App. Note Code: 3RF-G

APPLICATION NOTE

Time Division Polling

10/16

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Time Division Polling

Time division polling (TDP) is a data collection protocol built into the operating system (OS) of TD-RF radio modems offered by Campbell Scientific (see TABLE 1-1). TDP is designed to take advantage of the Data Advise or One-Way data collection methods available with table-based dataloggers. In a TD-RF network, TDP can significantly reduce the amount of time required to collect a given amount of data when compared to the *LoggerNet* scheduled data collection method. This application note will explain how this is accomplished and discuss some important operational considerations.

1. The TD-RF Network

When an RF network is constructed using radio modems from TABLE 1-1, it is referred to as a TD-RF network.

TABLE 1-1. TD-RF Modems

Radio Modem	Operating System
RF500M	PakBus (-PB) or ALERT (-AL) OS option
RF95A, RF310M, RF315M	PROM: #6898, #17451, #17452, #17453, #14229

The key operational characteristics of a TD-RF network:

- The base modem is the sole arbiter of network usage. *LoggerNet* has no control over the TD-RF network.
- TDP is a completely separate process from *LoggerNet*-initiated transactions, such as "hole" collections or clock checks. The base modem manages the interleaving of these individual processes so that only one is active on the network at any given time. The base modem checks for pending *LoggerNet* transactions between broadcast polling events.
- Once any individual transaction—whether a polling transaction or a *LoggerNet*-initiated transaction—is started, that transaction is allowed to continue until it is either successfully completed or its allotted *lifetime* expires.
- The base modem allocates a finite lifetime for an active transaction on the TD-RF network. Secondary transactions associated with broadcast polling events such as the transfer of collected records from a repeater to the base modem are allocated 120 seconds of lifetime. All *LoggerNet*-initiated transactions are allocated 90 seconds of lifetime. If the lifetime of a transaction expires before the transaction is successfully completed, the transaction is aborted.
- Remote modems and repeater modems only respond to polling events or directed commands; they do not arbitrarily initiate transmissions on

their own. This prevents simultaneous transmissions and over-the-air (OTA) data collisions.

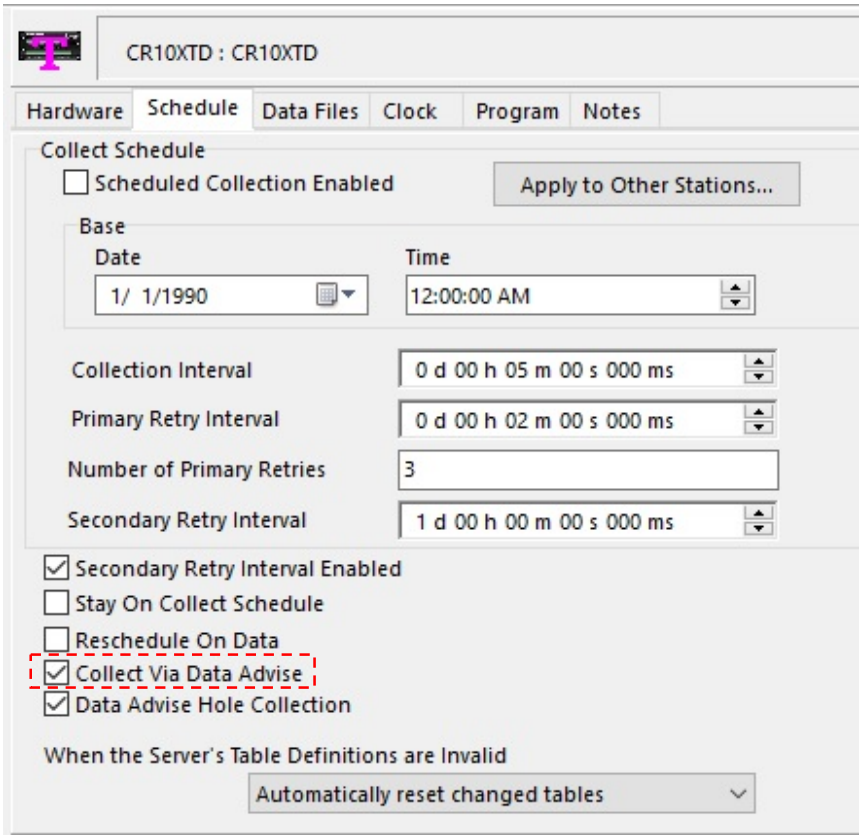
- With the exception of broadcast polling transactions, a three-way handshaking protocol (command/acknowledge/finished) is employed for OTA transfers to ensure the reliable transfer of information or data.

2. Data Advise

The Data Advise protocol is an arrangement established via communications between *LoggerNet* and a classic table-based datalogger (CR10T, CR510T, CR10X-TD, CR23X-TD) whereby the datalogger agrees to send the most recently logged record or records from a specified table whenever a communications link is established. The remote modem will establish this link when it receives a valid **Broadcast Poll** command. The arrangement is not part of the datalogger program.

The Data Advise arrangement includes a built-in timeout feature so that if *LoggerNet* does not receive table data within a predefined worse-case time, the arrangement is canceled and a new arrangement is established.

To use the Data Advise arrangement with TDP, it must be enabled in *LoggerNet*. This is done by checking the **Collect Via Data Advise** option on the datalogger **Schedule** tab in the *LoggerNet Setup Screen*.



3. One-Way Data

The One-Way data method relies on an instruction in a PakBus® datalogger program to push the most recently logged record from a specified table out a designated communication port each time the table is called. The remote modem attached to this port will buffer the data records until it receives a valid **Broadcast Poll** command.

For *CRBasic* programs, use the **SendData()** instruction:

```
SendData (COMRS232,0,4094,Sec_60,0)
```

For *Edlog* programs, use the **Send Final Storage Data** instruction:

```
11:  PakBus - Send Final Storage Data (P191)
 1: 17       SDC7
 2: 4094     Address
 3: 5        Table Number
```

4. *LoggerNet* Scheduled Data Collection Method

LoggerNet data collection transactions operate no differently on a TD-RF network than on any other type of network. The default collection algorithm first sends out a **data-collect** command packet requesting the most recently logged record from a specified table. When the **data-collect** response packet is received, the **Record Number** field is examined to determine if any additional uncollected records were logged to the table since the previous collection cycle. These "holes" in the records list occur most commonly when the table interval is shorter than the collection interval. If holes do exist, additional **data-collect** commands are sent to request the missing records. If no **data-collect** response packet is received within an allotted **response-time**, *LoggerNet* will retry the **data-collect** command up to two more times before failing the data collection transaction and moving on to the next transaction in the queue.

Each data collection transaction results in a minimum of two OTA transmissions propagating across the TD-RF network; an outgoing command packet and an incoming response packet. Under the best of circumstances, multiple OTA transmission are typically required to complete a collection cycle for a single table. If many holes are created or numerous retries are required, the number of OTA transmissions, and thus the time required to complete a collection cycle, will increase rapidly. In a large, busy TD-RF network, it may become impossible to achieve or maintain the desired collection interval.

5. The TDP Data Collection Method

TDP is an interval-driven, broadcast-polling process controlled exclusively by the base modem (RFBase-TD device) in a TD-RF network. To facilitate data collection by the TDP process, each datalogger in the network is configured to preemptively push the most recently logged table record to an attached remote modem using the Data Advise or One-Way methods. The as-logged records accumulate in the remote modem storage buffer until polled by the base modem. When the base modem transmits a **Broadcast Poll** command, all remote modems addressed by the command will respond synchronously by

means of a prearranged sequence to transfer the accumulated table records to the base modem. The base modem buffers the collected records until retrieved by the *LoggerNet* server.

The key features of the TDP data collection method:

- Up to fifteen dataloggers can be polled simultaneously via a single OTA transmission.

- Each of the responding dataloggers can transfer the most recent, plus any accumulated records, via a single OTA transmission.

These features provide a more effective use of network bandwidth than does *LoggerNet* scheduled collection method. The advantages of TDP become even more evident in larger networks.

6. The TDP Cycle

A TDP cycle is initiated when the base modem transmits a **Broadcast Poll** command to the first polling area defined in the current network description. The *network description* is the base modem's tabularized representation of the TD-RF network map as displayed in the *LoggerNet Setup Screen*. *LoggerNet* generates the network description and sends it to the base modem when the TD-RF network is initialized. *LoggerNet* will send an updated version of the network description whenever structural changes are made to the TD-RF network map.

A *polling area* is a logical grouping of remote modems that are local (one hop) to a base or repeater modem. Remote modems are assigned to polling areas based on their order and position in in the network description. Each area is identified by an *area number* and can contain a maximum of fifteen remote modems.

A **Broadcast Poll** command contains specific identifying information:

- *Network Number* – the RFID (address) of the base modem doing the polling
- *Broadcast Number* – a unique ID for this polling event
- *Area Number* – the polling area that should respond
- *Window Size* – the time duration allotted to each modem for responding (default is 1 second)

Before a remote modem can respond to a **Broadcast Poll** command, it must know its assigned polling area and its assigned position (time slot) in the sequence of responding modems. A remote modem is initialized with these parameters by a directed **Forced Broadcast Poll** command whenever it fails to respond to an initial **Broadcast Poll** command.

When a **Broadcast Poll** command is transmitted, all remote modems within RF earshot will receive the command, but only those remote modems assigned to the area number specified in the **Broadcast Poll** command will respond—and then only within their uniquely assigned time slot.

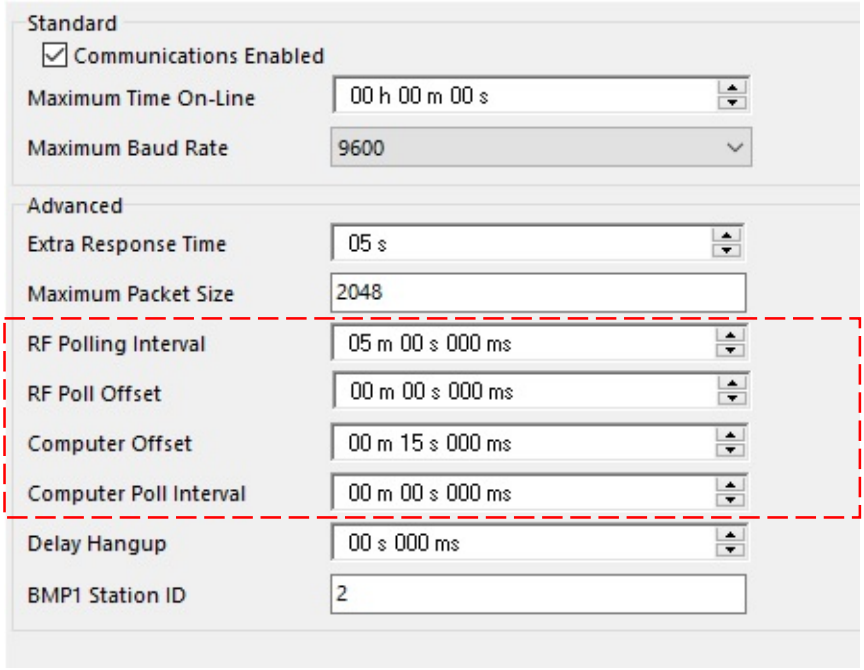
When polling of the first area is complete and *LoggerNet* is not requesting access to the network, the base modem will advance to the next polling area in

the network description. When all of the polling areas local to the base modem have been polled, the base modem will check the network description for any repeaters. The base modem cannot directly poll an area local to a repeater; it must use the repeater modem as a proxy. This is accomplished by sending the repeater modem a description of the polling area and temporarily passing control of the network to the repeater. The repeater modem will then transmit the **Broadcast Poll** command. When polling of the area is complete, the repeater modem will transfer the collected records back to the base modem and relinquish control of the network.

Polling will continue in this fashion until all of the polling areas in the TD-RF network have been polled and the TDP cycle for the current interval is complete.

7. *LoggerNet* Configuration for TDP

The user-configurable settings that directly manage the TDP process are found on the **Hardware** tab of the **RFBase-TD** device in the *LoggerNet Setup Screen*. These settings are sent to the base modem as part of the network description. Every network is different, so there are no set rules for configuring these settings. Experimentation is encouraged to obtain optimal settings.



7.1 RF Polling Interval and RF Poll Offset

RF Polling Interval and **RF Poll Offset** determine when and how often the base modem will initiate a TDP cycle.

RF Polling Interval is set relative to the top-of-the-hour and has a default setting of five minutes. The maximum allowed interval is twenty minutes. **RF Poll Offset** has a maximum value of twenty minutes, but is typically used only to delay the start of a TDP cycle by a small amount to compensate for any drift in a datalogger clock.

NOTE **DO NOT SET THE RF POLLING INTERVAL TO ZERO.** Some users have the mistaken belief that doing so will disable the TDP process. TDP cannot be permanently disabled. Setting the **RF Polling Interval** to zero will only cause the base modem to poll continuously. This is usually not a good idea. Especially if the reason for disabling TDP is a preference for the *LoggerNet* scheduled data collection method. More on this later.

7.2 Computer Offset and Computer Poll Interval

Computer Offset and **Computer Poll Interval** determine when and how often *LoggerNet* will attempt to retrieve the data records collected by the base modem.

Computer Offset is simply an offset from the **RF Polling Interval**. This is typically set to allow the TDP cycle sufficient time to complete the data collection process for the entire network before attempting to access the data. The time required for a TDP cycle to complete depends on the size of the network and the quality of the RF links. Communication failures between network modems can significantly extend the time required to complete a TDP cycle.

To access interim collections before the entire network has been polled, one can set the **Computer Poll Interval** so that *LoggerNet* will query the base modem more frequently. A setting of around ten seconds will usually result in retrieving data from the base modem about as quickly as it is collected.

8. Operational Considerations

8.1 The Base Modem Clock

If getting the most recently logged data into *LoggerNet* with a minimum of delay is important, one should keep the base modem clock (as well as the datalogger clock) synchronized with the *LoggerNet* clock.

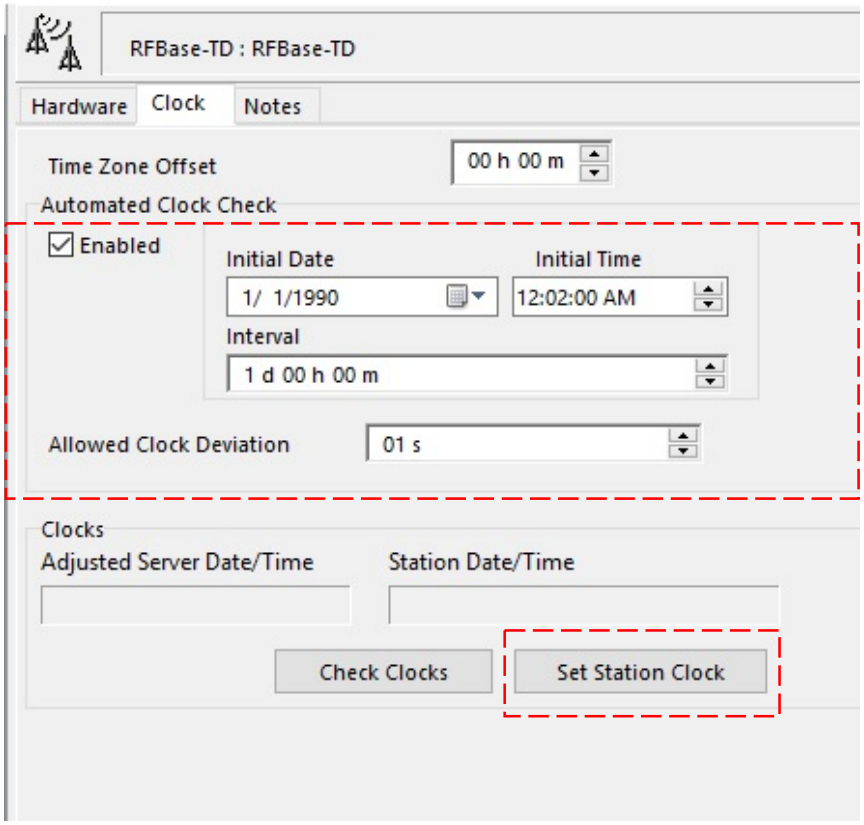
To manually synchronize the base modem clock with the *LoggerNet* clock, click the **Set Station Clock** button on the **Clock** tab of the **RFBase-TD** device in the *LoggerNet Setup Screen*. This should be done after *LoggerNet* initializes the TD-RF network (server startup) or whenever the base modem has been reset (power cycled).

NOTE A "feature" of the base modem OS is that it will not accept clock-set commands from *LoggerNet* until after it has received a valid network description. If the initial attempt to set the clock fails, wait a few seconds and try again; by this time a "*send network description complete"* message should have appeared in the *LoggerNet* transaction log.

```
"2016-07-20 15:33:59.119","RFBase-TD","37","Send network description started"
"2016-07-20 15:34:04.353","RFBase-TD","38","Send network description complete"
```

LoggerNet log files can be viewed using the *LogTool* client. It is strongly recommended that users become familiar with this application and the plethora of operational information provided by the log files.

Over time, the two clocks may drift apart, so it is recommended that automated clock checks be enabled to occur on a daily basis.



8.2 RF Link Quality

The importance of high quality RF links to the successful operation of a TD-RF network cannot be over emphasized. One or more noisy or marginal RF links in the TD-RF network can lead to extended collection cycles and/or the creation of holes, either of which can quickly diminish the advantages provided by TDP.

It has been noted that OTA transactions that propagate commands or data across the network are governed by a three-way transfer protocol and an allocated lifetime. If a sending modem does not receive an acknowledgement of its transmitted command, it will continue to resend the command until an acknowledgement is received or the transaction lifetime expires. Depending on the type of transaction, an intermittent link can extend the elapsed time for a single transaction by as much as two minutes. For comparison, it should take less than two minutes to complete an entire TDP collection cycle for a moderately sized (30 – 40 sites) TD-RF network with high quality RF links.

Holes can be created when data records become lost-in-transit due to an expired transaction lifetime (aborted data transfer) or when polling response packets fail to be received by the base modem. Hole collection, when enabled,

is accomplished via *LoggerNet*-initiated transactions that occur outside of the TDP process. The interleaving of these two processes can significantly extend the time required to complete a TDP collection cycle and the increase in OTA traffic further increases the potential for communication failures.

8.3 Blacklisting

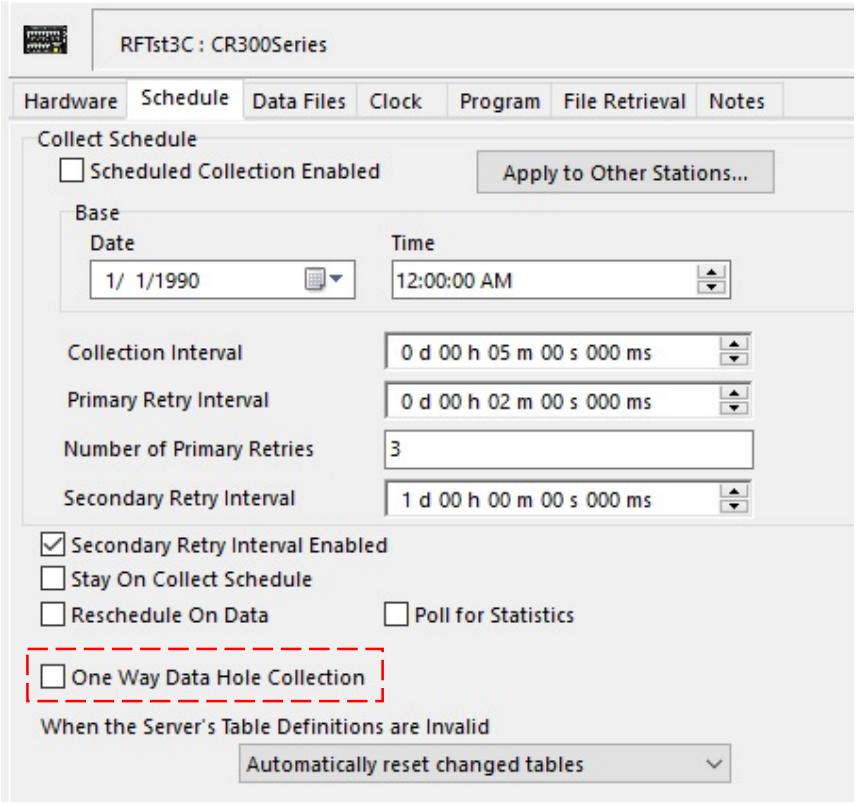
If the lifetime expires on a *LoggerNet*-initiated transaction, the repeater or remote modem associated with the transaction failure will be *blacklisted* by the base modem. As a result, the base modem will respond to any *LoggerNet*-initiated transaction attempting to use the blacklisted modem with an immediate **Packet Delivery Fault** notification. When *LoggerNet* receives this notification, the associated transaction is immediately failed and a **True** status is posted for the device in the **RFTD Blacklisted** column of the **Status Monitor**.

A blacklisted repeater modem is of special significance since any sites accessed through the repeater will become inaccessible.

A modem will remain blacklisted until it has successfully responded to a **TDP Broadcast Polling** command; at which time, *LoggerNet* is informed of the modem's renewed availability via a **Communications Status** notification.

8.4 Hole Collection

LoggerNet, by default, does not detect and collect holes created by the Data Advise or One-Way data collection methods. If a complete archival data set is required, one can enable hole collection by checking the **Data Advise Hole Collection** or **One Way Data Hole Collection** option on the **Schedule** tab for the respective datalogger.



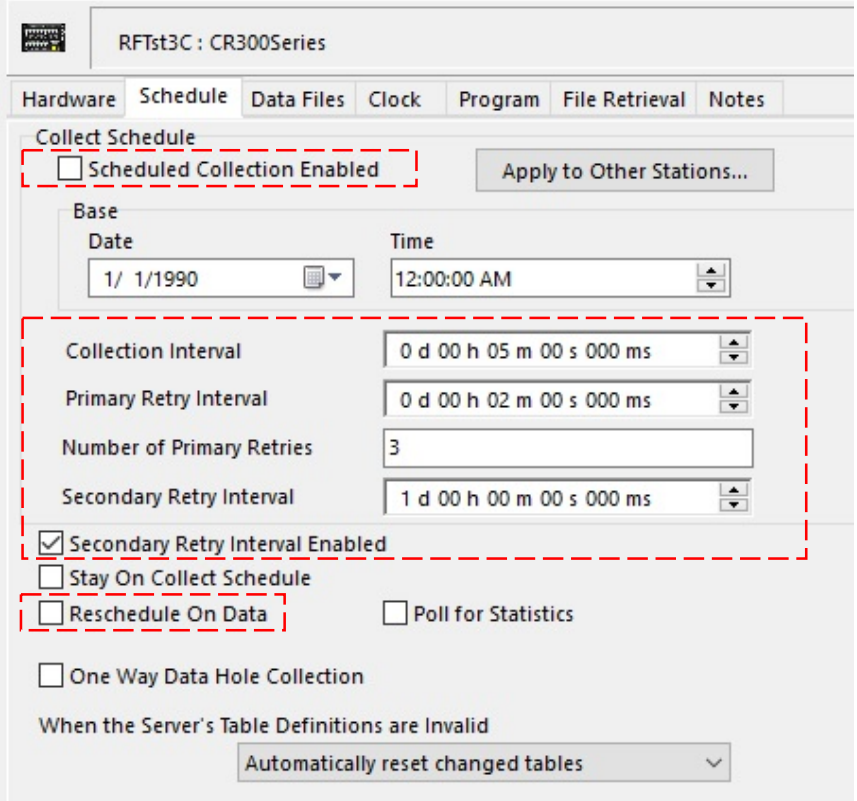
8.5 Reschedule On Data

In most cases, it is not recommended that both TDP and *LoggerNet* scheduled collection methods be used concurrently. Aside from the duplication of effort, their individual requirements for network usage may lead to access conflicts that become self-defeating. For small TD-RF networks (less than a dozen sites) with modest data bandwidth requirements, there may not be a noticeable impact on system performance. However, for larger networks that are pushing the limits of bandwidth capacity, the systemic use of both collection methods will likely lead to poor system performance overall.

There are, however, circumstances where a limited and targeted use of the *LoggerNet* scheduled collection method can be utilized as a sort of adjunct process for TDP. For example, when a site logging time-critical data is located on a noisy RF link, the relatively limited number of retries built into the broadcast polling process may not provide the success rate required for timely data updates. Whereas, the sustained retries of the thee-way transfer protocol, used by all *LoggerNet*-initiated transactions, will usually provide a statistically better success rate in a noisy environment.

The *LoggerNet* **Reschedule On Data** option provides a means of initiating a data collection transaction on a site when One-Way or Data Advise records have not been received within a specified interval. To use this feature, check the **Reschedule On Data** option on the datalogger **Schedule** tab in the *LoggerNet Setup Screen*. Set the **Collection Interval** to some value greater than the interval on which One-Way data is expected and check the **Scheduled Collection Enabled** option.

NOTE The optimal setting for the **Collection Interval** as well as the use of a **Primary** or **Secondary Retry Interval** is a judgment call based on one's knowledge of the network and the potential cost/benefit trade-off.



When One-Way or Data Advise records are received from any of the datalogger tables, the interval timer is reset so that the "Next Time to Poll" is adjusted to be equal to the current time plus the **Collection Interval**. Thus, as long as records are received more frequently than the **Collection Interval** setting, no *LoggerNet*-initiated collection transactions will be executed. Conversely, if no records are received within the **Collection Interval**, a scheduled collection cycle will be initiated for all of the datalogger tables enabled for scheduled collection (**Data Files** tab).

One should use this feature judiciously so as not to impact overall system performance. If **Reschedule On Data** is enabled for more than a small percentage of network sites, a far better solution would be to improve link quality.

9. Conclusion

Time division polling, coupled with the One-Way Data or Data Advise protocol, provides a very efficient means of data collection in small-to-large TD-RF networks. TDP is easily configured and requires little to no user (or *LoggerNet*) intervention. When operating over high quality RF links, data flows quickly and reliably across the network.

Designed to be fault-tolerant and adaptive to a range of anomalous conditions in its operational environment, TDP is, under the hood, a necessarily complex process. To successfully manage and maintain a TD-RF network running time division polling, an awareness of this complexity and an understanding of some operational characteristics are essential.

Campbell Scientific Companies

Campbell Scientific, Inc.
815 West 1800 North
Logan, Utah 84321
UNITED STATES
www.campbellsci.com • info@campbellsci.com

Campbell Scientific Canada Corp.
14532 – 131 Avenue NW
Edmonton AB T5L 4X4
CANADA
www.campbellsci.ca • dataloggers@campbellsci.ca

Campbell Scientific Africa Pty. Ltd.
PO Box 2450
Somerset West 7129
SOUTH AFRICA
www.campbellsci.co.za • cleroux@csafrica.co.za

Campbell Scientific Centro Caribe S.A.
300 N Cementerio, Edificio Breller
Santo Domingo, Heredia 40305
COSTA RICA
www.campbellsci.cc • info@campbellsci.cc

Campbell Scientific Southeast Asia Co., Ltd.
877/22 Nirvana@Work, Rama 9 Road
Suan Luang Subdistrict, Suan Luang District
Bangkok 10250
THAILAND
www.campbellsci.asia • info@campbellsci.asia

Campbell Scientific Ltd.
Campbell Park
80 Hathern Road
Shepshed, Loughborough LE12 9GX
UNITED KINGDOM
www.campbellsci.co.uk • sales@campbellsci.co.uk

Campbell Scientific Australia Pty. Ltd.
PO Box 8108
Garbutt Post Shop QLD 4814
AUSTRALIA
www.campbellsci.com.au • info@campbellsci.com.au

Campbell Scientific Ltd.
3 Avenue de la Division Leclerc
92160 ANTONY
FRANCE
www.campbellsci.fr • info@campbellsci.fr

Campbell Scientific (Beijing) Co., Ltd.
8B16, Floor 8 Tower B, Hanwei Plaza
7 Guanghua Road
Chaoyang, Beijing 100004
P.R. CHINA
www.campbellsci.com • info@campbellsci.com.cn

Campbell Scientific Ltda.
Fahrenheitstraße 13
28359 Bremen
GERMANY
www.campbellsci.de • info@campbellsci.de

Campbell Scientific do Brasil Ltda.
Rua Apinagés, nbr. 2018 ─ Perdizes
CEP: 01258-00 ─ São Paulo ─ SP
BRASIL
www.campbellsci.com.br • vendas@campbellsci.com.br

Campbell Scientific Spain, S. L.
Avda. Pompeu Fabra 7-9, local 1
08024 Barcelona
SPAIN
www.campbellsci.es • info@campbellsci.es

Please visit www.campbellsci.com to obtain contact information for your local US or international representative.