# Application Note

## What Voltage and Current is Applied to the Unknown?

When a device is tested with a Digibridge it is not uncommon to need to know what voltage is across the device or what current is passed through it. To compute the actual voltage or current it is necessary to understand the output configuration of the instrument. The test voltage is applied to the DUT with a range resistor ($R_S$) in series with it. The value of $R_S$ is known and varies as the impedance of the DUT changes. Table 1 lists the values of $R_S$ for the GenRad 1600 Series Digibridges.

### Table 1: Range Resistor Values of 1659, 1692, 1689, 1693 Digibridges

| Range # | $R_S$ | Auto Z Range |
|---------|-------|--------------|
| 1 | 102.4 kΩ | > 25 kΩ |
| 2 | 6.4 kΩ | 1.6 kΩ - 25 kΩ |
| 3 | 400 Ω | 100 Ω - 1.6 kΩ |
| 4 | 25 Ω | < 100 Ω |
| Constant Voltage | 25 Ω | any |

With known values of $V_{PROG}$, $R_S$, and $Z_{DUT}$, we can calculate the values of $V_{DUT}$ and $I_{DUT}$ using Ohms Law and derivative equations as illustrated in Figure 1.

$$X_{DUT} = 2\pi fL$$

$$= \frac{1}{2\pi fC}$$

$$Z_{TOT} = \sqrt{\left(X_{DUT}\right)^2 + \left(R_{DUT} + R_S\right)^2}$$

$$V_{PROG} = I_{DUT} \left(Z_{DUT}\right)$$

$$Z_{DUT} = \sqrt{\left(X_{DUT}\right)^2 + \left(R_{DUT}\right)^2}$$

$$I_{DUT} = \frac{V_{PROG}}{Z_{TOT}}$$

$$R_{DUT} = X_C D$$

$$= \frac{X_L}{Q}$$

$$V_{DUT} = \frac{Z_{DUT}}{Z_{TOT}} \left(V_{PROG}\right)$$

**Figure 1: Formulas for Calculating DUT Voltage, Current & Impedance**

Prior to determining the voltage across the DUT or the current through the DUT, one must first establish the test voltage and frequency. The source resistance is then established based on the resistance range used by the test instrument. A capacitor is used as an example to illustrate the calculation of the voltage across the DUT.
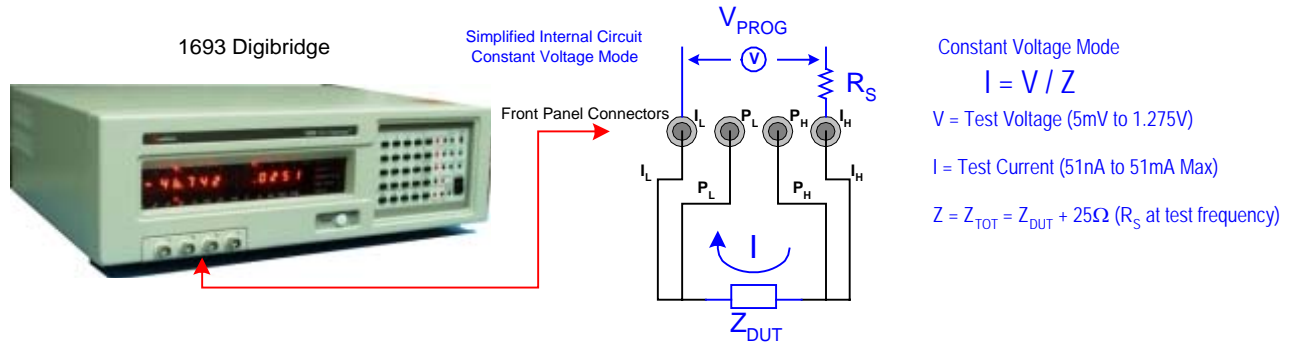
# Calculate the voltage across the DUT

1693 Digibridge

Simplified Internal Circuit
Constant Voltage Mode

$V_{PROG}$

$R_S$

Front Panel Connectors

$I_L$   $P_L$   $P_H$   $I_H$

$I_L$   $P_L$       $P_H$   $I_H$

I

$Z_{DUT}$

**Constant Voltage Mode**

$I = V / Z$

V = Test Voltage (5mV to 1.275V)

I = Test Current (51nA to 51mA Max)

$Z = Z_{TOT} = Z_{DUT} + 25\Omega$ ($R_S$ at test frequency)

**Figure 2: Constant Voltage Mode with 1600 Series Digibridge**

**Device Under Test:**

DUT = 2uF capacitor
D = 0.1
Test Voltage = VPROG = 1V
Test Frequency = f = 1kHz
1693 Resistance Range = range 4
Source Resistance = $R_S = 25\Omega$

$R_S = 25\Omega$   **DUT**

$V_{PROG}$ (∼) 1V   C=2uF   $Z_{DUT}$   $V_{DUT}$   $I_{DUT}$
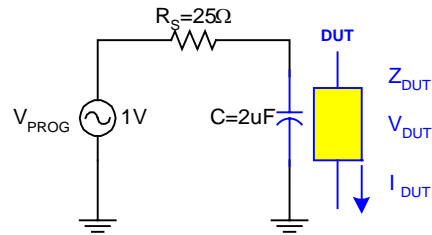
Given the above values for the capacitor under test and the test parameters, we can calculate $X_C$, $R_C$, $Z_{DUT}$ and $Z_{TOT}$. Once we have these values, we can calculate $V_{DUT}$ using the equations in Figure 1.

$$X_{DUT} = \frac{1}{2\pi\, fC} = \frac{1}{2\pi\, 1kHz\, 2uF} = 79.57\Omega$$

$$R_{DUT} = X_C D = (79.57\Omega)\,(0.1) = 7.957\Omega$$

$$Z_{DUT} = \sqrt{\left(X_{DUT}\right)^2 + \left(R_{DUT}\right)^2} = \sqrt{\left(79.57\Omega\right)^2 + \left(7.95\Omega\right)^2} = \sqrt{6394.58\Omega} = 79.96\Omega$$

$$Z_{TOT} = \sqrt{\left(X_{DUT}\right)^2 + \left(R_{DUT} + R_S\right)^2} = \sqrt{\left(79.57\Omega\right)^2 + \left(7.95\Omega + 25\Omega\right)^2} = \sqrt{7417.80\Omega} = 86.12\Omega$$

$$V_{DUT} = \frac{Z_{DUT}}{Z_{TOT}}\left(V_{PROG}\right) = \frac{79.96\Omega}{86.12\Omega}\left(1V\right) = 0.928V$$

After calculating the voltage across the DUT (0.928V), we calculate the current running through the DUT using Ohm's Law: V=RI or I=V/Z. $I_{DUT} = V_{DUT}/Z_{DUT} = (0.928V)/(79.96\Omega) = 0.0116A = 11.6mA$.

# Digibridge Voltage & Current Ranges

Figures 3 and 4 present graphical illustrations of the voltage across a DUT (for resistors or low loss capacitors and inductors) and the maximum current of the Digibridge instrument at 1.275V. Actual voltage and current values depend on the device being tested (DUT).
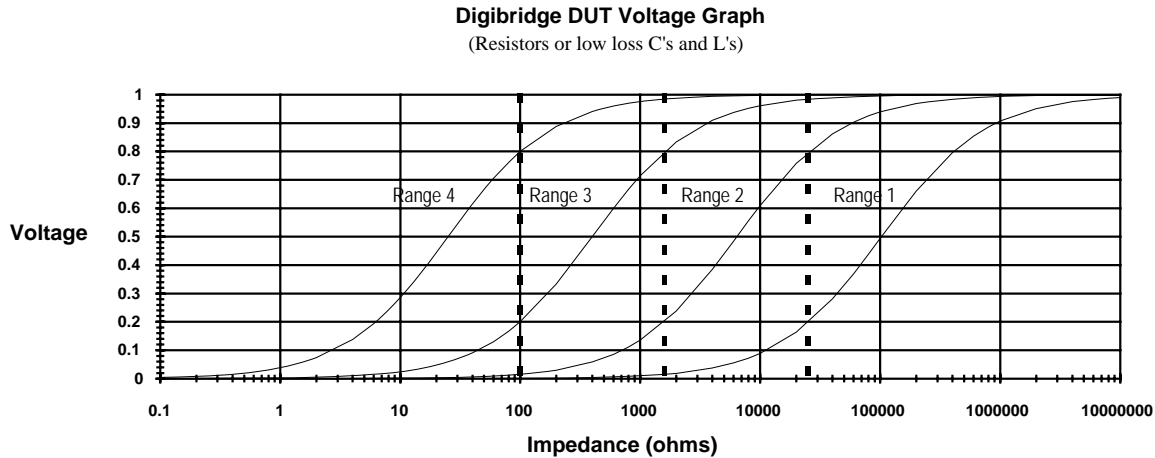
**Digibridge DUT Voltage Graph**
(Resistors or low loss C's and L's)



**Figure 3: 1600 Series Digibridge Voltage versus Impedance**

**Maximum Digibridge Current**
**(1689/1693 @ 1.275 volts)**
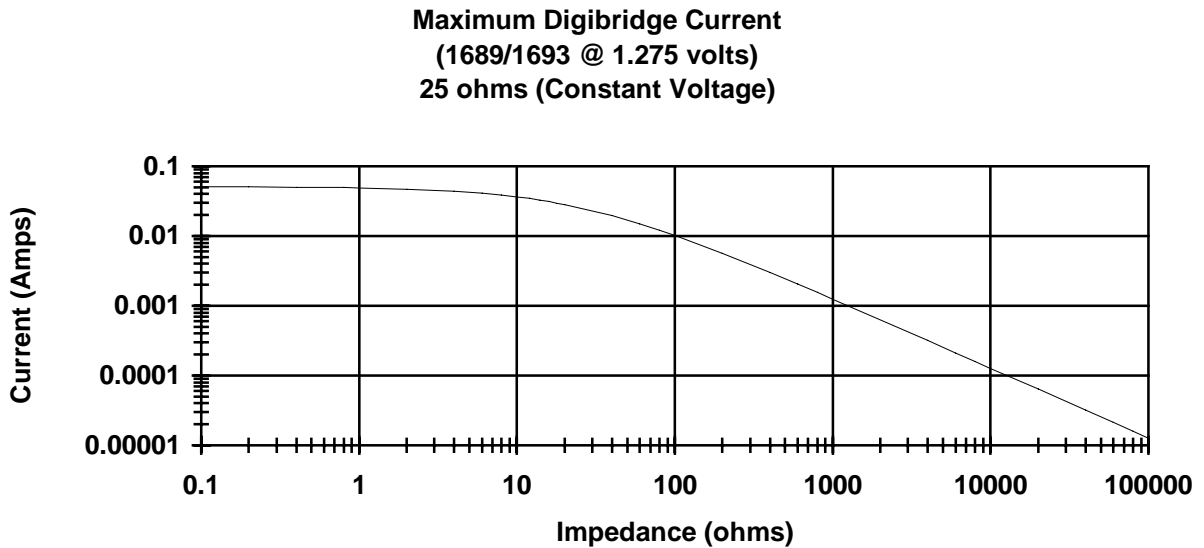**25 ohms (Constant Voltage)**



**Figure 4: 1600 Series Digibridge Current versus Impedance**

For complete product specifications on the Digibridge Line of LCR meters or any of IET's products, visit us at http://www.ietlabs.com/digibridges.html Do you have an application specific testing need? Call us at 1800-899-8436 or email engineering at sales@ietlabs.com and we'll work with you on a custom solution. Put IET to the test because we're committed to solving your testing requirements.