Murata Power Solutions

DMS APPLICATION NOTE 24

Extending Current Transformer Leads

Introduction

Murata Power Solutions presently offers two styles of digital meters for measuring ac current and power: the first style is supplied with a built-in current transformer (CT) permanently attached to the meter; the second style is designed to accept the secondary output of external 5 Amp CTs (commonly known as "donut" CTs). Adding lead extensions to external 5 Amp CTs will be discussed in the last section of this application note.

An example of ac ammeters with a built-in CT are our ACA-20PC series ammeters shown in Figure 1A. This series has the CT soldered directly to the ammeter's pc-board, or in some models by wire leads. In contrast, our ACA5-20PC series ammeters accept the output of external 5 Amp donut CTs; an example is shown in Figure 1B. Our ACM20 multifunction ac power meters and ACM3P 3-phase ammeters shown in Figures 2A and 2B are all supplied with built-in CTs that have wire lead lengths typically under six inches (15cm).

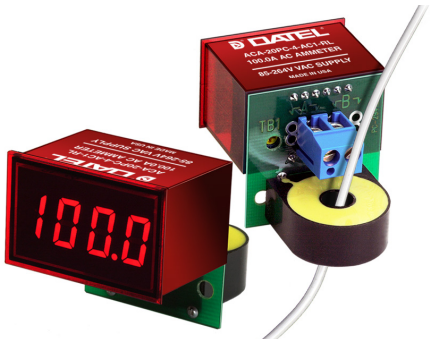

Figure 1A. ac ammeter with built-in CT

Figure 1B. ac ammeter for external 5 Amp CTs

It's important to note that lead extensions must not be added to our ac meters that have built-in, pc-board style CTs (i.e., those with no wire leads). These CTs are soldered in place, and removing them could damage the pc-board and/or the CT itself, as well as producing an electrically unsafe and unreliable installation. Also, please keep in mind, modifying our meters will void their warranty and, if applicable, their safety agency rating.

Why Use Lead Extensions?

In a perfect world, there would be no need to extend a CT's lead length. That is, the load conductor whose current one intends to measure would be located in the immediate vicinity of meter. However, in many applications, the ammeter or power meter must be located a significant distance from the load conductor. The purpose of this application note is to provide qualified technical personnel the information needed to add lead extensions to a CT in a manner that ensures a safe and reliable installation.

Figure 2A. Multi-function ac power meter

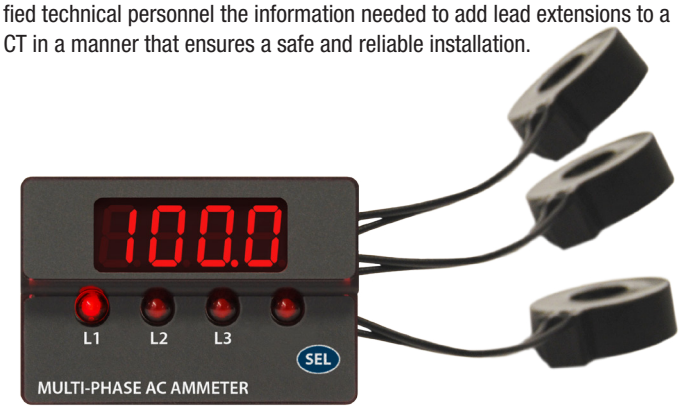

Figure 2B. 3-phase ac ammeter

!IMPORTANT!

Due to the presence of potentially lethal voltages and currents, and to ensure safe and reliable operation, our ac ammeters, voltmeters, and power meters must only be installed and serviced by qualified technical personnel.

Please note, modifications made to our ac ammeters, voltmeters, and power meters will void both their warranty and their UL recognized-component status. Therefore, we cannot accept returns for products that have been modified in any way.

All splices and/or modifications must only be performed after all associated ac power sources are de-energized (turned OFF); this includes the ac source powering the ammeter itself, as well as all ac sources supplying power to the load conductors being measured by the ammeter or power meter. Additional safety-related information contained in the respective product technical data sheet must be referenced before performing any installation, modification, or service-related operations.

From a technical standpoint, adding several feet (or meters) of lead extensions to our ac ammeters' and power meters' built-in CTs will not measurably degrade performance or accuracy. This is due to the fact that the currents circulating in the CTs' secondary output leads (i.e., the leads that will be extended) are very low, typically in the range of 30 to 50mA

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when the primary load current is at its maximum value. Because the secondary currents are so low, the additional voltage drop, commonly referred to as "burden," produced by the lead extensions is negligible, even with extensions in the 40 to 50 foot range (12 to 15m).

The phrase "will not measurably affect performance or accuracy" does not take into consideration those customer applications that involve extremely noisy environments, since such noise could be more easily coupled into the longer leads. However, by design, our ac meters' input circuits are relatively immune to high-frequency noise, so, in our experience, noise is normally not a factor when extending CT leads by 10 to 15 feet (three to five meters). However, if the ammeter readings become unstable after adding lead extensions, noise may be a factor and the use of twisted-pair leads, or even shielded cable, will need to be considered.

Note: In order to maintain the ACM3P's factory calibration specifications, before any cuts are made to the CTs, clearly mark / identify each CT to indicate its original as-shipped physical location (i.e., L1, L2, or L3). When splicing the CTs back onto the ACM3P, be sure to reconnect each CT in its original physical location. For ACM3P ammeters, maintaining CT phasing is not required, that is, the CT's two output leads are not polarity sensitive and can be interchanged.

Making the Connections

For safety, the wire used to make the lead extensions must be Underwriters Laboratory (UL) rated for a minimum of 300V. 20-22AWG (0.52 – 0.33mm^2) stranded copper wire is recommended. (This wire gauge range does not apply to lead extensions to external 5A output CTs; lead extensions for 5A CTs are discussed at the end of this application note.) Since ac line voltages are present on our CT leads, all splices and splicing components (twist-on wire nuts, butt splices, terminal blocks, sleeving, etc.) must also be UL rated for 300V minimum and suitable for the applicable installation.

It is the user's responsibility to ensure the lead extension materials and workmanship meet all of the electrical and mechanical requirements pertaining to their application. Mechanical splices and connections must be made in a manner that meets all applicable local and national safety codes and regulations, as well as any other codes and regulations that apply to the customer's application.

The most reliable connections are those made by soldering the splices and then applying appropriate heat shrink insulation over the splices. If wire nuts are used, make sure they are correctly sized for 20-22 AWG wire (0.52 – 0.33mm^2), as the use of over-sized wire nuts could lead to unsafe loose connections. If crimp style connectors are used to make splices, ensure the crimp tool is designed for the chosen crimp connector, and follow all of the crimp connector / crimp tool manufacturer's instructions.

Before applying ac power to the ammeter and load, recheck all connections to ensure they're mechanically secure by pulling on them. We also recommend using cable ties (tie wraps) to secure long leads to one another and, where appropriate, to provide physical separation from suspected sources of noise. Keep mind intermittent connections on the output leads of CTs can generate voltage transients that may adversely affect the ammeter's operation and long term reliability.

Lead Extensions for 5 Amp Output External "Donut" CTs

IMPORTANT! To ensure safe and reliable operation, "donut style" 5 Amp output current transformers and all associated equipment must be installed and serviced by qualified technical personnel. Never open the CT's secondary connections while the primary circuit is energized. Open CT secondary wiring can generate potentially lethal voltages when the primary circuit is energized. Contact Murata Power Solutions if you have any doubts regarding the installation or operation of any of our ac-mains measurement instruments and accessory CTs.

Figure 3. Typical 5 Amp output "donut" CT

Most of the information previously provided in this application note addressed adding lead extensions to meters with built-in CTs. However, much of it also applies to adding lead extensions to 5 Amp external donut CTs shown in Figure 3. With the exception of the difference in wire gauges (more on this later), all connections to external 5 Amp CTs must be made following the instructions and guidance in the "Making the Connections" section of this application note.

Because the secondary output current in donut style CTs can reach 5 Amps or higher, the voltage drop (or burden) imposed by lead extensions' series resistance plays a significant role in determining the maximum allowable length of the extensions. Therefore, the wire gauge of the extensions must be considerably larger than those stated earlier in "Making the Connections" section because series resistance cannot be ignored with 5A external CTs. For our 7020 series CTs (see table 1), we recommend using a minimum wire gauge of 16 AWG (1.31 mm^2).

When external 5 Amp CTs are used with ACA5-20PC ammeters, the lead extensions' series resistance for all practical purposes is equal to the maximum burden supported by the CT. However, ACA5-20PC ammeters, unlike competing models, do not use internal burden resistors to develop a signal, meaning the burden of these meters is, for all practical purposes, equal to zero Ohms. A meter burden of zero-Ohms enables the use of longer lead extensions, while not significantly degrading the CT's specified accuracy. The maximum burden and extension length supported by our 7020 CTs is contained in their data sheet's selection guide shown in Table 1 for convenience. The lead extension lengths listed in Table 1 include the CT's 16AWG output lead wires that measure approximately 24 inches (61cm).

In applications where multiple external 5 Amp output CTs are to be monitored with one ammeter, switches specifically designed for switching CTs in and out of the metering circuit are available from third party suppliers. These heavy-duty switches include make-before-break shorting contacts that apply short circuits to the outputs of the disconnected CTs (i.e., those not under measurement). This type of switch prevents the arcing and dangerous voltage spikes that can occur when the secondary output of a 5A CT under load is opened. Use and wiring of these specialty switches is beyond the scope of this application note; please refer to the respective manufacturer's data sheet for more information.

Table 1. Selection Guide for Murata Power Solutions 5 Amp CTs

MPS Part No.	Current Ratio (Amps)	Accuracy (@ 60Hz)	Burden VA (Ohms)	Lead Extension Length Feet (Meters)	Thermal Rating Factor (@30°C)
7020-01036-0	50:5	±2%	1.5 (0.06)	4 (1.2)	1.3
7020-01037-0	75:5	±2%	3.0 (0.12)	10 (3.0)	1.3
7020-01038-0	100:5	±1%	3.0 (0.12)	10 (3.0)	1.3
7020-01039-0	150:5	±1%	6.0 (0.24)	20 (6.1)	1.3
7020-01040-0	200:5	±1%	8.0 (0.32)	30 (9.1)	1.3
7020-01041-0	250:5	±1%	10.0 (0.40)	40 (12.2)	1.3
7020-01123-0	300:5	±1%	12.5 (0.50)	50 (15.2)	1.0
7020-01124-0	400:5	±1%	12.5 (0.50)	50 (15.2)	1.0
7020-01125-0	500:5	±1%	20.0 (0.80)	80 (24.4)	1.0
7020-01042-0	600:5	±1%	10.0 (0.40)	40 (12.2)	1.0
7020-01043-0	750:5	±1%	10.0 (0.40)	40 (12.2)	1.0
7020-01044-0	1000:5	±1%	10.0 (0.40)	40 (12.2)	1.0
7020-01045-0	1500:5	±1%	12.5 (0.50)	50 (15.2)	1.0
7020-01046-0	2000:5	±1%	15.0 (0.60)	60 (18.3)	1.0

Murata Power Solutions, Inc.
11 Cabot Boulevard, Mansfield, MA 02048-1151 U.S.A.
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