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# DCP0124
# Series

# Miniature 24V Input, 1W Isolated
# UNREGULATED DC/DC CONVERTERS

## FEATURES

- ● **STANDARD JEDEC PLASTIC PACKAGE**
- ● **LOW PROFILE: 0.15" (3.8mm)**
- ● **SYNCHRONIZABLE**
- ● **OUTPUT SHORT CIRCUIT PROTECTION**
- ● **THERMAL SHUTDOWN**
- ● **STARTS INTO ANY CAPACITIVE LOAD**
- ● **EFFICIENCY: 76% (±15V Out)**
- ● **1000Vrms ISOLATION**
- ● **400kHz SWITCHING**
- ● **93 MILLION HOURS MTTF**
- ● **AVAILABLE IN TAPE AND REEL**

## APPLICATIONS

- ● **POINT OF USE POWER CONVERSION**
- ● **GROUND LOOP ELIMINATION**
- ● **DATA ACQUISITION**
- ● **INDUSTRIAL CONTROL AND INSTRUMENTATION**
- ● **TEST EQUIPMENT**

## DESCRIPTION

The DCP0124 family is a series of high efficiency, 24V input isolated DC/DC converters. In addition to 1W nominal galvanically isolated output power capability, the range of DC/DCs are also fully synchronizable. The devices feature thermal shutdown, and overload protection is implemented via watchdog circuitry. Advanced power-on reset techniques give superior reset performance and the devices will start into any capacitive load up to full power output.

The DCP01 family is implemented in standard-molded IC packaging, giving outlines suitable for high volume assembly.
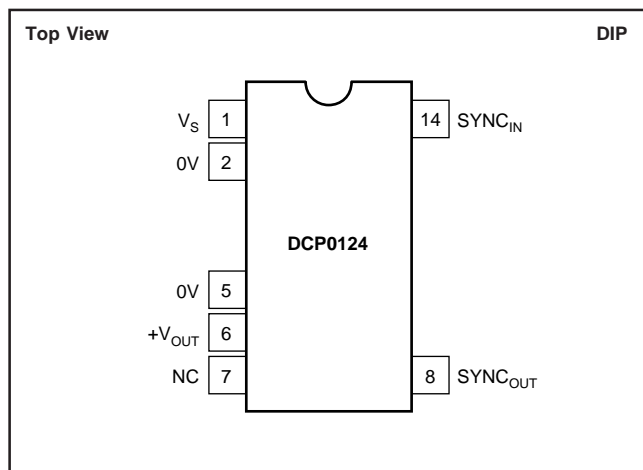
SBVS007
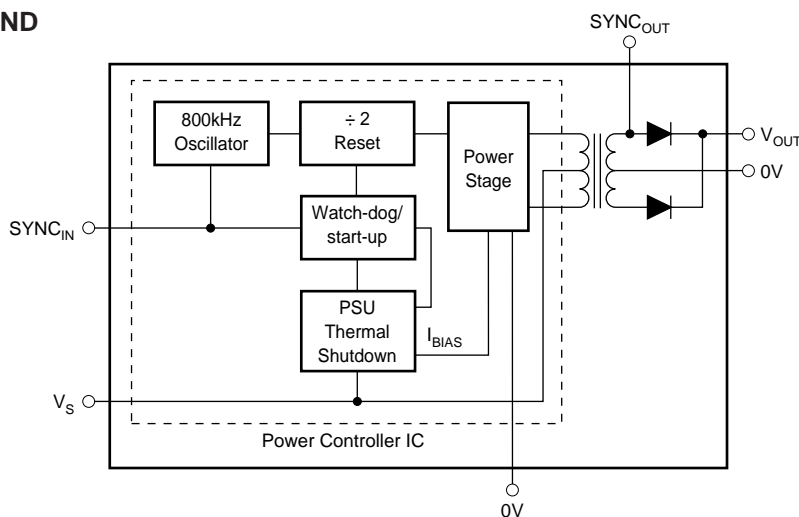
# SPECIFICATIONS

At $T_A$ = +25°C, $V_S$ = +24V, unless otherwise specified.

| PARAMETER | CONDITIONS | DCP0124 SERIES | | | UNITS |
|---|---|---|---|---|---|
| | | MIN | TYP | MAX | |
| **OUTPUT** | | | | | |
| Power | $V_S$ + 4% | | 1 | | W |
| | 100% Full Load | | 0.92 | | W |
| Voltage ($V_{NOM}$)[1] | | | | | |
| DCP012405 | 75% Full Load | 4.75 | 5 | 5.25 | V |
| DCP012415D (+V) | 75% Full Load | +14.25 | +15 | +15.75 | V |
| DCP012415D (−V) | 75% Full Load | −12 | −15 | −15.75 | V |
| Voltage vs Temperature | | | ±0.08 | | %/°C |
| Short Circuit Duration | $V_S$ ± 10% | Indefinite | | | |
| Ripple | $C_L$ = O/P Capacitor = 11µF | | 25 | | mVp-p |
| | 100% Full Load | | | | |
| **INPUT** | | | | | |
| Nominal Voltage ($V_S$) | | | 24 | | V |
| Voltage Range | | −10 | | 10 | % |
| Supply Current | 100% Full Load | | 59 | | mA |
| Reflected Ripple Current | $C_{IN}$ = I/P Capacitor = 1µF | | 8 | | mArms |
| | 50% Full Load | | | | |
| **ISOLATION** | | | | | |
| Voltage[2] | 1s Flash Test | 1 | | | kVrms |
| Continuous Voltage[3] | | | 1 | | kVrms |
| Insulation Resistance | | | >1 | | GΩ |
| Input/Output Capacitance | | | 2.5 | | pF |
| **LOAD REGULATION** | | | | | |
| DCP012405 | 10% to 100% Load | | 17 | 23 | % |
| | 10% to 75% Load | | 9 | | % |
| | 75% to 100% Load | | −4 | | % |
| DCP012415D | 10% to 100% Load | | 22 | 35 | % |
| | 10% to 25% Load | | 11 | | % |
| | 25% to 75% Load | | 8 | | % |
| | 75% to 100% Load | | −4 | | % |
| **SWITCHING/SYNCHRONIZATION** | | | | | |
| Oscillator Frequency ($f_{OSC}$) | Switching Frequency = $f_{OSC}$/2 | | 800 | | kHz |
| Sync Input Low | | 0 | | 0.8 | V |
| Sync Input Current | $V_{SYNC}$ = +2V | | 48 | | µA |
| Reset Time | | | 3.8 | | µs |
| SYNC$_{OUT}$ Frequency | | | 400 | | kHz |
| **GENERAL** | | | | | |
| No Load Current | | | | | |
| DCP012405 | 0% Full Load | | 14 | | mA |
| DCP012415D | 0% Full Load | | 17 | | mA |
| Efficiency | | | | | |
| DCP012405 | 100% Full Load | | 65 | | % |
| | 10% Full Load | | 34 | | % |
| DCP012415D | 100% Full Load | | 76 | | % |
| | 10% Full Load | | 36 | | % |
| MTTF[3] | $T_A$ = +85°C | 136,000 | | | hrs |
| | $T_A$ = +55°C | 2,630,000 | | | hrs |
| | $T_A$ = +25°C | 92,600,000 | | | hrs |
| Weight | 14-Pin PDIP | | 1.08 | | g |
| **THERMAL SHUTDOWN** | | | | | |
| Die Temperature | | 115 | | 140 | °C |
| Shutdown Current | | | 3 | | mA |
| **TEMPERATURE RANGE** | | | | | |
| Operating | | −40 | | 100 | °C |

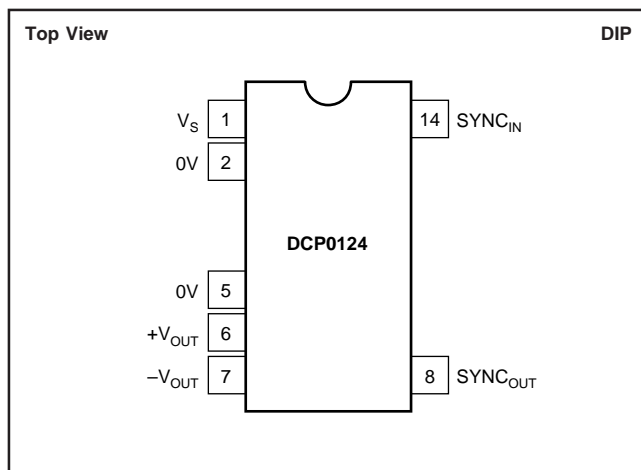NOTES: (1) 100 % load current = 1W/$V_{NOM}$ typical. (2) Rated working voltage = 130Vrms (IEC950 convention). (3) Life test data.

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## PIN CONFIGURATION (Single)

Top View             DIP

```
        ┌──────┐
 Vs   1 │      │ 14  SYNC_IN
 0V   2 │      │
        │DCP0124│
 0V   5 │      │
+V_OUT 6 │      │
 NC   7 │      │ 8   SYNC_OUT
        └──────┘
```

## PIN CONFIGURATION (Dual)

Top View             DIP

```
        ┌──────┐
 Vs   1 │      │ 14  SYNC_IN
 0V   2 │      │
        │DCP0124│
 0V   5 │      │
+V_OUT 6 │      │
-V_OUT 7 │      │ 8   SYNC_OUT
        └──────┘
```

## PIN DEFINITION (Single)

| PIN # | PIN NAME | DESCRIPTION |
|---|---|---|
| 1 | $V_S$ | Voltage Input. |
| 2 | 0V | Input Side Common. |
| 5 | 0V | Output Side Common. |
| 6 | $+V_{OUT}$ | +Voltage Out. |
| 7 | NC | No Connection. |
| 8 | $SYNC_{OUT}$ | Unregulated 400kHz Output from Transformer. |
| 14 | $SYNC_{IN}$ | Synchronization Pin. |

## PIN DEFINITION (Dual)

| PIN # | PIN NAME | DESCRIPTION |
|---|---|---|
| 1 | $V_S$ | Voltage Input. |
| 2 | 0V | Input Side Common. |
| 5 | 0V | Output Side Common. |
| 6 | $+V_{OUT}$ | +Voltage Out. |
| 7 | $-V_{OUT}$ | –Voltage Out. |
| 8 | $SYNC_{OUT}$ | Unregulated 400kHz Output from Transformer. |
| 14 | $SYNC_{IN}$ | Synchronization Pin. |

## ABSOLUTE MAXIMUM RATINGS

```
Input Voltage ......................................................................... 29V
Storage Temperature ...................................... –60°C to +150°C
Lead Temperature (soldering, 10s) ................................. 300°C
```

## ORDERING INFORMATION

```
                              DCP01  24  05  (D) ( )
Basic Model Number: 1W Product ─┘     │   │   │   │
Voltage Input: ───────────────────────┘   │   │   │
    24V In                                 │   │   │
Voltage Output: ───────────────────────────┘   │   │
    5V Out                                      │   │
Dual Output: ───────────────────────────────────┘   │
Package Code: ───────────────────────────────────────┘
    P = 14-Pin Plastic DIP
    P-U = 14-Pin Plastic Dip Gull Wing
```

## ⚠ 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.
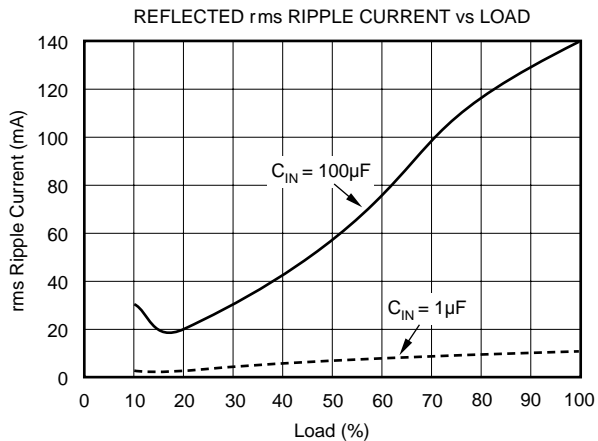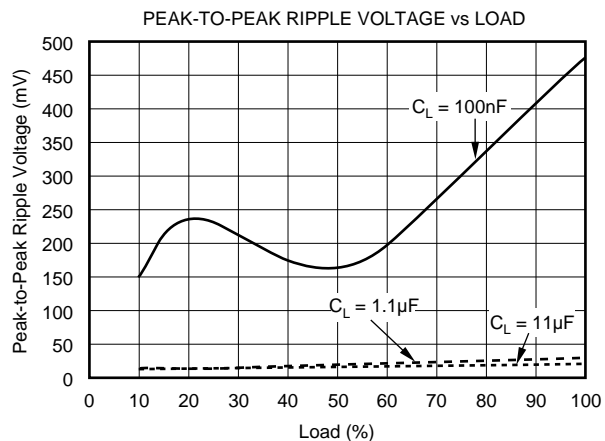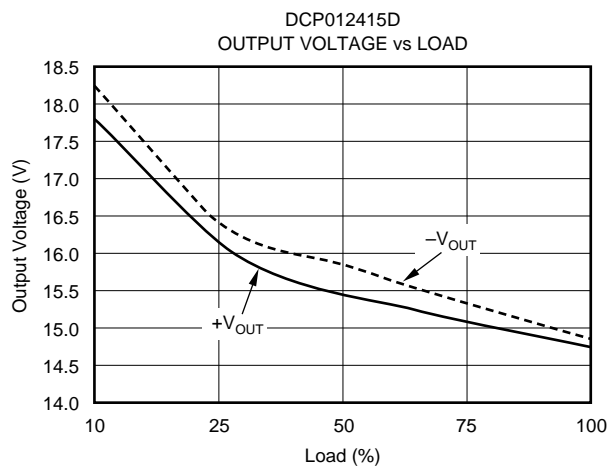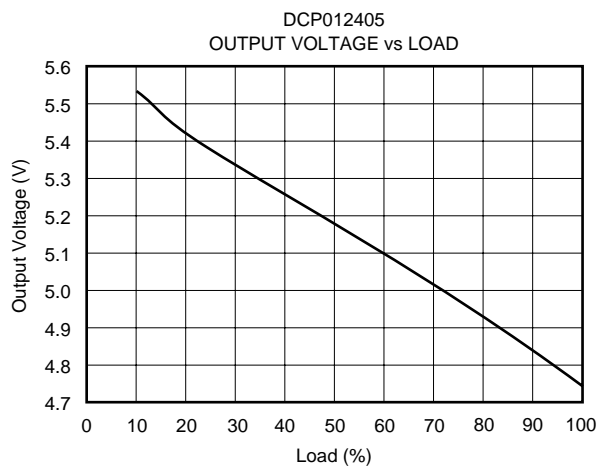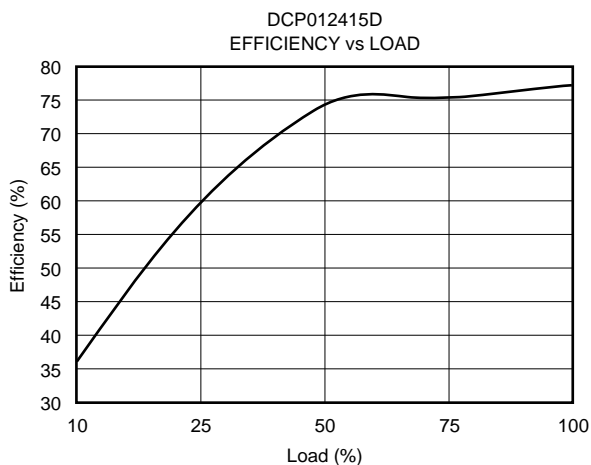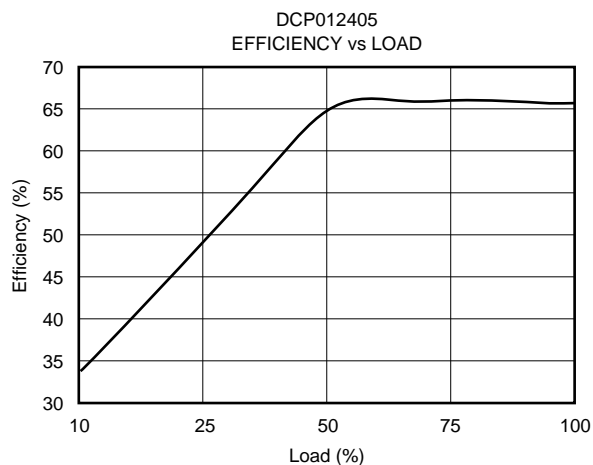
## PACKAGE/ORDERING INFORMATION

| PRODUCT | PACKAGE | PACKAGE DRAWING NUMBER[1] | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER[2] | TRANSPORT MEDIA |
|---|---|---|---|---|---|---|
| **Single** | | | | | | |
| DCP012405 | 14-Pin PDIP | 010-1 | –40°C to +100°C | DCP012405P | DCP012405P | Rails |
| DCP012405 | 14-Pin PDIP Gull Wing | 010-2 | –40°C to +100°C | DCP012405P-U | DCP012405P-U | Rails |
| " | " | " | " | " | DCP012405P-U/700 | Tape and Reel |
| **Dual** | | | | | | |
| DCP012415D | 14-Pin PDIP | 010-1 | –40°C to +100°C | DCP012415DP | DCP012415DP | Rails |
| DCP012415D | 14-Pin PDIP Gull Wing | 010-2 | –40°C to +100°C | DCP012415DP-U | DCP012415DP-U | Rails |
| " | " | " | " | " | DCP012415DP-U/700 | Tape and Reel |

NOTES: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book. (2) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /700 indicates 700 devices per reel). Ordering 700 pieces of DCP012405P-U/700 will get a single 700-piece Tape and Reel. For detailed Tape and Reel mechanical information, refer to Appendix B of Burr-Brown IC Data Book.
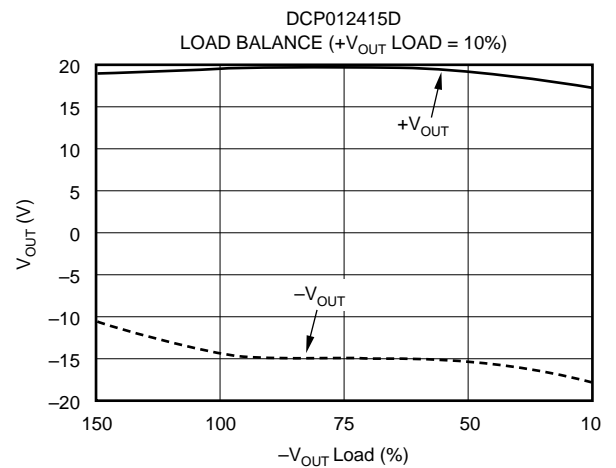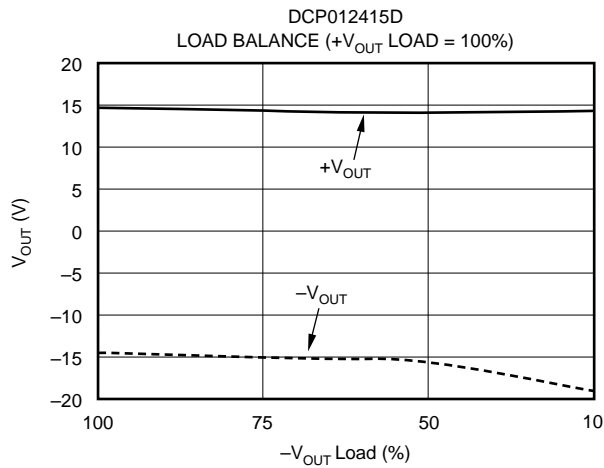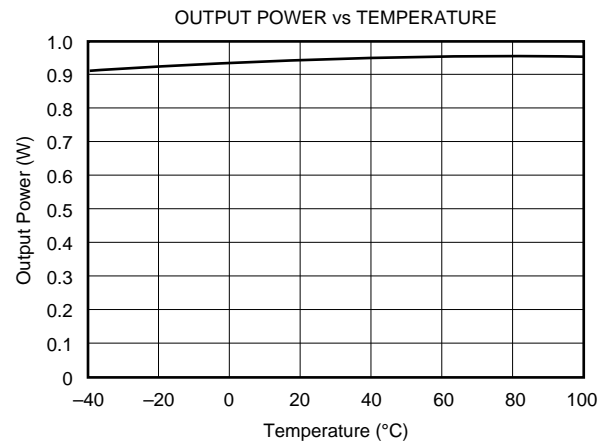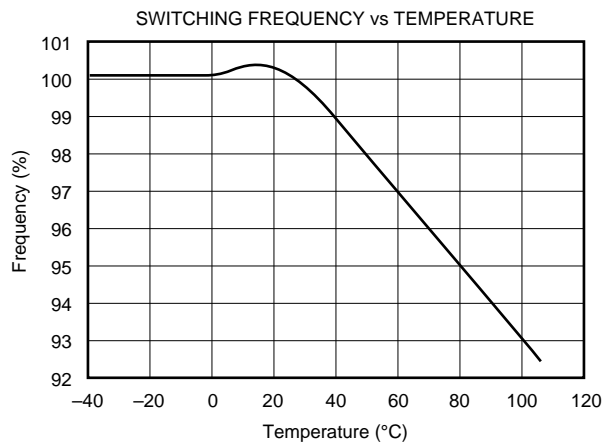
**DCP0124**

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# TYPICAL PERFORMANCE CURVES

At $T_A$ = +25°C, unless otherwise noted.

DCP012405
EFFICIENCY vs LOAD

DCP012415D
EFFICIENCY vs LOAD

DCP012405
OUTPUT VOLTAGE vs LOAD

DCP012415D
OUTPUT VOLTAGE vs LOAD

$-V_{OUT}$

$+V_{OUT}$

PEAK-TO-PEAK RIPPLE VOLTAGE vs LOAD

$C_L$ = 100nF

$C_L$ = 1.1µF

$C_L$ = 11µF

REFLECTED rms RIPPLE CURRENT vs LOAD

$C_{IN}$ = 100µF

$C_{IN}$ = 1µF

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# TYPICAL PERFORMANCE CURVES (CONT)

At $T_A$ = +25°C, unless otherwise noted.

DCP012405
OUTPUT VOLTAGE vs INPUT VOLTAGE (75% Load)

DCP012415D
OUTPUT VOLTAGE vs INPUT VOLTAGE (75% Load)

SWITCHING FREQUENCY vs TEMPERATURE

OUTPUT POWER vs TEMPERATURE

DCP012415D
LOAD BALANCE (+$V_{OUT}$ LOAD = 100%)

DCP012415D
LOAD BALANCE (+$V_{OUT}$ LOAD = 10%)
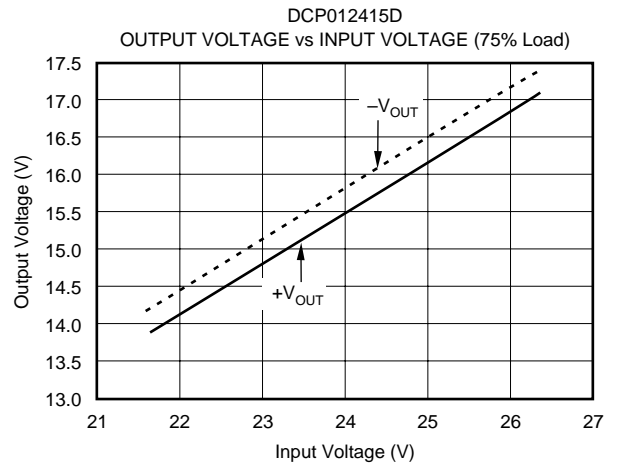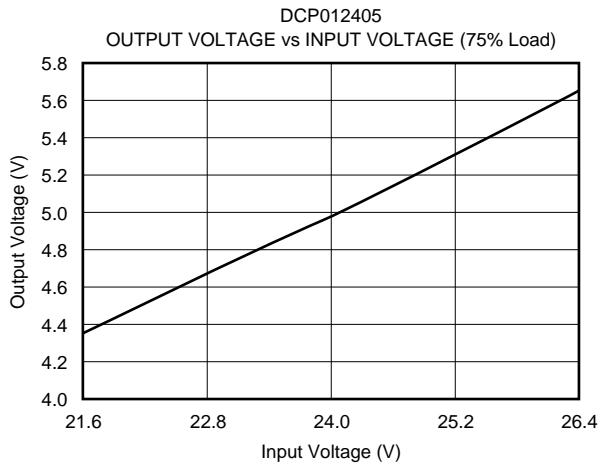
# FUNCTIONAL DESCRIPTION

## OVERVIEW

The DCP0124 offers up to 1W of unregulated output power from a 24V input source with a typical efficiency of up to 76%. This is achieved through highly integrated packaging technology and the implementation of a custom power stage and control IC.

## POWER STAGE

This uses a pull-pull, center-tapped topology switching at 400kHz (divide by 2 from 800kHz oscillator).

## OSCILLATOR AND WATCHDOG

The on-board 800kHz oscillator provides the switching frequency via a divide by 2 circuit and allows synchronization via the $SYNC_{IN}$ pins. To synchronize any number of DCP01 family of devices, simply tie the $SYNC_{IN}$ pins together (see the Synchronization section). The watchdog circuitry protects the DC/DC against a stopped oscillator and checks the oscillator frequency which will shut down the output stage if it drops below a certain threshold—i.e., it will be tri-stated after approximately 10μs.
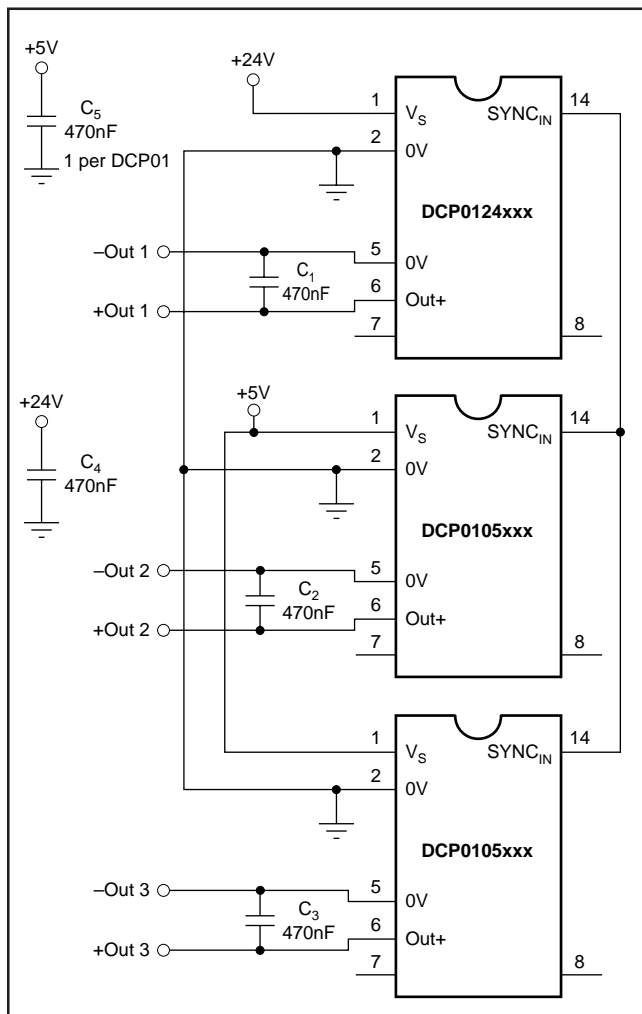


FIGURE 1. Standard Interface.

## THERMAL SHUTDOWN

The DCP0124 is also protected by thermal shutdown. If the on-chip temperature reaches a predetermined value, the DC/DC will shutdown. This effectively gives indefinite short circuit protection for the DC/DC.

## SYNCHRONIZATION

Any number of DCP01 family devices can be synchronized by connecting the $SYNC_{IN}$ pins on the devices together (see Figure 1). All the DCP01 devices will then self-synchronize.

This same synchronization method applies to any $V_{IN}$ version of the DCP01 family, allowing synchronization of various $V_{OUT}$ and $V_{IN}$ DC/DCs.

The $SYNC_{OUT}$ pin gives an unrectified 400kHz signal from the transformer. This can be used to set the timing of external circuitry on the output side. In noise sensitive applications any pick-up from the $SYNC_{OUT}$ pin can be minimized by putting a guard ring round the pin (see Figure 2).
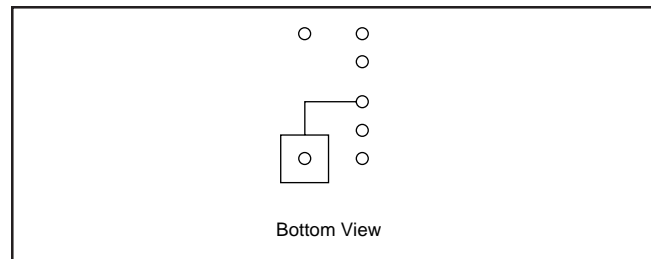


Bottom View

FIGURE 2. $SYNC_{OUT}$ Guard Ring.

## DIVIDE BY 2 RESET

Isolated DC/DC converter performance normally suffers after power reset. This is because a change in the steady state transformer flux creates an offset after power-up. The DCP01 family does not suffer from this problem. This is achieved through a patented[1] technique employed on the divide by 2 reset circuitry resulting in no change in output phase after power interruption.

## CONSTRUCTION

The DCP0124's basic construction is the same as standard ICs. There is no substrate within the molded package. The DCP0124 is constructed using an IC, rectifier diodes, and a wound magnetic toroid on a leadframe. As there is no solder within the package, the DCP0124 does not require any special PCB assembly processing. This results in an isolated DC/DC with inherently high reliability.

# ADDITIONAL FUNCTIONS

## DISABLE/ENABLE

The DCP0124 can be disabled or enabled by driving the $SYNC_{IN}$ pin with an open drain CMOS gate. If the $SYNC_{IN}$ pin is pulled low, the DCP0124 will disable. The disable time depends on the output loading but the internal shutdown takes

up to 10μs. Making the gate open drain will re-enable the DCP0124. However, there is a trade-off in using this function; the DCP0124 quiescent current may increase and the on-chip oscillator may run slower. This degradation in performance is dependent on the external CMOS gate capacitance, therefore the smaller the capacitance, the lower the performance decrease. Driving the $SYNC_{IN}$ pin with a CPU type tri-state output, which has a low output capacitance, offers the lowest reduction in performance.
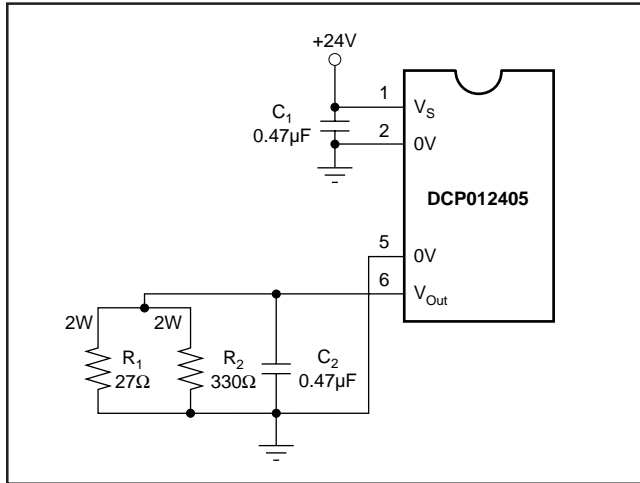


FIGURE 3. DCP012405 Fully Loaded.

## DECOUPLING

### Ripple Reduction

The high switching frequency of 400kHz allows simple filtering. To reduce ripple, it is recommended that 0.47μF capacitors are used on $V_S$ and $V_{OUT}$ (see Figure 3). Dual outputs should both be decoupled to pin 5. In applications where power is supplied over long lines and output loading is high, or there is significant inductance at the output, it may be necessary to use a 2.2μF capacitor on the input to insure startup.

There is no restriction on the size of the output capacitor used to reduce ripple. The DCP0124 will start into any capacitive load. Low ESR capacitors will give the best reduction.

## EXTERNAL SYNCHRONIZATION

The DCP0124 can be synchronized externally if required using a simple external interface. Figure 4 shows a universal interface using a 4066 quad switch. The CTL and $SYNC_{ON}$ pins are used to select external synchronization or self-synchronization.

This interface can also be used to stop (disable) the DCP0124.

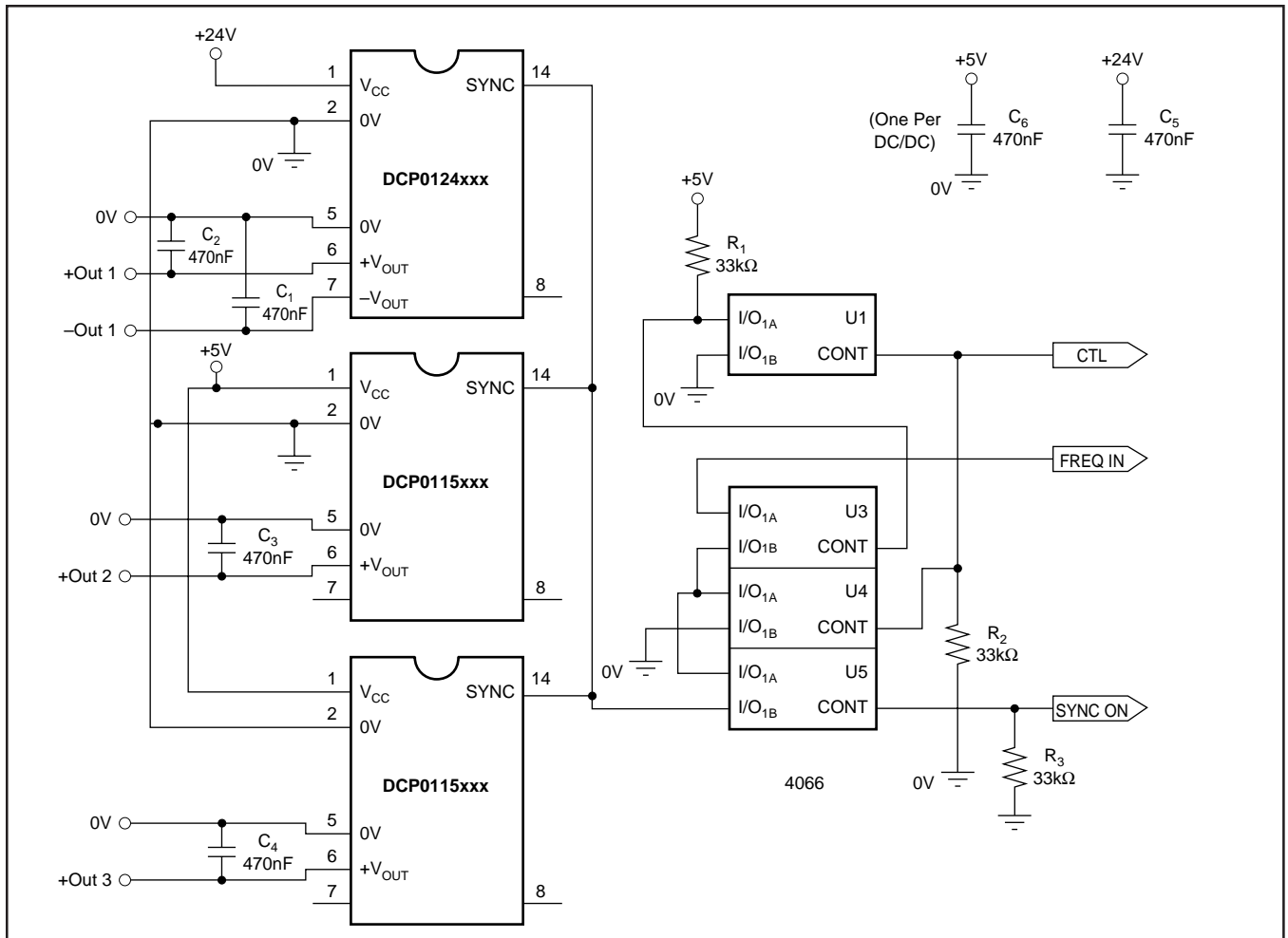| CTL | SYNC$_{ON}$ | FUNCTION |
|---|---|---|
| 1 | 1 | External Sync |
| — | 0 | Self-Sync |
| 0 | 1 | Device Stop |



FIGURE 4. Universal Interface.

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## Connecting the DCP0124 in Series

Multiple DCP01 isolated 1W DC/DC converters can be connected in series to provide non-standard voltage rails. This is possible by utilizing the floating outputs provided by the DCP01's galvanic isolation.

Connect the positive $V_{OUT}$ from one DCP01 to the negative $V_{OUT}$ (0V) of another (see Figure 5). If the $SYNC_{IN}$ pins are tied together, the self-synchronization feature of the DCP01 will prevent beat frequencies on the voltage rails. The SYNC feature of the DCP01 allows easy series connection without external filtering which is necessary in competing solutions.

The outputs on dual output DCP01 versions can also be connected in series to provide 2 times the magnitude of $V_{OUT}$ (see Figure 6). For example, a dual 15V DCP012415D could be connected to provide a 30V rail.

## Connecting the DCP0124 in Parallel

If the output power from one DCP0124 is not sufficient, it is possible to parallel the outputs of multiple DCP01s (see Figure 7). Again, the SYNC feature allows easy synchronization to prevent power-rail beat frequencies at no additional filtering cost.

## PREDICTING OUTPUT VOLTAGE VERSUS LOAD

The Load Regulation specifications are calculated as follows:

| CONDITION | CALCULATION |
|---|---|
| 10% to 100% Load | ($V_{OUT}$ at 10% load – $V_{OUT}$ at 100% load)/ $V_{OUT}$ at 75% load |
| 10% to 25% Load | ($V_{OUT}$ at 10% load – $V_{OUT}$ at 25% load)/ $V_{OUT}$ at 25% load |
| 10% to 75% Load | ($V_{OUT}$ at 10% load – $V_{OUT}$ at 75% load)/ $V_{OUT}$ at 75% load |
| 75% to 100% Load | ($V_{OUT}$ at 75% load – $V_{OUT}$ at 100% load)/ $V_{OUT}$ at 75% load |

1. To predict the output voltage at 100% load take the measured or specified voltage at 75% load and multiply by (1 + Load Reg 75% to 100%). For example a DCP012405P typical $V_{OUT}$ at 100% load will be 5V x (1 – 4%) = 4.8V.

2. To predict the output voltage at 10% load take the measured or specified voltage at 75% load and multiply by (1 + Load Reg 10% to 75%). For example a DCP012405P typical $V_{OUT}$ at 10% load will be 5V x (1 + 9%) = 5.4V.

3. To predict the output voltage at 25% load on higher $V_{OUT}$ versions take the measured or specified voltage at 75% load and multiply by (1 + Load Reg 25% to 75%). For example a DCP012415DP typical +$V_{OUT}$ at 25% load will be 12V x (1 + 8%) = 13.0V. To then estimate the voltage at 10% load take the previously calculated +$V_{OUT}$ at 25% load and multiply by (1 + Load Reg 10% to 25%). In this case the typical +$V_{OUT}$ at 10% load will be 13.0V x (1 + 11%) = 14.4V.

To obtain predictions for loads other than those specified assume the $V_{OUT}$ versus load characteristic is linear between the load points and calculate accordingly. The 10% to 100% load specification guarantees the maximum voltage excursion for any load between 10% to 100% with respect to $V_{OUT}$ at 75% load.

The above does not take into consideration line regulation and assumes a nominal input voltage. The 1:1 line regulation of the DCP01 family means that a percentage change in the input will give a corresponding percentage change in the output.
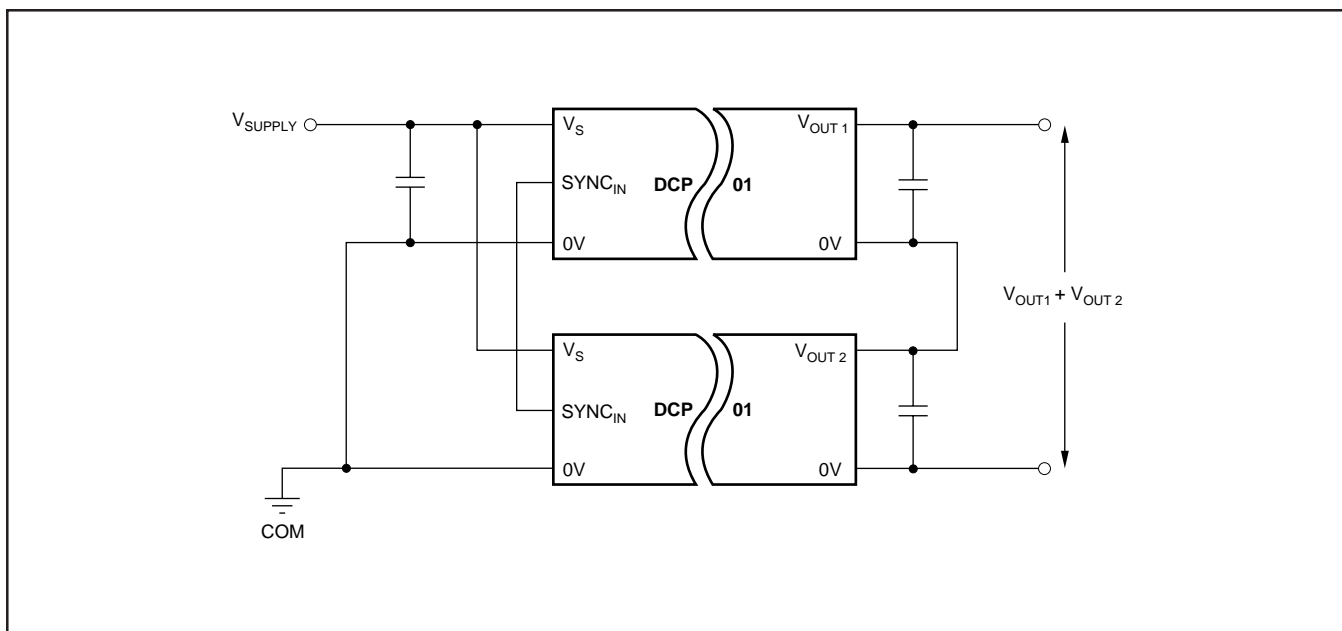

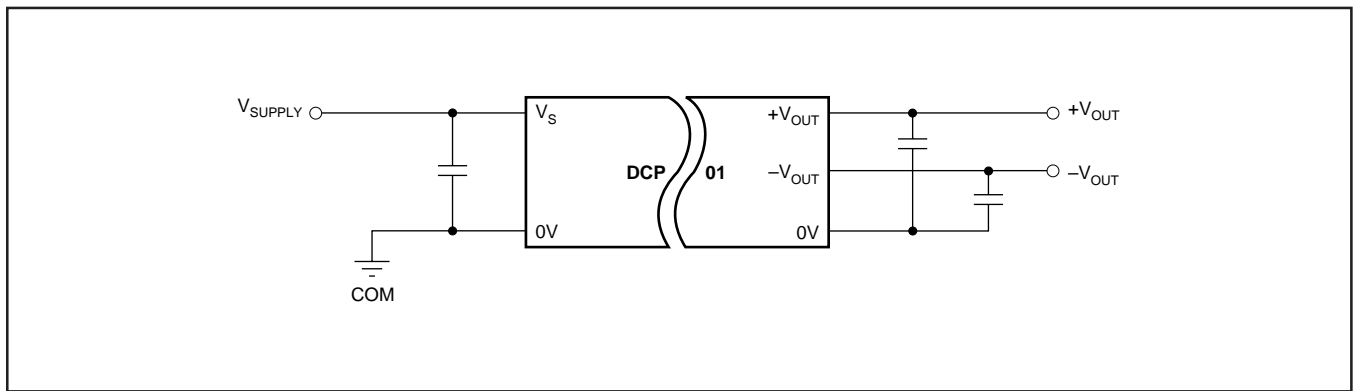
FIGURE 5. Connecting the DCP0124 in Series.
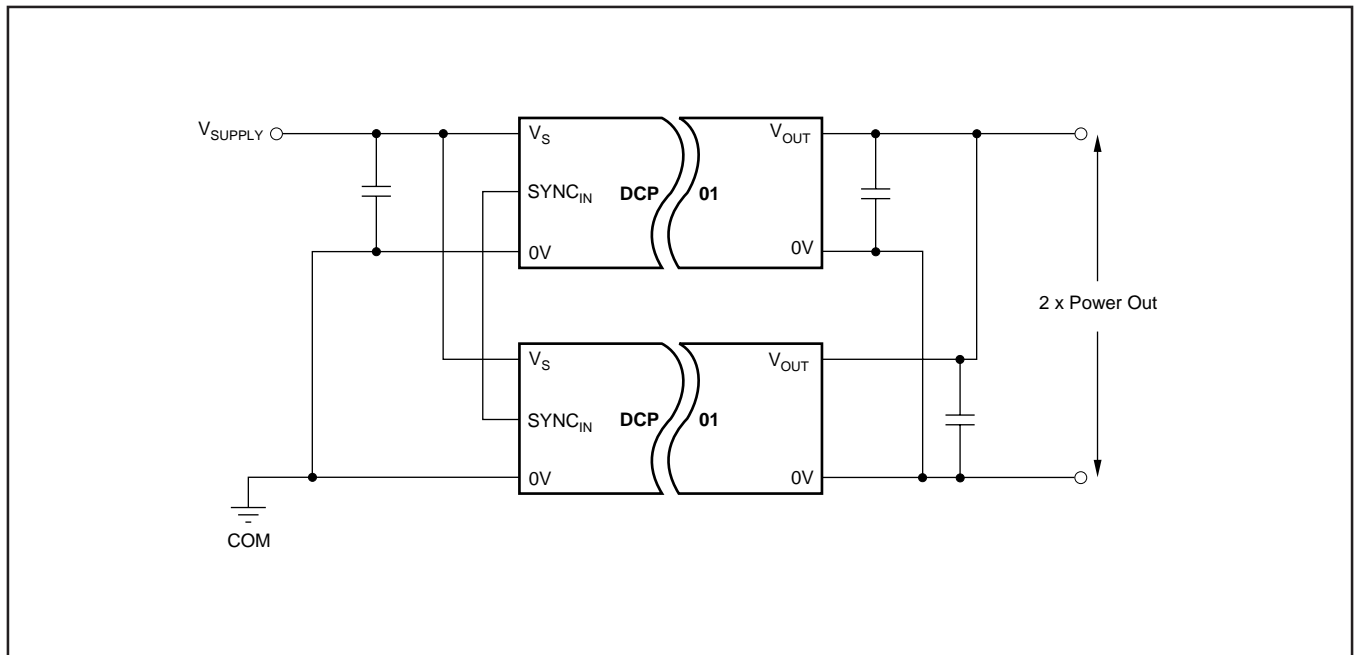
FIGURE 6. Connecting Dual Outputs in Series.
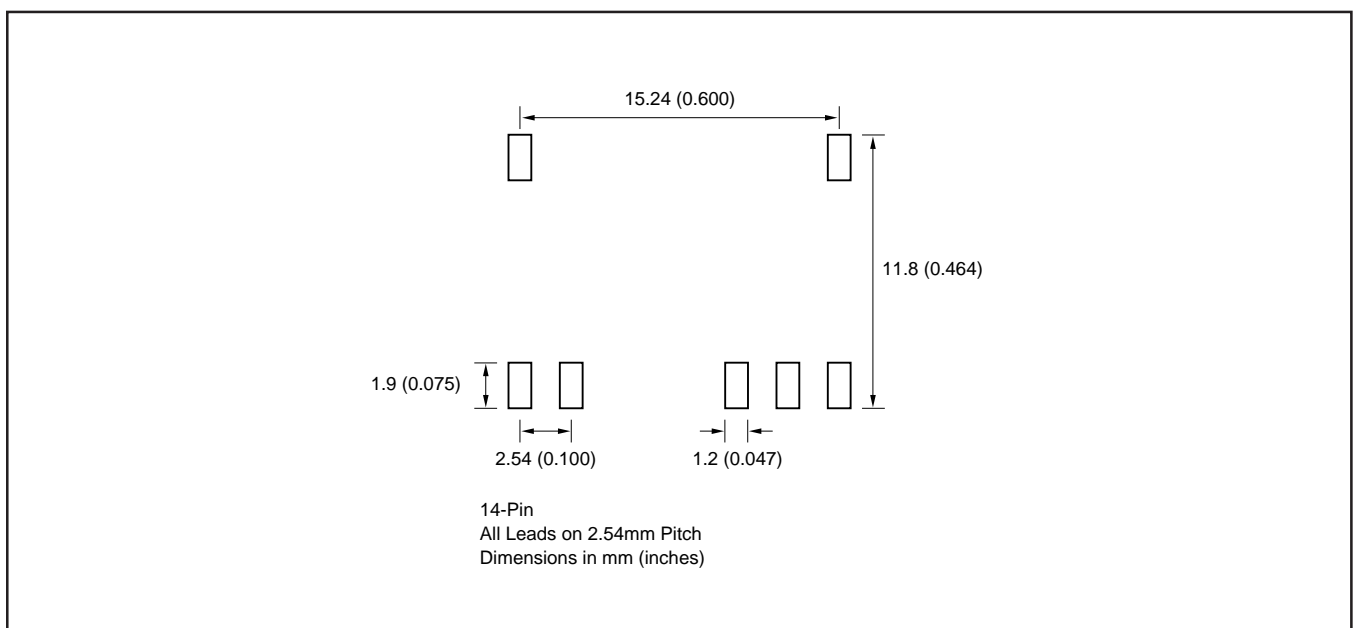


FIGURE 7. Connecting Multiple DCP0124s in Parallel.



15.24 (0.600)

11.8 (0.464)

1.9 (0.075)

2.54 (0.100)

1.2 (0.047)

14-Pin
All Leads on 2.54mm Pitch
Dimensions in mm (inches)

FIGURE 8. PCB Pad Size and Placement for "U" Package.

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DCP0124

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