Anders Electronics plc.

Application note for 8100 and 8400 series digital voltmeters

1. **Typical. Applications:** These notes refer to data sheet AED146. Note that Link J1 must be cut if voltage scaling resistors are fitted, and remain in place for current applications .

1.1 *I wish to convert an 8100 meter to read 2V FSD, or an 8100A to read 20V FSD:*

The 8100 meter has a full scale deflection (FSD) of 200mV. The display must therefore be multiplied by 10. The data sheet shows columns of basic sensitivity compared to the required FSD, and gives values for R_A and R_B of 1MΩ and 110KΩ respectively. The equation linking R_A and R_B is given by:

$$V_{IN} = V_{DISPLAY} \times (1 + R_A/R_B), \text{ or } R_A/R_B = (V_{IN}/ V_{DISPLAY} - 1).$$

This equation gives a value of $V_{IN} / V_{DISPLAY}$ of 10.09, i.e. less than 1% error. This error can, if required, be trimmed with the Span potentiometer. In most cases the values can be taken directly from the table without the need for calculations. Remember to cut link J1.

1.2 *I wish to convert an 8100 meter to read 20V FSD, or an 8100A to read 200V FSD:*

The table shows that the required values for R_A and R_B are 1MΩ and 10KΩ respectively. Note that the ratio of 1MΩ/10KΩ = 100, so that the factor 1 in the formula is not significant. Remember to cut link J1.

1.3 *I wish to convert an 8100A or an 8120A meter to read 650V FSD:*

The table shows values for R_A and R_B of 2MΩ and 2KΩ respectively. Note that the numerical FSD of the meter is 2V x 2MΩ/2KΩ = 2000V. However, the practical maximum is limited 650V for safety reasons. Remember to cut link J1. See section 2.3, choice of resistors, below.

1.4 *Can an 8100 or 8120 meter be used for 650V FSD?:*

Yes, with certain limitations. The resistor values are 2MΩ and 200Ω respectively. The signal is divided by a factor of 10,000 and so the display accuracy might be impaired and noise (flicker) might be apparent. Remember to cut link J1. See section 2.3 for further details.

1.5 *I wish to convert an 8100 or 8120 meter to read 0.2mA, 2mA, 20mA, 200mA or 2A FSD:*

The current flows through the internal shunt, R_C, to provide the 200mV FSD for the meter. The chart shows that values for R_C of 1KΩ, 100Ω, 10Ω, 1Ω, and 0.1Ω respectively are required. See drawing AED146 for the resistor mounting details. See section 1.7 and 2.4 for shunt details.

1.6 ***Can an 8100A or 8120A meter be used for current measurement?:***

Generally no, because the meter would require a voltage drop of 2V, which may affect the measurement accuracy. The FSD for an 8100A is 2V, so a 20mA meter would require a value for R_C of 100Ω (possible). An FSD of 200mA would require an R_C of 10Ω (possible, but the resistor would dissipate 0.4W). An FSD of 2A would require an R_C of 1Ω (not recommended because the resistor would dissipate 4W).

1.7 ***Can an 8100 or 8120 meter be used for higher currents such as 5A or 10A?:***

Yes. The limit depends upon the practicality of finding very low values for shunt resistor R_C. Note that for direct reading displays, a 5A or 10A meter would still require an FSD of 20A, which needs a value for R_C of 0.01Ω. With these values, the resistance of connecting leads can affect accuracy, especially if it is mounted externally to the case. This resistor *could* be made up from various parallel combinations, but it better to choose a single resistor such as RS 200-0787 (ER74 series, wirewound, 10%). Alternatively, for these and higher currents Anders can provide accurate shunts.

2. ***Which type of resistor can I use?.***

2.1 **Note:** The components listed are guides for general purpose use. It is the user's responsibility to ensure that the accuracy achieved is suitable for the application, and that the components chosen do not compromise safety aspects.

2.2 For 200V and below, use a 1% metal film, rated at 0.25W, 250Vac. The input voltage will appear directly across R_A, so choose one which can withstand this potential, such as RS 149-228 (1MΩ, 1%, 250V). Remember to cut link J1.

2.3 For greater than 200V (maximum 650V) choose carbon film resistors which have higher breakdown voltages. Note that R_A requires 2 resistors in series to share the potential. Types such as RS 133-217 (CRF50, 1MΩ, 0.5W, 350V, 5%) are suitable. Smaller types such as CRF25 are suitable for input voltages less than 500V. Remember to cut link J1.

2.4 For current measurement, use 1% metal film, such as RS 135-487 (0.1Ω, 0.25W, 5%); 149-616 (10Ω, 0.5W, 1%); 149-644 (100Ω, 0.5W, 1%), etc. The maximum current in a 0.1Ω, 0.5W resistor is 2A.

2.5 Consult Anders for information on higher external current shunts and current, voltage and power measuring instruments.

3. Scaling in engineering units.

3.1 *A tachometer gives 15V at 2000 RPM. How do I scale an 8100A to show an FSD of 2000 RPM?*

The 8100A is a 2V unit. By using the formula:
$V_{IN} = V_{DISPLAY} \times (1 + R_A/R_B)$ and entering the known values: $15 = 2 \times (1 + R_A/R_B)$.

Which gives $R_A/R_B = 6.5$. A value $R_A = 1M\Omega$ and $R_B = 150K\Omega$ would give this ratio within 2%. The remaining error can be trimmed with the Span potentiometer. The maximum display will be 1999 RPM. The 'headroom' (before the meter reads overload) is zero. Remember to cut link J1.

3.2 *In the above example, shall I make the FSD 2500 RPM, to give some 'headroom'?*

It's always useful to have 'headroom' or unused display capacity. But, in this example, don't use it unless you need it. The meter can only read to 1.999V, so an FSD of 2500 RPM will mean that the meter must display 0.250V, with each digit being equivalent to 10 RPM. The accuracy and resolution are both divided by 10. A solution would be to use the 8400, 4.5 digit meter with a maximum reading of 1.9999V. The FSD could then be 2500, with each digit equivalent to 1 RPM. The resolution is increased, but the accuracy is still less than the example is 3.1 because only 2500 counts in 20000, or 12.5% of the scale, is used.

3.3 *I have a transducer which gives 35V and I need the 8100A or 8120A meter to display 440V*

The meter will display 0.440V and therefore $R_A/R_B = (35/0.44 - 1) = 79.5$.
A value of $R_A = 1M\Omega$ and $R_B = 12K\Omega$ will give a value within 5%, which can be trimmed out. There is a headroom of 159V (2/0.44 x 35) for the transducer before the meter overloads. Remember to cut link J1.

3.4 *Can I use the 8100 or 8120 in the above example?*

Yes, but there are increasing errors and noise caused by the large attenuation ratio. The meter FSD is 0.1999V and so the meter will display 0.0440V. The attenuation is by a factor of nearly 800, and so it's better to use a meter with an FSD nearer to the input signal.
Therefore $R_A/R_B = (35/0.044 - 1) = 794$.
A value of $R_A = 1M\Omega$ and $R_B = 1.2K\Omega$ will give a value within 5%, which can be trimmed out. The headroom is again 159V.

3.5 *I have a transformer giving 600V and I want the 8120A display to read 220V*

The meter FSD is 1.999V and so the actual input to the meter will be 0.220V
$R_A/R_B = (600/0.22 - 1) = 2727$.

Because the voltage is high, R_A must be made from two resistors, R_{A1} and R_{A2}. If R_B is made to be 1K then R_{A1} and R_{A2} must be 1.35MΩ. There is not a value of 1.3MΩ in the carbon film CRF50 range, so make $R_{A1} = 1.2M\Omega$ and $R_{A2} = 1.5M\Omega$. Note that R_{A2} will take a higher voltage (333V) than R_{A2}, but it is still within its rating of 350V. As mentioned before, greater accuracy and resolution is possible if the meter reading is limited to 199V because the meter input can then be 1.99V which is a factor of 10 higher.

4. Frequently Asked Questions (FAQ)

These questions and answers are taken from the customer files.

4.1 Q: I have an 8100A used for current measurement. The shunt resistor is 0.1Ω and the current is 2A. But the meter reads overload even at 1A.
A: The resistor you have chosen is 10R (10Ω), rather than R10 (0.1Ω).

4.2 Q: I have three 8100A meters connected across various high voltage supplies (100 to 400Vdc). They all worked correctly until I press the Hold switch, whereupon the meters failed.
A: You have connected the three Hold inputs together. These are referenced to signal ground and so a high voltage appeared across the internal chip electronics. A separate contact must be used for each Hold input, i.e. a multipole switch or relay.

4.3 Q: I am measuring mains voltage with an 8120A, but the meter does not work.
A: You have connected mains earth to the GND signal terminal. This terminal is 0V from the 5V power supply. This can place a high voltage between an input terminal an 0V, causing chip failure. There is no mains earth required on the meter.

4.4 Q: I am measuring mains voltage with an 8120A, but the meter does not work.
A: You have forgotten to cut link J1. This has placed mains voltage on the chip input, which is limited to a protection of 100V.

4.5 Q: When I disconnect the signal (with a switch), the meter reads the same value, instead of zero.
A: The signal input contains a noise reducing capacitor which can retain its charge if the signal line becomes disconnected - because the input impedance of the amplifier is >100MΩ. Place a resistor across the IN-Hi and IN-Lo terminals. This can be external or internal in the R_C location. The value is not critical but should be chosen so as not to affect the measured circuit. A value between 10KΩ to 1MΩ would cover most applications.

4.6 Q: I am using a 8100 to measure the output from a load cell. The end two digits are flickering.
A: The 8100 reads 200mV FSD, so the scale is 0.1999. The last two figures represent millivolts and tenths of millivolts. The flicker is caused by noise pick-up on the input wires. Use a screened cable and connect the screen to GND.

4.7 Q: I have extended the scale of an 8100 from 200mV to 2V. The calibration is around 10% high and it can't be completely brought in with the Span pot.
A: The internal design of the circuit has been improved to provide better stability. This has required a slight difference in the ratio of the two resistors R_A and R_B. See the chart AED146 which shows a 110KΩ instead of the original 100KΩ. Generally, it is only the change from 200mV to 2V or 2V to 20V which is affected. There are worked examples for other intermediate values.

4.8 Q: The display on my meter is completely blank.
A: You have connected the 230Vac mains input to the 110Vac terminal and have blown the internal fuse (if fitted). The correct value is 100mA.