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QRW010/025/035/040 Series Power Modules; dc-dc Converters 36 Vdc - 75 Vdc Input, 1.0 to 12 Vdc Output; 10 A to 40 A

RoHS Compliant



Applications

- Enterprise Networks
- Wireless Networks
- Access and Optical Network Equipment
- Enterprise Networks
- Latest generation IC's (DSP, FPGA, ASIC) and Microprocessor-powered applications.

Options

- Positive Remote On/Off logic
- Case ground pin (-H Base plate version)
- Auto restart after fault shutdown

Description

The QRW-series dc-dc converters are a new generation of DC/DC power modules designed for optimum efficiency and power density. The QRW series provide up to 40A output current in an industry standard quarter brick, which makes it an ideal choice for small space, high current and low voltage applications. The converter uses synchronous rectification technology and innovative packaging techniques to achieve ultra high efficiency reaching 91% at 3.3V full load. Thanks to the ultra high efficiency of this converter, the power dissipation is such that for most applications a heat sink is not required. In addition, the QRW-series supports future migration of semiconductor and microprocessor supply voltages down to 1.0V.

Features

- Compatible with RoHS EU Directive 2002/95/EC (-Z Versions)
- Compatible in RoHS EU Directive 2002/95/EC with lead solder exemption (non -Z versions)
- Delivers up to 40A output current
- Ultra High efficiency: 91% at 3.3V full load
- Industry standard Quarter Brick:
57.9 mm x 36.8 mm x 9.5 mm
(2.28 in x 1.45 in x 0.375 in)
- Improved Thermal performance
23A at 70°C at 1ms-1 (200LFM) for 3.3Vo
- High power density: 100W/in³
- Low output ripple and noise
- Low output voltages down to 1V:
Supports migration to future IC and microprocessor supply voltages
- 2:1 input voltage
- Remote Sense
- Remote On/Off
- Constant switching frequency
- Output overvoltage and Overcurrent protection
- Overtemperature protection
- Adjustable output voltage (+10% / -20%)
- Meets the voltage and current requirements for ETSI 300-132-2 and complies with and is approved for Basic Insulation rating per EN60950-1
- UL* 60950 Recognized, CSA† C22.2 No. 60950-00 Certified, and VDE‡ 0805 (IEC60950, 3rd edition) Licensed
- CE mark meets 73/23/EEC and 93/68/EEC directives§
- ISO** 9001 certified manufacturing facilities

* UL is a registered trademark of Underwriters Laboratories, Inc.

† CSA is a registered trademark of Canadian Standards Association.

‡ VDE is a trademark of Verband Deutscher Elektrotechniker e.V.

§ This product is intended for integration into end-use equipment. All the required procedures for CE marking of end-use equipment should be followed. (The CE mark is placed on selected products.)

** ISO is a registered trademark of the International Organization of Standards

Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only, functional operation of the device is not implied at these or any other conditions in excess of those given in the operations sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect the device reliability.

Parameter	Device	Symbol	Min	Max	Unit
Input Voltage:Continuous Transient (100ms)	All	VI VI, trans	— —	80 100	Vdc Vdc
Operating Ambient Temperature (See Thermal Considerations section)	All	TA	-40	85	°C
Storage Temperature	All	Tstg	-55	125	°C
I/O Isolation Voltage (100% factory Hi-Pot tested) When using optional case ground pin (option 7)	—	—	1500 700	Vdc Vdc	

Electrical Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions.

Parameter	Device	Symbol	Min	Typ	Max	Unit
Operating Input Voltage	All	VIN	36	48	75	Vdc
Maximum Input Current (VI = 0 V to 75 V; IO = IO, max)	All		—	—	4.5	Adc
Inrush Transient	All	I^2t			1	A ² s
Input Reflected Ripple Current, peak-peak (5 Hz to 20 MHz, 12 μH source impedance See Test configuration section)	All			16		mAp-p
Input Ripple Rejection (120 Hz)	All			60		dB

CAUTION: This power module is not internally fused. An input line fuse must always be used.

This power module can be used in a wide variety of applications, ranging from simple stand-alone operation to an integrated part of a sophisticated power architecture. To preserve maximum flexibility, internal fusing is not included; however, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require a normal-blow fuse with a maximum rating of 10 A (see Safety Considerations section). Based on the information provided in this data sheet on inrush energy and maximum dc input current, the same type of fuse with a lower rating can be used. Refer to the fuse manufacturer's data for further information.

Electrical Specifications (continued)

Output Specifications for the QRW040A0S1R0 (Vo = 1.0Vdc)

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point (VI = 48 Vdc; IO = IO, min to IO, max, TA = 25 °C)	P	Vo	0.99	1.0	1.01	Vdc
Output Voltage (Over all operating input voltage, resistive load, and temperature conditions at steady state until end of life.)	P	Vo	0.98	—	1.02	Vdc
Output Regulation: Line (VI = VI, min to VI, max) Load (IO = IO, min to IO, max) Temperature (TA = TA, min to TA, max)	P	— — —	— — —	0.1 0.1 15	0.3 0.3 50	% VO, set % VO, set mV
Output Ripple and Noise RMS (5 Hz to 20 MHz bandwidth) Peak-to-peak (5 Hz to 20 MHz bandwidth)	P		— —	— —	30 80	mVrms mVp-p
External Load Capacitance				—	25,000	µF
Output Current (Vo = 90% of VO, nom.)	P	IO	0.0	—	40	Adc
Output Current-limit Inception (VO = 90% of VO, set)	P	IO, lim	—	49	—	Adc
Output Short-circuit Current (Average) VO = 0.25 V	Latched off					
Efficiency (VI = VIN, nom; IO = IO, max), TA = 25 °C		η	—	83	—	%
Switching Frequency	All	fSW	—	300	—	kHz
Dynamic Response (DIO/Dt = 1 A/10 µs, VI = 48 V, TA = 25 °C); tested with a 220 µF aluminium and a 1.0 µF ceramic capacitor across the load.): Load Change from IO = 50% to 75% of IO, max: Peak Deviation Settling Time (VO < 10% of peak deviation) Load Change from IO = 50% to 25% of IO, max : Peak Deviation Settling Time (VO < 10% of peak deviation)				160 200 180 200		mV µs mV µs

Isolation Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Isolation Capacitance	Ciso	—	5600	—	PF
Isolation Resistance	Riso	10	—	—	MΩ

General Specifications

Parameter	Min	Typ	Max	Unit
Calculated MTBF (Io = 80% of Io, max Ta = 40 °C)		TBD		Hours
Weight	—	37(1.31)	—	g (oz.)

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions for additional information.

Parameter	Symbol	Min	Typ	Max	Unit
Remote On/Off Signal Interface* (VI = 0 V to 75 V; open collector or equivalent compatible; signal referenced to VI(-) terminal; see Figure 52 and Feature Descriptions.): Preferred Logic: Logic Low—Module On Logic High—Module Off Optional Logic: Logic Low—Module Off Logic High—Module On Logic Low: At Ion/off = 1.0 mA At Von/off = 0.0 V Logic High: At Ion/off = 0.0 μ A Leakage Current Turn-on Time; see Typical Start-up Curve (IO = IO max; Vo within \pm 1% of steady state)	Von/off Ion/off Von/off Ion/off	0 — — —	— — — 2	1.2 1.0 15 50 4	V mA V μ A ms
Output Voltage Adjustment (See Feature Descriptions): Output Voltage Remote-sense Range Output Voltage Set-point Adjustment Range (trim)	— —	— 80	— —	10 110	%VO, rated %VO, nom
Output Overvoltage Protection	VO, ovsd	1.25	—	1.5	V
Overtemperature Protection (IO = IO, max)	Tref1	—	127	—	$^{\circ}$ C

Characteristic Curves

The following figures provide typical characteristics curves for the QRW040A0S1R0 ($V_O = 1.0\text{ V}$) module at room temperature ($T_A = 25\text{ }^\circ\text{C}$). The figures are identical for both on/off configurations.

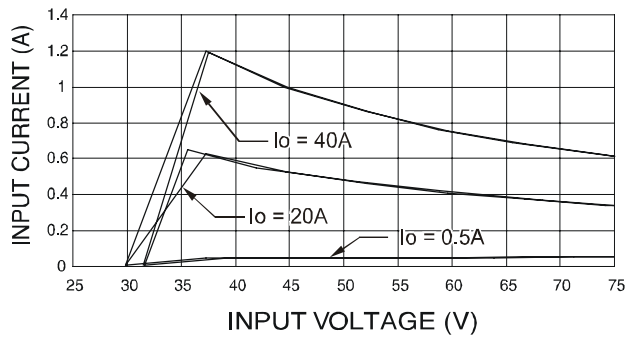


Figure 1. Input Voltage and Current Characteristics.

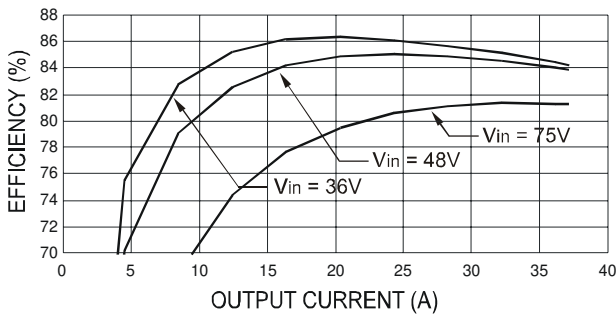


Figure 2. Converter Efficiency vs. Output Current.

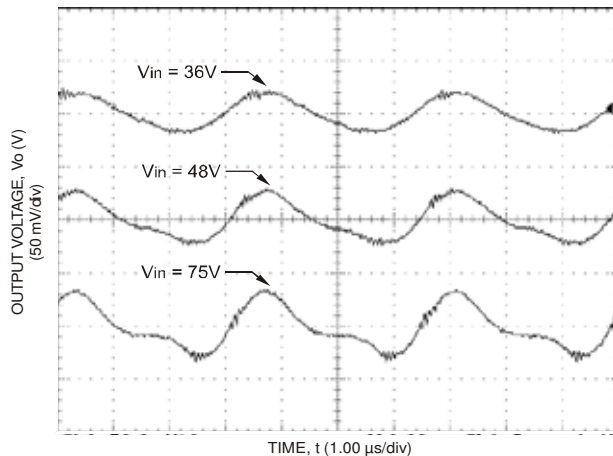
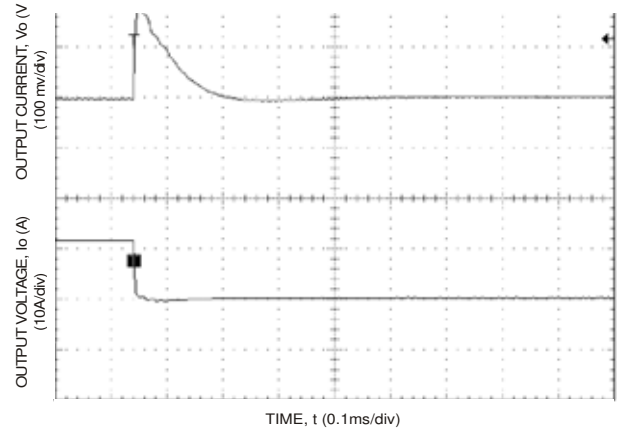


Figure 3. Output Ripple Voltage ($I_O = I_{O, \text{max}}$).

Lineage Power



Tested with a $220\mu\text{F}$ aluminium and a $1.0\mu\text{F}$ ceramic capacitor across the load.

Figure 4. Transient Response to Step decrease in Load from 50% to 25% of Full Load ($V_I = 48\text{ Vdc}$).

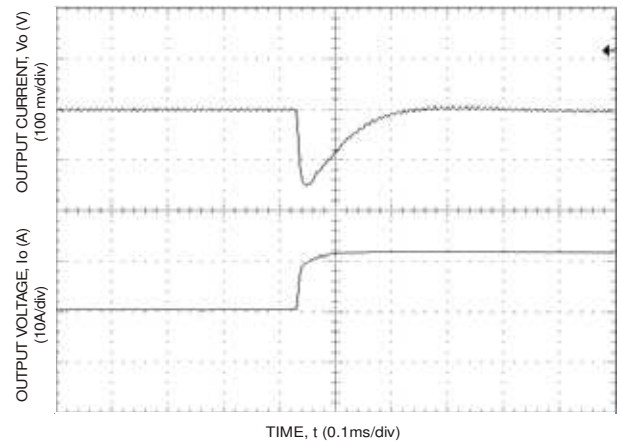


Figure 5. Transient Response to Step Increase in Load from 50% to 75% of Full Load ($V_I = 48\text{ Vdc}$).

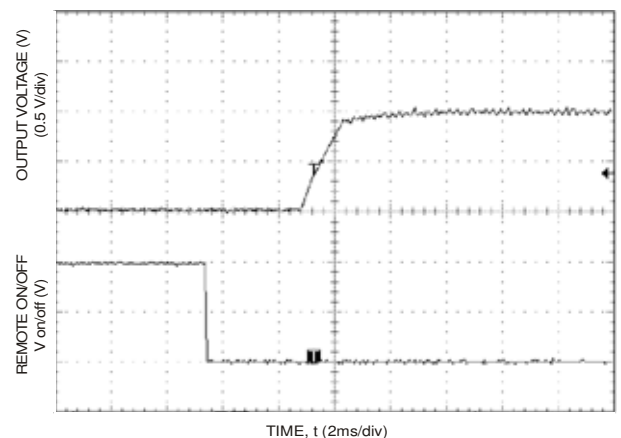


Figure 6. Start-up from Remote On/Off ($I_O = I_{O, \text{max}}$).

Electrical Specifications (continued)

Output Specifications for the QRW040AP (Vo = 1.2Vdc)

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point (VI = 48 Vdc; IO = IO, min to IO, max, TA = 25 °C)	P	Vo	1.18	1.2	1.22	Vdc
Output Voltage (Over all operating input voltage, resistive load, and temperature conditions at steady state until end of life.)	P	Vo	1.16	—	1.24	Vdc
Output Regulation: Line (VI = VI, min to VI, max) Load (IO = IO, min to IO, max) Temperature (TA = TA, min to TA, max)	P	— — —	— — —	0.05 0.05 15	0.3 0.3 50	% VO, set % VO, set mV
Output Ripple and Noise RMS (5 Hz to 20 MHz bandwidth) Peak-to-peak (5 Hz to 20 MHz bandwidth)	P		— —	— —	30 80	mVrms mVp-p
External Load Capacitance				—	25,000	µF
Output Current (Vo = 90% of VO, nom.)	P	IO	0.0	—	40	Adc
Output Current-limit Inception (VO = 90% of VO, set)	P	IO, lim	—	45	—	Adc
Output Short-circuit Current (Average) VO = 0.25 V	Latched off					
Efficiency (VI = VIN, nom; IO = IO, max), TA = 25 °C		η	—	85	—	%
Switching Frequency	All	fSW	—	300	—	kHz
Dynamic Response (DIO/Dt = 1 A/10 µs, VI = 48 V, TA = 25 °C); tested with a 220 µF aluminium and a 1.0 µF ceramic capacitor across the load.): Load Change from IO = 50% to 75% of IO, max: Peak Deviation Settling Time (VO < 10% of peak deviation) Load Change from IO = 50% to 25% of IO, max : Peak Deviation Settling Time (VO < 10% of peak deviation)				120 200 120 200		mV µs mV µs

Isolation Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Isolation Capacitance	Ciso	—	5600	—	PF
Isolation Resistance	Riso	10	—	—	MΩ

General Specifications

Parameter	Min	Typ	Max	Unit
Calculated MTBF (Io = 80% of Io, max Ta = 40 °C), Issue 1, M1, C1		1,271,000		Hours
Weight	—	37(1.31)	—	g (oz.)

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions for additional information.

Parameter	Symbol	Min	Typ	Max	Unit
Remote On/Off Signal Interface* (VI = 0 V to 75 V; open collector or equivalent compatible; signal referenced to VI(-) terminal; see Figure 52 and Feature Descriptions.): Preferred Logic: Logic Low—Module On Logic High—Module Off Optional Logic: Logic Low—Module Off Logic High—Module On Logic Low: At Ion/off = 1.0 mA At Von/off = 0.0 V Logic High: At Ion/off = 0.0 μ A Leakage Current Turn-on Time; see Typical Start-up Curve(I _O = I _O max; Vo within \pm 1% of steady state)	Von/off Ion/off Von/off Ion/off	0 — — —	— — — 2	1.2 1.0 15 50 4	V mA V μ A ms
Output Voltage Adjustment (See Feature Descriptions): Output Voltage Remote-sense Range Output Voltage Set-point Adjustment Range (trim)	— —	— 80	— —	10 110	%VO, rated %VO, nom
Output Overvoltage Protection	VO, ovsd	1.42	—	1.58	V
Overtemperature Protection (I _O = I _O , max)	Tref1	—	127	—	$^{\circ}$ C

* A Minimum OFF Period of 1 sec is recommended.

Characteristic Curves

The following figures provide typical characteristics curves for the QRW040A0P ($V_O = 1.2\text{ V}$) module at room temperature ($T_A = 25\text{ }^\circ\text{C}$)

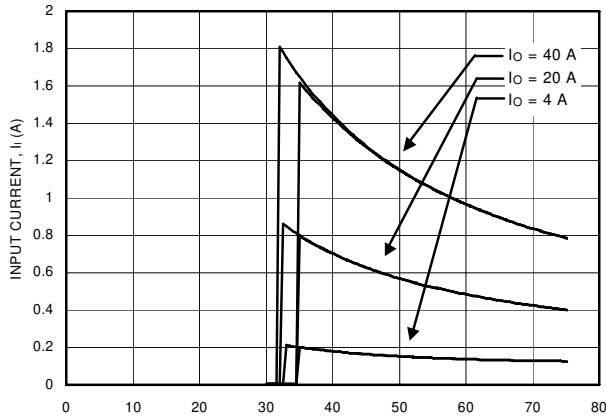


Figure 7. Input Voltage and Current Characteristics.

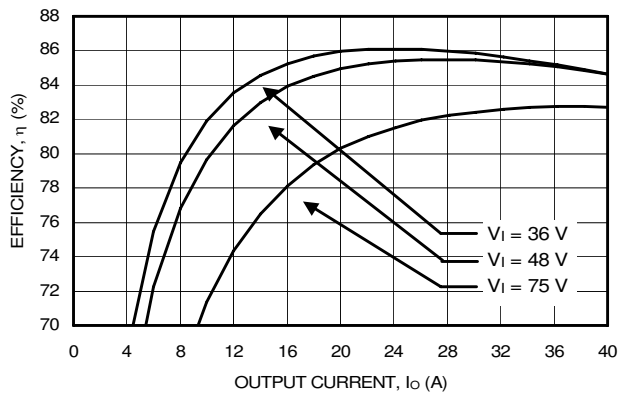


Figure 8. Converter Efficiency vs. Output Current.

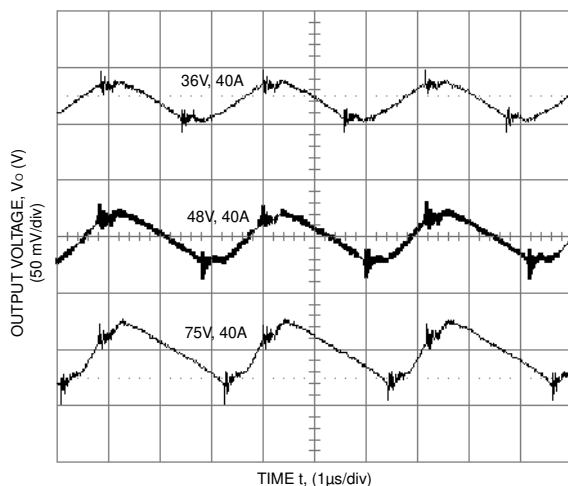
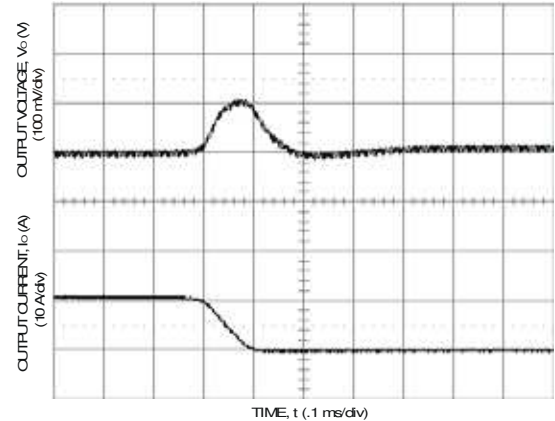


Figure 9. Output Ripple Voltage ($I_O = I_{O, \text{max}}$).

Lineage Power



Tested with a $220\mu\text{F}$ aluminium and a $1.0\mu\text{F}$ ceramic capacitor across the load.

Figure 10. Transient Response to Step Decrease in Load from 50% to 25% of Full Load ($V_I = 48\text{ Vdc}$).

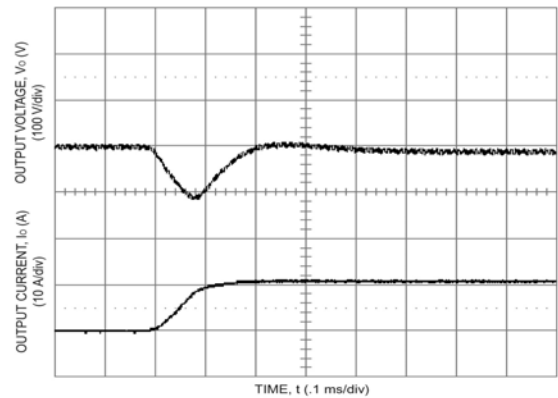
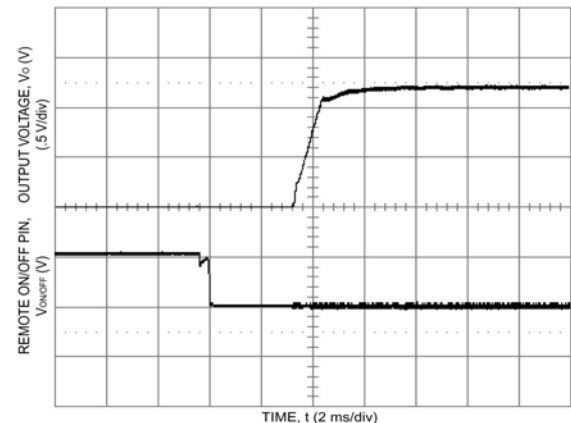


Figure 11. Transient Response to Step Increase in Load from 50% to 75% of Full Load ($V_I = 48\text{ Vdc}$).



Tested with a $10\mu\text{F}$ aluminium and a $1.0\mu\text{F}$ tantalum capacitor across the load.

Figure 12. Start-up from Remote On/Off ($I_O = I_{O, \text{max}}$).

Electrical Specifications (continued)

Output Specifications for the QRW040AOM (Vo = 1.5Vdc)

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point (VI = 48 Vdc; IO = IO, min to IO, max, TA = 25 °C)	M	Vo	1.47	1.5	1.52	Vdc
Output Voltage (Over all operating input voltage, resistive load, and temperature conditions at steady state until end of life.)	M	Vo	1.45	—	1.55	Vdc
Output Regulation: Line (VI = VI, min to VI, max) Load (IO = IO, min to IO, max) Temperature (TA = TA, min to TA, max)	M	— — —	— — —	0.05 0.05 15	0.2 0.2 50	% VO, set % VO, set mV
Output Ripple and Noise RMS (5 Hz to 20 MHz bandwidth) Peak-to-peak (5 Hz to 20 MHz bandwidth)	M		— —	— —	20 100	mVrms mVp-p
External Load Capacitance				—	25,000	µF
Output Current (Vo = 90% of VO, nom.)	M	IO	0.0	—	40	Adc
Output Current-limit Inception (VO = 90% of VO, set)	M	IO, lim	—	47	—	Adc
Output Short-circuit Current (Average) VO = 0.25 V	Latched off					
Efficiency (VI = VIN, nom; IO = IO, max), TA = 25 °C		η	—	86.5	—	%
Switching Frequency	All	fSW	—	300	—	kHz
Dynamic Response (DIO/Dt = 1 A/10 µs, VI = 48 V, TA = 25 °C); tested with a 220 µF aluminium and a 1.0 µF ceramic capacitor across the load.): Load Change from IO = 50% to 75% of IO, max: Peak Deviation Settling Time (VO < 10% of peak deviation) Load Change from IO = 50% to 25% of IO, max : Peak Deviation Settling Time (VO < 10% of peak deviation)					120 200 120 200	mV µs mV µs

Isolation Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Isolation Capacitance	Ciso	—	5600	—	PF
Isolation Resistance	Riso	10	—	—	MΩ

General Specifications

Parameter	Min	Typ	Max	Unit
Calculated MTBF (Io = 80% of Io, max Ta = 40 °C), Issue 1, M1, C1		1,548,000		Hours
Weight	—	38(1.54)	—	g (oz.)

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions for additional information.

Parameter	Symbol	Min	Typ	Max	Unit
Remote On/Off Signal Interface* (VI = 0 V to 75 V; open collector or equivalent compatible; signal referenced to VI(-) terminal; see Figure 52 and Feature Descriptions.): Preferred Logic: Logic Low—Module On Logic High—Module Off Optional Logic: Logic Low—Module Off Logic High—Module On Logic Low: At Ion/off = 1.0 mA At Von/off = 0.0 V Logic High: At Ion/off = 0.0 μ A Leakage Current Turn-on Time; see Typical Start-up Curve (IO = IO max; Vo within \pm 1% of steady state)	Von/off Ion/off Von/off Ion/off	0 — — —	— — — 2	1.2 1.0 15 50 4	V mA V μ A ms
Output Voltage Adjustment (See Feature Descriptions): Output Voltage Remote-sense Range Output Voltage Set-point Adjustment Range (trim)	— —	— 80	— —	10 110	%VO, rated %VO, nom
Output Overvoltage Protection	VO, ovsd	1.69	—	2.07	V
Overtemperature Protection (IO = IO, max)	Tref1	—	127	—	$^{\circ}$ C

* A Minimum OFF Period of 1 sec is recommended.

Characteristic Curves

The following figures provide typical characteristics curves for the QRW040A0M ($V_O = 1.5\text{ V}$) module at room temperature ($T_A = 25\text{ }^\circ\text{C}$)

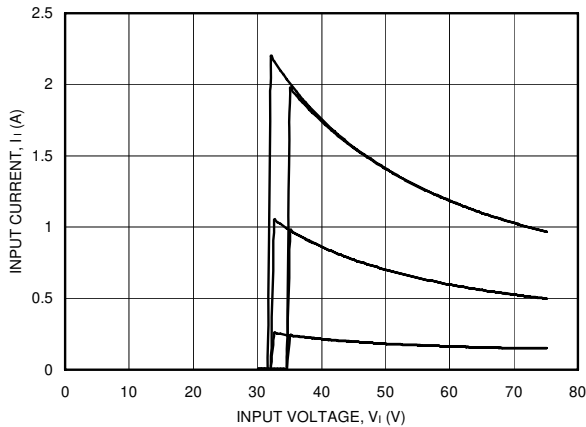


Figure 13. Input Voltage and Current Characteristics.

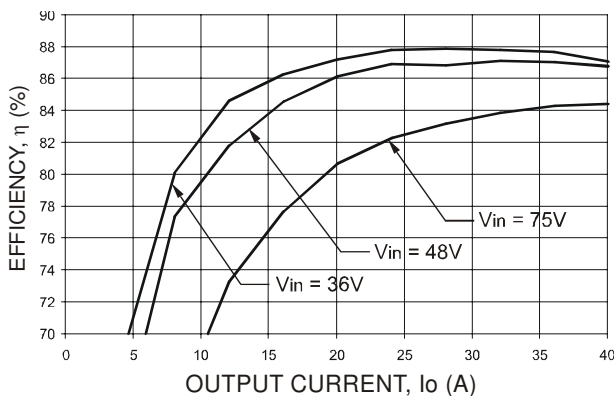


Figure 14. Converter Efficiency vs. Output Current.

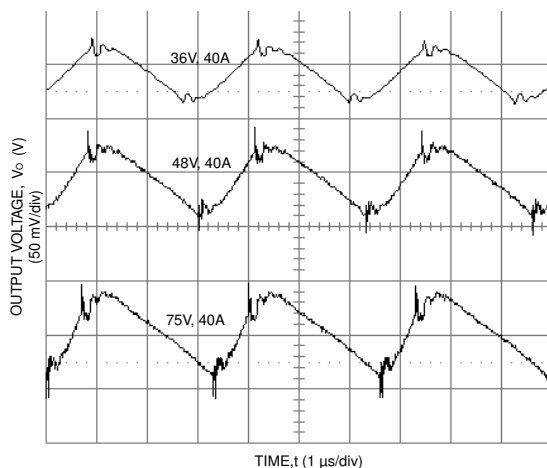
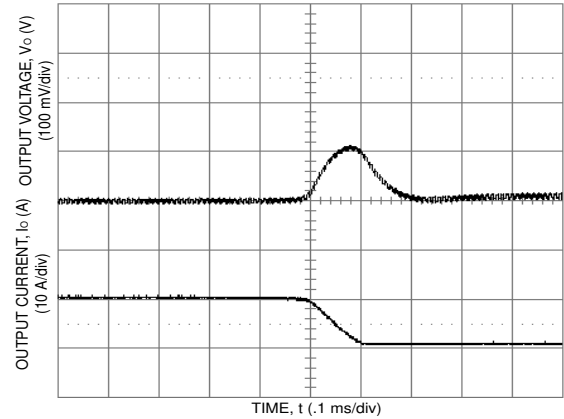


Figure 15. Output Ripple Voltage ($I_O = I_{O, \text{max}}$).



Tested with a $220\mu\text{F}$ aluminium and a $1.0\mu\text{F}$ ceramic capacitor across the load.

Figure 16. Transient Response to Step Decrease in Load from 50% to 25% of Full Load ($V_I = 48\text{ Vdc}$).

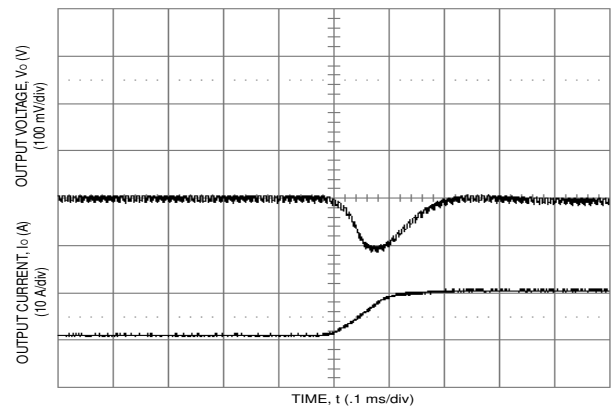
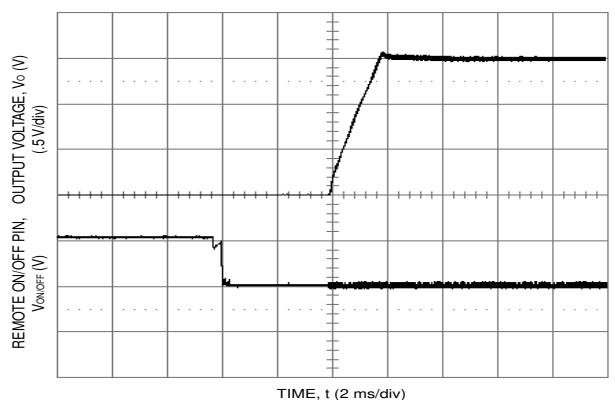


Figure 17. Transient Response to Step Increase in Load from 50% to 75% of Full Load ($V_I = 48\text{ Vdc}$).



Tested with a $10\mu\text{F}$ aluminium and a $1.0\mu\text{F}$ tantalum capacitor across the load.

Figure 18. Start-up from Remote On/Off ($I_O = I_{O, \text{max}}$).

Electrical Specifications (continued)

Output Specifications for the QRW040A0Y (Vo = 1.8Vdc)

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point (VI = 48 Vdc; IO = IO, min to IO, max, TA = 25 °C)	Y	Vo	1.77	1.8	1.83	Vdc
Output Voltage (Over all operating input voltage, resistive load, and temperature conditions at steady state until end of life.)	Y	Vo	1.75	—	1.85	Vdc
Output Regulation: Line (VI = VI, min to VI, max) Load (IO = IO, min to IO, max) Temperature (TA = TA, min to TA, max)	Y	— — —	— — —	0.05 0.05 15	0.2 0.2 50	% VO, set % VO, set mV
Output Ripple and Noise RMS (5 Hz to 20 MHz bandwidth) Peak-to-peak (5 Hz to 20 MHz bandwidth)	Y		— —	— —	35 100	mVrms mVp-p
External Load Capacitance				—	25,000	µF
Output Current (Vo = 90% of VO, nom.)	Y	IO	0.0	—	40	Adc
Output Current-limit Inception (VO = 90% of VO, set)	Y	IO, lim	—	45	—	Adc
Output Short-circuit Current (Average) VO = 0.25 V	Latched off					
Efficiency (VI = VIN, nom; IO = IO, max), TA = 25 °C		η	—	88	—	%
Switching Frequency	All	fSW	—	300	—	kHz
Dynamic Response (DIO/Dt = 1 A/10 µs, VI = 48 V, TA = 25 °C); tested with a 220 µF aluminium and a 1.0 µF ceramic capacitor across the load.): Load Change from IO = 50% to 75% of IO, max: Peak Deviation Settling Time (VO < 10% of peak deviation) Load Change from IO = 50% to 25% of IO, max : Peak Deviation Settling Time (VO < 10% of peak deviation)				200 200 200 200		mV µs mV µs

Isolation Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Isolation Capacitance	Ciso	—	5600	—	PF
Isolation Resistance	Riso	10	—	—	MΩ

General Specifications

Parameter	Min	Typ	Max	Unit
Calculated MTBF (IO = 80% of IO, max TA = 40 °C)		TBD		Hours
Weight	—	38(1.34)	—	g (oz.)

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions for additional information.

Parameter	Symbol	Min	Typ	Max	Unit
Remote On/Off Signal Interface* (VI = 0 V to 75 V; open collector or equivalent compatible; signal referenced to VI(-) terminal; see Figure 52 and Feature Descriptions.): Preferred Logic: Logic Low—Module On Logic High—Module Off Optional Logic: Logic Low—Module Off Logic High—Module On Logic Low: At Ion/off = 1.0 mA At Von/off = 0.0 V Logic High: At Ion/off = 0.0 μ A Leakage Current Turn-on Time; see Typical Start-up Curve(I _O = I _O max; Vo within \pm 1% of steady state)	Von/off Ion/off Von/off Ion/off	0 — — —	— — — 2	1.2 1.0 15 50	V mA V μ A ms
Output Voltage Adjustment (See Feature Descriptions): Output Voltage Remote-sense Range Output Voltage Set-point Adjustment Range (trim)	— —	— 80	— —	10 110	%VO, rated %VO, nom
Output Overvoltage Protection	VO, ovsd	2.0	—	2.5	V
Overtemperature Protection (I _O = I _O , max)	Tref1	—	127	—	$^{\circ}$ C

* A Minimum OFF Period of 1 sec is recommended.

Characteristic Curves

The following figures provide typical characteristics curves for the QRW040A0Y ($V_O = 1.8\text{ V}$) module at room temperature ($T_A = 25\text{ }^\circ\text{C}$)

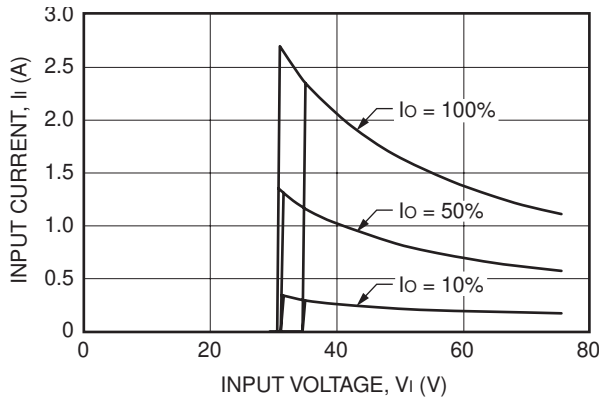


Figure 19. Input Voltage and Current Characteristics.

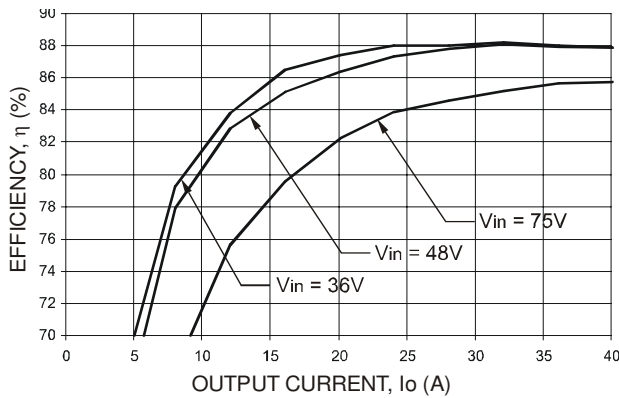


Figure 20. Converter Efficiency vs. Output Current.

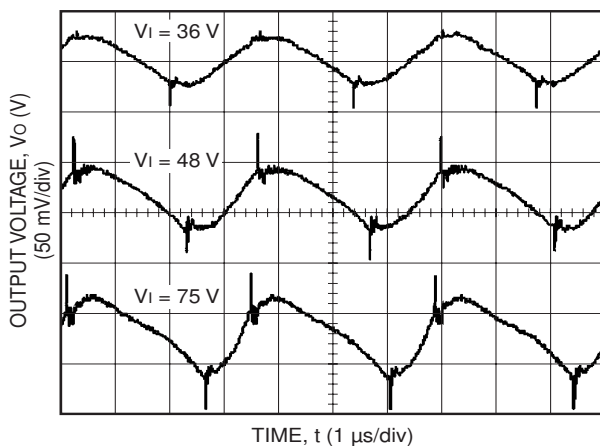
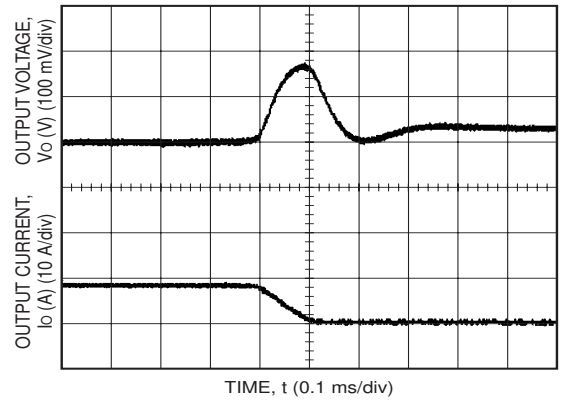


Figure 21. Output Ripple Voltage ($I_O = I_{O, \text{max}}$).



Tested with a $220\mu\text{F}$ aluminium and a $1.0\mu\text{F}$ ceramic capacitor across the load.

Figure 22. Transient Response to Step Decrease in Load from 50% to 25% of Full Load ($V_I = 48\text{ Vdc}$).

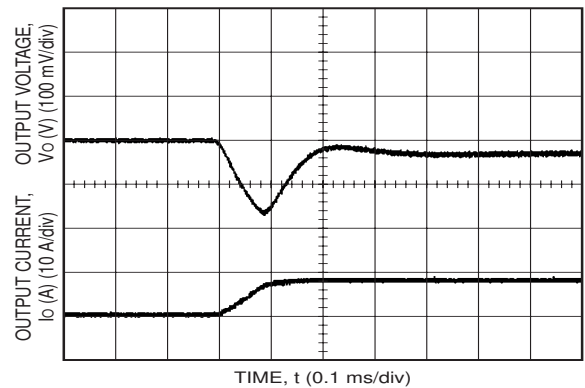
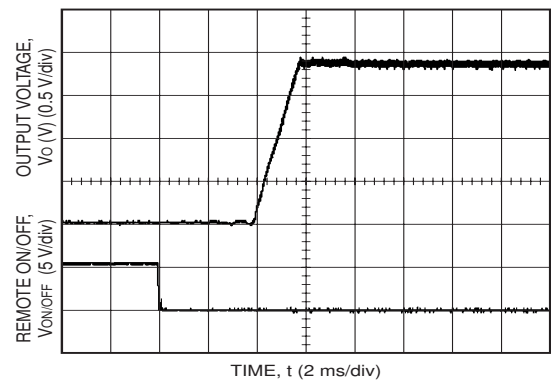


Figure 23. Transient Response to Step Increase in Load from 50% to 75% of Full Load ($V_I = 48\text{ Vdc}$).



Tested with a $10\mu\text{F}$ aluminium and a $1.0\mu\text{F}$ tantalum capacitor across the load.

Figure 24. Start-up from Remote On/Off ($I_O = I_{O, \text{max}}$).

Electrical Specifications (continued)

Output Specifications for the QRW035A0G (Vo = 2.5Vdc)

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point (VI = 48 Vdc; IO = IO, min to IO, max, TA = 25 °C)	G	Vo	2.47	2.5	2.53	Vdc
Output Voltage (Over all operating input voltage, resistive load, and temperature conditions at steady state until end of life.)	G	Vo	2.42	—	2.58	Vdc
Output Regulation: Line (VI = VI, min to VI, max) Load (IO = IO, min to IO, max) Temperature (TA = TA, min to TA, max)	G	— — —	— — —	0.05 0.05 15	0.2 0.2 50	%, VO, set %, VO, set mV
Output Ripple and Noise RMS (5 Hz to 20 MHz bandwidth) Peak-to-peak (5 Hz to 20 MHz bandwidth)	G		— —	— —	35 100	mVrms mVp-p
External Load Capacitance				—	25,000	µF
Output Current (Vo =90% of VO, nom.)	G	IO	0.0	—	35	Adc
Output Current-limit Inception (VO = 90% of VO, set)	G	IO, lim	—	39	—	Adc
Output Short-circuit Current (Average)VO = 0.25 V	Latched off					
Efficiency (VI = VIN, nom; IO = IO, max), TA = 25 °C		η	—	90	—	%
Switching Frequency	All	fSW	—	300	—	kHz
Dynamic Response (DIO/Dt = 1 A/10 µs, VI = 48 V, TA = 25 °C); tested with a 220 µF aluminium and a 1.0 µf ceramic capacitor across the load.): Load Change from IO = 50% to 75% of IO, max: Peak Deviation Settling Time (VO < 10% of peak deviation) Load Change from IO = 50% to 25% of IO, max : Peak Deviation Settling Time (VO < 10% of peak deviation)				150 200 150 200		mV µs mV µs

Isolation Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Isolation Capacitance	Ciso	—	5600	—	PF
Isolation Resistance	Riso	10	—	—	MΩ

General Specifications

Parameter	Min	Typ	Max	Unit
Calculated MTBF (IO = 80% of IO, max TA = 40 °C)		TBD		Hours
Weight	—	38(1.34)	—	g (oz.)

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions for additional information.

Parameter	Symbol	Min	Typ	Max	Unit
Remote On/Off Signal Interface* (VI = 0 V to 75 V; open collector or equivalent compatible; signal referenced to VI(-) terminal; see Figure 52 and Feature Descriptions.): Preferred Logic: Logic Low—Module On Logic High—Module Off Optional Logic: Logic Low—Module Off Logic High—Module On Logic Low: At Ion/off = 1.0 mA At Von/off = 0.0 V Logic High: At Ion/off = 0.0 μA Leakage Current Turn-on Time; see Typical Start-up Curve (IO = IO max; Vo within ±1% of steady state)	Von/off Ion/off Von/off Ion/off	0 — — —	— — — 2	1.2 1.0 15 50 4	V mA V μA ms
Output Voltage Adjustment (See Feature Descriptions): Output Voltage Remote-sense Range Output Voltage Set-point Adjustment Range (trim)	— —	— 80	— —	10 110	%VO, rated %VO, nom
Output Overvoltage Protection	VO, ovsd	2.9	—	3.2	V
Overtemperature Protection (IO = IO, max)	Tref1	—	127	—	°C

* A Minimum OFF Period of 1 sec is recommended.

Characteristic Curves

The following figures provide typical characteristics curves for the QRW035A0G ($V_O = 2.5\text{ V}$) module at room temperature ($T_A = 25\text{ }^\circ\text{C}$)

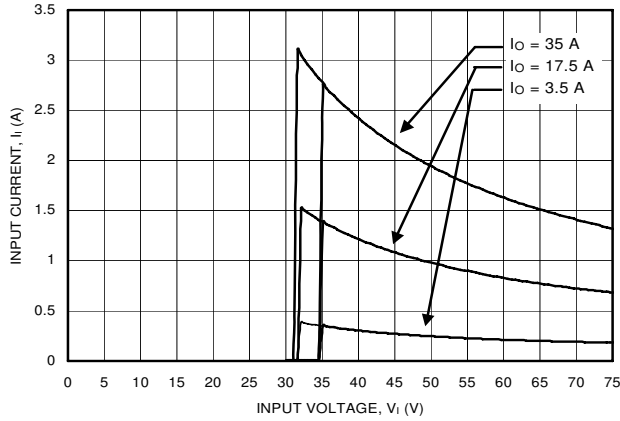


Figure 25. Input Voltage and Current Characteristics.

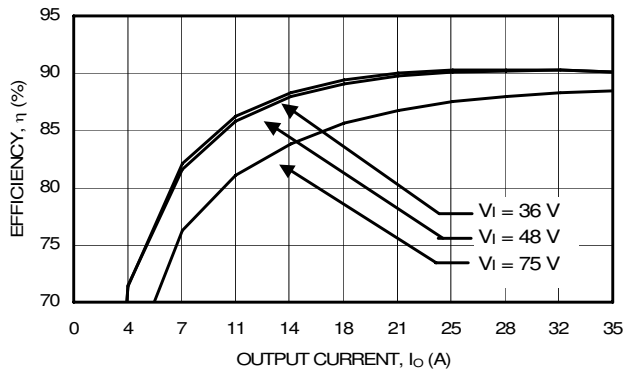


Figure 26. Converter Efficiency vs. Output Current.

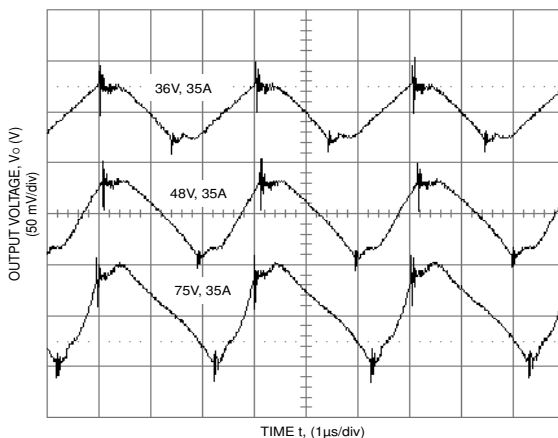
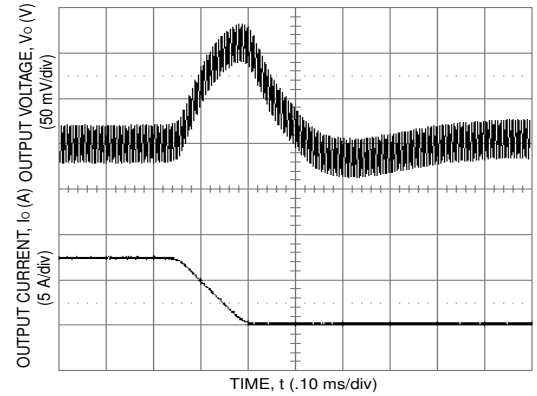


Figure 27. Output Ripple Voltage ($I_O = I_{O, \text{max}}$).



Tested with a $220\mu\text{F}$ aluminium and a $1.0\mu\text{F}$ ceramic capacitor across the load.

Figure 28. Transient Response to Step Decrease in Load from 50% to 25% of Full Load ($V_I = 48\text{ Vdc}$).

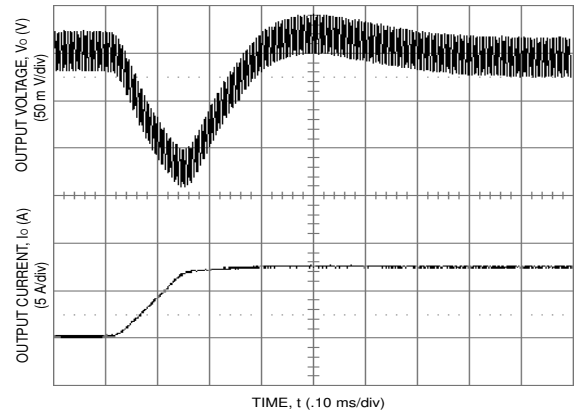
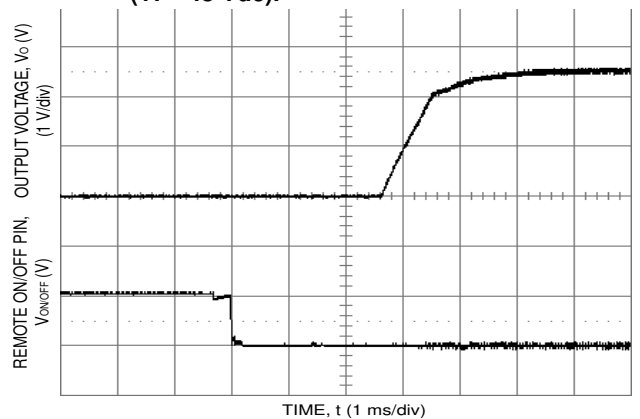


Figure 29. Transient Response to Step Increase in Load from 50% to 75% of Full Load ($V_I = 48\text{ Vdc}$).



Tested with a $10\mu\text{F}$ aluminium and a $1.0\mu\text{F}$ tantalum capacitor across the load.

Figure 30. Start-up from Remote On/Off ($I_O = I_{O, \text{max}}$).

Electrical Specifications (continued)

Output Specifications for the QRW035A0F (Vo = 3.3Vdc)

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point (VI = 48 Vdc; IO = IO, min to IO, max, TA = 25 °C)	F	Vo	3.24	3.3	3.36	Vdc
Output Voltage (Over all operating input voltage, resistive load, and temperature conditions at steady state until end of life.)	F	Vo	3.2	—	3.4	Vdc
Output Regulation: Line (VI = VI, min to VI, max) Load (IO = IO, min to IO, max) Temperature (TA = TA, min to TA, max)	F	— — —	— — —	0.05 0.05 15	0.2 0.2 50	%, VO, set %, VO, set mV
Output Ripple and Noise RMS (5 Hz to 20 MHz bandwidth) Peak-to-peak (5 Hz to 20 MHz bandwidth)	F		— —	— —	30 100	mVrms mVp-p
External Load Capacitance				—	30,000	µF
Output Current (Vo = 90% of VO, nom.)	F	IO	0.0	—	35	Adc
Output Current-limit Inception (VO = 90% of VO, set)	F	IO, lim	—	39	—	Adc
Output Short-circuit Current (Average) VO = 0.25 V	Latched off					
Efficiency (VI = VIN, nom; IO = IO, max), TA = 25 °C		η	—	91	—	%
Switching Frequency	All	fSW	—	300	—	kHz
Dynamic Response (DIO/Dt = 1 A/10 µs, VI = 48 V, TA = 25 °C); tested with a 220 µF aluminium and a 1.0 µF ceramic capacitor across the load.): Load Change from IO = 50% to 75% of IO, max: Peak Deviation Settling Time (VO < 10% of peak deviation) Load Change from IO = 50% to 25% of IO, max : Peak Deviation Settling Time (VO < 10% of peak deviation)				160 300 160 300		mV µs mV µs

Isolation Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Isolation Capacitance	Ciso	—	5600	—	PF
Isolation Resistance	Riso	10	—	—	MΩ

General Specifications

Parameter	Min	Typ	Max	Unit
Calculated MTBF (Io = 80% of Io, max Ta = 40 °C), Issue 1, M1, C1		1,700,000		Hours
Weight	—	37(1.31)	—	g (oz.)

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions for additional information.

Parameter	Symbol	Min	Typ	Max	Unit
Remote On/Off Signal Interface* (VI = 0 V to 75 V; open collector or equivalent compatible; signal referenced to VI(-) terminal; see Figure 52 and Feature Descriptions.): Preferred Logic: Logic Low—Module On Logic High—Module Off Optional Logic: Logic Low—Module Off Logic High—Module On Logic Low: At Ion/off = 1.0 mA At Von/off = 0.0 V Logic High: At Ion/off = 0.0 μ A Leakage Current Turn-on Time; see Typical Start-up Curve(I _O = I _O max; Vo within \pm 1% of steady state)	Von/off Ion/off Von/off Ion/off	0 — — —	— — — 2	1.2 1.0 15 50 4	V mA V μ A ms
Output Voltage Adjustment (See Feature Descriptions): Output Voltage Remote-sense Range Output Voltage Set-point Adjustment Range (trim)	— —	— 80	— —	0.5 110	V %V _{O,nom}
Output Overvoltage Protection	VO, ovsd	3.8	—	4.6	V
Overtemperature Protection (I _O = I _O , max)	Tref1	—	127	—	$^{\circ}$ C

* A Minimum OFF Period of 1 sec is recommended.

Characteristic Curves

The following figures provide typical characteristics curves for the QRW035A0F ($V_O = 3.3\text{ V}$) module at room temperature ($T_A = 25\text{ }^\circ\text{C}$)

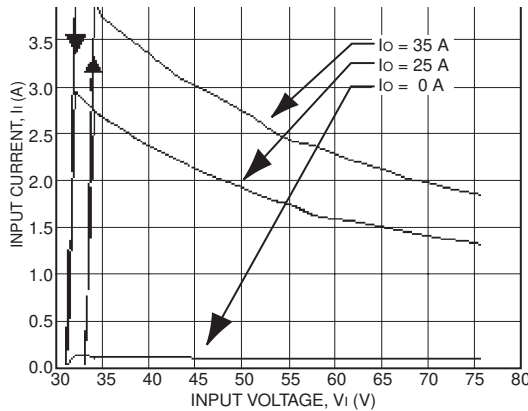


Figure 31. Input Voltage and Current Characteristics.

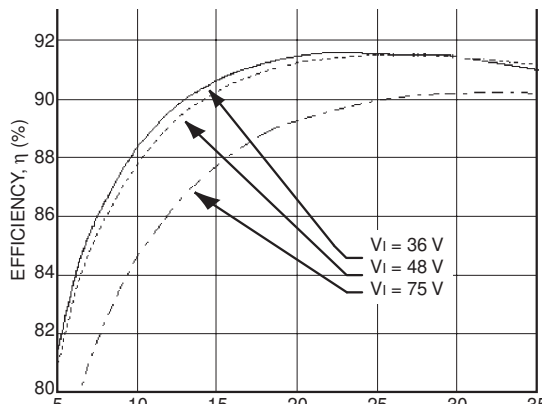


Figure 32. Converter Efficiency vs. Output Current.

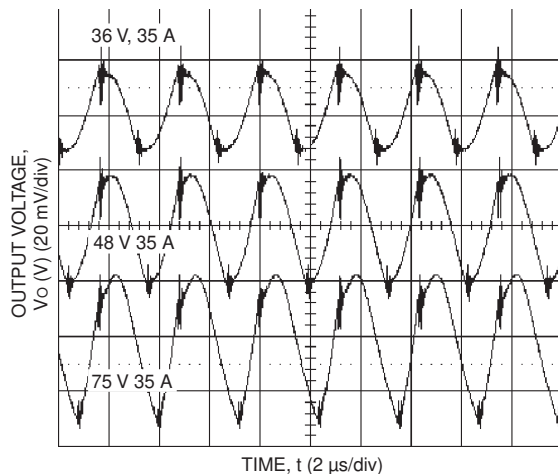
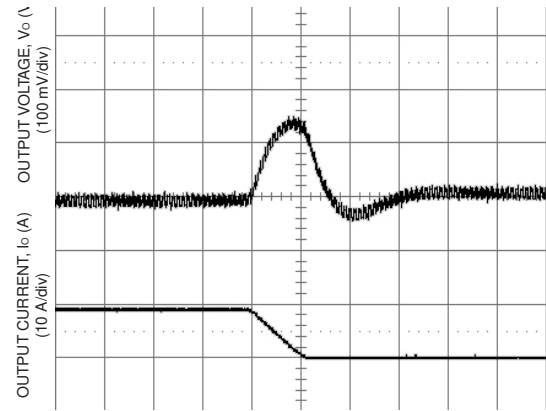


Figure 33. Output Ripple Voltage ($I_O = I_{O, \text{max}}$).



Tested with a $220\mu\text{F}$ aluminium and a $1.0\mu\text{F}$ ceramic capacitor across the load.

Figure 34. Transient Response to Step Decrease in Load from 50% to 25% of Full Load ($V_I = 48\text{ Vdc}$).

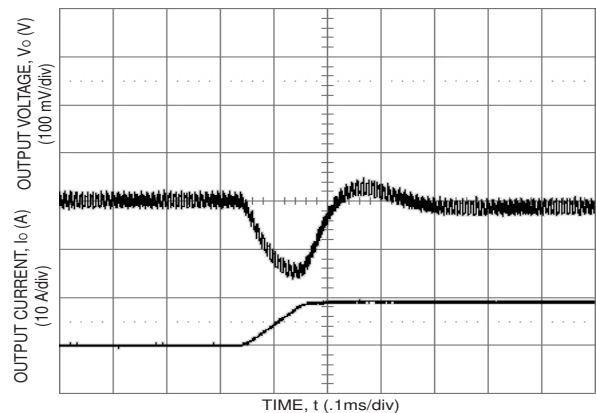
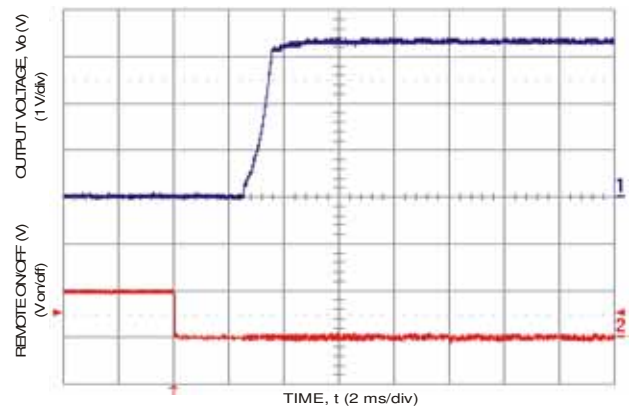


Figure 35. Transient Response to Step Increase in Load from 50% to 75% of Full Load ($V_I = 48\text{ Vdc}$).



Tested with a $10\mu\text{F}$ aluminium and a $1.0\mu\text{F}$ tantalum capacitor across the load.

Figure 36. Start-up from Remote On/Off ($I_O = I_{O, \text{max}}$).

Electrical Specifications (continued)

Output Specifications for the QRW025A0A (Vo = 5.0 Vdc)

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point (VI = 48 Vdc; IO = IO, min to IO, max, TA = 25 °C)	A	Vo	4.95	5.0	5.05	Vdc
Output Voltage (Over all operating input voltage, resistive load, and temperature conditions at steady state until end of life.)	A	Vo	4.85	—	5.15	Vdc
Output Regulation: Line (VI = VI, min to VI, max) Load (IO = IO, min to IO, max) Temperature (TA = TA, min to TA, max)	A	— — —	— — —	0.05 0.05 15	0.2 0.2 50	% VO, set % VO, set mV
Output Ripple and Noise RMS (5 Hz to 20 MHz bandwidth) Peak-to-peak (5 Hz to 20 MHz bandwidth)	A		— —	— —	30 100	mVrms mVp-p
External Load Capacitance				—	10,000	µF
Output Current (Vo = 90% of VO, nom.)	A	IO	0.0	—	25	Adc
Output Current-limit Inception (VO = 90% of VO, set)	A	IO, lim	—	30	—	Adc
Output Short-circuit Current (Average) VO = 0.25 V	Latched off					
Efficiency (VI = VIN, nom; IO = IO, max), TA = 25 °C		η	—	91.5	—	%
Switching Frequency	All	fSW	—	300	—	kHz
Dynamic Response (DIO/Dt = 1 A/10 µs, VI = 48 V, TA = 25 °C); tested with a 220 µF aluminium and a 1.0 µf ceramic capacitor across the load.): Load Change from IO = 50% to 75% of IO, max: Peak Deviation Settling Time (VO < 10% of peak deviation) Load Change from IO = 50% to 25% of IO, max : Peak Deviation Settling Time (VO < 10% of peak deviation)				250 200 250 200		mV µs mV µs

Isolation Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Isolation Capacitance	Ciso	—	5600	—	PF
Isolation Resistance	Riso	10	—	—	MΩ

General Specifications

Parameter	Min	Typ	Max	Unit
Calculated MTBF (Io = 80% of Io, max Ta = 40 °C), Issue 1, M1,C1		1,219,777		Hours
Weight	—	37(1.31)	—	g (oz.)

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions for additional information.

Parameter	Symbol	Min	Typ	Max	Unit
Remote On/Off Signal Interface* (VI = 0 V to 75 V; open collector or equivalent compatible; signal referenced to VI(-) terminal; see Figure 52 and Feature Descriptions.): Preferred Logic: Logic Low—Module On Logic High—Module Off Optional Logic: Logic Low—Module Off Logic High—Module On Logic Low: At Ion/off = 1.0 mA At Von/off = 0.0 V Logic High: At Ion/off = 0.0 μ A Leakage Current Turn-on Time; see Typical Start-up Curve (IO = IO max; Vo within \pm 1% of steady state)	Von/off Ion/off Von/off Ion/off	0 — — —	— — — 1	1.2 1.0 15 50 4	V mA V μ A ms
Output Voltage Adjustment (See Feature Descriptions): Output Voltage Remote-sense Range Output Voltage Set-point Adjustment Range (trim)	— —	— 80	— —	0.5 110	V %V0,nom
Output Overvoltage Protection	VO, ovsd	5.6	—	6.8	V
Overtemperature Protection (IO = IO, max)	Tref1	—	127	—	$^{\circ}$ C

* A Minimum OFF Period of 1 sec is recommended.

Characteristic Curves

The following figures provide typical characteristics curves for the QRW025A0A ($V_O = 5.0V$) module at room temperature ($T_A = 25^\circ C$)

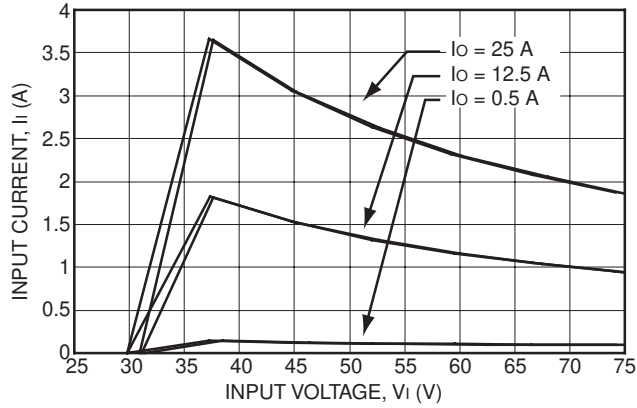


Figure 37. Input Voltage and Current Characteristics.

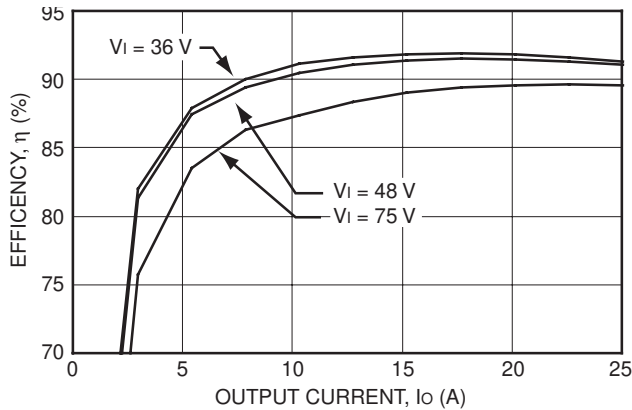


Figure 38. Converter Efficiency vs. Output Current.

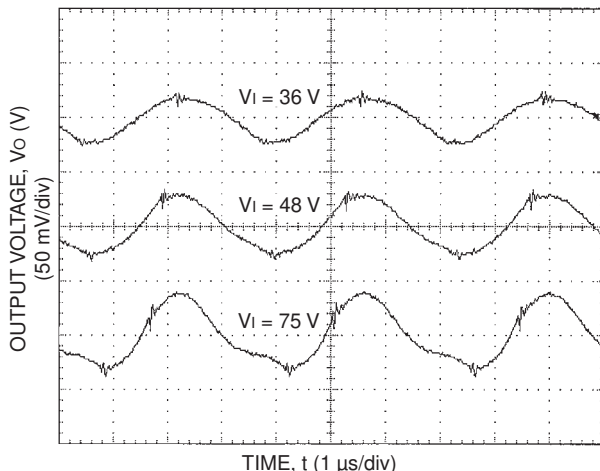
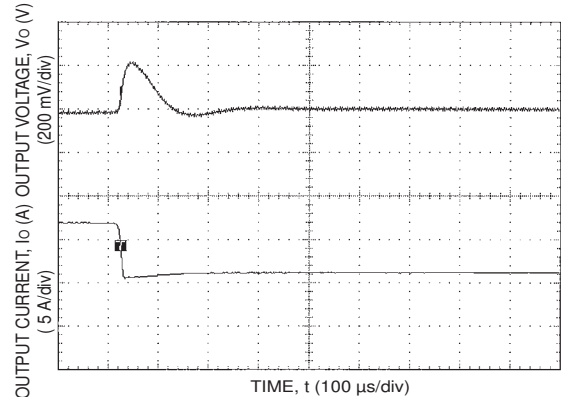


Figure 39. Output Ripple Voltage ($I_O = I_{O, max}$).



Tested with a 220 μF aluminium and a 1.0 μF ceramic capacitor across the load.

Figure 40. Transient Response to Step Decrease in Load from 50% to 25% of Full Load ($V_I = 48 V_{dc}$).

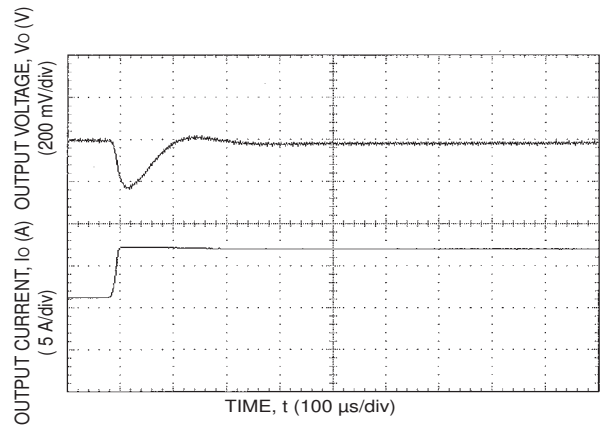
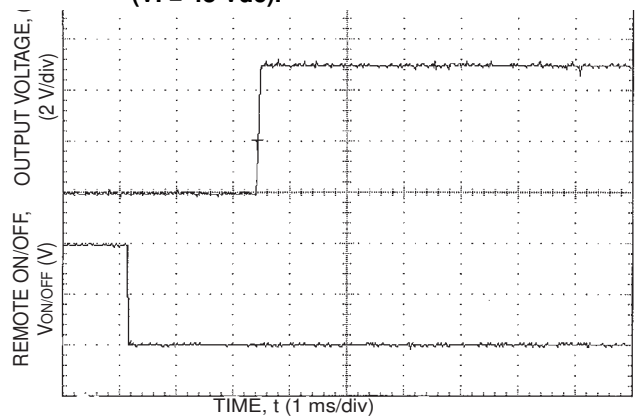


Figure 41. Transient Response to Step Increase in Load from 50% to 75% of Full Load ($V_I = 48 V_{dc}$).



Tested with a 10 μF aluminium and a 1.0 μF tantalum capacitor across the load.

Figure 42. Start-up from Remote On/Off ($I_O = I_{O, max}$).

Electrical Specifications (continued)

Output Specifications for the QRW010A0B (Vo = 12.0 Vdc)

Parameter	Device	Symbol	Min	Typ	Max	Unit
Output Voltage Set Point (VI = 48 Vdc; IO = IO, min to IO, max, TA = 25 °C)	B	Vo	11.76	12	12.24	Vdc
Output Voltage (Over all operating input voltage, resistive load, and temperature conditions at steady state until end of life.)	B	Vo	11.64	—	12.36	Vdc
Output Regulation: Line (VI = VI, min to VI, max) Load (IO = IO, min to IO, max) Temperature (TA = TA, min to TA, max)	B	— — —	— — —	0.05 0.05 15	0.2 0.2 50	% VO, set % VO, set mV
Output Ripple and Noise RMS (5 Hz to 20 MHz bandwidth) Peak-to-peak (5 Hz to 20 MHz bandwidth)	B		— —	— —	30 100	mVrms mVp-p
External Load Capacitance				—	2200	µF
Output Current (Vo = 90% of VO, nom.)	B	IO	0.0	—	10	Adc
Output Current-limit Inception (VO = 90% of VO, set)	B	IO, lim	—	12	—	Adc
Output Short-circuit Current (Average) VO = 0.25 V	Latched off					
Efficiency (VI = VIN, nom; IO = IO, max), TA = 25 °C		η	—	92.5	—	%
Switching Frequency	All	fSW	—	300	—	kHz
Dynamic Response (DIO/Dt = 1 A/10 µs, VI = 48 V, TA = 25 °C); tested with a 220 µF aluminium and a 1.0 µF ceramic capacitor across the load.): Load Change from IO = 50% to 75% of IO, max: Peak Deviation Settling Time (VO < 10% of peak deviation) Load Change from IO = 50% to 25% of IO, max : Peak Deviation Settling Time (VO < 10% of peak deviation)				360 300 360 300		mV µs mV µs

Isolation Specifications

Parameter	Symbol	Min	Typ	Max	Unit
Isolation Capacitance	Ciso	—	5600	—	PF
Isolation Resistance	Riso	10	—	—	MΩ

General Specifications

Parameter	Min	Typ	Max	Unit
Calculated MTBF (Io = 80% of Io, max, Ta = 40 °C), Issue 1, M1,C1		1,227,000		Hours
Weight	—	37(1.31)	—	g (oz.)

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions for additional information.

Parameter	Symbol	Min	Typ	Max	Unit
Remote On/Off Signal Interface* (VI = 0 V to 75 V; open collector or equivalent compatible; signal referenced to VI(-) terminal; see Figure 52 and Feature Descriptions.): Preferred Logic: Logic Low—Module On Logic High—Module Off Optional Logic: Logic Low—Module Off Logic High—Module On Logic Low: At Ion/off = 1.0 mA At Von/off = 0.0 V Logic High: At Ion/off = 0.0 μA Leakage Current Turn-on Time; see Typical Start-up Curve (IO = IO max; Vo within ±1% of steady state)	Von/off Ion/off Von/off Ion/off	0 — — —	— — — 2	1.2 1.0 15 50 4	V mA V μA ms
Output Voltage Adjustment (See Feature Descriptions): Output Voltage Remote-sense Range Output Voltage Set-point Adjustment Range (trim)	— —	— 80	— —	0.5 110	V %VO,nom
Output Overvoltage Protection	VO, ovsd	13.5	15	16.5	V
Overtemperature Protection (IO = IO, max)	Tref1	—	127	—	°C

* A Minimum OFF Period of 1 sec is recommended.