

LF Reader Synchronization

Application Report

July 2004



SCBA019 (11-06-26-001)

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*Allan Goulbourne**UK Technical Support Center***Edition Two – July 2004**

This is the second edition of the Technical Application Note about LF Reader Synchronization.

It contains a description of when we may need to Synchronize Reader units for use with the following products:

TI-RFid LF Reader Family: S2000 Series

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LF Reader Synchronization

ABSTRACT

In this document you will find the descriptions of different Synchronization methods which are available for the S2000 Series and S2510 LF Readers.

The objective of this paper is to give detailed background information about the various synchronization methods available, to help RF Engineers in their choice for a particular application.

1 Why Do We Need to Synchronize Reader Units?

In applications that require multiple readers operating at the same time and in the same area, it is necessary to coordinate their transmit and receive functions in order to avoid mutual interference.

This is known as synchronization.

The separation distance between reader antenna systems can and does vary before there is a need to implement a method of synchronization. Variations in local conditions can affect the general noise background. For example, radio frequency interference (RFI) and electrical noise can travel from one reader to another, not only through the air (radiated) but via metal structures (conducted). Metal structures can include the frames of metal buildings, conveyors, reinforcing bars in concrete floors and power or data cables.

If you consider only radiated signals from standard antennas, listed in [Table 1](#) below are the separation distances between antennas, without the need for synchronization.

Table 1. Separation of Standard Antennas

STANDARD ANTENNA TYPE	SEPARATION DISTANCE
S02-C	18 meters
G02-E	32 meters
G01-E	55 meters
G04-E	105 meters

Depending on the antennas' spatial orientation to one another, or if the antennas are heavily shielded by metal, the distances shown in [Table 1](#) could be reduced. However, the separation distances may have to be greater if there are groups of synchronized readers in the same area and application.

Where customized and balanced antennas are used the System Integrator will need to determine the limits of separation themselves, to avoid 'noise' problems.

Where no provision is made for synchronization, the reading of transponders will become erratic, the reading distances will reduce and in extreme cases, no readings will result.

2 Methods of Synchronization

There are differing techniques to synchronize the S2000 Series and S2510 readers. The method chosen will depend on the type of transponder, the type of operation performed on that transponder (Charge-only read, General read, Program page, lock page), the size of the antennas and the speed at which the transponder is moving.

The S2000 Series and S2510 readers can be configured to synchronize in a number of different ways:

- No Sync
- Wireless Sync
- Wired Sync
- Combined Wireless/Wired Sync
- Master/Slave (M/S) Sync
 - Master/Slave **without** Acknowledgment
 - Master/Slave **with** Acknowledgment
 - Triggered Sync

These methods are discussed in the following sections.

3 No Synchronization

This option is only used in conjunction with Software synchronization.

If the same RS485 data network connects multiple readers, coordination of the readers can be controlled directly by the Host Computer. For example, the Host Computer may issue a Broadcast command for all readers to simultaneously perform a read cycle and buffer the result.

Another technique possible, using the RS485 data network, is to issue individual commands to each reader in turn. This technique is used when writing data to Multi-Page Transponders (MPTs).

Where a Programmable Logic Controller (PLC) has a number of point-to-point connections to readers, it is also possible to coordinate the activities via the ladder logic. With Software synchronization all readers will either be simultaneously transmitting or, only one reader will be transmitting, at any one time. In both cases, the readers can be configured to have No Sync.

4 Wireless Synchronization

Wireless synchronization can be used to control the coordination of readers, with standard and customized antennas. The proviso is that the electrical noise in the environment is low and the RFI noise is constant, for the type of antennas in use.

Wireless Synchronization is only valid for charge-only reading of transponders.

Each reader and its antenna is adjusted (in-situ) to set the background electrical noise level at its installed location, with all the other readers inhibited. Then, during operation, when the reader detects noise above the background level, it assumes that it is another reader and 'backs-off' for a set period before commencing its own cycle.

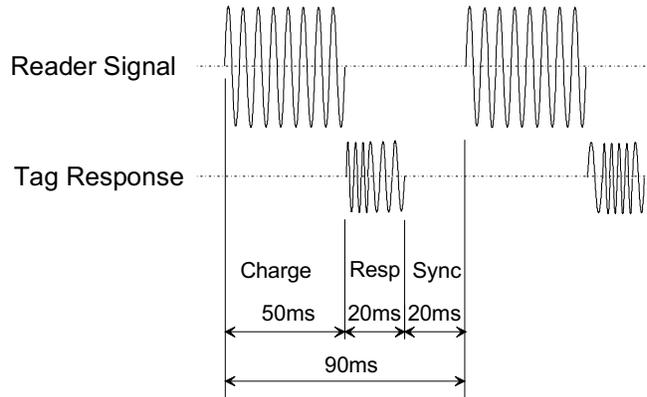


Figure 1. Wireless Synchronization – No Other Signals Detected

In [Figure 1](#), two complete read cycles are shown – the reader has not had to ‘back-off’ because of another reader’s transmission. The reader turns on its transmitter for 50 ms after which the transponder, recognizing the end of the charge burst, responds with its data. The reader does not immediately initiate the next charge burst, but listens for 20 ms. This is a precaution to stop another reader’s receive data from being corrupted, when that transponder is on the limit of the first reader’s detection range. If no other signal is detected during this time, the reader starts the next cycle, which is 90 ms long.

Note: The cycle time may be extended by data processing whenever a transponder is read.

In [Figure 2](#), the initial reader having completed its first read cycle, detects that another reader is already transmitting and waits 70 ms to allow that read cycle to complete. This is called ‘backing off’.

After this 70-ms delay the initial reader will always start its next cycle. This is to prevent constantly ‘backing off’ and never reading any transponders. The cycle time in this worst case is 140 ms.

The best case synchronization time is 70 ms and this occurs when the reader detects another transmission just after beginning the 20-ms synchronization listening period and immediately starts (synchronizes) its own cycle, to the other reader(s).

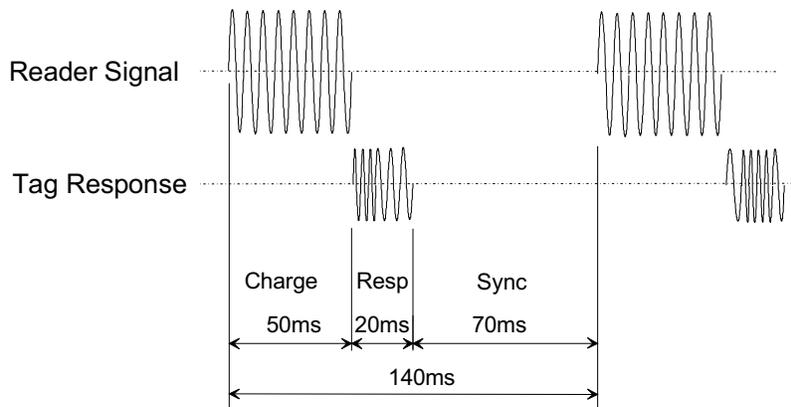


Figure 2. Wireless Synchronization – Signal Detected and 2nd Cycle Delayed

Wired Synchronization

In practice, reader units using Wireless Synchronization, tend to be read together (90 ms/approximately 10 reads/s) until one unit reads a transponder, gets out of phase with the others and then the units may run alternately (140 ms/approximately 6 reads/s). As the other readers see transponders, they may get back into phase again. So with Wireless Synchronization, we get the read cycle time alternating between 10 and 6 reads a second. This may not be reliable enough for higher speed operations. The description of operation above assumes that the readers are set to the standard times of operation.

Note: Where the reader configuration has changed, i.e., the charge-time or the interval between reads, all units must be set to the same parameters for correct operation.

4.1 Wireless Synchronization Pros and Cons

The method of wireless synchronization has a number of advantages over some of the other methods:

- There are no wires to run.
- All readers are autonomous (no Master unit).
- Enables hand held readers to co-exist with fixed units (using wireless synchronization).

However, there are disadvantages too:

- In noisy environments, there is too much sensitivity with larger antennas (TI Antenna RI-ANT-G04E and larger custom antennas) to allow accurate setting of the background levels.
- It is not suitable for operations other than a Charge-read on MPTs.
- It cannot be used when other readers are writing information to transponders.
- Where the environmental conditions change, e.g., a ground loop antenna characteristics' change when a vehicle is positioned over it, the synchronization adjustment could then be wrong.

5 Wired Synchronization

Wired Synchronization operates the same as described for Wireless Synchronization when no other signal is detected and also exhibits the alternating read cycle times – 90 ms or 140 ms.

5.1 Wired Synchronization Pros and Cons

The advantages of this technique are:

- It is a Peer-to-Peer network and does not need a Master unit.
- It uses a single twisted pair cable.
- It operates independently of background noise.

The disadvantages are as follows:

- Readers may operate as slowly as 6 reads/s.
- It is only suitable for Charge-only reading of transponders.
- It cannot be used for operations other than Charge-read on MPTs.
- It cannot be used when other readers are writing information to transponders.
- If the power fails at a reader, the bus will fail.

Note: To overcome power failure use a relay held closed at power-up by the readers I/O. If power is lost, the relay releases the connection.

6 Combined Wireless/Wired

When this option is selected, groups of readers connected by the Wired Synchronization cabling can synchronize with other groups of Wired Synchronized readers, or with individual readers, by using Wireless Synchronization.

For example, at a site, all fixed readers could be connected on the same Wired Sync cable whilst allowing a hand held reader with Wireless Sync to be used for occasional audit purposes without conflict.

The advantages and disadvantages given for each of the above methods still apply.

7 Master-Slave Synchronization

Master/Slave (M/S) Synchronization is probably the most commonly used form of synchronization.

One reader is configured to be the Master and this reader then controls all the other readers, which are configured as Slaves.

There are three variants:

- M/S Synchronization **without** Acknowledgment
- M/S Synchronization **with** Acknowledgment
- Triggered Synchronization.

7.1 M/S Synchronization without Acknowledgment

The M/S method of synchronization is the fastest technique for reading transponders and was originally developed for reading moving vehicles. It assumes that all readers are on the same synchronization bus and the readers would not, for example, recognize a handheld reader that is trying (probably unsuccessfully) to perform a reading.

The S2000 Series and S2510 readers have a two-wire synchronization bus, which connects all readers. To implement this type of synchronization, connector ST24 for the S2000 Series and connector 'C' (Sync) on the S2510 are used. Physically a shielded twisted pair cable is connected to the transmit pair, pins 4 and 5 at the Master, whilst at the Slaves, the cable is connected to receive pins 1 and 2 on both the S2000 Series and S2510 readers. [For more details consult the Individual Reader Control Module Manual].

Note: Information: The bus referred to is built into the S2000 Series and S2510 reader for synchronization purposes and should not be confused with the RS485 data network that is available on the MA6A and S2510 readers.

Immediately the Master has finished a complete read cycle, it transmits a synchronization pulse on its transmit lines. Any Slave reader that has finished its cycle, looks for this pulse on its receive lines and on seeing it, will immediately start the next cycle. Assuming that the readers are set to the standard 50-ms charge pulse, the Master will be cycling about every 70 ms (14 reads/s). If vehicle series transponders are being used, it may be possible to reduce the charge time and further reduce the reading cycle time for high-speed applications.

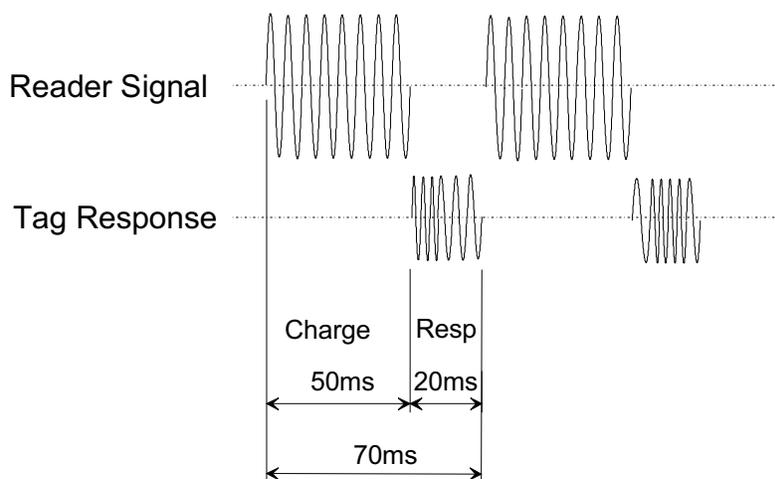


Figure 3. Master/Slave Synchronization (Without Acknowledgment)

This method has the following advantages:

- Uses a single twisted pair cable.
- Has the fastest read rate.
- The Master can be used for Charge-read or Write/Program.

There are disadvantages too:

- All readers must be on the same synchronization bus.
- It is not suitable for operations involving paged reads with MPTs.
- If the Master fails, all units stop.
- Slave units cannot be individually tested without the Master running.

7.2 Master/Slave (M/S) Synchronization With Acknowledgment

In 'M/S Synchronization **without** Acknowledgment', if a Slave reads a transponder and the Master does not, the Slave may miss the next pulse while it is processing the reading from that transponder.

In 'M/S Synchronization **with** Acknowledgment' the Master has to wait until all Slaves have completed their current cycles before initiating the next cycle. This is achieved by using a 4 wire synchronization bus (twin twisted pair) with the Slave transmit lines coupled back to the Master receive lines. [See the reference manual for further details].

With M/S synchronization, the readers are free running (gate Mode) and buffer the data or respond to their respective Host Computers via a point to point data connection. If configured as M/S synchronization, a Slave will not respond to a command from a Host Computer, unless it is getting the Master pulse – the cycle of a reader is suspended until the pulse is seen. The System Integrator should be aware that, if individual Host computers are issuing read commands i.e., "X" commands, these commands would only be actioned at the next pulse. Any delay configured into the Master will be affective to all Slaves.

Note: For correct functioning of M/S synchronization, the charge times of all Slaves must match those of the Master.

This method has the following advantages over M/S without Acknowledge:

- All units can Write/Program 64 bit tags (providing they do it together).
- They wait for the slowest to complete.

There are disadvantages too:

- The cable is a twin twisted pair.

- The readers cannot be too close together if writing is performed, because of the possibility of corrupted data. This restriction also includes the Paged Read of MPT.

7.3 Triggered Synchronization

Triggered Synchronization is an M/S Synchronization Bus where the pulse signal is external and not an S2000 Series reader (although it is possible to change the software of a reader to allow it to function in this role). All readers are configured as Slaves but it is the external Master (trigger circuit) that issues the synchronization pulse at suitable intervals for the required operations on the transponder.

7.3.1 Timing Bus

The more complex version of this is known as a 'Timing Bus', when various time windows are defined for different operations that have to be carried out. For example, if multiple readers are required to read addressed pages of MPT, then to write data back to the transponders, the timing bus would start a read window lasting 90ms then initiate a time window of 320 ms for a write operation. In this way the differing times required for the two operations can be accommodated. At the same time, the readers would be instructed over their data cables, about which command to execute during each window.

The external Master unit must be capable of producing signals to the same voltage levels as the S2000 Series reader [see the reference manual]. This could be a custom timer board or the controls lines of a RS485 interface board.

7.3.2 PLC Output Timing Bus

Another type of timing bus can be used with a PLC output. All readers must be configured as Masters, but one reader has to be modified as shown below:

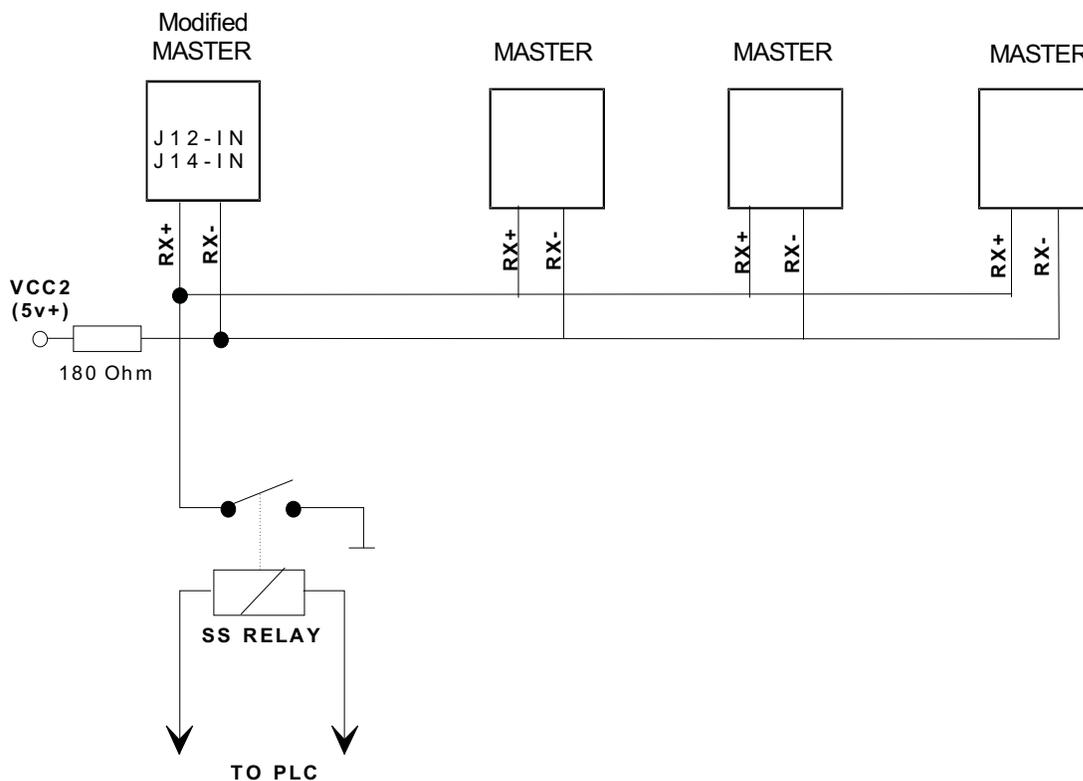


Figure 4. PLC Operated Timing Bus

Master-Slave Synchronization

When the PLC closes the relay, the signal on the synchronization bus initiates the next cycle at each reader. By controlling the pulses, the PLC, can coordinate different operations.

For instance, if the readers were alternately reading and writing (as in a Ski Pass application), the pulse might be as follows:

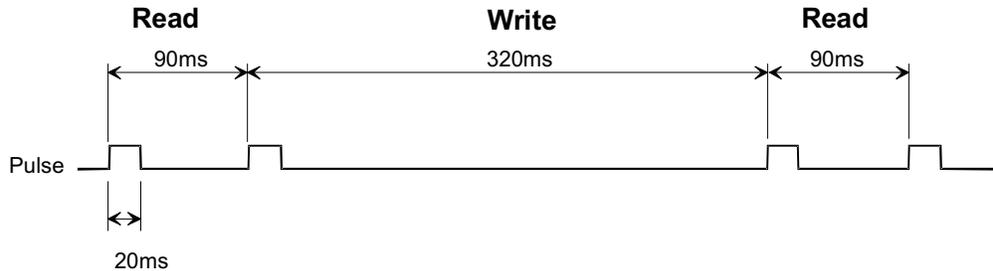


Figure 5. Timing Pulses From a Master Controller

'Triggered' and 'Timing' buses have the following advantages:

- The Master unit has total control over the coordination of the connected devices and can allow 'windows' for particular operations.
- Reading and Writing to 64 bit tags can be accommodated, if there is sufficient separation to prevent data corruption during the Write process.

There are disadvantages too:

- The Master unit is more complex and needs intelligence or to be controlled by an intelligent device.
- Cannot be used for addressing MP transponders if readers are close together because addressing conflicts can arise.

MPT represent the most challenging synchronization situations if 'Paged reads' and 'Paged Writes' need to be performed. To read 64 bit tags or the first page of MPT, the Reader's transmitter is turned on for 50 ms and any transponder in the field that is sufficiently charged, responds with its data when it detects the end of the charge-up burst.

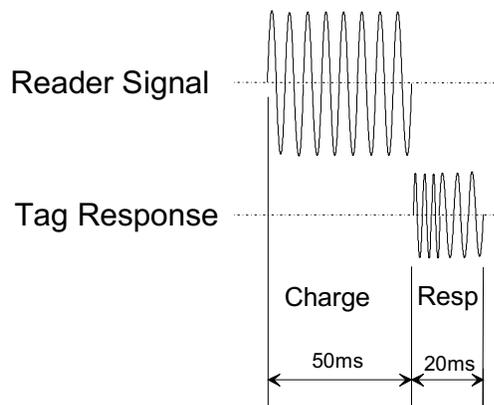


Figure 6. Typical Charge-Only Read

For a 'Paged Read', in addition to the charge-up burst, the transponder must hand the address of the page to be read. There is no checksum associated with this address, so if another reader is close to the first reader, the two addresses could become mixed and the wrong pages returned.

Note: Information: It is advisable that programmers confirm that the number of the returned page matches the requested page and immediately re-try if an error occurs

Figure 7 shows the sequence of signals.

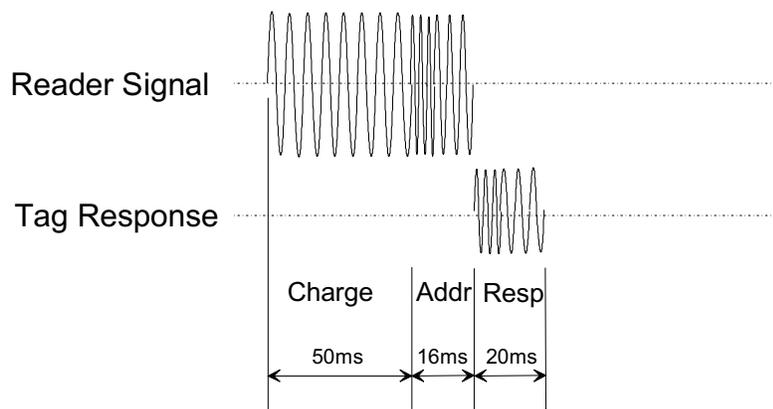


Figure 7. A Paged Read of a Multi-Page Tag

For the most effective method of writing data to particular pages of MPT in a multi-reader system, we recommend sending commands to each individual reader in sequence.

8 References

S2000 Reference Manual 11-06-21-029

S2510 Reference Manual 11-06-21-031

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