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Miniature, 1W Isolated REGULATED DC/DC CONVERTERS

FEATURES

- UL1950 RECOGNIZED
- PDIP-18, SO-28⁽¹⁾
- 53W/in³ (3.3W/cm³) POWER DENSITY
- DEVICE-TO-DEVICE SYNCHRONIZATION
- THERMAL PROTECTION
- 1000Vrms ISOLATION
- 400kHz SWITCHING
- 125 FITS AT 55°C
- ±10% INPUT RANGE
- SHORT-CIRCUIT PROTECTED
- 5V, 12V, 24V INPUTS
- 3.3V, 5V OUTPUTS
- HIGH EFFICIENCY

NOTE:(1) SO version available Q1 2001.

APPLICATIONS

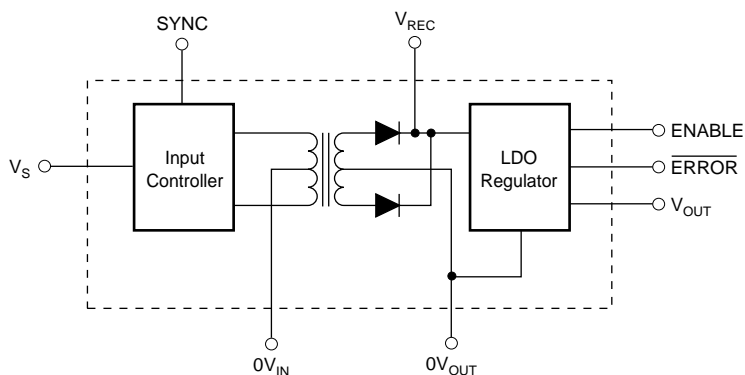
- POINT-OF-USE POWER CONVERSION
- DIGITAL INTERFACE POWER
- GROUND LOOP ELIMINATION
- POWER-SUPPLY NOISE REDUCTION

DESCRIPTION

DCR01 family is a series of high-efficiency, input-isolated, output-regulated DC/DC converters. In addition to 1W nominal, galvanically-isolated output power capability, this range of DC/DCs offer very low output noise, thermal protection and high accuracy.

The DCR01 family is implemented in standard molded IC packaging, giving standard JEDEC outlines suitable for high-volume assembly.

The DCR01 is manufactured using the same technology as standard IC packages, thereby achieving very high reliability.



SPECIFICATIONS

At $T_A = +25^\circ\text{C}$, $V_S = \text{nominal}$, $I_O = 10\text{mA}$, $C_O = 0.1\mu\text{F}$, unless otherwise specified.

PARAMETER	CONDITIONS	DCR01 SERIES			UNITS
		MIN	TYP	MAX	
OUTPUT					
Setpoint					
DCR010503			3.3		V
DCR010505			5		V
DCR011203			3.3		V
DCR011205			5		V
DCR012403			3.3		V
DCR012405			5		V
Setpoint Accuracy			0.5	2.0	%
Maximum Output Current					
DCR010503P		300			mA
DCR010503U ⁽¹⁾		300			mA
DCR010505P		200			mA
DCR010505U ⁽¹⁾		200			mA
DCR011203P		390			mA
DCR011203U ⁽¹⁾		300			mA
DCR011205P		200			mA
DCR011205U ⁽¹⁾		200			mA
DCR012403P		390			mA
DCR012403U ⁽¹⁾		300			mA
DCR012405P		200			mA
DCR012405U ⁽¹⁾		390			mA
Output Short-Circuit Protected	Duration		Infinite		
Line Regulation					
DCR010503			1		mV/V
DCR010505			1		mV/V
DCR011203			1		mV/V
DCR011205			1		mV/V
DCR012403			1		mV/V
DCR012405			1		mV/V
Over Line and Load					
DCR010503	10mA to 300mA Load, 4.5V to 5.5V Line		1.0	2.5	%
DCR010505	10mA to 200mA Load, 4.5V to 5.5V Line		1.0	2.5	%
DCR011203P	10mA to 390mA Load, 10.8V to 13.2V Line		1.0	2.5	%
DCR011203U ⁽¹⁾	10mA to 300mA Load, 10.8V to 13.2V Line		1.0	2.5	%
DCR011205	10mA to 200mA Load, 10.8V to 13.2V Line		1.0	2.5	%
DCR012403P	10mA to 390mA Load, 21.6V to 26.4V Line		1.0	2.5	%
DCR012403U ⁽¹⁾	10mA to 300mA Load, 21.6V to 26.4V Line		1.0	2.5	%
DCR012405	10mA to 200mA Load, 21.6V to 26.4V Line		1.0	2.5	%
Versus Temperature	-40°C to +85°C		1.0		%
Ripple and Noise					
DCR010503P Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		5		mVp-p
DCR010503P Noise	100MHz Bandwidth, 50% Load ⁽²⁾		35		mVp-p
DCR010503U ⁽¹⁾ Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		8		mVp-p
DCR010503U ⁽¹⁾ Noise	100MHz Bandwidth, 50% Load ⁽²⁾		23		mVp-p
DCR010505P Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		6		mVp-p
DCR010505P Noise	100MHz Bandwidth, 50% Load ⁽²⁾		20		mVp-p
DCR010505U ⁽¹⁾ Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		9		mVp-p
DCR010505U ⁽¹⁾ Noise	100MHz Bandwidth, 50% Load ⁽²⁾		20		mVp-p
DCR011203P Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		10		mVp-p
DCR011203P Noise	100MHz Bandwidth, 50% Load ⁽²⁾		54		mVp-p
DCR011203U ⁽¹⁾ Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		8		mVp-p
DCR011203U ⁽¹⁾ Noise	100MHz Bandwidth, 50% Load ⁽²⁾		22		mVp-p
DCR011205P Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		6		mVp-p
DCR011205P Noise	100MHz Bandwidth, 50% Load ⁽²⁾		45		mVp-p
DCR011205U ⁽¹⁾ Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		6		mVp-p
DCR011205U ⁽¹⁾ Noise	100MHz Bandwidth, 50% Load ⁽²⁾		21		mVp-p
DCR012403P Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		10		mVp-p
DCR012403P Noise	100MHz Bandwidth, 50% Load ⁽²⁾		22		mVp-p
DCR012403U ⁽¹⁾ Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		8		mVp-p
DCR012403U ⁽¹⁾ Noise	100MHz Bandwidth, 50% Load ⁽²⁾		22		mVp-p
DCR012405P Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		10		mVp-p
DCR012405P Noise	100MHz Bandwidth, 50% Load ⁽²⁾		22		mVp-p
DCR012405U ⁽¹⁾ Ripple	20MHz Bandwidth, 50% Load ⁽²⁾		13		mVp-p
DCR012405U ⁽¹⁾ Noise	100MHz Bandwidth, 50% Load ⁽²⁾		32		mVp-p
INPUT					
Nominal Voltage (V_S)					
	DCR0105xx		5		V
	DCR0112xx		12		V
	DCR0124xx		24		V
Voltage Range		-10		+10	%

SPECIFICATIONS (Cont.)

At $T_A = +25^\circ\text{C}$, $V_S = \text{nominal}$, $I_O = 10\text{mA}$, $C_O = 0.1\mu\text{F}$, unless otherwise specified.

PARAMETER	CONDITIONS	DCR01 SERIES			UNITS
		MIN	TYP	MAX	
Supply Current					
DCR010503P	$I_O = 0\text{mA}$		18		mA
	$I_O = 10\text{mA}$		28		mA
	$I_O = 300\text{mA}$		335		mA
DCR010503U ⁽¹⁾	$I_O = 0\text{mA}$		24		mA
	$I_O = 10\text{mA}$		33		mA
	$I_O = 300\text{mA}$		339		mA
DCR010505P	$I_O = 0\text{mA}$		25		mA
	$I_O = 10\text{mA}$		40		mA
	$I_O = 200\text{mA}$		306		mA
DCR010505U ⁽¹⁾	$I_O = 0\text{mA}$		25		mA
	$I_O = 10\text{mA}$		40		mA
	$I_O = 200\text{mA}$		306		mA
DCR011203P	$I_O = 0\text{mA}$		13		mA
	$I_O = 10\text{mA}$		17		mA
	$I_O = 390\text{mA}$		173		mA
DCR011203U ⁽¹⁾	$I_O = 0\text{mA}$		13		mA
	$I_O = 10\text{mA}$		17		mA
	$I_O = 390\text{mA}$		136		mA
DCR011205P	$I_O = 0\text{mA}$		13		mA
	$I_O = 10\text{mA}$		18		mA
	$I_O = 200\text{mA}$		125		mA
DCR011205U ⁽¹⁾	$I_O = 0\text{mA}$		14		mA
	$I_O = 10\text{mA}$		19		mA
	$I_O = 200\text{mA}$		123		mA
DCR012403P	$I_O = 0\text{mA}$		17		mA
	$I_O = 10\text{mA}$		18		mA
	$I_O = 390\text{mA}$		97		mA
DCR012403U ⁽¹⁾	$I_O = 0\text{mA}$		15		mA
	$I_O = 10\text{mA}$		17		mA
	$I_O = 390\text{mA}$		75		mA
DCR012405P	$I_O = 0\text{mA}$		15		mA
	$I_O = 10\text{mA}$		18		mA
	$I_O = 200\text{mA}$		69		mA
DCR012405U ⁽¹⁾	$I_O = 0\text{mA}$		15		mA
	$I_O = 10\text{mA}$		18		mA
	$I_O = 200\text{mA}$		67		mA
Reflected Ripple Current	20MHz Bandwidth, 100% Load $C_{IN} = 2.2\mu\text{F}$, $C_{FILTER} = 1\mu\text{F}$		8		mAp-p
ISOLATION					
Voltage	1s Flash Test	1			kVrms
	60s Test, UL1950 ⁽³⁾	1			kVrms
Input/Output Capacitance			25		pF
OUTPUT ENABLE CONTROL					
Logic High Input Voltage	$2.0 < V_{ENABLE} < V_{REC}$	2.0		V_{REC}	V
Logic High Input Current			100		nA
Logic Low Input Voltage		-0.2		0.5	V
Logic Low Input Current	$0 < V_{ENABLE} < 0.5$		100		nA
V_{REC}	All 3.3V Outputs		3.3		V
V_{REC}	All 5V Outputs		5		V
ERROR FLAG					
Logic High Open Collector Leakage	$V_{ERROR} = 5\text{V}$			10	μA
Logic Low Output Voltage	Sinking 2mA			0.4	V
THERMAL SHUTDOWN					
Junction Temperature					
Temperature Activated			150		$^\circ\text{C}$
Temperature Deactivated			130		$^\circ\text{C}$
SYNCHRONIZATION PIN					
Max External Capacitance on SYNC Pin				3	pF
Internal Oscillator Frequency		720	800	880	kHz
External Synchronization Frequency		720		880	kHz
External Synchronization Signal High		2.5	2.5	5.0	V
External Synchronization Signal Low		0		0.4	V
TEMPERATURE RANGE					
Operating		-40		+85	$^\circ\text{C}$

NOTES: (1) SO version available Q1 2001. (2) $C_{IN} = 2.2\mu\text{F}$, $C_{FILTER} = 1\mu\text{F}$, $C_{OUT} = 0.1\mu\text{F}$. (3) During UL approval only.

ABSOLUTE MAXIMUM RATINGS

Input Voltage:	
DCR0105	7V
DCR0112	15V
DCR0124	29V
Storage Temperature	-60°C to +125°C
Lead Temperature (soldering, 10s)	270°C



ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ORDERING INFORMATION

Basic Model Number: 1W Product	DCR01	05	05	(P)
Voltage Input:	_____			
5V In	_____			
Voltage Output:	_____			
5V Out	_____			
Package Code:	_____			
P = 18-Pin Plastic DIP, U = 28-Pin SO ⁽¹⁾				

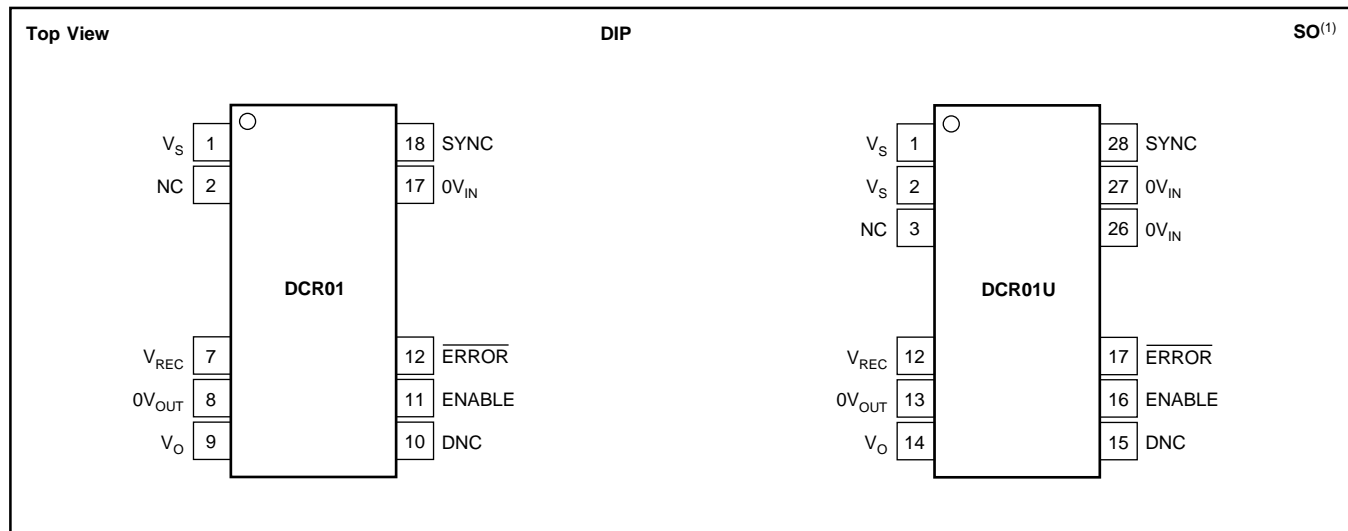
NOTE: (1) SO version available Q1 2001.

PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER ⁽¹⁾	TRANSPORT MEDIA
DCR010503P	DIP-18	218-1	-40°C to +85°C	DCR010503P	DCR010503P	Rails
DCR010503U ⁽²⁾	SO-28	217-2	-40°C to +85°C	DCR010503U	DCR010503U/1K	Tape and Reel
DCR010505P	DIP-18	218-1	-40°C to +85°C	DCR010505P	DCR010505P	Rails
DCR010505U ⁽²⁾	SO-28	217-2	-40°C to +85°C	DCR010505U	DCR010505U/1K	Tape and Reel
DCR011203P	DIP-18	218-1	-40°C to +85°C	DCR011203P	DCR011203P	Rails
DCR011203U ⁽²⁾	SO-28	217-2	-40°C to +85°C	DCR011203U	DCR011203U/1K	Tape and Reel
DCR011205P	DIP-18	218-1	-40°C to +85°C	DCR011205P	DCR011205P	Rails
DCR011205U ⁽²⁾	SO-28	217-2	-40°C to +85°C	DCR011205U	DCR011205U/1K	Tape and Reel
DCR012403P	DIP-18	218-1	-40°C to +85°C	DCR012403P	DCR012403P	Rails
DCR012403U ⁽²⁾	SO-28	217-2	-40°C to +85°C	DCR012403U	DCR012403U/1K	Tape and Reel
DCR012405P	DIP-18	218-1	-40°C to +85°C	DCR012405P	DCR012405P	Rails
DCR012405U ⁽²⁾	SO-28	217-2	-40°C to +85°C	DCR012405U	DCR012405U/1K	Tape and Reel

NOTES: (1) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /1K indicates 1000 devices per reel). Ordering 1000 pieces of "DCR010503U/1K" will get a single 1000-piece Tape and Reel. (2) SO version available Q1 2001.

PIN CONFIGURATIONS



PIN DEFINITION (DIP)

PIN #	PIN NAME	DESCRIPTION
1	V _S	Voltage Input
2	NC	No Connection
7	V _{REC}	Rectified Output
8	0V _{OUT}	Output Ground
9	V _O	Voltage Output
10	DNC	Do Not Connect
11	ENABLE	Output Voltage Enable
12	ERROR	Error Flag Active Low
17	0V _{IN}	Input Ground
18	SYNC	Synchronization Input

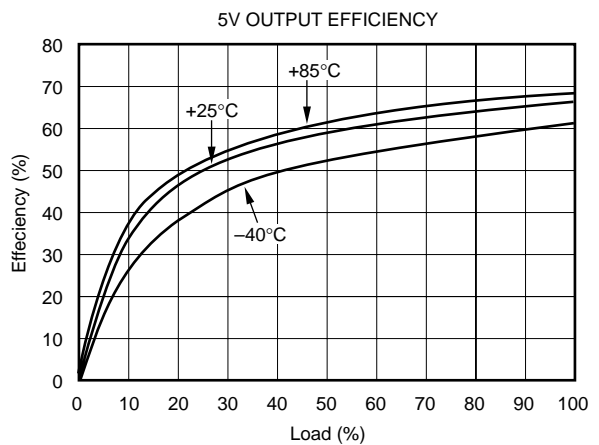
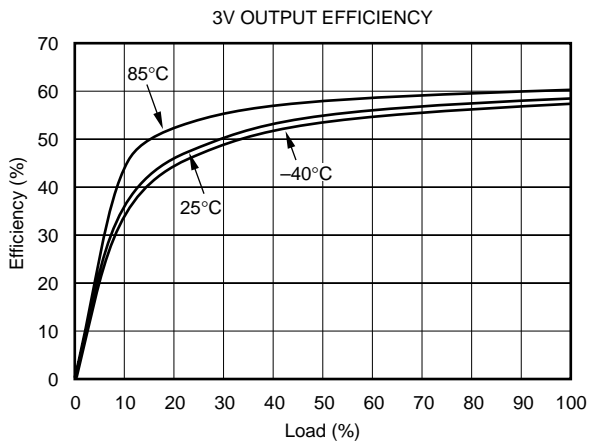
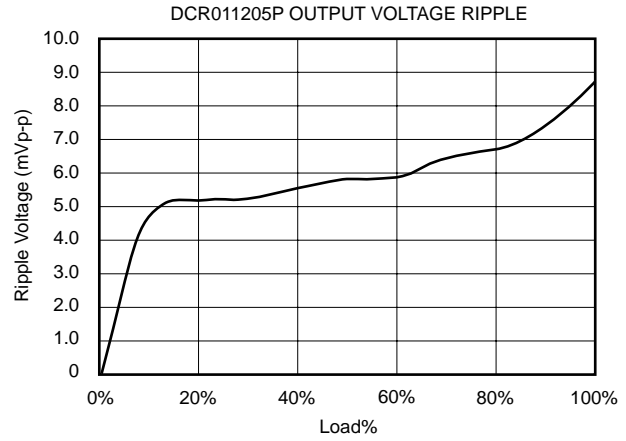
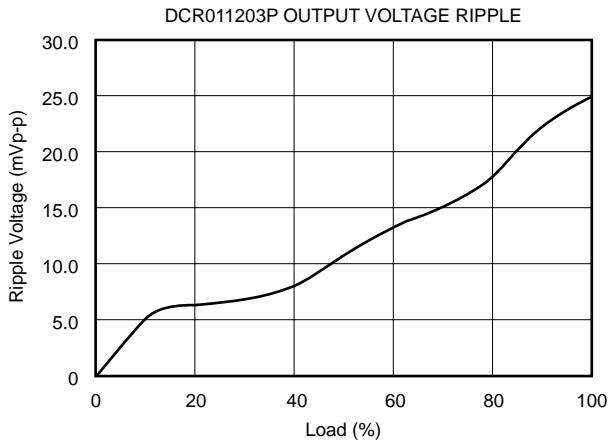
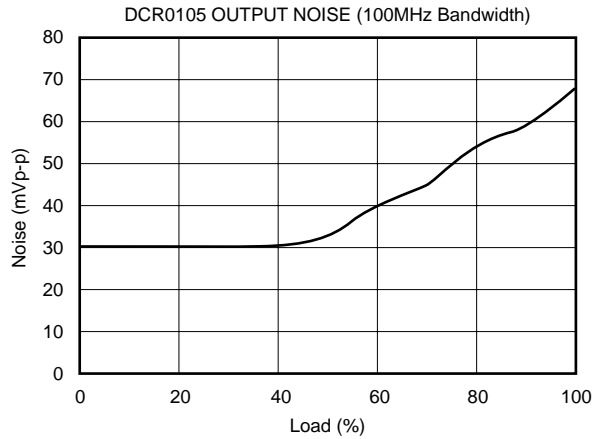
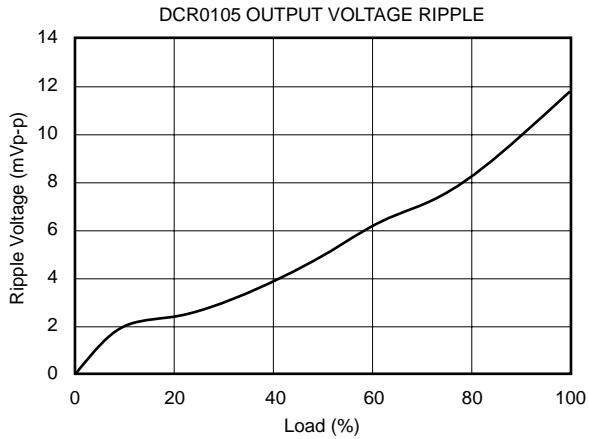
PIN DEFINITION (SO)⁽¹⁾

PIN #	PIN NAME	DESCRIPTION
1	V _S	Voltage Input
2	V _S	Voltage Input
3	NC	No Connection
12	V _{REC}	Rectified Output
13	V _{OUT}	Output Ground
14	V _O	Voltage Output
15	DNC	Do Not Connect
16	ENABLE	Output Voltage Enable
17	ERROR	Error Flag Active Low
26	0V _{IN}	Input Ground
27	0V _{IN}	Input Ground
28	SYNC	Synchronization Input

NOTE: (1) SO version available Q1 2001.

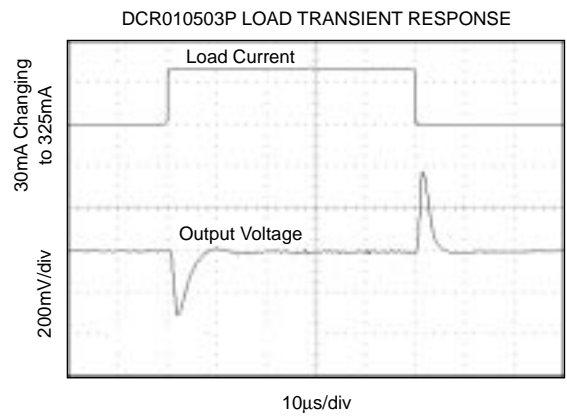
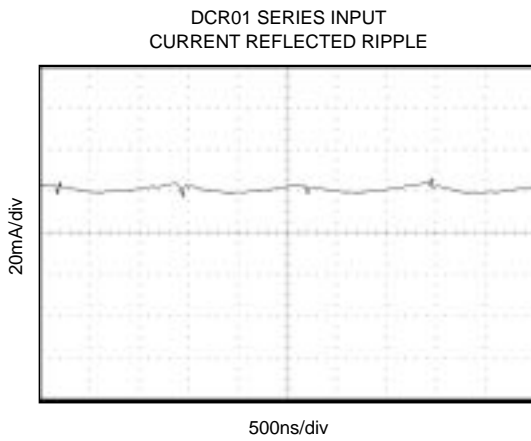
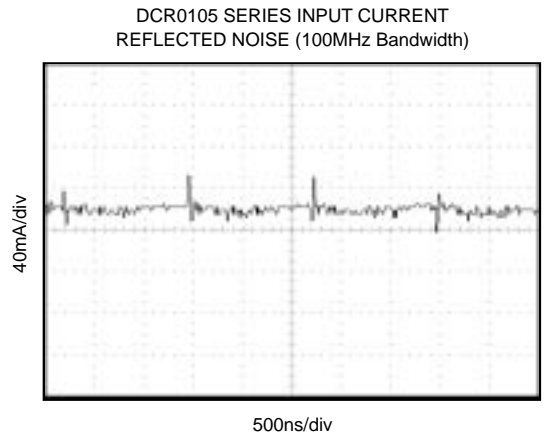
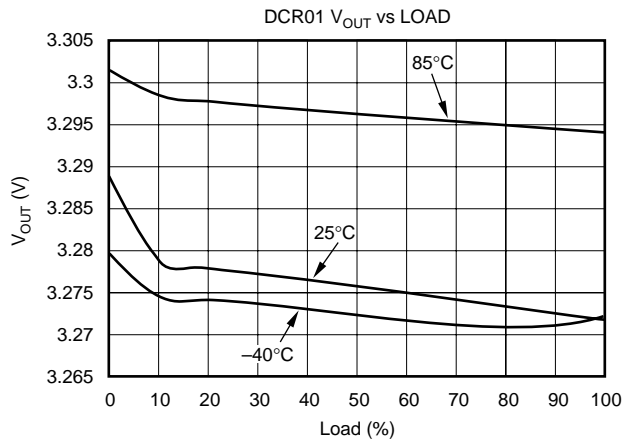
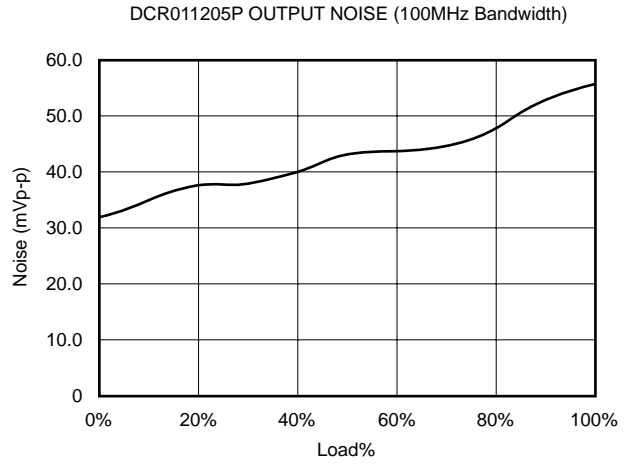
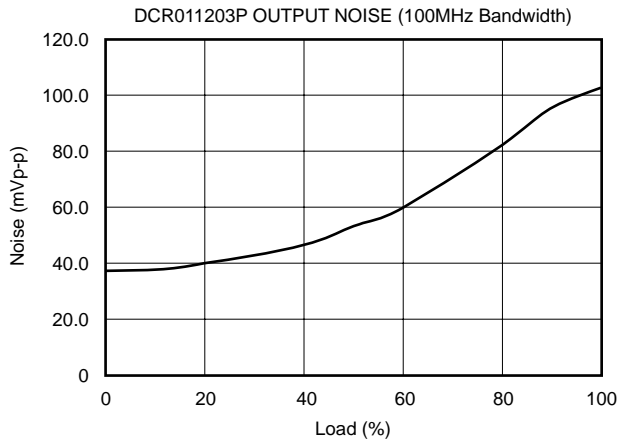
TYPICAL PERFORMANCE CURVES

At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $I_O = 10\text{mA}$, $C_O = 0.1\mu\text{F}$, unless otherwise specified.



TYPICAL PERFORMANCE CURVES (Cont.)

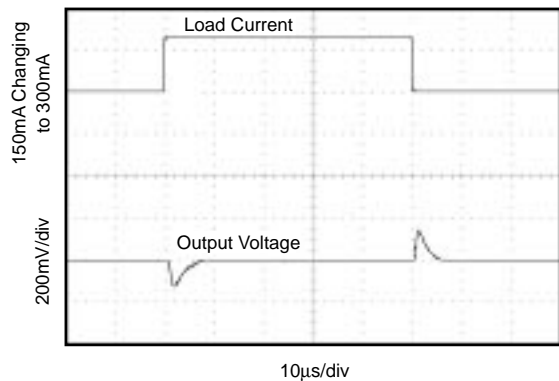
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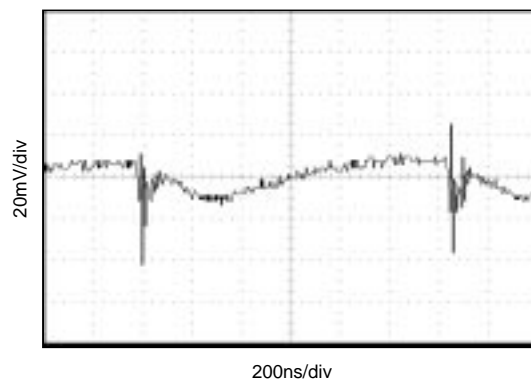
TYPICAL PERFORMANCE CURVES (Cont.)

At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $I_O = 10\text{mA}$, $C_O = 0.1\mu\text{F}$, unless otherwise specified.

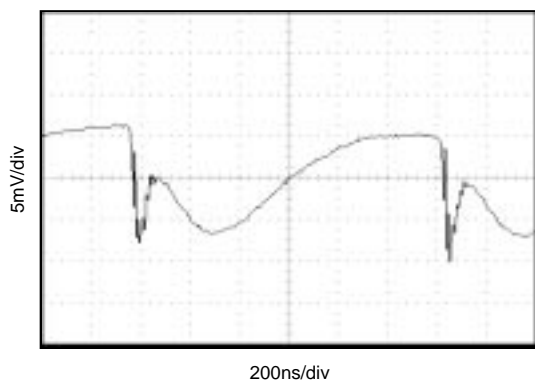
DCR010503P LOAD TRANSIENT RESPONSE



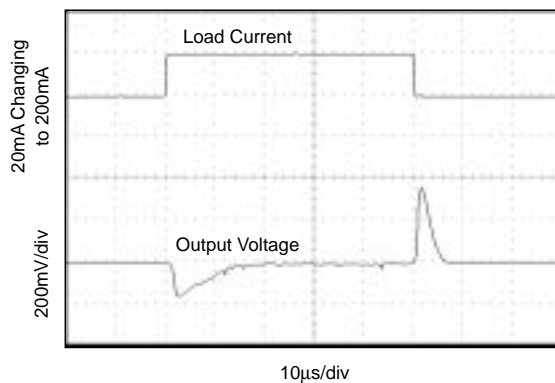
DCR010503P OUTPUT VOLTAGE NOISE AT 100% LOAD (100MHz Bandwidth)



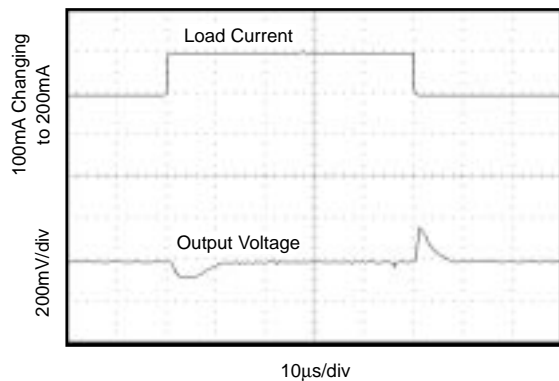
DCR010503P OUTPUT VOLTAGE RIPPLE AT 100% LOAD (20MHz Bandwidth)



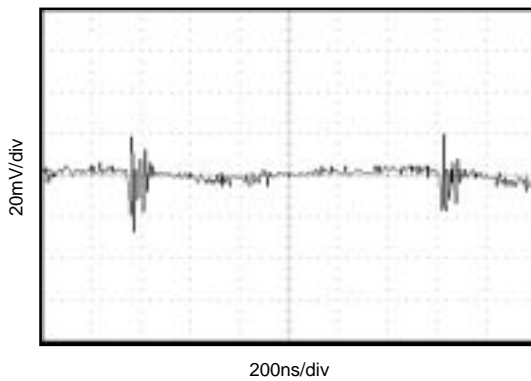
DCR010505P LOAD TRANSIENT RESPONSE



DCR010505P LOAD TRANSIENT RESPONSE



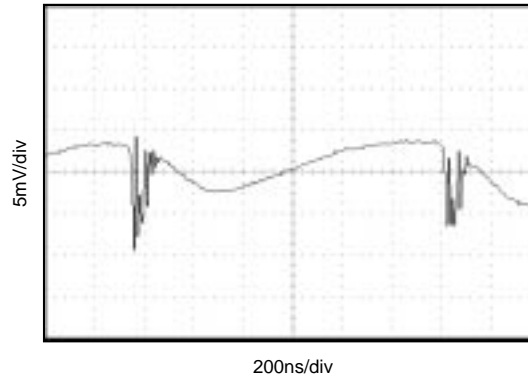
DCR010505P OUTPUT VOLTAGE NOISE AT 100% LOAD (100MHz Bandwidth)



TYPICAL PERFORMANCE CURVES (Cont.)

At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $I_O = 10\text{mA}$, $C_O = 0.1\mu\text{F}$, unless otherwise specified.

DCR010505P OUTPUT VOLTAGE RIPPLE
AT 100% LOAD (20MHz Bandwidth)



FUNCTIONAL DESCRIPTION

OVERVIEW

The DCR01 series offers isolation from an unregulated power supply operating from a choice of input voltages. The DCR01s provide a variety of regulated output voltages at a nominal output power of 1W or above.

POWER STAGE

The input supply is chopped at a frequency of 400kHz (internal oscillator divided by 2), which is used to drive the center-tapped toroidal transformer.

RECTIFICATION

The transformer's output is full wave rectified and smoothed by the external capacitor connected to V_{REC} .

REGULATOR

The internal low drop-out regulator provides a well-regulated output voltage, throughout the operating range of the device.

OSCILLATOR AND WATCHDOG

The DCR01 uses an internal saw-tooth generator to provide the 800kHz onboard oscillator that is used to drive the power switching circuit. The operation of the oscillator is monitored by the watchdog, which will tri-state the output driver circuit if the oscillator fails, or if the SYNC pin is taken LOW, (shutdown mode). When the SYNC pin is returned HIGH, normal operation resumes.

SYNCHRONIZATION

If more than one DCR01 is being used, beat frequencies and other electrical interference can be generated. This is due to the small variations in switching frequencies between the converters.

The DCR01 overcomes this by allowing devices to be synchronized to one another. Up to eight devices can be synchronized by connecting the SYNC pins together, with care being taken to minimize the capacitance of tracking.

Significant stray capacitance on the SYNC pin will have the effect of reducing the frequency of the internal oscillator. If this is large, the DCR01 may be taken outside its optimized operating parameters, and saturation of the magnetics may result, damaging the device.

If devices are synchronized, it should be noted that all devices will draw maximum current simultaneously at start up. This can cause the input voltage to dip. Should it fall below the minimum input voltage, the devices may not start up. A $2.2\mu\text{F}$ capacitor (low ESR) should be connected as close to the device input pins as possible for the 5V input devices, and a $0.47\mu\text{F}$ capacitor for the 12V and 24V devices.

If more than eight devices are required to be synchronized, it is recommended that external synchronization be used. Details are contained in Burr-Brown's Application Bulletin AB-153 (literature number SBAA035) available at www.ti.com.

CONSTRUCTION

The DCR01 is manufactured using the same technology as standard IC packages. There is no substrate within the package. The DCR01 is constructed using a driver IC, low-dropout voltage regulator, rectifier diodes, and a wound magnetic toroid, all mounted on a leadframe. The DCR01 requires no special PCB assembly processing, as there is no solder within the package. The result is an isolated DC/DC converter with inherently high reliability.

ADDITIONAL FUNCTIONS

DISABLE/ENABLE

The DCR01 can be disabled or enabled by driving the SYNC pin using an open drain CMOS gate. If the SYNC pin is pulled LOW, the DCR01 will be disabled. The disable time depends upon the external loading. The internal disable function is implemented in 2 μ s. Removal of the pull down will enable the DCR01.

Capacitance loading on the SYNC pin should be minimized in order to prevent a reduction in the internal oscillator's frequency. See Application Bulletin AB-153 "External Synchronization of the DCP01/02 Series of DC/DC Converters". This document contains information on how to null the effects of additional capacitance on the SYNC pin. The oscillator's frequency can be measured at V_{REC} , as this is the fundamental frequency of the ripple component.

OUTPUT ENABLE/DISABLE

The regulated output of the DCR01 can be disabled by pulling the ENABLE pin LOW. Holding the ENABLE pin HIGH enables the regulated output voltage, thus allowing the output to be controlled from the isolated side.

ERROR FLAG

The DCR01 has an \overline{ERROR} pin which provides a "power good" flag, as long as the internal regulator is in regulation.

DECOUPLING

Ripple Reduction

Due to the very low forward resistance of the DMOS switching transistors, high current demands are placed upon the input supply for a short time. By using a good quality low Equivalent Series Resistance (ESR) capacitor of 2.2 μ F (minimum) for the 5V input devices and a 0.47 μ F capacitor for the 12V and 24V devices, placed close to the IC supply input pins, the effects on the power supply can be minimized.

The high switching frequency of 400kHz allows relatively small values of capacitors to be used for filtering the rectified output voltage. A good quality low ESR capacitor of 1 μ F placed close to the V_{REC} pin and output ground will reduce the ripple.

It is not recommended that the DCR01 be fitted using an IC socket as this will degrade performance.

The output at V_{REC} is full wave rectified and produces a ripple of 800kHz.

It is recommended that a 0.1 μ F low ESR capacitor is connected close to the output pin and ground to reduce noise on the output. The capacitor values listed are minimum values. If lower ripple is required then the filter capacitor should be increased in value to 0.47 μ F.

NOTE: As with all switching power supplies the best performance is only obtained with low ESR capacitors connected close to the switcher. If low ESR capacitors are not used, the ESR will generate a voltage drop when the capacitor is supplying the load power. Often a larger capacitor is chosen for this purpose when a low ESR smaller capacitance would perform as well.

PCB LAYOUT

RIPPLE AND NOISE

Careful consideration should be given to the layout of the PCB in order for the best results to be obtained.

The DCR01 is a switching power supply and as such can place high peak current demands on the input supply. In order to avoid the supply falling momentarily during the fast switching pulses, ground and power planes should be used to track the power to the input of DCR01 (this will also serve to reduce noise on the circuit). If this is not possible, the supplies must be connected in a star formation, with the tracks made as wide as possible.

If the SYNC pin is being used, the tracking between device SYNC pins should be short to avoid stray capacitance. If the SYNC pin is not being used it is advisable to place a guard ring (connected to input ground) around this pin to avoid any noise pick up.

The output should be taken from the device using ground and power planes. This will ensure minimum losses.

A good quality low ESR capacitor placed as close as practicable across the input will reduce reflected ripple and ensure a smooth start up.

A good quality low ESR capacitor placed as close as practicable across the rectifier output terminal and output ground will give the best ripple and noise performance.

THERMAL MANAGEMENT

Due to the high power density of this device, it is advisable to provide a ground plane on the output. The output regulator is mounted on a copper leadframe, and a ground plane will serve as an efficient heatsink.

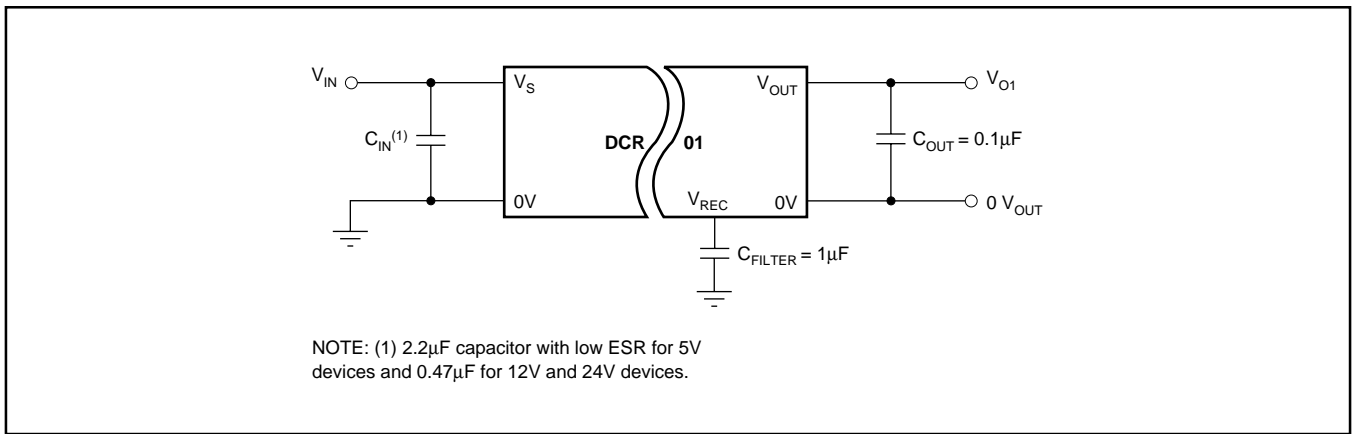


FIGURE 1. DCR01 with a Single Output.

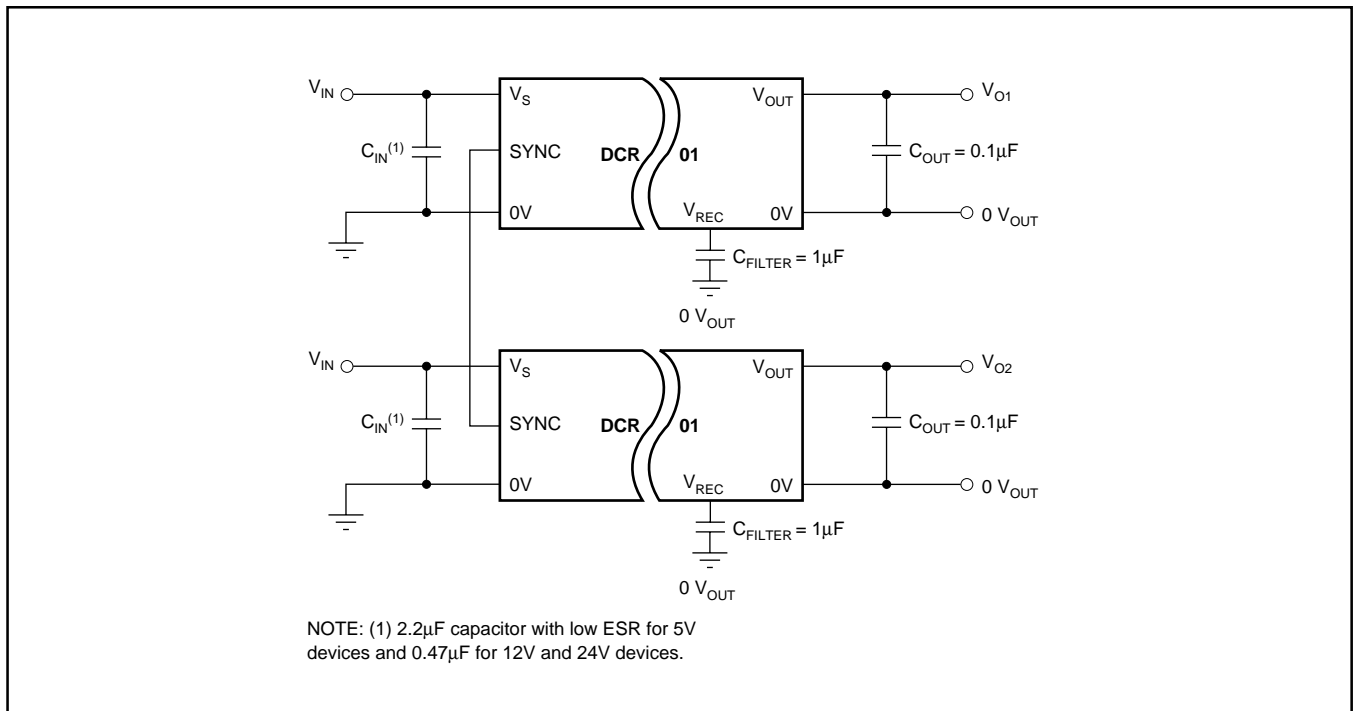


FIGURE 2. Self-Synchronizing DCR01s with a Dual Output.

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