

FOR MEASURING VOLTS, THE BLACK TEST LEAD GOES IN THE 'COM' JACK. FOR ALL VOLTS RANGES 1500V OR LOWER, THE RED TEST LEAD GOES IN THE '+' JACK. FOR MEASURING UP TO 5kV, THE RED TEST LEAD GOES IN EITHER THE '5kV (DC)' JACK (FOR DC VOLTAGE) OR THE '5kV (AC)' JACK FOR AC VOLTAGE. WHEN EITHER OF THESE TWO HIGHER VOLTAGE JACKS ARE IN USE, THE 'FUNCTION/RANGE' SWITCH MUST BE SET TO THE '1500V' POSITION.

FOR MEASURING AMPS USING THE 0.5A OR 15A RANGE, THE 'FUNCTION/RANGE' SWITCH MUST BE SET TO THE '150mA' POSITION. THE BLACK TEST LEAD GOES INTO THE '-15A' JACK, AND THE RED TEST LEAD GOES INTO THE APPROPRIATE JACK, EITHER '+0.5A' OR '+15A'. FOR ALL OTHER CURRENT RANGES, SET THE 'FUNCTION/RANGE' SWITCH TO THE APPROPRIATE '150mA', '15mA', OR '150µA' POSITIONS. THE BLACK TEST LEAD GOES IN THE 'COM' JACK AND THE RED TEST LEAD GOES IN THE '+' JACK.

FOR MEASURING RESISTANCE, THE BLACK TEST LEAD GOES IN THE 'COM' JACK AND THE RED TEST LEAD GOES IN THE '+' JACK. THE 'FUNCTION/RANGE' SWITCH MUST BE SET TO WHICHEVER OF THE THREE OHMS RANGES IS APPROPRIATE, EITHER 'Rx1', 'Rx100', OR 'Rx10k'.

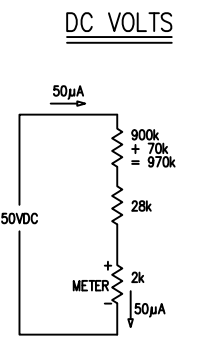
* THE 'DB OUTPUT' POSITION OF THE 'POLARITY' SWITCH ENGAGES A SERIES CAPACITOR ON THE (+) INPUT, TO BLOCK ANY DC COMPONENT OF AN AC SIGNAL APPLIED TO THE METER. THIS POSITION MUST ALSO BE USED IN ORDER FOR THE DECIBEL SCALE OF THE METER TO BE USED MEANINGFULLY. THE MAXIMUM AC VOLTAGE APPLIED BETWEEN THE (+) JACK AND THE 'COM' JACK IS 1500V. DO NOT USE THE 'DB OUTPUT' SWITCH POSITION WHEN MEASURING HIGHER VOLTAGES VIA THE '5kV (AC)' JACK (USE THE 'AC' SWITCH POSITION INSTEAD).

** S1A AND S1B HAVE A COMPLEX CONNECTION SCHEME BETWEEN THOSE TWO WAFERS' CONTACTS AND THE TWO SEPARATE ROTORS OF THOSE WAFERS, WHICH ARE ELECTRICALLY CONNECTED TOGETHER IN SOME SWITCH POSITIONS. THE WAY THE SWITCH CONTACTS ARE SHOWN ON THIS DRAWING, ALONG WITH ADJACENT DESCRIPTIVE TEXT, IS AN ATTEMPT TO MAKE THE ULTIMATE INTERCONNECTIONS CLEARER.

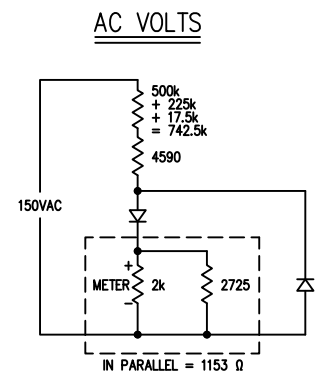
THE DC VOLTS FUNCTION WORKS WITH THE 'POLARITY' SWITCH IN EITHER THE 'DC-' OR 'DC+' POSITIONS. THE AMP/mA/µA FUNCTIONS WORK WITH THE 'POLARITY' SWITCH IN EITHER THE 'DC-' OR 'DC+' POSITIONS; THIS METER CANNOT MEASURE AC CURRENT.

*** SWITCH WAFERS 'S1D' & 'S1F' USE THEIR PIN 6 CONNECTION FOR BOTH THE 1500V POSITION AND THE COMMON WIPER/ROTOR. THIS IS DEPICTED ON THIS SCHEMATIC BY SHOWING THE COMMON/ROTOR CONNECTION AS '(6)' AND THE 1500V POSITION CONNECTION AS '6'. THIS KEEPS ALL OF THE RESISTORS IN THE VOLTAGE ATTENUATORS CONNECTED, WITH THE VOLTAGE RANGE SWITCH(S) SHORTING OUT ANY UNNEEDED RESISTORS.

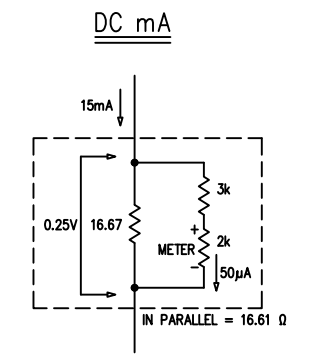
EXAMPLE CALCULATIONS USING SIMPLIFIED FUNCTION CIRCUITS



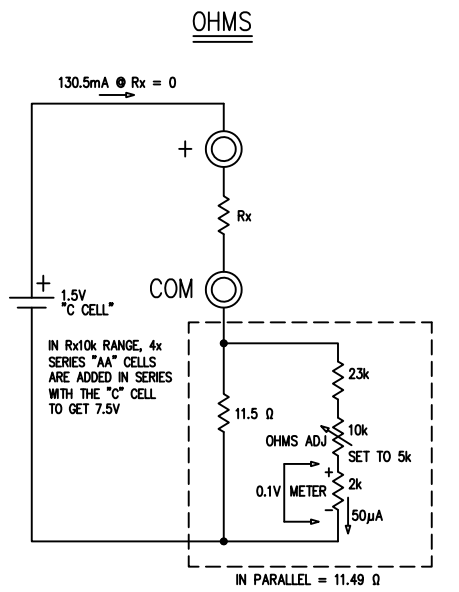
- USING 50VDC RANGE IN THIS EXAMPLE
- RESISTANCES IN 50V ATTENUATOR = 970k
- SERIES RESISTANCE = 970k ATTENUATOR + 28k + 2k METER = 1M Ω
- 50V APPLIED / 1M Ω = 50µA
- 50µA THROUGH METER GIVES A FULL SCALE READING OF 50V



- USING 150VAC RANGE IN THIS EXAMPLE
- 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 ADDED TO MAKE METER LESS SENSITIVE
- METER BYPASSED ON NEGATIVE HALF OF AC WAVEFORM; THIS AVOIDS ISSUE OF REVERSE LEAKAGE ON THE PRIMITIVE METAL RECTIFIER IN SERIES WITH THE METER MOVEMENT
- CALCULATIONS ARE NOT SHOWN SINCE CHARACTERISTICS OF RECTIFIER ARE NOT KNOWN AND DEGREE OF METER DAMPING IS NOT KNOWN



- USING 15mA RANGE IN THIS EXAMPLE
- IN 15mA RANGE, SHUNT RESISTORS 15 + 1.17 + 0.483 + 0.0167 Ω = 16.67. 3k IN SERIES WITH 2k METER = 5k. 16.67 Ω IN PARALLEL WITH 5k = 16.61 Ω
- 15mA THROUGH 16.61 Ω = 0.25V
- 0.25V / 5k = 50µA THROUGH METER, GIVING FULL SCALE READING OF 15mA
- IN OTHER RANGES, SOME RESISTANCE IS REMOVED FROM BEING IN SERIES WITH THE METER MOVEMENT, AND ADDED TO THE PARALLEL SHUNT RESISTANCE, CHANGING THE RATIO OF METER AND SHUNT RESISTANCES, THUS THE PROPORTION OF CURRENT THROUGH THE SHUNT AND CURRENT THROUGH THE METER CHANGES.



- 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. ALL OTHER RESISTORS ARE PRESUMED TO BE 1/2W. RESISTORS ARE ALL WIREWOUND TYPES.
 - 3) OLD STYLE HEATHKIT PART NUMBERS ARE SHOWN FOR MOST COMPONENTS IN ().
 - 4) HEATHKIT'S DOCUMENTATION AND THE GRAPHICS ON THE MM-1 METER USE 'M' FOR 'MILLI', RATHER THAN THE MODERN 'm'.
 - 5) THE METER USES TWO SELECTOR SWITCHES; THE 'RANGE/FUNCTION' SWITCH 'S1' HAS THREE DECKS, EACH WITH TWO SIDES (WAFERS). WAFERS A & B ARE ON THE DECK CLOSEST TO THE FRONT PANEL (S1A & S1B), WAFERS C & D ARE ON THE MIDDLE DECK (S1C & S1D) [S1C IS BLANK], AND WAFERS E & F ARE ON THE REAR DECK (S1E & S1F). ON THIS SCHEMATIC, WAFER S1F IS SHOWN DIVIDED INTO TWO PARTS, S1F(1) & S1F(2), FOR REASONS OF LAYOUT CLARITY. THE 'POLARITY' SWITCH 'S2' LIKEWISE HAS TWO DECKS, WITH WAFER S2A BEING THE FRONT SIDE OF THE DECK CLOSEST TO THE FRONT PANEL [THIS WAFER IS BLANK], S2B BEING THE REAR SIDE OF THAT DECK, AND WAFERS S2C & S2D BEING THE FRONT AND REAR SIDES OF THE REAR DECK; WAFER S2B IS ALSO DIVIDED INTO HALVES S2B(1) & S2B(2) FOR LAYOUT REASONS. ON THIS SCHEMATIC, SOME OF THE MORE COMPLEX CONTACT ARRANGEMENTS REQUIRED DEPICTING PARTS OF THESE ROTARY SWITCHES AS SIMPLISTIC SWITCHES, E.G. S1A, S1B, S2C, EACH HAVING DESCRIPTIVE TEXT TO DEFINE THEIR OPERATION. ALL PARTS OF A GIVEN SWITCH ARE UNDERSTOOD TO MOVE TOGETHER, UNDER CONTROL OF THEIR KNOB SHAFT, WITHOUT THIS BEING EXPLICITLY SHOWN VIA CONNECTING DASHED LINES, ETC.
 - 6) THIS SCHEMATIC WAS DRAWN, USING AUTOCAD, AS A MEANS TO GET A MORE LEGIBLE SCHEMATIC FOR THE HEATHKIT MM-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.

HEATHKIT MM-1
VOM / MULTIMETER
SCHEMATIC DIAGRAM