Capacitor Wizard®

IN-CIRCUIT ESR METER

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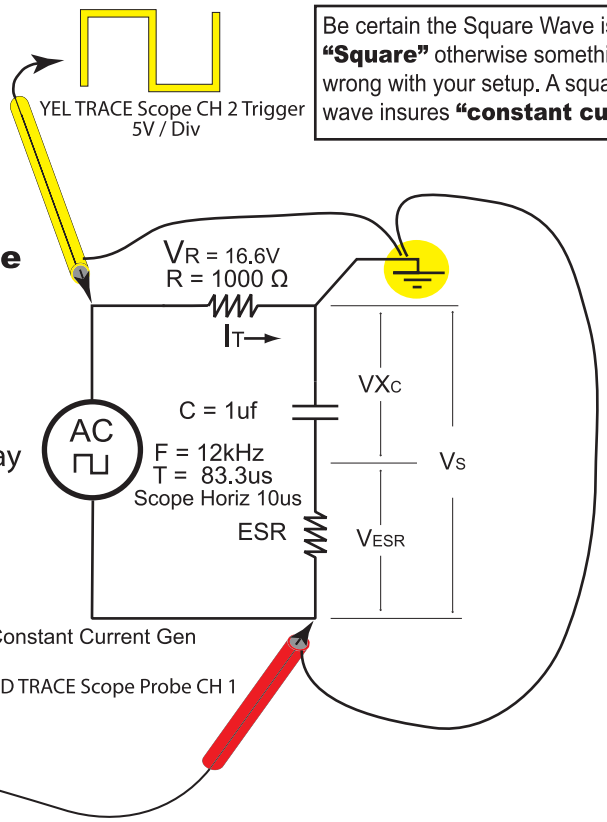
ESR Measurement using Square Wave, Resistor and Oscilloscope

WARNING! I have isolated the safety grounds on the power plugs of both the oscilloscope and the waveform Gen. The safety grounds are tied to the BNC connectors on both the Waveform Gen and the Scope. In the circuit configuration below you must isolate the safety grounds or you will short out the waveform generator.

Units: Voltage "V_R", "V_{ESR}" in VOLTS, amperage "I_T" in AMPS, resistance "R", "ESR" in OHMS Ω

Scope Settings for: 1uf ESR
Horiz: 10us
CH1: DC X1 50mv/div
CH2: DC X1 5V/div Trigger
R = 1000 Ω
Acquire Mode: 16
Acquire Length 1000

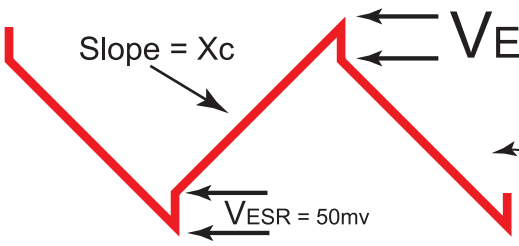
Waveform Gen: State 1
Output Square High Z
F = 12kHz
VPPgen = 20.00vpp



Be certain the Square Wave is **"Square"** otherwise something is wrong with your setup. A square wave insures **"constant current"**

1) Measure ESR with Sq Wave Gen and Scope

a) Demonstrate how to measure ESR with this setup
b) Verify agreement with Capacitor Wizard®
c) Demonstrate that ESR is not frequency dependent
d) Show Fluke 87-V capacitance meter misses bad caps
e) Demonstrate inverse temp coefficient with freeze spray



Adjust the scope horiz and vertical & waveform gen until a pattern such as above is observed.

Measure V_R. ***V_R and I_T will remain constant throughout our tests.***

$V_R = 16.6V$

$ESR = V_{ESR} / I_T$

Calculate the value of I_T by dividing the measured value of V_R by R.

$I_T = V_R / R = 16.6V / 1000\Omega = 0.0166A$ $I_T = 0.0166A$

Calculate ESR by dividing the measured value of V_{ESR} by I_T. $ESR = V_{ESR} / I_T$.

$V_{ESR} = 50mv = 0.050V$ 1uf 50v: $ESR = V_{ESR} / I_T = 0.050V / 0.0166A = 3.01\Omega$ $ESR = 3.01\Omega$

Test other capacitors. Notice "I_T" remains the same

100uf 35v: ESR = 0.0064V / 0.0166A = 0.39Ω
220uf 35v: ESR = 0.0033V / 0.0166A = 0.20Ω
1500uf 6.3v: ESR = 0.0352V / 0.0166A = 2.12Ω
1000uf 16v: ESR = 0.0296V / 0.0166A = 1.80Ω

Bad Capacitors. These are high uf and low voltage. They should be less than 0.5 ohm.

Now check these capacitor's with the Capacitor Wizard® and verify agreement!

DOUGS TECH NOTES
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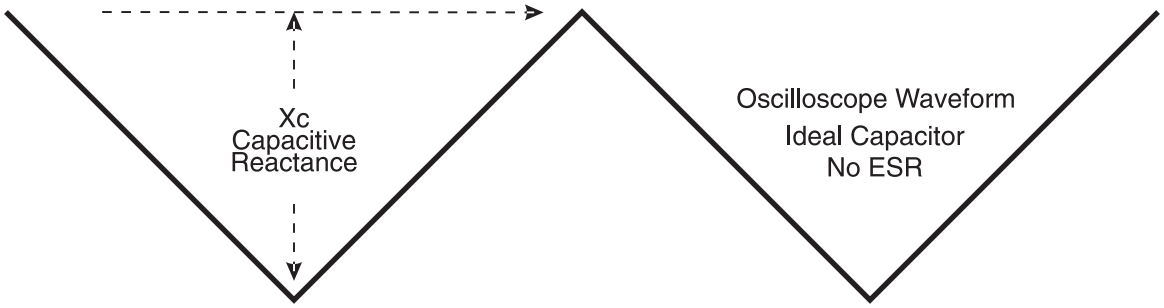
Square Wave Analysis of ESR

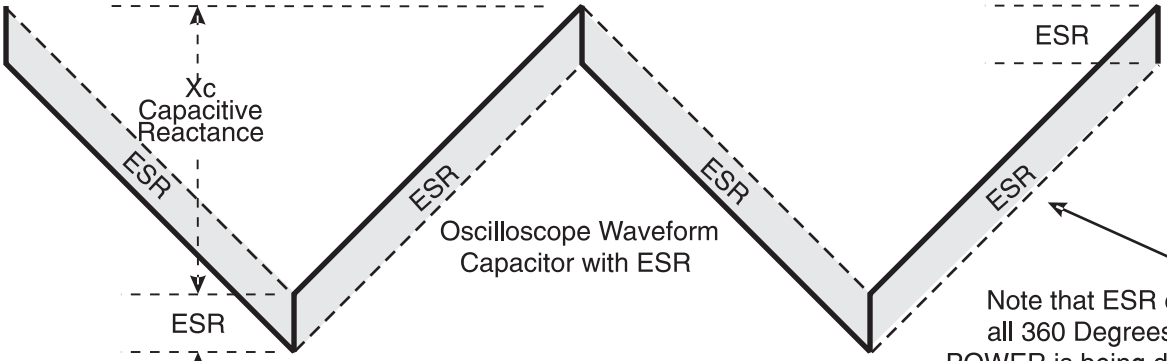
0 Deg 180 Deg 0 Deg 180 Deg 0 Deg

"A"
Current Waveform

"B"
Voltage Waveform No ESR



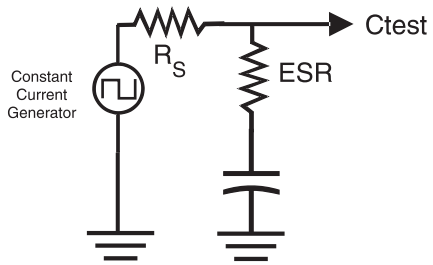
"C"
Voltage Waveform With ESR



Note that ESR exists through all 360 Degrees. That means POWER is being dissipated through the entire 360 Degrees. $P=I^2*ESR$

"D"

Waveform after Xc is "Zero'd Out" by raising the frequency. ***Only ESR is Left!!***
Now we can calculate ESR directly: ESR = Peak to Peak AC Voltage (E Ctest) / Constant Current (R_S)



$ESR = E(Ctest)/I(R_S)$, $(E = I \times R)$