Technote 42 - Modbus RS-485 Timing Issues

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This document discusses communication timing effects on Data Acquisition Servers (DAS) AcquiSuite EMB A8810, AcquiSuite A8812, and AcquiLite EMB A7810 (using Modbus/TCP).

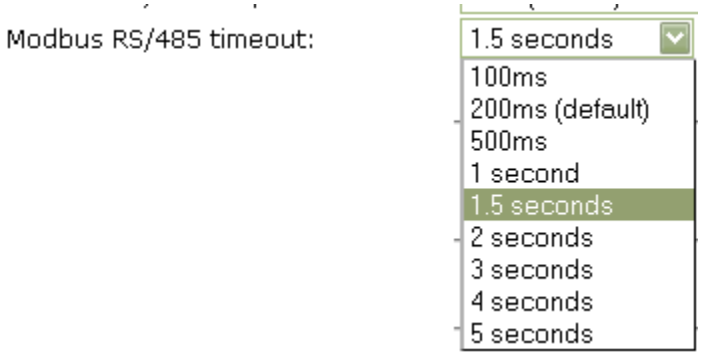
Optimal Settings

Timing considerations are an important aspect of installations and optimal DAS configuration. The specifics are very unique to each installation. Many factors affect timing, including:

- number of monitored devices
- amount of data in responses from monitored devices
- response time of monitored devices
- hardwired-only, or hardwired and wireless devices
- baud rate or baud rates
- log interval
- log upload cycle

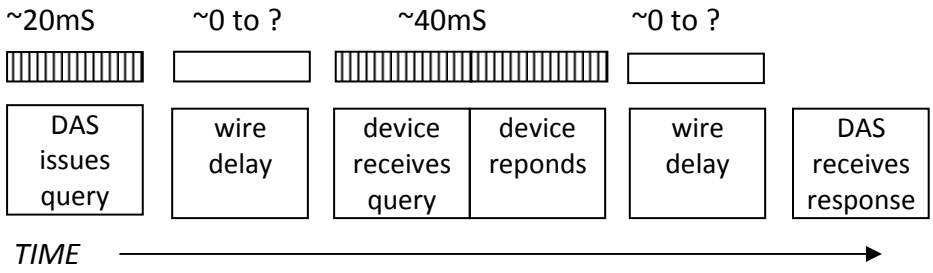
Query and Response Time

The DAS continuously scans the Modbus loop for all possible addresses, which is about 250 according to the limits of the Modbus language. For more details about Modbus, see *modbus.org*. Regardless of how many devices you may have actually connected, in order to properly detect changes in the bus loop, the DAS continuously scans the entire list, one device at at time. The scanning process basically consists of a DAS query and a device reply. Each query takes a certain amount of time, as the DAS toggles bits of information onto the Modbus loop at a certain speed. The wire itself has some delay, especially if the "wire" is TCP/Modbus or a radio transceiver pair (like ModHoppers), in which the query gets processed by another device, transmitted, received, and then processed by another device which translates back into Modbus. Each device adds some delay. Once the Modbus query arrives at a device, that device then has to process the query, create a response and then transmit bits of information back onto the loop. Because each step in the process needs a certain amount of time, the DAS provides an overall Timeout choice on the Modbus Setup page.



Timing Example

Pictured is an idealized visual representation of that timing, with some approximate times:



Given this example and a single device, if the wire delay was 20mS, then the total time is:

20ms + 20mS + 40mS + 20mS = 100mS

Too Little Time, Too Much Time

Using the *Timing Example*, consider what would happen if the DAS only waited 50mS for the response from the start of its query. According to the illustration, the device would just be processing the received query from the DAS at that moment. In that scenario, the DAS would report that the device was in an error condition since it never got a device response.

Note that the example also illustrates that variances exist, such as delays on a TCP gateway (which could be the "wire") in the illustration. Typically adding more time to the Timeout reduces the probability that the variations cause data loss because of those delays. So a reasonable time added to pad the example timeout might put it at 150mS.

So if 150mS is good, then why is 1500mS not better? Why is 15,000mS not better still? At the other extreme, waiting too long for responses causes other types of problems, including:

- Latency delays prevent quick visibility of live device or sensor information. As you watch an actual event in real time, like a temperature change, rather than seeing an immediate difference on a browser page of the DAS, it displays much later.

- Since the DAS polls all possible devices, it may run out of log cycle time to read them all. A big timeout delay, such as 5 seconds (5000mS) becomes a big total time to check all of them. Roughly calculated, this is

  250 x 5 seconds = 1250 seconds = approx. 20 minutes.

  So despite the available CPU speed of the DAS and devices, theoretically each device would only report 3 times an hour. Stated another way, you may have to wait 20 minutes to see updated information on a device which you just adjusted. Additionally, if the time exceeds the log cycle, the information may only update every other cycle.

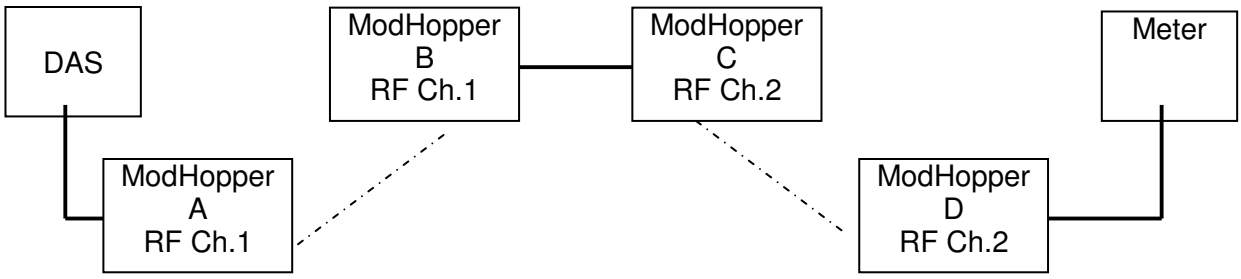
Additional Factors

Device Response Time

Because a device may be very simple or very complex, the amount of time needed to gather that data and to communicate that data may vary. The more data, the longer time needed to send that data. Some requirements exist within the Modbus protocol. Some devices have been known to exceed recommended response times, in some cases taking over a second.

Intermediate devices also transfer information from groups of devices, so they may need additional timeouts. such as TCP gateways or ModHoppers For example, it is recommended to add 500mS for each wireless hop.

Complex Timing Example



Solid lines represent RS-485 wiring Dashed lines represent radio comms

The *Complex Timing Example* is an illustration of a much more complex timing situation, with some environmental or device effects introducing considerable delays. ModHoppers B and C are assumed to be ForceMaster/ForceSlave. ModHoppers each have their own configurable Timeout for devices wired to them. In this scenario, the various timeouts may be:

- DAS 2Sec-5Sec
- MH A N/A
- MH B 1Sec
- MH C N/A
- MH D 200mS*

* The value of 200mS is a typical value. If the meter was an Onicon SYSTEM-10, then ModHopper D would possibly need a Timeout of 500mS to 1000mS. If the meter was a GE kV2™, it would possibly need up to 2 Seconds. Other hardware may require similar times.

This could be further complicated if the DAS shown was also used as a Modbus/TCP gateway to another DAS. On the other DAS, any additional network delays would also need to be added to the Timeout used on the DAS shown in the example.

Note that ModHopper transmission times vary as they encounter changing radio conditions.

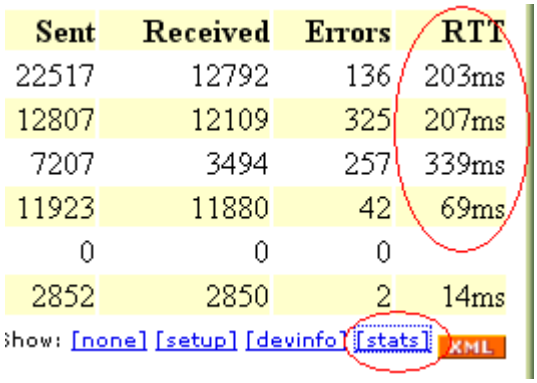
DAS Features

Fortunately, the AcquiSuite EMB A8810, AcquiSuite A8812, and AcquiLite EMB A7810 (using Modbus/TCP) have valuable optimization techniques. For example, the timeout only regards devices which do not respond. Once a device responds, waiting is no longer necessary and the exchange of data drives the remaining time devoted to that device. Other optimizations exist, such as prioritization.

The DAS configuration includes Modbus Setup, which has multiple choices. An optimal site is one with mutual hardware communication values, such as a single baud rate. The optimizations provided on that page should be considered regarding a particular site.

Discovering Query and Response Time

The DAS provides a very handy way to help find that perfect balance between too little time and too much time. On the Device List page, click on the "stats" link. The RTT column on the right side will the display the last-known Round Trip Time (RTT) of each device. In the *Timing Example* illustration, that device would likely show round trip times around 100mS in that column.



Sent	Received	Errors	RTT
22517	12792	136	203ms
12807	12109	325	207ms
7207	3494	257	339ms
11923	11880	42	69ms
0	0	0	
2852	2850	2	14ms

Show: [none] [setup] [devinfo] [stats] XML

To best tune the system, watch the times and communications health for all the devices, and set the timeout to something slightly larger than the longest RTT. Try it for a while that way, and if no devices go into Error, it is fine. Aside from errors, also look at the ratio of Sent (queries) and Received (device responses). Many Sent but fewer or no Received, may indicate the need for a longer timeout. The top row in the above picture shows such a 2:1 difference. If using ModHoppers, view the ModHoppers page, under Wireless, which also has timing information including number of wireless hops.

Advanced Techniques

In addition to the optimizations in the AcquiSuite EMB A8810, AcquiSuite A8812, and AcquiLite EMB A7810 (using Modbus/TCP), when used with care certain techniques may help sites with problematic timing. When in doubt, use defaults or contact Obvius Support.

- Disable the Modbus Setup option *Search for Modbus devices*. Note that later adding a device will require enabling that option.
- If not wired to pulse meters, configure a ModHopper *Data log points* option to *None*.
- Set the Modbus Setup option *Modbus RS/485 debug information* to *Full Debug*, and enable debugging on the System Log Files page. View the Debugging Messages log, then disable debugging again. The log shows timing of Modbus communication events.
- In a similar way, set the level to *Transactions* for a while, to watch for unexpected traffic such as Modbus/TCP queries to the DAS.