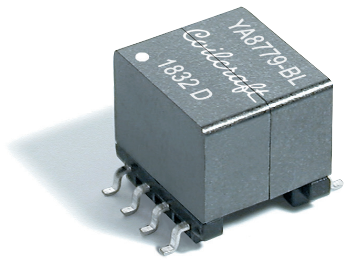
Compact Transformers for No-opto Flyback Topology



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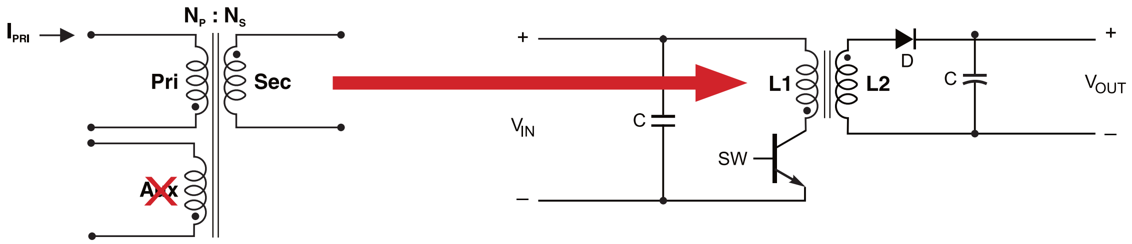
The "no-opto" flyback topology enables primary-side regulation by deriving the isolated output voltage directly from the primary-side flyback waveform. This provides an isolated flyback without the need for an extra transformer winding – or opto coupler – to provide feedback across the isolation barrier from secondary side to primary side. Without the feedback winding, transformers may be designed for optimal coupling, best efficiency, smallest size and lowest cost.

Coilcraft offers a variety of off-the-shelf transformers that have been optimized for these converters and designed for the most common output voltages and output power up to 24 Watts.



No-opto Isolated Flyback Converters

Controllers for no-opto flyback topology isolated converters are offered by several major IC manufacturers and are becoming increasingly popular for wide-range input-voltage, low-power, isolated converters across a variety of applications.

- Telecom/Datacom
- Isolated Power Rails for PLC Systems
- Car Battery Charging
- Motor Drive: IGBT Gate Drive Supplies
- Building Automation HVAC Systems
- Isolated Field Transmitters and Field Actuators
- Isolated Auxiliary/Housekeeping Power Supplies

IC Manufacturer	Switch	IC	V_{IN} Range (V)	Max P_{OUT} (W)
Analog Devices Power by Linear	Internal	LT8301	2.7 – 42	6/18/24
		LT8302	2.8 – 42	6/18/24
		LT8304	3 – 100	6/18/24
Analog Devices Power by Linear	External	LT3748	5 – 100	80 – 100
		LT3798	20 – 400	80 – 100
Texas Instruments	Internal	LM5181	4.5 – 65	3.5
		LM5180	4.5 – 65	7
		LM25180	4.5 – 42	7
		LM25183	4.5 – 42	12
		LM25184	4.5 – 42	18
Maxim Integrated	External	MAX17690	4.5 – 60	8 – 100

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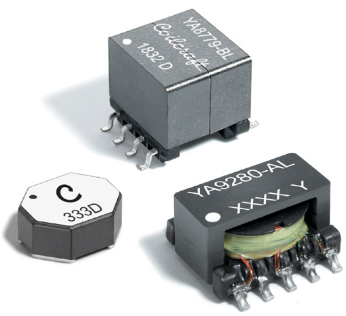
Coilcraft Off-the-shelf Flyback Transformers

The no-opto isolated flyback topology allows the use of highly-compact and low-profile transformers from Coilcraft to provide tight output voltage regulation in a simple design without an auxiliary winding.

Features:

- Small size
- Low leakage inductance
- Low DCR
- High efficiency
- Low cost



These transformers are optimized for converter efficiency and size reduction.

Selecting the proper off-the-shelf transformer can be completed in three easy steps:

1. Determine turns ratio
2. Calculate minimum primary inductance
3. Calculate primary peak current

Simply identify the target Lp, Np/Ns, and Isat, and request a sample at www.coilcraft.com.

Output Power	Input Voltage	Output	Part Number
3.5 W	4.5 – 70 V	20 V, 0.1 A (sec1) 5 V, 0.3 A (sec2)	YA8864-BL
4.6 W	4.5 – 70 V	15 V, 0.2 A (sec1) 8 V, 0.2 A (sec2)	YA8916-BL
6 W	4.5 – 70 V	5 V, 1.2 A	YA8779-BL
7.5 W	17 – 36 V	5 V, 1.5 A	YA9280-AL

Output Power	Input Voltage	V_{out}						
		3.3 V	5 V	8 W	12 V	15 V	24 V	48 V
6 W (EPQ7)	8 – 28 V		YA9123-BE		YA9124-BE		YA9125-BE	
	18 – 60 V		YA9126-BE		YA9127-BE		YA9128-BE	
6 W (EP7)	4 – 65 V			YA9033-AL	YA9034-AL	YA9035-AL	YA9036-AL	YA9037-AL
8 W – 10 W (EPQ7)	4 – 42 V	ZB1050-AE	ZB1051-AE	ZB1052-AE		ZB1053-AE	ZB1054-AE	ZB1055-AE
12 W (EPQ7)	4 – 42 V	ZA9670-BE	ZA9670-BE		ZA9670-BE		ZA9670-BE	ZA9670-BE
12 W (EPQ10)	8 – 28 V		YA9165-BE		YA9166-BE		YA9167-BE	
	18 – 60 V		YA9168-BE		YA9169-BE		YA9170-BE	
24 W (EP13)	8 – 28 V		YA9171-CE		YA9172-CE		YA9173-CE	
	18 – 60 V		YA9174-CE		YA9175-CE		YA9176-CE	

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Design Example #1: Texas Instruments LM5180

The LM5180 70-Vin PSR flyback converter from Texas Instruments operates in three modes depending on the load current:

1. Boundary conduction mode (BCM) at heavy loads
2. Discontinuous conduction mode (DCM) at medium loads
3. Frequency foldback mode (FFM) at light loads

Design Parameters	Value
$V_{IN\ (nom)}$	24 V
$V_{IN\ (MIN)}$ to $V_{IN\ (MAX)}$	10 V to 70 V
V_{OUT}	5 V
I_{OUT}	1 A
Minimum switch off-time ($t_{OFF\text{-}MIN}$)	500 ns
$I_{PEAK\ (TYP)}$	1.5 A

Step 1: Determine turns ratio

Choose a turns ratio based on an approximate 60% max duty cycle at $V_{IN\ (MIN)}$.

$$N = \frac{D_{MAX} \times V_{IN(MIN)}}{(1 - D_{MAX}) \times (V_{OUT} + V_f)} = \frac{0.6 \times 10}{(1 - 0.6) \times (5 + 0.3)} \approx 3$$

Step 2: Calculate minimum primary inductance

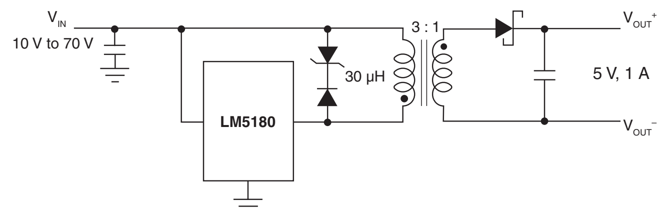
At light loads, the primary peak current decreases to a minimum level of 0.3 A and operates in FFM mode. The minimum primary inductance is calculated based on the minimum load current requirement:

$$L_{pri} \geq \frac{(V_{OUT} + V_f) \times N \times t_{OFF(MIN)}}{I_{PRI-PK(FFM)}} = \frac{(5 + 0.3) \times 3 \times 500}{0.3} = 26.5\ \mu H$$

Step 3: Calculate primary peak current

Efficiency η is assumed to be approximately 90%:

$$I_{pri} \geq \frac{2 \times (V_{OUT} + V_f) \times I_{OUT}}{\eta \times V_{IN} \times D_{MAX}} = \frac{2 \times (5 + 0.3) \times 1}{0.9 \times 10 \times 0.6} \approx 2\ A$$



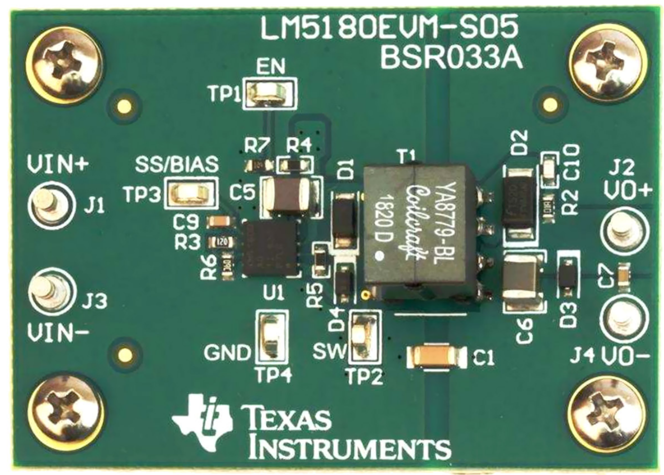


Photo courtesy of Texas Instruments, Inc.

Design Example #2: Analog Devices LT8301

The LT8301 from Analog Devices is also a micropower no-opto isolated flyback converter.

Design Parameters	Value
$V_{IN\ (nom)}$	12 V
$V_{IN\ (MIN)}$ to $V_{IN\ (MAX)}$	8 V to 32 V
V_{OUT}	5 V
I_{OUT}	0.5 A
Minimum switch on-time	170 ns
Minimum switch off-time ($t_{OFF\text{-}MIN}$)	450 ns
$I_{PEAK\ (TYP)}$	1.5 A

Step 1: Determine turns ratio

For this particular IC, a maximum value for N is given as:

$$N < \frac{65\ V - V_{IN(MAX)} - V_{LEAKAGE}}{V_{OUT} - V_F} = \frac{62 - 32 - 15}{5 - 0.3} = 3.4$$

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Design Example #2 (continued): Analog Devices LT8301

Step 2: Calculate minimum primary inductance

Primary inductance should meet the minimum switch-off and switch-on time requirements:

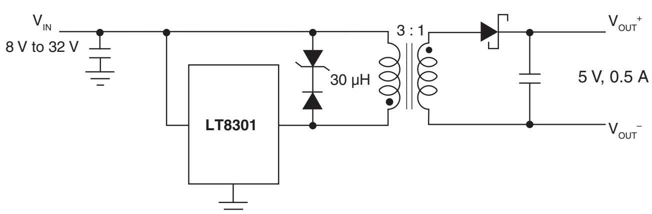
$$L_{pri} \geq \frac{(V_{OUT} + V_f) \times N \times t_{OFF(MIN)}}{I_{SW(MIN)}} = \frac{(5 + 0.3) \times 3 \times 450}{0.29} = 25\ \mu H$$

$$L_{pri} \geq \frac{V_{IN(MAX)} \times t_{ON(MIN)}}{I_{SW(MIN)}} = \frac{32 \times 170}{0.29} = 19\ \mu H$$

Step 3: Calculate primary peak current

Efficiency η is assumed to be approximately 90%:

$$I_{pri} \geq \frac{2 \times (V_{OUT} + V_F) \times I_{OUT}}{\eta \times V_{IN} \times D_{MAX}} = \frac{2 \times (5 + 0.3) \times 0.5}{0.9 \times 8 \times 0.6} \approx 1.2\ A$$



Design Example #3: Maxim MAX17690

The MAX17690 from Maxim Integrated is a 60 V no-opto isolated flyback controller operated in Discontinuous Conduction Mode. Coilcraft's YA9280-AL is optimized to eliminate extra components and reduce board area by 30%, with a low profile of only 6.2 mm!

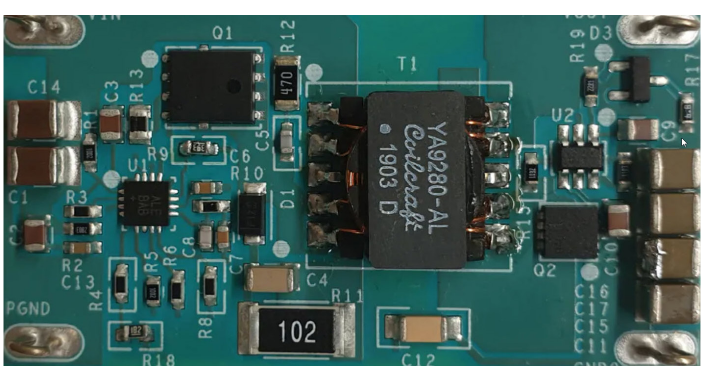


Photo courtesy of Maxim Integrated

Design Parameters	Value
$V_{IN\ (MIN)}$ to $V_{IN\ (MAX)}$	17 V to 36 V
f_{SW}	128 kHz
η_{MAX}	87%
η_{MIN}	60%
V_{OUT}	5 V
ΔV_{OUT}	50 mV
I_{OUT}	1.5 A
P_{OUT}	7.5 W

Step 1: Determine turns ratio

Choose a turns ratio based on 46% duty cycle.

$$\frac{N_S}{N_P} = \frac{V_{OUT} \times (1 - D)}{V_{IN} \times D} \sim 0.4$$

Step 2: Calculate minimum primary inductance

$$L_P = \frac{\eta_{MAX} \times {V_{IN\ (MIN)}}^2 \times {D_{MAX}}^2}{2 \times V_{OUT} \times I_{OUT} \times f_{SW}}$$

$$L_P = \frac{\eta_{MAX} \times 17^2 \times 0.42^2}{2 \times 5 \times 1.5 \times 128.4} \sim 18\ \mu H$$

Step 3: Calculate primary peak current

$$I_{SW} = \frac{V_{IN\ (MIN)} \times D_{MAX}}{L_P \times f_{SW}} \sim 2.69\ A$$

In addition to small bobbin-wound transformers, Coilcraft offers many off-the-shelf coupled inductors that meet no-opto flyback design requirements. For example, our LPD8035V Series coupled inductors achieve 1500 Vrms one-minute isolation in a package that measures just 8.0 × 6.4 × 3.5 mm. They are well suited for operating conditions requiring a 1:1 turns ratio.

Contact us at tech_support@coilcraft.com to discuss how each type of component can meet your particular design requirements.

www.coilcraft.com/no-opto

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