Data Sheet No. PD-5.014D

International IƏR Rectifier

HEXFET® Power Module

CPY203E & IRFT003
Power H-Bridges

Description/Features

The CPY203E and the IRFT003 are intended for use in driving sub-fractional horsepower DC motors and stepper motors, as well as applications in servo amplifiers and power supplies. Connected in an H-bridge configuration these modules are offered at 60 volts current ratings up to 11.9 amperes.

The CPY203E and IRFT003 simplifies circuit design and construction by replacing up to six discrete devices with a single, electrically-isolated and tested part. The CPY203E module offers free-wheeling diodes across the P-channel HEXFETs for greater efficiency. In addition, current-sensing HEXSense devices are used on the low-side of each leg providing the user with lossless current capability.
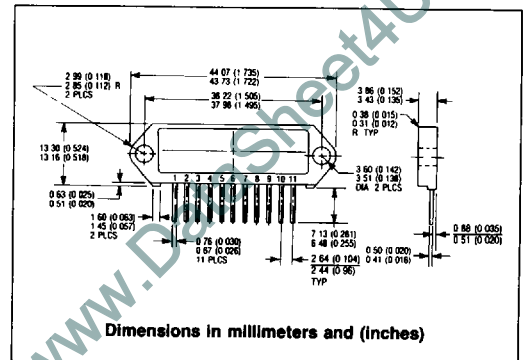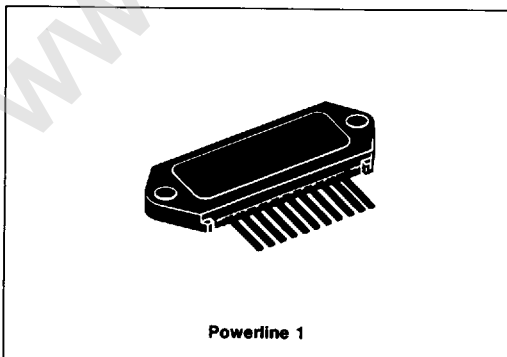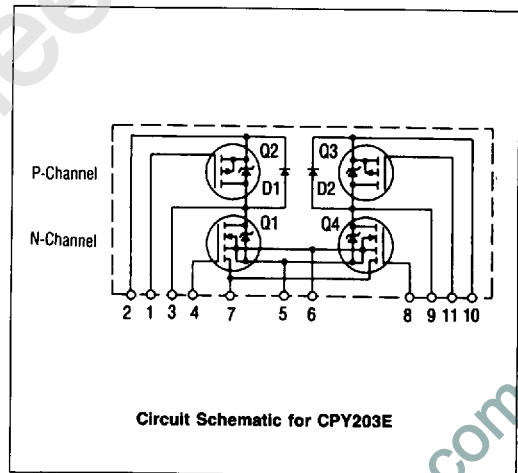
These modules minimize the space requirements of your power components while also serving to simplify thermal management and reduce assembly time and cost.

Typical Applications:

- Amplifiers
- Printers and plotters
- Small appliances
- Robotics
- Switching power supplies

Product Summary

Part Number	V_{DS}	R_{DS} (on)		I_D
		Low Side	High Side	
CPY203E	60V	0.05Ω	0.14Ω	11.9A
IRFT003	60V	0.10Ω	0.28Ω	6.0A

Circuit Schematic for CPY203E

Powerline 1

Dimensions in millimeters and (inches)

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CPY203E, IRFT003

Absolute Maximum Ratings

Parameter	CPY203E	IRFT003	Units	Conditions/Notes
Breakdown Voltage	60	60	V	
Gate-to-Source Voltage	±20			
Continuous Current	11.9	6.0		Any two complementary devices, $T_C = 25°C$
	10.9	6.0	A	Any two complementary devices, $T_C = 45°C$
	7.5	4.6		Any two complementary devices, $T_C = 100°C$
Operating & Storage Temperature	−40 to +150		°C	
Lead Temperature	300			1.6mm (0.063") from case for 10 sec
Mounting Torque	2.5 to 3.5		in • lb	For mounting & assy recommendations, see page 86.
RMS Isolation Voltage	2500		V	Any pin to case

HEXFET Electrical Characteristics @ T_C = 25°C (Unless otherwise specified)

Parameter		Type	CPY203E	IRFT003	Units	Conditions/Note
BV_{DSS}	Min. Drain Source Breakdown	N-Channel	60	60	V	$V_{GS} = 0$, $I_D = 250\ \mu A$, $T_J = 25°C$ to 150°C
		P-Channel	−60	−60		
$V_{GS(th)}$	Gate Threshold Voltage	N-Channel	2.0 to 4.0			$V_{DS} = V_{GS}$, $I_D = 250\ \mu A$
		P-Channel	−2.0 to −4.0			
I_{GSS}	Max. Gate Source Leakage, Forward Voltage	N-Channel	500			$V_{GS} = 20V$
		P-Channel	−500		nA	$V_{GS} = -20V$
	Max. Gate Source Leakage, Reverse Voltage	N-Channel	−500			
		P-Channel	500			$V_{GS} = 20V$
I_{DSS}	Max. Zero Gate Voltage Drain Current	N-Channel	250			$V_{DS} = $ Max. Rating, $V_{GS} = 0V$
		P-Channel	−250		μA	
		N-Channel	1000			$V_{DS} = $ Max. Rating x 80%, $V_{GS} = $ V, $T_J = 125°C$
		P-Channel	−1000			
$R_{DS(on)}$	Max. Static Drain-Source On-State Resistance of Die	N-Channel	0.05	0.10		$V_{GS} = 10V$, Pulse Test: Pulse Width ≤ 300 μs, duty cycle ≤ 2%
		P-Channel	0.14	0.28	Ω	
R_p	Max. Resistance Contribution of Package		0.015			
g_{fs}	Min. Forward Transconductance	N-Channel	10.0	5.5	$S(\sigma)$	$V_{DS} = 2$ x V_{GS}, $I_{DS} = $ Max. I_D Rating @ 100°C
		P-Channel	5.9	2.9		
r	Typical Current Sensing Ratio		1300	—		Refer to HEXSense fundamentals in this data sheet

HEXFET Dynamic Characteristics @ T_C = 25°C (Unless otherwise specified)

Parameter		Type	CPY203E	IRFT003	Units	Conditions/Note
C_{iss}	Typical Input Capacitance	N-Channel	1300	640		$V_{GS} = 0V$, $V_{DS} = 25V$, f = 1.0 MHz
		P-Channel	1100	570		
C_{oss}	Typical Output Capacitance	N-Channel	640	350	pF	
		P-Channel	620	360		
C_{rss}	Typical Reverse Transfer Capacitance	N-Channel	96	51		
		P-Channel	100	65		
$t_{d(on)}$	Max. Turn-on Delay Time	N-Channel	20	13		
		P-Channel	27	20		
t_r	Max. Rise Time	N-Channel	150	58		$V_{DD} = 50\%$ of Rated Value, $I_D = $ Max. Cont. Rating (MOSFET switching times are essentially independent of operating temperature).
		P-Channel	158	100	nS	
$t_{d(off)}$	Max. Turn-off Delay Time	N-Channel	44	25		
		P-Channel	30	23		
t_f	Max. Fall Time	N-Channel	78	42		
		P-Channel	87	44		
Q_g	Max. Total Gate Charge	N-Channel	46	25		
		P-Channel	34	19		$V_{GS} = 10V$, $I_D = $ Max. Cont. Rating, $V_{DS} = $ Max. Rating x 80%. (Gate charge is essentially independent of operating temperature).
Q_{gs}	Typical Gate-to-Source Charge	N-Channel	6.8	3.9	nC	
		P-Channel	6.9	4.1		
Q_{gd}	Typical Gate-to-Drain ("Miller") Charge	N-Channel	15.0	7.0		
		P-Channel	9.7	5.7		

CPY203E, IRFT003

Source-Drain Diode Electrical Characteristics @ T_C = 25°C (Unless otherwise specified)

	Parameter	Type	CPY203E	IRFT003	Units	Conditions/Note
I_S	Max. Continuous Source Current (Body Diode)		11.9	6.0*	A	*Package limited
V_{SD}	Max Diode Forward Voltage	N-Channel	16	1.5	V	V_{GS} = 0V, I_S = Max. Rating, T_J = 25°C
		P-Channel	–1.5*	–6.3		*Value is for conduction through free-wheeling diode.
t_{rr}	Max. Reverse Recovery Time	N-Channel	220	180	nS	I_F = I_S Max. Rating, dI_F/dt = 100 A/μS,
		P-Channel	200	200		T_J = 25°C
Q_{RR}	Max. Reverse Recovery Charge	N-Channel	0.96	0.64	μC	*Typical Value
		P-Channel	0.52	0.64		

Free-Wheeling Diode Characteristics @ T_C = 25°C (Unless otherwise specified)

	Parameter	CPY203E	IRFT003	Units	Conditions/Notes
V_{FM}	Max. Peak Forward Voltage Drop	1.3	—	V	
t_{rr}	Max. Reverse Recovery Time	200	—	nS	
V_{RRM}	Max. Repetitive Peak Reverse Voltage	60	—	V	
I_F	Max. Average Forward Current	3	—	A	T_C = 60°C

Thermal Characteristics

	Parameter	CPY203E	IRFT003	Units	Conditions/Notes
R_{thJC}	Max. Thermal Resistance Junction-to-Case	3.8	5.6	°C/W	Any one device
R_{thJA}	Typical Thermal Resistance Junction-to-Ambient	50	50		
P_D	Max. Power Dissipation	33	22	W	Any one device, T_C = 25°C

For additional HEXFET characteristics, the electrical characteristic curves located from pages 67 to 85 can be referenced. This data represents the typical performance of each of the HEXFET die included in these power modules.

Parameter	Type	CPY203E	IRFT003	Units	Conditions/Notes
HEXFET Electrical Characteristic Curves	N-Channel	IRCC034 See page 68	IRFC024 See page 72	—	
	P-Channel	IRFC9034 See page 80	IRFC9024 See page 78	—	

These power modules can be manufactured in a variety of voltages and on-resistances along with substituted or additional components. For additional information on these semi-custom possibilities, refer to the Custom Capabilities section on page v.

HEXSense Fundamentals

In practice, a HEXSense device consists of two paralleled MOSFETs with isolated sources (Figure 1), commonly referred to as "power device" and "sense device." The key parameter of this combination is the *current sensing ratio* (r). This is the ratio between the current in the source pin and the current in the sense pin (I_{source}/I_{sense}). This ratio will, of course, be slightly different in terms of drain current, which is the sum of both currents:

$$I_D = (r + 1)\, I_C$$

For the CPY203E HEXFET power module, the pins used for current-sensing have the following designations:

Pin 5   Power source
Pin 6   Source kelvin
Pin 7   Current sense

Figure 1. Schematic Representation of HEXSense Device
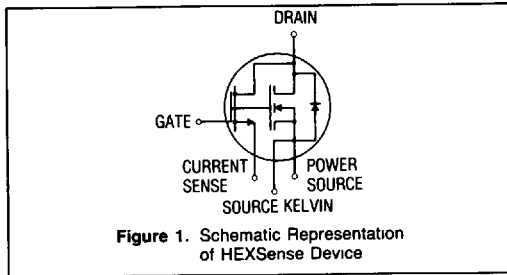
HEXSense Application

The circuit that gives the best performance in terms of speed, accuracy and noise immunity is shown in Figure 2.

For fully enhanced operation the accuracy of this circuit may be estimated directly from the data sheets and the tolerance of r. Neither the offset nor the bias current of the operational amplifier should have any significant effect on the overall static performance.

Figure 2. Virtual Earth Sensing Circuit

Figure 3. Resistor Sensing Circuit

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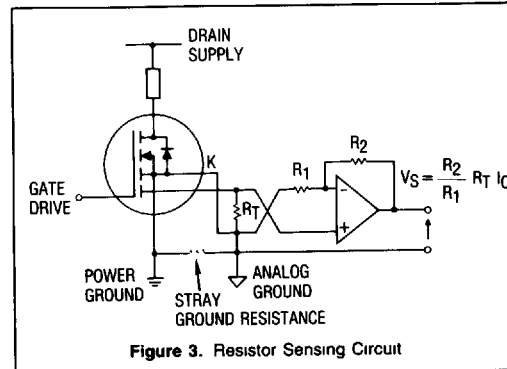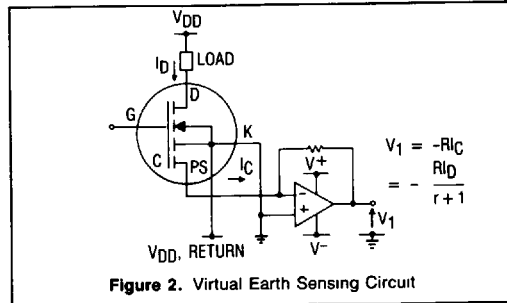
HEXSense Applications (cont)

However, this is not the case when it comes to dynamic performance. Current swings of 10A in 100 nsec are common in switch mode power supplies (SMPS) and similar applications. For a 5 volt output at 10A this translates into a required slew rate of 50 V/μs which is an order of magnitude above that which commonly available operational amplifiers are capable of. The settling time of high slew-rate operational amplifiers will also affect the dynamic performance of this circuit.

Two disadvantages of this circuit are the dual power supply requirement for the operational amplifier and the negative polarity of the output voltage.

Resistor Sensing

A second circuit, shown in Figure 3, overcomes these disadvantages at a significant penalty in accuracy and performance.

In this circuit the current-to-voltage translation is performed by the sensing resistor R_T, while the operational amplifier provides the necessary amplification. Input and output voltages are both positive and no negative supply is required, provided the common mode input range of the operational amplifier includes ground (CA3130, CA3140, LM324, LM358, TLC271, etc.).
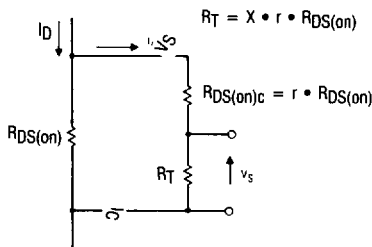

Figure 4. Evaluation of Error
Introduced by R_T

The sense ratio of the circuit will vary from the nominal sense ratio due to the introduction of R_T. With reference to Figure 4, assuming that R_T is a share of (X) of the on-resistance of the sensing cells, which, in turn, is r times the $R_{DS(on)}$ of the main device,

$$\frac{I_D}{I_C} = 1 + r (1 + X)$$

The voltage across the sensing resistor will be:

$$V_S = \frac{X}{X + 1} R_{DS(on)} I_D$$

Ideally, it should be:

$$V_S = X \cdot R_{DS(on)} I_D$$

This error, $1/(1 + X)$, can be compensated for by increasing the gain of the operational amplifier by the same coefficient. However, it should be remembered that the coefficient X is not a constant because the $R_{DS(on)}$ of the device (and of the sensing cells) is a function of temperature, current, gate voltage and production spread.

The value of R_T should be such that the voltage across its terminals at the lowest level of current at which the prescribed measurement accuracy is still required should be significantly higher than the offset of the operational amplifier. Furthermore, if it is necessary to amplify the sense signal over a wide voltage range then the output voltage range of the operational amplifier may pose a limitation. An operational amplifier with a low output saturation voltage will be necessary if low level drain currents are to be sensed, or a negative supply may be required.

Changes in MOSFET on-resistance with temperature have an adverse effect on the overall accuracy of the sensing circuit of Figure 3. It can be shown, however, that sensitivity of V_S to temperature changes becomes negligible as R_T tends to values in the order of 10% of $R_{DS(on)c}$.

With reference to Figure 4,

$$V_S = \frac{R_T}{R_T + R_{DS(on)c}} \cdot I_D \cdot R_{DS(on)}$$

$$\cong \frac{R_T}{R_{DS(on)c}} \cdot I_D \cdot R_{DS(on)}$$

$$= R_t \cdot I_D \cdot \frac{R_{DS(on)}}{R_{DS(on)c}}$$

Since $R_{DS(on)}$ and $R_{DS(on)c}$ should change by the same factor for a given change in temperature, the ratio $R_{DS(on)}/R_{DS(on)c}$ should remain constant. Therefore, provided $R_T \ll R_{DS(on)c}$, V_S should not be greatly affected by changes in the device temperature.

In final analysis the value of R_T will be the lowest compatible with the offset of the operational amplifier and the noise immunity requirements of the circuit.

For more detailed information on the use of application
of HEXSense current sensing, refer to these application
notes available from International Rectifier:

AN-959 "An Introduction to the HEXSense
        Current Sensing Device"

AN-961 "Using HEXSense Current Sense
        HEXFETs in Current Mode Control
        Power Supplies"

Power Interface Products

Custom Packaging Capability

The Power Interface Products Group of International Rectifier has many years of design and manufacturing experience in custom packaging of power components. This expertise provides us with the flexibility necessary to meet your unique power application requirements.

Design Expertise
International Rectifier is dedicated to meeting the design needs of its customers. Computer-aided design and thermal analysis capabilities are utilized to minimize the time and cost for achieving the most complex and demanding design requirements. The combined experience of our development team offers design support and customer-responsiveness second to none.

Advanced Manufacturing
Our manufacturing facility houses a full compliment of automatic assembly and test equipment necessary to develop and produce power modules to meet virtually any application-specific packaging requirement. This facility also offers the flexibility to provide hybrid prototype quantities in a short cycle time and high volume capacity to meet most any production and delivery requirement. Dedicated thick-film or direct-bond processing, production tooling, automatic testing, lead form capabilities and a self-contained clean room provide the foundation for total and immediate responsiveness to product quality, reliability, performance and delivery.

Technology Leadership
International Rectifier's technological leadership in power semiconductors has, in turn, propelled its Power Interface Products Group to establish itself as an innovative leader in semiconductor packaging. Available at the forefront of our power hybrid expertise are both screen-printing thick film and direct-bond leadframe technologies. Ceramics or insulated metal substrates with integrated heatsink systems are also offered. Whatever the need, our power packaging capabilities can provide the most advanced integration for optimized performance in the required space.

Total Accountability
International Rectifier makes both the semiconductor die and the package. We have accurate control of wafer fab to correct and improve die-related problems. This means we take complete responsibility for the total solution with total commitment and total control. Three good reasons why International Rectifier is your best source for power module quality, reliability, cost, convenience, and performance.