BACK TO BASICS

# BASICS OF THE BIPOLAR TRANSISTOR

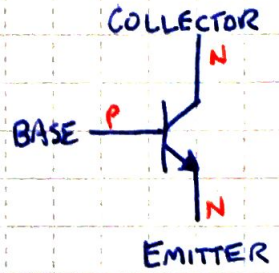
W2AEW ①

AKA: BJT - BIPOLAR JUNCTION TRANSISTOR

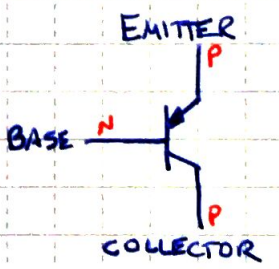
- TWO BASIC TYPES: NPN & PNP

SEE #219 FOR FET BASICS

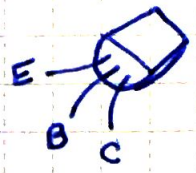
NPN:



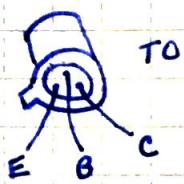

PNP:




COMMON PINOUTS (BUT NOT UNIVERSAL)




TO-92




TO-18


SOT-23

- IT IS COMMON TO SEE A DIAGRAM LIKE THIS TO SHOW THE "JUNCTIONS" OF A BJT


(NPN EXAMPLE)

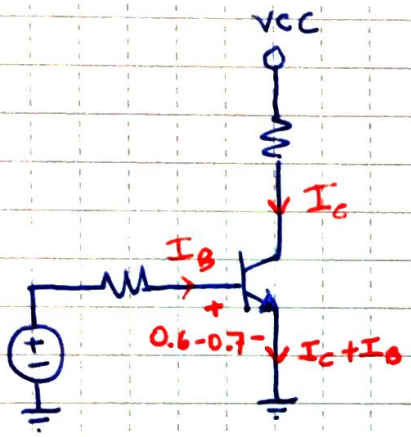
* - WHILE THIS DOES ILLUSTRATE THE PN JUNCTIONS, IT DOES **NOT** DESCRIBE THE OPERATION OF THE BJT (EXCEPT FOR B-E JUNCTION)

1 SQUARE =

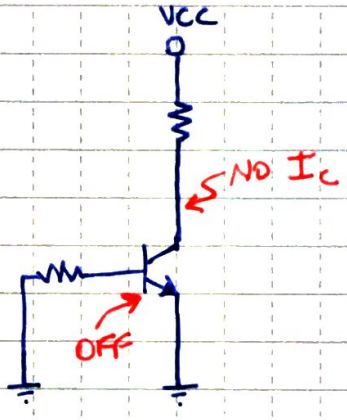
W2AEW
(2)

# BASIC OPERATING PRINCIPLES

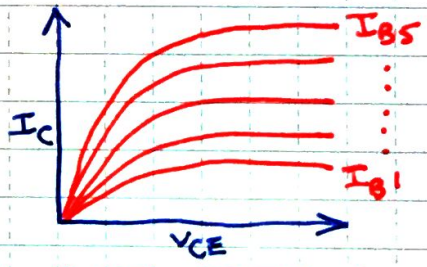
- THE BASE-EMITTER JUNCTION BEHAVES LIKE A DIODE
- WHEN BASE-EMITTER IS FORWARD-BIASED...
  ... CURRENT CAN FLOW BETWEEN COLLECTOR & EMITTER
- WHEN BASE-EMITTER IS NOT FORWARD-BIASED...
  ... NO CURRENT FLOWS BETWEEN COLLECTOR & EMITTER




"ON"




"OFF"



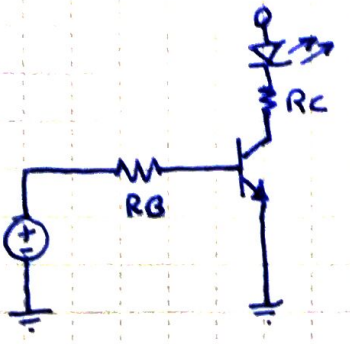

- "LINEAR" OPERATION
  - B-E FORWARD BIASED
  - C-B REVERSE BIASED! ← HOW DO WE GET CURRENT FLOW THRU A REVERSE BIASED PN JUNCTION? (STAY TUNED)
- "SWITCH" OPERATION (SATURATION)
  - B-E FORWARD BIASED
  - C-B FORWARD BIASED
    ($V_{CE}$ VERY SMALL)

1 SQUARE = _____

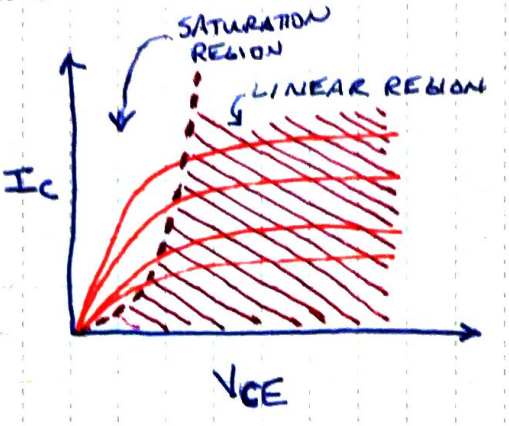
W2AEW
(5)

- SWITCH OPERATION : TRANSISTOR IN SATURATION MODE

  - BASE - EMITTER IS FORWARD-BIASED
  - VOLTAGE DEVELOPED ACROSS THE LOAD IN THE COLLECTOR PATH DRIVES THE COLLECTOR VOLTAGE BELOW THE BASE
  - THIS FORWARD-BIASES THE BASE-COLLECTOR JUNCTION
  - TRANSISTOR $\beta$ (CURRENT GAIN) DROPS - TYPICALLY TO $\approx$ 10-20
  - THUS, BASE CURRENT INCREASES




EXAMPLE




  - IN SATURATION, $V_{CE}$ IS A FEW HUNDRED mV
  - $I_C$ DETERMINED BY SUPPLY VOLTAGE & LOAD IN COLLECTOR PATH & $I_B \approx I_C/10$ or 20

1 SQUARE =

W2AEW
(6)

MORE VIDEOS ON BIPOLAR TRANSISTOR CIRCUITS & APPLICATIONS

#185: BIPOLAR TRANSISTOR BIAS CONSIDERATIONS & BETA DEPENDENCE

#113: BIPOLAR TRANSISTOR AMPLIFIER BIAS & CLASS OF OPERATION

#114: COMMON EMITTER, COMMON BASE & COMMON COLLECTOR AMPLIFIERS

#273: COMMON EMITTER AMPLIFIER TIPS & TRICKS

#67: COMMON EMITTER AMPLIFIER GAIN & FREQUENCY RESPONSE

#356: BASICS OF THE EMITTER FOLLOWER AMPLIFIER

#198: $V_{BE}$ MULTIPLIER TUTORIAL & APPLICATIONS

#190/191: CURRENT MIRROR BASICS

#327: CURRENT MIRRORS & EARLY EFFECT

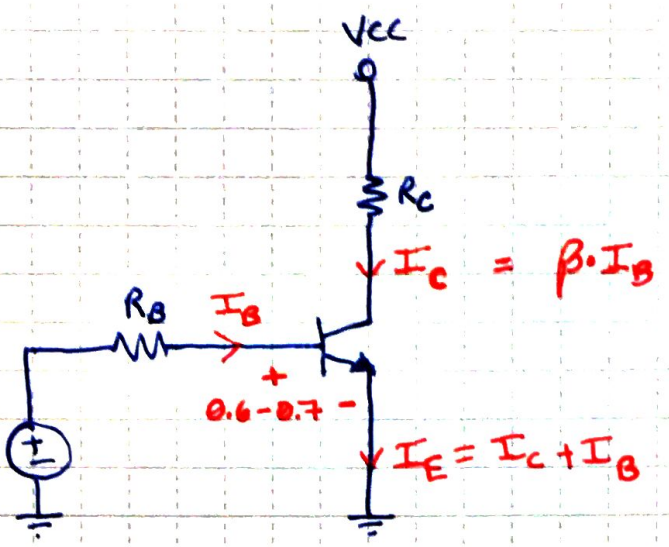
#193: BASICS OF THE EMITTER COUPLED DIFFERENTIAL PAIR AMP

1 SQUARE = _____

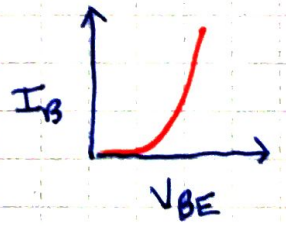
... A FEW MORE DETAILS ...

WRAEW ③

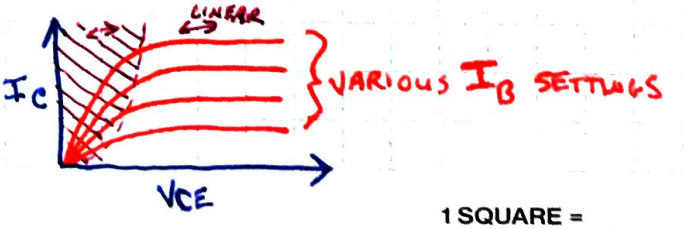
- FOR LINEAR OPERATION




- $V_{BE}$ TYPICALLY 0.6V TO 0.7V
- $I_C = \beta \cdot I_B$ , $\beta$ TYPICALLY $\approx 100-200$
- $I_E = I_C + I_B$
- BASE-EMITTER BEHAVES LIKE A DIODE:




- COLLECTOR CURRENT DETERMINED BY BASE CURRENT



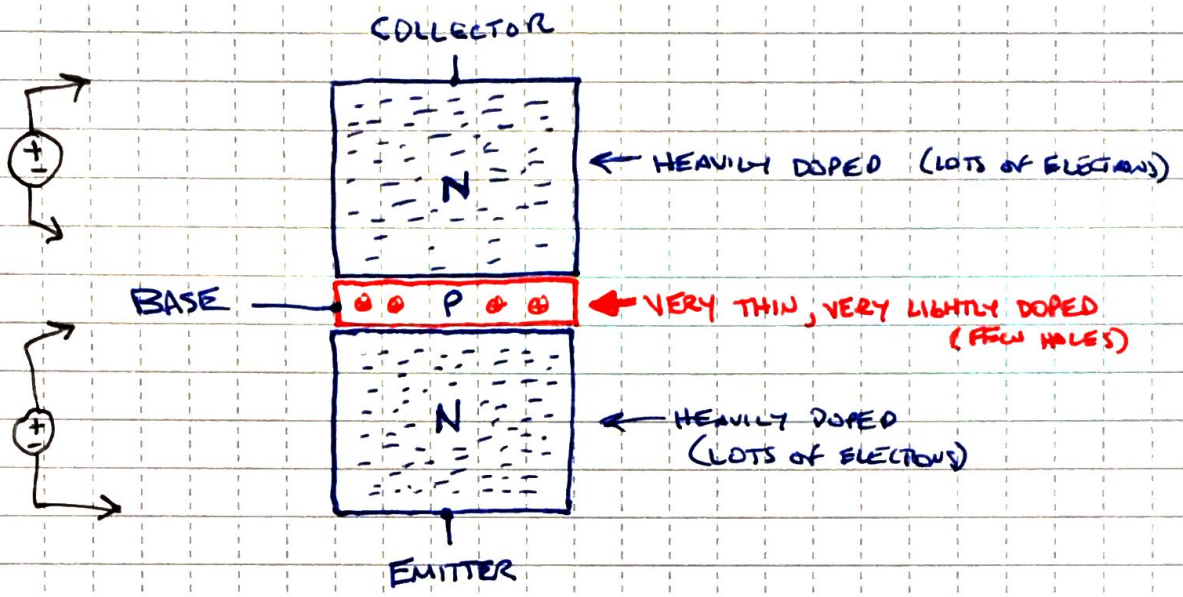

1 SQUARE =

W2AEW

④

- HOW DOES CURRENT FLOW THRU THE REVERSE-BIASED COLLECTOR-BASE JUNCTION?

- LOOK AT VERY BASIC STRUCTURE & PHYSICS

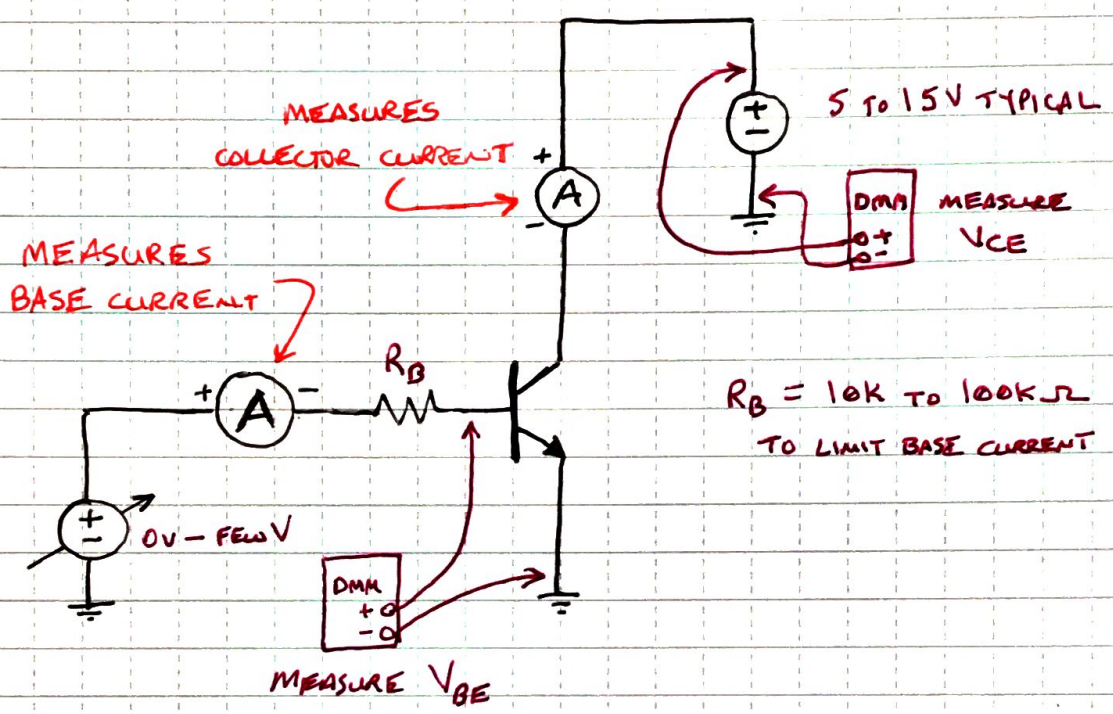



- BASE VOLTAGE HIGHER THAN EMITTER
- FORWARD BIAS B-E JUNCTION
- LOTS OF ELECTRONS DRAWN INTO BASE REGION
- SINCE BASE IS VERY LIGHTLY DOPED - FEW ELECTRONS RECOMBINE WITH HOLES
- SINCE BASE IS SO THIN, A LOT OF ELECTRONS TRAVEL ACROSS THE BASE, DRAWN BY THE POSITIVE POTENTIAL OF THE COLLECTOR
- THESE ELECTRONS CROSS THE C-B DEPLETION REGION AND BECOME THE COLLECTOR CURRENT
- ONLY ABOUT 1% OF THE ELECTRONS RE-COMBINE AND MAKE UP BASE CURRENT
- ≈ 99% OF ELECTRONS FROM EMITTER TRAVEL THRU THE BASE REGION AND BECOME COLLECTOR CURRENT

1 SQUARE = _____

W2AEW
(1)

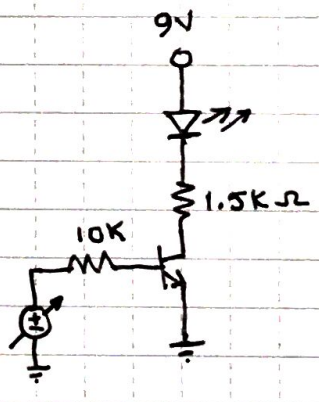
# TEST CIRCUIT DIAGRAM




$R_B$ = 10K TO 100K Ω
TO LIMIT BASE CURRENT

2 VARIABLE POWER SUPPLIES
2 AMMETERS
2 VOLTMETER / DMM
1 RESISTOR

FOR SATURATION




1 SQUARE = _____