Application of UL1414 and IEC60384-14 Safety X-Y Capacitor Standards to AC20424-01 External Antenna RF Coupler/Isolation Circuit

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Figure 1.0 AC20424-01
RF Coupler/Isolation Circuit*

In the SMART energy market, there is an increasing recognition of the need for improved read rates for SMART utility meters (end points) that are remotely connected to the internet via public LTE, private spectrum, ISM band mesh and other wireless networks. This is being driven in part due to contractual obligations that provide for monthly penalties/fines for less than 100% read rates for vendors responsible for these deployments.
In addition, powerful AI processors are starting to play a critical role in grid-edge integration where energy consumption data analytics is processed and acted upon real-time relying on multiple radio connections within the meter.

Alternate Solution to Costly Densification

While densification (deploying more base stations) is a costly method to improve connectivity, improved meter read-rates can be achieved for less cost by using remotely mounted higher-efficiency external antennas. These external antennas by-pass less efficient internal-to-meter antennas that are often cross-polarized verses the base station antenna resulting in poorer wireless range.

This solution, depicted in Figure 2.0, increases wireless range and connectivity to distant base stations. An example multi-band LTE antenna (Antenna Company AC94541-01) is shown in figure 2.0.

Safety Isolation Circuit

The latter solution requires careful consideration for electrical isolation of the remote antenna, from the high voltage power supply within the meter, by using a low RF loss (<1.0dB typ.) high electrical isolation (10KV typ.) circuit such as the AC20424-01 RF coupler shown in figure 1.0.

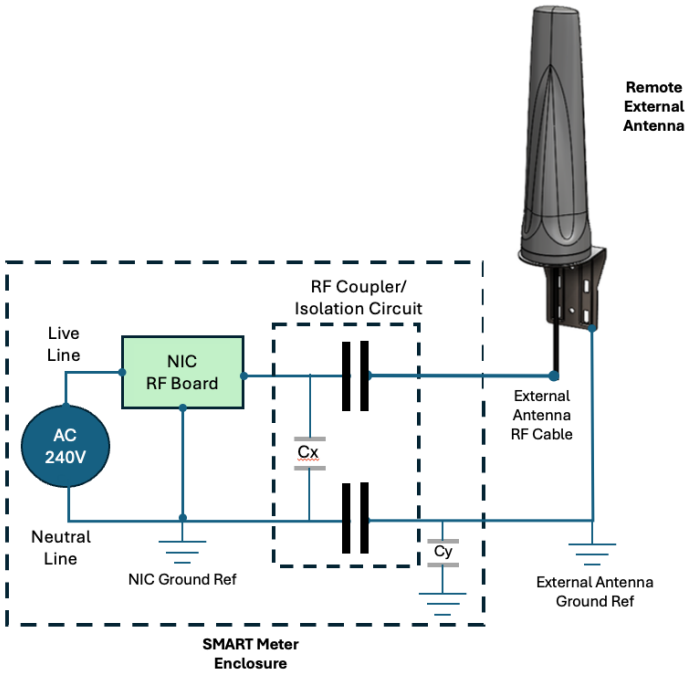

Figure 2.0 SMART Meter Schematic showing X-Y Capacitor References for RF Coupler

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1 - https://webstore.iec.ch/p-preview/info_iec60384-14%7Bed3.0%7Den.pdf
2 - https://webstore.ansi.org/standards/ul/ul1414ed2000
3 - https://www.allaboutcircuits.com/technical-articles/safety-capacitor-class-x-and-class-y-capacitors/

*RFST LLC US Patent 9,118,095 B2

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Applicable Safety Standards

This paper describes the applicability of electrical safety standards, such as X-Y capacitor standards specified in IEC 60384-14[1] and UL1414[2], to the RF coupler external antenna isolation circuit* referenced in figure 2.0.
This device is suitable for ANSI and IEC form-factor SMART utility meters and other similar applications such as LED street lighting poles.

Since the RF coupler/electrical isolation circuit (figure 2.0) is placed within a SMART utility meter, between the radio card known as a Network Interface Card (NIC) and the external to meter remote mounted antenna, it can be treated as an X-Y safety capacitor from a safety standards standpoint.

The reason is the RF coupler structure is a parallel plate capacitor that electrically isolates both the RF signal (AC live feed) and ground (AC neutral feed) between the NIC AC power supply source and the external remote antenna outside of the meter.

UL1414[2] references X (line to line) and Y (line to ground) safety capacitor classifications where figure 3 illustrates, failure of a class X safety capacitor could result in fire and failure of a class Y capacitor could result in electric shock.

There are various Y sub classes (Y1-Y4).
Y1 provides for worst case scenario,
it applies to devices with up to 500VAC
rated voltage, and specifies an impulse
voltage of 8KV without failure.
Similarly, there are various X sub-classes
with a maximum impulse voltage of 4KV
specified.
As such, the 8KV Y1 sub class is the highest applicable impulse voltage requirement in this standard. The AC20424-01 shown in figure 1.0 is designed to meet 10KV electrical isolation (derated by 20% from Y1 sub-class).

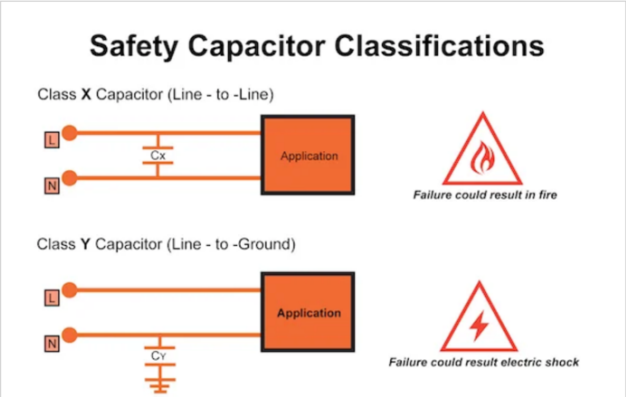

Figure 3.0 Placement of Class-X (Cx) and Class Y (Cy) safety capacitors, (image source all about circuits blog[3])

In addition to IEC 60384-14[1] and UL1414[2] safety standards, SMART utility electric meters must comply with industry standards for creepage and clearance norms for printed circuit boards.
As such the integration of the RF coupler external antenna isolation circuit inside the SMART meter must observe creepage and clearance standards, including RF cable routing to its input and output ports, to maintain specified electrical isolation.

For further information contact sales@antennacompany.com

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1 - https://webstore.iec.ch/p-preview/info_iec60384-14%7Bed3.0%7Den.pdf
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