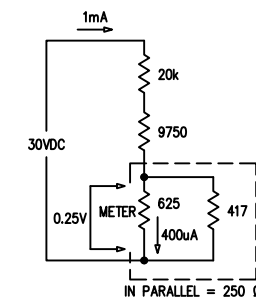


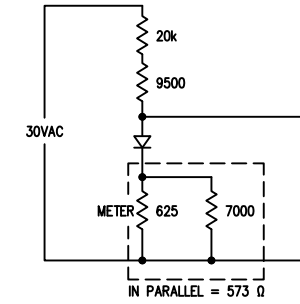
EXAMPLE CALCULATIONS USING SIMPLIFIED FUNCTION CIRCUITS

DC VOLTS



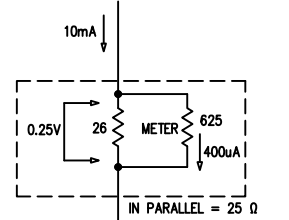
- USING 30VDC RANGE IN THIS EXAMPLE
- SERIES RESISTANCE = $20k + 9750 + 250 = 30k$
- $30V \text{ APPLIED} / 30k = 1mA$
- $1mA \times \text{PARALLEL } 250 \Omega = 0.25V$
- $0.25V / 625 \Omega \text{ METER} = 400\mu A$ THROUGH METER, GIVING A FULL SCALE READING OF 30V

AC VOLTS



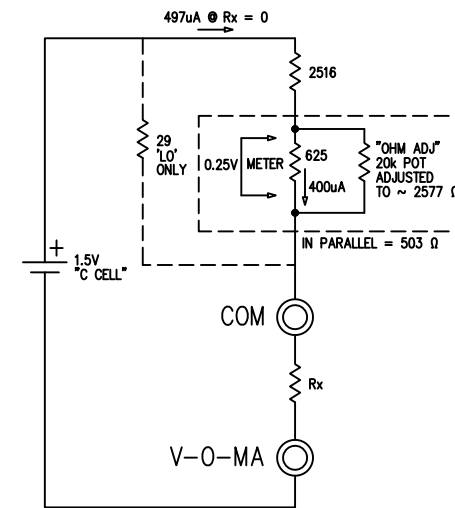
- SIMILAR TO DC VOLTS
- RESISTANCES ARE CHANGED TO ACCOUNT FOR RECTIFIER VOLTAGE DROP, HALF WAVE RECTIFICATION WITH PASSIVE FILTERING VIA METER MOVEMENT'S DAMPING ACTION, ETC.
- METER SHUNT RESISTOR CHANGED TO MAKE METER LESS SENSITIVE
- METER BYPASSED ON NEGATIVE HALF OF AC WAVEFORM
- CALCULATIONS ARE NOT SHOWN SINCE CHARACTERISTICS OF RECTIFIER ARE NOT KNOWN AND DEGREE OF METER DAMPING IS NOT KNOWN

DC mA

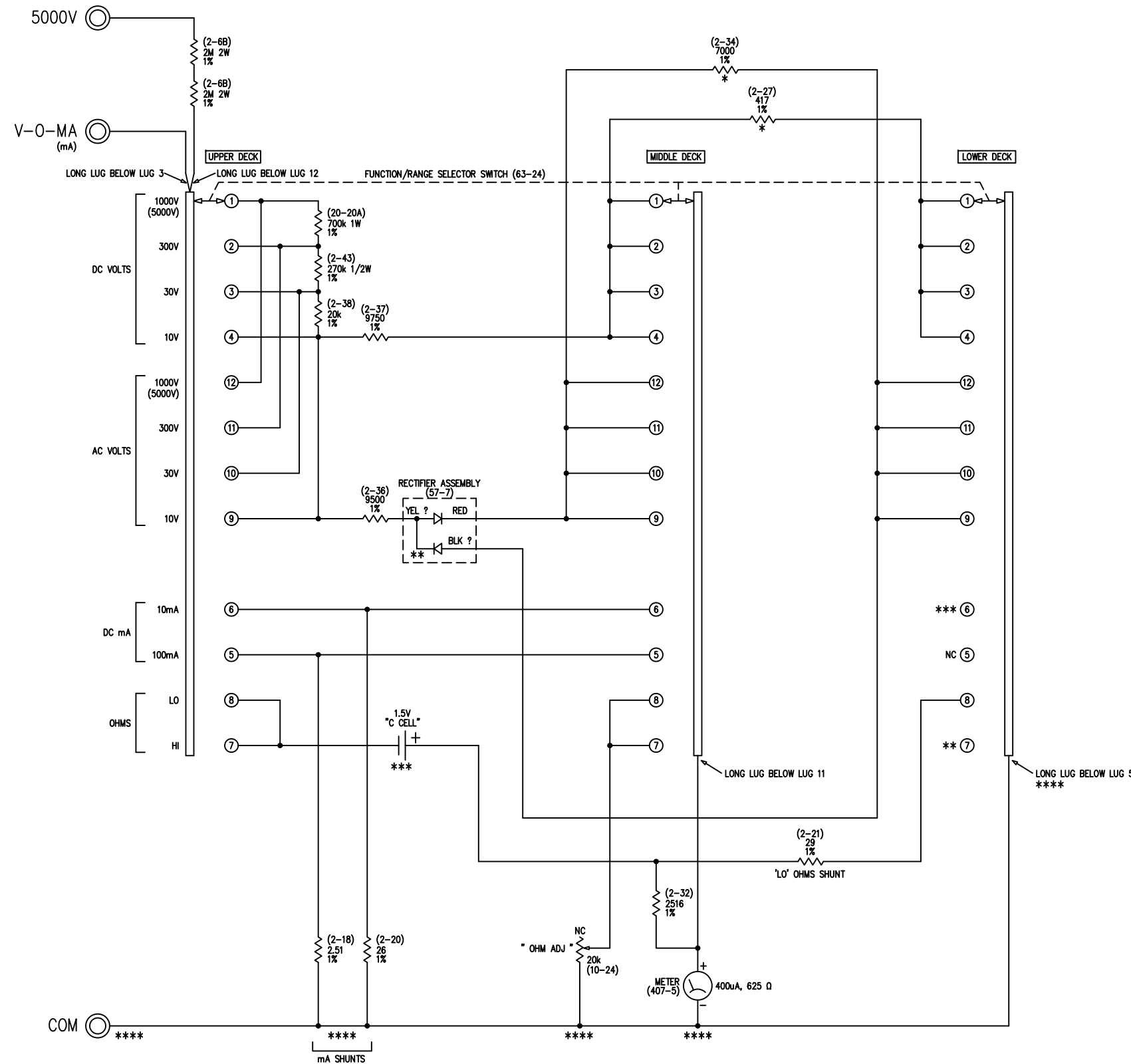


- USING 10mA RANGE IN THIS EXAMPLE
- IN 10mA RANGE, METER WITH 26 OHM SHUNT IN PARALLEL IS 24.96 OHM (25 OHM)
- $10mA \text{ THROUGH } 25 \Omega = 0.25V$
- $0.25V / 625 \Omega = 400\mu A$ THROUGH METER, GIVING FULL SCALE READING OF 10mA
- IN 100mA RANGE, PARALLEL METER AND 2.51 OHM SHUNT = 2.499 OHM (2.5 OHM)
- $100\mu A \text{ THROUGH } 2.5 \Omega = 0.25V$
- $0.25V / 625 \Omega = 400\mu A$ THROUGH METER, GIVING FULL SCALE READING OF 100mA

OHMS



- USING 'HI' OHMS RANGE IN THIS EXAMPLE
- ASSUMING $R_x = 0 \Omega$
- ASSUMING "OHM ADJ" POTENTIOMETER IS SET TO ABOUT 2577 OHM (OUT OF 20k POSSIBLE), AND THIS PARALLELED WITH THE 625 OHM METER MOVEMENT = 503 OHM
- TOTAL SERIES RESISTANCE = 3019 OHM
- $1.5V / 3019 \Omega = 497\mu A$
- $497\mu A \times 503 \Omega = 0.25V$ ACROSS METER
- $0.25V / 625 \Omega = 400\mu A$ THROUGH METER, THUS FULL SCALE METER DEFLECTION, FOR A READING OF 0Ω (EQUAL TO R_x)
- NOW ASSUMING $R_x = 3100 \Omega$, ALL OTHER ASSUMPTIONS ARE THE SAME AS ABOVE
- TOTAL RESISTANCE = 6119 OHM, MAIN CURRENT = 245uA
- $245\mu A \times 503 \Omega = 0.123V$ ACROSS METER MOVEMENT
- $0.123V / 625 \Omega = 197\mu A$ THROUGH METER, GIVING APPROXIMATELY HALF SCALE READING, WHICH IS ABOUT 31 ON THE OHMS SCALE.
- BECAUSE METER IS IN THE 'HI' OHMS RANGE, THE READING MUST BE MULTIPLIED BY 100 TO GET THE FINAL RESISTANCE, SO $31 \times 100 = 3100 \Omega$ (EQUAL TO R_x)
- NOW CHANGING THE METER TO THE 'LO' OHMS RANGE, AN ADDITIONAL SHUNT RESISTANCE OF 29 OHM IS PLACED ACROSS ALL INTERNAL METER RESISTANCES (BUT NOT ACROSS THE EXTERNAL R_x)
- THE NEW SHUNT, PLUS THE LOWER RESISTANCES LIKELY TO BE USED IN THE 'LO' OHMS RANGE, RESULTS IN A MUCH HIGHER CURRENT FROM THE 1.5V CELL, BUT MOST OF THIS CURRENT FLOWS THROUGH THE SHUNT RATHER THAN THROUGH THE RESISTANCES IN THE NORMAL METER SUBCIRCUIT. 29 OHM IS OF A RATIO WITH THE NORMAL METER CIRCUIT RESISTANCES SUCH THAT 99% OF THE CURRENT FROM THE 1.5V CELL FLOWS THROUGH THE NEW SHUNT, AND ONLY 1% OF THE CURRENT FLOWS THROUGH THE NORMAL METER SUBCIRCUIT, STILL GIVING THE CORRECT RESISTANCE VALUE WITHOUT NEEDING TO MULTIPLY THE OHMS SCALE NUMBER BY 100



NOTES:

- 1) ALL RESISTANCES ARE SHOWN IN OHMS UNLESS MARKED 'k' (KILO) OR 'M' (MEGA).
- 2) RESISTOR WATTAGES OF 1W OR 2W ARE AS MARKED IN HEATHKIT DOCUMENTATION. OTHER WATTAGES SHOWN HERE ARE BASED ON APPROPRIATE VALUES ACCORDING TO CIRCUIT STUDY. ALL OTHER RESISTORS ARE 1/4W. RESISTORS ARE ALL WIREWOUND TYPES.
- 3) OLD STYLE HEATHKIT PART NUMBERS ARE SHOWN FOR MOST COMPONENTS IN ().
- 4) THE + SIDE OF THE RECTIFIER WILL HAVE A RED WIRE. THE COLORS FOR THE OTHER TWO RECTIFIER WIRES ARE NOT SHOWN IN HEATHKIT DOCUMENTATION, AND AS SHOWN HERE ARE BASED ON STUDY OF TWO M-1 METERS.
- 5) HEATHKIT'S DOCUMENTATION AND THE GRAPHICS ON THE M-1 METER USE 'M' FOR 'MILLI', RATHER THAN THE MODERN 'm'. THIS SCHEMATIC WAS DRAWN, USING AUTOCAD, AS A MEANS TO GET A MORE LEGIBLE SCHEMATIC FOR THE HEATHKIT M-1. AN EFFORT HAS BEEN MADE TO SIZE AND SCALE COMPONENTS AND TEXT FOR THE LARGEST AND BEST VISIBILITY AND LEGIBILITY WHILE STILL FITTING ON A NORMAL 11 X 17" SHEET OF PAPER.
- 7) THE COPYRIGHT HOLDER HEREBY GIVES PERMISSION TO FREELY DISTRIBUTE THIS DOCUMENT, AS LONG AS NO ALTERATIONS ARE MADE AND CREDIT IS GIVEN, ALONG WITH THE COPYRIGHT NOTICE.

* ONE OF THESE TWO SHUNT RESISTORS GETS CONNECTED ACROSS THE METER WHILE IN DC VOLTS OR AC VOLTS.

** CENTER WIRE FROM RECTIFIER CONNECTS TO OTHER COMPONENTS VIA A TIE POINT (DUMMY LUG 7 ON SELECTOR SWITCH LOWER SWITCH DECK/WAFER); THERE IS NO SWITCH CONTACT ASSOCIATED WITH THIS LUG.

*** BATTERY (+) WIRE CONNECTS TO OTHER COMPONENTS VIA A TIE POINT (DUMMY LUG 6 ON SELECTOR SWITCH LOWER DECK/WAFER); THERE IS NO SWITCH CONTACT ASSOCIATED WITH THIS LUG. THE 2516 OHM AND 29 OHM RESISTORS ALSO CONNECT TO DUMMY LUG 6.

**** LONG LUG 5 ON THE SELECTOR SWITCH LOWER DECK/WAFER IS A TIE POINT FOR THE 'COM' TERMINAL ON THE FRONT PANEL, AND ALSO FOR THE 2.51 OHM AND 26 OHM RESISTORS. LONG LUG 5 IS ALSO ELECTRICALLY COMMON (VIA THE LOWER DECK ROTOR) WITH LONG LUG 8 ON THE SAME DECK/WAFER, AND METER (-) AND ONE SIDE OF THE "OHM ADJ" POTENTIOMETER CONNECT TO THAT SAME LUG.

HEATHKIT M-1 "HANDITESTER"
VOM / MULTIMETER
SCHEMATIC DIAGRAM