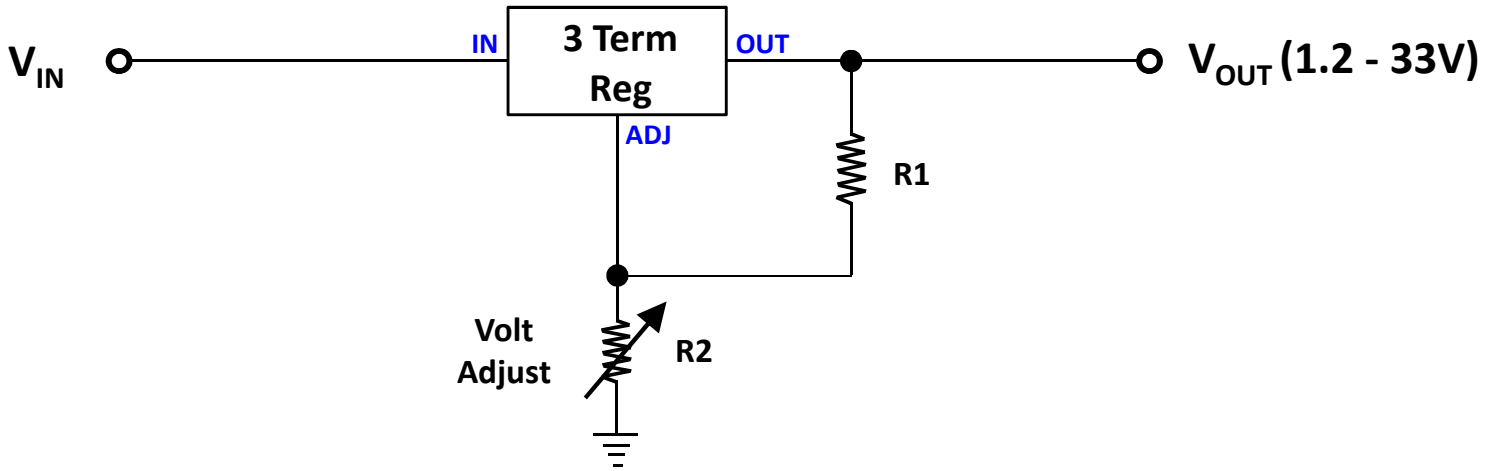
Three Terminal Regulators & Overvoltage Protection

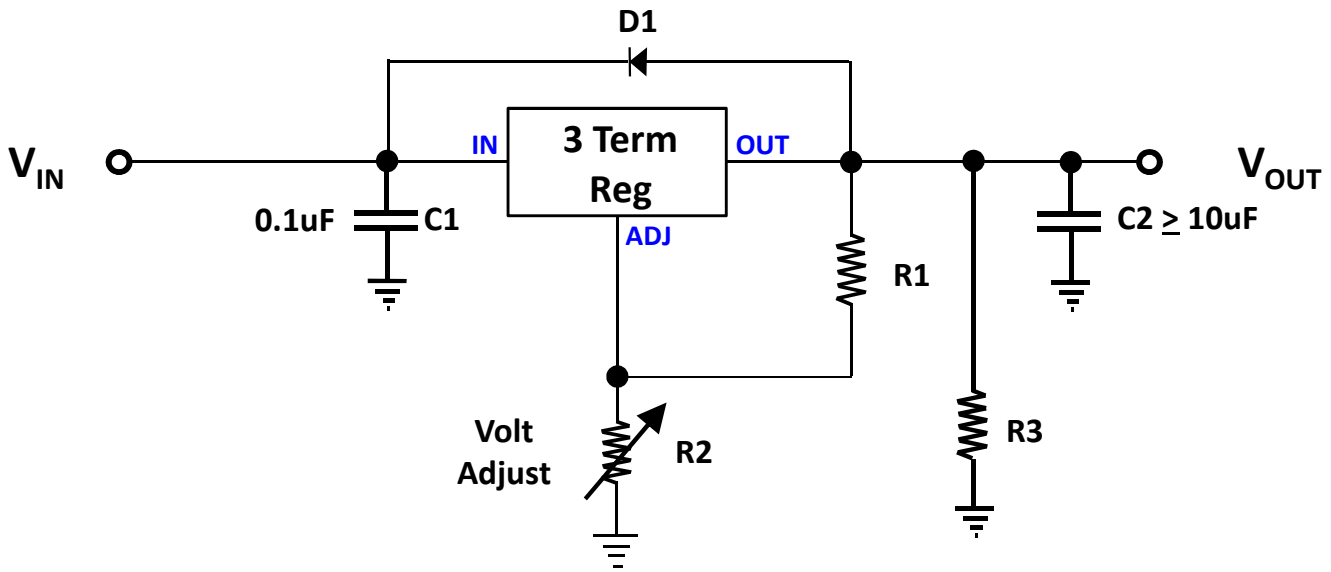
Bill Leonard N0CU

Three Terminal Regulators 101



- Current & power dissipation limits vary with P/N & case style
- Available for both positive and negative supplies
- Maximum current is internally limited
- Case temperature is internally limited
- $V_{OUT} = V_{REF} \times (1+R2/R1) \simeq 1.25 \times (1+R2/R1)$
  - $R2 \simeq R1 \times (V_{OUT} - 1.25)/1.25$
  - Recommended **R1 = 240 Ω**
    - **$R2 \simeq 192 \times (V_{OUT} - 1.25)$**
- MANY uses besides voltage regulation (see data sheet)

Three Terminal Regulators - Gotchas

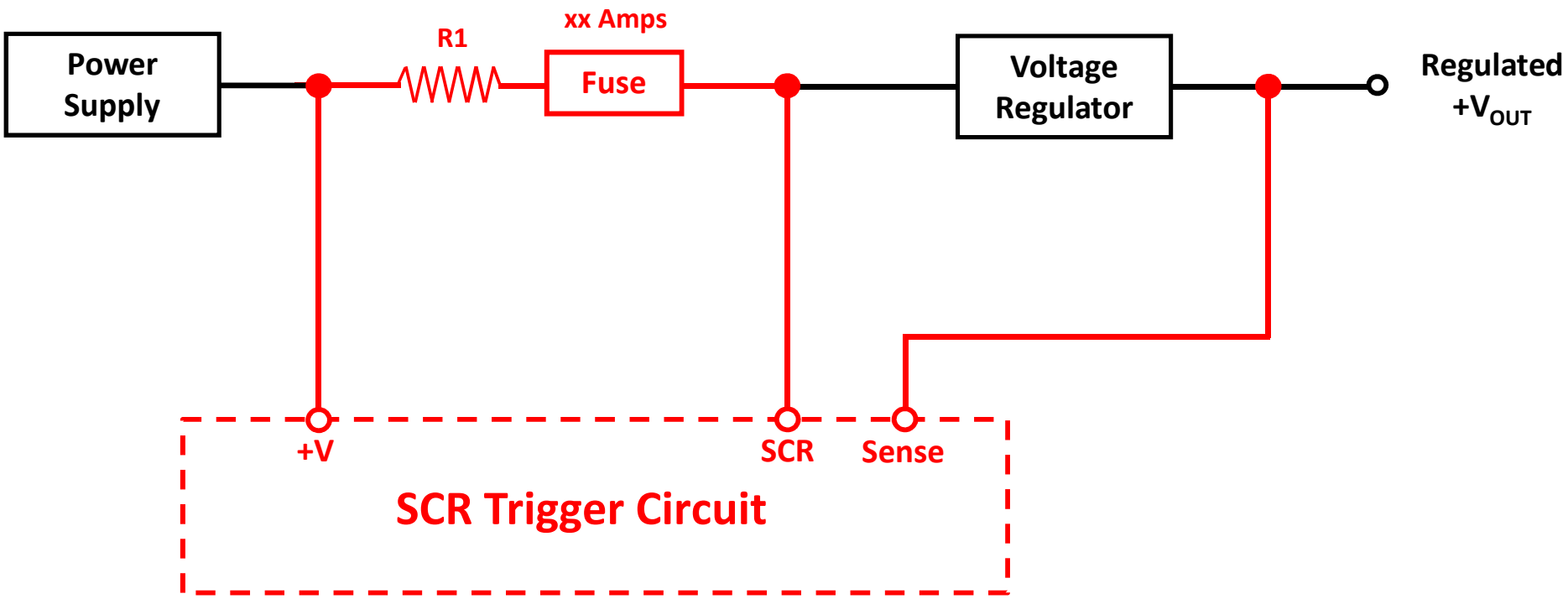


- C1 is needed to insure stability (ie, no oscillations)
- C2 improves transient response
- D1 is needed to protect regulator
- $V_{IN} - V_{OUT} > 2.5$ V (Spec)
- Case is usually connected to V_{OUT}
- R3 may/may not be required
  - I_{OUT} must always be > 10 mA (Spec) for regulation to occur

Why Add Overvoltage Protection (OVP)?

- **Whenever the cost of the load exceeds the cost of OVP**
- **Transients on AC power line**
- **Warranty concerns with new transceivers**
  - **Commercial Power Supplies May Not Have Adequate Protection**
  - From **eHam** reviews: **MFJ-4245MV Switching Power Supply**:
    - "MFJ-4245 is falsely advertising that this power supply has an overvoltage protection per specs....output went to about 35 volts! My IC-735 is now fried."
    - "...my NEW FT950 transceiver was damaged."
    - "...it burned up my 2m Rig..."
    - "***If you touch the output leads together,*** your 13 volt supply suddenly puts out 33 volts."

Typical Overvoltage Protection Approach



Response Time of Fuses

- **Fuses open based upon "energy" dissipated in the fuse**
  - **Ampere squared seconds (I^2t):**

    "The melting, arcing, or clearing integral of a fuse, termed I^2t, is the thermal energy required to melt, arc, or clear a specific current. It can be expressed as melting I^2t, arcing I^2t or the sum of them, clearing I^2t."
- **UL listed or recognized fast acting fuses would typically open within 5 seconds maximum when subjected to 200% to 250% of its rated current.**

Overvoltage Protection Circuit in ARRL Handbook

Crowbar circuit.pdf - Adobe Reader

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3 / 3 150% Tools Sign Comment

From ARRL Handbook 2004 page 11.39

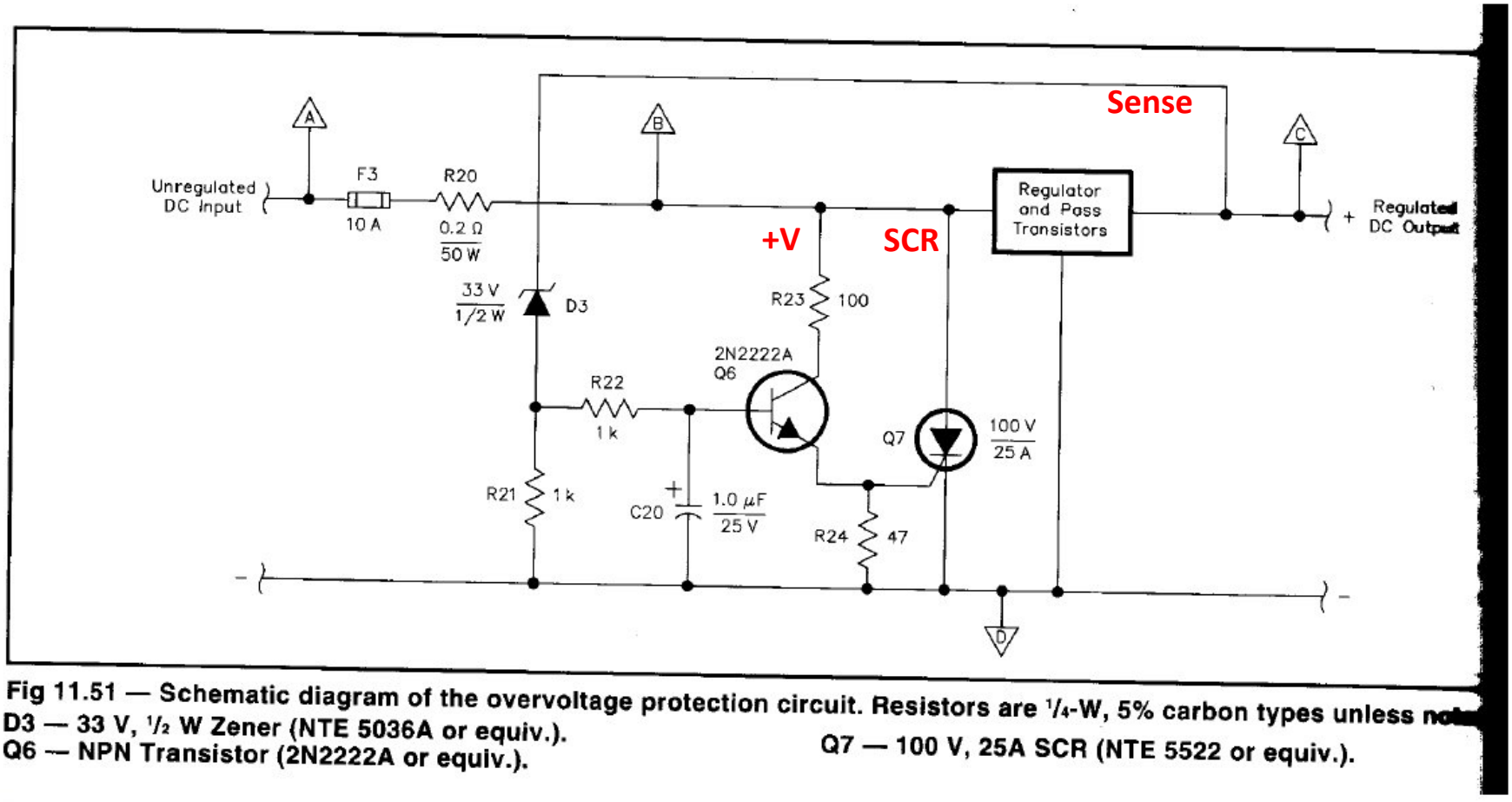

Fig 11.51 — Schematic diagram of the overvoltage protection circuit. Resistors are ¼-W, 5% carbon types unless no

D3 — 33 V, ½ W Zener (NTE 5036A or equiv.).

Q6 — NPN Transistor (2N2222A or equiv.).

Q7 — 100 V, 25A SCR (NTE 5522 or equiv.).

8.50 x 11.00 in

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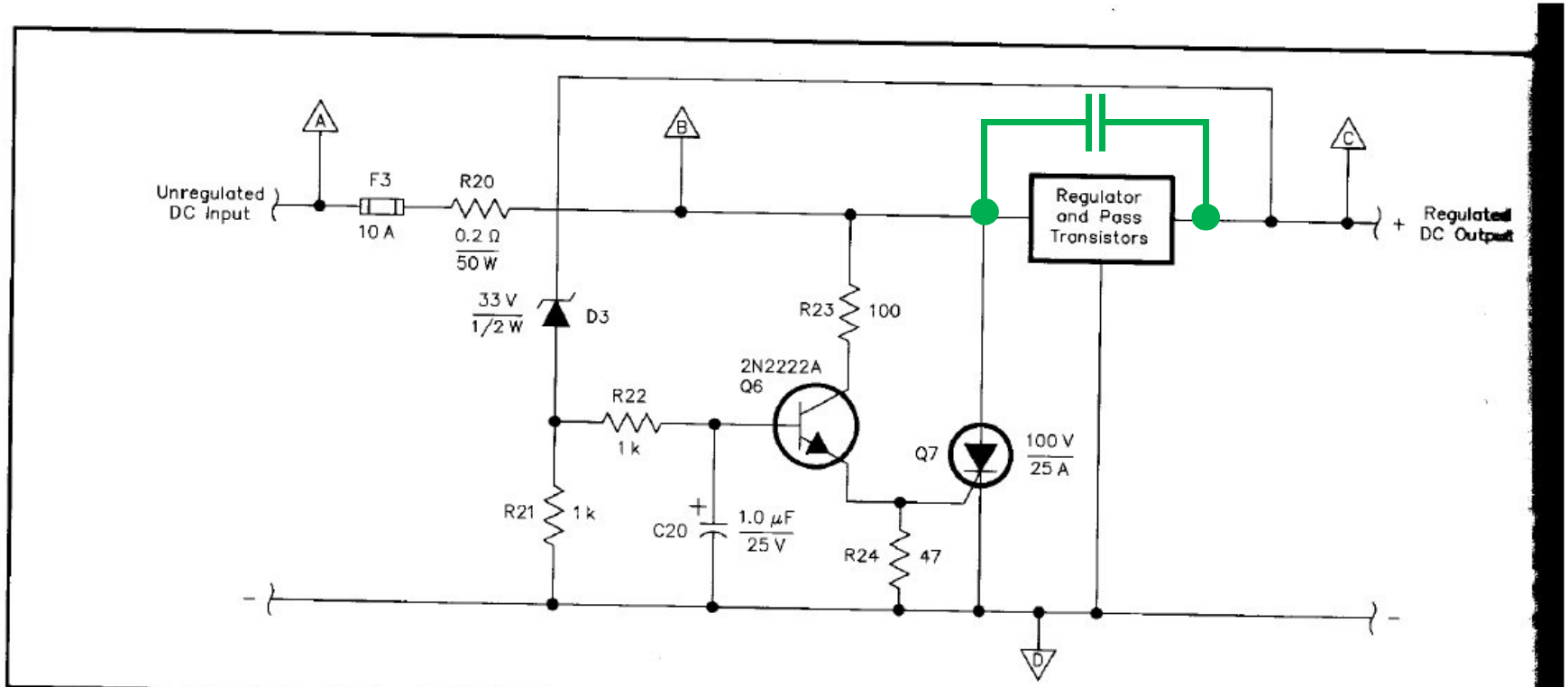

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Problem 1: Transient Feedthru in Voltage Regulators

Transient Feedthru in Voltage Regulators

LM117_317.pdf (SECURED) - Adobe Reader

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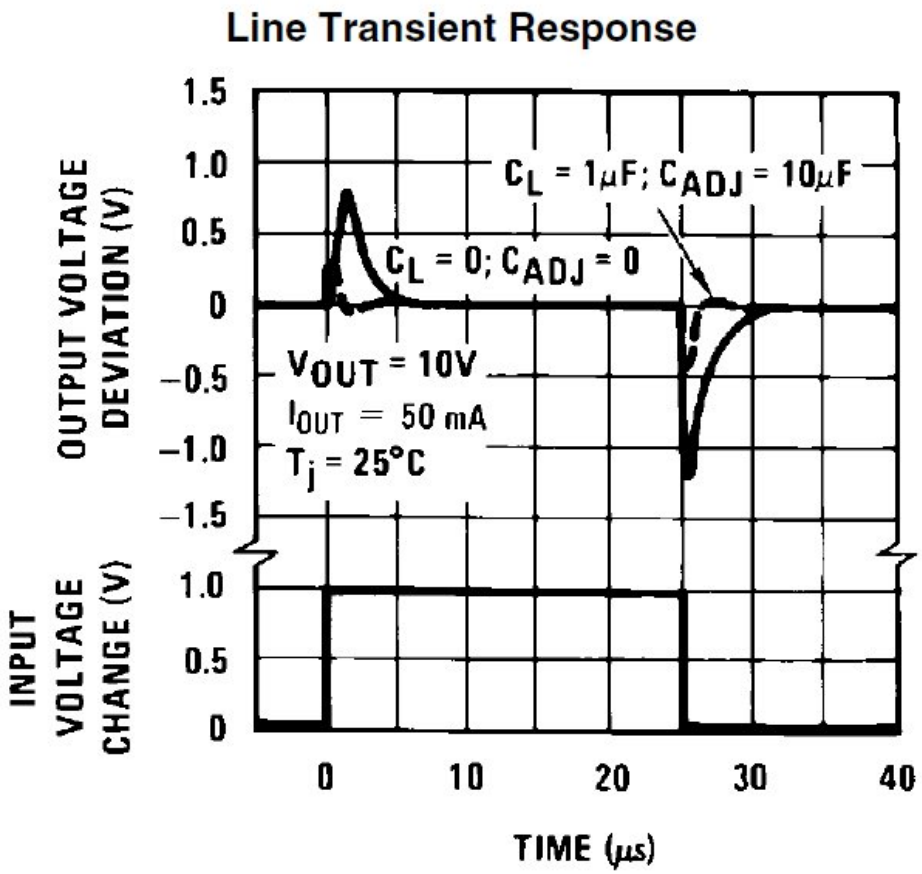
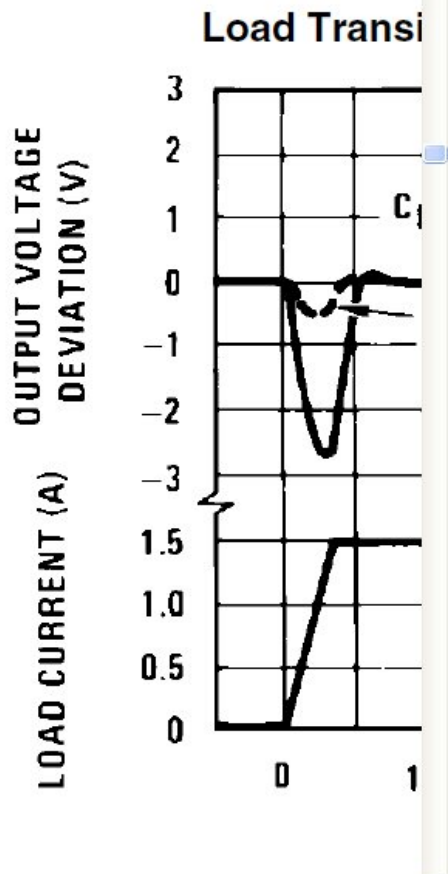
8 / 28 200% Tools Sign Comment

LM117/LM317A/LM317





8.13 x 10.90 in

To Reduce Transient Feedthru in Voltage Regulators

Make (R1 xC1) > 100 usec

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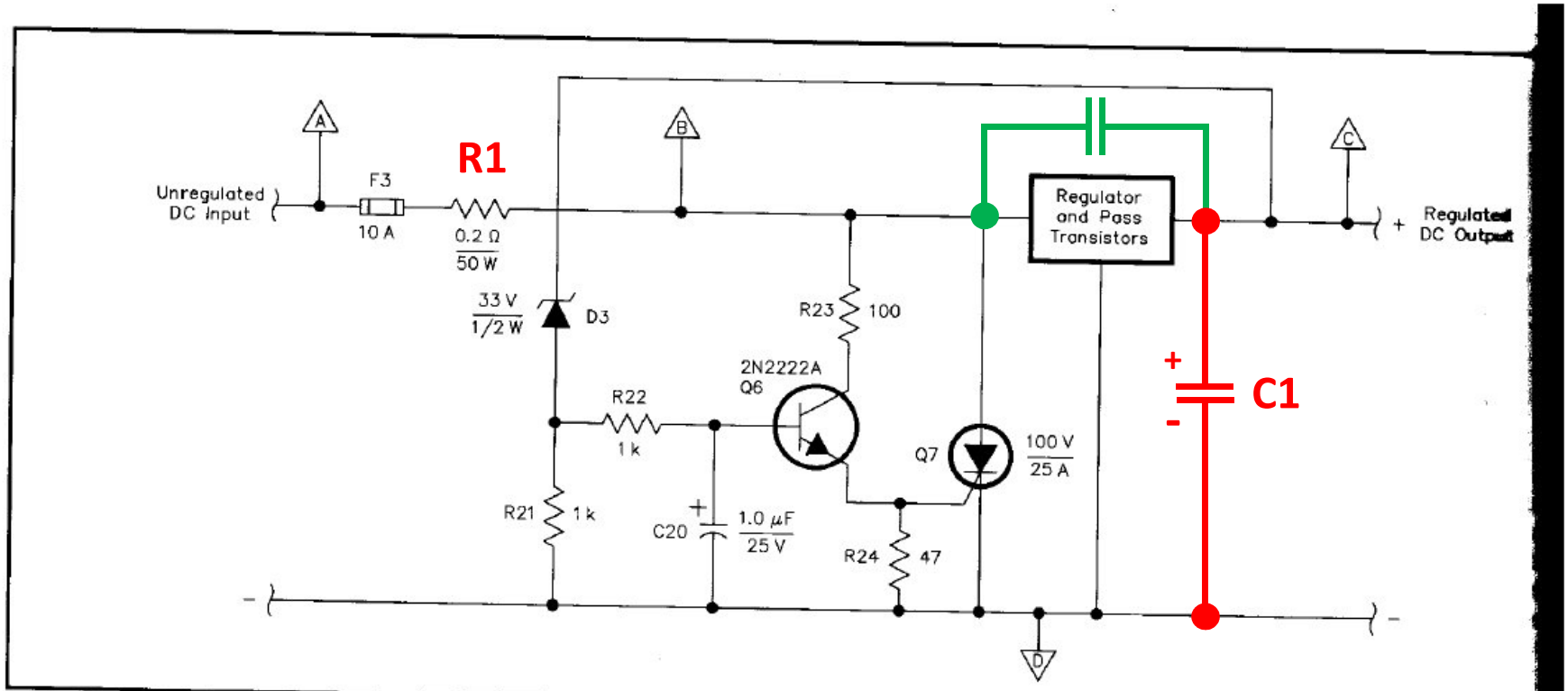

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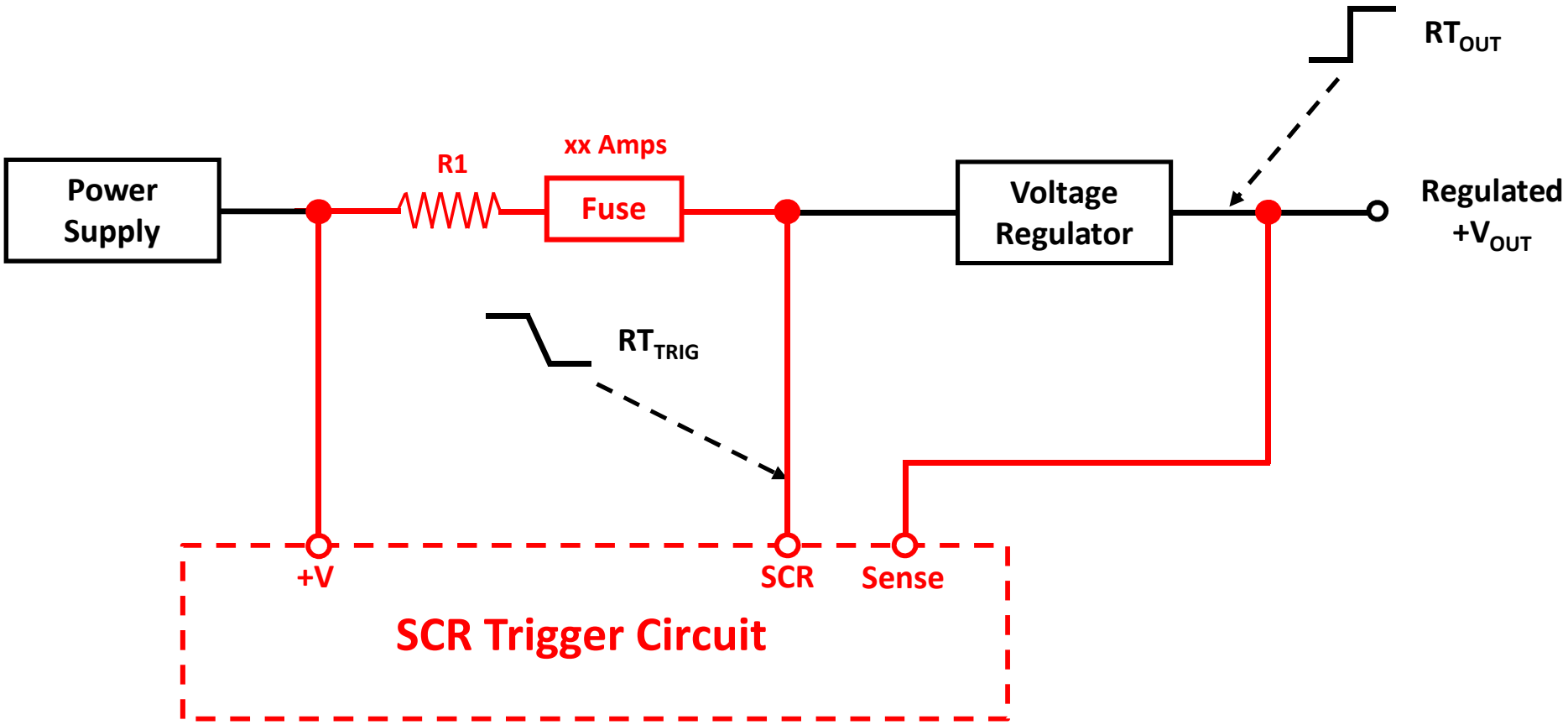
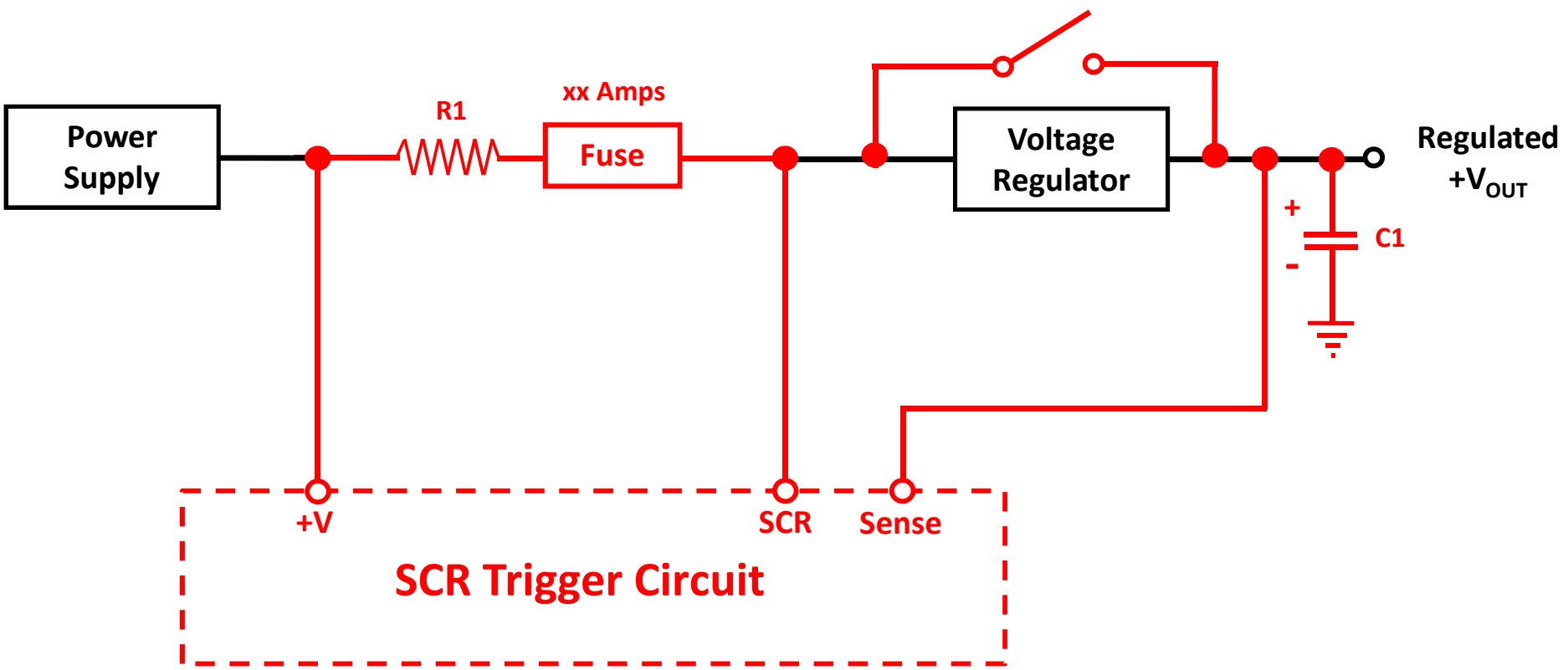


Problem 2: Two critical response times need to be addressed or the protection circuit ***may not protect the load***

- Response Time at +V_{OUT} (RT_{OUT})
- Response Time of the Trigger Circuit (RT_{TRIG})

Response Time At Output (RT_{OUT})



- RT_{OUT} RT1 ≅ R1 x C1
  - No C1 specified => RT1 = R1 x C1 = R1 x 0 = 0

Response Time of the Trigger Circuit (RT_{TRIG})

- $RT_{TRIG} = RT_{SCR} + RT2 \simeq RT_{SCR} + R2 \times C2 \simeq 1\ usec + R2 \times C2$

Crowbar circuit.pdf - Adobe Reader

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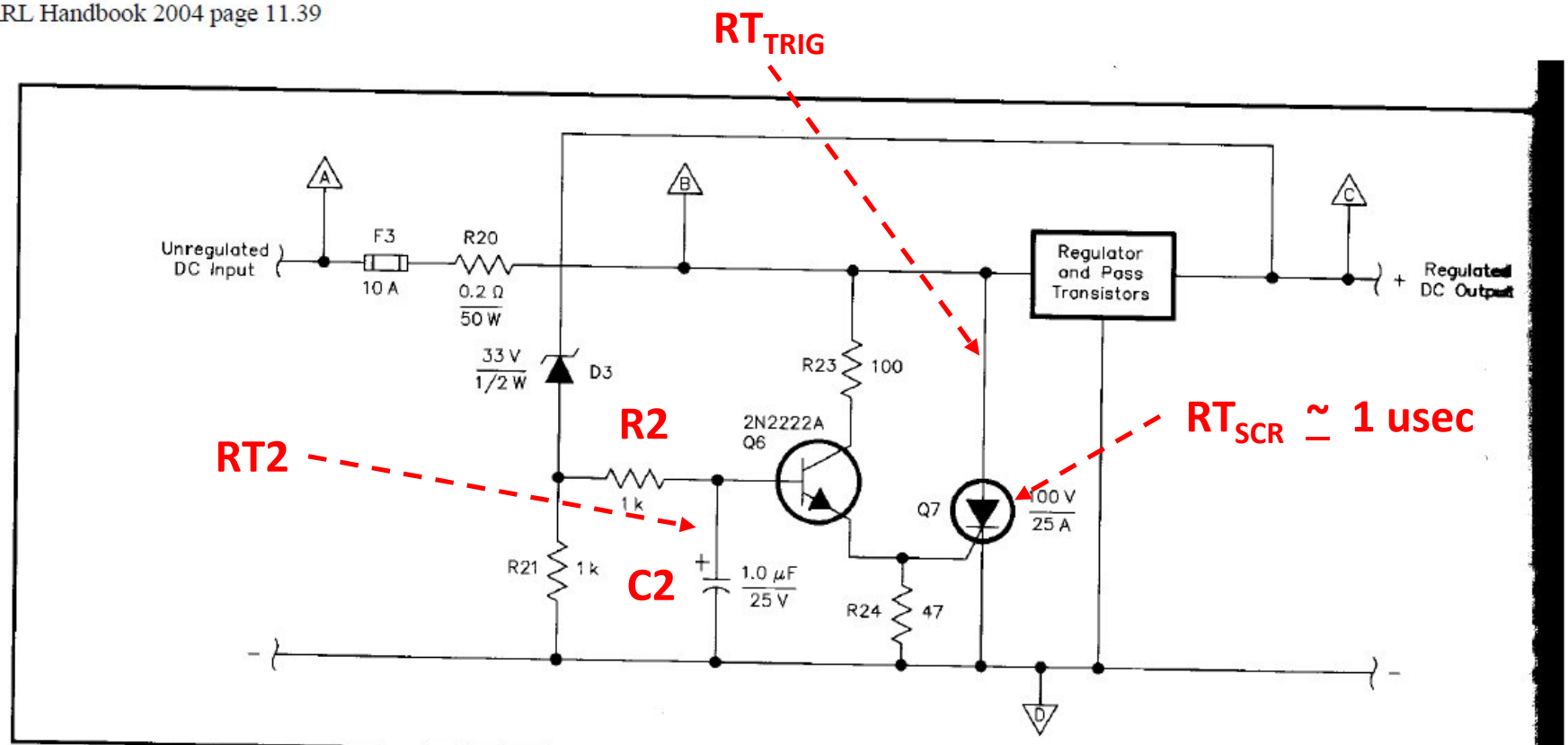

Fig 11.51 — Schematic diagram of the overvoltage protection circuit. Resistors are 1/4-W, 5% carbon types unless no
D3 — 33 V, 1/2 W Zener (NTE 5036A or equiv.).
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Q7 — 100 V, 25A SCR (NTE 5522 or equiv.).

8.50 x 11.00 in

Response Time of the Trigger Circuit (RT_{TRIG})

RT2 ~ R2 x C2 =1000 ohms x 0.000001 Farad = 0.001 sec = 1 msec

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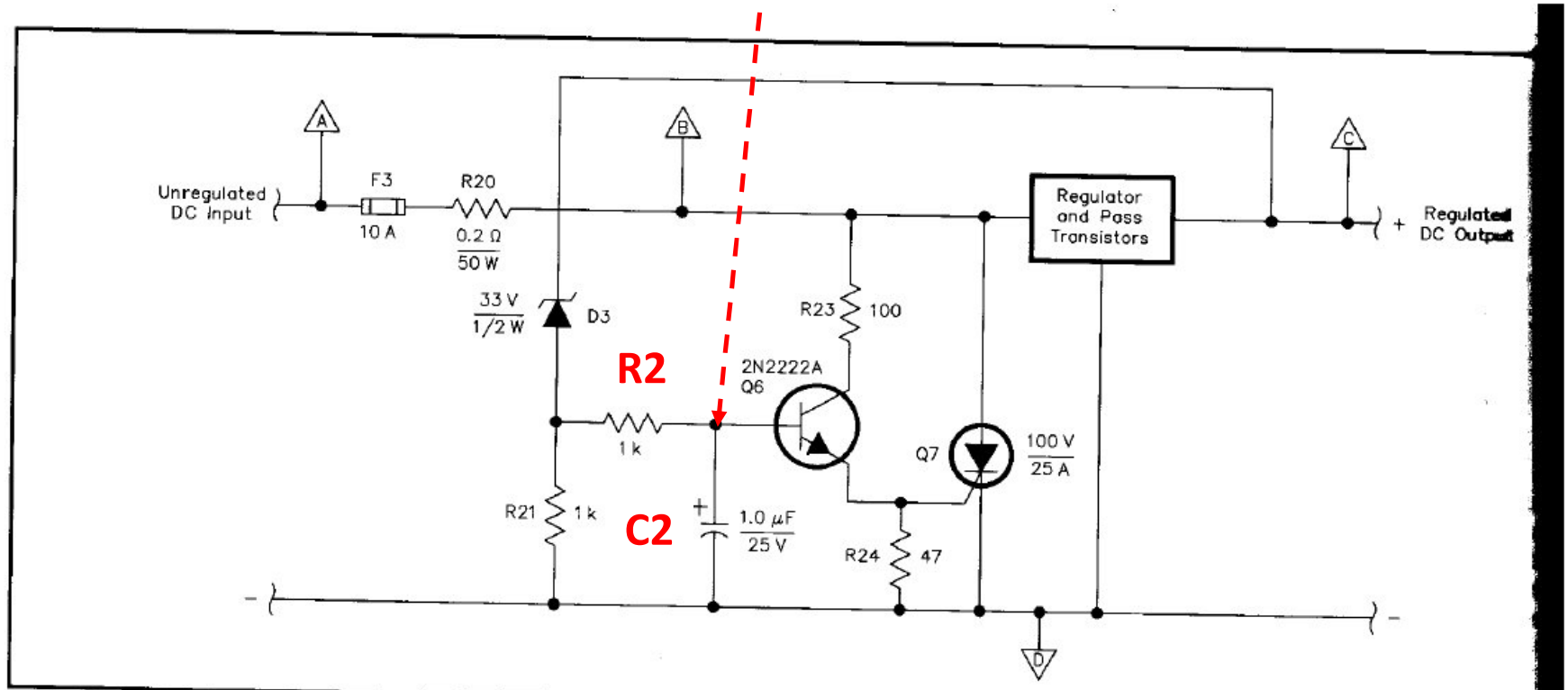

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8.50 x 11.00 in

Response Time of the Trigger Circuit (RT_{TRIG})

RT2 ~ R2 x C2 = 1 usec

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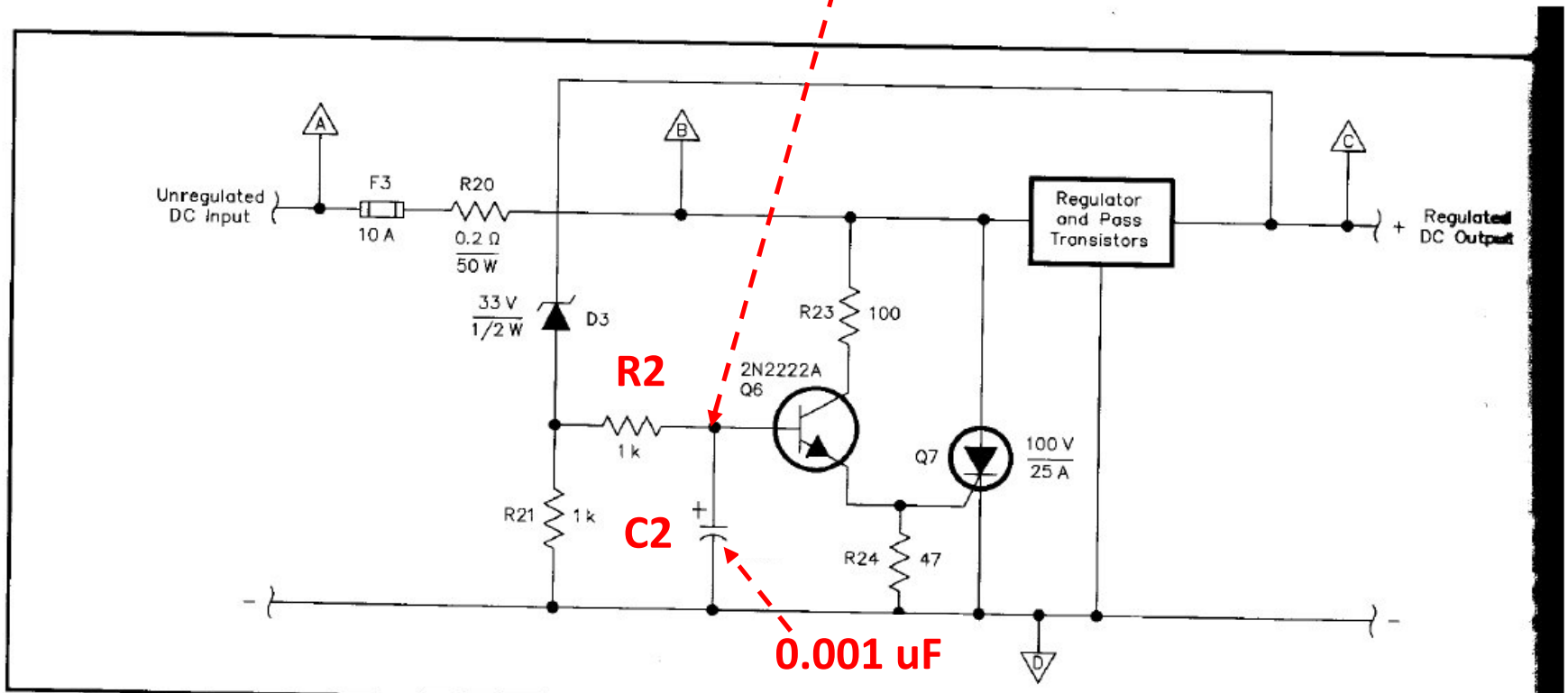

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8.50 x 11.00 in

Design Goal for Response Times

- **RT1 > 10 x RT_{TRIG}**

RT2 ~ 1 usec

RT1 ~ R1 x C1

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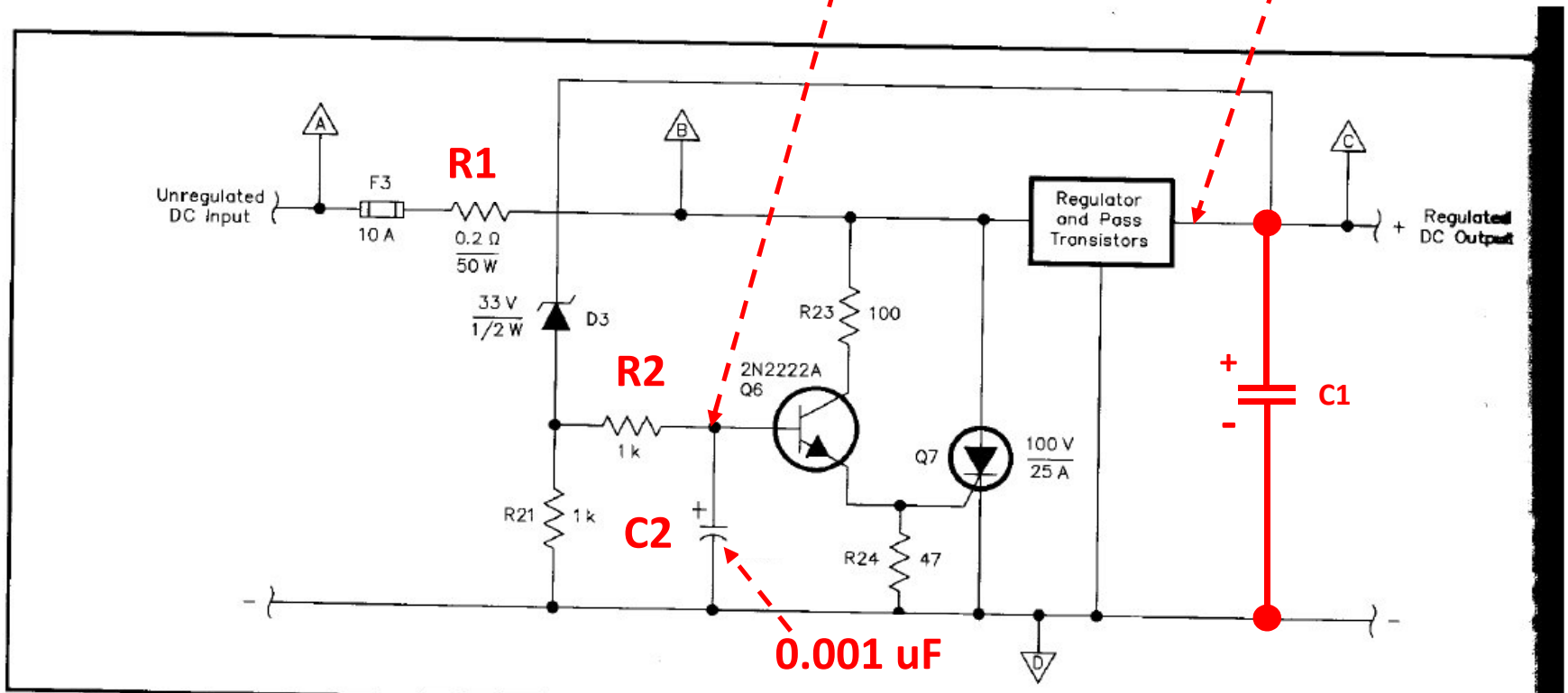

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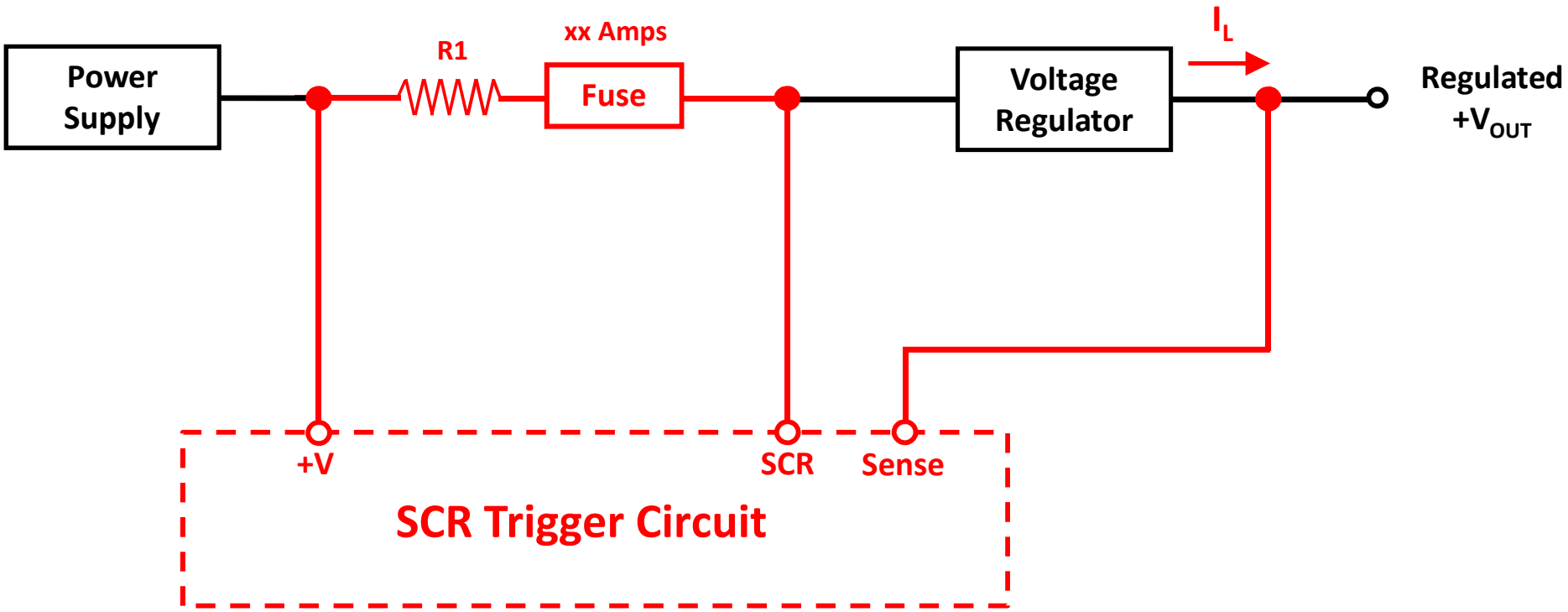
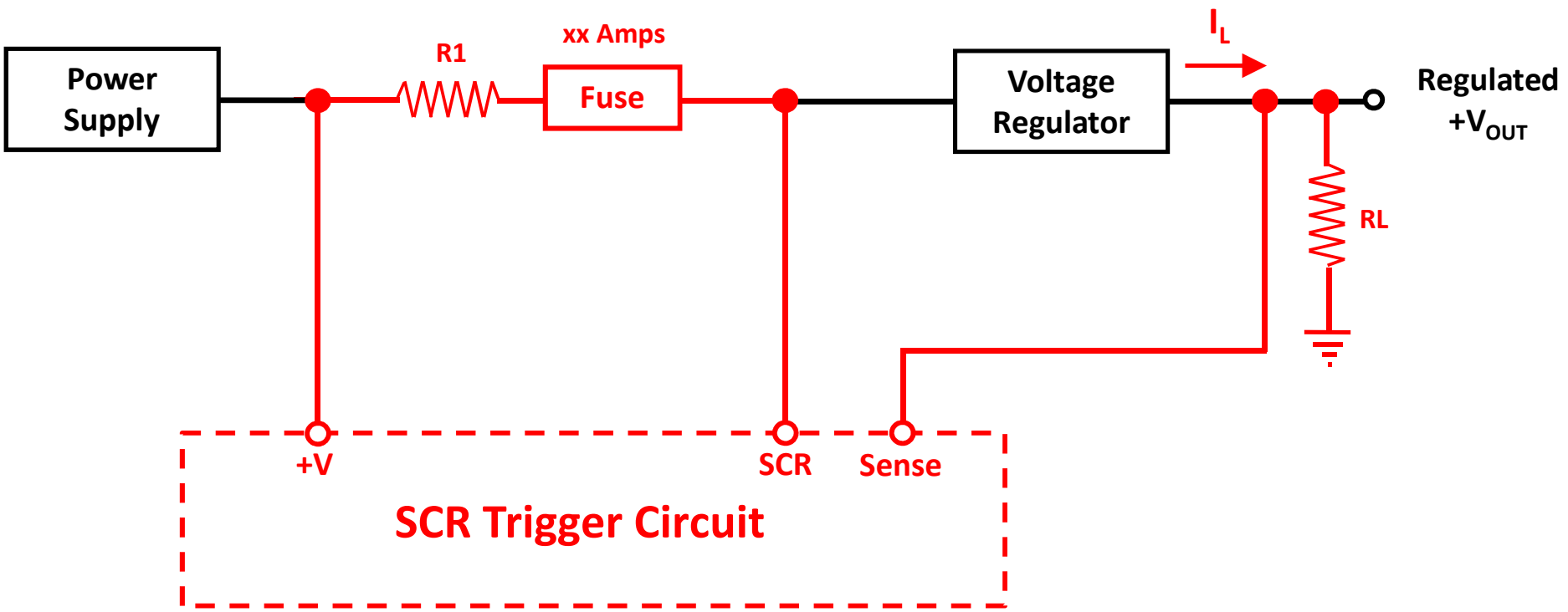


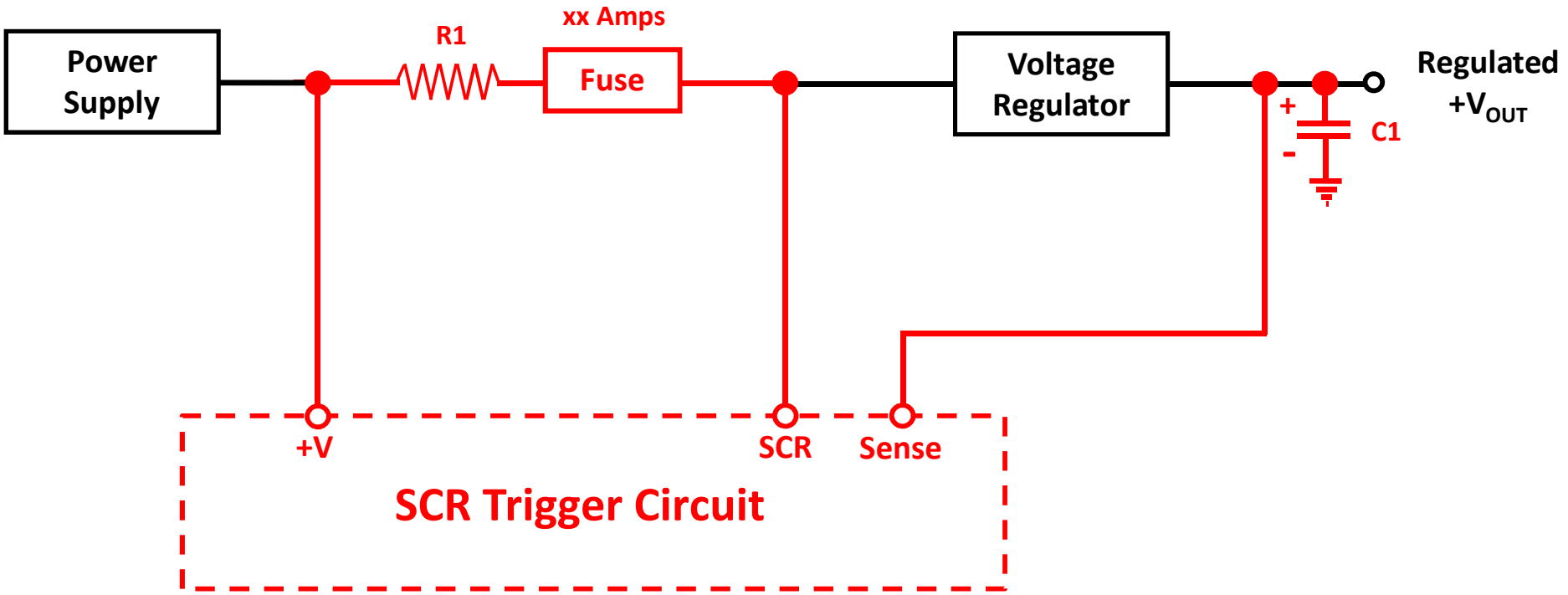
Problem 3: No specified minimum load current (I_L)

Overvoltage Protection Circuit in ARRL Handbook



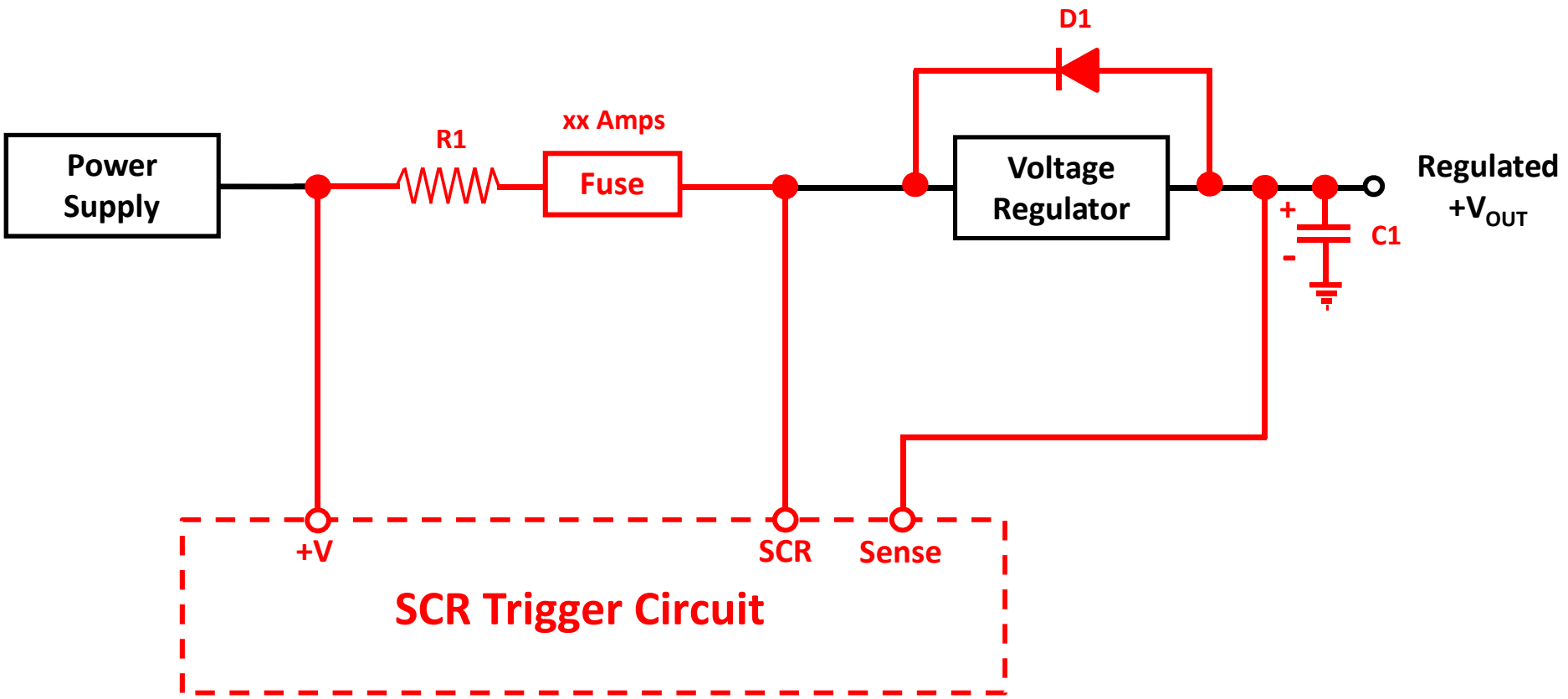
Problem 3: Most three terminal regulators must source 3-5 mA for regulation to occur

Overvoltage Protection Circuit in ARRL Handbook



Problem 4: Most three terminal regulators should be protected from damage that could result from a short on the input

Overvoltage Protection Circuit in ARRL Handbook



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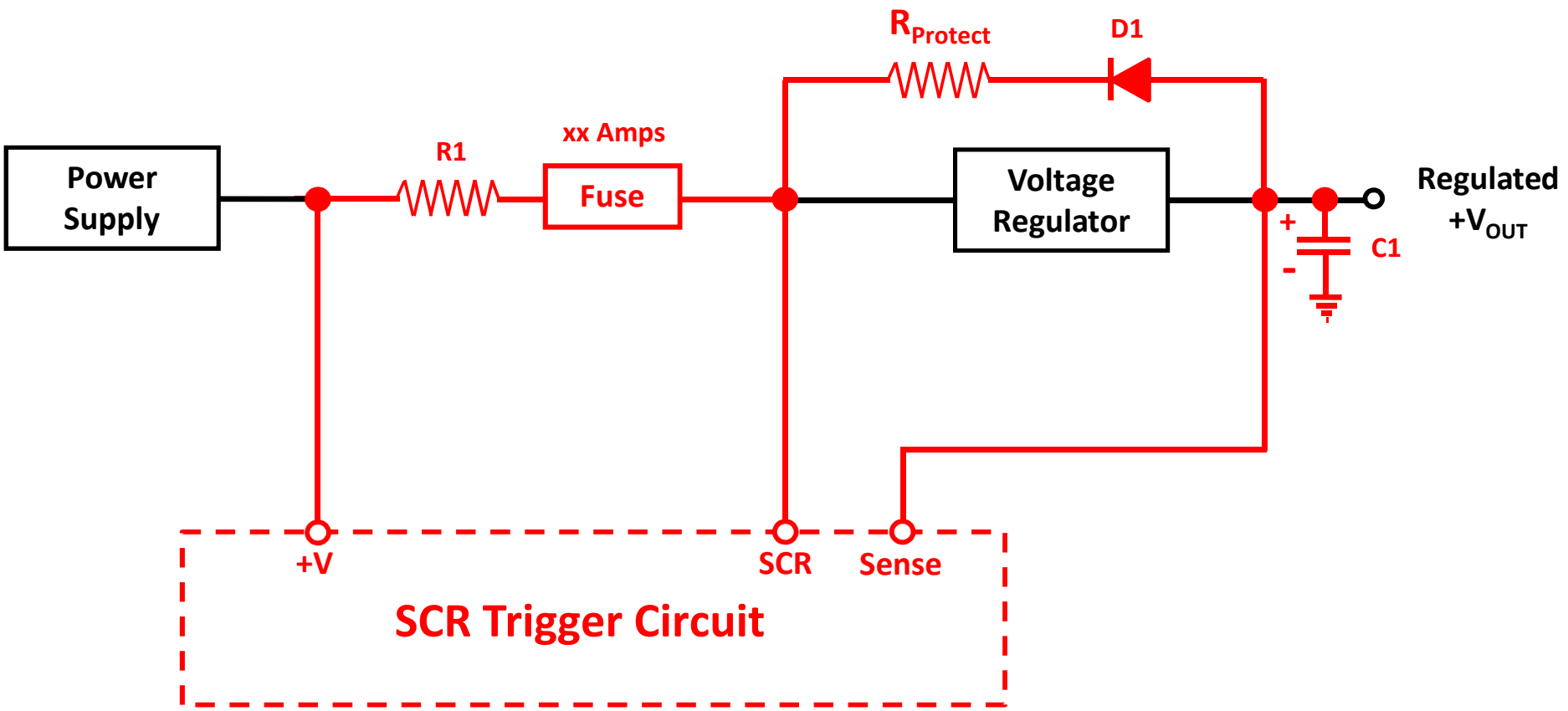
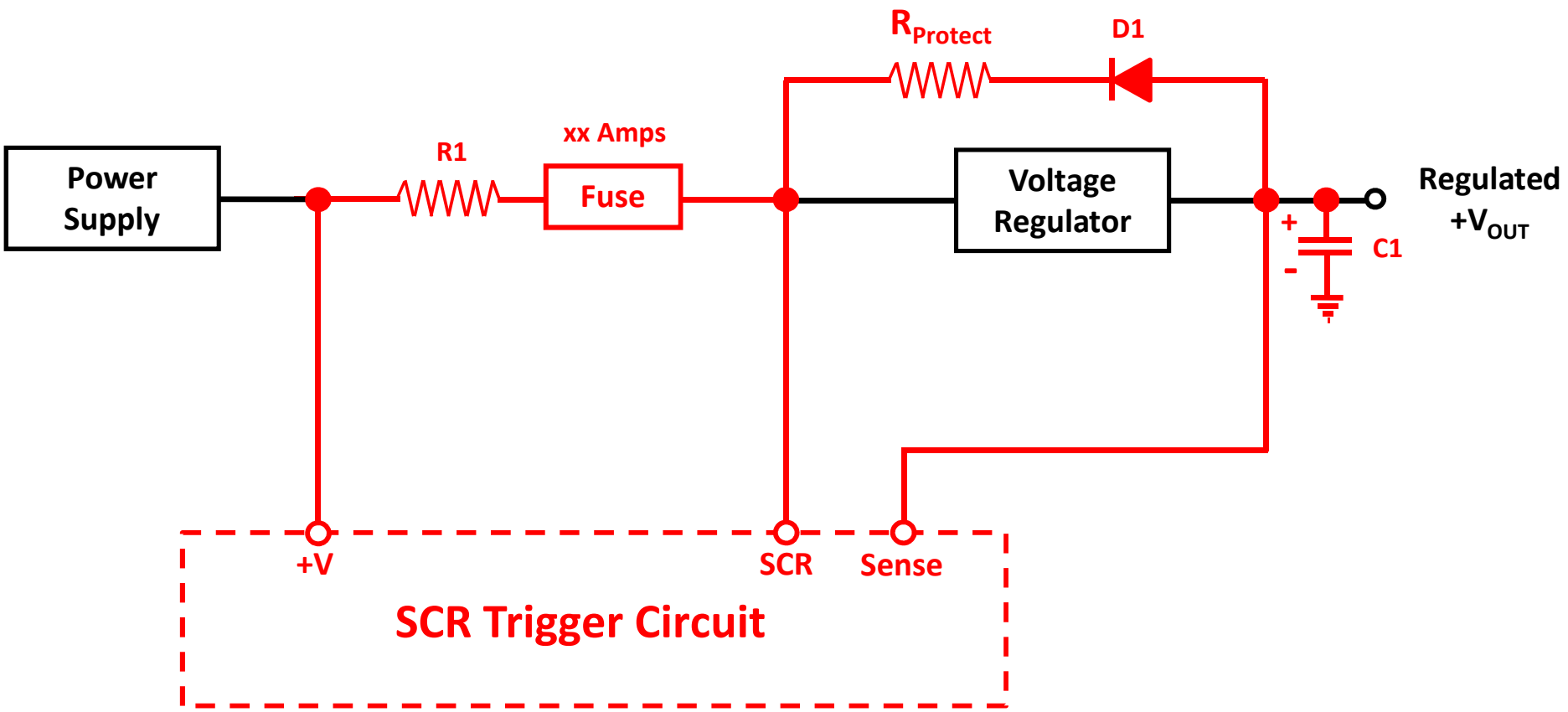


Problem 4: Maximum current through D1 should be limited whenever an overvoltage protection circuit is used

Overvoltage Protection Circuit in ARRL Handbook



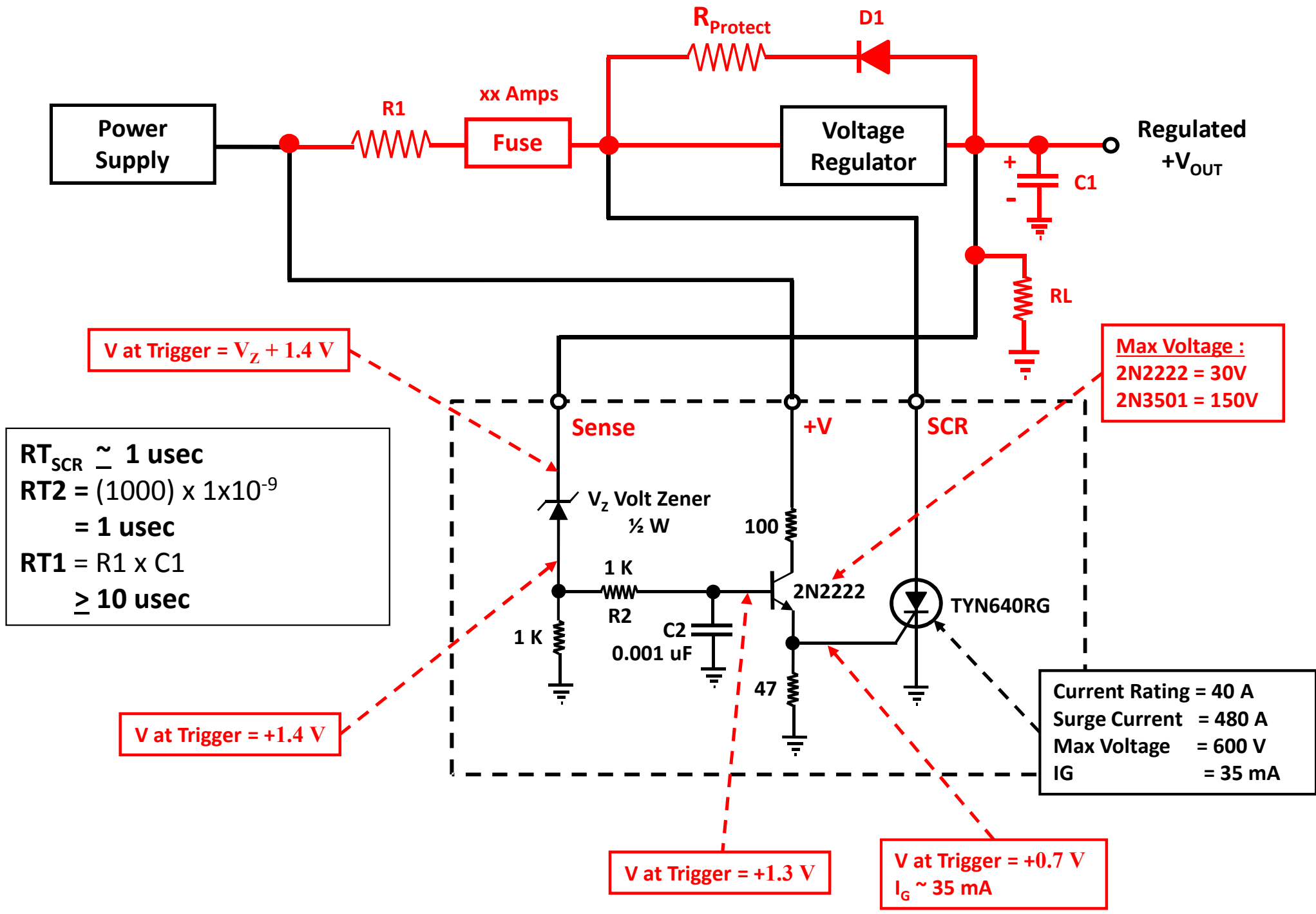
Note: R1 & $R_{Protect}$ may need to be high wattage

- **Don't want them to blow open when SCR fires**

Solid Copper Wire

Wire Size	**Fusing Current**	**Resistance**
Gauge	Amps	Ohms/10 ft
26	20	0.408
24	29	0.257
22	41	0.161
20	58	0.102
18	83	0.064
16	117	0.040

Modified Overvoltage Protection Circuit



$RT_{SCR} \underline{\sim}$ **1 usec**

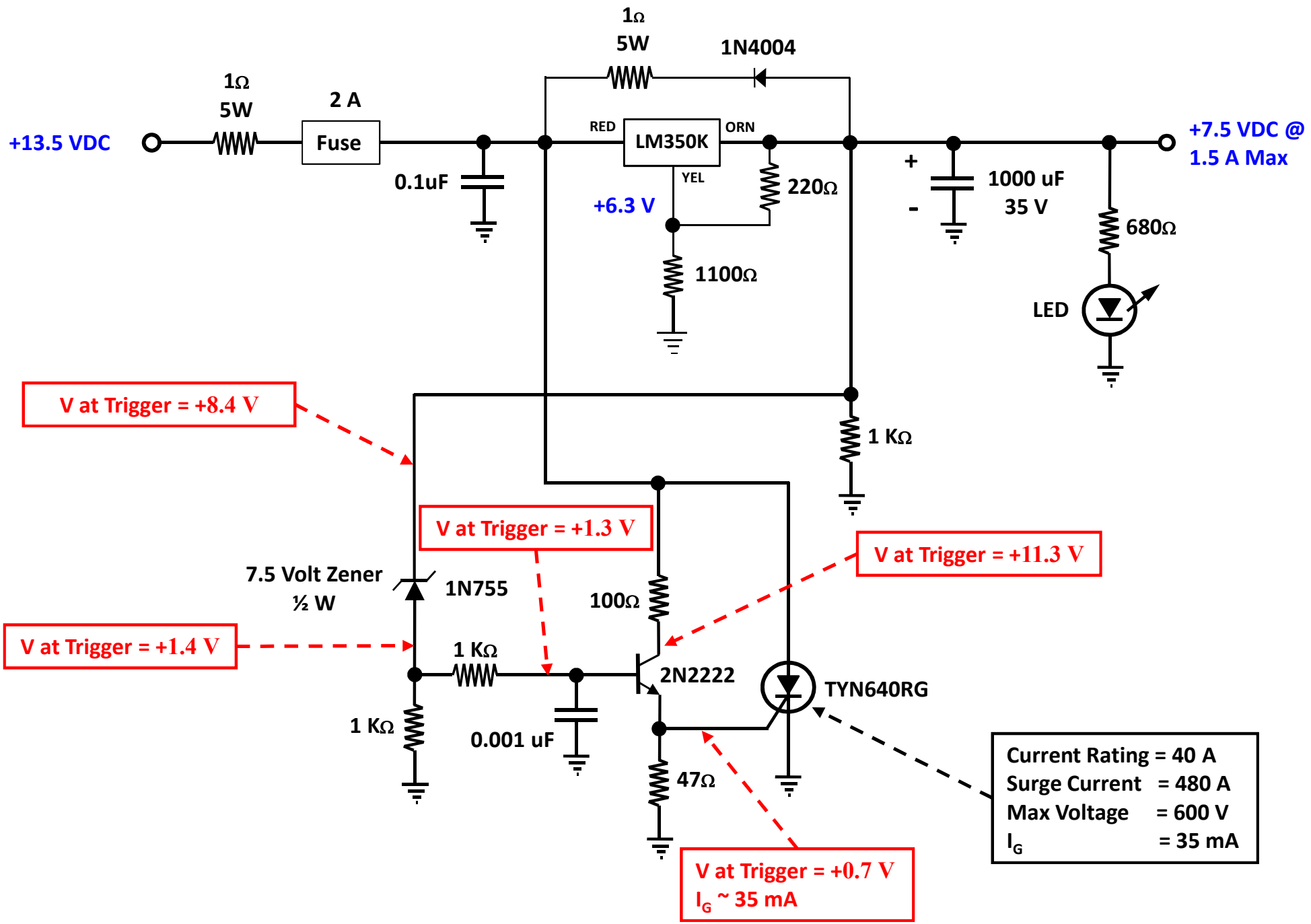
RT2 = (1000) x $1x10^{-9}$

= 1 usec

RT1 = R1 x C1

$\underline{\geq}$ **10 usec**

ICOM V80 Power Supply With Overvoltage Protection



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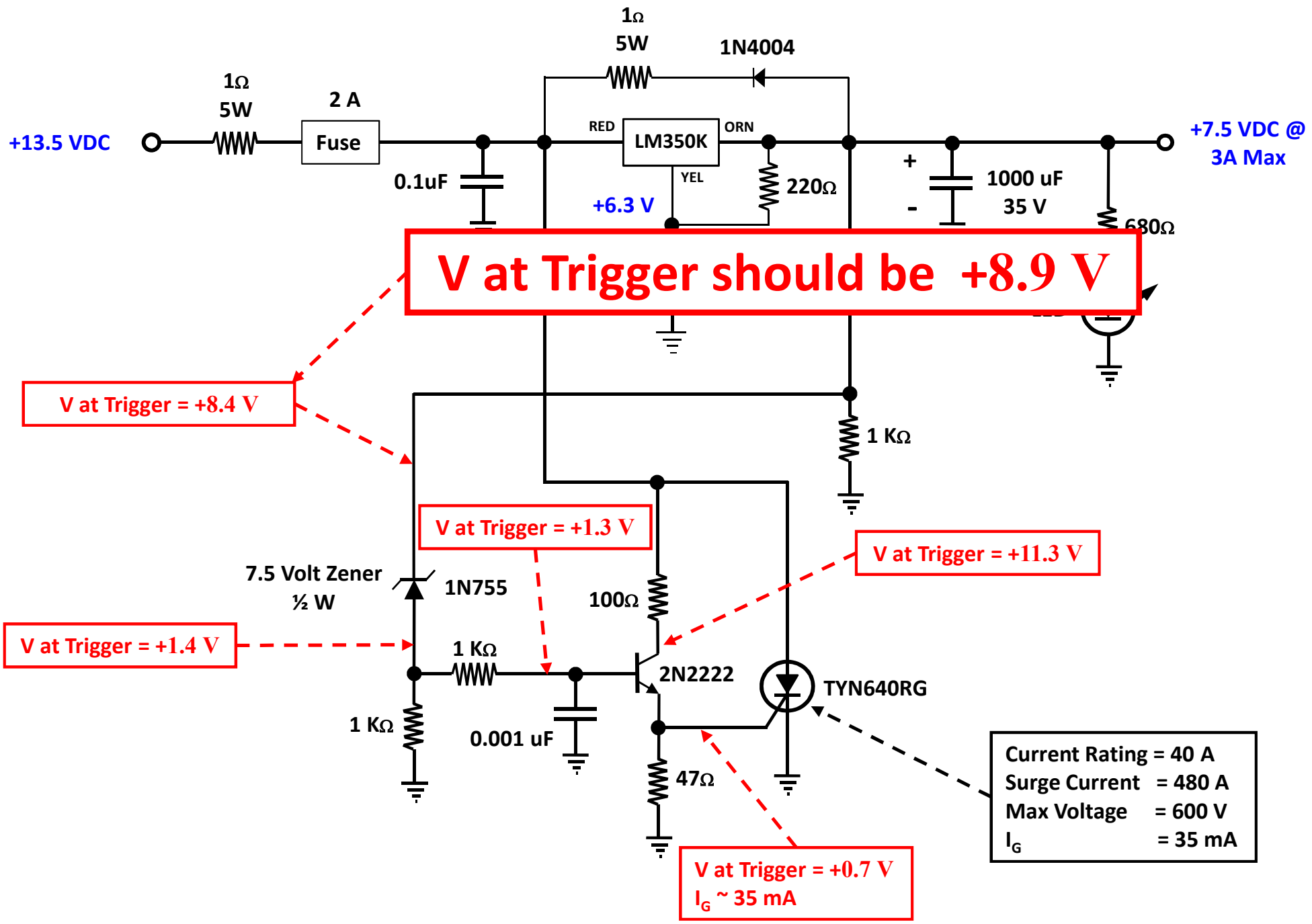
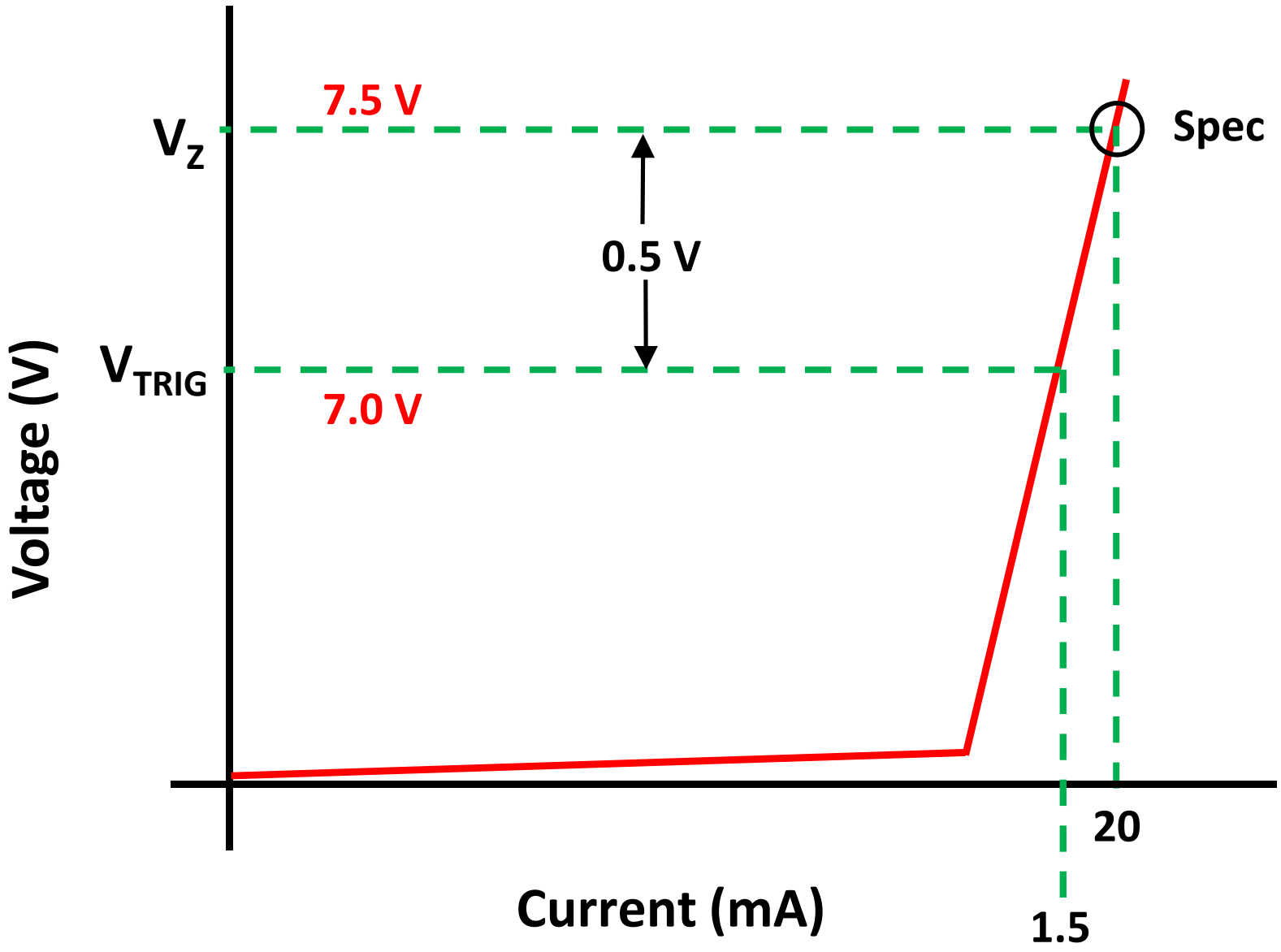


Zener Diode Characteristics



Check your SCR after installation!!!!