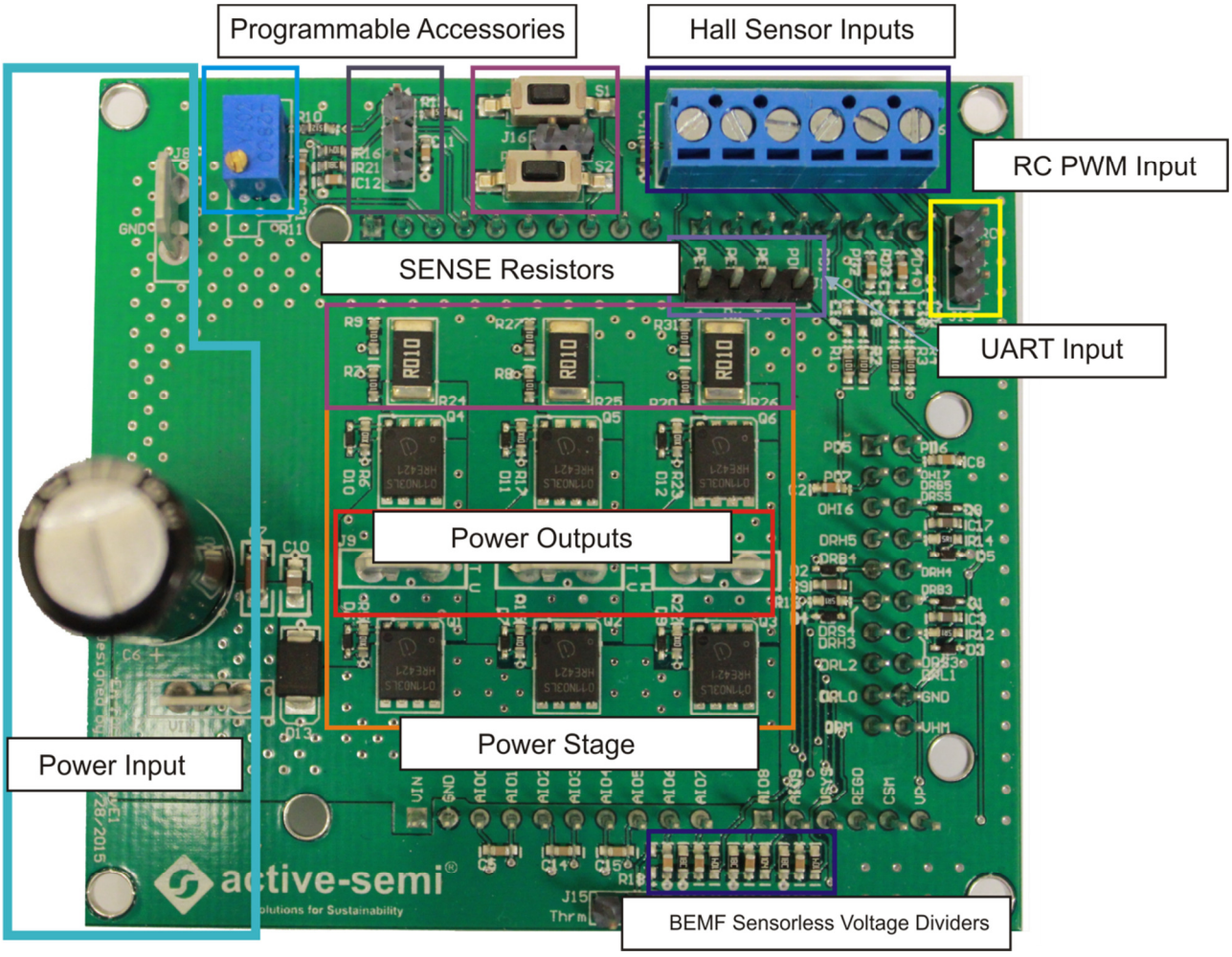

Figure 1: HYDRA-X FOC Head Block Diagram

Solution Benefits:

- Ideal for most medium voltage and high current motor driving applications.
- Six powerful FET switches allow for high current motor driving.
- Motor can be controlled remotely through an RC radio or an UART based serial communications channel such as a BlueTooth module (Bluetooth module not included).
- Can be programmed to drive FOC motors in sensored or sensorless implementations.
- Schematics, BOM, Layout drawings available

The following sections provide information about the hardware features of Active-Semi's HYDRA-X FOC Head turnkey solution.

HYDRA-X FOC HEAD RESOURCES

Header Descriptions

The following table shows the female header descriptions for the HYDRA-X10 Body module.

Header	Pin	Description
J1	1-10	Refer to HYDRA-X20 pinout diagram
J2	1-8	Refer to HYDRA-X20 pinout diagram
J3	1-20	Refer to HYDRA-X20 pinout diagram
J4	1-10	Refer to HYDRA-X20 pinout diagram
J5	1-6	Refer to HYDRA-X20 pinout diagram
J6	-	Hall Sensor Inputs
	1	Hall Sensor VCC (5V)
	2	Hall Sensor U Phase
	3	Hall Sensor V Phase
	4	Hall Sensor W Phase
	5	Optional Hall Sensor Input (FG)
	6	Hall Sensor GND
J7	-	VIN Power Input -Spade connector (16V to 48V)
J8	-	GND Power Input – Spade Connector
J9	-	U Phase Output – Spade Connector
J10	-	V Phase Output – Spade Connector
J11	-	W Phase Output – Spade Connector
J12	-	Extern UART connector.
	1	UART VCC (5V)
	2	UART RX
	3	UART TX
	4	UART GND
J13	-	External RC PWM connector.
	1	RC PWM Signal Digital Input (PD4)
	2	RC PWM VCC (5V)
	3	RC PWM GND
J14	-	External Potentiometer Input
	1	External Potentiometer VCC (Voltage Divided VCC = 5V)
	2	External Potentiometer Analog Input (PC4)
	3	External Potentiometer GND
J15	-	Optional Thermistor connector
	1	Thermistor Analog Input (AIO2)
	2	Thermistor GND
J16		External Push Button
	1	External Push Button Digital Input (PE5)
	2	Extern Push Button GND

HYDRA-X20 FOC System Pinout and Signal Connectivity

The following diagram shows the male header pinout for the HYDRA-X FOC Head module, as seen from above:

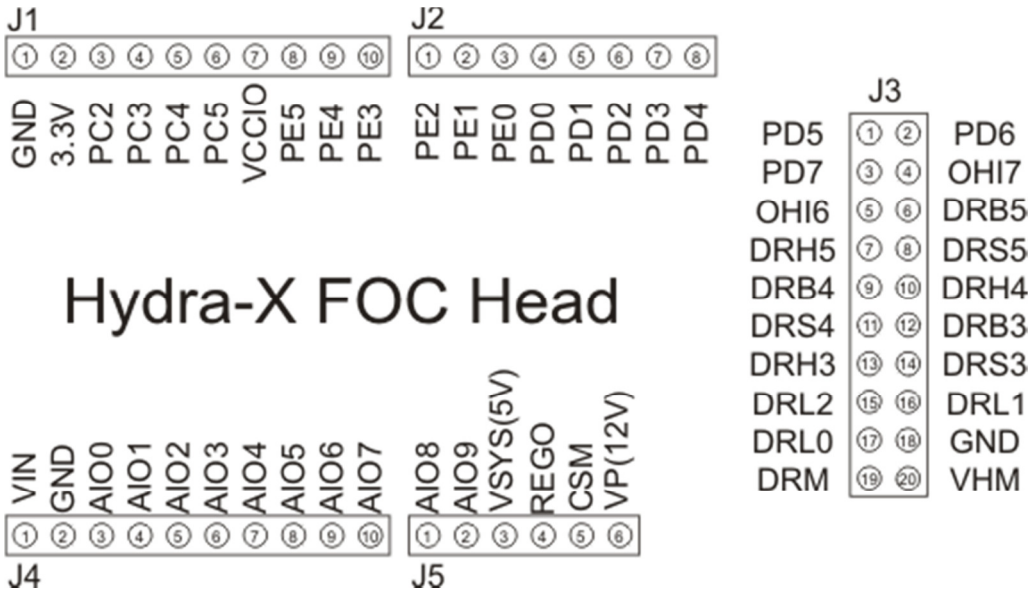

Figure 2 HYDRA-X FOC Head Pinout

The HYDRA-X FOC Head module interfaces with the HYDRA-X20 and Hydra-X23/23S Body modules.

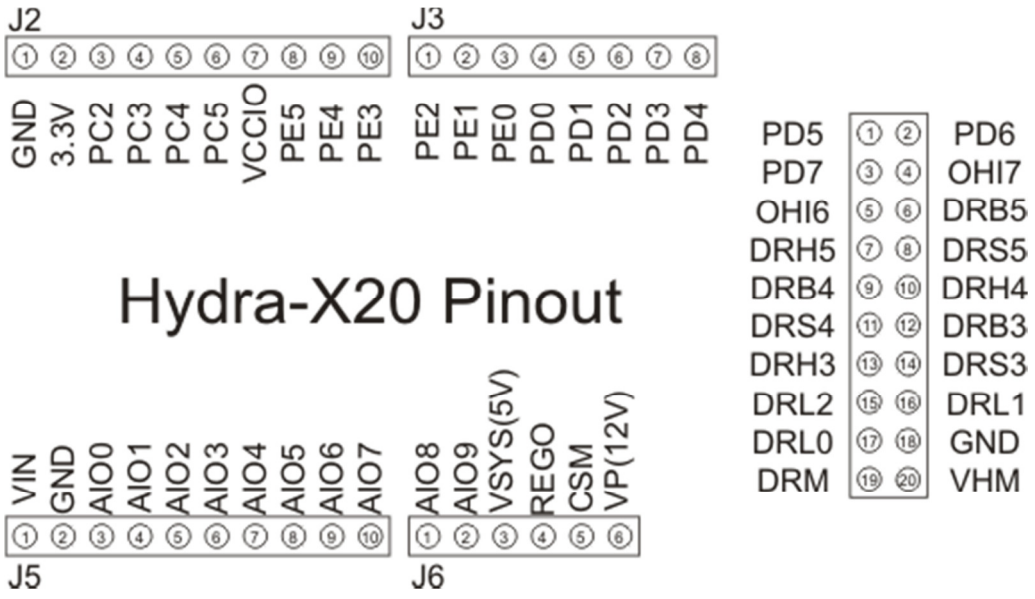

Figure 3 HYDRA-X20 Body Pinout

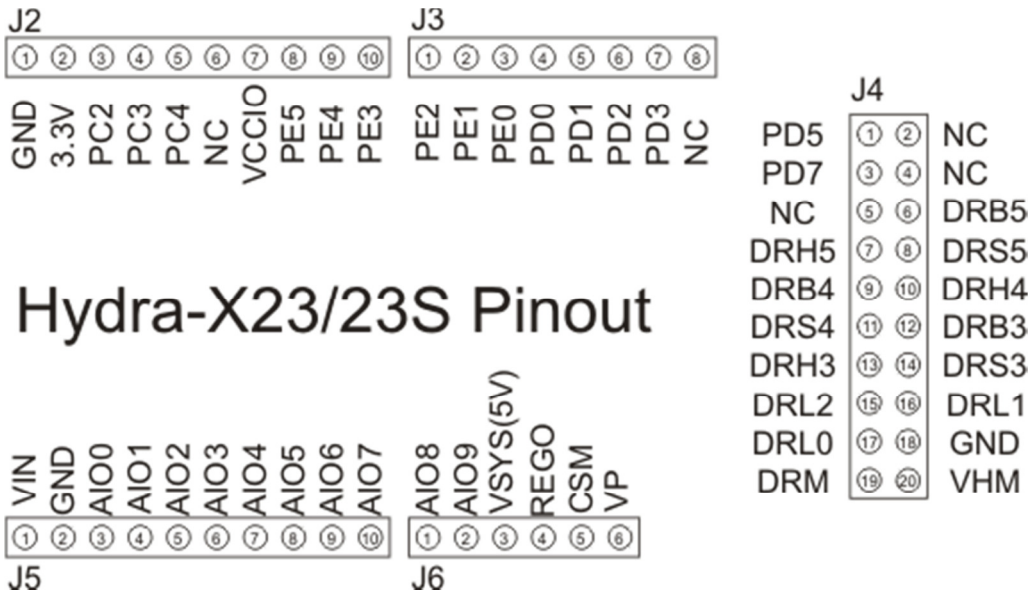

Figure 4 HYDRA-X23/23S Body Pinout

More information on the HYDRA-X20/23/23S Body modules, and their respective User's Guide, can be downloaded from the HYDRA-X website at www.active-semi.com/hydra.

Power Input

Power to the Hydra-X FOC Head module should be connected to the J7/J8 Spade connectors. The voltage magnitude applied to the module should not exceed the employed FET VDS voltage. Default FETs (BSC011N03LS) have a VDS of 30V. A suggested alternative for up to 60V voltage applications is the BSC076N06NS3 with a VDS of 60V.

Powering the HYDRA-X FOC Head through the J7/J8 connectors will power the HYDRA-X20/23 Body board. Power to the body board is applied through the J4 VIN and GND terminal.

NOTE: Applying power to the HYDRA-X FOC system through the HYDRA-X20/23 J7 connector is not recommended. Since this is a high current application, and the header connectors are not rated to handle such high currents, it is crucial that current is supplied through the spade connectors into the headers and not vice versa.

The HYDRA-X FOC Head is not protected against voltage reversal. Voltage polarity must be observed before applying power to the module. Failing to follow correct voltage polarity connections will adversely affect HYDRA-X FOC Head power FETs.

External and Internal Resources

The following table illustrates the systems resources utilized

Header	Pin	Description	GPIO Resource
J6	2	Hall Sensor U Phase	PD2
J6	3	Hall Sensor V Phase	PD3
J6	4	Hall Sensor W Phase	PD6
J6	5	Optional Hall Sensor Input (FG)	PD7
J12	2	UART RX	PE2
J12	3	UART TX	PE1
J13	1	RC PWM Signal Digital Input	PD4
J14	2	External Potentiometer Analog Input	PC4
J15	1	Thermistor Analog Input	AIO2
J16	1	External Push Button Digital Input	PE5
Internal	-	VIN Analog Input	PC4
Internal	-	R11 Potentiometer Analog Input	PC2
Internal	-	S1 Push Button Digital Input	PE4
Internal	-	S2 Push Button Digital Input	PE5
Internal	-	PHASE U Output (Voltage Divided)	AIO7
Internal	-	PHASE V Output (Voltage Divided)	AIO8
Internal	-	PHASE W Output (Voltage Divided)	AIO9
Internal	-	SENSE Resistor + Terminal	AIO1
Internal	-	PHASE U Low Side FET Gate Drive	DRL0
Internal	-	PHASE U High Side FET Gate Drive	DRH3
Internal	-	PHASE U Boot Strap	DRB3
Internal	-	PHASE U High Side Source	DRS3
Internal	-	PHASE V Low Side FET Gate Drive	DRL1
Internal	-	PHASE V High Side FET Gate Drive	DRH4
Internal	-	PHASE V Boot Strap	DRB4
Internal	-	PHASE V High Side Source	DRS4
Internal	-	PHASE W Low Side FET Gate Drive	DRL2
Internal	-	PHASE W High Side FET Gate Drive	DRH5
Internal	-	PHASE W Boot Strap	DRB5
Internal	-	PHASE W High Side Source	DRS5

HYDRA-X FOC HEAD HARDWARE

External Potentiometer (J14)

For applications wanting to utilize an external potentiometer, the 3 pin header connector gives access to analog input PC4. The potentiometer resource is pulled up via a 5.1K resistor. In the event the external potentiometer requires a different pull up resistance, resistor R19 can be modified accordingly with a 0603 package of suitable resistive value.

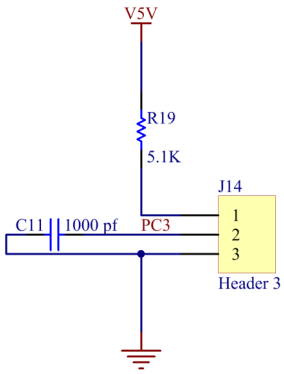

Figure 5 External Potentiometer Circuitry

External Thermistor (J15)

In order to protect power FETs from being adversely affected by extremely high temperatures, a thermistor input is provided. Thermistor temperature can be sampled through analog input AIO2.

By default, the thermistor's pull up resistor is a Non Populate component. User can select appropriate pull up resistor (0603 package) and populate at the R18 footprint location.

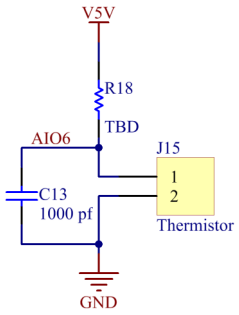

Figure 6 External Thermistor Circuitry

S1 and S2 Push Buttons

Two push buttons (S1 and S2) are made available for users requiring to add further control functionality to the motor drive system. Push button S1 is assigned to resource PE4 whereas push button S2 is assigned to resource PE5.

Alternatively, a non-populated two pin connector (J16) is made available in order to allow for an external switch to be added at a later time, if required.

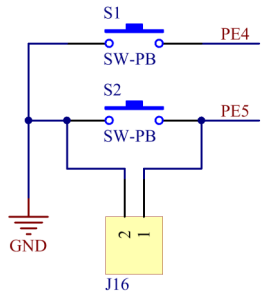

Figure 7 External Thermistor Circuitry

RC PWM Remote Control Input (J13)

Users wanting to control a motor by employing an off the shelf Remote Control (RC) radio, can take advantage of the 3 pin header connector J13. This pin provides 5V power to the receiver module and accepts the typical 1.0 to 2.0 ms PWM signal. Firmware decoding the RC PWM signal is part of our sample code made available at the HYDRA-X Blog.

RC PWM control signal can be sampled via the PD4 resource.

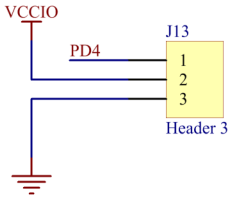

Figure 8 RC PWM Interface Circuitry

Hall Sensor Inputs (DAC Outputs – Optional) (J6)

The terminal block J6 offers users with access to 4 PDx pin resources. Although the initial intention for this connector is to allow for hall sensors to be interfaced to the microcontroller, an alternate function is to use the PDx resources as outputs. Some applications may take advantage of the output configuration to implement a DAC by adding a simple RC filter to a programmable PWM output.

The module ships with the resistors and capacitors for the Hall Sensor feature populated. That is R1, R2, R3 and R4; and C1, C2, C4 and C8.

To enable the DAC feature, the C1, C2, C4 and C8 should be removed and the C16, C18, C19 and C20 capacitors populated. Depending on the PWM frequency employed to generate the DAC function, it may become necessary to change the R1, R2, R3 and R4 as well. Typical values utilized with the FOC firmware are 0.1 uF for the capacitors and 4.3K for the resistor.

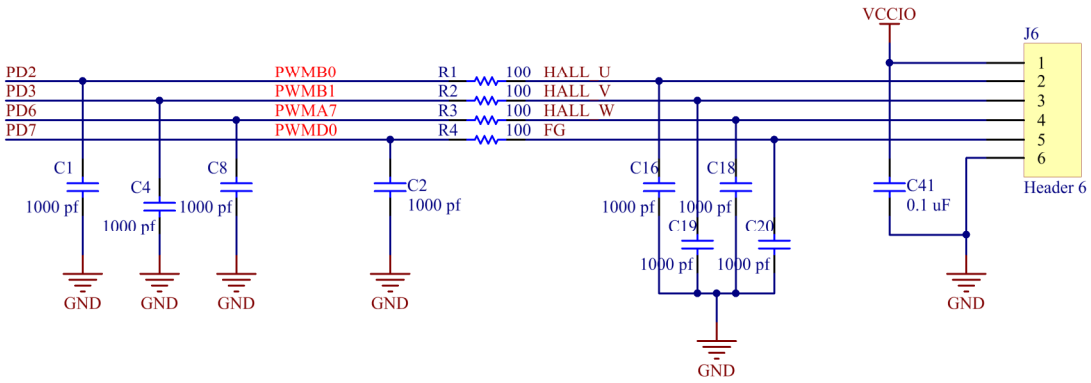

Figure 9 Hall Sensor Input / DAC outputs

HYDRA-X FOC HEAD SCHEMATIC

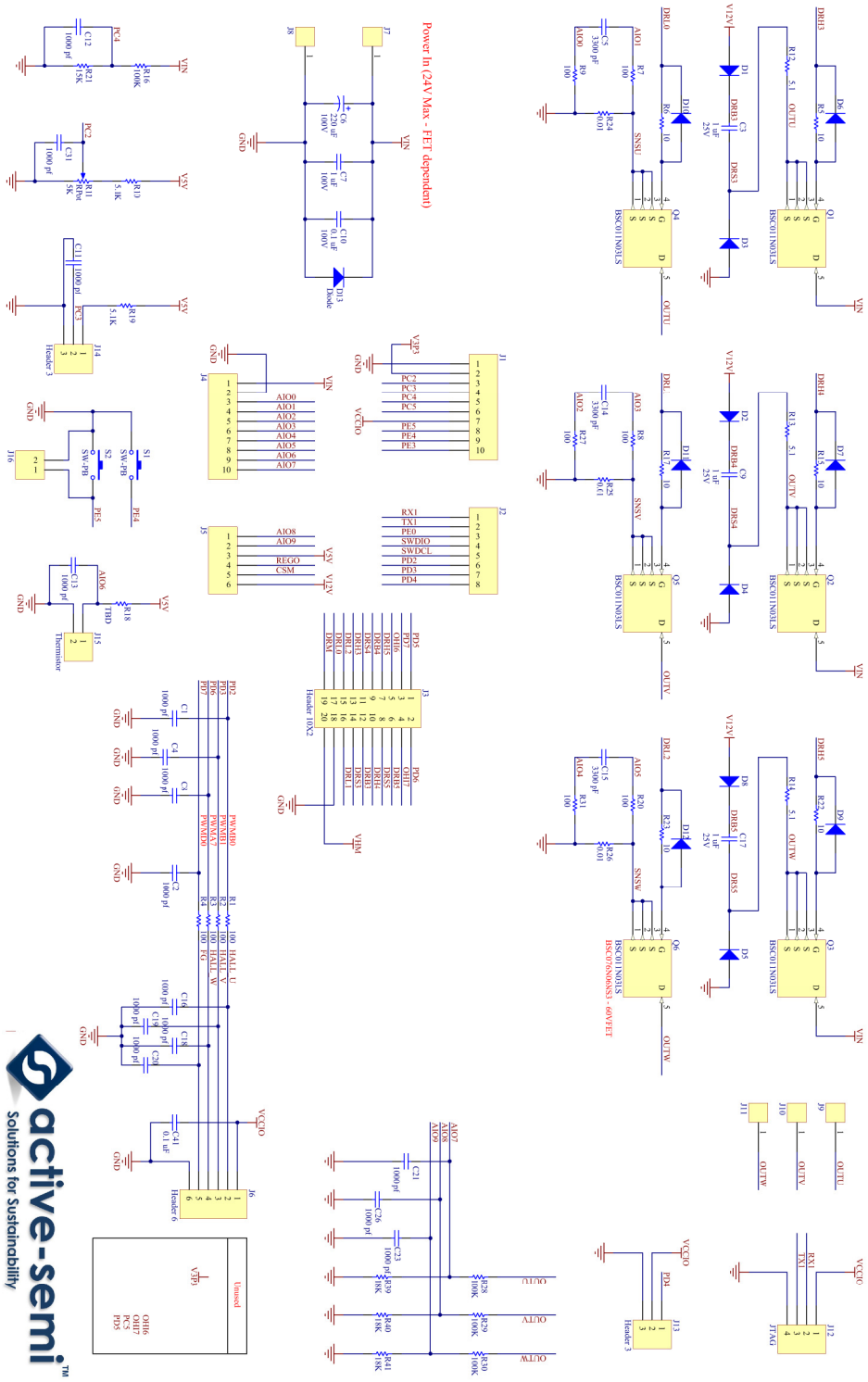

Figure 10:HYDRA-X FOC Head Schematic Diagram

ABOUT ACTIVE-SEMI

Founded in 2004 in Silicon Valley and headquartered in Allen, Texas, Active-Semi is a rapidly emerging leader in the multi-billion dollar power management IC and intelligent digital motor drive IC markets. The company's portfolio of analog and mixed signal SoCs (systems-on-chips) are scalable core platforms used in charging, powering and embedded digital control systems for end applications such as industrial, commercial and consumer equipment. The company offers power application microcontrollers, DC/DC, AC/DC, PMU and LED drivers that significantly reduce solution size and cost while improving system-level reliability. Active-Semi's turnkey solutions deliver energy-saving power conversion architectures that minimize energy usage and compress system development cycle-time by greater than 50 percent. Active-Semi ships 50 million power ICs per quarter and reached the "one billion units shipped" milestone in May 2012. The multi-national company focuses on commercializing industry leading power management IC solution platforms and has developed broad intellectual property with over 150 patents granted and pending. For more information visit: http://active-semi.com/

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