Body Composition (BC) Calculations

Variables:
- Excitation Frequency
- Excitation Voltage
- Unknown Impedance
- Access Impedance
- Calibration Resistor ($R_{CAL}$)
- TIA Resistor ($R_{TIA}$)
- Instrumentation Amplifier Gain Resistor ($R_g$)

Excitation Frequency:
High frequency excitation is required for BC measurements. Good accuracy is achieved using 50 kHz.

Excitation Voltage:
Large excitation voltage used to achieve best SNR. 600 mV$_{PEAK}$ recommended.

Unknown Impedance:
The impedance range of unknown impedance ($Z_{UNKNOWN}$) for BC applications (4 electrode, wrist worn BC solution) is typically 100 Ω - 5 kΩ (from left wrist to right finger).

Access Impedance:
Current limiting resistor ($R_{LIMIT}$) and DC blocking / isolating capacitors ($C_{ISO1}$ and $C_{ISO2}$) are required to meet the IEC 60601 Standard. These components will contribute towards the total access impedance of the excitation leg ($Z_{ACCESS1}$) and measurement leg ($Z_{ACCESS2}$).

$$Z_{ACCESS1} = R_{LIMIT} + C_{ISO1}$$
$$Z_{ACCESS2} = C_{ISO2}$$

$R_{LIMIT}$:
IEC 60601 Standard limit for patient leakage at 50 kHz is 500 µA$_{RMS}$

$$500 \text{ µA}_{RMS} = 707 \text{ µA}_{PEAK}$$
$$600 \text{ mV}_{PEAK} / 707 \text{ µA}_{PEAK} = 848 \Omega$$
Use 1 kΩ for additional safety margin.

$C_{ISO}$:
$C_{ISO}$ should be large, but also needs to be cost effective. 47 nF should satisfy both metrics.

Calibration Resistor ($R_{CAL}$):
$R_{CAL}$ should be set to be close to the minimum value of the expected unknown impedance. In this example, close to 100 Ω

TIA Resistor ($R_{TIA}$):
For $R_{TIA}$ calculations use the minimum $Z_{UNKNOWN}$.
Minimum impedance seen by the TIA is $Z_{ACCESS1} + Z_{UNKNOWN} + Z_{ACCESS2} = 1108.31 \Omega - 7.02^\circ$
$$600 \text{ mV}_{PEAK} / 1108.31 \Omega = 541 \text{ µA}_{PEAK}$$
Max ADC range = 750 mV$_{PEAK}$
To avoid non-linearities at the ends of the range, use 80% of the total range = 600 mV
$$600 \text{ mV}_{PEAK} / 541 \text{ µA} = 1108 \Omega$$
Use $R_{TIA} = 1 \text{ kΩ}$
Instrumentation Amplifier (AD8226) Gain Resistor (RG):
Maximum impedance of $Z_{\text{UNKNOWN}} = 5 \text{ k} \Omega$
Maximum current into TIA = 541 µA
Maximum voltage drop across $R_{\text{TIA}} = 1 \text{ k} \Omega \times 541 \mu\text{A} = 541 \text{ mV}$
ADuCM350 max ADC range = 750 mV_{PEAK}
Gain required = 750 mV / 541 mV = 1.386
AD8226 gain $G = 1 + (49.4 \text{ k} \Omega / R_G) = 1.386$ (see AD8226 datasheet for details)
$R_G = 127.98 \text{ k} \Omega$
Use $R_G = 120 \text{ k} \Omega$

Note if 2-Wire Relative Measurement Only:
Same maths apply for ADuCM350 – ignore AD8226 maths – part is not required.
RCAL measurement will need to be included so use the 2-Wire Impedance measurement example in SDK.