ANALOG DEVICES

Isolated DCDC Converter Topology
- Flyback
- Forward

David.Ka
Senior Engineer, Field Applications

analog.com

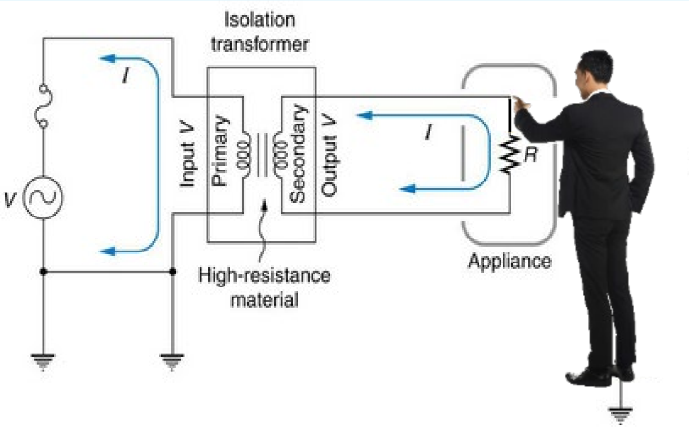
Contents

- 전기적 절연의 필요성
  - 전기적 절연이 필요한 경우
  - 절연 관련 국제 규격 및 관련 사양 설명
  - 산업 별 절연형 DCDC Converter의 적용 사례

- 절연형 DCDC Converter Topology의 비교
  - Transformer
  - Flyback Topology
  - Forward Topology

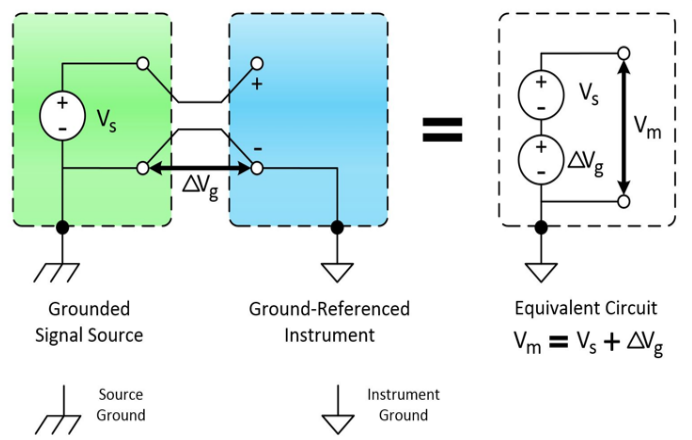
- Topology 비교 및 제품 선택 가이드

Why Do We Need Isolation?



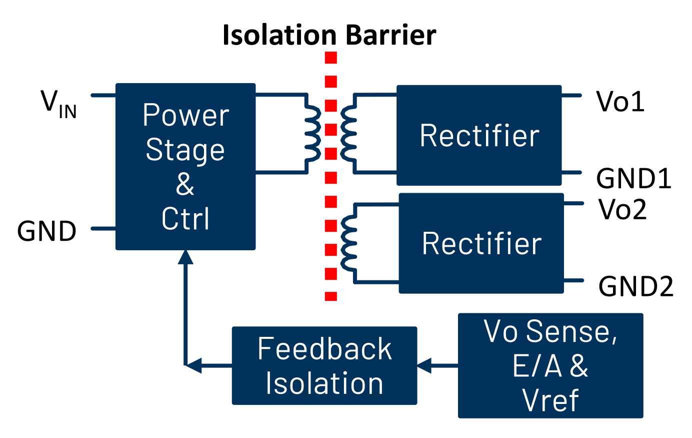
Safety

- Prevents current surges from damaging equipment
- Protects humans from mains voltage



Avoid Ground Loops

- Avoids disruptive ground loops where different ground potentials are involved
- Isolates digital noise from precision analog system



Level Shifting

- Generates multiple isolated positive and/or negative outputs

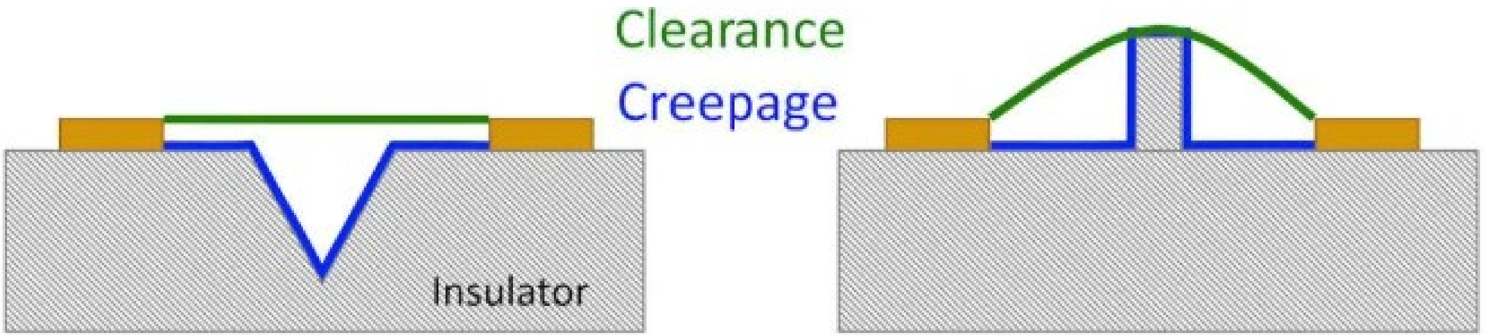
International Standard

- UL 1577
  - Underwriters Laboratories : 1894년에 시작된 미국 시험 인증 기관(회사)
  - Insulation의 breakdown을 평가하는 목적
  - V_{ISO} : Isolation voltage
    - V_{ISO} = 5700 V_{RMS}, 1분 동안 5700VRMS 전압을 인가했을때 절연층이 파괴되지 않음을 의미.

- VDE 0884-17 (IEC60747-17)
  - VDE : 독일 표준 → Global Standard.
  - 절연 제품의 수명을 평가하는 목적
  - V_{IORM} : Working Voltage (Maximum Repetitive Peak Voltage)
    - 예 : V_{IORM} = 1173 V_{PK}, 지속적으로 1173V의 peak 전압을 가진 sinewave를 견딜 수 있음을 의미.
  - V_{IOSM} : Surge Insulation Voltage, 번개를 맞는 상황에 대한 실험
    - 인증 시험시에는 업체에서 주장하는 V_{IOSM}에 배수를 곱하여 파형 인가
  - V_{IOTM} : Transient Insulation Voltage, Transient 상황에 대한 시험
    - High dV/dt에 대한 영향성으로 점점 중요해짐

IEC60664-1(KC60664-1)

- 국제 표준으로 1000V AC, 1500V DC 이하의 전압을 사용하는 제품을 사용할 때 electrical breakdown, short circuit 등을 방지하기 위한 가이드 라인을 제공하는 것을 목적으로함.
  - Clearance(공간 거리)
    - 정의 : The shortest distance through air between two conductive parts. (공간거리)
    - 급격한 순간적인 overvoltage나 arcing 을 방지하기 위한 거리
  - Creepage(연면 거리)
    - 정의 : The shortest distance along the surface of an insulating material between two conductive parts.
    - 전도성 물질 표면에 있는 dust나 moisture 에 의한 점진적인 short 성 불량을 방지하기 위한 거리



IEC60664-1(KC60664-1)

➢ Creepage, Clearance를 확인하기 위해 아래 4가지에 대한 고려 필요

1. Overvoltage Category
    1. OVC I: Protected electronic circuits with low-energy transient risks (e.g., small household electronics).
    2. OVC II: Energy-consuming appliances plugged into a fixed wall socket (e.g., laptops, TVs).
    3. OVC III: Equipment permanently wired into the building's distribution panel (e.g., industrial motor drives, solar inverters).
    4. OVC IV: Point of entry to the grid infrastructure where lightning exposure is massive (e.g., electric meters, outdoor power cables).

2. Pollution Degree
    1. PD1 : No Pollution
    2. PD2 : Only non-conductive pollution occurs, but temporary condensation can cause brief conductivity
    3. PD 3: Conductive pollution or dry, non-conductive pollution occurs which becomes conductive due to expected condensation (e.g., unheated industrial plants or outdoor enclosures)
    4. PD 4: Continuous conductivity caused by conductive dust, rain, or snow (e.g., exposed heavy mining equipment)

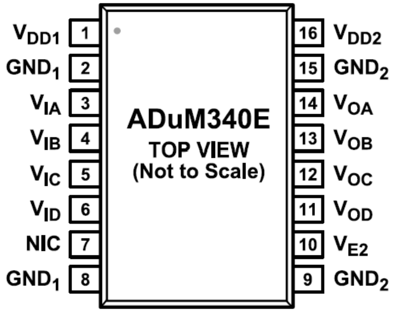
3. Material Group
    1. Material Group I : CTI > 600 V
    2. Material Group II : 400 V < CTI < 600 V
    3. Material Group IIIa : 175 V < CTI < 400 V
    4. Material Group IIIb : 100 V < CTI < 175 V

4. Altitude Correction Factors
    - 위 3개로 결정된 creepage 와 clearance 에 마지막 곱하기 factor
      $Required\ Clearance = baseline\ clearance\ (2000m)\ \times Kd$

Datasheet Analysis_ADuM34xe (Digital Isolator)

- 800V system에 맞는 규격
  - V_{ISO}
    - Basic Isolation > 2500 V_{RMS}
    - Reinforced Isolation > 5000 V_{RMS}
  - V_{IORM} > 1000 V_{PK}
  - V_{IOTM} > 6000V_{PK} ~ 8000V_{PK}
  - Creepage > 8mm
- 400V system에 맞는 규격
  - V_{ISO}
    - Basic Isolation > 1500 V_{RMS}
    - Reinforced Isolation > 2500 V_{RMS} ~ 3750 V_{RMS}
  - V_{IORM} > 500 V_{PK} ~ 600 V_{PK}
  - V_{IOTM} > 4000V_{PK} ~ 6000V_{PK}
  - Creepage > 4mm ~ 5.5mm

- Safety and regulatory approvals
  - DIN EN IEC 60747-17 (VDE 0884-17)
    - V_{IORM} = 1173 V peak, SOIC (RW-16)
    - V_{IORM} = 566 V peak, QSOP (RQ-16)
  - UL 1577
    - V_{ISO} = 5700 V rms for 1 minute, SOIC (RW-16)
    - V_{ISO} = 3000 V rms for 1 minute, QSOP (RQ-16)
  - IEC/EN/CSA 62368-1
  - IEC/CSA 60601-1
  - IEC/CSA 61010-1
  - CQC GB4943.1



Examples of Isolated Converter Applications by Industry

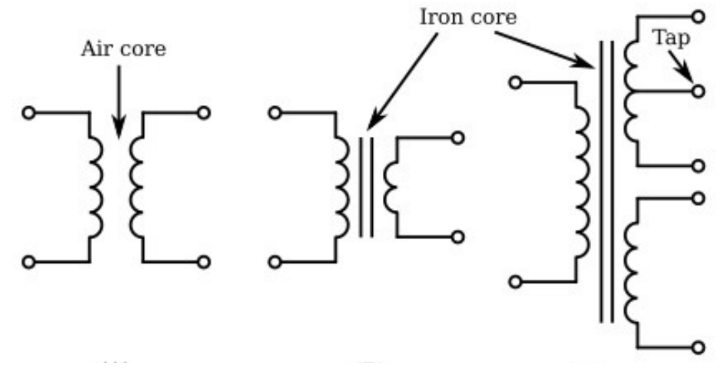
Industry	Typical Power	Key Purpose	Typical Topology	ADI Solution
Data Center	1kW~100kW	Safety, High efficiency, 400V/48V conversion	DAB, LLC	• Isolated Gate Driver : **ADuM4250** • Isolated OpAmp : **ADuM4195-1** • Digital Isolator : **ADuM340x**
Medical	1W~500W	Patient protection	Flyback, Push-Pull	• Isolated Gate Driver : **ADuM4250** • Active Clamp Forward Converter : **ADP1074, ADP1055** • Flyback Converter : **LT830x, MAX25351** • IsoPower : **ADuM6020**
Military	10W~kW	Reliability, Fault isolation	Flyback, Half-Bridge, Full-Bridge	• Isolated Gate Driver : **ADuM4250** • Isolated OpAmp : **ADuM4195-1** • Digital Isolator : **ADuM340** • Flyback Converter : **LT830x, MAX25351**
Automotive	1kW~22kW	Safety isolation	LLC, PSFB, ACFF, Flyback	• Isolated Gate Driver : **ADuM4250** • Isolated OpAmp : **ADuM4195-1** • Digital Isolator : **ADuM340** • Flyback Converter : **LT830x, MAX25351** • Active Clamp Forward Converter : **ADP1074, ADP1055**

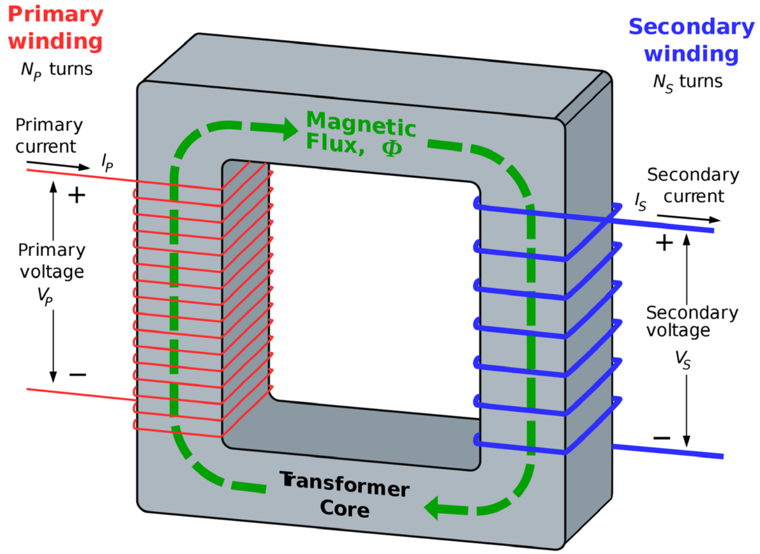
Transformer

- Definition : A device that transfers electrical energy from one circuit to another by electromagnetic induction
  - Switching frequency of primary winding does not change.
  - The current and voltage can change between primary and secondary winding.

- The components of a transformer
  - Primary winding : Receives energies from the source.
  - Secondary winding : Deliver energies to the load.
  - Core : Provides a path for the magnetic lines of flux. (Iron core, Air core, etc.)

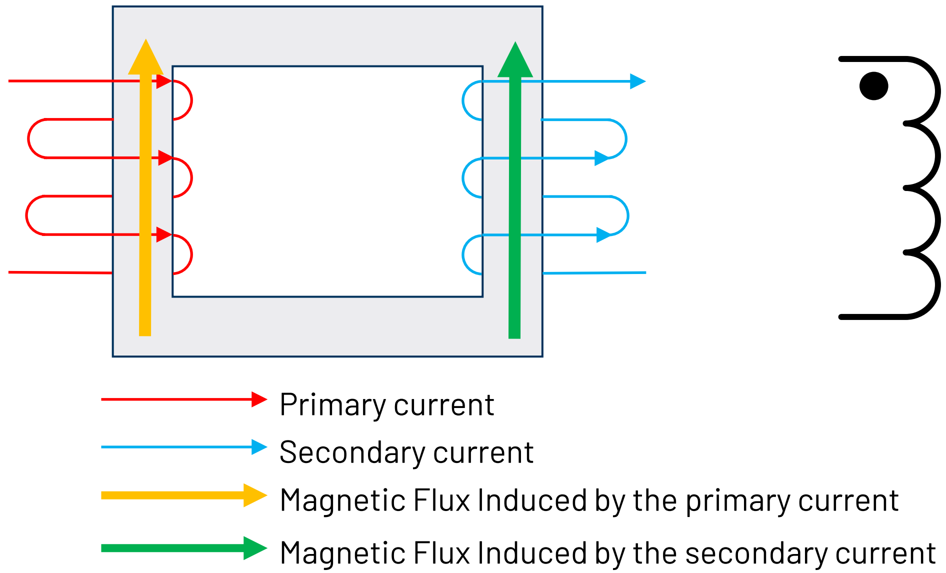
- Schematic symbols for transformers

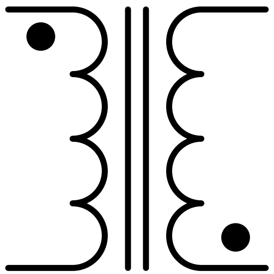




Transformer – Dot Notation

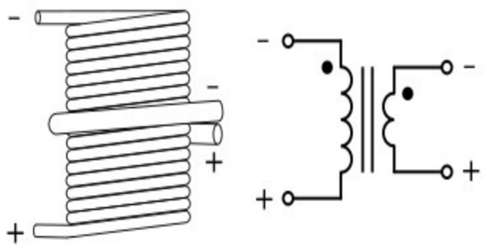
- How to define the dot in transformer
  - Set the current direction arbitrary on the primary side. And then put the dot there.
  - Find the induced flux direction according to the 'right-hand rule'.
  - Set the current direction arbitrary on the secondary side.
  - And find the induced flux direction by the secondary current according to the 'right-and rule'.
  - If the direction of the two fluxes is same, then put the dot on the same side.
  - Otherwise put the dot on the opposite side.



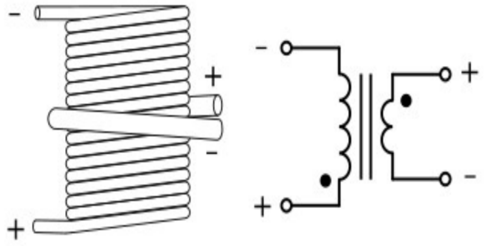


Transformer – Dot Notation

- Practical way to build transformer
  - Like-wound : Transformers in which the secondary winding is in phase with the primary winding.
  - Unlike-wound : Transformers in which the primary and secondary winding have opposite directions. (phase : 180°)
  - In general, transformer companies design transformers with the same winding direction and different winding start positions.



<Like-wound>



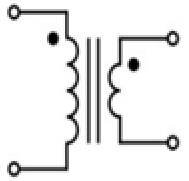
<Unlike-wound>

- The current direction of transformers with regarding dots.
  - The currents flow into the dot at the primary winding → Flow out from the dot at the secondary winding
  - The currents flow out from the dot at the primary winding → Flow into the dot at the secondary winding

Transformer

- Ideal Transformer
  - In the Ideal transformer, the magnetic energy transferred from the primary to the secondary, and not remained in the magnetic core. (Coupling Coefficient = 100%)

- Basic equations related with the ideal transformer



	Primary	Secondary
Turns	N_P	N_S
Voltage	V_P	V_S
Current	I_P	I_S
Inductance	L_P	L_S

$$\frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{I_P}{I_S}$$

$$\left(\frac{N_S}{N_P}\right)^2 = \frac{L_S}{L_P}$$

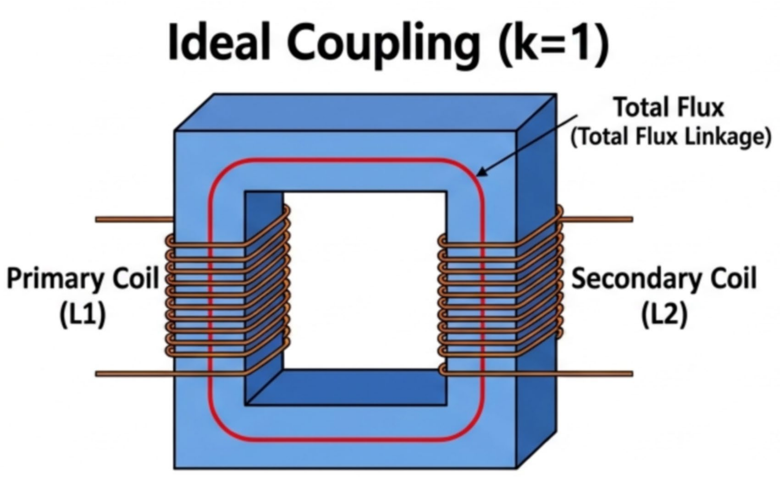
Important Parameters of Transformer

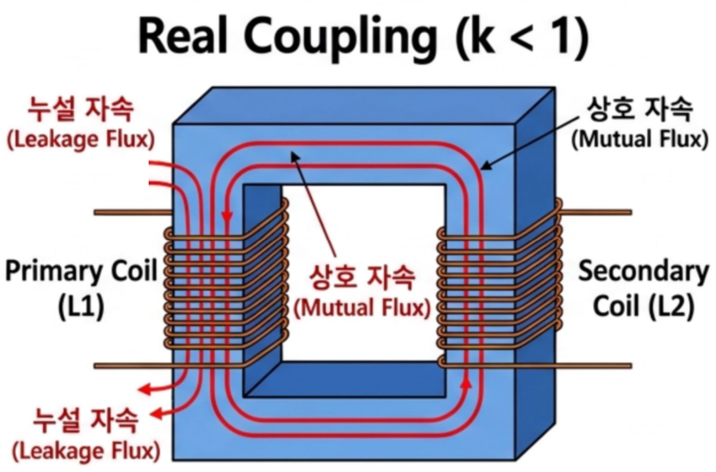
- Coupling Coefficient & Leakage Inductance
  - A ratio indicating the degree of magnetic coupling between two coils.
  - $K = \frac{M}{\sqrt{L1 \times L2}}$
  - Ideal Transformer (K = 1) : No leakage inductance
  - Real Transformer (K < 1)

- Insulation & Interwinding Capacitance
  - Insulation Degree : Determined by the distance between the two coils
  - Interwinding Capacitance : The unwanted, parasitic capacitance that forms physically between the two coils.

Inversely Proportional

Negotiate!!



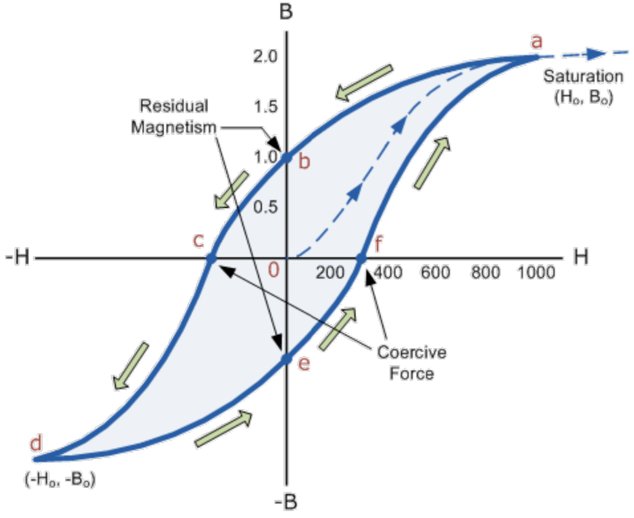


✓ Relation of Leakage Inductance and Interwinding capacitance
  - To increase the Coupling Coefficient(K)
    → Decrease the distance of the two coils
    → Increase the Interwinding Capacitance
  - To decrease the Interwinding Capacitance
    → Increase the distance of the two coils
    → Decrease the Coupling Coefficient

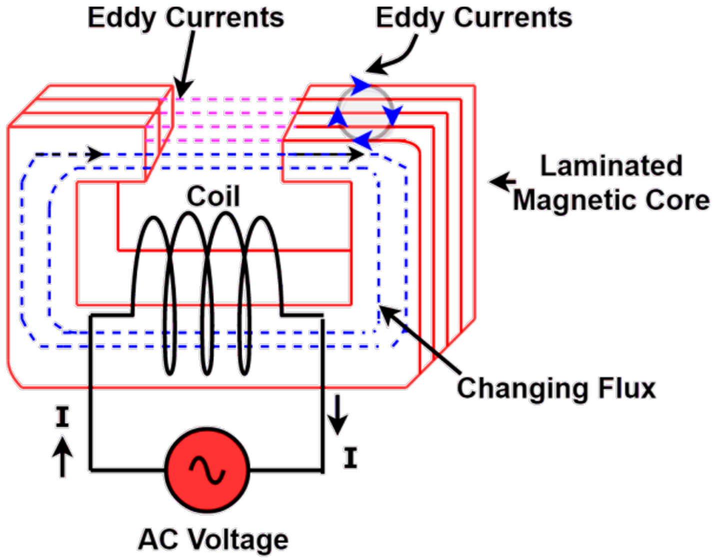
Transformer Loss

- Iron Loss (core loss)
  - Definition : the energy dissipated in a transformer's magnetic core due to the alternating magnetic flux.
  - Main Components
    - Hysteresis Loss
    - Eddy current Loss

- Hysteresis Loss
  - Caused by the energy required to reverse the magn etic domains in the core material with each alternati ng current (AC) cycle.



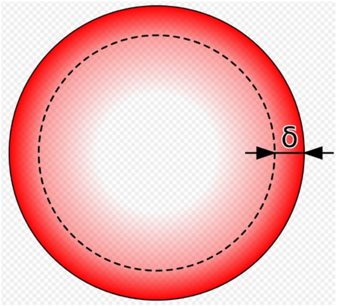
- Eddy Current Loss
  - Caused by circulating currents induced within the c ore itself by the changing magnetic field.



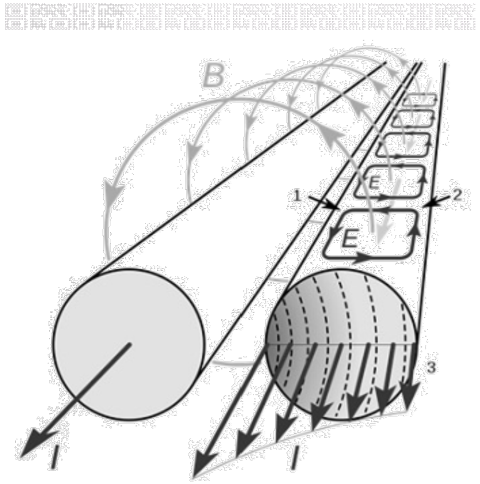
Transformer Loss

- Copper Loss (Winding loss)
  - Definition : the energy dissipated as heat due to the electrical resistance of the transformer's primary and secondary windings.
  - Main Components of I^2R loss
    - Skin Effect
    - Proximity Effect

- Skin Effect
  - As AC flows, it generates a changing magnetic field that induces opposing eddy currents within the conductor.

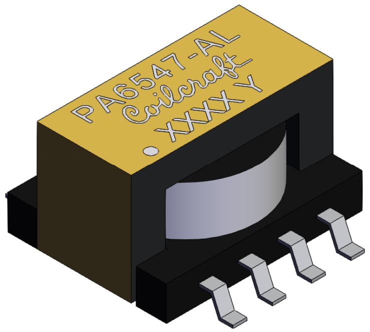


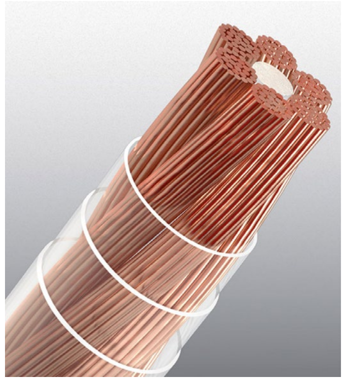
- Proximity Effect
  - an electromagnetic phenomenon where the distribu tion of alternating current (AC) in a conductor is dist orted by the magnetic fields generated by nearby cu rrent-carrying conductors



Transformer Selection Guide

- Single-Wire Transformer
- Litz-Wire Transformer
- Planar Transformer

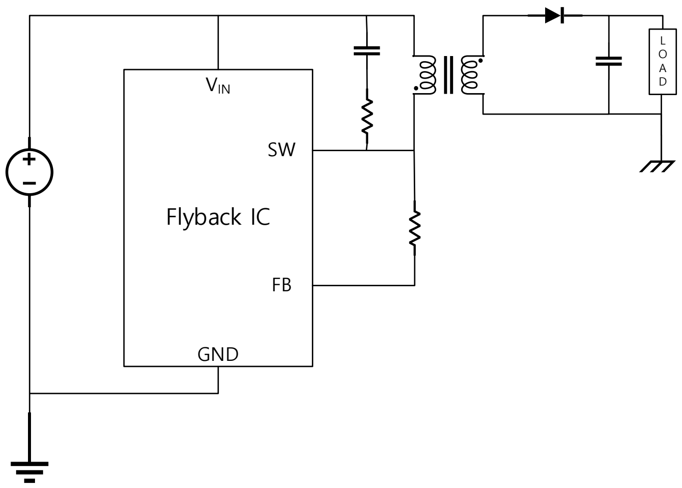




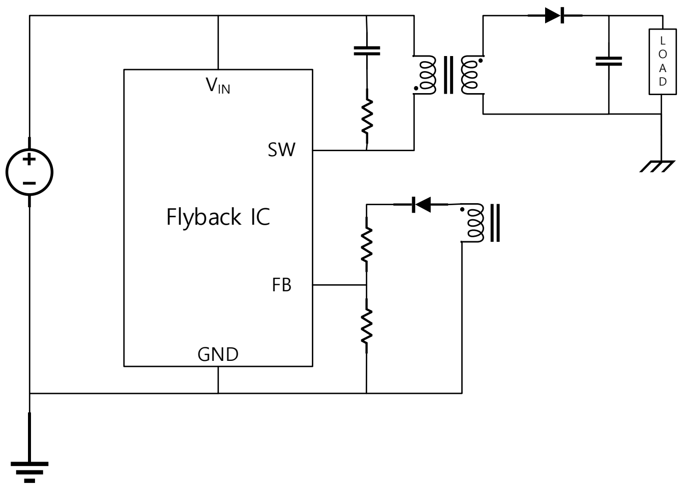
Item	Single Wire Transformer	Litz Wire Transformer	Planar Transformer
Winding Structure	Single enamel-coated copper wire	Many insulated strands twisted together	Copper traces on PCB or copper foils
Operating Frequency	Low to medium frequency (<100 kHz typical)	Medium to high frequency (50 kHz to 1 MHz+)	High frequency (100 kHz to several MHz)
Power Loss (Skin / Proximity Effect)	High at high frequency	**Very low**	Low
Transformer Height	Highest	Highest	**Lowest**
Power Density	Lowest	Medium	**Highest**
Manufacturing Repeatability	Moderate	Moderate	**Excellent**
Typical Efficiency	Good	Excellent	Excellent
Cost	**Lowest**	Highest	Moderate to High
Typical Applications	Flyback, offline SMPS	LLC, CLLC, high-efficiency OBC	Datacenter PSU, EV OBC

About the Flyback Converter

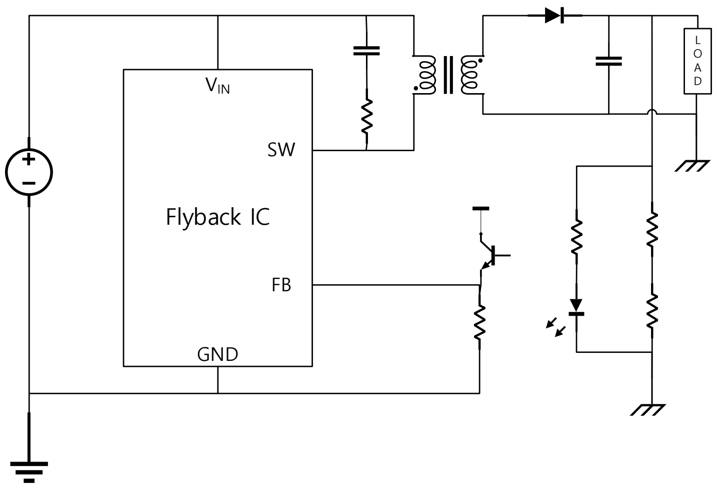
- Definitions
  - The flyback converter is used in both AC/DC, and DC/DC conversion with **galvanic isolation** between the input and any outputs.
  - The flyback converter is a **buck-boost converter** with the inductor split to form a transformer, so that the voltage ratios are multiplied with an additional advantage of isolation.
- How does Flyback Converter regulate the output voltage.
  - Tertiary feedback winding
  - Opto-coupler feedback
  - Monitoring the Flyback pulses (No-Opto)



No-Opto



Tertiary Winding

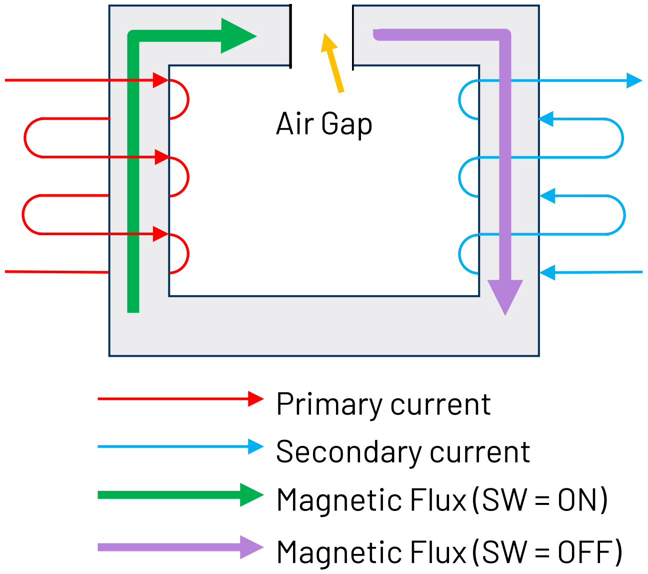


Opto-Coupler

About a Flyback Transformer

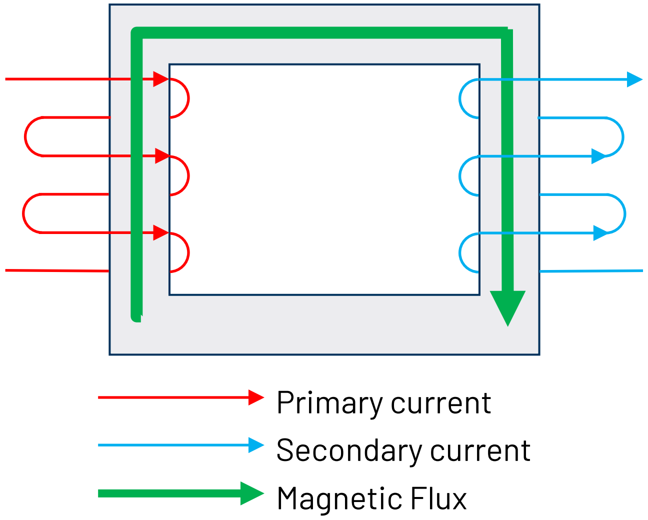
- Structure of a flyback transformer
  - A flyback transformer is a coupled inductor with a gapped core.
  - During each cycle, when the input voltage is applied to the primary winding, energy is stored in the gap of the core. It is then transferred to the secondary winding to provide energy to the load.

<Flyback Transformer>



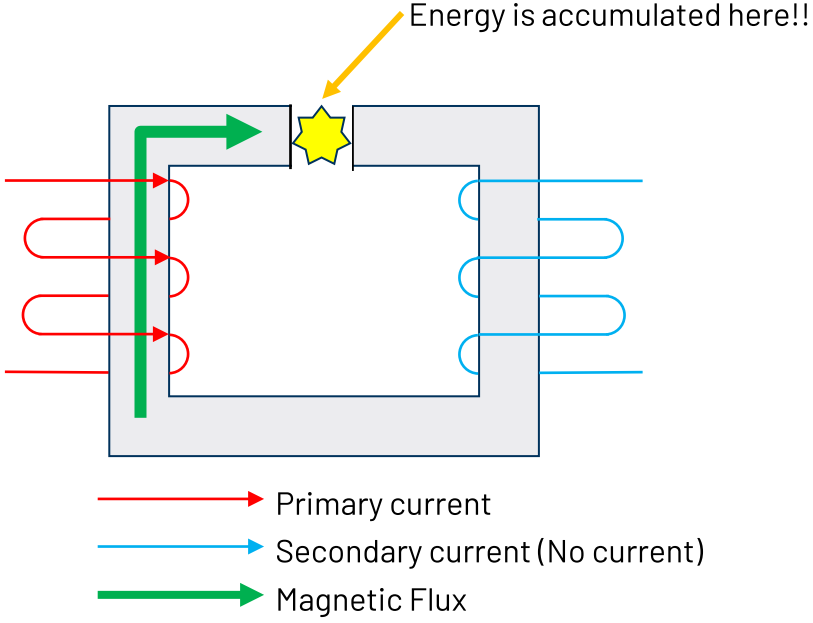
Flyback Transformer		Normal Transformer
O	Air Gap	X
According to the SW On/Off	Energy Transfer	Simultaneously
Stored at the airgap	Energy Storage	Not stored

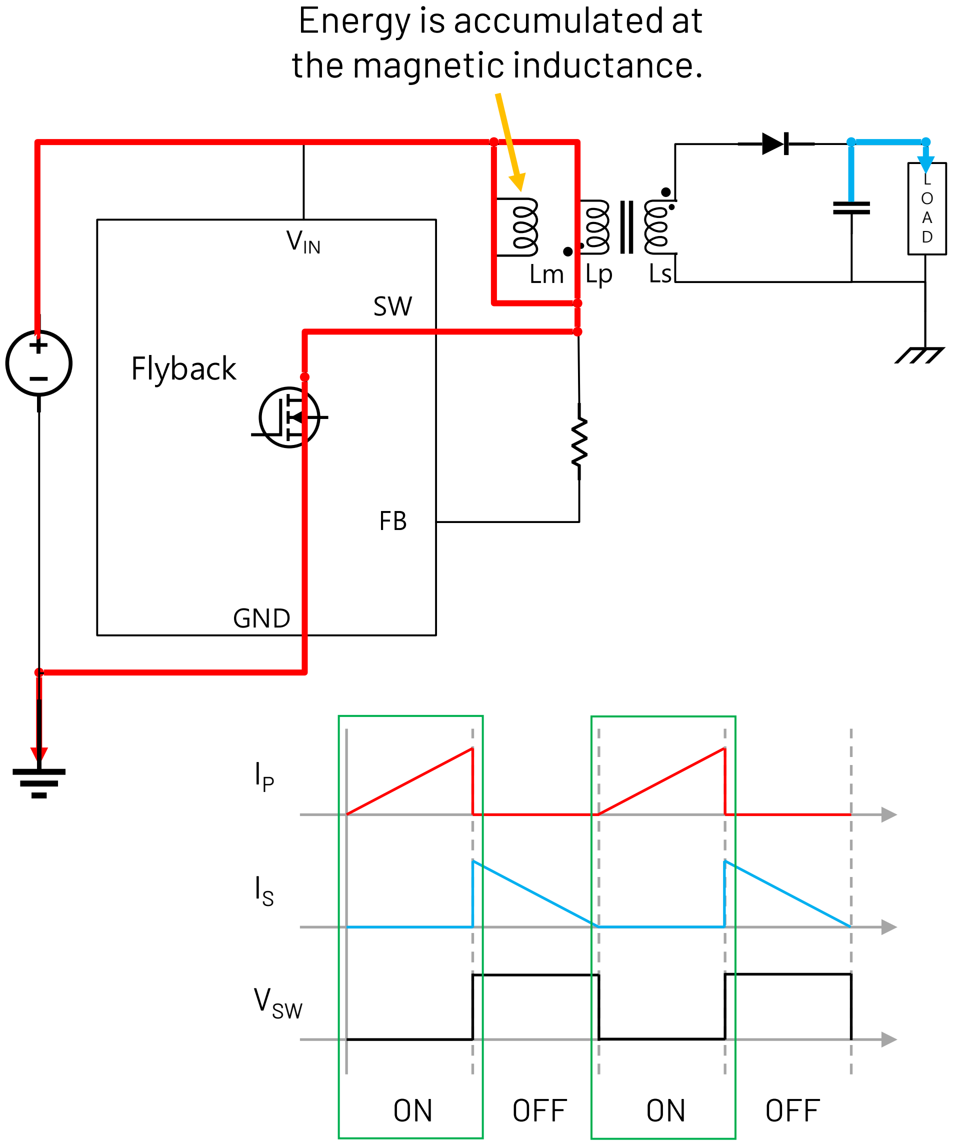
<Normal Transformer>



Basic Operation of Flyback Converter

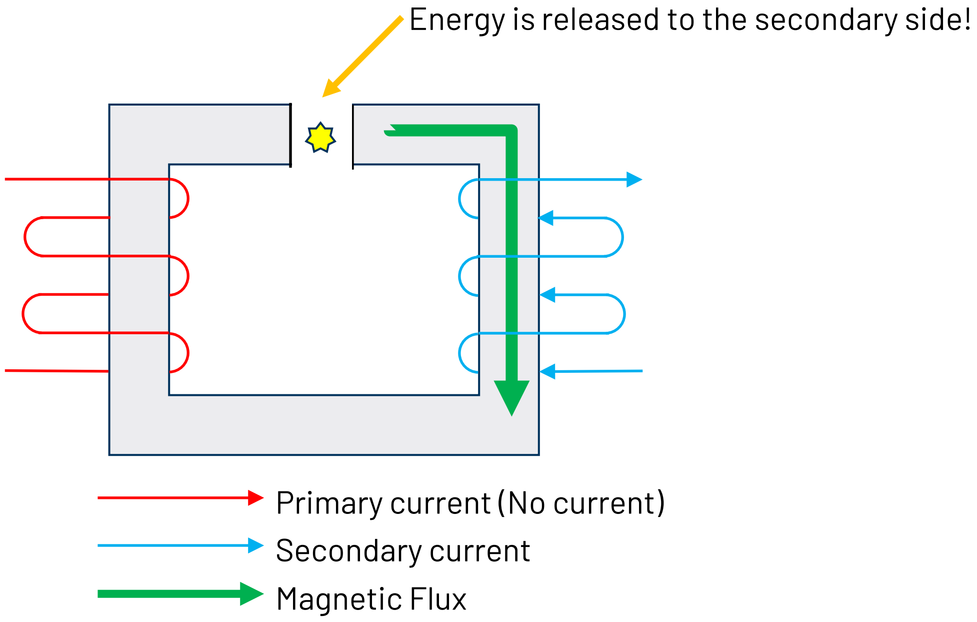
- Phase 1 : FET turn on
  - The current flows through the primary side of transformer.
  - No current flows at the secondary side of transformer due to the airgap.
  - Electrical energy is stored in the air gap in the form of magnetic energy.
  - The magnetic Inductance (Lm) is not existed (imaginary) part.

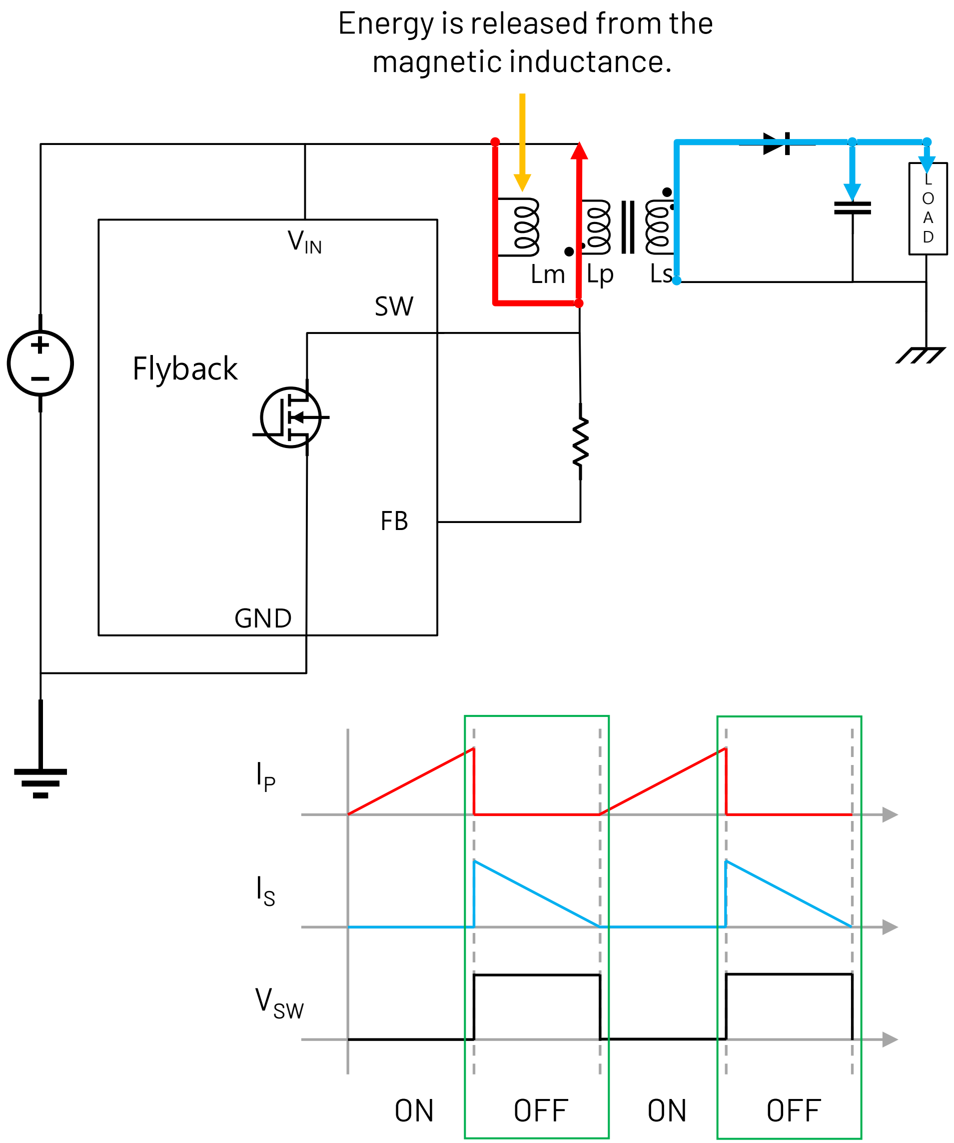




Basic Operation of Flyback Converter

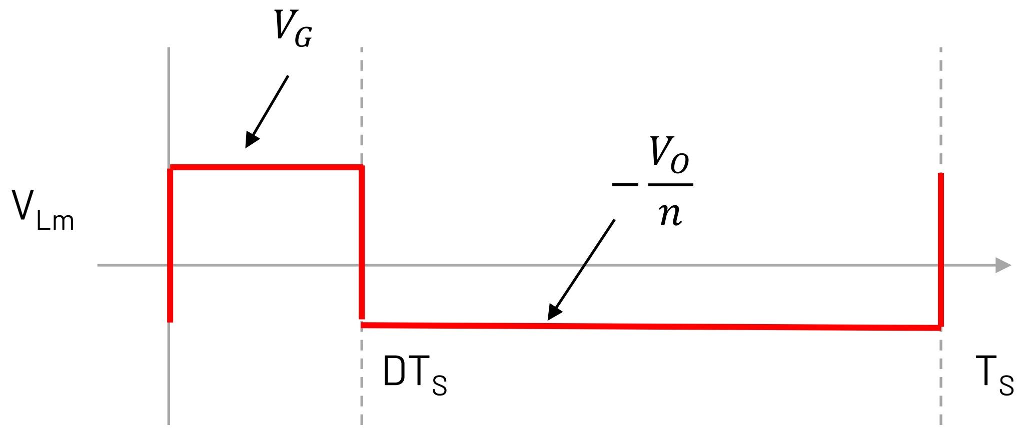
- Phase 2 : FET turn off
  - The magnetic energy stored in the air gap is transferred to the secondary side along the transformer core.
  - Current flows at secondary side of transformer due to the airgap.
  - The magnetic Inductance (Lm) is not existed (imaginary) part.

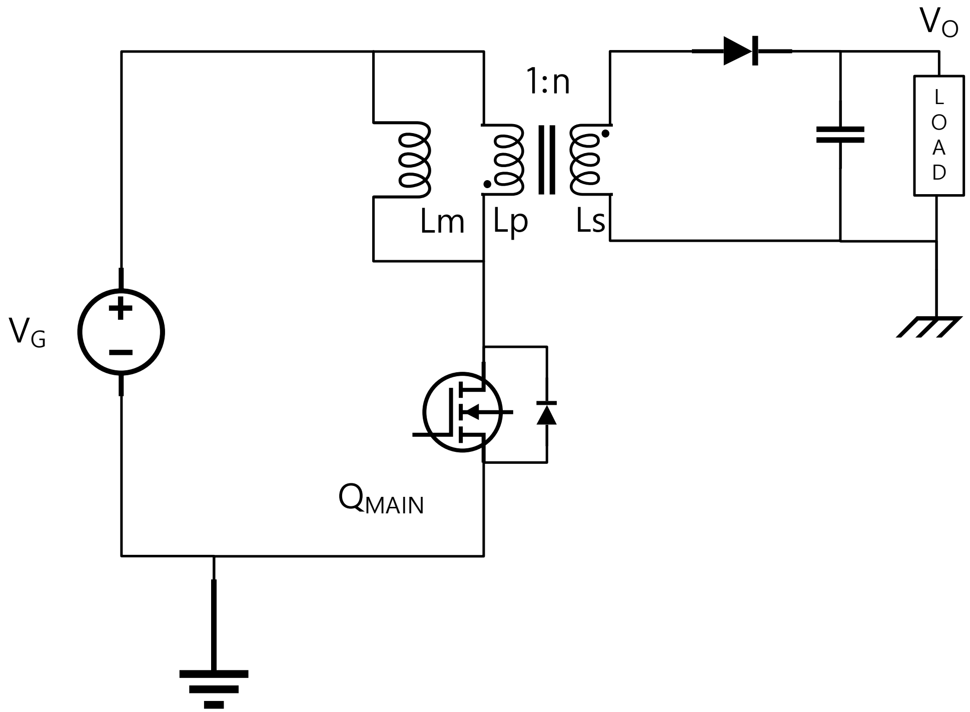




Basic Operation of Flyback Converter

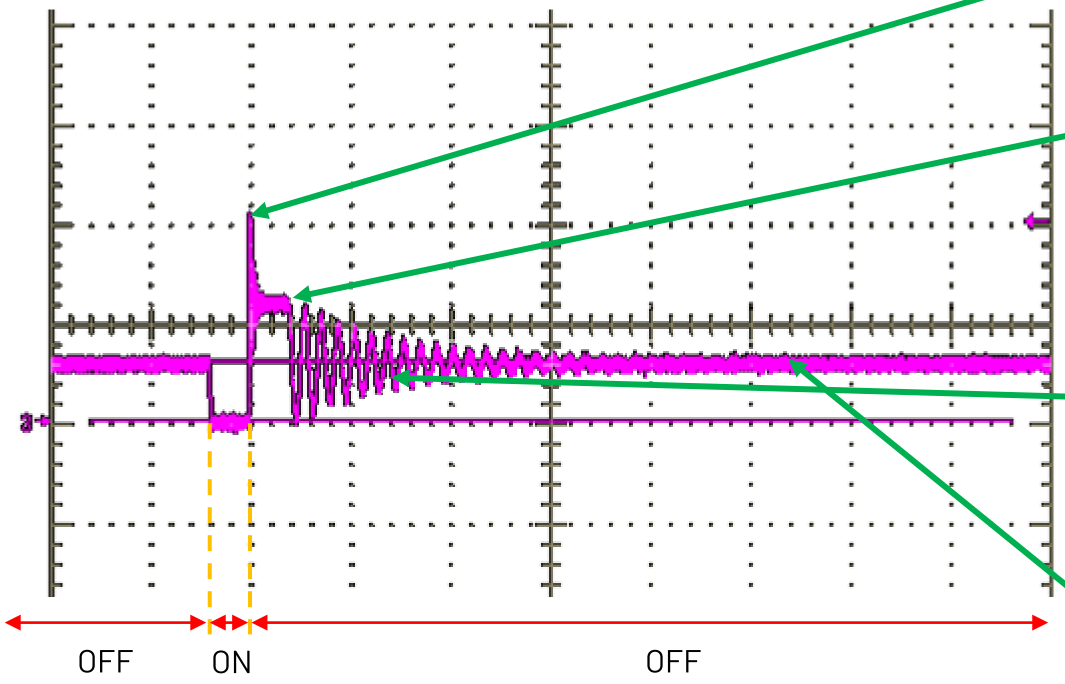
- Properties on CCM (continuous conduction mode)
  - Gain
    - $D \times V_G = (1 - D) \times \frac{V_O}{n}$
    - $\frac{V_O}{V_G} = \frac{n \times D}{1 - D}$ → **절연형 Buck-Boost**





Analyses of the Flyback Pulse Waveform

- Flyback Pulse Waveform (Discontinuous Conduction Mode)
  - The waveform at SW pin, when the FET of flyback converter is turned off.



- The Voltage spikes is due to ringing between the leakage inductance of transformer and parasitic capacitance of SW node.
- $V_{SW} = V_{IN}+(V_{OUT}+V_F)*N_{PS}$

  → Voltage of SW node after the ringing removed by leakage inductance

  → The voltage of the SW node is increased by multiplying the voltage on the secondary side and the turn ratio of the transformer.
- $V_{SW} = V_{IN}$ +Ringing

  → Ringing occurs due to decrease the secondary side current to zero.

  → SW of the flyback may be turned on according to the load at any time.
- $V_{SW} = V_{IN}$

  → The voltage of SW eventually becomes the same as the V_{IN}.

LT8300/1/2/4/6 : No-Opto Isolated Flyback

Benefits & Features

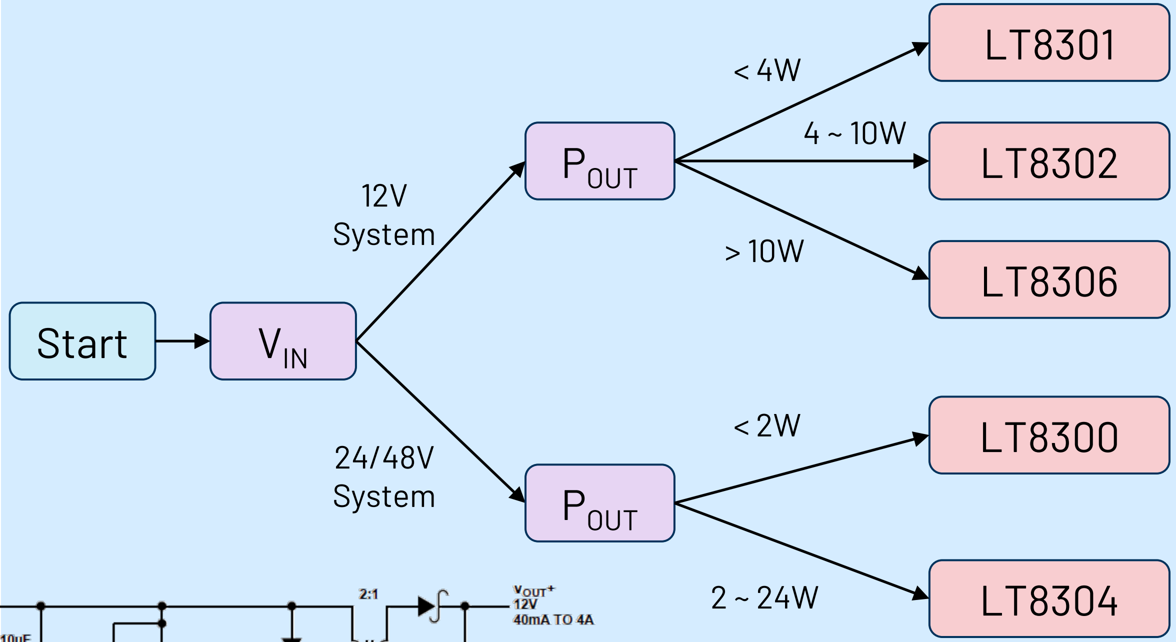
No-Opto Flyback Converter/Controller

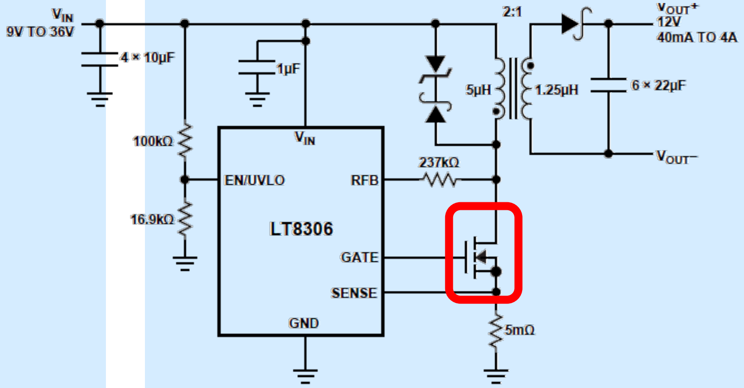
- No Transformer Third Winding or Opto-Coupler required
- Input Voltage Range
  - LT8301/2 : Max 42V
  - LT8300/4 : Max 100V
  - LT8306 : Max 60V
- Current Capacityy of the Power Switch
  - LT8300 : 150V/0.26A DMOS Power Switch
  - LT8301 : 65V/1.2A DMOS Power Switch
  - LT8302 : 65V/3.6A DMOS Power Switch
  - LT8304 : 150V/2A DMOS Power Switch
  - LT8306 : External Nch MOSFET
- Boundary Mode at Heavy Load, Burst Mode at Light Load
- VOUT Set with a Single External Resistor
- Internal Compensation and Soft-Start

Packages

- LT8300/1 : 5 pin TSOT23
- LT8302 : 8 pin SO
- LT8304 : 8 pin SO
- LT8306 : 6 pin TSOT23

Selection Guide





LT8315/6 : 560VIN No-Opto Isolated Flyback

Benefits & Features

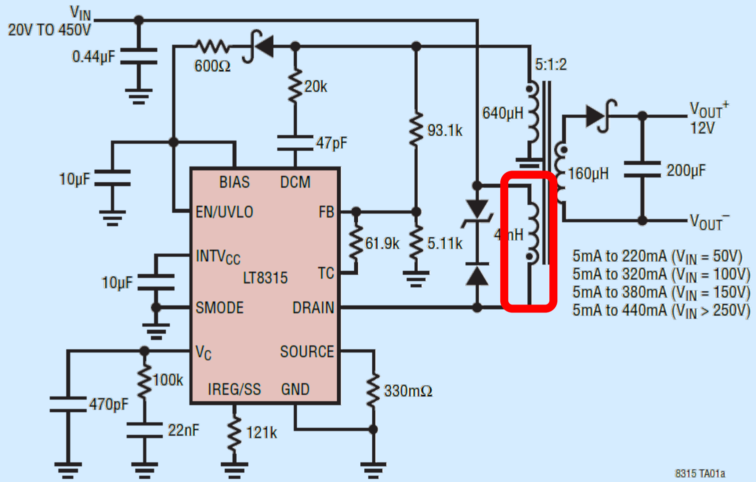
No-Opto Flyback Converter/Controller

- No Opto-Coupler required
- Input Voltage Range
  - LT8315 : 18V ~ 560V
  - LT8316 : 16V ~ 560V
- Current Capacity of the Power Switch
  - LT8315 : 630V/0.3A Power Switch
  - LT8316 : External Nch MOSFET
- Boundary Mode at Heavy Load
- Burst Mode at Light Load
- VOUT Set through the Third Winding
- External Compensation and Soft Start

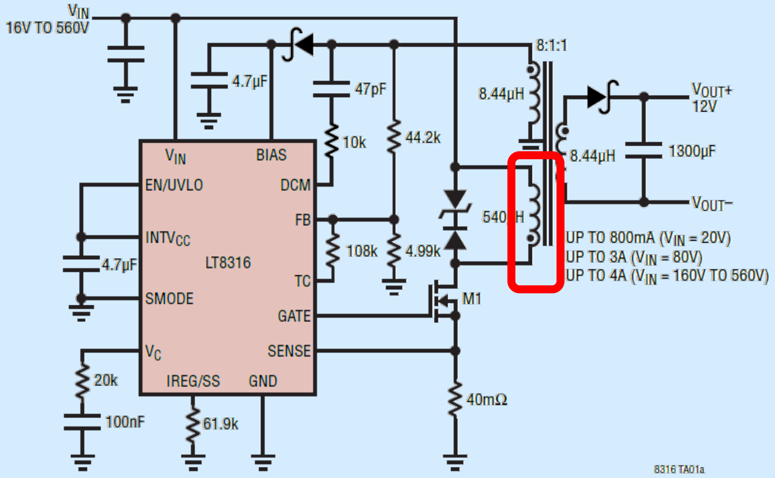
Packages

- LT8315 : 20 pin TSSOP
- LT8316 : 20 pin TSSOP (Automotive Qualified)

LT8315 :
Pout < 15W



LT8316 :
Pout > 15W



MAX25351 : No-Opto Flyback Converter with 1700V Integrated SiC FET

Benefits/ Features

No-Opto Flyback Converter

- **Integrated 1700V High-Voltage Switch**
- Input Voltage Range: 30V to 1200V
- Boundary Mode, DCM, and Standby Operation for High Efficiency
- Low Operating Iq in Burst/Standby Mode with EN Pin for Low IQ Shutdown
- **Integrated on-chip self-biased startup** supply with short-circuit protection
- Constant-Current/Constant-Voltage (CC/CV) Regulation
- Up to 300kHz Operation for Smaller External Components
- Valley Detection Control for lower switching losses
- TC pin to compensate for output diode forward-voltage drift over temperature
- **Fast Startup operation ~8ms**
- Programmable Current Limit, Soft-Start and Minimum ON and OFF time

Safety – ASIL-B Compliant

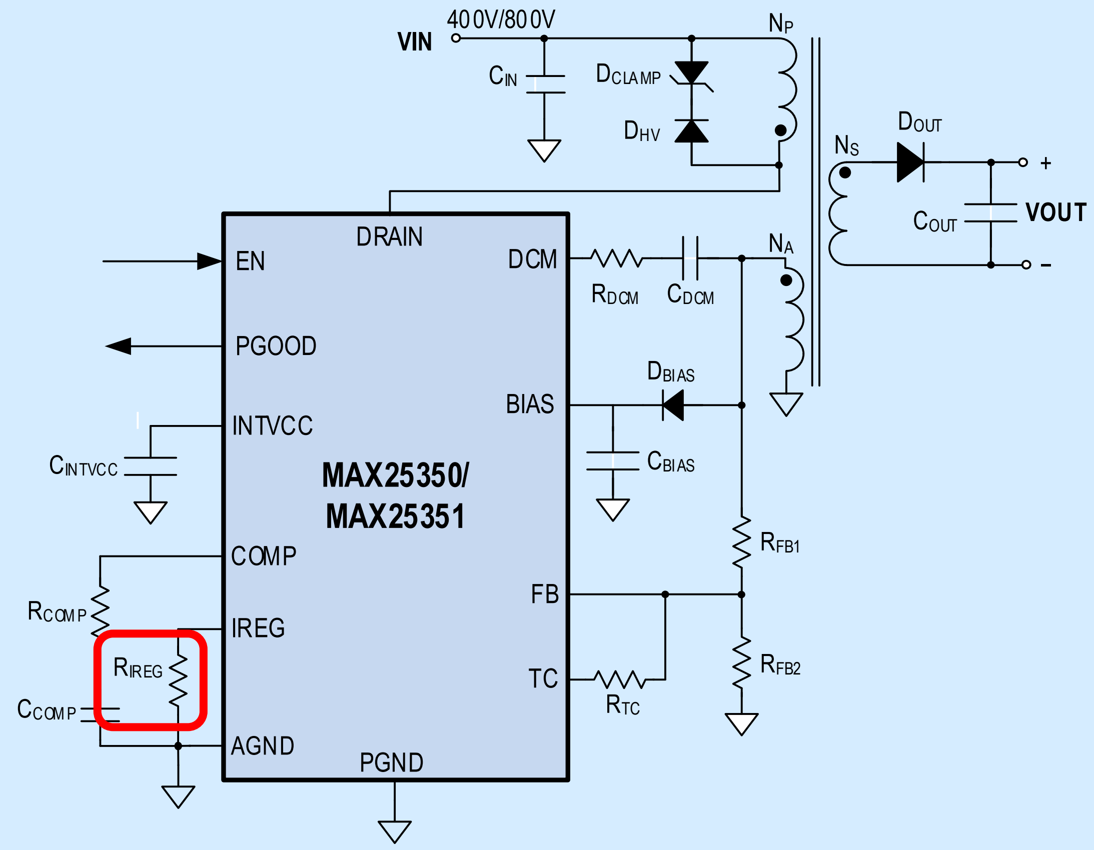
- Redundant Reference & Self-Diagnostics for OV/UV Monitoring
- Accurate (8±1.5%) OV/UV Monitor
- Built-in Self Test (BIST) for OV/UV Comparators

Package

- 10.3mm x 10.3mm x 2.5mm 28-Pin SSOP Package
- 7.5mm Clearance/Creepage between High, Low Voltage Pins

AEC-Q100

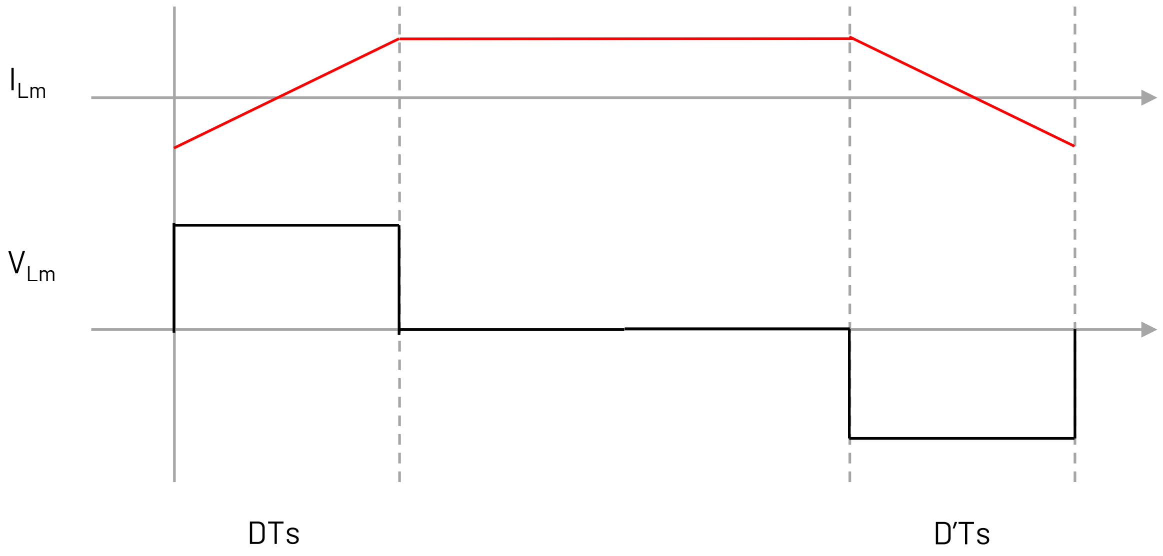
- T_A: -40°C to +125°C; T_J: -40°C to +150°C

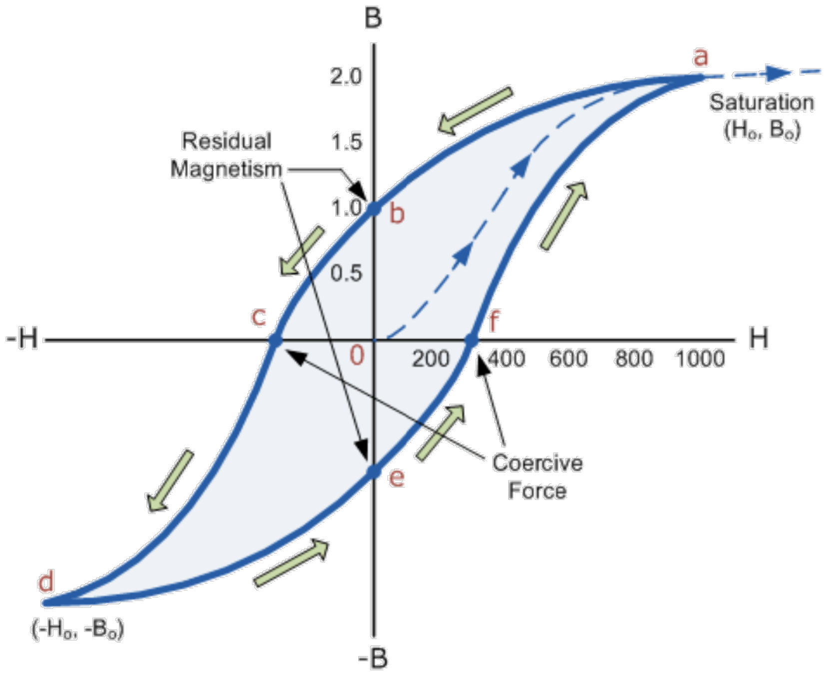


Forward Converter

➢ Saturation of Transformer (very similar to inductor saturation)

- Transformer saturation occurs when the magnetic core reaches its maximum magnetic flux density and can no longer support a proportional increase in magnetic flux, even with increasing magnetizing force (current/voltage).
- Transformer reset needs to be done properly.
- If D ≠ D′, this will tend to saturate core over many cycles.

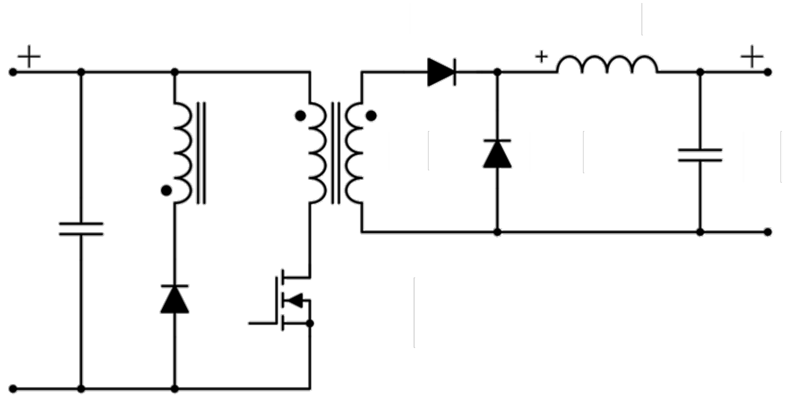




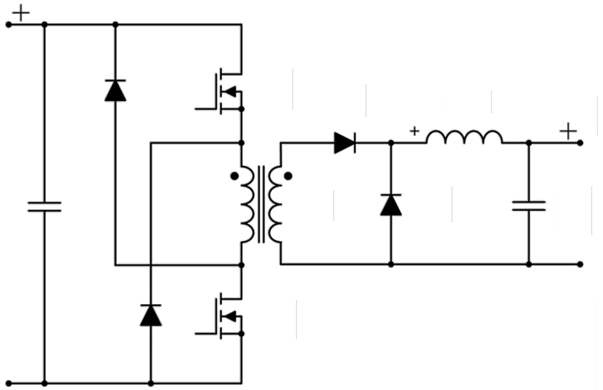
Forward Converter

- The Definition of the Forward Converter
  - Forward converter use a separate winding to “relax/reset” the core.
  - It discharge the energy stored in the core **via another path**.

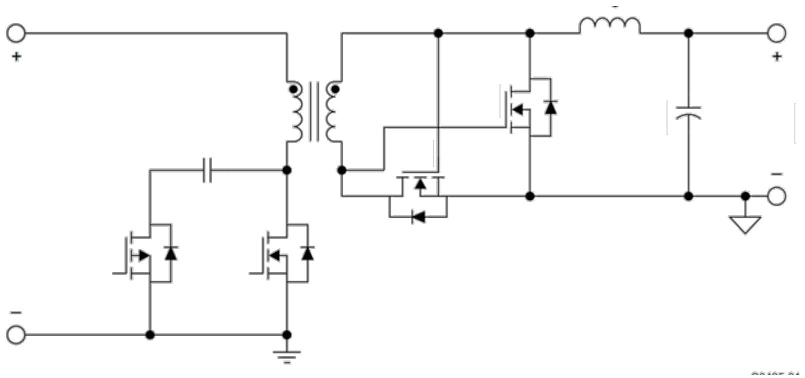
- Various Kind of Forward Converter.



Single Switch Forward Converter



Two Switch Forward Converter

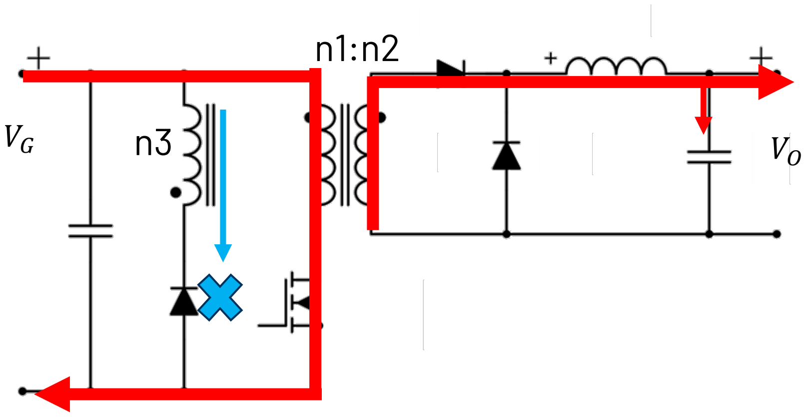


Active Clamp Forward Converter

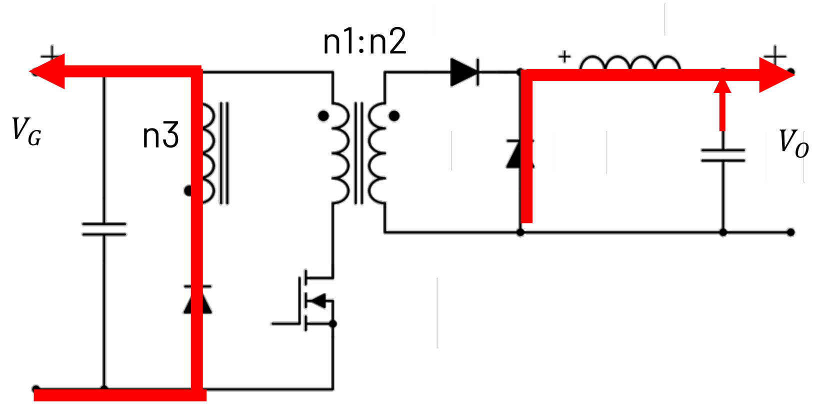
Single Switch Forward Converter (SSFC)

- ➢ Operation and Current Path

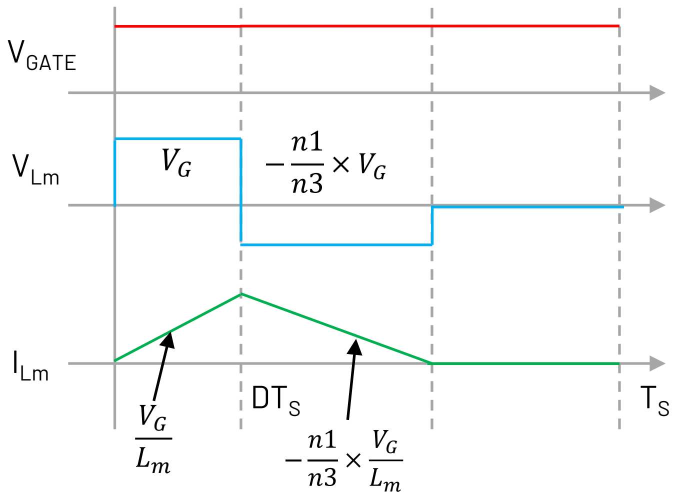
FET ON

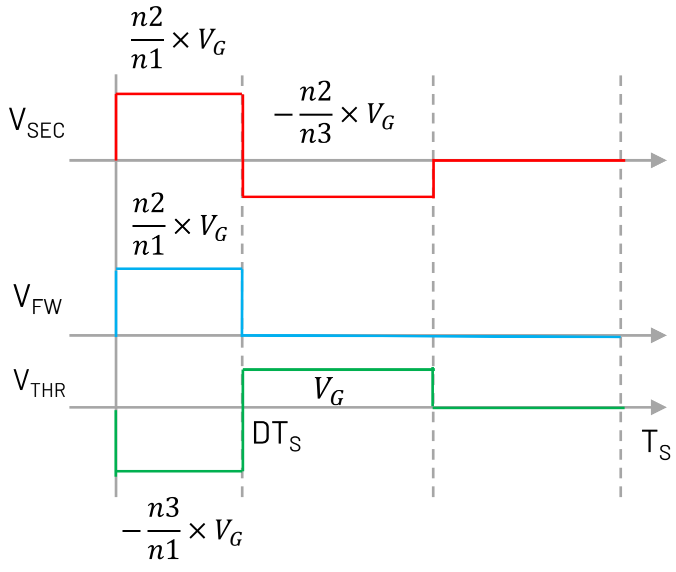


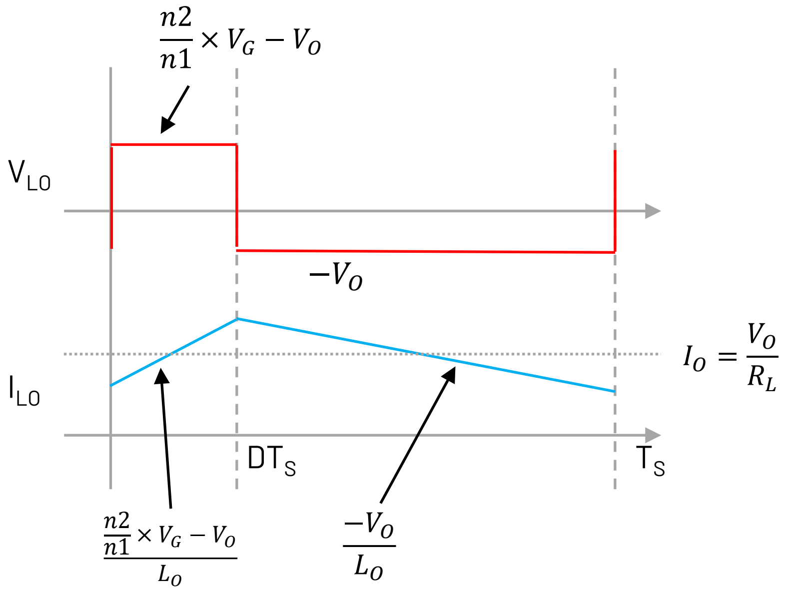
FET OFF



- ➢ Waveform

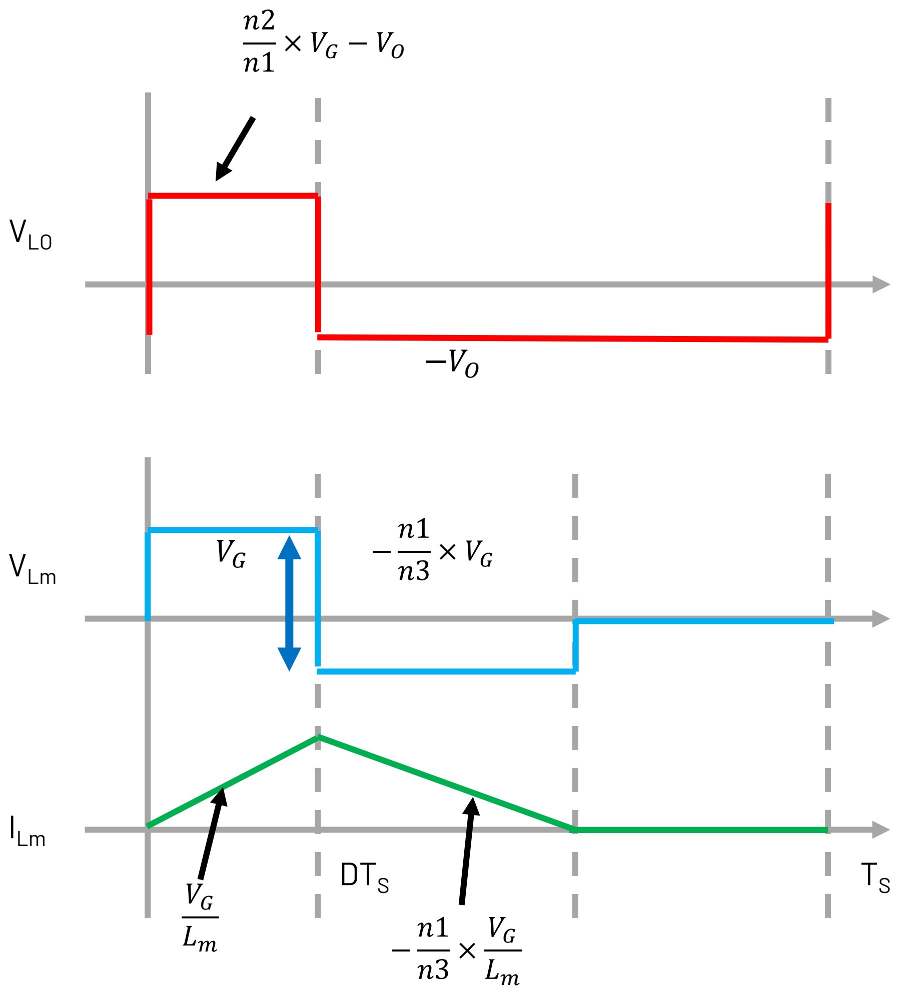






Single Switch Forward Converter (SSFC)

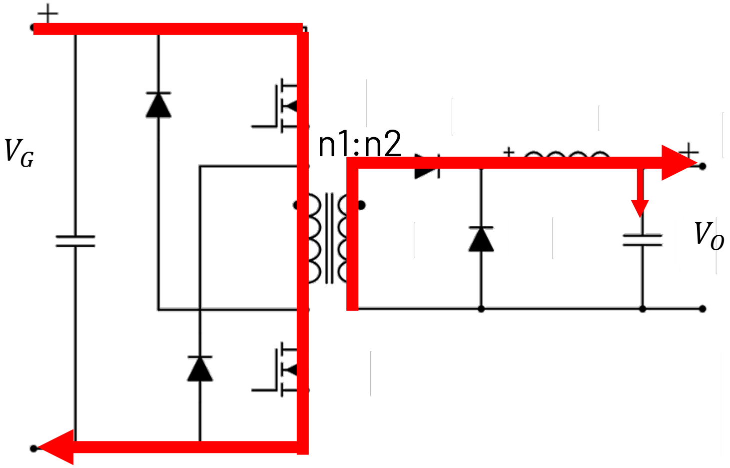
- Properties
  - Gain
    - $(\frac{n2}{n1} \times V_G - V_O) \times DT_S = V_O \times (1 - D) \times T_S$
    - $\frac{V_O}{V_G} = \frac{n2}{n1} \times D$ → **절연형 Buck**
  - Maximum Duty Cycle
    - $i_{PK\_Lm} = \frac{V_G}{L_m} \times DT_S = \frac{\frac{n1}{n3} \times V_G}{L_m} \times (1 - D) \times T_S$
    - $D \times \left(V_G + \frac{n1}{n3} \times V_G\right) = \frac{n1}{n3} \times V_G$ → generally n1 = n3
    - $D_{MAX} = 0.5$
  - Maximum V_{DS}
    - $V_{DS} = V_G + \frac{n1}{n3} \times V_G$ → $V_{DS\_MAX} = 2 \times V_G$



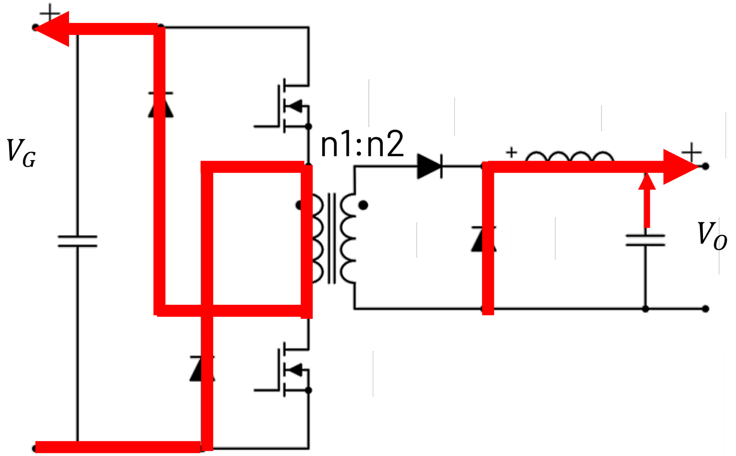
Two Switch Forward Converter (TSFC)

- Operation and Current Path

FET ON



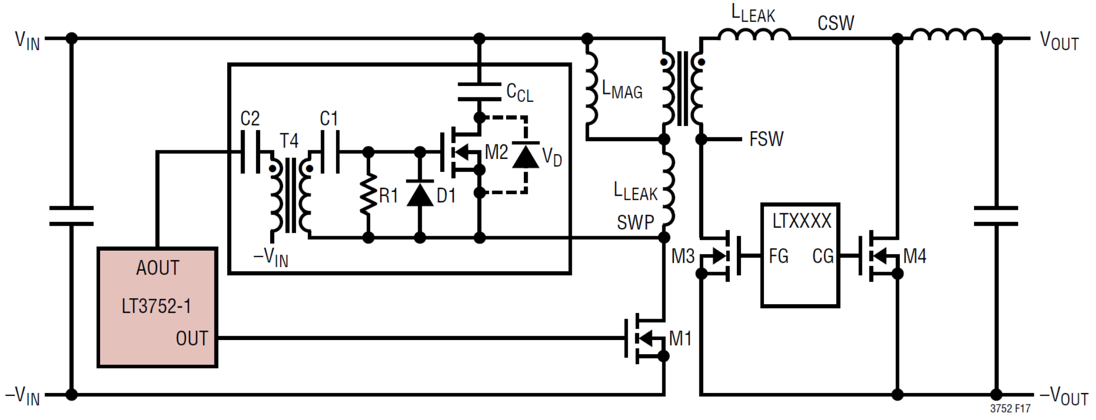
FET OFF
(Transformer
Reset)



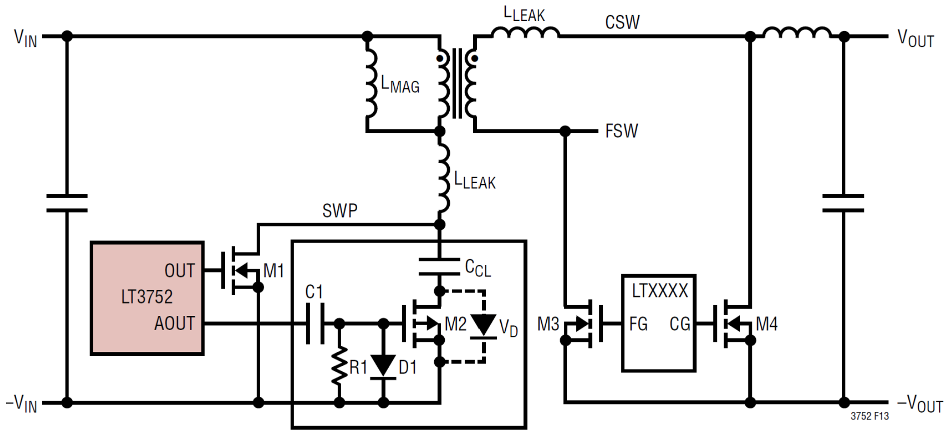
- Comparison between SSFC and TSFC
  - Advantages of TSFC
    - Voltage stress of FET is half of the SSFC.
  - Disadvantage of TSFC
    - Number of FETs and Diodes are increased.
  - The maximum duty cycle of both topologies are equal to 50%.

Active Clamp Forward Converter (ACFC)

- Definition of ACFC
  - DC-DC converter which has an active clamping circuit (Q_{AUX}, C_{CLAMP}) to reset the transformer core.
  - Topologies of ACFC (depends on where you want to clamp)



High-side Clamp ACFC

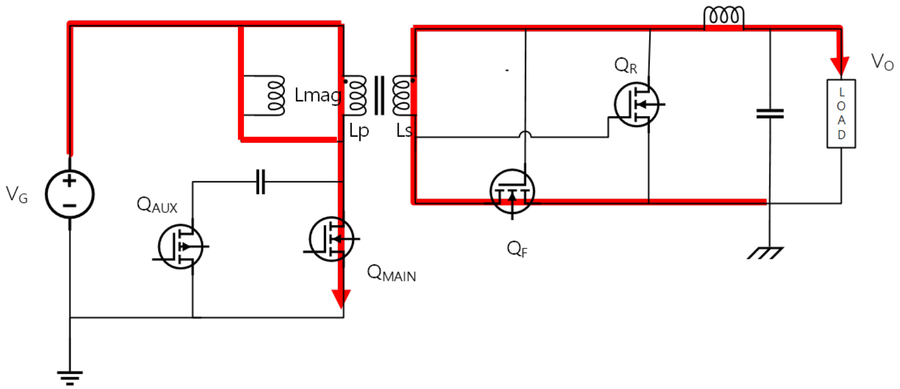


Low-side Clamp ACFC

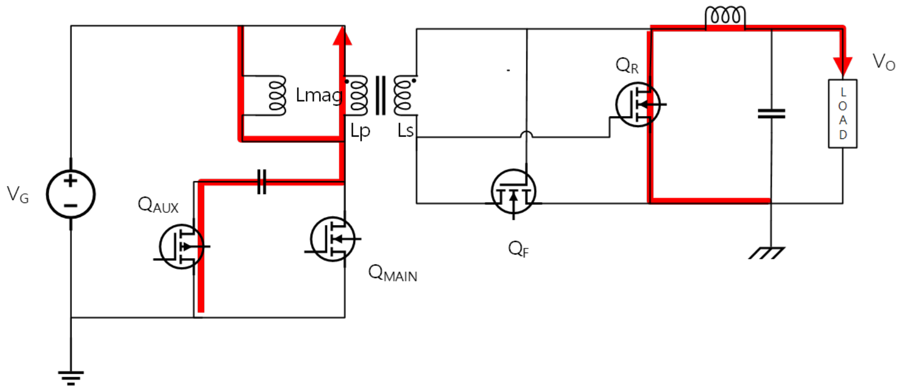
- Advantages of ACFC
  - ZVS is possible so, ACFC can minimize the switching losses.
  - Maximum duty cycle can be increased.

Operating Theory of ACFC

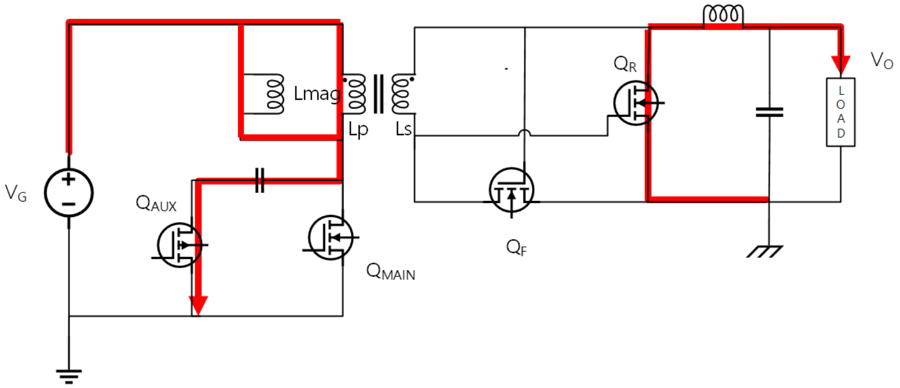
➤ Operating Phase 1 : Power Transfer



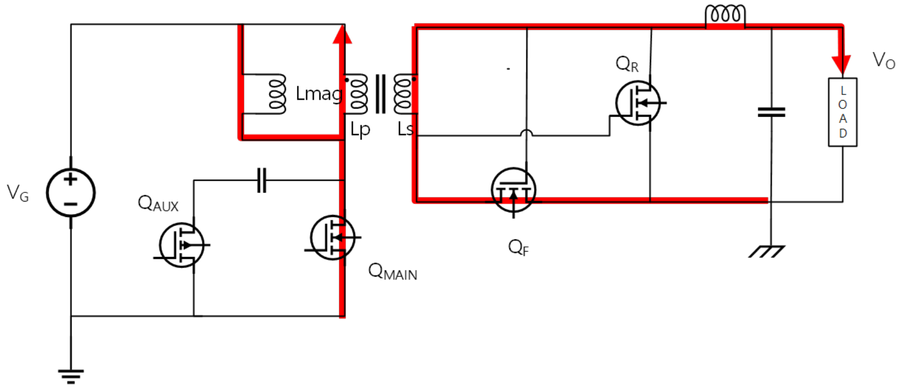
➤ Operating Phase 3 : Active Clamp



➤ Operating Phase 2 : Resonant



➤ Operating Phase 4 : Resonant



LT8310 : 100VIN Forward Converter Controller

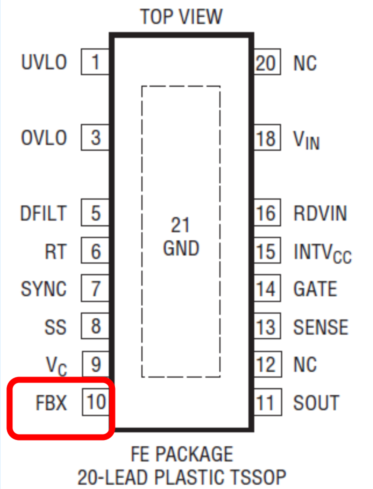
Benefits & Features

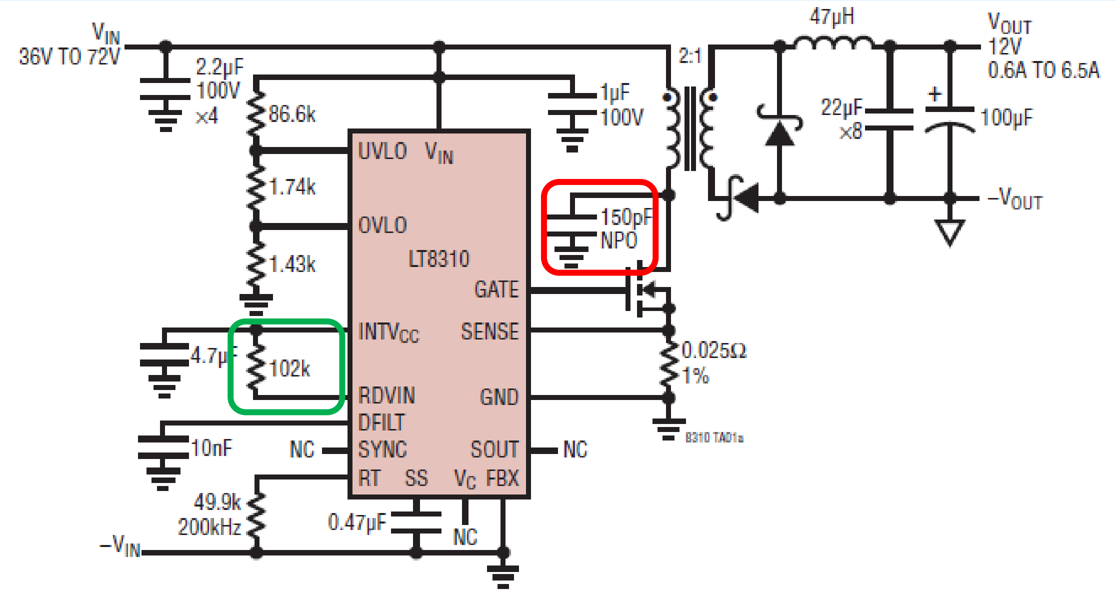
Resonant Reset Forward Converter/Controller

- Duty Mode Control Regulates an Isolated Output without an Opto
- Input Voltage Range : 6V to 100V
- Current Capacityy of the Power Switch
- LT8310 : External Nch MOSFET
- Programmable Frequency (100kHz to 500kHz)
- Programmable UVLO/OVLO with Hysteresis
- VOUT Set with a Single External Resistor
- Programmable Soft-Start

Packages

- 20 Pin TSSOP (HV pin spacing)

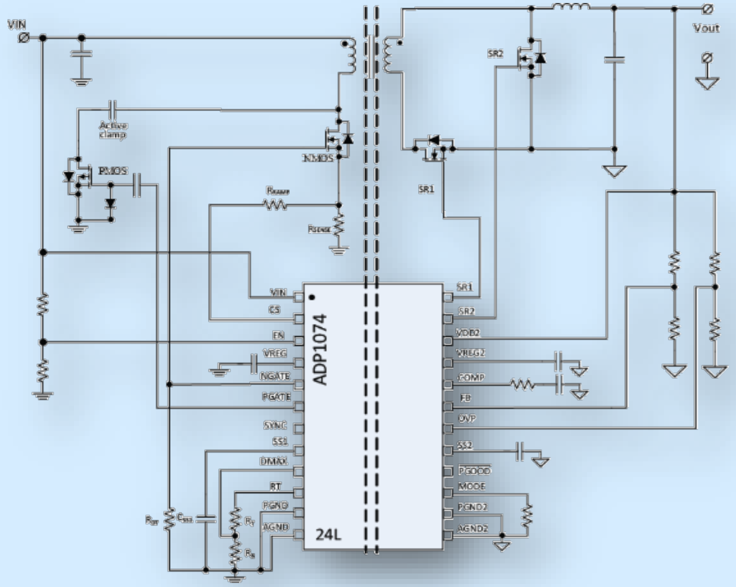




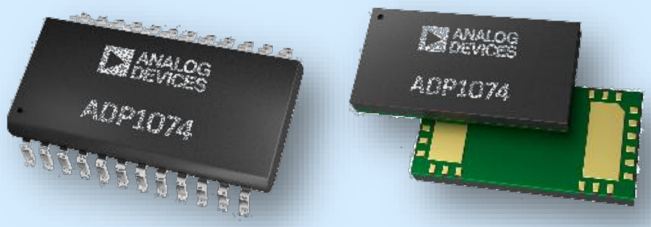
ADP1074 :Isolated Synchronous Forward Controller with active clamp and *i*Coupler

- **Features**
  - Wide V_{IN} range: 4.7V to 60V
  - Peak Current mode controller with active clamp for forward topology
  - Power saving light load mode
  - Tracking from Secondary side and remote shutdown/reset capability
  - Programmable F_{sw} 50kHz-600 kHz with external synchronization
  - Programmable slope compensation and max duty cycle limit
  - Programmable dead time and soft-start
  - PGOOD pin for system flagging
  - Over-current, over or under-voltage, over-temperature protection
  - 24-lead SOIC_W package and 24 terminal LGA package
  - AECQ-100 qualified for automotive applications
- **Applications**
  - Isolated dc-to-dc or ac-to-dc power conversion
  - Telecom, industrial, Enterprise switches and routers, base station/antenna PSU
  - Small cell , PoE powered device

Application Diagram



ADI iCoupler®



ADP1055: Digital Controller for Power Supply with PMBus

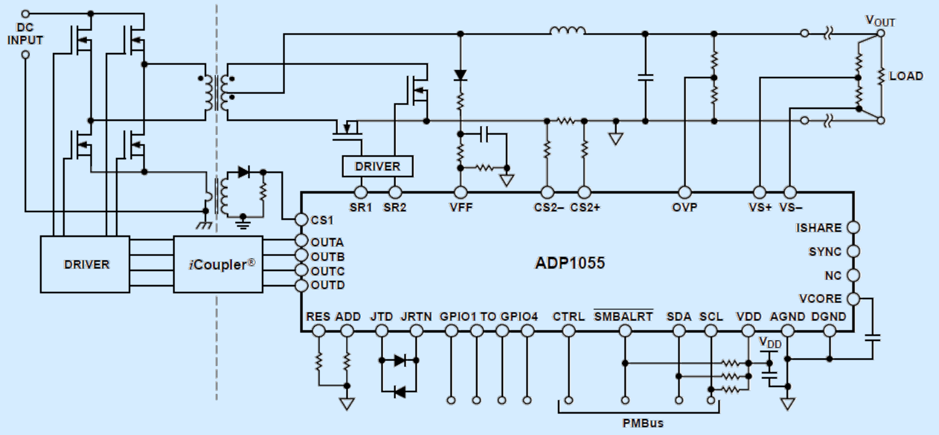
Features

- PMBus 1.2 compliant with PEC and extended manufacturer specific commands
- 32-bit password protection with command masking
- 64 address selections (16 base addresses, expandable to 64)
- 6 PWM control signals, 625 ps resolution
- 4 GPIOs (2 GPIOs configurable as PGOOD, 2 as active clamp snubber PWMs)
- Extended Black box data recorder for fault recording
- Switching Frequency: 49kHz to 1MHz with Frequency synchronization
- Duty cycle double update rate
- Analog and Digital current sharing
- Digital control loop (PID + additional pole or zero configurability)
- Voltage mode control
- Average and peak constant current mode
- Soft start and soft stop functionality

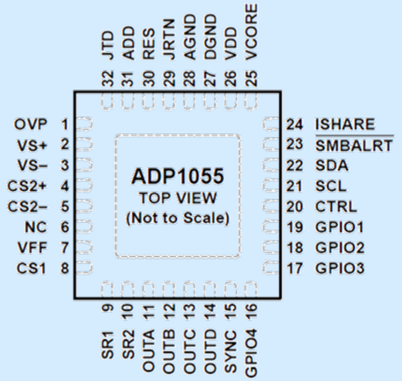
Applications

- Isolated AC-DC or DC-DC power supplies in Industrial, Cloud/Comms, sustainable energy applications

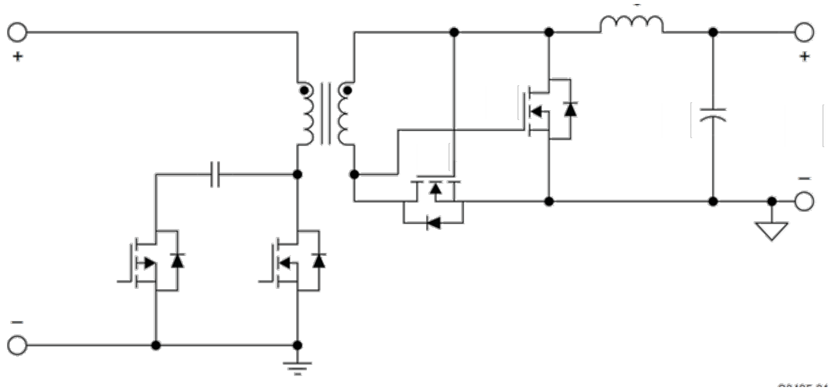
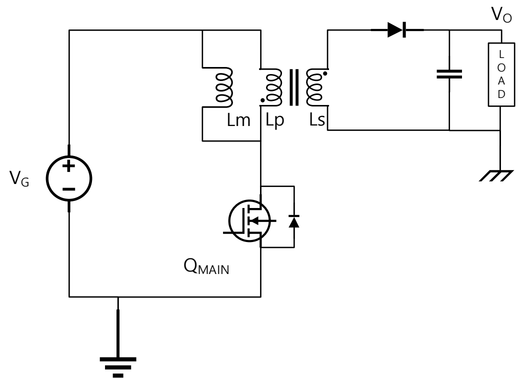
Application Diagram



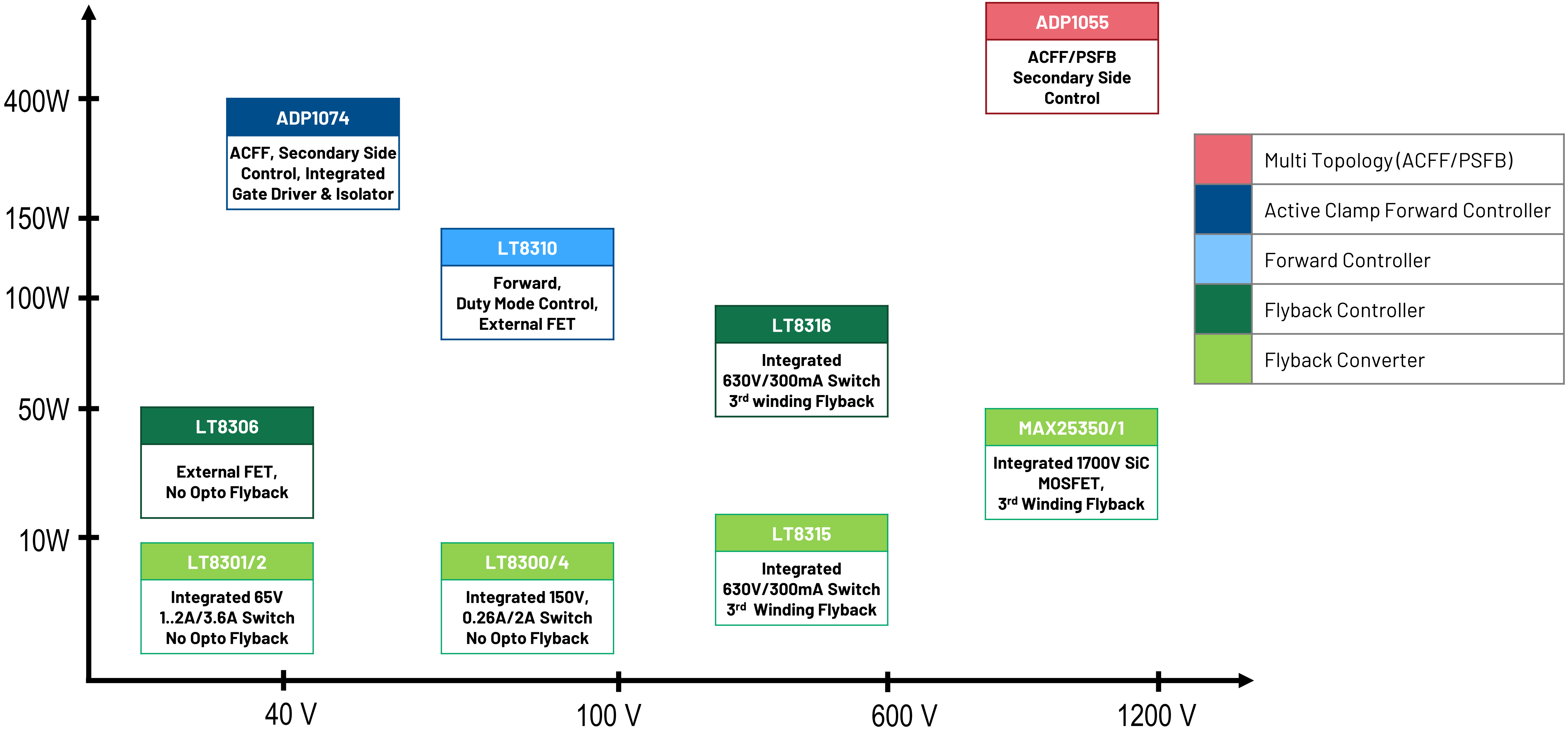
- Simpler and smaller footprint variants: ADP1050/ADP1051/ADP1052



Comparison : Forward Vs. Flyback

Forward (Isolated Buck)	Features	**Flyback** (Isolated Buck/Boost)
	Circuit Diagram	
Directly transferred through the Transformer when SW is ON.	Energy Transfer	Stored in the transformer core when SW is ON, released when SW is OFF
Generally, 500W ~ 100W	Maximum Power	Under 100W → Due to the limitation for making airgap.
85% ~ 85% → Soft-switching possible!	Efficiency	70% ~ 85%
Acts as a true transformer (no airgap)	Transformer	Needs airgap
Complex and Higher Cost	Complexity / Cost	Simple and Lower Cost

Topology Selection Guide



AHEAD OF WHAT'S POSSIBLE

analog.com

©2024 Analog Devices, Inc. All Rights Reserved.