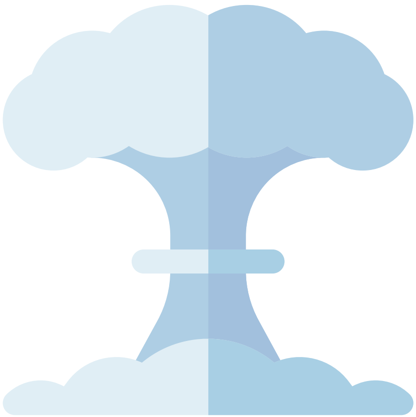

Blue Smoke Team
Hardware Project

Paul Brown
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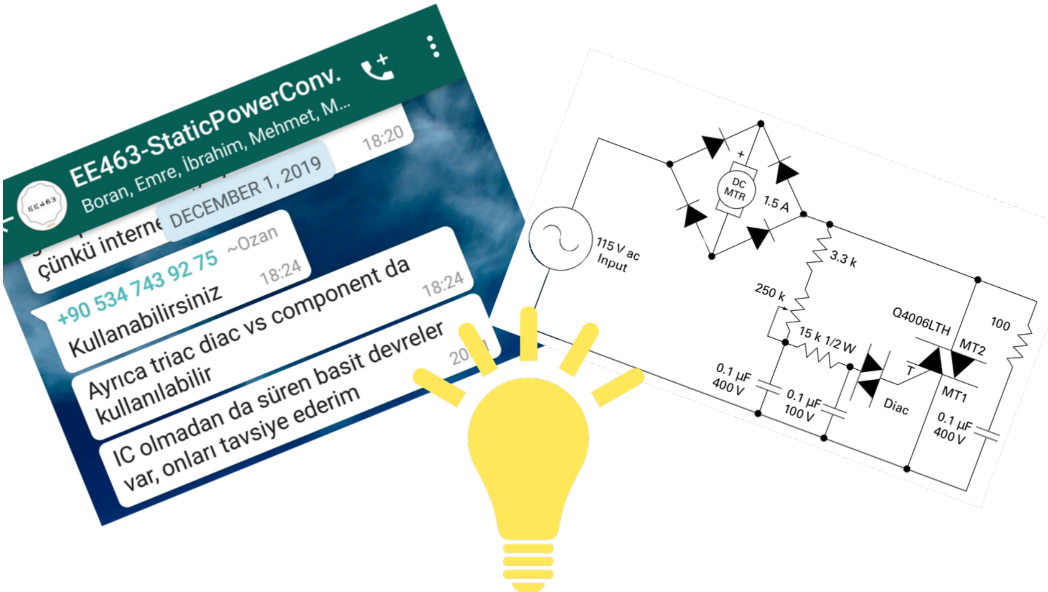
11 December 2019

Topology Options Considered

1. Three-phase thyristor rectifier (SCR)
2. Three-phase diode rectifier + buck converter
3. Single-phase thyristor rectifier (SCR)
4. Single-Phase Diac-Controlled Triac Rectifer

Single-Phase Diac-Controlled Triac Rectifer



Single-Phase Diac-Controlled Triac Rectifer

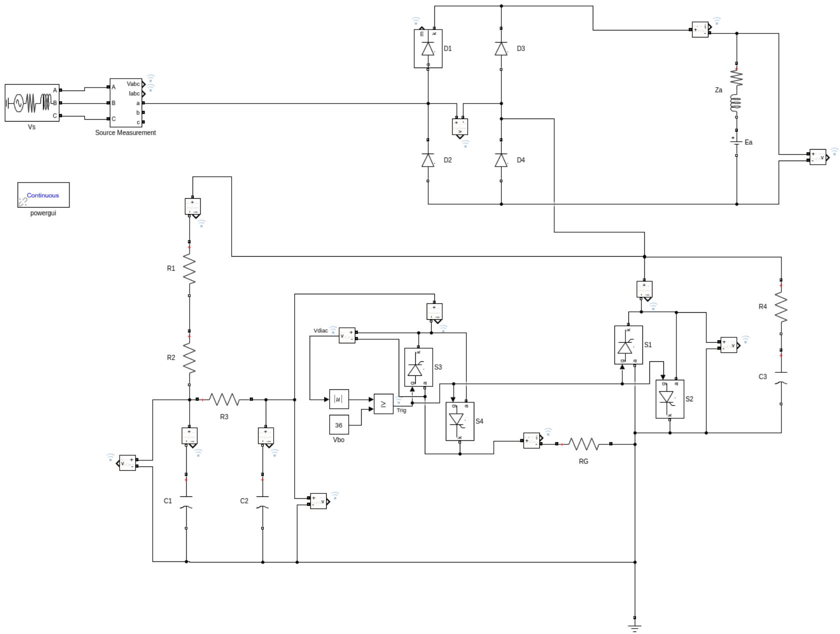
Advantages

- Circuit is very simple with few components (simplicity bonus!)
- Single control circuit needed
- Different from other groups in the past
- Recommended by prof. - practically guaranteed to work!!

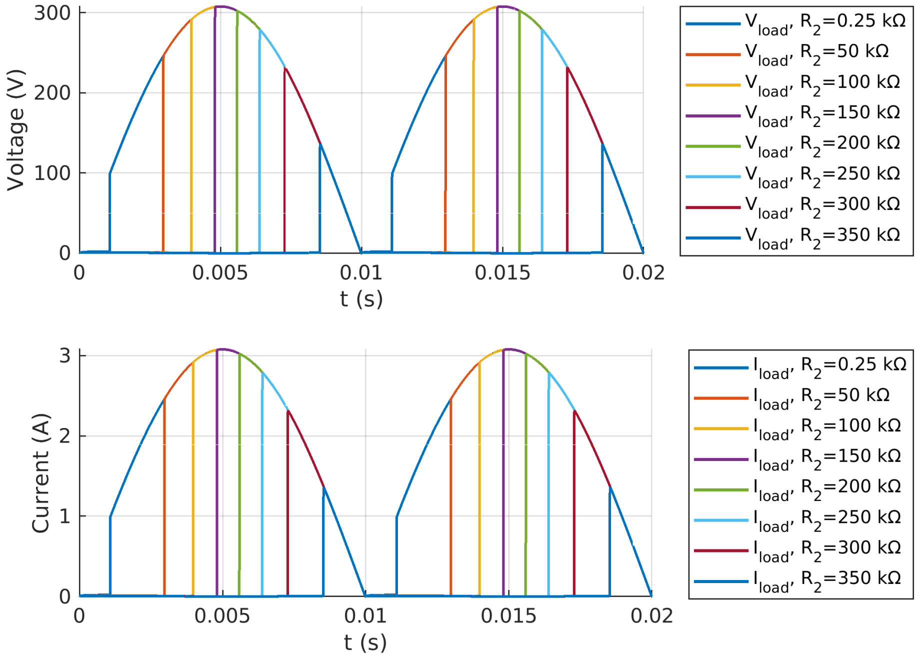
Disadvantages

- "Snap on" at maximum firing angle
- Introduction of feedback control difficult to incorporate

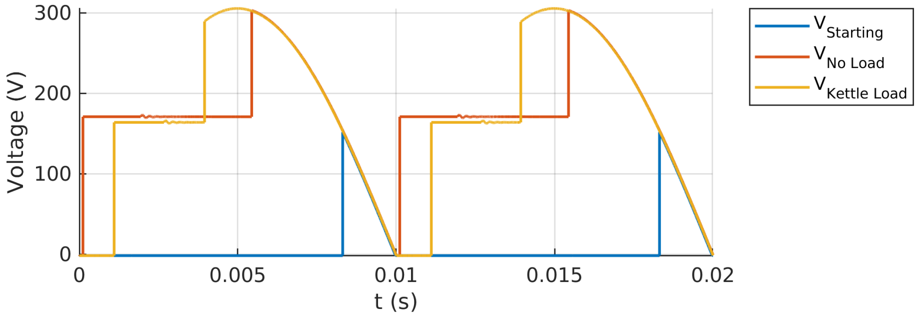
Simulation Model

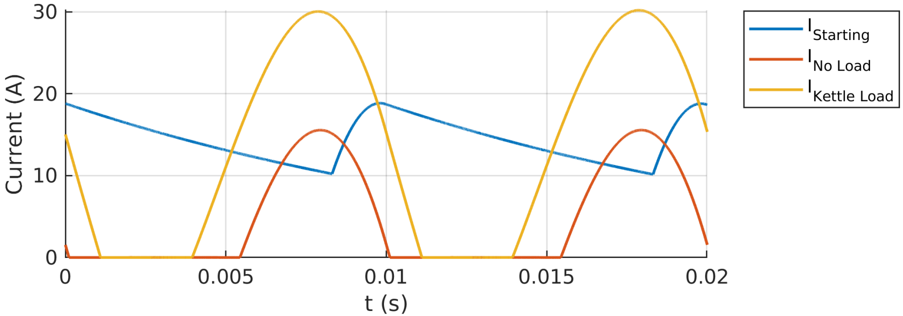


Simulation Results



Simulation Results





Input Side Simulation Summary

Load	R_2 (kΩ)	V_{IN} (V_{RMS})	I_{IN} (A_{RMS})	P_{IN} (W)	Q_{IN} (var)	S_{IN} (VA)	PF	I_{IN} THD (%)
Starting	190	219.8	7.07	199.3	1541	1554	0.13	133.5
No Load	25	219.5	7.68	878.1	1439	1686	0.52	66.62
Kettle Load	20	218.8	17.64	2505	2936	3859	0.65	40.31

Input current THD is high, especially at high firing angle.

Output Side Simulation Summary

Load	V_{OUT} (V_{AVG})	V_{OUT} Ripple	I_{OUT} (A_{AVG})	I_{OUT} Ripple	P_{OUT} (W)	Efficiency (%)
Starting	11.47	153.4	14.46	8.69	170.9	85.76
No Load	174.8	304.8	4.77	15.56	863	98.27
Kettle Load	175	307.1	13.45	30.2	2463	98.33

Simulation Key Diode Values

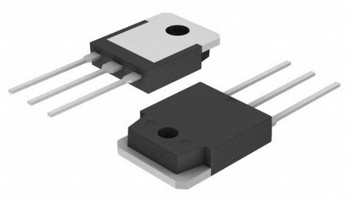
Load	I_{avg} (A)	I_{RMS} (A)	V_{MAX} (V)	P_{Loss} (W)
Starting	7.23	8.16	152.6	5.85
No Load	2.39	5.43	304	1.94
Kettle Load	6.7	12.49	306.3	5.52

Diode bridge, 1000V, 35A

Simulation Key Triac Values

Load	I_{avg} (A)	I_{RMS} (A)	V_{MAX} (V)	P_{Loss} (W)
Starting	3.04	7.07	311.1	4.61
No Load	4.77	7.68	138.6	7.21
Kettle Load	12.84	17.64	128.8	19.57

Triac 600V, 25A



Simulation Key Capacitor Values

Load	C_1 I_{RMS} (A)	C_1 V_{MAX} (V)	C_2 I_{RMS} (A)	C_2 V_{MAX} (V)
Starting	0.95	42.67	2.39	36
No Load	1.64	59.79	2.38	36
Kettle Load	1.64	56.68	2.38	36

< 60 V (But Littlefuse application note lists 400 V & 100 V)

Capacitor, polyester 100nF 400V for C_1 & C_2

Simulation Key Resistor Values

Load	R_1 I_{RMS} (mA)	R_1 P (mW)	R_2 I_{RMS} (mA)	R_2 P (mW)	R_3 I_{RMS} (mA)	R_3 P (mW)
Starting	1.04	1.08	1.04	205.3	0.82	10.05
No Load	1.77	3.12	1.77	78.09	1.03	15.82
Kettle Load	1.73	3	1.73	60.06	0.94	13.35

All < 1/4 W. (But Littlefuse application note recommends 1/2 W for R_3)

Project Plan

- Complete bill of material
- Procure components (Direnc.net + Konya Sokak)
- Build prototype
- Test on increasing loads (load bank ⇒ motor)
- Troubleshoot & modify prototype as needed
- Once working prototype is obtained, as time allows
    - Consider modifications for feedback in firing circuit
    - Add remaining touches like enclosure, PCB, etc

Credits

Nuclear explosion logo made by Freepik from Flaticon.com

Idea Bulb by Subhashish Panigrahi, derived from "Light Bulb" by Ian Mawle from The Noun Project. CC BY-SA 3.0