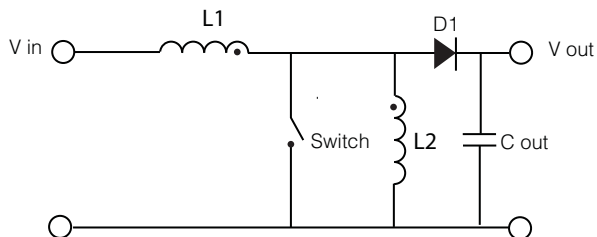


# Inductor Selection for SEPIC Designs

## Introduction/Basic Operation

The single ended primary inductor converter (SEPIC) allows the output voltage to be greater than, less than, or equal to the input voltage in DC-DC conversion. Some typical applications include digital cameras, cellular phones, CD/DVD players, PDA's and GPS systems. During the switch (SW) ON time the voltage across both inductors is equal to  $V_{in}$ . When the switch is ON capacitor  $C_p$  is connected in parallel with  $L_2$ . The voltage across  $L_2$  is the same as the capacitor voltage,  $-V_{in}$ . Diode  $D_1$  is reverse bias and the load current is being supplied by capacitor  $C_{out}$ . During this period, energy is being stored in  $L_1$  from the input and in  $L_2$  from  $C_p$ .



**Figure 1:**  
Simple SEPIC Circuit

During the switch (SW) OFF time the current in  $L_1$  continues to flow through  $C_p$ ,  $D_1$  and into  $C_{out}$  and the load recharging  $C_p$  ready for the next cycle. The current in  $L_2$  also flows into  $C_{out}$  and the load, ensuring that  $C_{out}$  is recharged ready for the next cycle. During this period the voltage across both  $L_1$  and  $L_2$  is equal to  $V_{out}$ . The voltage across  $C_p$  is equal to  $V_{in}$  and that the voltage on  $L_2$  is equal to  $V_{out}$ , in order for this to be true the voltage at the node of  $C_p$  and  $L_1$  must be  $V_{in} + V_{out}$ . The voltage across  $L_1$  is  $(V_{in} + V_{out}) - V_{in} = V_{out}$ .

## Inductor Selection Procedures

### Case 1: Two Separate Inductors

#### Application Conditions:

- Input voltage ( $V_{in}$ ) – 2.8V – 4.5V
- Output ( $V_{out}$  &  $I_{out}$ ) – 3.3V, 1A
- Switching Frequency ( $F_s$ ) – 250kHz
- Efficiency - 90%

#### Step 1. Calculate The Duty Cycle:

$$D = \frac{V_{out}}{V_{out} + V_{in}}$$

The worst case condition for inductor ripple current is at maximum input voltage  $D = 3.3 / (3.3 + 4.5) = 0.423$ .

The output inductor is sized to ensure that the inductor current is continuous at minimum load and that the output voltage ripple does not affect the circuit that the converter is powering. In this case we will assume a 20% minimum load thus allowing a 40% peak-to-peak ripple current in the output inductor  $L_2$ .

## Dual Winding Inductor Solutions

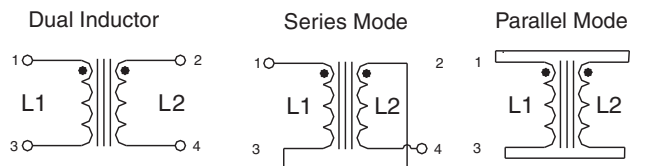


DRQ Series



SDQ Series

## Dual Winding Schematics



### Step 2. Calculate The Value of $L_2$

$$V = L \frac{di}{dt}$$

- $V$  is the voltage applied to the inductor
- $L$  is the inductance
- $di$  is the inductor peak to peak ripple current
- $dt$  is the duration for which the voltage is applied

$$L = \frac{V \cdot dt}{di}$$

- $dt = 1 / F_s \times D$
- $dt = 1 / (250 \times 10^3) \times 0.423 = 1.69 \mu\text{-Sec}$
- $V = V_{in}$  during the switch ON time so;
- $L_2 = 4.5 \times (1.69 \times 10^{-6} / 0.4)$
- $L_2 = 19 \mu\text{H}$

**Result:** Using the nearest preferred value would lead to the selection of a 22 $\mu\text{H}$  inductor. It is common practice to select the same value for both input and output inductors in SEPIC designs although when two separate parts are being used it is not essential.



SDQ Series



DRQ Series

### Step 3. Calculate RMS and Peak Current Ratings for Both Inductors

#### Input Inductor L<sub>1</sub>

- $I_{rms} = (V_{out} \times I_{out}) / (V_{in} (min) \times efficiency)$
- $I_{rms} = (3.3 \times 1) / (2.8 \times 0.9) = 1.31A$
- $I_{peak} = I_{rms} + (0.5 \times I_{ripple})$
- $I_{ripple} = (V \cdot dt) / L$
- $I_{ripple} = (2.8 \times 2.2 \times 10^{-6}) / 22 \times 10^{-6} = 0.28A$
- $I_{peak} = 1.31 + 0.14 = 1.45A$

Although worst case ripple current is at maximum input voltage the peak current is normally highest at the minimum input voltage.

**Result:** 22μH, 1.31A<sub>rms</sub> and 1.45A<sub>pk</sub> rated inductor is required. For example the Coiltronics® **DR73-220** which has 1.62A<sub>rms</sub> and 1.67A<sub>pk</sub> current ratings.

#### Output Inductor L<sub>2</sub>

- $I_{rms} = I_{out} = 1A$
- $I_{ripple} = (4.5 \times 1.69 \times 10^{-6}) / 22 \times 10^{-6} = 0.346A$
- $I_{peak} = 1 + 0.173 = 1.173A$

**Result:** A 22μH, 1A<sub>rms</sub> and 1.173A<sub>pk</sub> rated inductor is required, which for simplicity could be the same **DR73-220** inductor used for L<sub>1</sub>

### Case 2: Coupled Inductor

#### Step 1. Perform Step 1 and The I<sub>rms</sub> Portion of Step 3 from the Two Separate Inductor Selection

The application information listed for the two inductor selection will be used.

#### Step 2. Calculate The Inductance Value

$$L = V \cdot dt / di$$

From our earlier example the output ripple current needs to be 0.4A<sub>pk-pk</sub>, so now we calculate for 0.8A as the ripple current is split between the two windings

$$L = 4.5 \times (1.69 \times 10^{-6} / 0.8) = 9.5\mu H$$

- A coupled inductor has the current flowing in one inductor and if the two windings are closely coupled the ripple current will be split equally between them.
- Using a coupled inductor reduces the required inductance by half.
- Since the two winding are on the same core they must be the same inductance value.

#### Step 3. Calculate the Peak Current

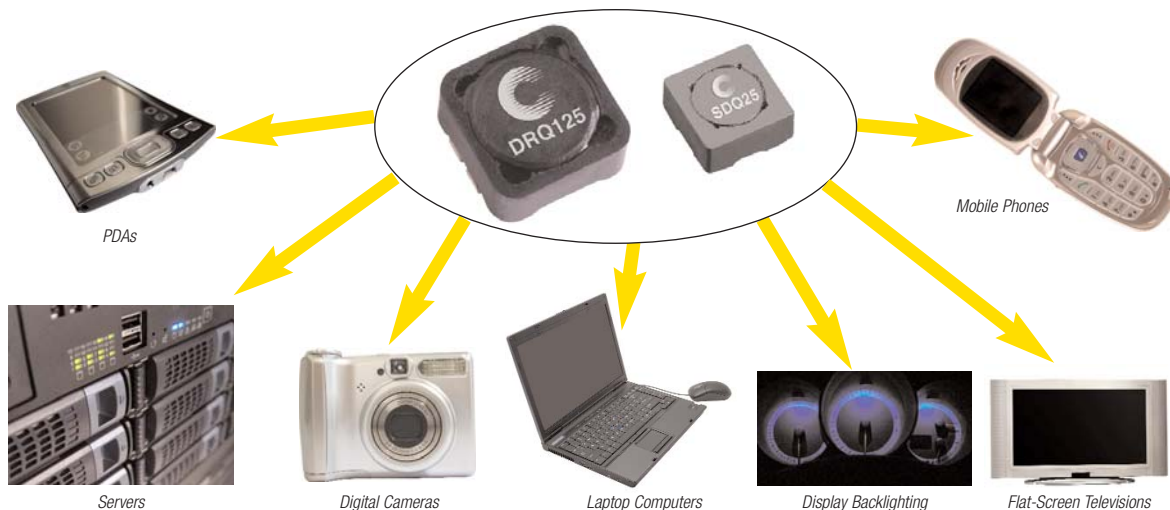
Continuing with the example using an inductance value of 10μH we now need to calculate the worst case peak current requirement. The RMS current in each winding is already known.

- Input inductor RMS current = 1.31A
- Output inductor RMS current = 1A
- $I_{peak} = I_{in} + I_{out} + (0.5 \times I_{ripple})$
- $I_{ripple} = (2.8 \times 2.2 \times 10^{-6}) / 10 \times 10^{-6} = 0.62A$
- $I_{peak} = 1.31 + 1 + 0.31 = 2.62A$  @ minimum input voltage

**Result:** A 10μH coupled inductor with 2.31A<sub>rms</sub> and 2.62A<sub>pk</sub> current ratings is required, for example the Coiltronics® **DRQ74-100**.

Using a coupled inductor takes up less space on the PCB and tends to be lower cost than two separate inductors. It also offers the option to have most of the inductor ripple current flow in either the input or the output. By doing this the need for input filtering can be minimized or the output ripple voltage can be reduced to very low levels when supplying sensitive circuits.

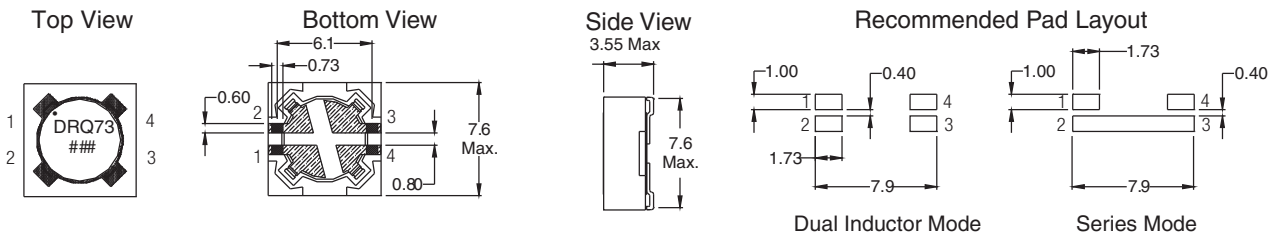
### Typical Applications Using Inductors for SEPIC Designs



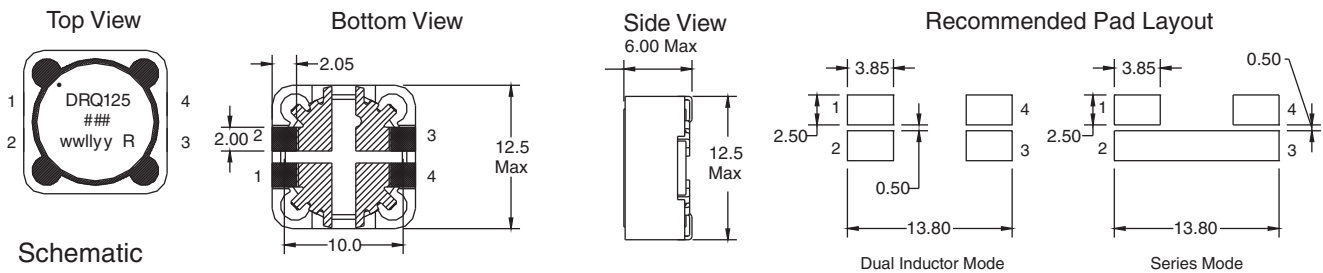
DRQ Series		Parallel Ratings				Series Ratings			
Part Number	Rated Inductance (μH)	OCL +/-2A (μH)	I <sub>rms</sub> Amps	I <sub>sat</sub> Amps Peak	DCR Ω Typ.	OCL +/-20% (μH)	I <sub>rms</sub> Amps	I <sub>sat</sub> Amps Peak	DCR Ω Typ.
DRQ73-1R0-R	1.00	0.992	5.25	7.97	0.0103	3.968	2.63	3.99	0.0411
DRQ73-2R2-R	2.20	2.070	4.11	5.52	0.0167	8.280	2.06	2.76	0.0669
DRQ73-3R3-R	3.30	3.540	3.31	4.22	0.0259	14.16	1.66	2.11	0.1035
DRQ73-4R7-R	4.70	4.422	3.09	3.78	0.0297	17.69	1.55	1.89	0.1188
DRQ73-100-R	10.0	10.30	2.08	2.47	0.0656	41.20	1.04	1.24	0.2623
DRQ73-220-R	22.0	22.65	1.62	1.67	0.107	90.60	0.811	0.83	0.429
DRQ73-330-R	33.0	34.41	1.31	1.35	0.166	137.6	0.653	0.68	0.665
DRQ73-470-R	47.0	48.62	1.08	1.14	0.241	194.5	0.542	0.57	0.965
DRQ73-680-R	68.0	68.91	0.89	0.96	0.358	275.6	0.444	0.48	1.43
DRQ73-101-R	100	101.4	0.73	0.79	0.527	405.6	0.367	0.39	2.11
DRQ73-221-R	220	223.3	0.52	0.53	1.05	893.2	0.260	0.27	4.20
DRQ73-331-R	330	325.5	0.42	0.44	1.59	1302	0.211	0.22	6.36
DRQ73-471-R	470	465.8	0.35	0.37	2.36	1863	0.173	0.18	9.44
DRQ125-1R0-R	1.00	0.894	15.0	23.6	0.0024	3.576	7.51	11.8	0.0096
DRQ125-1R5-R	1.50	1.478	13.8	18.3	0.0029	5.912	6.89	9.15	0.0114
DRQ125-2R2-R	2.20	2.208	10.9	15.0	0.0045	8.832	5.46	7.50	0.0182
DRQ125-3R3-R	3.30	3.084	9.26	12.7	0.0063	12.34	4.63	6.35	0.0253
DRQ125-4R7-R	4.70	5.274	7.18	9.71	0.0105	21.10	3.59	4.86	0.0420
DRQ125-100-R	10.0	9.654	5.35	7.17	0.0189	38.62	2.67	3.59	0.0757
DRQ125-220-R	22.0	22.36	3.70	4.71	0.0396	89.44	1.84	2.36	0.159
DRQ125-330-R	33.0	33.74	3.28	3.84	0.0505	135.0	1.64	1.92	0.203
DRQ125-470-R	47.0	47.47	2.71	3.24	0.0740	189.9	1.35	1.62	0.297
DRQ125-680-R	68.0	67.91	2.22	2.70	0.101	271.6	1.11	1.35	0.440
DRQ125-101-R	100	102.7	1.78	2.20	0.170	410.8	0.892	1.10	0.682
DRQ125-221-R	220	216.8	1.19	1.51	0.384	867.2	0.594	0.755	1.54
DRQ125-331-R	330	332.6	1.06	1.22	0.482	1330	0.530	0.610	1.93
DRQ125-471-R	470	473.1	0.87	1.02	0.718	1892	0.434	0.510	2.87

**Note:** DRQ 74 and DRQ127 not shown. For full product information and a listing of all available inductor values, see <http://www.cooperbussmann.com/3/Coiltronics.html>, Data sheet number 4311.

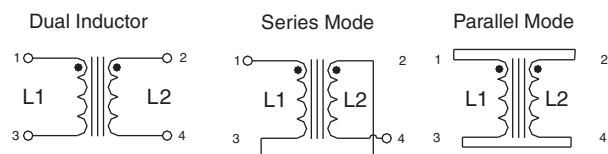
### DRQ73 Dimensions - mm



### DRQ125 Dimensions - mm



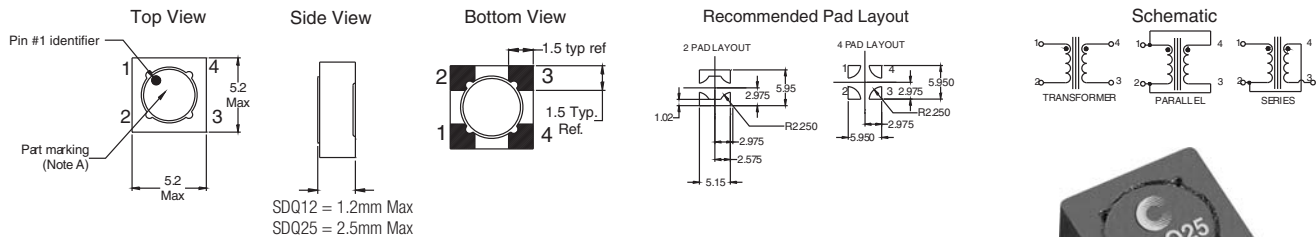
### Schematic



SDQ Series			Parallel Ratings				Series Ratings			
Part Number	Rated Inductance ( $\mu\text{H}$ )	Part Marking	OCL +/--20% ( $\mu\text{H}$ )	$I_{\text{rms}}$ Amps	$I_{\text{sat}}$ Amps	DCR $\Omega$ Typ.	OCL +/--20% ( $\mu\text{H}$ )	$I_{\text{rms}}$ Amps	$I_{\text{sat}}$ Amps	DCR $\Omega$ Typ.
SDQ12-1R0-R	1	B	0.81	2.49	3.38	0.0403	3.24	1.25	1.69	0.1611
SDQ12-2R2-R	2.2	D	2.25	1.60	2.03	0.0977	9.00	0.800	1.01	0.3908
SDQ12-3R3-R	3.3	E	3.61	1.28	1.60	0.1527	14.44	0.640	0.800	0.6106
SDQ12-4R7-R	4.7	F	4.41	1.12	1.45	0.1990	17.64	0.560	0.724	0.7959
SDQ12-100-R	10	J	9.61	0.831	0.981	0.3620	38.44	0.416	0.490	1.45
SDQ12-220-R	22	L	22.09	0.548	0.647	0.8332	88.36	0.274	0.323	3.33
SDQ12-330-R	33	M	32.49	0.439	0.533	1.29	130.0	0.220	0.267	5.18
SDQ12-470-R	47	N	47.61	0.401	0.441	1.55	190.4	0.201	0.220	6.21
SDQ25-1R0-R	1	C	0.97	3.15	4.09	0.0252	3.87	1.58	2.05	0.1007
SDQ25-2R2-R	2.2	E	2.31	2.67	2.65	0.0351	9.25	1.34	1.32	0.1402
SDQ25-3R3-R	3.3	F	2.89	2.50	2.37	0.0399	11.55	1.25	1.18	0.1595
SDQ25-4R7-R	4.7	G	5	1.96	1.80	0.0653	20.00	0.98	0.900	0.2612
SDQ25-100-R	10	K	9.8	1.53	1.29	0.1068	39.20	0.765	0.643	0.4273
SDQ25-220-R	22	M	22.47	1.01	0.849	0.2431	89.89	0.507	0.425	0.9724
SDQ25-330-R	33	N	33.8	0.812	0.692	0.3795	135.2	0.406	0.346	1.52
SDQ25-470-R	47	O	47.43	0.749	0.584	0.4461	189.7	0.374	0.292	1.78
SDQ25-680-R	68	P	69.19	0.603	0.484	0.6865	276.8	0.302	0.242	2.75
SDQ25-101-R	100	R	98.57	0.499	0.405	1.00	394.3	0.249	0.203	4.02
SDQ25-221-R	220	T	223.1	0.326	0.269	2.36	892.4	0.163	0.135	9.42
SDQ25-331-R	330	U	329.7	0.292	0.222	2.93	1318.7	0.146	0.111	11.71
SDQ25-471-R	470	V	472.4	0.243	0.185	4.25	1889.6	0.121	0.093	16.99

**Note:** For full product information and a listing of all available inductor values, see <http://www.cooperbussmann.com/3/Coiltronics.html>, Data Sheet number SDQ Series.

### SDQ12 and SDQ25 Dimensions - mm



SDQ Series

The Cooper Bussmann® Coiltronics® Brand of magnetics specializes in standard and custom solutions, offering the latest in state-of-the-art low-profile high power density magnetic components. We remain at the forefront of innovation and new technology to deliver the optimal mix of packaging, high efficiency and unbeatable reliability. Our designs utilize high frequency, low core loss materials, and new and custom core shapes in combination with innovative construction and packaging to provide designers with the highest performance parts available on the market. The Coiltronics Brand product line of power magnetics continually expands to satisfy shifts in technology and related market needs. Standard Product Categories include:

- Shielded Drum Inductors
- Unshielded Drum Inductors
- High Current Inductors
- Toroidal Inductors
- Specialty Magnetics
- Custom Magnetics

Please visit <http://www.cooperbussmann.com/3/Coiltronics.html> to see the wide variety of inductor solutions we have to offer.

Order samples online - [www.cooperbussmann.com](http://www.cooperbussmann.com)

© 2008 Cooper Bussmann  
St. Louis, MO 63178  
636-394-2877  
[www.cooperbussmann.com](http://www.cooperbussmann.com)

