1. OBJECTIVE

Details the troubleshooting self powered, DC isolated current loops.

Controllers with installed options **IC**, **IO**, **IP, IR** in the controller part number have from one to four, 4-20mA current outputs.

Testing requires a digital voltmeter with ohms and DC voltage ranges.

2. FUNCTION

Aquatrac's controller powered, 4-20mA outputs are magnetically coupled, rated maximum 22VDC at 20mA.

OPEN CURRENT LOOPS
Un-terminated current loops will read 40VDC due to switching noise charging of the output filter capacitor. This voltage is not sustained on a terminated loop with the maximum current limited by saturation of the coupling transformer. See **Open Loop Power Calculation**, page 2

If you connect a voltmeter on DC volts across an unterminated loop **+I-** terminals you'll measure the open loop voltage decay at rate proportional to the input impedance of your voltmeter. For typical voltmeters, decay to 0 VDC will require 37 minutes.

USE DC VOLTS RANGE NOT DC mA
It's easier to fail a mA Current measurement than a DC Volts measurement. Zero mA readings may be caused by fusing in the meter and/or an open or intermittent connection on either test lead. DC Volts measurements diagnose more quickly and with few measurement errors.

VERIFYING LOOP TERMINATION
Disconnect the field wiring terminations from the controller **+I-** terminals.
Set your DVM to OHMS range and measure the resistance between the two wires.

If you measure an open circuit, the loop is not terminated; that's why it's not working.
If you are wired to a DCS or PLC, terminate the loop. If you are wired to a pump, the problem is typically internal to the pump or due to the pump connector.

If you measure 22 +/-2 ohms, you're likely connected to an LMI pump.
If you measure from 50 to 250 ohms you are correctly connected to an automation system, PLC or a 4-20mA controlled pump.

Reconnect the wiring to the **+I-** terminals.

VERIFYING LOOP FUNCTION

You need to terminate a current loop to verify loop function.
If you have a problem on the terminating end then install a 100 ohm resistor at the **+I-** terminals.

Measure the DC voltage at the **+I-** terminals. Ignoring the typically small drop due to cable resistance. You'll measure a DC voltage, which varies with the 4-20mA output for each terminating resistance:

Termination	4mA	12mA	20mA
22 ohms LMI	88 mVDC	264 mVDC	440 mVDC
100 ohms	0.4 VDC	1.2 VDC	2 VDC
250 Ohms	1 VDC	2.5 VDC	5 VDC

Where the loop **mA** = (Measured VDC) / Terminating resistance

Use Trackster or the TV remote keypad and the ADJUST 4-20mA LOOPS? Function to span the current loop OFF, 4mA and then full ON, 20mA to verify function.

For example: If the current pH = 8.
Setting the span to *4mA=10* and *20mA=12* will adjust the loop to 4mA, full OFF.
Setting the span to *4mA=4* and *20mA=6* will adjust the loop to 20mA, full ON.

Make sure you're adjusting the right loop. Controllers may have up to 4 current loops **D/A1** to **D/A4.** Open the controller door and note which of **D/A1** through **D/A4** is cabled to your output card.

Open Loop Power Calculation

WORST CASE @ 250 OHM termination
If you terminate a 250 ohm loop running at 4mA when the output is 40VDC, you discharge the filter capacitor from 40V to 39V through the 250 ohm loop terminating resistor.

Energy stored in a capacitor is CV^2/2 where C= 220uF.
Power dissipated in the terminating resistor is the energy in the capacitor/discharge time plus the loop current. Capacitor power @ 250 ohms is dissipated in 5 time constants, nominally 5 x 260 ohms x 220uF = 286 mSec. (Note: there's a 10ohm resistance is series with the current loop output)
Therefore instantaneous power dissipated in ¼ sec due to the capacitor is nominally 0.167J / 286mS = 584mW.

WORST CASE thermally occurs if the loop is initially @ 20mA, ramping down to 4mA
The steady state current loop also contributes 100mW (0.02A x 0.02A x 250 ohms)
For that first ¼ second the terminating resistor dissipates 584mW.
In the first second the average power is therefore 146mW, well within the rating of a typical ¼ to ½ Watt terminating resistor.

Terminating Resistor Wattage Rating
250 Ohm loop termination represents a thermal worst case. Designers use minimum ½ Watt resistors since a faulted, uncontrolled loop at 24VDC dissipates 2.3 Watts and a 100% overrange 40mA dissipates 400mW. You can now appreciate LMI's decision to terminate at 22 ohms where 100% overrange 40mA dissipates only 35mW.