#216 - BACK TO BASICS: 555 BASED MONOSTABLE MULTIVIBRATOR / 555 TUTORIAL

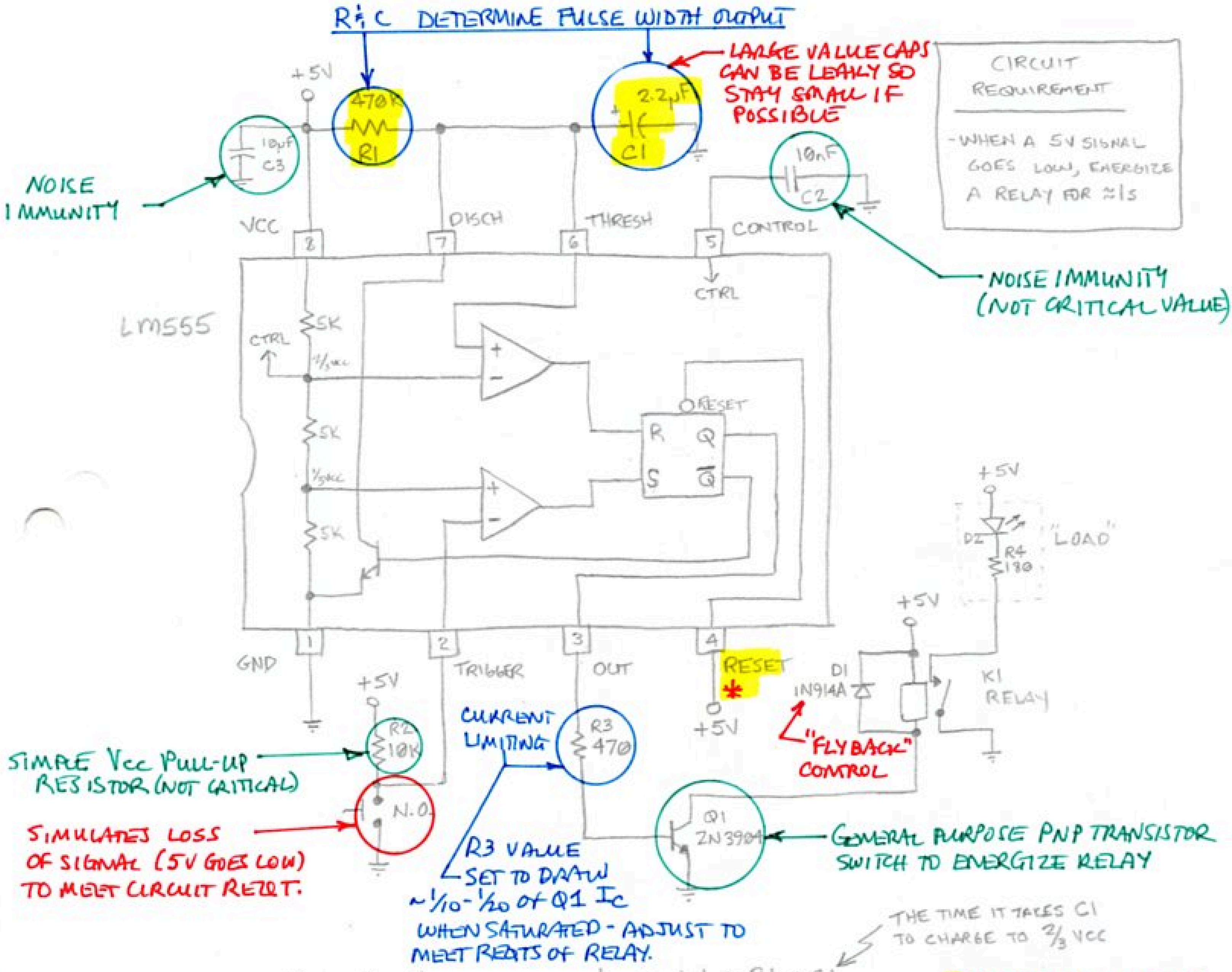
W2AEW

BACK TO BASICS

555 BASED "ONE-SHOT"

MONOSTABLE MULTIVIBRATOR

- OUTPUTS A SINGLE PULSE IN RESPONSE TO A TRIGGER



- PULSE "ON" TIME IS: $t_{on} = 1.1 * R1 * C1$

THE TIME IT TAKES C1 TO CHARGE TO 2/3 VCC

* RESET LINE TIED TO 5V SINCE WE'RE NOT USING THAT FUNCTION

REMEMBER, A SIMPLE RC CIRCUIT CHARGES TO 63% IN ONE RC TIME CONSTANT. HERE, WE WANT 66.7%, SO IT MAKES SENSE THAT THE TIME IS JUST OVER 1 RC

BACK TO BASICS

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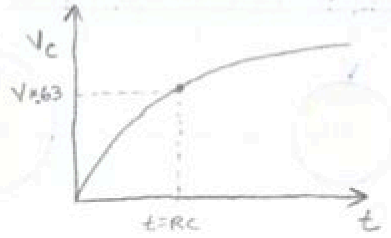
555 ONE-SHOT MATH

- WHY IS THE TIME = 1.1 * RC

FOR RC CIRCUIT
(CHARGING)



$$V_c(t) = V * \left(1 - e^{-t/RC}\right)$$

RE-ARRANGE TO SOLVE FOR t

DIVIDE BY V: $$\frac{V_c(t)}{V} = 1 - e^{-t/RC}$$

SUBTRACT/SWAP: $$e^{-t/RC} = 1 - \frac{V_c}{V}$$

NATURAL LOG: $$\frac{-t}{RC} = \ln\left(1 - \frac{V_c}{V}\right)$$

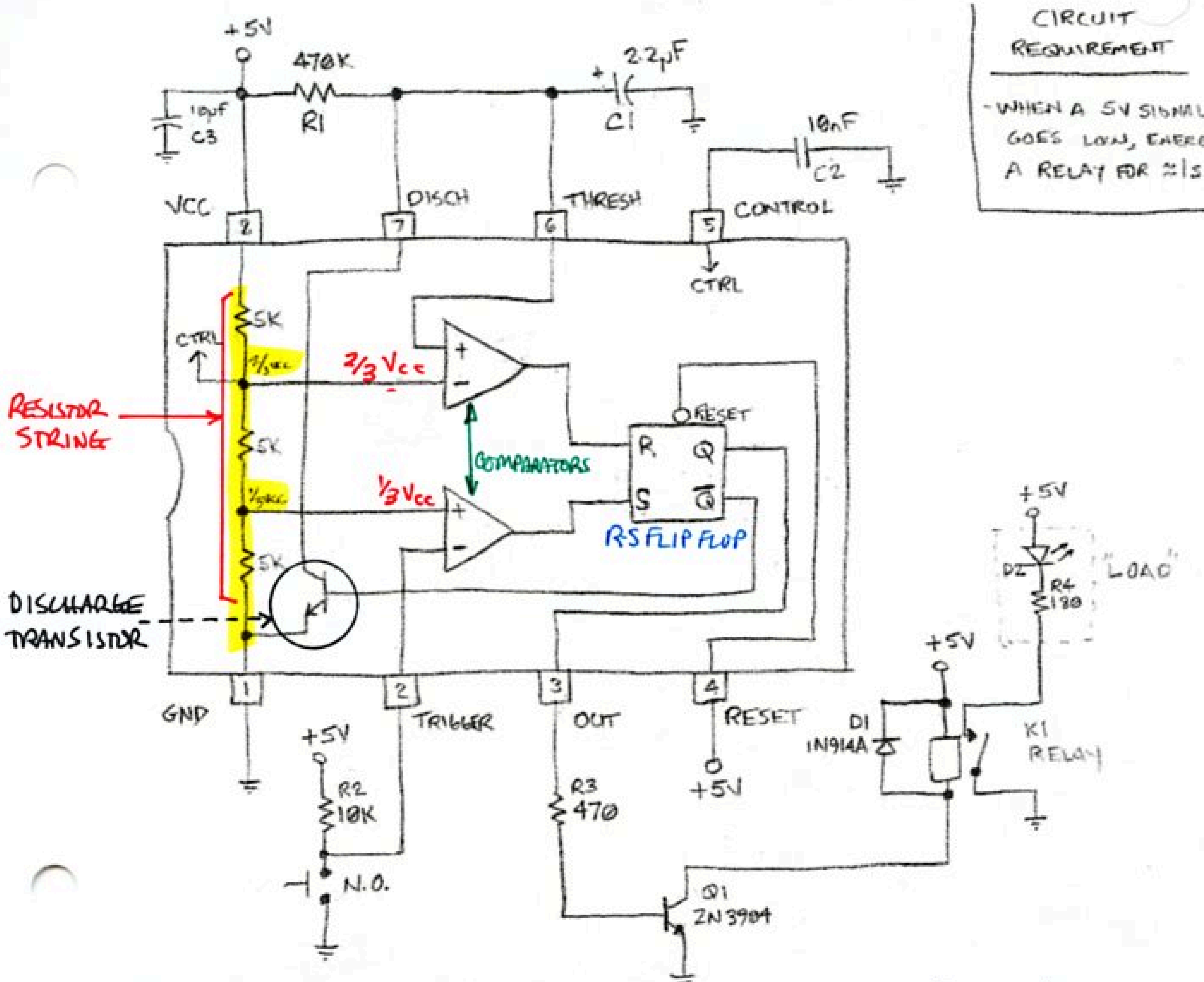
MULTIPLY BY -RC: $$\boxed{t = -RC * \ln\left(1 - \frac{V_c}{V}\right)}$$

IN OUR CASE, $\frac{V_c}{V} = 2/3$

THUS
$$t = -RC * \ln\left(1 - \tfrac{2}{3}\right)$$
$$t = -RC * \ln\left(\tfrac{1}{3}\right)$$
$$t = 1.1 * RC$$

CIRCUIT REQUIREMENT

- WHEN A 5V SIGNAL GOES LOW, ENERGIZE A RELAY FOR ≈1s



- RESISTOR STRING SETS UP A VOLTAGE DIVIDER PRESENTING 2/3 AND 1/3 Vcc AT THE INPUTS OF THE TWO COMPARATORS
- AT POWER UP THE R-S FLIP FLOP IS IN A RESET CONDITION
  - "Q" OUTPUT IS LOW ∴ Q1 IS OFF AND LOAD (RELAY) IS <u>NOT</u> ENERGIZED
  - "$\overline{Q}$" OUTPUT IS HIGH ∴ THE TRANSISTOR AT THE BOTTOM OF THE RESISTOR STRING IS TURNED ON AND IS PULLING CURRENT DOWN THRU R1 VIA THE "DISCH" PIN #7 PIN WHICH SATURATES THE TRANSISTOR AND PREVENTING C1 FROM CHARGING UP. THIS MEANS THE VOLTAGE AT PIN #6 "THRESH" REMAINS LOW (NEAR GND) → THUS THE OUTPUT OF THE TOP COMPARATOR IS LOW AND WE'RE NOT GOING TO RESET THE FLIP FLOP ("R").
  - WITH 5V APPLIED TO THE TRIGGER (PIN #2) INPUT THE OUTPUT OF THE LOWER COMPARATOR IS ALSO LOW ∴ THE FLIP FLOP WILL <u>NOT</u> CHANGE STATE.
- IF THE TRIGGER VOLTAGE (PIN #2) IS BROUGHT BELOW 1/3 Vcc THE OUTPUT OF THE LOWER COMPARATOR GOES HIGH → DO THIS BY PRESSING THE SWITCH (N.O.) TO BRING PIN #2 TO GND (AND < 1/3 Vcc).
- THE FLIP FLOP OUTPUT THEN GOES HIGH, IN TURN CAUSING Q1 TO TURN ON AND THE RELAY AS WELL.
- AT THE SAME TIME "$\overline{Q}$" GOES LOW TURNING OFF THE DISCHARGE TRANSISTOR AT THE BOTTOM OF RESISTOR STRING BRINGING THE "DISCH" PIN (PIN #7) TO ESSENTIALLY OPEN CIRCUIT NOW ALLOWING C1 TO CHARGE UP THRU R1; IT CHARGES EXPONENTIALLY.

- C1 CHARGES EXPONENTIALLY UNTIL IT REACHES 2/3 OF Vcc AT WHICH POINT THE TOP COMPARATOR GOES HIGH AND RESETS THE FLIP FLOP.
- AS SOON AS THE FLIP FLOP RESETS "Q" OUTPUT GOES LOW THUS TURNING Q1 OFF AGAIN WHICH TURNS OFF THE RELAY AGAIN.
- "$\bar{Q}$" GOES HIGH AT THE SAME TIME THUS TURNING ON THE DISCHARGE TRANSISTOR AND QUICKLY TAKES THE CHARGE OFF C1 BRINGING THAT POINT BACK TO THE SATURATION VOLTAGE OF THE TRANSISTOR.
- WE'RE NOW READY FOR THE NEXT TRIGGER EVENT.
- NOTE THAT t_{ON} IS A LITTLE BIGGER THAN THE PRODUCT OF R1 × C1 SINCE THE R-C CIRCUIT ONLY CHARGES TO 63% IN ONE TIME CONSTANT SO WE'RE MAKING SURE IT'S ON LONG ENOUGH TO BRING THE 2/3 Vcc POINT ON THE TOP COMPARATOR'S INPUT TO ITS FULL VALUE; SO WE USE A MULTIPLICATION FACTOR OF ×1.1 TO ENSURE IT DOES.

*NOTE: ONCE THE CIRCUIT IS TRIGGERED IT WON'T BE AVAILABLE TO RE-TRIGGER UNTIL IT RESETS. DEMONSTRATE THIS BY TRIGGERING QUICKLY THE TRIGGER PIN (COULD BE SWITCH BOUNCE)