



## DCR01 Series

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# Miniature, 1W Isolated REGULATED DC/DC CONVERTERS

## FEATURES

- UL1950 RECOGNIZED
- PDIP-18, SO-28<sup>(1)</sup>
- 53W/in<sup>3</sup> (3.3W/cm<sup>3</sup>) 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

## APPLICATIONS

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

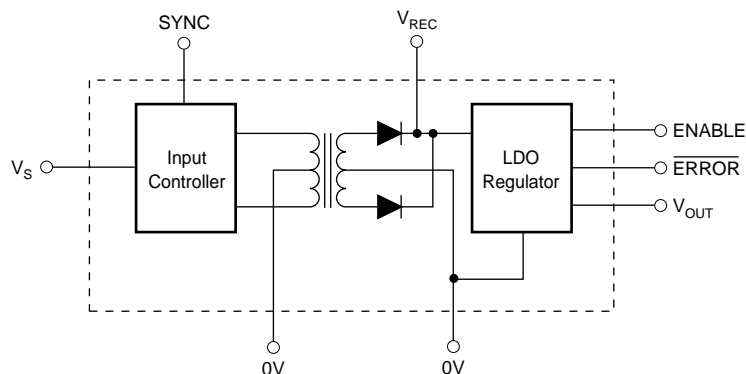
## DESCRIPTION

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.

NOTE: (1) SO version available Q3 2000.



# 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 |                |
| <b>OUTPUT</b>                  |  |              |                 |     |                |
| Setpoint                       |  |              |                 |     |                |
| DCR010503                      |  |              | 3.3             |     | V              |
| DCR010505                      |  |              | 5               |     | V              |
| DCR011203 <sup>(2)</sup>       |  |              | 3.3             |     | V              |
| DCR011205 <sup>(2)</sup>       |  |              | 5               |     | V              |
| DCR012403 <sup>(3)</sup>       |  |              | 3.3             |     | V              |
| DCR012405 <sup>(3)</sup>       |  |              | 5               |     | V              |
| Setpoint Accuracy              |  |              | 0.5             | 2.0 | %              |
| Maximum Output Current         |  |              |                 |     |                |
| DCR010503                      |  | 300          |                 |     | mA             |
| DCR010505                      |  | 200          |                 |     | mA             |
| DCR011203 <sup>(2)</sup>       |  | 390          |                 |     | mA             |
| DCR011205 <sup>(2)</sup>       |  | 200          |                 |     | mA             |
| DCR012403 <sup>(3)</sup>       |  | 390          |                 |     | mA             |
| DCR012405 <sup>(3)</sup>       |  | 200          |                 |     | mA             |
| Output Short-Circuit Protected | Duration   |              | Infinite        |     |                |
| Line Regulation                |  |              |                 |     |                |
| DCR010503                      |  |              | 1               |     | mV/V           |
| DCR010505                      |  |              | 1               |     | mV/V           |
| DCR011203 <sup>(2)</sup>       |  |              | 1               |     | mV/V           |
| DCR011205 <sup>(2)</sup>       |  |              | 1               |     | mV/V           |
| DCR012403 <sup>(3)</sup>       |  |              | 1               |     | mV/V           |
| DCR012405 <sup>(3)</sup>       |  |              | 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 | %              |
| DCR011203                      | 10mA to 390mA 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 | %              |
| DCR012403                      | 10mA to 390mA 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               |  |              |                 |     |                |
| DCR0105 Ripple                 | 20MHz Bandwidth, 50% Load<br>$C_{IN} = 2.2\mu\text{F}$ , $C_{FILTER} = 1\mu\text{F}$ , $C_{OUT} = 0.1\mu\text{F}$  |              | 5               |     | mVp-p          |
| DCR0105 Noise                  | 100MHz Bandwidth, 50% Load<br>$C_{IN} = 2.2\mu\text{F}$ , $C_{FILTER} = 1\mu\text{F}$ , $C_{OUT} = 0.1\mu\text{F}$ |              | 35              |     | mVp-p          |
| <b>INPUT</b>                   |  |              |                 |     |                |
| Nominal Voltage ( $V_S$ )      | DCR0105xx<br>DCR0112xx<br>DCR0124xx  |              | 5<br>12<br>24   |     | V<br>V<br>V    |
| Voltage Range                  |  | -10          |                 | +10 | %              |
| Supply Current                 |  |              |                 |     |                |
| DCR010503                      | $I_O = 0\text{mA}$<br>$I_O = 10\text{mA}$<br>$I_O = 300\text{mA}$  |              | 18<br>28<br>335 |     | mA<br>mA<br>mA |
| DCR010505                      | $I_O = 0\text{mA}$<br>$I_O = 10\text{mA}$<br>$I_O = 200\text{mA}$  |              | 25<br>40<br>310 |     | mA<br>mA<br>mA |
| DCR011203 <sup>(2)</sup>       | $I_O = 0\text{mA}$<br>$I_O = 10\text{mA}$<br>$I_O = 390\text{mA}$  |              | 13<br>17<br>173 |     | mA<br>mA<br>mA |
| DCR011205 <sup>(2)</sup>       | $I_O = 0\text{mA}$<br>$I_O = 10\text{mA}$<br>$I_O = 200\text{mA}$  |              | 13<br>18<br>125 |     | mA<br>mA<br>mA |
| DCR012403 <sup>(3)</sup>       | $I_O = 0\text{mA}$<br>$I_O = 10\text{mA}$<br>$I_O = 390\text{mA}$  |              | 15<br>17<br>94  |     | mA<br>mA<br>mA |
| DCR012405 <sup>(3)</sup>       | $I_O = 0\text{mA}$<br>$I_O = 10\text{mA}$<br>$I_O = 200\text{mA}$  |              | 15<br>17<br>71  |     | mA<br>mA<br>mA |
| Reflected Ripple Current       |  |              |                 |     |                |
| DCR010503, DCR01505            | MHz Bandwidth, 100% Load<br>$C_{IN} = 2.2\mu\text{F}$ , $C_{FILTER} = 1\mu\text{F}$                                |              | 8               |     | mAp-p          |

# 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                           |                                      |
| <b>ISOLATION</b><br>Voltage<br>Input/Output Capacitance  | 1s Flash Test<br>60s Test, UL1950 <sup>(1)</sup>                            | 1<br>1                 | 25         |                               | kVrms<br>kVrms<br>pF                 |
| <b>OUTPUT ENABLE CONTROL</b><br>Logic High Input Voltage<br>Logic High Input Current<br>Logic Low Input Voltage<br>Logic Low Input Current<br>DCR010503<br>DCR010505   | $2.0 < V_{\text{ENABLE}} < V_{\text{REC}}$<br>$0 < V_{\text{ENABLE}} < 0.5$ | 2.0<br>-0.2            | 100<br>100 | $V_{\text{REC}}$<br>0.5       | V<br>nA<br>V<br>nA<br>V<br>V         |
| <b>ERROR FLAG</b><br>Logic High Open Collector Leakage<br>Logic Low Output Voltage   | $V_{\text{ERROR}} = 5\text{V}$<br>Sinking 2mA                               |                        |            | 10<br>0.4                     | $\mu\text{A}$<br>V                   |
| <b>THERMAL SHUTDOWN</b><br>Junction Temperature<br>Temperature Activated<br>Temperature Deactivated  |   |                        | 150<br>130 |                               | $^\circ\text{C}$<br>$^\circ\text{C}$ |
| <b>SYNCHRONIZATION PIN</b><br>Max External Capacitance on SYNC Pin<br>Internal Oscillator Frequency<br>External Synchronization Frequency<br>External Synchronization Signal High<br>External Synchronization Signal Low |   | 720<br>720<br>2.5<br>0 | 800<br>2.5 | 3<br>880<br>880<br>5.0<br>0.4 | pF<br>kHz<br>kHz<br>V<br>V           |
| <b>TEMPERATURE RANGE</b><br>Operating  |   | -40                    |            | +85                           | $^\circ\text{C}$                     |

NOTES: (1) During UL approval only. (2) DCR011203, DCR011205 available Q2 2000. (3) DCR0112403, DCR012405 available Q3 2000.

## ABSOLUTE MAXIMUM RATINGS

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

## 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 <sup>(1)</sup> |       |    |    |     |

NOTE: (1) SO version available Q3 2000.



## 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.

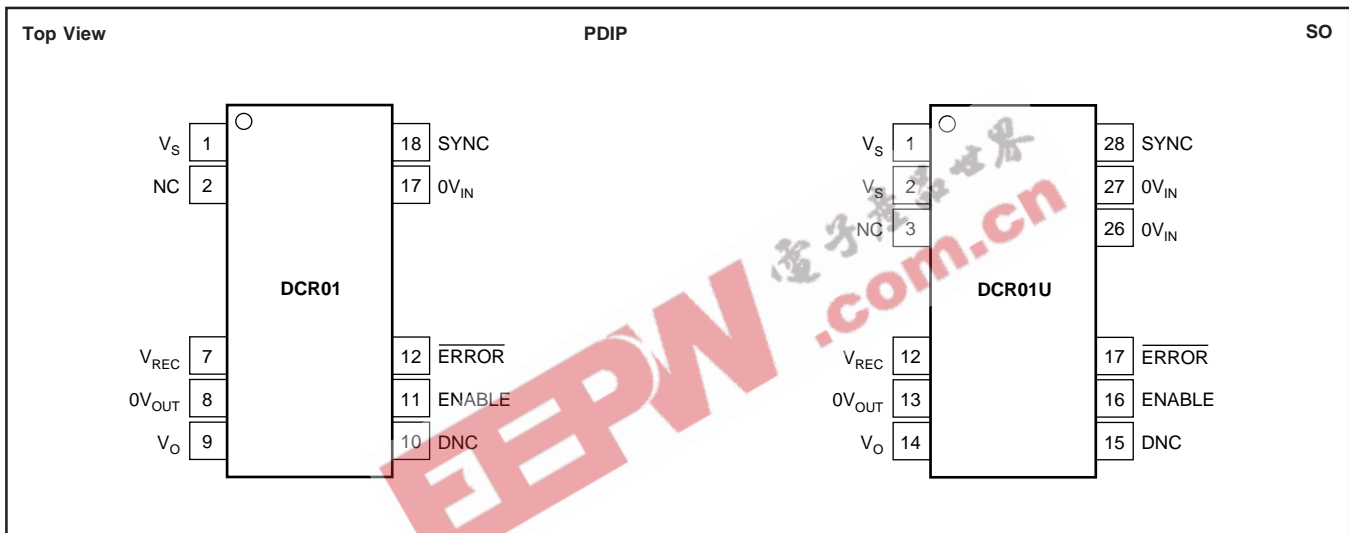
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## PACKAGE/ORDERING INFORMATION

| PRODUCT                      | PACKAGE | PACKAGE DRAWING NUMBER | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER <sup>(1)</sup> | TRANSPORT MEDIA |
|------------------------------|---------|------------------------|-----------------------------|-----------------|--------------------------------|-----------------|
| DCR010503P                   | PDIP-18 | 218-1                  | -40°C to +85°C              | DCR010503P      | DCR010503P                     | Rails           |
| DCR010505P                   | PDIP-18 | 218-1                  | -40°C to +85°C              | DCR010505P      | DCR010505P                     | Rails           |
| DCR010503U <sup>(3)</sup>    | SO-28   | 217-2                  | -40°C to +85°C              | DCR010503U      | DCR010503U/1K                  | Tape and Reel   |
| DCR010505U <sup>(3)</sup>    | SO-28   | 217-2                  | -40°C to +85°C              | DCR010505U      | DCR010505U/1K                  | Tape and Reel   |
| DCR011203P <sup>(2)</sup>    | PDIP-18 | 218-1                  | -40°C to +85°C              | DCR011203P      | DCR011203P                     | Rails           |
| DCR011203U <sup>(1, 3)</sup> | SO-28   | 217-2                  | -40°C to +85°C              | DCR011203U      | DCR011203U/1K                  | Tape and Reel   |
| DCR011205P <sup>(2)</sup>    | PDIP-18 | 218-1                  | -40°C to +85°C              | DCR011205P      | DCR011205P                     | Rails           |
| DCR011205U <sup>(1, 3)</sup> | SO-28   | 217-2                  | -40°C to +85°C              | DCR011205U      | DCR011205U/1K                  | Tape and Reel   |
| DCR012403P <sup>(3)</sup>    | PDIP-18 | 218-1                  | -40°C to +85°C              | DCR012403P      | DCR012403P                     | Rails           |
| DCR012403U <sup>(1, 3)</sup> | SO-28   | 217-2                  | -40°C to +85°C              | DCR012403U      | DCR012403U/1K                  | Tape and Reel   |
| DCR012405P <sup>(3)</sup>    | PDIP-18 | 218-1                  | -40°C to +85°C              | DCR012405P      | DCR012405P                     | Rails           |
| DCR012405U <sup>(1, 3)</sup> | SO-28   | 217-2                  | -40°C to +85°C              | DCR012405U      | DCR012405U/1K                  | Tape and Reel   |

NOTE: (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) Available Q2 2000. (3) Available Q3 2000.

## PIN CONFIGURATIONS



### PIN DEFINITION (PDIP)

| PIN # | PIN NAME | DESCRIPTION           |
|-------|----------|-----------------------|
| 1     | VS       | Voltage Input         |
| 2     | NC       | No Connection         |
| 7     | VREC     | Rectified Output      |
| 8     | OVOUT    | Output Ground         |
| 9     | VO       | Voltage Output        |
| 10    | DNC      | Do Not Connect        |
| 11    | ENABLE   | Output Voltage Enable |
| 12    | ERROR    | Error Flag Active Low |
| 17    | 0VIN     | Input Ground          |
| 18    | SYNC     | Synchronization Input |

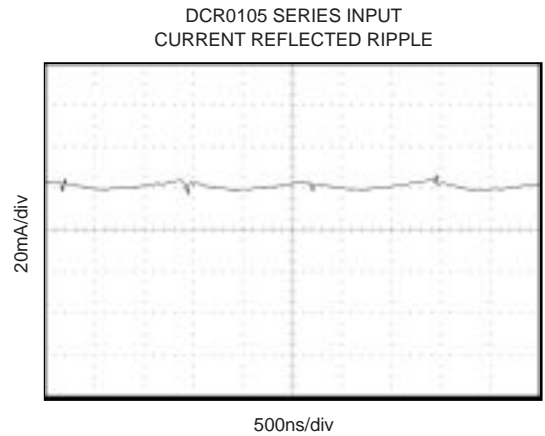
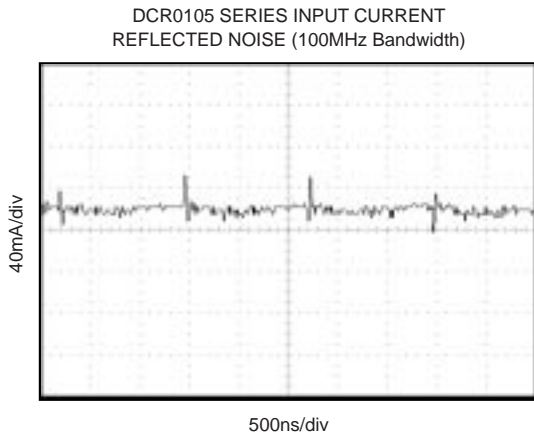
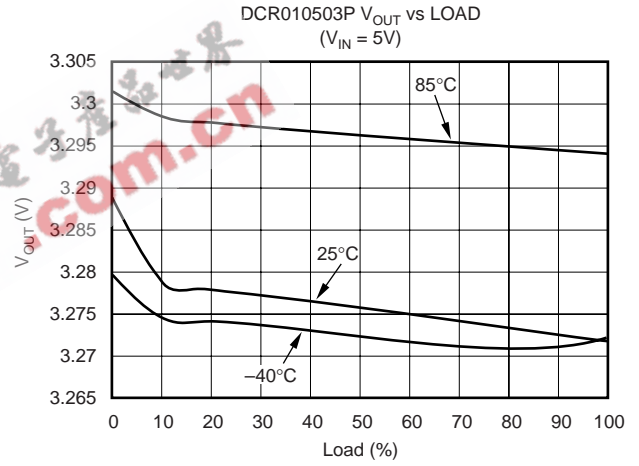
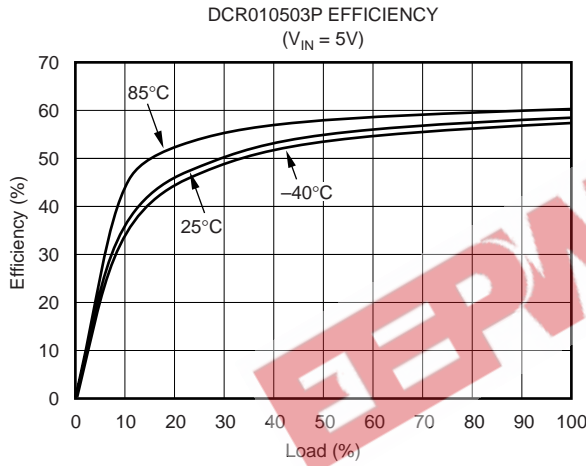
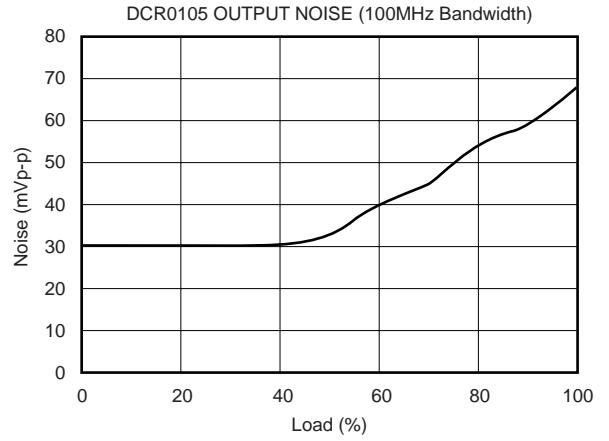
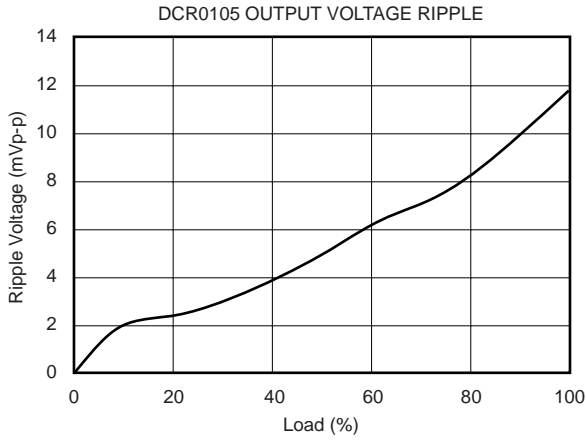
NOTE: (1) SO version available Q3 2000.

### PIN DEFINITION (SO)

| PIN # | PIN NAME | DESCRIPTION           |
|-------|----------|-----------------------|
| 1     | VS       | Voltage Input         |
| 2     | VS       | Voltage Input         |
| 3     | NC       | No Connection         |
| 12    | VREC     | Rectified Output      |
| 13    | VOOUT    | Output Ground         |
| 14    | VO       | Voltage Output        |
| 15    | DNC      | Do Not Connect        |
| 16    | ENABLE   | Output Voltage Enable |
| 17    | ERROR    | Error Flag Active Low |
| 26    | 0VIN     | Input Ground          |
| 27    | 0VIN     | Input Ground          |
| 28    | SYNC     | Synchronization Input |

# TYPICAL PERFORMANCE CURVES

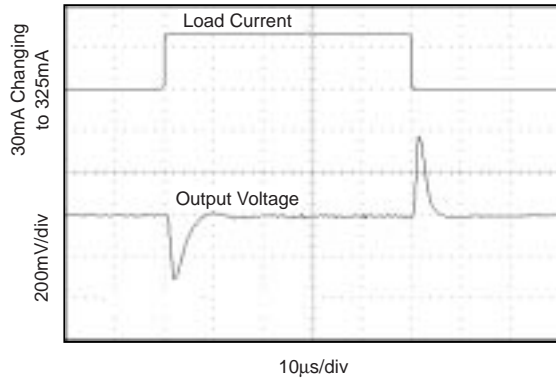
At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $I_O = 10\text{mA}$ ,  $C_O = 0.1\mu\text{F}$ , unless otherwise specified.



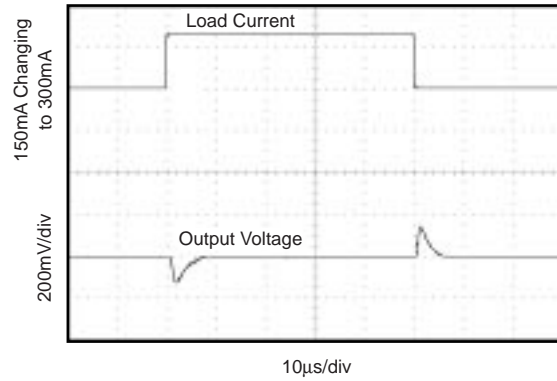
# TYPICAL PERFORMANCE CURVES (Cont.)

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.

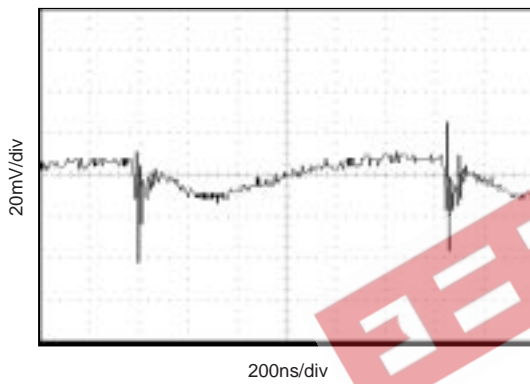
DCR010503P LOAD TRANSIENT RESPONSE



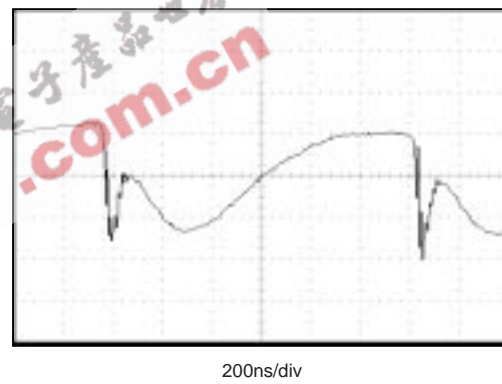
DCR010503P LOAD TRANSIENT RESPONSE



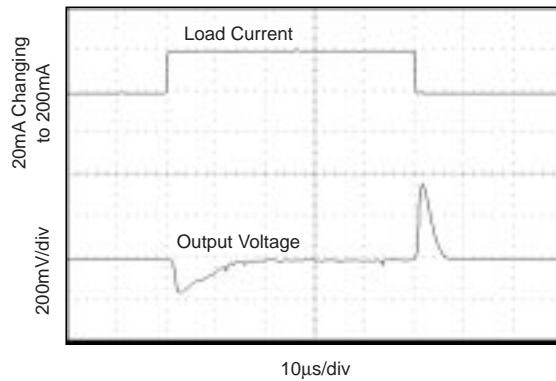
DCR010503P OUTPUT VOLTAGE NOISE  
AT 100% LOAD (100MHz Bandwidth)



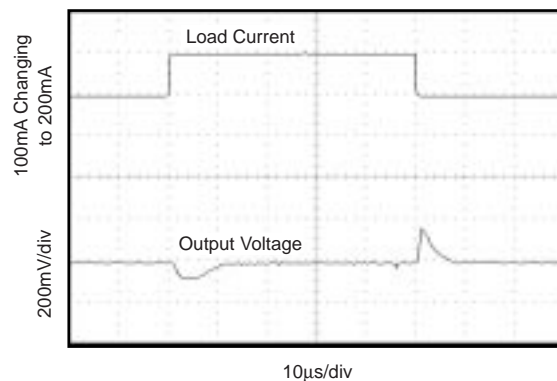
DCR010503P OUTPUT VOLTAGE RIPPLE  
AT 100% LOAD (20MHz Bandwidth)



DCR010505P LOAD TRANSIENT RESPONSE

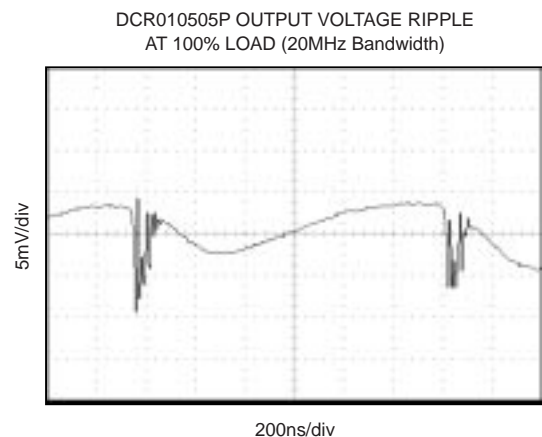
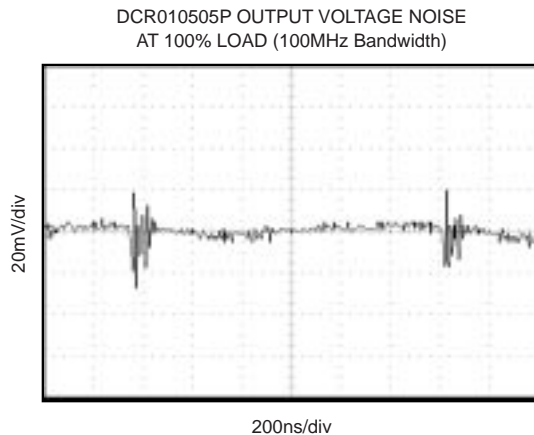


DCR010505P LOAD TRANSIENT RESPONSE



# 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.



## FUNCTIONAL DESCRIPTION

### OVERVIEW

The DCR01 series offers isolation from an unregulated power supply operating from a choice of input voltages. The DCR01's 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  $V_{\text{REC}}$ .

### 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 on-board 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 out with 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.

### 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 $\mu$ 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 oscillators 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  $\overline{\text{Error}}$  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 $\mu$ F (minimum) for the 5V input devices and a 0.47 $\mu$ 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 $\mu$ 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 $\mu$ 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 $\mu$ 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.



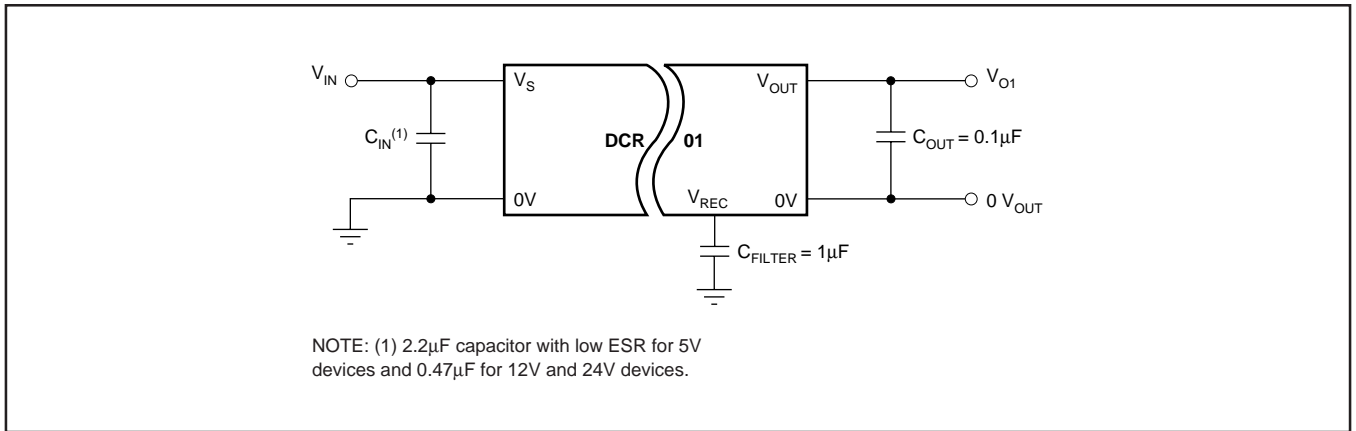


FIGURE 1. DCR01 with a Single Output.

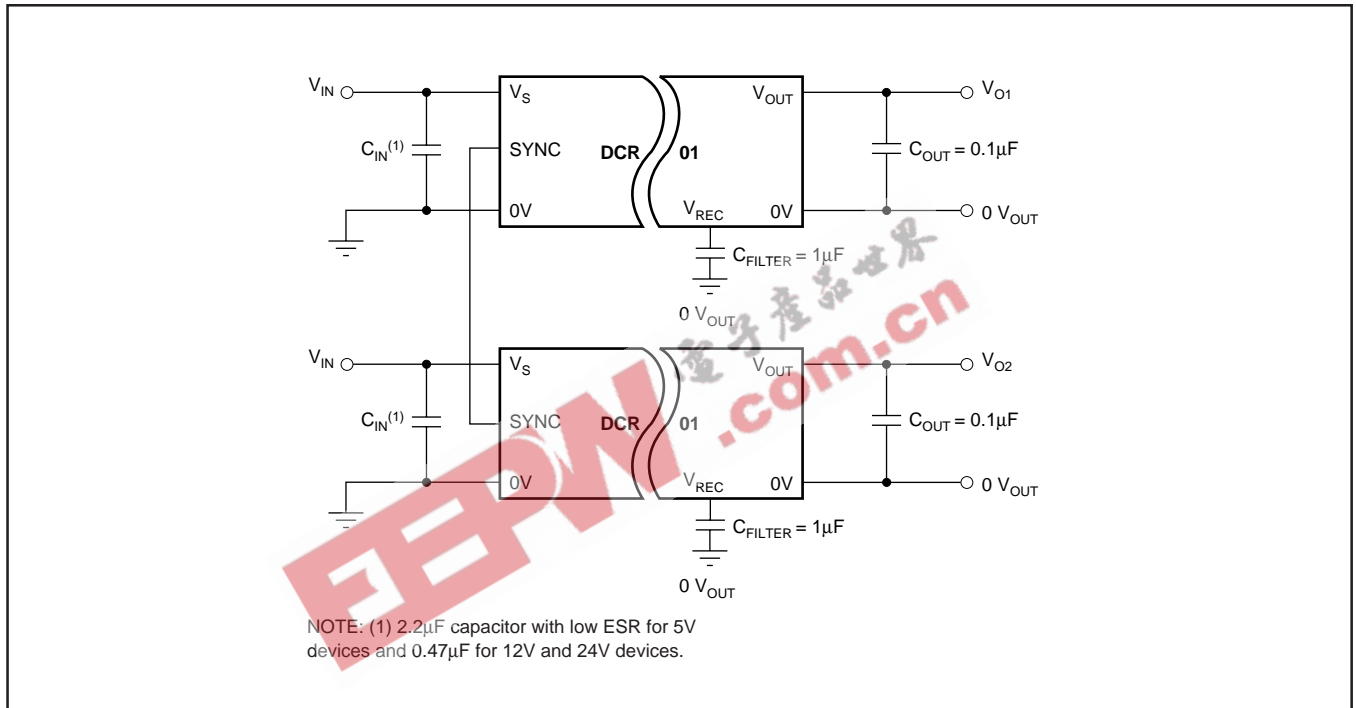


FIGURE 2. Self-Synchronizing DCR01s with a Dual Output.