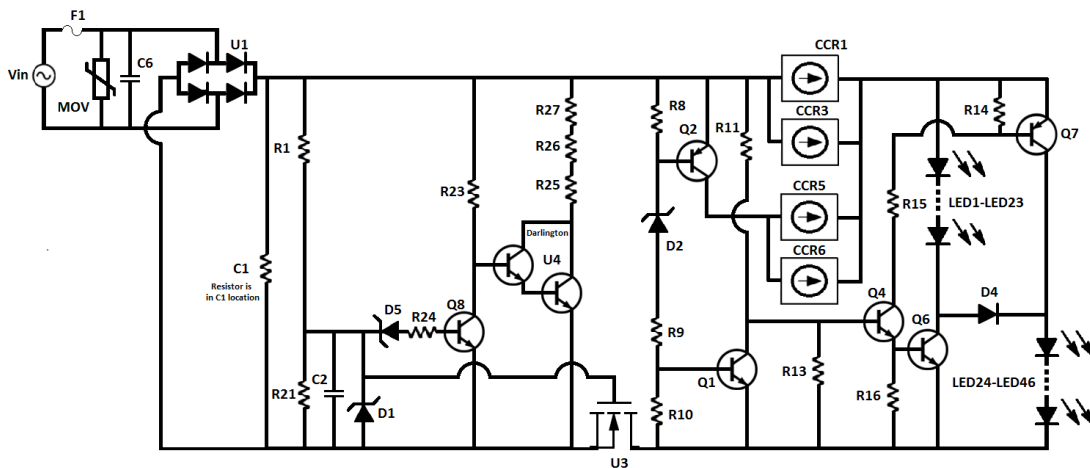




Constant Current Regulator LED Circuit Enhanced for TRIAC Dimmability

ON Semiconductor

Application	Input Voltage	Topology	Output Power	Input Power	Efficiency
LED Lighting, AC	110 to 130 Vac	Parallel-to-Series	9.0 W	11.7 W	77%



Key Features

- No electrolytic capacitors; all components are surface mount except for one capacitor (C6 film capacitor)
- 0.98 power factor and 17% THD
- Prevents dimming issues like flash-on and off-state leakage to the LEDs
- Total LED voltage needs to be 135 to 145 V for best efficiency

Circuit Performance Data

Specification	110 V _{AC}	120 V _{AC}	130 V _{AC}
I _{RMS(out)} (mA)	72.8	85.4	92.0
Power Factor	0.978	0.980	0.984
THD _{Total} (I _{RMS} , %)	19.2	16.6	14.3
Input Power (W)	9.68	11.7	13.3
LED Power (W)	7.41	8.99	9.95
Efficiency (%)	77	77	75

Circuit Operation and Description

This circuit is a sophisticated variation on the LED lighting circuits described in design notes DN05084 and DN05088. It runs on 120 VAC and uses several special design features to optimize the dimming performance. The LED voltages should be between 60 and 68 volts per string during operation.

While the circuits in DN05084 and DN05088 are also TRIAC dimmable, this circuit suppresses the “flash-on” phenomenon that is observed with some dimmers. The flash-on is a description for light appearing immediately after the dimmer is turned on, followed by a sub one second period of darkness, and then full brightness thereafter.

In order to reduce or eliminate the flash-on, the circuit does two things. Essentially the circuit initially provides a dummy load, then switches in the real LEDs after the dimmer has had time to begin normal operation. First, the circuit temporarily separates the LEDs from the supply voltage with a switching mechanism comprising 4 transistors and two diodes. U3, a high voltage NFET, is controlled by the R1 and R21 voltage divider and the C2 timing capacitor. When the input voltage has been high enough to charge C2, the MOSFET turns on.

The second thing the circuit does to suppress the dimming issues is draw current through a bleeder path. This causes allows the dimmer to start while U3 is keeping the LEDs off. Once C2 charges up and D5 and Q8 turn on, then the temporary bleeding current through Q4 is stopped.

The actual LED driving portion of the circuit is set up in a similar manner to DN05084 and DN05088. The LEDs alternate between a parallel and series configuration depending on the instantaneous AC input voltage. This allows the circuit to achieve THD below 20% and power factor above 0.97. It also enables TRIAC dimming because the LEDs are running even at relatively low LED voltages.

Bill of Materials

Designator	Quantity	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed
R1,R14, R16, R24	5	Resistor SMD	100k, 1/8th W	5%	0805	Any	Any	Yes
R8	1	Resistor SMD	402, 1/8th W	1%	0805	Any	Any	Yes
R9	1	Resistor SMD	45.3k, 1/8th W	1%	0805	Any	Any	Yes
R10	1	Resistor SMD	374, 1/8th W	1%	0805	Any	Any	Yes
R11,R21,R23	3	Resistor SMD	510k, 1/8th W	5%	0805	Any	Any	Yes
R13	1	Resistor SMD	10k, 1/8th W	5%	0805	Any	Any	Yes
R15	1	Resistor SMD	51k, 1/8th W	5%	0805	Any	Any	Yes
R25, R26,R27	3	Resistor SMD	1.2k, 1 W	5%	2512	Any	Any	Yes
C1 (Resistor)	1	Resistor SMD	243k, 1/8th W	5%	0805	Any	Any	Yes
C2	1	Capacitor SMD	10 μ F, 50 V	10%	0805	Any	Any	Yes
C6	1	X2 Film Capacitor	220 nF, 275 VAC	10%	Through Hole	Würth Electronics Inc	890324023028	Yes
U1	1	Bridge Rectifier	600 V	N/A	TO-269AA	Vishay	MB6S-E3/80	Yes
U3	1	N-Channel MOSFET	600V	N/A	DPAK	ON Semiconductor	NDD02N60ZT4G	No
U4	1	NPN Darlington	350V 45W	N/A	DPAK	ON Semiconductor	NJD35N04G	No
D1	1	Diode SMD	24V	5%	SOD-123	ON Semiconductor	MMSZ5252BT1G	No
D2	1	Diode SMD	62 V	5%	SOD-123	ON Semiconductor	MMSZ5265BT1G	No
D4	1	Diode SMD	250 V	N/A	SOD-23	ON Semiconductor	BAS21L	No
D5	1	Diode SMD	18V	N/A	SOD-323	ON Semiconductor	MMSZ5248BT1G	No
L1-L46	46	SMD LED	3V	N/A	SMD	Samsung	SPMWH541MD5WAT 0S3	Yes

DN05098/D

Q1	1	NPN Bipolar Transistor SMD	N/A	N/A	SOT-23	ON Semiconductor	MMBT3904LT1G	No
Q2	1	PNP Bipolar Transistor SMD	N/A	N/A	SOT-23	ON Semiconductor	MMBTA56LT1G	No
Q4, Q8	1	NPN Bipolar Transistor SMD	N/A	N/A	SOT-23	ON Semiconductor	MMBTA42LT1G	No
Q6	1	NPN Bipolar Transistor SMD	N/A	N/A	SOT-23	ON Semiconductor	NSS1C201LT1G	No
Q7	1	PNP Bipolar Transistor SMD	N/A	N/A	SOT-23	ON Semiconductor	NSS1C200LT1G	No
CCR1	1	Constant Current Regulator SMD	120V, 50mA	15%	SMB	ON Semiconductor	NSIC2050JB	No
CCR3, CCR5, CCR6	3	Constant Current Regulator SMD	120V, 30mA	15%	SMB	ON Semiconductor	NSIC2030JB	No
F1	1	Fuse SMD	1.5A, 250V	N/A	2-SMD	Littelfuse	044301.5DR	Yes
MOV1	1	Varistor SMD	198V,	N/A	2-SMD	Littelfuse	V220CH8T	Yes

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Design note created by Andrew Niles and Dmitri Mihailov