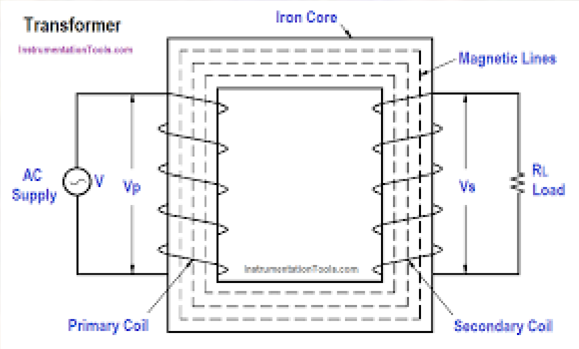
Rectification

Last updated 1/18/24

Transformers

- Transformers
  - Basics

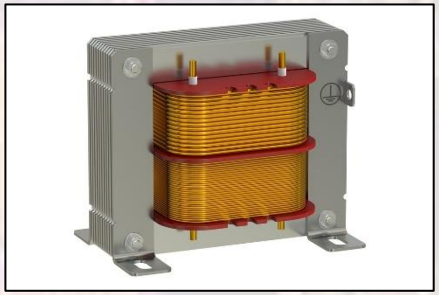
Concept

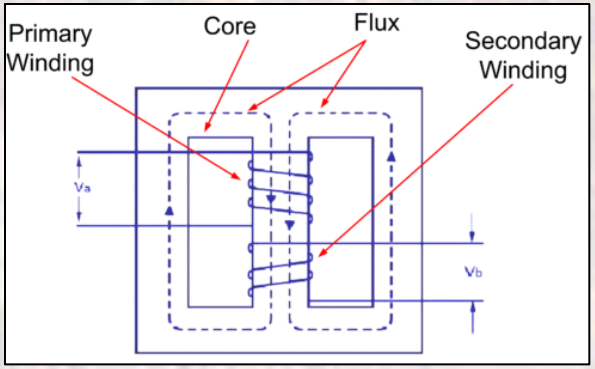


AC voltage on the Primary coil creates a magnetic field (concentrated by the core)

The magnetic field in the core creates a voltage on the secondary coil

Implementation

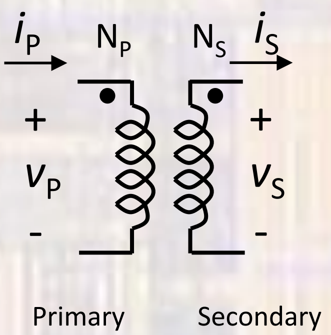




Transformers

- Characteristic Equation

Schematic



Characteristic Equation

$$\frac{v_P}{v_S} = \frac{i_S}{i_P} = \frac{N_P}{N_S}$$ Transformer turns ratio

Transformers

- Example 1
  - The cube shaped transformer you plug into a wall socket is sometimes called a “wall wart”
  - v_P is approximately 120v rms

What transformer turns ratio would be required to generate an 18v rms secondary voltage

$$\frac{N_1}{N_2} = \frac{v_P}{v_S} = \frac{120v\ rms}{18v\ rms} = 6.66$$

Transformers

- Example 2

How much does the secondary voltage from the previous slide vary due to power line voltage variation

US power line voltage can vary from 114v rms to 126v rms (range A)

$$v_S = \frac{N_2}{N_1} v_P = \frac{1}{6.66} v_P$$

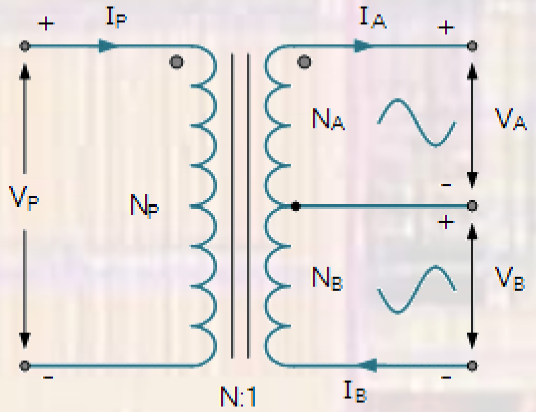
@ 114v rms, v_S = 17.1v rms

@ 126v rms, v_S = 18.8v rms

Note: this is +/- 5%

Transformers

- Center Tap
  - 1 primary coil, 2 secondary coils

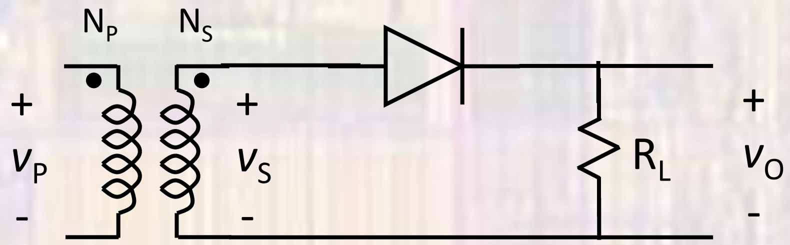


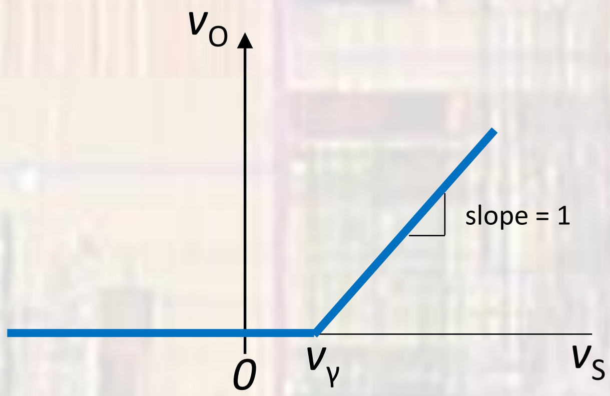
$$V_A = \frac{N_A}{N_P} . V_P$$

$$V_B = \frac{N_B}{N_P} . V_P$$

Half-Wave Rectifier

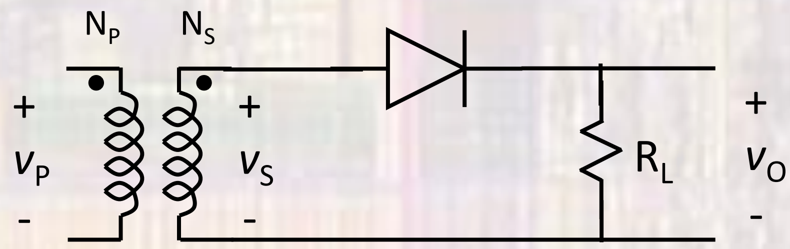
- Half Wave Rectifier
  - Basic Implementation



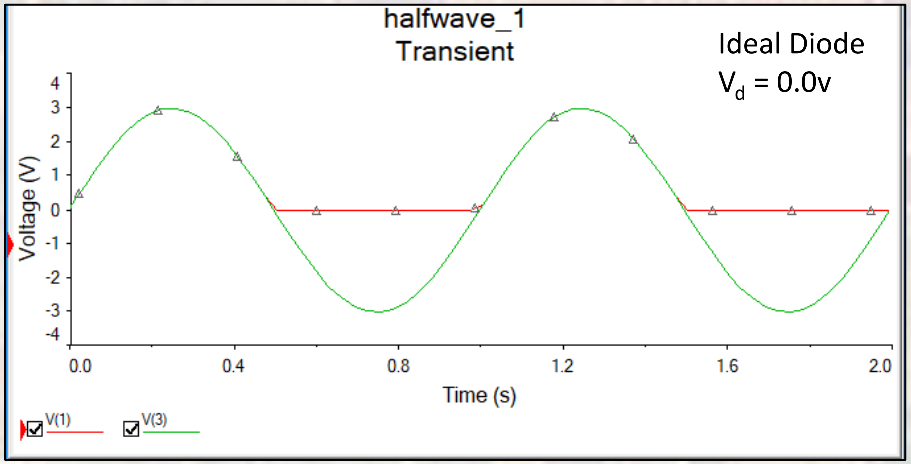


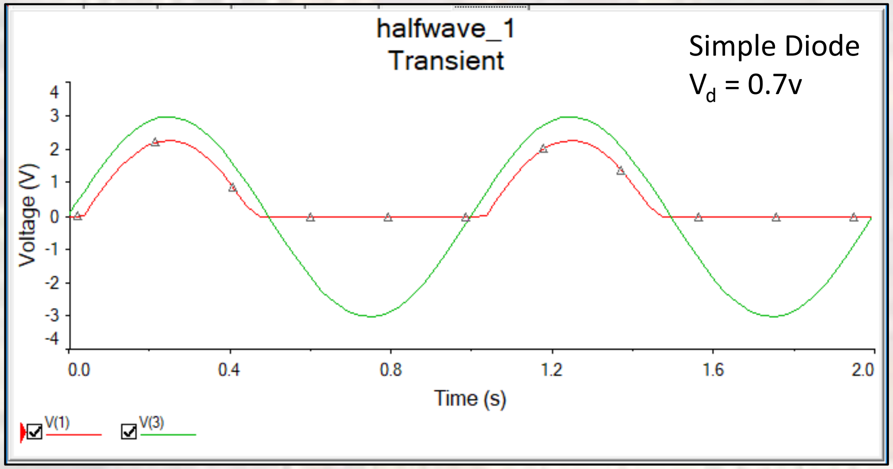
Half-Wave Rectifier

- Simulation



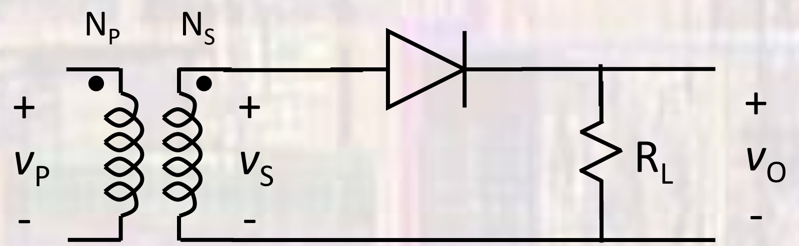
$v_S = \pm 3V$

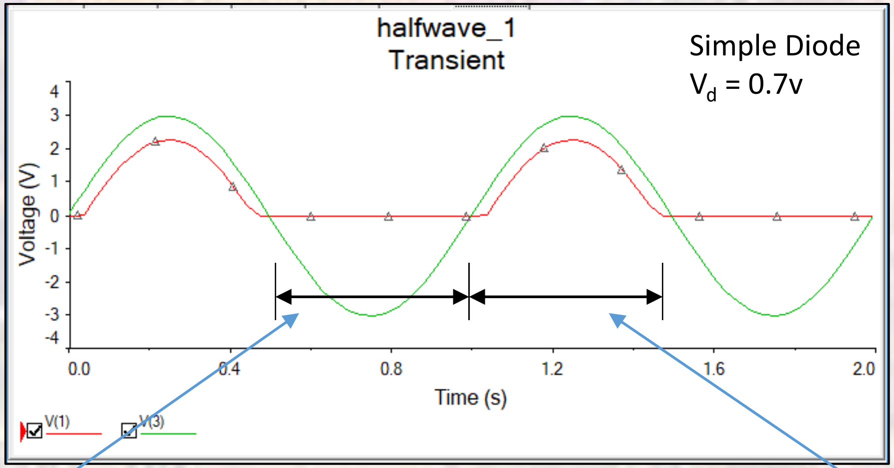




Half-Wave Rectifier

- Design Considerations



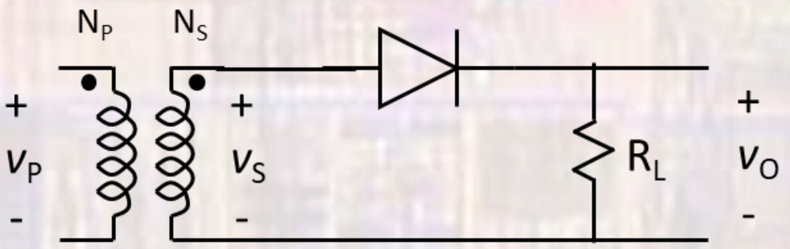


Reversed biased region
$v_D max = -v_S peak$
→ breakdown requirement

Forward biased region
$i_D max = (v_S peak - v_D)/R$
→ current requirement

Half-Wave Rectifier

- Design Example
  - 120v rms primary voltage
  - Transformer turns ratio: 12
  - Load resistance: 1KΩ



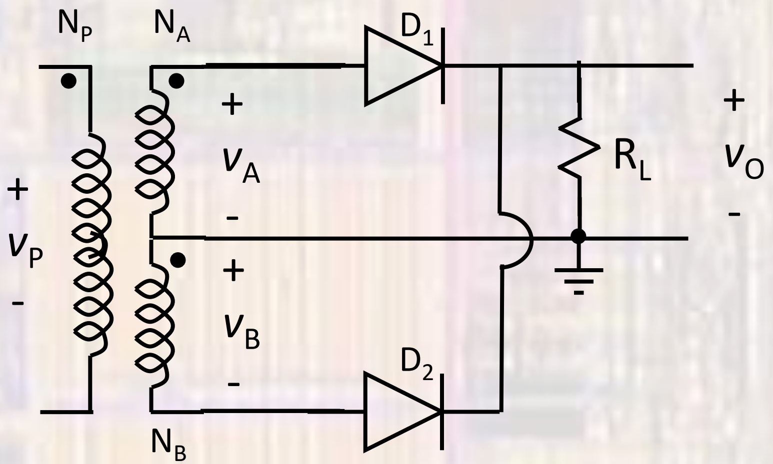
  - What are the diode requirements?

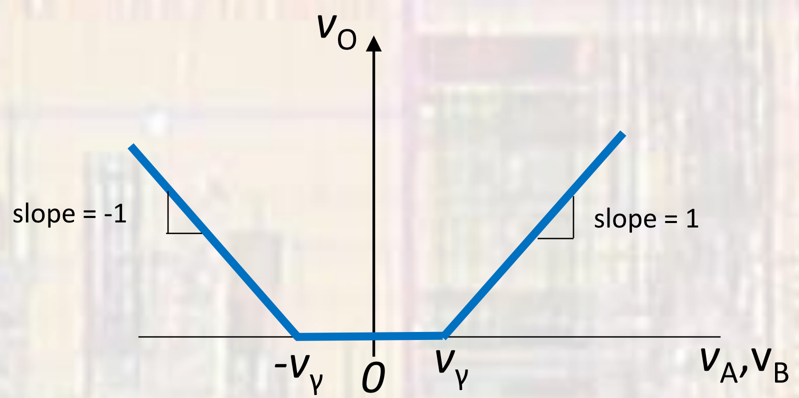
Breakdown:
120v rms, 12 turns ratio → v_S = 10v rms
10v rms → $v_S$peak = 14.14v
Current:
(14.14v - v_D)/1KΩ → 14.14ma – v_D/1ΩK
typical v_F is 0.6v → 13.54ma

guard band the design:
$v_F \approx 0.6v$
$V_{breakdown}$ > 20v (14v rms)
I_{max} > 20ma

Full-Wave Rectifier

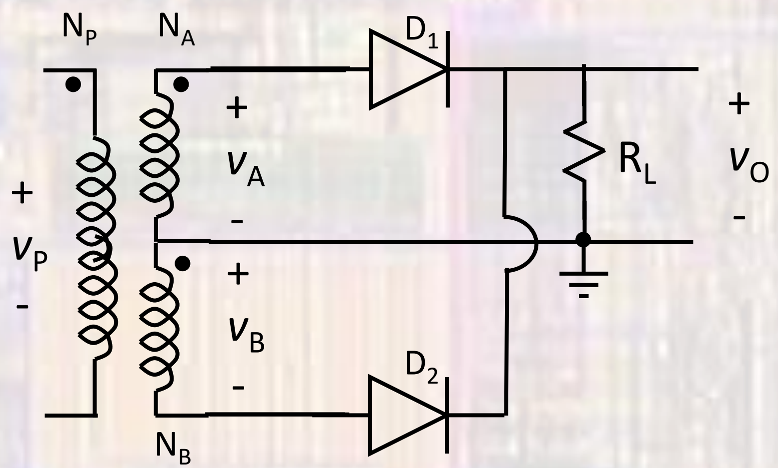
- Full-Wave Rectifier
  - Basic Implementation

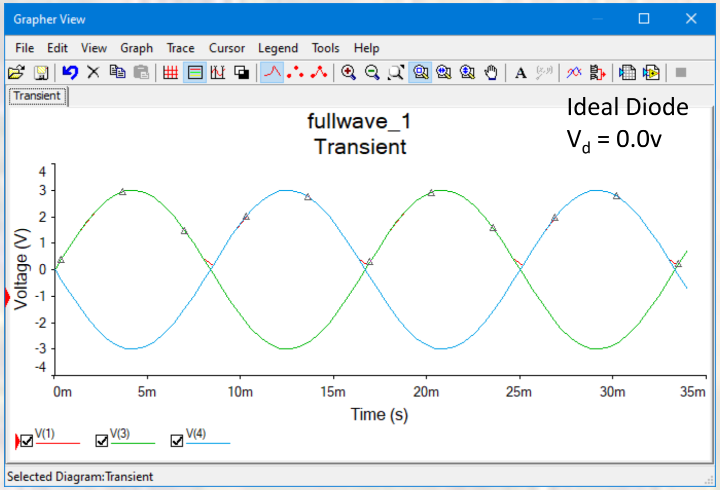


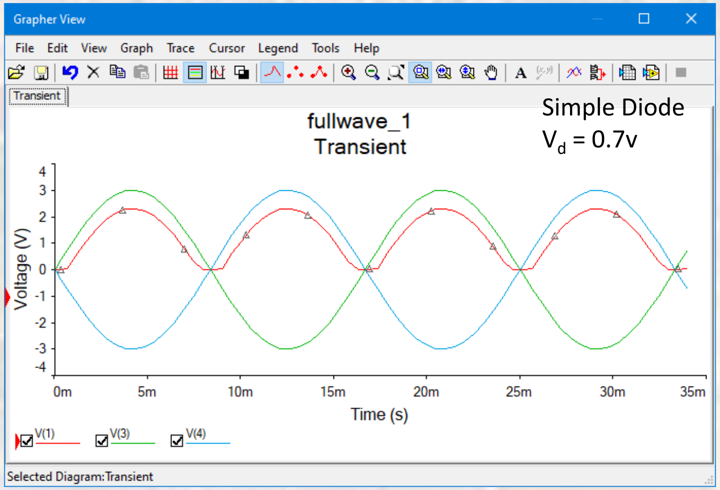


Full-Wave Rectifier

- Simulation

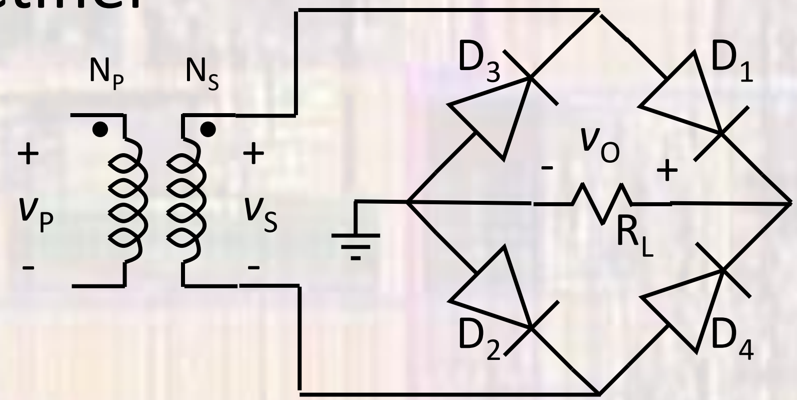




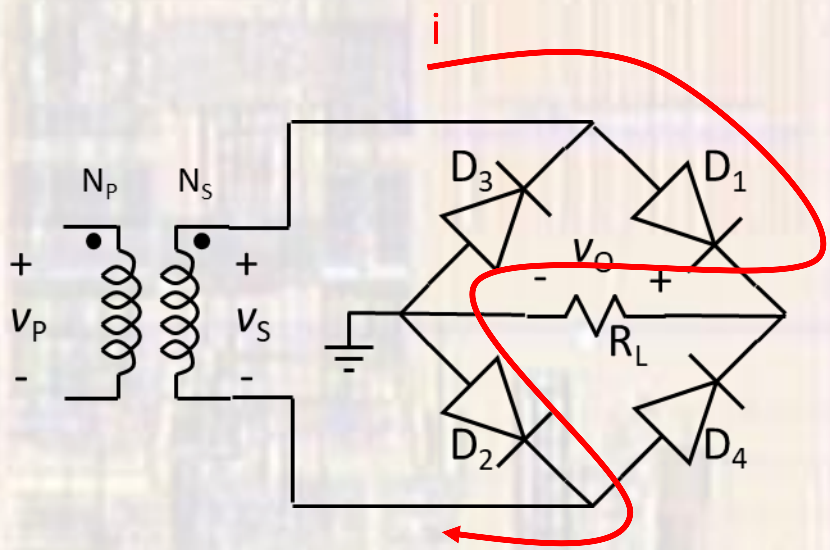


Full-Wave Rectifier

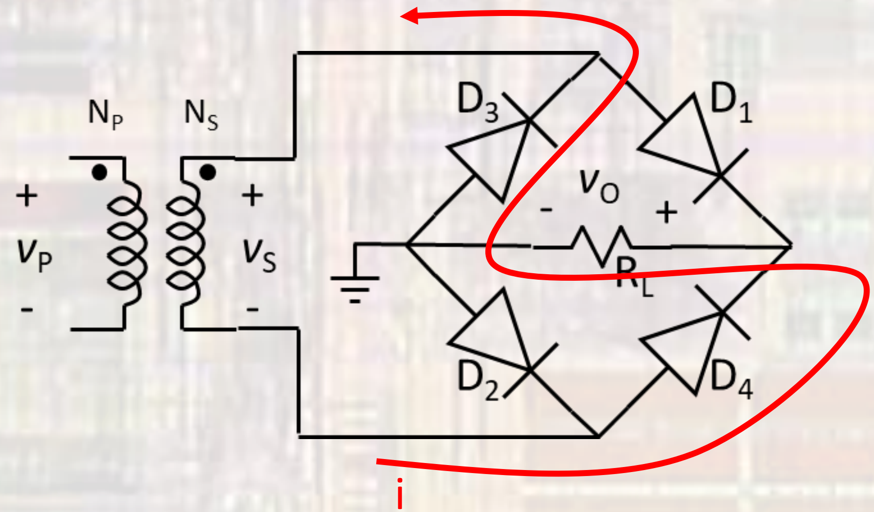
- Bridge Rectifier



Positive voltage and current to the load in both half cycles



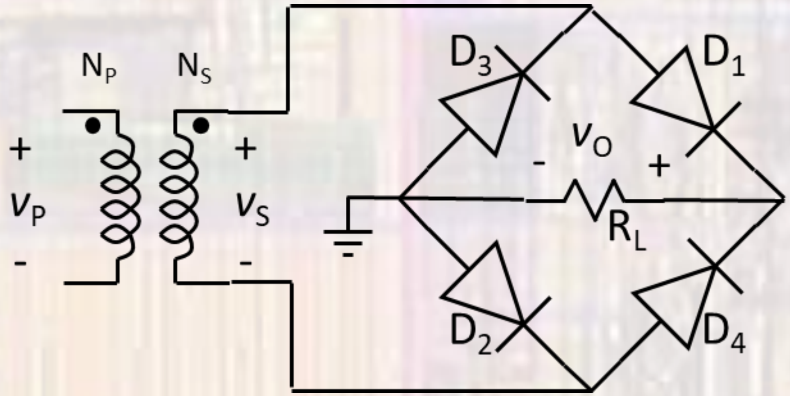
Positive half cycle

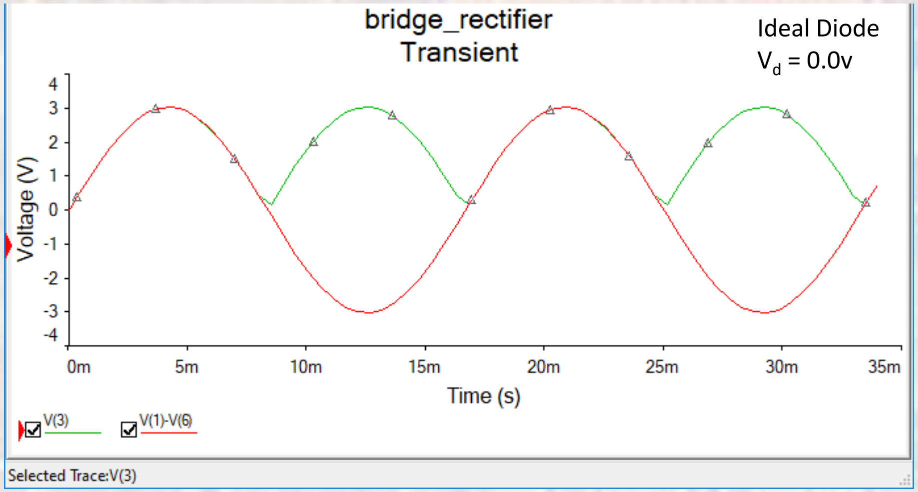


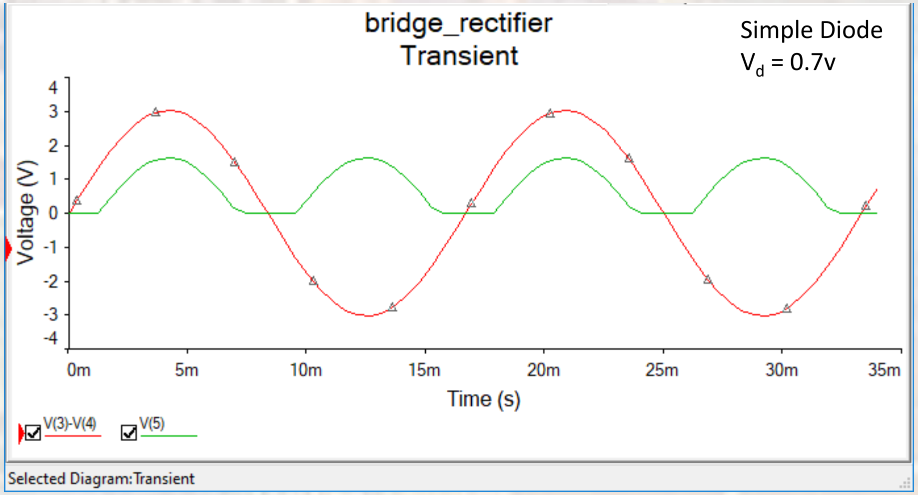
Negative half cycle

Full-Wave Rectifier

- Bridge Rectifier

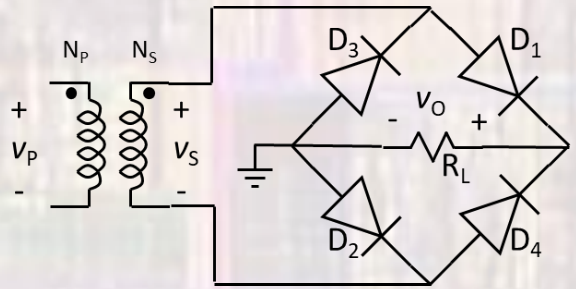


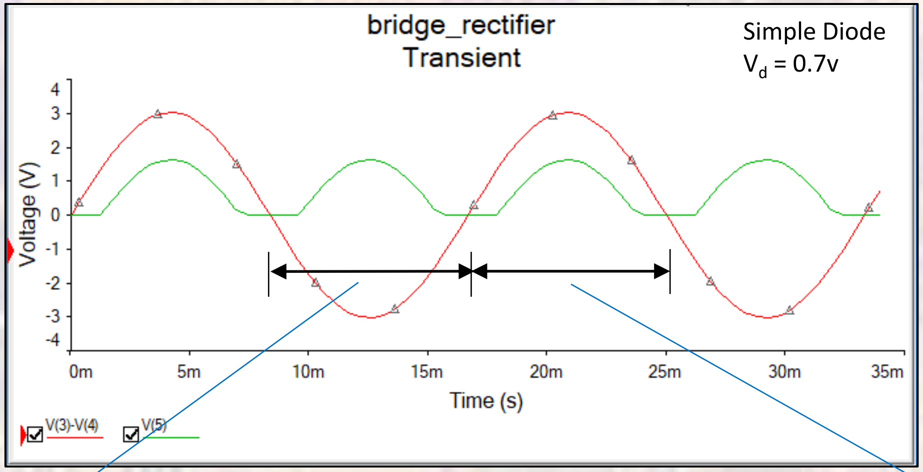




Full-Wave Rectifier

- Bridge Rectifier



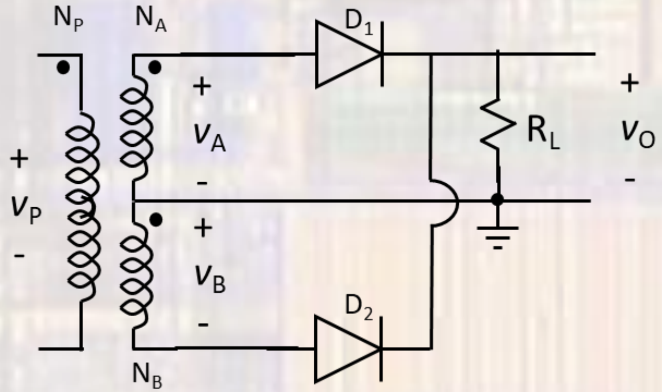


Reversed biased region D1,D2
$v_D max = -v_S peak / 2$
→ breakdown requirement

Forward biased region D1, D2
$i_D max = (v_S peak – 2v_D)/R$
→ current requirement

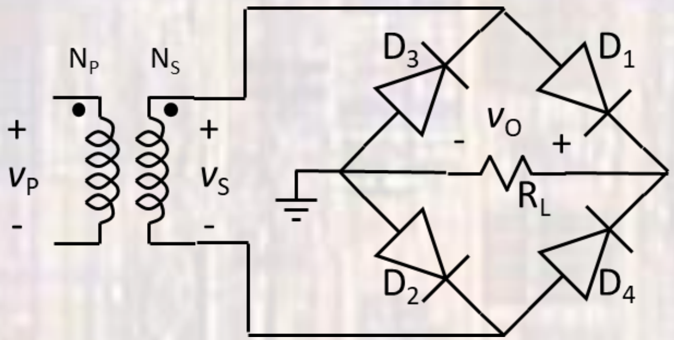
Full-Wave Rectifier

- Comparison



Lower voltage drop – 1 v_D
Fewer active components – 2 diodes
More complex transformer - $$

transformer - $16
diodes - $0.10

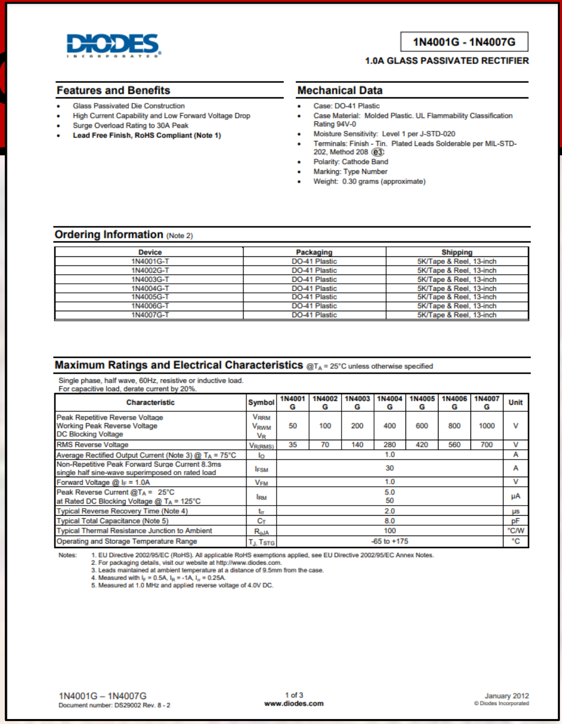


Higher voltage drop – 2 v_D
More active components – 4 diodes
Less complex transformer - $

transformer - $10
diodes - $0.20

Full-Wave Rec

- Real world



DIODES INCORPORATED

1N4001G - 1N4007G

1.0A GLASS PASSIVATED RECTIFIER

Features and Benefits

- Glass Passivated Die Construction
- High Current Capability and Low Forward Voltage Drop
- Surge Overload Rating to 30A Peak
- **Lead Free Finish, RoHS Compliant (Note 1)**

Mechanical Data

- Case: DO-41 Plastic
- Case Material: Molded Plastic. UL Flammability Classification Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish - Tin. Plated Leads Solderable per MIL-STD-202, Method 208 (e3)
- Polarity: Cathode Band
- Marking: Type Number
- Weight: 0.30 grams (approximate)

Ordering Information (Note 2)

Device	Packaging	Shipping
1N4001G-T	DO-41 Plastic	5K/Tape & Reel, 13-inch
1N4002G-T	DO-41 Plastic	5K/Tape & Reel, 13-inch
1N4003G-T	DO-41 Plastic	5K/Tape & Reel, 13-inch
1N4004G-T	DO-41 Plastic	5K/Tape & Reel, 13-inch
1N4005G-T	DO-41 Plastic	5K/Tape & Reel, 13-inch
1N4006G-T	DO-41 Plastic	5K/Tape & Reel, 13-inch
1N4007G-T	DO-41 Plastic	5K/Tape & Reel, 13-inch

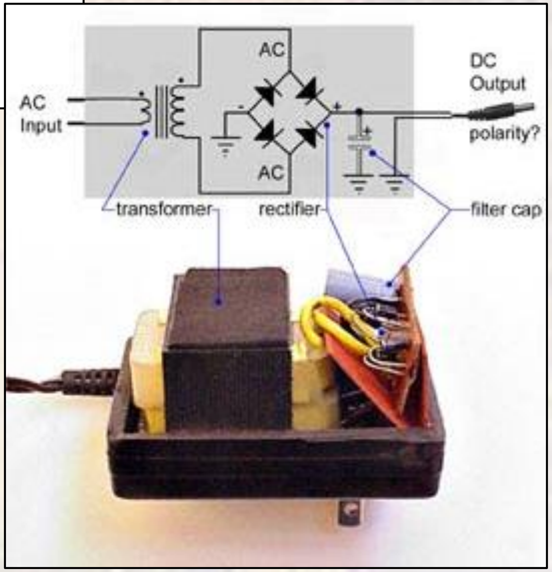
Maximum Ratings and Electrical Characteristics @T_A = 25°C unless otherwise specified

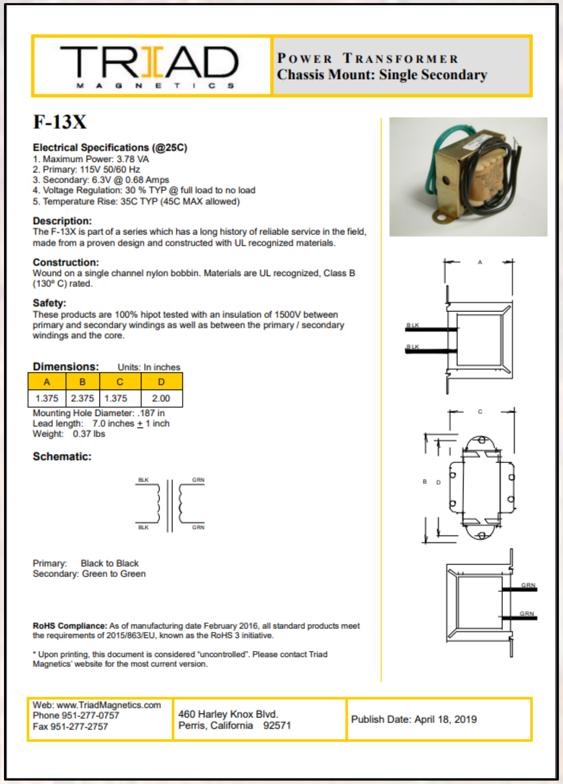
Single phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N4001 G	1N4002 G	1N4003 G	1N4004 G	1N4005 G	1N4006 G	1N4007 G	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
Average Rectified Output Current (Note 3) @ T_A = 75°C	I_O	1.0							A
Non-Repetitive Peak Forward Surge Current 8.3ms single half sine-wave superimposed on rated load	I_{FSM}	30							A
Forward Voltage @ I_F = 1.0A	V_{FM}	1.0							V
Peak Reverse Current @T_A = 25°C at Rated DC Blocking Voltage @ T_A = 125°C	I_{RM}	5.0 50							µA
Typical Reverse Recovery Time (Note 4)	t_{rr}	2.0							µs
Typical Total Capacitance (Note 5)	C_T	8.0							pF
Typical Thermal Resistance Junction to Ambient	$R_{\theta JA}$	100							°C/W
Operating and Storage Temperature Range	T_J, T_{STG}	-65 to +175							°C

Notes:
1. EU Directive 2002/95/EC (RoHS). All applicable RoHS exemptions applied, see EU Directive 2002/95/EC Annex Notes.
2. For packaging details, visit our website at http://www.diodes.com.
3. Leads maintained at ambient temperature at a distance of 9.5mm from the case.
4. Measured with I_F = 0.5A, I_R = -1A, I_{rr} = 0.25A.
5. Measured at 1.0 MHz and applied reverse voltage of 4.0V DC.

1N4001G – 1N4007G
Document number: DS29002 Rev. 8 - 2
1 of 3
www.diodes.com
January 2012
© Diodes Incorporated





TRIAD MAGNETICS

Power Transformer
Chassis Mount: Single Secondary

F-13X

Electrical Specifications (@25C)
1. Maximum Power: 3.78 VA
2. Primary: 115V 50/60 Hz
3. Secondary: 6.3V @ 0.68 Amps
4. Voltage Regulation: 30 % TYP @ full load to no load
5. Temperature Rise: 35C TYP (45C MAX allowed)

Description:
The F-13X is part of a series which has a long history of reliable service in the field, made from a proven design and constructed with UL recognized materials.

Construction:
Wound on a single channel nylon bobbin. Materials are UL recognized, Class B (130º C) rated.

Safety:
These products are 100% hipot tested with an insulation of 1500V between primary and secondary windings as well as between the primary / secondary windings and the core.

Dimensions: Units: In inches

A	B	C	D
1.375	2.375	1.375	2.00

Mounting Hole Diameter: .187 in
Lead length: 7.0 inches ± 1 inch
Weight: 0.37 lbs

Schematic:

BLK GRN
BLK GRN

Primary: Black to Black
Secondary: Green to Green

RoHS Compliance: As of manufacturing date February 2016, all standard products meet the requirements of 2015/863/EU, known as the RoHS 3 initiative.

* Upon printing, this document is considered "uncontrolled". Please contact Triad Magnetics' website for the most current version.

Web: www.TriadMagnetics.com
Phone 951-277-0757
Fax 951-277-2757

460 Harley Knox Blvd.
Perris, California 92571

Publish Date: April 18, 2019