INSTRUMENTATION TECHNICIAN (TECH LEVEL 2 - INTERMEDIATE)

PROGRESS WORKBOOK #8

CORE INSTRUMENTATION TEST EQUIPMENT

Revision Date: Dec 28, 2024 12:47pm [MRG]

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I. CORE INSTRUMENTATION TEST EQUIPMENT – PREP WORK

A. PROCESS METERS (FLUKE 789, ETC.)

The following table shows the expectations for a level 2 Instrument Technician in this area.

Technicians pursuing Tech 2 must also meet the Tech 3 KSA expectations.

In addition to completing the requirements below, the technician must have taken and passed a hands-on "Instrumentation Basics Course" covering the bulk of the material covered in the following expectations lists.

KSA Expectations
Process Meters – Fluke 789 (T3) *Be familiar with the IO jacks of the Fluke 789 and be able to setup typical tests using the IO manual.* *Be familiar with the rotary switch and the buttons on the Fluke 789 and be able to setup typical tests using the IO manual.* *Be familiar with typical functions and features of the Fluke 789 and be able to setup and utilize them using the IO manual.* *Be able to perform the typical tasks listed below (using manual as needed):* *Be able to measure current, voltage, and resistance* *Be able to source or simulate loop current in each possible modes (loop powered/meter powered, current source/transmitter simulation, 250Ω resistance included/not included).* *Be able to adjust and enter values* *Be able to setup ramping and/or stepping modes* *Be able to adjust the resolution and range of the meter readings.* *Be familiar with the user manual.* **Process Meters – Fluke 789 (T2)** Be able to setup the proper IO jacks when using a Fluke 789 (without a manual) Be able to setup the proper switch and button settings when using a Fluke 789 (without a manual) Be able to setup the typical functions and features of the Fluke 789 (without a manual) Be able to perform the typical tasks listed below (without using the manual): • Measure current, voltage, and resistance. • Source OR simulate loop current in each possible modes (loop powered/meter powered, current source/transmitter simulation, 250Ω resistance included/not included). • Adjust and source & simulation values using each available method. • Set up ramping and/or stepping modes. • Adjust the resolution and range of the meter readings.

Resources
Fluke 789 – User Manual Fluke 789 – Quick Sheet

1) Assignment

Find/Download/Save/Print a copy of the Fluke 789 / 787B Users Manual. Then, answer the following questions.

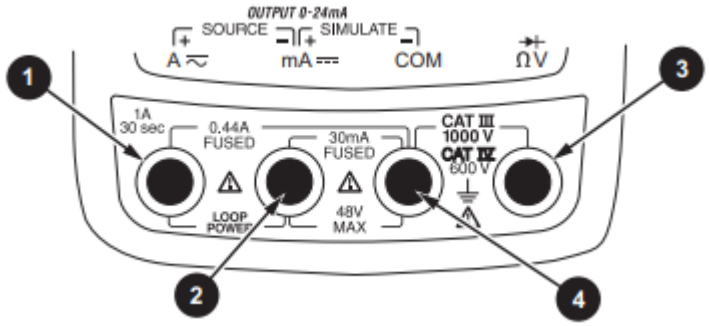
This section is based on rev 4 (1/17). If you use different revisions you may need to adjust accordingly. An electronic copy may serve best for future use in CMAS and for easier storage – but a temporary paper copy is also helpful if printing 50 pages is not a problem.

2) Questions (Table 3 - IO Jacks):

a. According to table 3 (IO Jacks), which jacks should you connect to when measuring 4-20mA? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

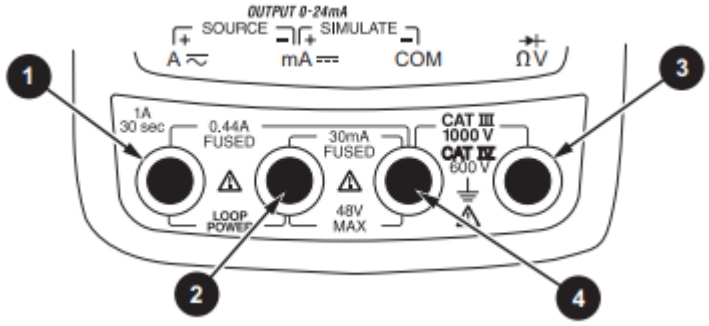
a.	2 to 4



b. According to table 3 (IO Jacks), which jacks should you connect to when measuring the current from a 24vdc output to a 240 ohm solenoid valve. Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

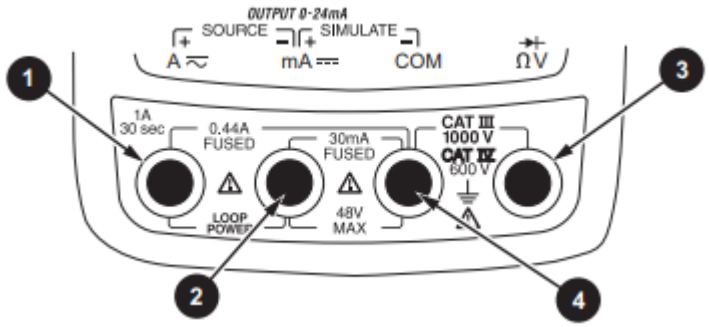
b.	1 to 2 (because 2-4 can only measure up to 30mA and the expected value is 24/240 (100mA).



c. According to table 3 (IO Jacks), what is the maximum current that you can measure continuously with a Fluke 789, and which leads would I use for that measurement? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

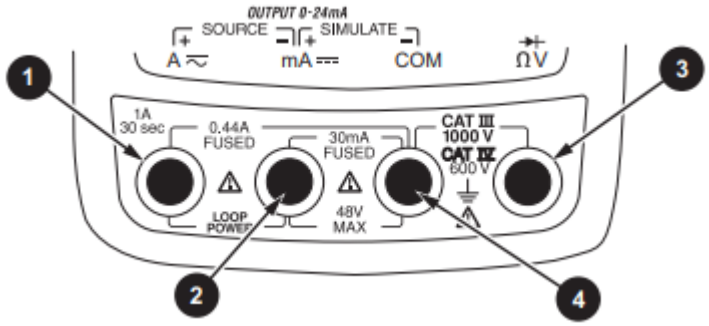
c.	440mA or 0.44A continuous, via jacks 1 and 2.



d. According to table 3 (IO Jacks), which jacks should you connect to when measuring voltage? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

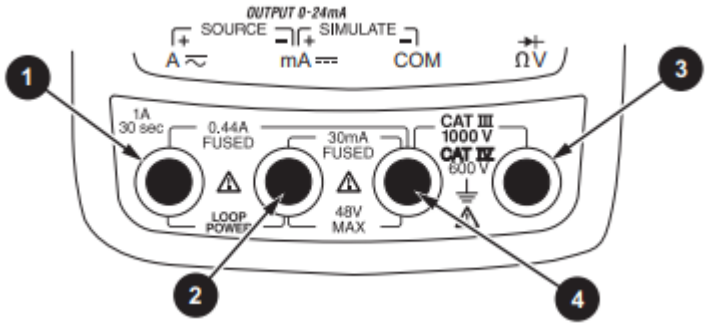
d.	3 and 4



e. According to table 3 (IO Jacks), which jacks should you connect to when measuring resistance? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

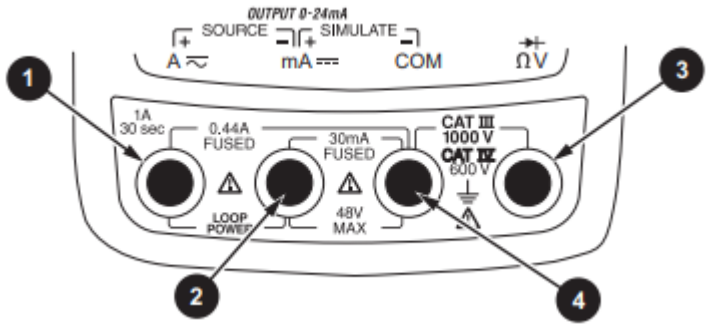
e.	3 and 4



f. According to table 3 (IO Jacks), which jack would you place the positive and negative leads on to output a 4-20mA signal? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

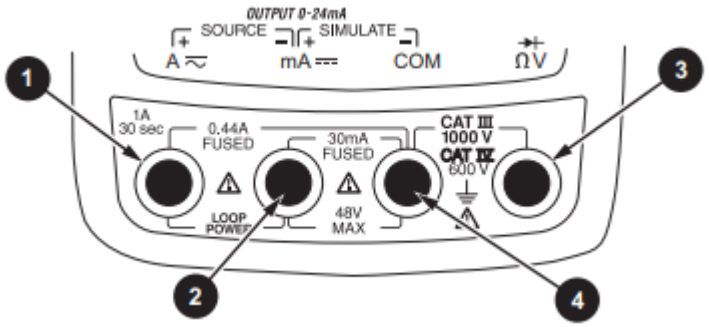
f.	Jacks 1 and 2



g. According to table 3 (IO Jacks), which jacks would you place the positive and negative leads on to simulate a transmitter? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

g.	Jacks 2 and 4



3) Questions (Tables 4, 5, & 6 - Rotary Function Switch Positions):

h. Which pushbuttons could apply when measuring DC voltage? Click or tap here to enter text.

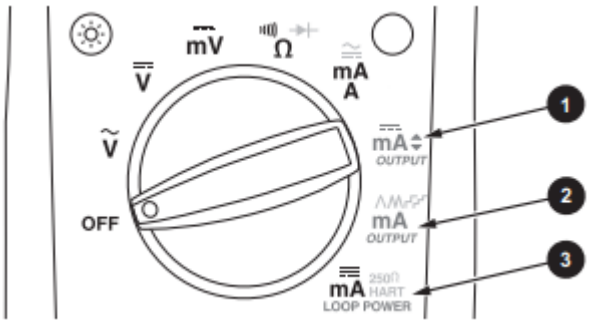
ANSWER KEY (Answers in white font - Change font color to view):

a.	**MIN MAX** **RANGE (Hold for 1 sec to Auto range)** **HOLD Toggles HOLD function)** **REL (Toggles relative references – useful for setting a zero point when comparing voltages)**

i. What rotary switch position do you go to for a resistance check, continuity test, or diode test? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

b.	The continuity/diode-check/Ohmmeter position (4th position from left)



j. How do you switch between resistance/continuity test and diode test? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

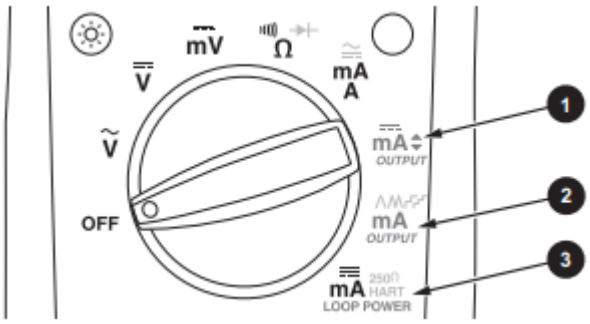
c.	Toggle between continuity, diode test, and ohmmeter functions (and ranges) by pushing the blue button. The applicable function icon will appear above reading.

k. How do you silence the continuity test beep function? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

d.	By toggling the BEEP icon (second button on bottom row).

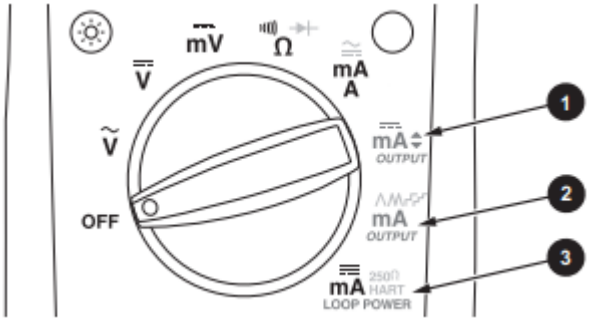
l. What rotary switch position do you go to in order to measure the current in a 4-20mA loop that is sourced by an external power supply? Click or tap here to enter text.



ANSWER KEY (Answers in white font - Change font color to view):

e.	The button above #1 in the diagram shown.

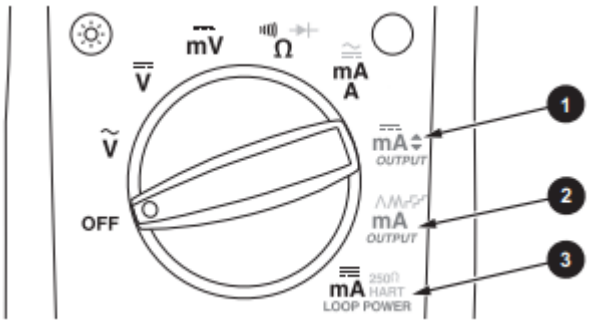
m. What rotary switch position do you go to in order to output 4-20mA (such as to a valve positioner?)? Click or tap here to enter text.



ANSWER KEY (Answers in white font - Change font color to view):

f.	Rotary switch position #2 on image above.

n. What rotary switch position would you go to in order to configure and measure 4-20mA that is on the bench, using the internal power of the meter? Click or tap here to enter text.



ANSWER KEY (Answers in white font - Change font color to view):

g.	Rotary switch position #3 on image above; Toggle blue button to 250ohm series resistance switched in.

i. What would you do to utilize the internal 250 ohm resistance in this setup? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

g.i.	Toggle blue button to 250ohm series resistance switched in.

4) Questions (Tables 5, 6, & 7 – Rotary Switch, Pushbuttons, Display):

a. When using the DC mA output function, how do you adjust the output in 25% step functions? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

h.	By adjusting the up or down arrows labeled %STEP (in orange font). *These are 2nd set of buttons from left side.*

b. When using the DC mA output function, how would you adjust the output to 13.45 mA? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

i.	Bump STEP button to 12.00 mA; Then bump COURSE up button to 14 times to 13.4 Then bump FINE up button 5 times to 13.45

c. When using the Ramping DC output function, how would you setup for a repeating slowly ramping 0-100% up and 100-0% down signal (such as for testing valve positioner)? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

j.	Toggle blue button until the " ^ " icon is shown.

d. How would you setup the meter to measure the MAX value? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

k.	MIN MAX recording stores the lowest and highest measurements, and maintains the average of all measurements. Press M to turn on MIN MAX recording. Readings are stored until the meter is turned off, switched to another measurement or source function, or MIN MAX is turned off. The beeper sounds when a new maximum or minimum is recorded. Auto power-off is disabled and auto ranging is turned off during MIN MAX recording. Press M again to cycle through the MAX, MIN, and AVG displays. Press and hold M for 1 second to erase stored measurements and exit. In MIN MAX recording, press H to suspend recording; press H again to resume recording.

e. How would you setup to HOLD a measurement (and when would you push the button)? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

l.	Note MIN MAX recording must be off to use AutoHold. AutoHold will not capture unstable or noisy readings. Activate AutoHold to freeze the meter's display on each new stable reading (except in the frequency counter mode). Press HOLD to activate AutoHold. This feature allows measurements to be taken in situations in which it is difficult to look at the display. The meter beeps and updates the display with each new stable reading.

f. How do you setup to measure frequency (such as when calibrating a turbine flow meter)? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

m.	With rotary switch in mV DC, VDC or VAC position (as applicable based on peak voltages of sensor/signal), Then, toggle the “Hz” button. Note – trigger level is only about 5% of full scale of the voltage range you have selected, so it is important to select correct voltage range.

g. When in Loop Power mode, how do you switch the 250 ohm resistor in and out of the circuit? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

n.	By toggling the blue function button until the LCD shows 250Ω HART.

h. How do you enter a ‘relative mode’ – such as compensating for lead resistance when doing precision resistance measurements? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

o.	By toggling the REL button (3rd button on bottom row).

i. Based on table 7, answer the following:

   i. What does OUTPUT mean on the display? Click or tap here to enter text.

   ii. What shows up (and where on screen is it), when the battery gets low? Click or tap here to enter text.

iii. What does the 'lightning bolt' indicate? Click or tap here to enter text.

iv. What does the Δ symbol indicate? Click or tap here to enter text.

v. What shows up (and where on the screen is it), when the continuity test function is on? Click or tap here to enter text.

vi. How do you tell whether the meter is in Auto or Manual Range? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

p.i	Either source or simulate function is active. *Meter is providing power to circuit.*
p.ii	Battery icon in upper left corner
p.iii	Dangerous voltage detected
p.iv	Relative reading is ON.
p.v	Beep icon "))) " (symbol 3 on table 7)
p.vi	Shown in fine print on LCD below reading values

j. Explain how to test a diode in your own words (page 18). Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

q.	Rotary switch to DIODE TEST position, leads in Volts & Common jacks, place negative lead on cathode. Should read a voltage of ~0.7v in forward bias direction (+ on anode, - on cathode), and should read OL in reverse bias direction (- on anode, + on cathode). Anode is triangle on schematic diagram. Cathode is horizontal bar on schematic diagram and usually has a silver bar across the cathode side of typical rectifier diodes. For other case styles, see references.

k. Explain the potential problem with using the RELATIVE mode (per page 20), and describe the icon you should look for when doing measurements to ensure the meter was not left in RELATIVE mode: Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

r.	If the REL button is pushed and meter goes into RELATIVE mode while taking a non-zero measurement it will compare all readings to that non-zero value until the meter is taken out of RELATIVE mode. This could introduce substantial errors. *NOTE – The small "delta" triangle in the upper left corner of the meter is a bad thing, unless you are purposefully performing a relative measurement.*

l. How is SOURCE or SIMULATE mode selected – and how can you tell whether the meter is in SOURCE or SIMULATE mode, when outputting dc mA (page 20)? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

s.	If the REL button is pushed and meter goes into RELATIVE mode while taking a non-zero measurement it will compare all readings to that non-

	zero value until the meter is taken out of RELATIVE mode. This could introduce substantial errors. *NOTE – The small "delta" triangle in the upper left corner of the meter is a bad thing, unless you are purposefully performing a relative measurement.*

m. Identify which mode each of the following would require (SOURCE / SIMULATE) per page 23:

i. The meter is being used in place of a transmitter in a 4-20mA loop to troubleshoot a PLC input card with the normal 24v power supply still in the loop: Click or tap here to enter text.

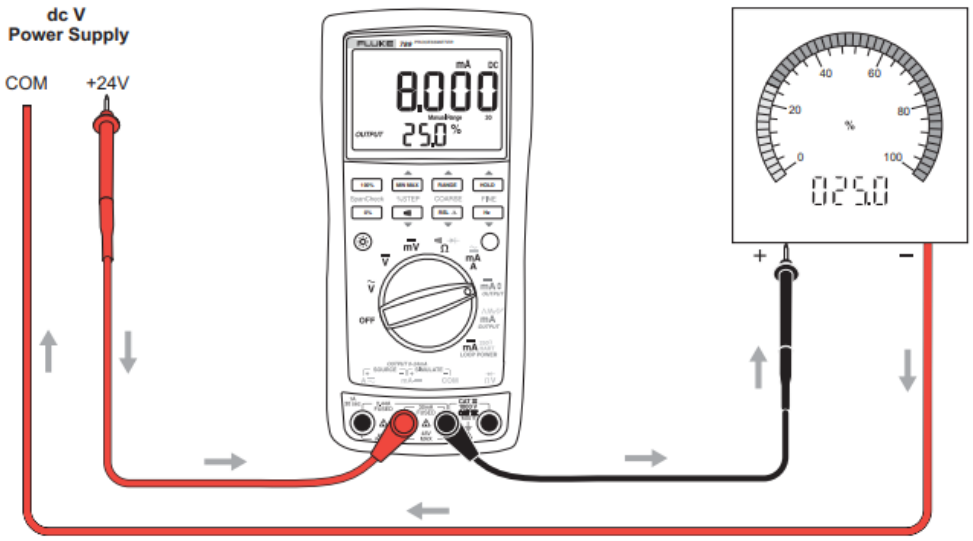
ii. The meter is being used to directly drive a PLC input (with no external power supply connected): Click or tap here to enter text.

iii. The meter is being used to drive a 4-20mA command to a valve positioner: Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view):

t.i	SIMULATE (meter leads in middle two jacks)
t.ii	SOURCE (meter leads in left two jacks)
t.iii	SOURCE (meter leads in left two jacks)

n. Answer the following for the diagram below (page 23):



i. This transmitter would be in SOURCE or SIMULATE mode? Click or tap here to enter text.

ii. The circular graphic showing 25.0 would be equivalent to the analog input of a PLC? Click or tap here to enter text.

iii. Is this meter properly setup to simulate a 4-20mA signal as a PLC, taking the place of a loop powered transmitter in the field? Click or tap here to enter text.

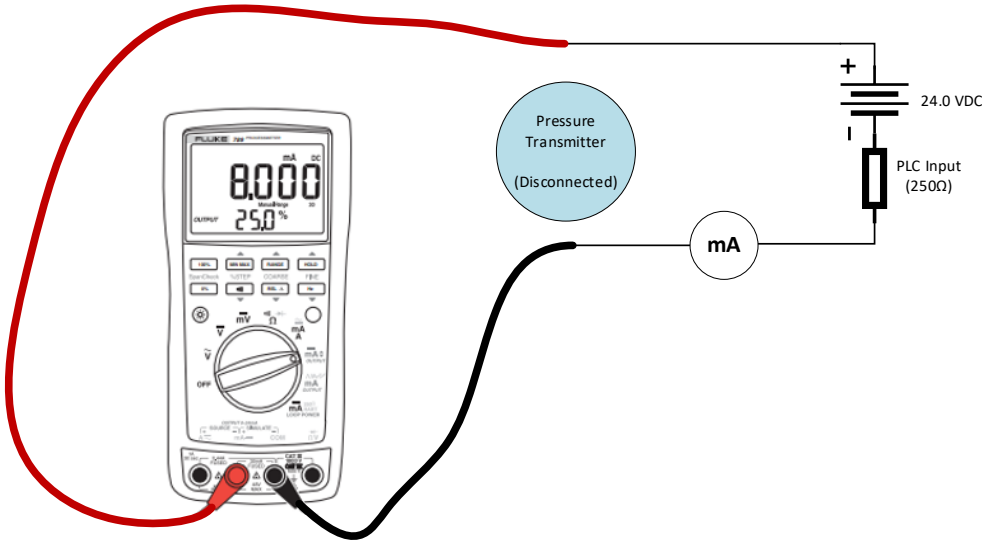
ANSWER KEY (Answers in white font - Change font color to view):

u.i	SIMULATE (meter leads in middle two jacks)
u.ii	True (or a 4-20mA panel meter or repeater, etc.)
u.iii	Yes

5) Exercise – Practical Performance Verification (Fluke 789)

Construct the circuit below. (Note the transmitter is disconnected and you are going to simulate a transmitter ramping up and down using the Fluke 789). Then, refer to page 26 to set the Fluke 789 up to simulate an output with a stair-step ramp in 25% increments pausing 15 seconds 4, 8, 12, 16, and 20 mA. Observe the ramping functionality on the second (series) ammeter. Explain what steps you have to take to setup the meter to perform this function (ensure the meter jacks are properly setup for this task – if not, redraw them as needed):

Have a knowledgeable, qualified instrument technician (or designated mentor) observe your work and ensure your understanding of this exercise, and have them sign below. If you are using only the digital copy of the workbook, record the time, date, and name of the observer and certify that the data is accurate (it will be spot-checked):



Observer (Name)	Observer (Signature)	Observer (Date / Time)
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

6) Questions (Meter Specifications Familiarity)

According to the Specifications section (starts on page 38), answer the following:

Note – the purpose for finding this information is to increase your familiarity with what is in the manual. As you learn more, you will be surprised how often some of this information can come into play. You do not need to remember the details – but you must be able to find the information when needed.

Answers shown in reference.

a. What is the resolution and accuracy of the dc voltage measurements in the 4.000 vdc range (page 38)?

b. What is the nominal input impedance of a dc voltage measurement (page 38)?

c. What is the resolution and accuracy of a typical 4-20mA measurement (page 40)?

d. What is the resolution and accuracy of a typical 0-400 ohm measurement (page 41)?

e. What is the resolution and accuracy of a typical frequency counter at 1999.9 Hz (page 42)?

f. What is the typical frequency counter sensitivity for a 4vdc signal (page 42)?

g. According to the Diode and Continuity Test specs (page 43), what is the maximum forward bias voltage drop that the diode test can measure? What is the typical current flow of a diode test with a standard 0.6vdc forward biased diode?

h. According to the Diode and Continuity Test specs (page 43), below what resistance does the constant tone sound?

i. According to the Loop Power Supply Voltage specs (page 43), is the loop power supply output short circuit protected?

j. According to the Loop Power Supply Voltage specs (page 43), what is the accuracy of the DC current output in source mode?

k. According to the Loop Power Supply Voltage specs (page 43), what is the accuracy of the Simulate Mode current output?

ANSWER KEY (Answers are shown on specs of reference manual)

B. AMS TREX COMMUNICATOR

The following table shows the expectations for a level 2 Instrument Technician in this area.

Technicians pursuing Tech 2 must also meet the Tech 3 KSA expectations.

In addition to completing the requirements below, the technician must have taken and passed a hands-on "Instrumentation Basics Course" covering the bulk of the material covered in the following expectations lists.

KSA Expectations
AMS TREX Communicator (T3) *Be familiar with the overall capabilities of the AMS TREX.* *Be familiar with the common Applications available on the AMS TREX.* *Be familiar with the options (modules) provided on your site's AMS TREX units and know how to find this information (for interpreting reference material applicability).* *Be familiar with use of Upgrade Studio.* *Be familiar with DD and DDL files (basic concepts only for T3).* *Be familiar with the AMS TREX settings (such as time settings)* *Be familiar with the AMS TREX display setup and calibration.* *Be familiar with the AMS TREX memory and power management.* *Be familiar with typical addresses set for HART field devices and know what the default is (0).* *Be familiar with the application switcher function/screen.* *Be familiar with the standard AMS TREX icons.* *Be familiar with connecting the AMS TREX to a PC (Upgrade Studio).* *Be familiar with which ports do what on the AMS TREX (HART, HART + PWR, mA).* *Be familiar with how the AMS TREX startup screens help with port connections.* *Be aware of issues when connecting to HART Wireless devices with AMS TREX (Future).* *Be familiar with the basic Menu functionality of commonly used instruments such as Rosemount 3051, and 3144P.* *Be familiar with Saving and Sending HART configurations from/to HART devices and know how to transfer a configuration from one device to another.* *Be familiar with the loop diagnostic functionality of the AMS TREX, and be able to find specific solutions in the TREX User Guide.* *Be familiar with the loop diagnostic terminal connections for different modes, and be able to find specific guidance on each possible mode per the AMS TREX User Guide.* *Know the reasons you cannot use an AMS TREX Communicator for calibrations.* *Be familiar with the specs and functionality of the AMS TREX mA ports, in each mode (measure and control).* *Be familiar with and able to interpret and use the Troubleshooting Guidance in section A.1 of the AMS TREX User Guide.* *Be familiar with and able to find key specification information in the AMS TREX User Guide (Fuse ratings, internal resistance ratings, etc.).* **AMS TREX Communicator (T2)** Know the overall capabilities of the AMS TREX. Know the common Applications available on the AMS TREX. Know the options (modules) provided on your site's AMS TREX units and know how to find this information (for interpreting reference material applicability). Be able to use of Upgrade Studio. Understand the functionality and differences between DD and DDL files. Be proficient with the AMS TREX settings (such as time settings) Be proficient with the AMS TREX display setup and calibration. Be proficient with the AMS TREX memory and power management. Be proficient with typical addresses set for HART field devices and know what the default is (0). Be proficient with the application switcher function/screen. Be proficient with the standard AMS TREX icons. Be proficient with connecting the AMS TREX to a PC (Upgrade Studio). Be proficient with which ports do what on the AMS TREX (HART, HART + PWR, mA).

Be proficient with how the AMS TREX startup screens help with port connections.
Know the key issues when connecting to HART Wireless devices with AMS TREX (Future).
Be proficient at using the basic Menu functionality of commonly used instruments such as Rosemount 3051, and 3144P.
Be proficient with Saving and Sending HART configurations from/to HART devices and know how to transfer a configuration from one device to another.
Be proficient with the loop diagnostic functionality of the AMS TREX, and be able to find specific solutions in the TREX User Guide.
Be proficient with the loop diagnostic terminal connections for different modes, and be able to find specific guidance on each possible mode per the AMS TREX User Guide.
Know the reasons you cannot use an AMS TREX Communicator for calibrations.
Be proficient with the specs and functionality of the AMS TREX mA ports, in each mode (measure and control).
Be proficient with and able to interpret and use the Troubleshooting Guidance in section A.1 of the AMS TREX User Guide.
Be proficient with and able to find key specification information in the AMS TREX User Guide (Fuse ratings, internal resistance ratings, etc.).

Resources

How to Setup AMS TREX in HART Applications – Downloadable 1 hour webinar from Emerson (detailed, with good content, mostly fluff until 4:45 point)

AMS TREX User Guide – Manual from Emerson (206 pages)

Rosemount 3051 Reference Manual

Rosemount 3144P Reference Manual

How to use Power in the Loop on AMS TREX – Video (3:00)

Managing Device Configs with AMS TREX – Video (2:51)

How to upgrade AMS TREX using Upgrade Studio software – Video (42:51)

How to use AMS TREX Loop Diagnostics to troubleshoot issues – Video (2:43)

Configure Rosemount Radar Devices with AMS TREX and RADAR MASTER – Video (3:05) to provide basic overview and awareness of potential only. Details of Radar Master will be covered later within the Level Measurement course.

1) **Questions (AMS TREX - Overview):**

Watch the Emerson Webinar on AMS TREX (~4:45 to 14:45) and answer the following questions in relation to AMS TREX overview.

a. [TRUE or FALSE] A TREX communicator can power the HART loop for bench testing or when power is not available to device in the field: Click or tap here to enter text.
b. [TRUE or FALSE] A TREX communicator supports device-specific applications (such as ValveLink Mobile SNAP-IN, Radar Master+, etc.: Click or tap here to enter text.
c. [TRUE or FALSE] A TREX communicator has the ability to work with older DD files as well as newer EDDL files: Click or tap here to enter text.
d. Which of the following capabilities does a TREX communicator with the Communications Plus Module have (there may be more than one correct answer): Click or tap here to enter text.
    a. Connect to an externally powered HART device
    b. Power a HART device
    c. Power a HART device and measure 4-20mA current through the same plugs.
e. The TREX typically requires about Click or tap here to enter text. hours to fully charge, and lasts Click or tap here to enter text. or more hours under continuous use in normal conditions.
f. [TRUE or FALSE] The AMS TREX Power Pack is certified for use in class 1 Div 1 areas, so you could replace the battery pack for a spare in the field if needed. Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view)

a.	True – TREX communicators include options to configure it to power the loop.
b.	True
c.	True
d.	A, B, and C – It has each of these capabilities
e.	3-4 hours to charge; 8 hours or more continuous use
f.	False – disconnecting or reconnecting the power module is not certified for hazardous areas.

2) **Questions (AMS TREX - Applications):**

Watch the Emerson Webinar on AMS TREX (~14:45 to 20:25) and answer the following questions in relation to AMS TREX applications.

a. [TRUE or FALSE] The TREX communicator comes with a USB mini-port connection for connecting to a PC. This is primarily used in conjunction with Upgrade Studio (which comes with the TREX, but which must be actively licensed) and this allows for easily updating DD/EDDL files as needed: Click or tap here to enter text.
b. Compare the Model# of your TREX unit to the screen shown at the 18:40 point. What options and features does your TREX have? Does your unit have Communications Plus Module? Click or tap here to enter text.
c. [TRUE or FALSE] A TREX communicator has the ability to work with older DD files as well as newer EDDL files: Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view)

a.	True
b.	Varies – information only; It should have the Comms+ module, but this may not always be the case.

3) Questions (AMS TREX - Interface):

Watch the Emerson Webinar on AMS TREX (~20:45 to 22:25) and answer the following questions in relation to AMS TREX interface details.

a. Do you need to take your gloves off to use the AMS TREX?: Click or tap here to enter text.

b. The touch gestures of the TREX are similar to most modern phones? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view)

a.	You should NOT need to take off your gloves. The system uses a resistive touch screen, so you may have to press harder but it should respond to gloved finger touches.
b.	True – in general. *Mostly* Intuitive.

4) Questions (AMS TREX - Settings):

Watch the Emerson Webinar on AMS TREX (~22:25 to 23:48) and answer the following questions in relation to AMS TREX settings.

a. Can you configure the TREX to automatically adjust for daylight savings time. Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view)

a.	Yes – but be careful in 2023, because DST will be changing.

5) Questions (AMS TREX - Display):

Watch the Emerson Webinar on AMS TREX (~23:50 to 24:20) and answer the following questions in relation to AMS TREX display details.

a. Explain how you calibrate the touch screen (if needed) on an AMS TREX communicator?: Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view)

a.	Go to DISPLAY \ CALIBRATE TOUCH SCREEN; Touch each cross-hair to calibrate. Be sure you touch accurately or you will be mis-calibrating the touch screen.

6) Questions (AMS TREX – Memory & Power Management):

Watch the Emerson Webinar on AMS TREX (~24:23 to 25:53; 26:30 to 28:05) and answer the following questions in relation to AMS TREX memory & power management details.

a. Explain how you would check the memory available on an AMS TREX communicator?: Click or tap here to enter text.

b. Describe each power management options available on your TREX and the value that is currently set for each. Click or tap here to enter text.

c. What address are HART devices typically set to? How is the TREX setup to only check this particular address and how would you change to look for ALL addresses (in case you had a transmitter at a different address for some reason or because of a mistake). Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view)

a.	Go to memory management
b.	Dim display after (time); Suspend after (time); Turn off after (time); settings vary per user choice.
c.	In App Settings (Field Communicator App Settings) box you can deselect the Auto-Connect mode and it will look for HART addresses other than zero (which is the standard address applied to all HART devices typically). Otherwise it just looks for HART address zero. TREX may offer / suggest ways to solve connection problems…

7) Questions (AMS TREX – Application Switcher):

Watch the Emerson Webinar on AMS TREX (~29:36 to 30:35) and answer the following questions in relation to AMS TREX application switcher details.

a. Circle (or describe) the area on the screen below that you would use to access the Application Switcher menu:
Click or tap here to enter text.

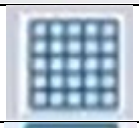
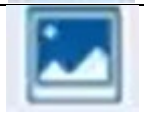
ANSWER KEY (Answers in white font - Change font color to view)

a.	The small black downward tab at top of the menu screen with a small silver/white line across it (below the clock).

8) Questions (AMS TREX – Icons on the menus):

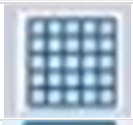
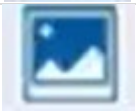
Watch the Emerson Webinar on AMS TREX (~30:35 to 31:15) and answer the following questions in relation to AMS TREX icon details.

a. Describe the function / operation of each of the icon's shown below:

Icon	Description
	Click or tap here to enter text.
	Click or tap here to enter text.
	Click or tap here to enter text.
	Click or tap here to enter text.
	Click or tap here to enter text.
	Click or tap here to enter text.
	Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view)

Icon	Description
	A parameter that you can EDIT
	A DEVICE METHOD (such as loop test)
	This option has sub-menus with additional options

	This option is a graph or chart.
	This option is a gauge chart
	This option is a grid
	This option is an image

9) Questions (AMS TREX – Connect to PC):

Watch the Emerson Webinar on AMS TREX (~31:17 to 32:21) and answer the following questions in relation to AMS TREX interface details.

a. What physical connection is used to connect to Upgrade Studio (PC) ? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view)

a.	The Provided USB cable (mini to standard USB)

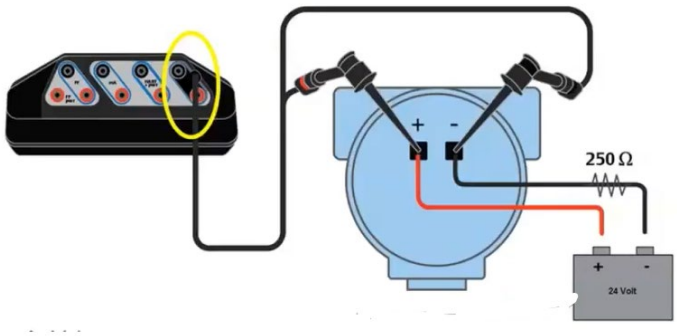
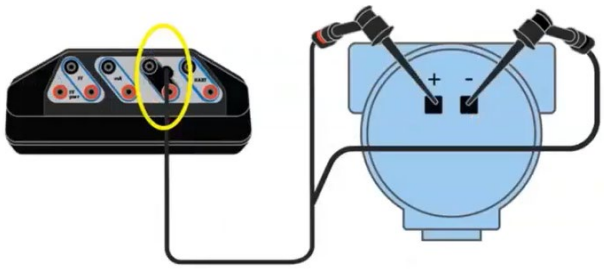
10) Questions (AMS TREX – HART Connection):

Watch the Emerson Webinar on AMS TREX (~32:25 to 33:00; and 33:03 to 35:01) and answer the following questions in relation to AMS TREX HART connection details.

a. Which figure below represents the setup you would use for configuring a transmitter on the bench that does not have power connected? Click or tap here to enter text.

b. Which figure below represents the setup you would use for a field powered transmitter that is currently energized and connected to a PLC or DCS system? Click or tap here to enter text.

c. When a site begins using Wireless HART transmitters/devices, which figure accurately shows the ports you would use to connect to them? Click or tap here to enter text.

TREX Connection Port Options	
Figure A	
Figure B	

ANSWER KEY (Answers in white font - Change font color to view)

a.	Figure B shows ports used for providing loop power.
b.	Figure A shows the typical (Field Powered) port option.
c.	Figure A shows the correct ports to use when connecting to wireless HART devices. This is because the wireless devices have a builtin battery that provides power to the transmitter.

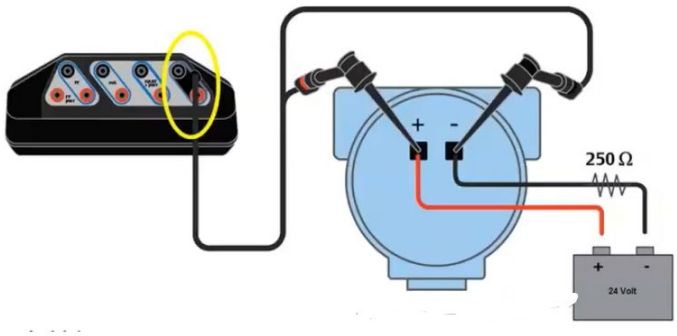
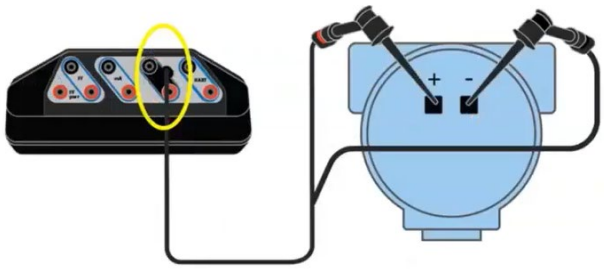
11) Questions (AMS TREX – HART Startup Screens):

Watch the Emerson Webinar on AMS TREX (~36:05 to 38:03) and answer the following questions in relation to AMS TREX HART startup screen details.

a. Explain the typical screens you would see and choices you would have to select on the TREX to connect to powered HART transmitter in the field. Click or tap here to enter text.

b. Explain the typical screens you would see and choices you would have to select on the TREX to connect to an un-powered HART transmitter. Click or tap here to enter text.

c. When using Wireless HART transmitters/devices, which figure accurately shows the ports you would use to connect to them? Click or tap here to enter text.

TREX Connection Port Options	
Figure A	
Figure B	

ANSWER KEY (Answers in white font - Change font color to view)

a.	Select Field Communicator. Select HART application if needed. It should connect automatically (assuming you are using correct ports and transmitter is properly powered)
b.	Select HART application. TREX will notice no power and no comms stats indicators on TREX, and the TREX will ask if you want the TREX to supply power. Select Yes. Next, the TREX will ask if you are connecting to a Positioner or to a Transmitter. Select as appropriate. This causes the TREX to configure it's electronic circuitry to either provide a driving current (when POSITIONER is selected); or to just provide power and allow the loop current, which is controlled by transmitter, to pass through the TREX when TRANSMITTER is selected. Then it should connect and go to the OVERVIEW screen (unless diagnostic alerts are present – which will be discussed later in this course).
c.	Figure A shows the correct ports to use when connecting to wireless HART devices. This is because the wireless devices have a built-in battery that provides power to the transmitter.

12) Questions (AMS TREX – Rosemount 3051 Menu Tree):

Watch the Emerson Webinar on AMS TREX (~38:05 to 46:15) and answer the following questions in relation to a Rosemount 3051 transmitter.

a. Print out the menu tree pages from the Rosemount 3051 Reference Manual for future reference and to aid in answering the following questions.
   a. The HART menus are located in Appendix B.1 (page 121-125).
   b. *It is wise to keep a copy of menu trees for common equipment you work on in your tool bag.*

b. List the (3) main menu categories for a typical Rosemount 3051 menu tree. Click or tap here to enter text.

c. Based on the diagram at 38:15, what key information does the OVERVIEW menu provide? Click or tap here to enter text.

d. Based on the diagram at 38:15, what key information does the CONFIGURE menu provide? Click or tap here to enter text.

e. Based on the diagram at 38:15, what key information does the SERVICE TOOLS menu provide? Click or tap here to enter text.

f. Describe the menu path to perform a D/A trim on a Rosemount 3051. Click or tap here to enter text.

g. Describe the menu path to configure the range of a Rosemount 3051. Click or tap here to enter text.

h. Describe the menu path to perform a full sensor trim of a Rosemount 3051. Click or tap here to enter text.

i. Describe the menu path to alter the Damping setting of a Rosemount 3051. Click or tap here to enter text.

j. Describe the menu path to configure security settings of a Rosemount 3051. Click or tap here to enter text.

k. [TRUE or FALSE] When performing Manual Setups, you will need to SEND the changes from the TREX to the transmitter. Click or tap here to enter text.

l. Does your facility have any Rosemount 3051's that use a different menu tree? If so make a note of it in your own records and find the applicable menu tree as a reference.

ANSWER KEY (Answers in white font - Change font color to view)

a.	Continue once printed / available for reference.
b.	Overview Configure Service Tools
c.	Device Status, Comms Status, PV, Analog Output, URV/LRV, and Device Info
d.	Guided Setup, Manual Setup, and Alert Setup
e.	Device Alerts, Variables, Trends, Routine Maintenance, Simulate Mode
f.	Service Tools \ Routine Maintenance \ Analog Output Calibration \ D/A or Scaled D/A Trim
g.	Configure \ Guided Setup \ Basic Setup \ Pressure URV & LRV
h.	Service Tools \ Routine Maintenance \ Pressure Calibration \ Upper Sensor Trim & Lower Sensor Trim
i.	Configure \ Manual Setup \ Basic Setup \ Pressure Damping
j.	Configure \ Manual Setup \ Security
k.	TRUE
l.	Varies per facility and application (based on age of transmitters)

13) Questions (AMS TREX – Rosemount 3051 Menu Tree):

Watch the Emerson Webinar on AMS TREX (~46:17 to 49:13) and answer the following questions in relation to a Rosemount 3144 transmitter.

a. Print out the menu tree pages from the Rosemount 3144P Reference Manual for future reference and to aid in answering the following questions.
   a. The HART menus are located in section 3.4.2 (page 36-41).
   b. *It is wise to keep a copy of menu trees for common equipment you work on in your tool bag.*

b. List the (3) main menu categories for a typical Rosemount 3144P menu tree. Click or tap here to enter text.

c. Based on the diagram at 46:18, what key information does the OVERVIEW menu provide? Click or tap here to enter text.

d. Based on the diagram at 46:18, what key information does the CONFIGURE menu provide? Click or tap here to enter text.

e. Based on the diagram at 46:18, what key information does the SERVICE TOOLS menu provide? Click or tap here to enter text.

f. Describe the menu path to perform a D/A trim on a Rosemount 3144P. Click or tap here to enter text.

g. Describe the menu path to configure the range of a Rosemount 3144P. Click or tap here to enter text.

h. Describe the menu path to perform a full sensor trim of a Rosemount 3144P. Click or tap here to enter text.

i. Describe the menu path to alter the Damping setting of a Rosemount 3144P. Click or tap here to enter text.

j. Describe the menu path to configure the temperature sensor of a Rosemount 3144P. Click or tap here to enter text.

k. [TRUE or FALSE] When performing Manual Setups, you will need to SEND the changes from the TREX to the transmitter. Click or tap here to enter text.

l. Does your facility have any Rosemount 3144P's that use a different menu tree? If so make a note of it in your own records and find the applicable menu tree as a reference.

ANSWER KEY (Answers in white font - Change font color to view)

a.	Continue once printed / available for reference.
b.	Overview Configure Service Tools
c.	Device Status, Comms Status, PV, Analog Output, URV/LRV, and Device Info
d.	Guided Setup, Manual Setup, and Alert Setup
e.	Device Alerts, Variables, Trends, Routine Maintenance, Simulate Mode
f.	Service Tools \ Routine Maintenance \ Analog Output Calibration \ D/A or Scaled D/A Trim
g.	Configure \ Guided Setup \ Basic Setup \ Pressure URV & LRV
h.	Service Tools \ Routine Maintenance \ Pressure Calibration \ Upper Sensor Trim & Lower Sensor Trim
i.	Configure \ Manual Setup \ Basic Setup \ Pressure Damping
j.	Configure \ Guided Setup \ Configure Sensor (pick #) \ Select Sensor Type \ Select Sensor Connection (if RTD type) \ Finish Sensor Setup
k.	TRUE
l.	Varies per facility and application (based on age of transmitters)

14) Questions (AMS TREX – Saving & Sending HART Configurations):

Watch the Emerson Webinar on AMS TREX (~46:35 to 51:35) and answer the following questions in relation to a Saving and/or Sending HART Configurations.

a. List the steps needed to transfer a configuration from one transmitter to another intended to take it's place (assume the transmitter has mechanical damage and requires replacement but is still operable). Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view)

a.	From MENU screen click SAVE CONFIG; Enter Config Name (typically Tag Name) & click OK, then Disconnect; Then, from MENU screen, click SEND CONFIG; Select File & verify info and SEND;

15) Questions (AMS TREX – Loop Diagnostics):

Watch the Emerson Webinar on AMS TREX (~51:46 to) AND review the Loop Diagnostics section of the TREX User Guide (pages 125-150), to answer the following questions in relation to using TREX Loop Diagnostics.

a. List the 3 main functions shown on the Loop Diagnostics Startup Screen Click or tap here to enter text.
b. Summarize the functionality of the Measurement Section of Loop Diagnostics in your own words. Click or tap here to enter text.
c. Summarize the functionality of the Power/Help Section of Loop Diagnostics in your own words. Click or tap here to enter text.
d. Summarize the functionality of the Current Control / Output Section of Loop Diagnostics in your own words. Click or tap here to enter text.
e. [TRUE or FALSE] According to page 131 of TREX User Guide; When using TREX to power a transmitter, the transmitter has a 167 ohm resistance in series (internally). Therefore, if you are using an external 250 ohm resistor, you would have a combined loop resistance of 417 ohms. Therefore at 20mA you would be dropping 8.34 volts across the loop resistances, and that would only leave 15.66 volts available at transmitter. At saturation or high fault current you would have even less voltage available at transmitter and could easily go below transmitter minimum acceptable voltage levels. Click or tap here to enter text.
f. According to section 4.4 of TREX User Guide; which terminals are used when measuring voltage when TREX unit power is OFF? And which terminals are used when measuring voltage when TREX unit power is ON? Click or tap here to enter text.
g. According to section 4.4 of TREX User Guide; which terminals are used when measuring current when TREX unit power is OFF and TREX unit Current is OFF? Click or tap here to enter text.
h. According to section 4.4 of TREX User Guide; which terminals are used when measuring current when TREX unit power is OFF and TREX unit Current is ON? Click or tap here to enter text.
i. According to section 4.4 of TREX User Guide; which terminals are used when measuring current when TREX unit is powering a transmitter? Click or tap here to enter text.
j. According to section 4.4 of TREX User Guide; which terminals are used when measuring current when TREX unit power is ON and TREX unit is powering a positioner? Click or tap here to enter text.
k. Summarize the warnings given in section 4.5 of the TREX User Guide in your own words.

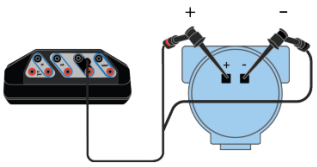
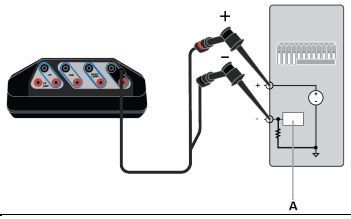
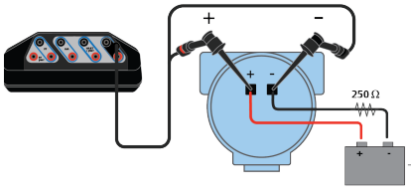
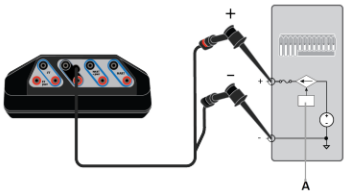
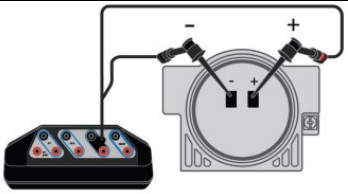
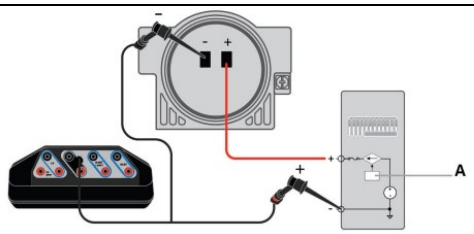
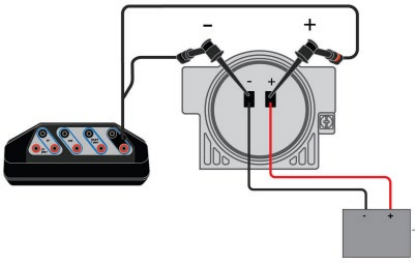
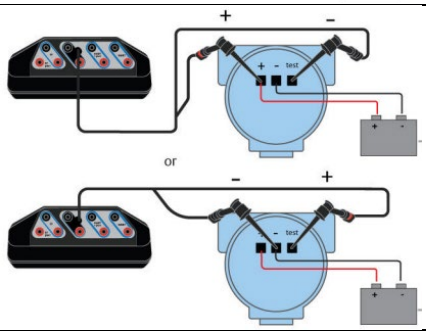
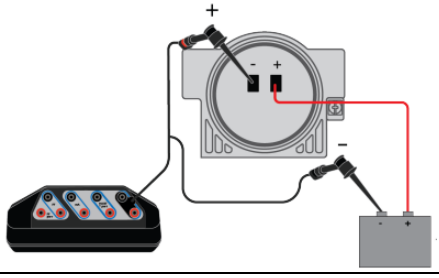
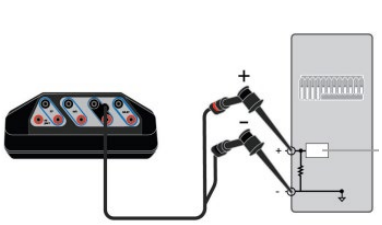
ANSWER KEY (Answers in white font - Change font color to view)

a.	Per page 127 of TREX User Guide: • Measurement Section • Power/Help Section • Current Control / Output Section
b.	Per page 127 of TREX User Guide
c.	Per page 127 of TREX User Guide
d.	Per page 128 of TREX User Guide
e.	TRUE
f.	Per page 132 of TREX User Guide: Use **HART** terminals when TREX unit power is OFF. Use **HART + PWR** terminals when TREX unit power is ON.
g.	Per page 132 of TREX User Guide: Use **mA** terminals when TREX unit power is OFF and TREX unit current is OFF. Note – if device has TEST terminals, you can measure current via mA terminals of TREX unit.
h.	Per page 132 of TREX User Guide: Use **HART** terminals when TREX unit power is OFF and TREX unit current is ON.
i.	Per page 132 of TREX User Guide: Use **HART + PWR** terminals when TREX unit power is OFF and TREX unit is powering a transmitter.
j.	Per page 132 of TREX User Guide: Use **HART + PWR** terminals when TREX unit power is OFF and TREX unit is powering a positioner.
k.	The following per your own words. *Note – The intention of this question is to familiarize you with important warnings and likely mistakes made when using the TREX communicator.* WARNING Do not connect lead sets to the HART and HART + pwr terminals at the same time. If the lead sets are connected to devices, this increases the chance of wiring mistakes and could create a short in the HART loop. Do not add any external power to the device when the Trex unit is powering the device. This can blow a fuse inside the Trex unit. The repair/replacement will need to be completed at an authorized service center. Ensure the device is disconnected from the loop/segment and no other wires are connected to the device before providing power from the Trex unit. The Trex unit cannot power a 4-wire device. Do not connect Trex unit to the power terminals of a 4-wire device. This can blow a fuse inside the Trex unit. The repair/ replacement will need to be completed at an authorized service center. Do not connect the mA terminals (ammeter) in parallel with a powered 4-20 mA current loop. Ammeters have low resistance. This can disrupt the loop and cause devices to report incorrect values or positioners to move unexpectedly. Do not connect the mA terminals on the Trex unit to a power supply that is not current limited to 250 mA. This can blow a fuse inside the Trex unit. The repair/replacement will need to be completed at an authorized service center.

16) Questions (AMS TREX – Loop Diagnostic Terminal Connection Setups):

Based on section 4.5 of the TREX User Guide, list which figure below best matches the described setup.

a. Power a HART transmitter for simple configuration: Click or tap here to enter text.
b. Measure voltage on an externally powered HART transmitter: Click or tap here to enter text.
c. Power and control current to a positioner: Click or tap here to enter text.
d. Connect to an externally powered positioner in parallel. Click or tap here to enter text.
e. Connect to an externally powered positioner in series. Click or tap here to enter text.
f. Control current to SIMULATE a transmitter or externally powered loop. Click or tap here to enter text.
g. Read current for an analog output LOOP CHECK.
h. Connect to an externally powered positioner and read current.
i. Measure current from an externally powered transmitter device with TEST terminals.
j. Power and control current to simulate a transmitter on an unpowered loop.

TREX Loop Diagnostic Connections			
Fig A		**Fig F**	
Fig B		**Fig G**	
Fig C		**Fig H**	
Fig D		**Fig I**	
Fig E		**Fig J**	

ANSWER KEY (Answers in white font - Change font color to view)

a.	A
b.	B
c.	C
d.	D
e.	E
f.	F
g.	G
h.	H
i.	I
j.	J

17) Questions (AMS TREX – mA Measurements):

Review the specs for Device Comms Module in TREX User Guide (~page 184).

a. What does section 2.17.2 say about using the TREX for Calibration purposes? Click or tap here to enter text.

b. What is the Accuracy (in % of span), and resolution for the **HART** terminals of the TREX unit? Click or tap here to enter text.

c. What is the Accuracy (in % of span), and resolution for the **HART + PWR** terminals of the TREX unit in AMMETER mode and for CONTROL mode? Click or tap here to enter text.

d. What is the drive capability of the **HART** terminals of the TREX unit in Control mode? Click or tap here to enter text.

e. What is the drive capability of the **HART + PWR** terminals of the TREX unit in Control mode? Click or tap here to enter text.

f. What is the Accuracy (in % of span) for the **mA** terminals of the TREX unit? Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view)

a.	Calibration is not supported by TREX! (in other words, you still need your mA meter!) *The mA and other measurements are not certified or traceable to NIST standards and are therefore not suitable for use in calibration work.* *The various measurements also have poor accuracy specs, which is another reason they should never be used for calibration purposes or for certified testing such as SIS functional testing.*
b.	Accuracy is 0.25% of *span* (for 4-20mA) – this equates to +/- 0.04 mA, which is a substantial uncertainty. This should NEVER be used for performing calibrations or for certified testing such as SIS functional testing. Resolution is 0.04 mA, which is also poor (Note - this is due to the increment size of the low end A/D converter used in the circuit).
c.	**AMMETER mode:** Accuracy is 0.25% of *reading* (for 4-20mA) – this equates to +/- 0.04 mA, which is a substantial uncertainty. This should NEVER be used for performing calibrations or for certified testing such as SIS functional testing. Resolution is 0.01 mA **CONTROL mode:** Accuracy is 0.25% of span (for 4-20mA) – this equates to +/- 0.04 mA, which is a substantial uncertainty. This should NEVER be used for performing calibrations or for certified testing such as SIS functional testing. Resolution is 0.1 mA, which equates to 0.625% of a 4-20mA span. This is very poor and another reason this should never be used for calibration purposes or for certified testing such as SIS functional testing.
d.	650 ohms impedance at 22.5 mA.
e.	650 ohms impedance at 22.5 mA.
f.	Accuracy is not stated here, but it is not better than others and per section 2.17.2 of the User Guide, it should NEVER be used for performing calibrations or for certified testing such as SIS functional testing. Resolution is 0.04 mA, which is also poor (Note - this is due to the increment size of the low end A/D converter used in the circuit).

18) Questions (AMS TREX – Troubleshooting):

a. Review section A.1 of the TREX User Guide, then fill in the following table.

Symptom	Possible Cause	Solution
'*No voltage detected*' message is displayed.	Click or tap here to enter text.	Click or tap here to enter text.
There is intermittent communication.	Click or tap here to enter text.	Click or tap here to enter text.
There is no communication with device.	Click or tap here to enter text.	Click or tap here to enter text.
Control system is communicating HART, but the TREX unit is not communicating properly.	Click or tap here to enter text.	Click or tap here to enter text.
A HART device appears at multiple addresses.	Click or tap here to enter text.	Click or tap here to enter text.
When the TREX unit tries to power a device, a message stating '*voltage still detected at HART terminals*' appears.	Click or tap here to enter text.	Click or tap here to enter text.
The TREX unit needs to supply more current than the typical 4mA to power a positioner. *This can occur when the positioner needs more current to power the CPU at faster speed for diagnostics.*	Click or tap here to enter text.	Click or tap here to enter text.

ANSWER KEY (Answers in white font - Change font color to view)

Symptom	Possible Cause	Solution
'*No voltage detected*' message is displayed.	The lead set is improperly connected to the device.	Attach the lead set to the device.
	The Trex unit is connected to a 4-wire device or a wireless device that is powered by its battery.	None. This is expected behavior
There is intermittent communication.	Insufficient loop current and voltage at the device terminals.	Verify there is at least 4 mA and 12 VDC at the device terminals.
	Noise on the loop, or noise or signal distortion from the control system. For example, noise from the power supply powering the devices, or front end analog circuitry inside the control system may be distorting the HART signal.	An oscilloscope can help determine noise or signal distortion of HART signals.
	Poor wiring.	Check the wiring terminations and exposed signal wire for damage.
There is no communication with device.	Insufficient loop resistance at the HART frequencies.	Add an additional 250 ohm resistor in series in the loop. Place the leads across the resistor and verify communication occurs.
	Insufficient loop current and voltage at the device terminals.	Verify there is at least 4 mA and 12 VDC at the device terminals.
	The AC adapter is attached to the Trex unit.	Remove the AC adapter from the Trex unit and try to connect to the device.
	Device may be set to a HART address other than zero (multidrop mode).	Change the polling mode to Poll by Address
Control system is communicating HART, but the TREX unit is not communicating properly.	An internal fuse may be blown.	Connect a meter capable of measuring M ohms to the HART or mA terminals. An OPEN reading may indicate a blown fuse.
	HART communication is being prevented by the control system.	Stop HART communications on the control system and verify if communication between the devices and the Trex unit is restored.
	More than one Trex unit or other secondary master may be attached to the control loop.	Ensure there is only one primary master and one secondary master on the control loop.
A HART device appears at multiple addresses.	The incorrect polling addresses may be used.	Change the addresses being polled.
	HART Universal Revision 5 (or earlier), 6, and 7 devices are on the same loop.	Put HART Universal Revision 5 or earlier devices on a separate loop from HART Universal Revision 6 or 7 devices.
When the TREX unit tries to power a device, a	This message can appear if the Trex unit connects to a device that was	The Trex unit asks if you want to ignore the voltage warning and

message stating '*voltage still detected at HART terminals'* appears.	recently powered. Some devices may hold voltage for several minutes after the power is removed.	proceed with sourcing power. If you select Yes, Trex powers the device. You can also wait a few minutes before connecting to and powering the device.
The TREX unit needs to supply more current than the typical 4mA to power a positioner. *This can occur when the positioner needs more current to power the CPU at faster speed for diagnostics.*	Use the device connection wizard in the Field Communicator application to increase mA.	1. In the Field Communicator application, connect to the positioner. 2. Change its polling address to a non-zero value. 3. Disconnect the positioner and restart the Field Communicator application. 4. Tap HART. 5. Tap Yes when prompted if you want to provide power from the Trex unit. 6. Tap Positioner. 7. Tap Yes when prompted to increase current. 8. Select the current value.

19) Questions (AMS TREX – Specs):

Review the TREX User Guide Communications Module Specs (~page 183-184) and answer the following questions to gain familiarity with information and know where to find it when needed.

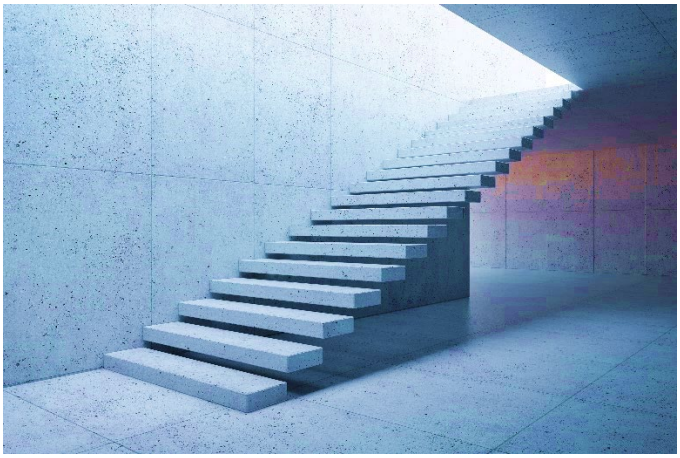
a. What is the internal fuse rating for the **HART** terminals? Click or tap here to enter text.
b. What are the optional internal resistance values for the **HART** terminals? Click or tap here to enter text.
c. What is the resistance included in the HART power supply when using the **HART + PWR** terminals? Click or tap here to enter text.
d. What is the internal fuse rating of the **HART + PWR** terminals? Click or tap here to enter text.
e. What is the resistance of the SHUNT resistor when using the **mA** terminals?
f. What is the internal fuse rating of the **mA** terminals? Click or tap here to enter text.
g.

ANSWER KEY (Answers in white font - Change font color to view)

a.	50mA
b.	250 or 500 ohms
c.	167 ohms
d.	50mA
e.	2.43 ohms
f.	250 mA

II. CONCLUSION & REVIEW SIGNOFF

This concludes this workbook.



Have your designated mentor review your workbook for completion and spot check your readiness as needed.