

SEMI D51-0709

SPECIFICATION FOR HANDSHAKE METHOD OF SINGLE SUBSTRATE FOR HANDLING OFF/ON TOOL IN FPD PRODUCTION

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1 Purpose

1.1 Due to the migration to large substrate sizes in FPD production, the demand for single substrate transfer, with the extensive combined use of Automated Material Handling Systems (AMHS), robots and conveyors, is increasing. On the other hand, each FPD fab uses different handshake specifications for single substrate transfer, which creates issues such as increase in cost, as well as delay in delivery and testing. It is imperative to define a handshake method for transferring single substrates to the process equipment in order to solve these issues.

1.2 The purpose of this specification is to standardize the handshake methods for transferring single substrates, which are currently different at each FPD fab. It is expected that this will result in improved efficiency in the design, production and installation of equipment, as well as in cost reduction.

2 Scope

2.1 The scope of this standard is limited to the handshake associated with the transfer operation of single substrates between the single substrate transfer system and the process equipment. Examples are single substrate transfer between the process equipment and the single substrate transfer system, between the single substrate transfer system and the buffers, etc.

2.2 The handshake specification for transferring single substrates includes:

- Signal definition (refer to ¶ 7.1)
- Single substrate transfer sequence definition (refer to ¶ 7.2)
- Guideline for detecting timeout errors (refer to ¶ 7.3 and ¶ 7.4)

2.3 This standard only defines the handshake process and basic handshake signals with their meanings and handling method, for transferring single substrates from single substrate transfer systems to the process equipment.

2.4 The single substrate transfer handshake that is defined in this standard may also be applied to single substrate transfer between different pieces of process equipment.

NOTICE: This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This standard defines the control procedure for each handshake signal while it does not define the relation between the operation of the transfer mechanism and each handshake signal.

3.2 The physical layout or electrical specification of the handshake signals is not defined in this standard.

3.3 The transfer of data such as the single substrate process data that are transferred between the single substrate transfer systems and the process equipment is not defined in this document.

3.4 The handshake signals for single substrate transfer require error recovery procedures. However, these are proprietary procedures specific to the equipment and may need operator assistance. Therefore, error recovery procedures are not defined in this document.

3.5 The signal states defined in this standard are logical states. The logical design for implementation is not defined in this document.

4 Background

4.1 Due to the migration to large glass substrate sizes in FPD production, the demand for a single substrate transfer process is increasing. The mechanism for the transfer of single substrates is assumed to be similar to the process shown in Figure 1 Example of the Control Mechanism between a Single Substrate Transfer System and Equipment; however, the handshake method employed between a single substrate transfer system and the process equipment is not clearly defined. Therefore, this standard defines the handshake method for transferring single substrates between a single substrate transfer system and the process equipment.

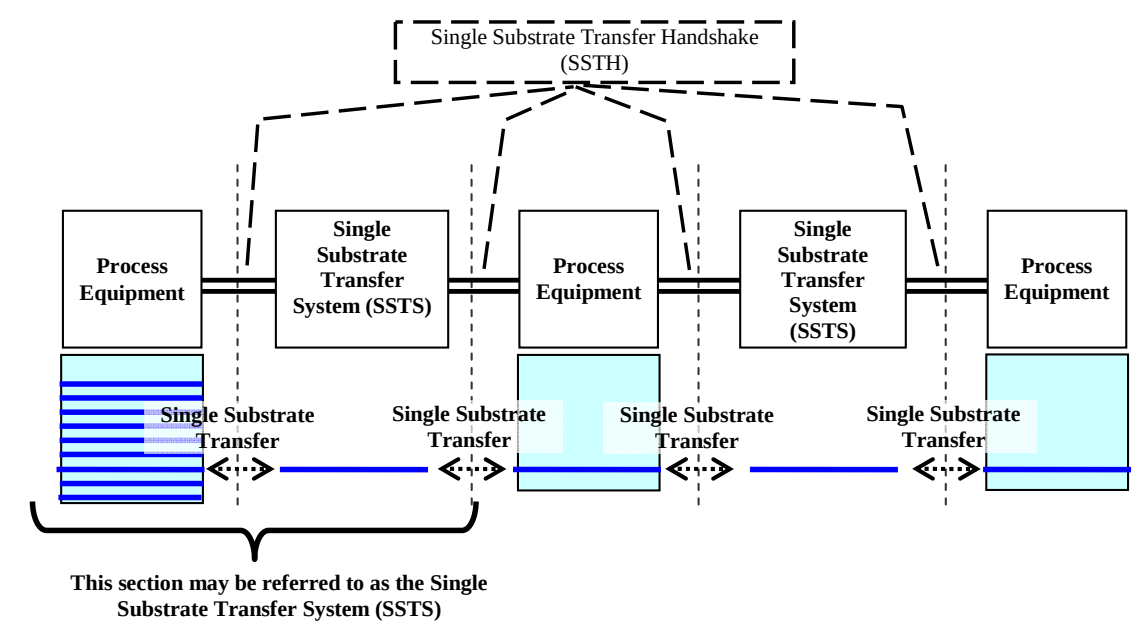


Figure 1
Example of the Control Mechanism between a Single Substrate Transfer System and Equipment

5 Referenced Standards and Document

5.1 SEMI Standard

SEMI D44 — Specification for Reference Position of Single Substrate for Handling Off On Tool

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

6 Terminology

6.1 Definitions

6.1.1 *process equipment* — processing equipment, testing equipment, buffer equipment, etc. that are used for FPD manufacturing.

6.1.2 *receiver* — equipment or device that is basically on the receiving side of single substrates in the single substrate transfer process.

6.1.3 *sender* — equipment or device that is basically on the sending side of single substrates in the single substrate transfer process.

6.1.4 *single substrate* — a glass substrate that is transferred by single units in the fab.

6.1.5 *single substrate transfer* — transfer to handover single substrates between single substrate transfer system and process equipment. Figure 2 shows examples of single substrate transfer.

6.1.6 *single substrate transfer handshake* — an exchange of signals between process equipment and single substrate transfer system to transfer single substrates.

6.1.7 *single substrate transfer system* — equipment or control mechanism having substrate transfer capabilities for transferring single substrates from one piece of process equipment to another piece of process equipment.

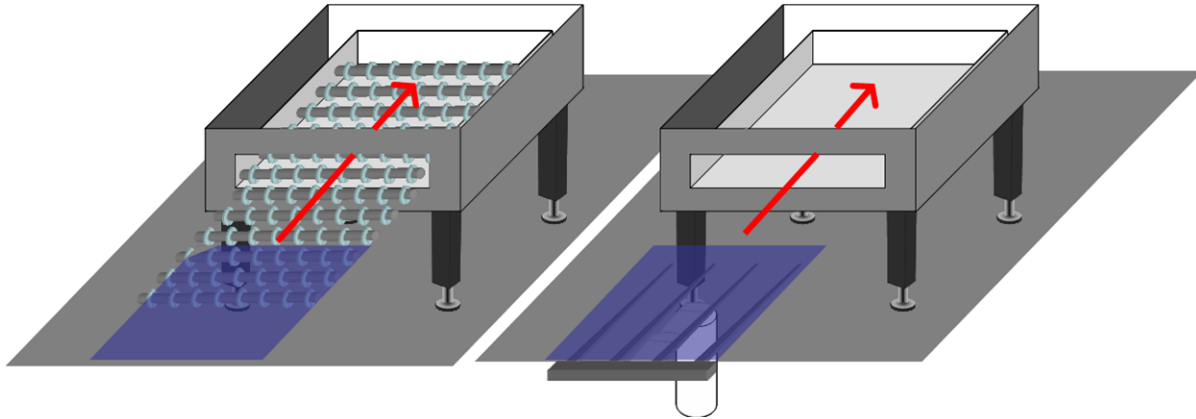


Figure 2
Examples of Single Substrate Transfer

7 Single Substrate Transfer Handshake for Single Substrate Transfer

7.1 *Signal Definitions* — The following signals are used in single substrate transfer handshake. These signals are prepared by both the process equipment and the single substrate transfer system and are used to transfer the single substrates smoothly.

VALID	Handshake Valid Signal (basic signal)
R_REQ (Receive_Request)	Single Substrate Receive Request (basic signal)
S_REQ (Send_Request)	Single Substrate Send Request (basic signal)
BUSY	Transfer Started, Transferring (basic signal)
COMPT (Complete)	Transfer Completed (basic signal)
RESERVE n	Reserved Signal (optional signal)
HS_RST n (Handshake_Reset)	Handshake Reset Signal (optional signal)
PAUSE	Pause Signal (optional signal)

NOTE 1: R_REQ and S_REQ signals can be set by both the receiver and sender so that they can be used as the transfer requests as required.

NOTE 2: Basic signals are mandatory and optional signals can be also used, if necessary.

7.1.1 *Single Substrate Transfer Handshake Assignment Signals* — Table 1 shows the signals required for single substrate transfer handshake when transferring single substrates. Table 1 Signals for Single Substrate Transfer Handshake in Single Substrate Transfer defines the signal name and the description. In the description, the meaning of the signal, the indication of the signal level and comments are included.

Table 1 Signals for Single Substrate Transfer Handshake in Single Substrate Transfer

Signal Name	Description
VALID	Indicates that the Single Substrate Transfer Handshake signals are valid. If this signal is not ON, all the following signals are not valid: ON: Single Substrate Transfer Handshake signals are valid. OFF: Single Substrate Transfer Handshake signals are invalid.

Signal Name	Description
R_REQ (Receive Request)	Indicates that the own equipment is ready to receive a single substrate. This signal indicates the request for receiving a single substrate to the own equipment or ready status for receiving a single substrate. ON: Ready to receive a single substrate. OFF: Not ready to receive a single substrate. This signal is ON while the VALID signal is ON and the equipment is ready to receive a substrate. This signal is OFF when the equipment is not ready to receive substrates or the single substrate transfer is completed and the request for receiving a substrate is satisfied. However, in a normal sequence, R-REQ shall be kept ON after either piece of equipment turns the BUSY signal (or RESERVE signal) ON until the COMPT signal is turned ON. If the S_REQ signal of the counter equipment turns ON while the R-REQ signal is ON, the substrate transfer conditions are met between both pieces of equipment, and the transfer can be started.
S_REQ (Send Request)	Indicates that the equipment is ready to send a single substrate. This signal indicates the request for sending a single substrate or ready status for sending a single substrate. ON: Ready to send a single substrate. OFF: Not ready to send a single substrate. This signal is ON while the VALID signal is ON and the equipment is ready to send a substrate. This signal is OFF when the equipment is not ready to send substrates or the single substrate transfer is completed and the request for sending a substrate is satisfied. However, in a normal sequence, S-REQ shall be kept ON after either piece of equipment turns the BUSY signal (or RESERVE signal) ON until the COMPT signal is turned ON. If the R_REQ signal of the counter equipment turns ON while the S-REQ signal is ON, the substrate transfer conditions are met between both pieces of equipment, and the transfer can be started.
BUSY	Indicates that the internal single substrate transfer mechanism is starting or it is in operation. ON: The single substrate transfer mechanism is starting or it is in operation. OFF: The transfer mechanism is not starting or in operation. This signal is turned ON when own equipment starts the transfer mechanism. This signal is turned OFF when own equipment stops the transfer mechanism.
COMPT (Complete)	Indicates that the single substrate transfer handshake is completed. ON: The single substrate transfer handshake is completed. OFF: The single substrate transfer handshake is not completed. This signal is ON when own equipment completes a series of substrate transfer operations and the counter equipment also completes the substrate transfer operation. This signal is OFF when the counter equipment confirms withdrawal of the transfer request (S_REQ or R_REQ turns OFF).
RESERVE n (Option)	Depending on the substrate transfer mechanism, the above basic signals alone may not be sufficient for transfer operation or may require additional signals for directing transfers. Optional RESERVE n (n=1...) signals are reserved for transfer progress control in such cases. Assignments to RESERVE n signals are defined individually between the process equipment and the single substrate transfer system depending on the substrate transfer mechanism.
PAUSE (Option)	Signal to pause the handshake operation. ON: Pauses the single substrate transfer and the handshake. OFF: Does not pause the single substrate transfer and the handshake. This is a signal to pause the single substrate transfer and the handshake. How to stop the transfer equipment when pausing and how to restart it after resetting the pause operation are defined individually between the process equipment and the single substrate transfer system, depending on the substrate transfer mechanism.
HS_RST n (Option)	The handshake may need to completely restart if the single substrate transfer is interrupted due to the substrate breakage or failure of transfer equipment. The optional HS_RST n (n=1...) signal is available for resetting the handshake at an appropriate timing after removing the cause of the interruption. Assignment of HS_RST n (n=1...) signals, resetting method and timing, and restarting the handshake are defined individually between the process equipment and the single substrate transfer system, depending on the substrate transfer mechanism.

7.2 *Single Substrate Transfer Sequences* — The single substrate transfer handshake signals compliant to this specification must follow these sequences. The time diagram of the single substrate transfer handshake signal status is shown in Figure 3. Figure 4 is an example of handshakes when a single substrate is transferred from the sender to the receiver.

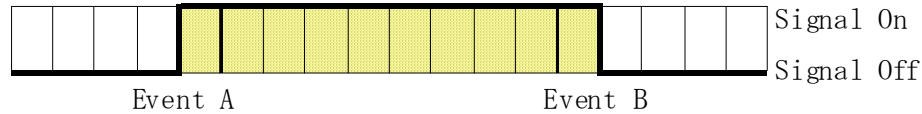


Figure 3
Time Diagram Signal State

7.2.1 *Single Substrate Transfer Handshake Sequences* — The following describes a typical example of how to use the signals defined in this standard in the substrate transfer handshake sequences. Below is the time diagram of the handshake sequence when a substrate is transferred from the sender to the receiver in the single substrate transfer system for transferring single substrates by a conveyor.

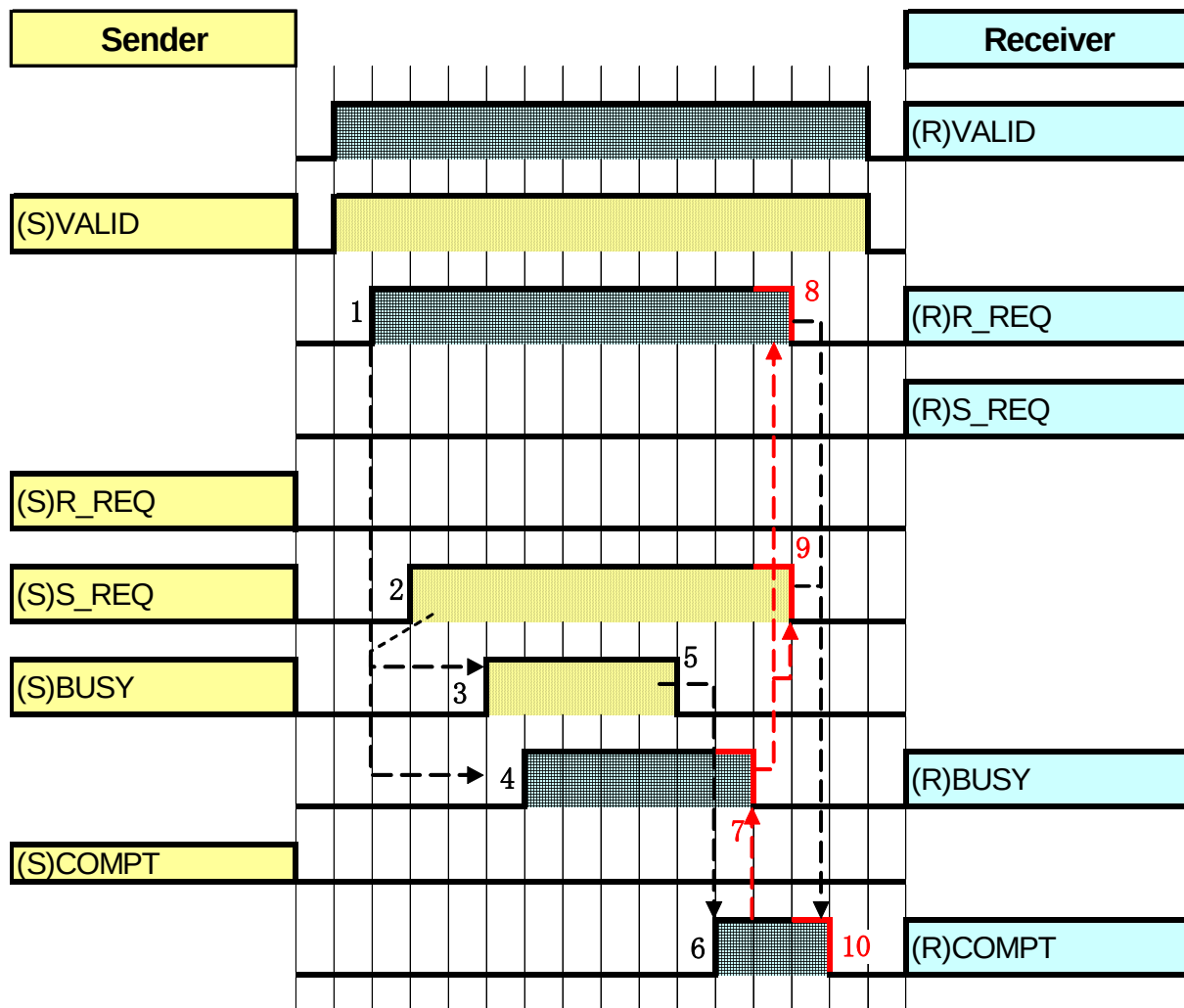


Figure 4
Single Substrate Transfer Sequences

7.2.2 The substrate transfer operation steps in Figure 4 are as follows. The notations (S) and (R) before the signal names in the text and table indicate the signals are for the sender and receiver, respectively. However, this is simply an example and the actual handshake sequences may differ as they heavily depend on the transfer mechanism of the single substrate transfer system.

1. **A single substrate is available for being transferred at the “Sender” location.** “Sender” turns the “(S) S_REQ” signal ON, indicating that a single substrate is available to be transferred.
2. **“Receiver” is ready to receive the single substrate.** “Receiver” turns the “(R) R_REQ” signal ON, indicating that it is ready to receive a single substrate.

NOTE 3: Transfer requests do not occur sequentially, therefore, the above 1) and 2) may not occur in this order. 1) may occur before 2).

3. **The “Sender” starts sending the substrate by setting the “(S) BUSY” signal to ON when it recognizes the substrate transfer condition from “Sender” to “Receiver” is satisfied when the corresponding REQ signals from both sides are ON.** The “Sender” recognizes that its “(S) S_REQ” signal and the “(R) R_REQ” signal of its counterpart are both ON and determines that it is possible to start transferring substrates. The “Sender” notifies the start of operation by sending “(S) BUSY” signal.
4. **The “Receiver” then starts substrate transfer operation.** The “Receiver” confirms that the “Sender’s” “(S) BUSY” signal is ON and starts receiving substrates by setting the “(R) BUSY” signal to ON.

NOTE 4: This example assumes the use of a transfer mechanism that requires confirmation of the sender’s state before the receiver’s operation begins. In the handshake operation with the transfer mechanism that requires confirmation of the “Receiver’s” action before the “Sender” begins operation, the operation for 3) and 4) will be different.

5. **The “Sender” completes sending the substrate.** The “Sender” confirms the completion of transfer through its own driving mechanism and sets the “(S) BUSY” signal to OFF.
6. **The “Receiver” indicates that receiving the substrate is completed.** The “Receiver” confirms that it has completed receiving the single substrate and indicates the completion of the single substrate transfer operation by setting the “(R) COMPT” signal to ON.

NOTE 5: This example assumes the use of a transfer mechanism that requires confirmation of the receiver’s completion notification. If the transfer mechanism requires the “Sender” to confirm the completion of transfer, it is the “Sender” that must set the “COMPT” signal to ON.

7. **The “Receiver” completes receiving the substrate.** The “Receiver” confirms that it has appropriately completed receiving the single substrate, stops the transfer equipment and sets the transfer “(R) BUSY” signal to OFF.

NOTE 6: This example assumes the use of a transfer mechanism that requires the sender’s operation to stop before the receiver stops its operation. For transfer mechanisms that do not operate in accordance with this assumption, the operation 5 and 6 will be different.

8. **The “Receiver” completes receiving request for the substrate.** The “Receiver” confirms the ON state of the “(R) COMPT” signal and recognizes the completion of the handshake operation as the “BUSY” signals on both sides are set to OFF and turns the “(R) R_REQ” signal OFF to withdraw the transfer request.
9. **The “Sender” completes the substrate transfer request.** The “Sender” confirms the ON state of the “(R) COMPT” signal and recognizes the completion of the handshake operation when the “BUSY” signals on both sides are set to OFF and turns the “(S) S_REQ” signal OFF to withdraw the transfer request.
10. **The “Receiver” completes the single substrate transfer handshake operation.** By confirming that the transfer request signals on both sides are OFF, the “Receiver” recognizes that a series of the handshake sequence is now completed and sets the “(R) COMPT” signal to OFF to complete the single substrate transfer handshake sequence.

NOTE 7: In this example, the receiver confirms the OFF state of the REQ signal on both sides to set the COMPT signal to ON/OFF; however, this may be accomplished by the sender depending on the single substrate transfer mechanism. In such a case, the operations in 6) to 10) will be different at the sender and receiver sides.

7.3 Timeout Error Indication and Detection

7.3.1 *Purpose of Timeout Error Indication* — This specification needs to have the capacity to indicate timeout errors in the single substrate transfer handshake process to adjacent devices or an operator to support operational

reliability and facilitate rapid resolution of substrate transfer problems. The indication methods are not defined in this specification.

7.3.2 Timeout Error Detection — Interlock timeout is required for a single substrate transfer handshake in order to detect transfer sequence errors between the Single Substrate Transfer System and Process Equipment and to minimize substrate breakage and keep unnecessary no-response time to a minimum. This specification defines the interlock timeout monitored by the single substrate transfer systems and process equipment. However, the monitoring segments or timing of the interlock timeout, and the error detection timing are dependent on the mechanism implementing the actual single substrate transfer, therefore, this specification only defines the meaning and the events to be monitored and the specific monitoring segments are simply shown as examples. Detailed specifications should be defined by the users of this specification.

7.3.2.1 Specific Examples of Timeout Errors — Specific examples of interlock timeout errors are described in order to facilitate a better understanding of this specification. Table 2 Sender: Examples of Interlock Timeout Timers, Table 3 Receiver: Examples of Interlock Timeout Timer and Figure 5 Examples of Interlock Timeout Error Monitoring show examples of how to implement interlock timeout for single substrate transfer systems. TSx (where x is a number) of Table 2 Sender: Examples of Interlock Timeout Timers represents the timer that the sender monitors and TRx (where x is a number) of Table 3 Receiver: Examples of Interlock Timeout Timer represents the timer that the receiver monitors. Basically, the range of all the timers shall be from 1 second to 999 seconds. All timer setpoints shall be user programmable. The minimum value of the timer is defined as 1 second; however, shorter time may be specified if a transfer mechanism requires it in order to prevent damage to substrates at the time of failures. A broad range of interlock timeout patterns are considered depending on the definition of monitoring segments, monitoring timing, transfer system structure, etc. This document shows an example of common patterns; however, not all the equipment needs to implement all the interlock timers described in this specification. Only those interlock timers that are required based on the equipment structure need to be implemented. Likewise, the range of monitoring segments and timings can be set as required based on the equipment structure.

Table 2 Sender — Examples of Interlock Timeout Timers

<i>Timer Name</i>	<i>Monitoring Segments (Signal State)</i>	<i>Range (Seconds)</i>
TS1	Both REQUESTs match – (R) BUSY ON	1–999
TS2	Both BUSY ON – (R) COMPT ON	1–999
TS3	(S) COMPT ON – (R) BUSY OFF	1–999
TS4	(R) BUSY OFF – (R) R_REQ OFF	1–999
TS5	(R) R_REQ OFF – (R) COMPT OFF	1–999

#1 The response time of the single substrate transfer systems is not defined in the minimum timer value.

#2 These timer values need to be executed to detect the timeout. They are not intended to specify the signal delay times. The response times of the equipment need to be faster than the timeout values of the timers.

#3 REQUEST represents both S_REQ and R_REQ, which are the transfer requests from the sender and the receiver.

Table 3 Receiver — Examples of Interlock Timeout Timers

<i>Timer Name</i>	<i>Monitoring Segments (Signal State)</i>	<i>Range (Seconds)</i>
TR1	Both REQUESTs match – (S) BUSY ON	1–999
TR2	Both BUSY ON – (S) BUSY OFF	1–999
TR3	(R) COMPT ON – (S) S_REQ OFF	1–999

#1 The response time of the single substrate transfer systems is not defined in the minimum timer value.

#2 These timer values are required to detect the timeout. They are not intended to specify the signal delay times. The response times of the equipment need to be faster than the timeout values of the timers.

#3 REQUEST represents both S_REQ and R_REQ, which are the transfer requests from the sender and the receiver.

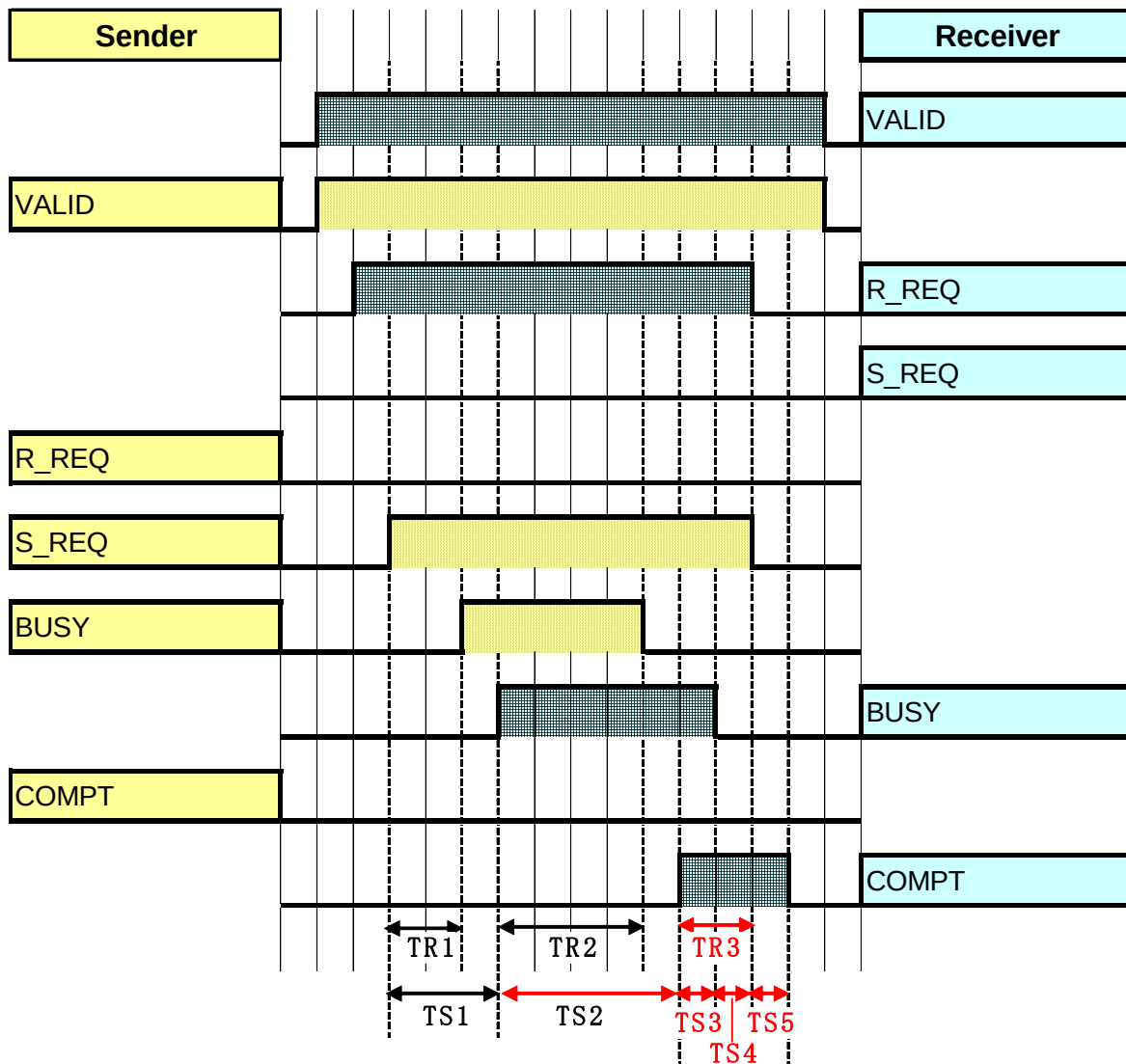


Figure 5
Examples of Interlock Timeout Error Monitoring

7.3.3 Recovery Procedures from Timeout Errors — The recovery procedures from timeout errors are not defined in this specification. Because recovery procedures may require operator assistance and/or proprietary procedures specific to the equipment, no standard definition is given. Instead, it is recommended to define recovery procedures between two systems, the single substrate transfer system and process equipment (e.g., pause, restart and completion of interlock process).

7.4 Connector Type, Signal and Pin Assignment — Connector type, signal and pin assignment and signal voltages are not defined in this specification. These interface specifications are to be determined between each single substrate transfer system and process equipment. Currently, there are numerous interface methods available and they are likely to change along with the progress of technology. Therefore, we do not consider that this specification needs to determine the physical aspect of the interfaces.