CAPACITOR TESTING
(MOTOR START & RUN)

The purpose of this tech note is to help technicians diagnose a motor start or run capacitor that is about to fail. (Please read caution at the end of this note)
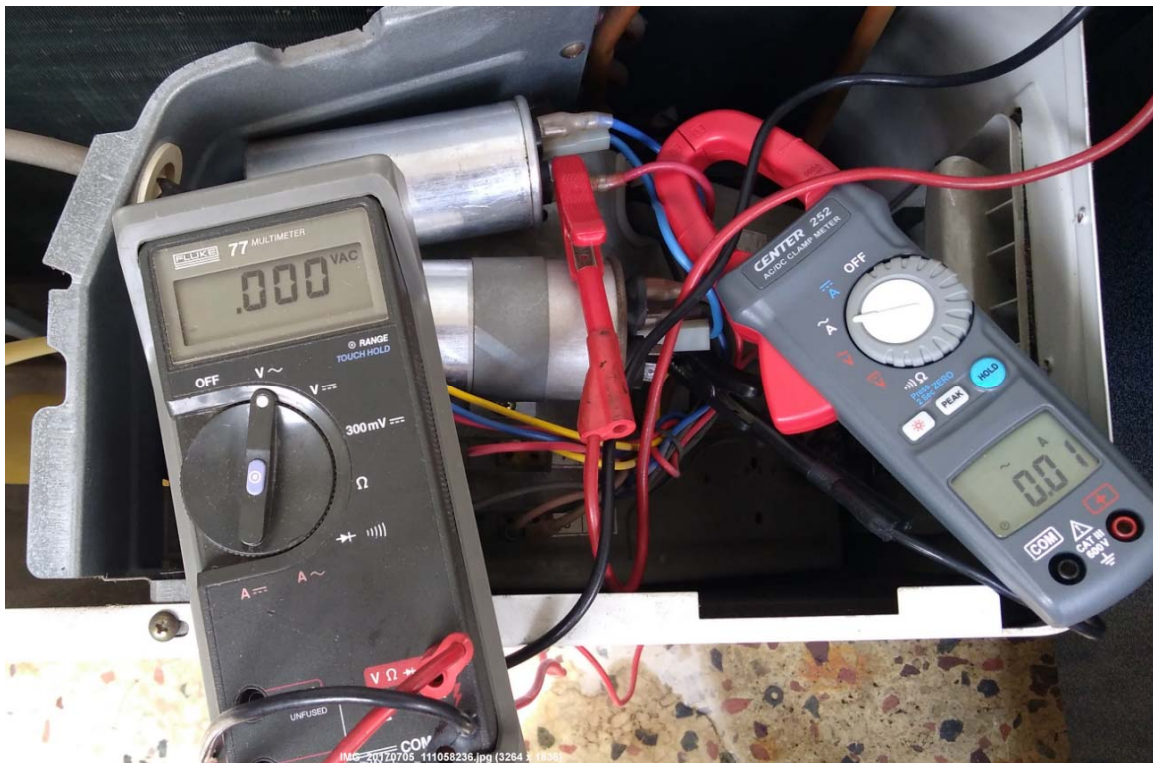
A faulty start or run capacitor can prevent a motor from starting or running. If the capacitor is defective and the motor fails to start or run, the diagnosis is relatively simple.

Most Digital Multi Meters (DMM) designed for HVAC/R use have a capacitor test. In order to do this test, the capacitor must be disconnected from its circuit and discharged.

Capacitors are very complex electronic devices whose construction and materials determine the exact internal circuit they actually have which is far from the two plate concept we learn at school with some dielectric in-between them.

A better and more accurate way to test a capacitor is when the motor is running.

To do this you need a clamp current meter and a DMM. You can use a DMM with a clamp current meter but you will have to measure the voltage and the current one at a time.

Connect your DMM across the capacitor leads preferably with quality alligator clips and the clamp meter in one of the capacitor leads as shown in picture above. Note the system is not energized.

Turn the system on, measure the current and write it down. Then measure the voltage between the terminal the clamp meter is on and the other one which could be common for a dual capacitor.

From Ohm's law we know $\dfrac{V}{I} = Xc$ where V is the terminal voltage, not the supply voltage,

I is the current you just measured and Xc is the capacitive impedance of the capacitor.

$Xc = \dfrac{1}{2\pi f C}$, f is the AC supply frequency and C is the capacitance we are trying to find its

value. The units are V in Volts, I in Amperes, f in Hertz, C in Farad

Plugging Xc back into $\dfrac{V}{I} = Xc$ and solving for C we get $\quad C = \left(\dfrac{1}{2\pi f}\right)\left(\dfrac{I}{V}\right)$

$2\pi f$ for 60Hz is 120π or 377 and $1/377 = 2652 \times 10^{-6}$

Just remember the number 2652 (it is 26 and 2 x 26=52)

Since the multiplier in the 2652 number is 10^{-6} the result will be in μF or micro Farad, so simply multiply the current you measured by the number 2652 and divide by the voltage you measured to get the actual capacitance as the motor is running.

$$C = (2652)\left(\dfrac{I}{V}\right)$$

The picture below is from an 18000 BTU split AC running on 220VAC @ 50Hz

$2\pi f$ at 50 Hz is 100π and $1/2\pi f$ = 3183x10^{-6}. The number 3183 is more difficult to remember so just remember one over 100 π. Our formula is:

$$C = (3183)\left(\frac{I}{V}\right)$$

For this example (3183)x(2.33)A/(324)V=22.89 μF

The capacitor we measured was listed as a 30 μF -5% to +10%
22.89 μF is 23.7% below the 30 μF listed on the capacitor whose lowest value (the -5% of 30) is 28.5 μF.

This capacitor is failing.

To summarize, measure the current at the cap and the voltage on its terminals-NOT the supply.

For 60Hz, multiply the current you measured times 2652 and divide the result with the voltage you measured. This is the actual capacitance of the capacitor in micro Farad. Compare your result to the value listed on the cap and if it is below the lower limit of the tolerance, replace it.

For 50Hz AC supply multiply the current you measured times 3183 and divide by the voltage. Similarly, if the result is below the lower limit of the tolerance of the capacitor value listed on it, replace it. This is preventative maintenance.

Tools & instruments used:

CAUTION

Follow all applicable safety procedures while working with live electrical circuits. Use caution around motors, fans and other machinery that can start automatically.

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