

FPGA Serial Accelerometer Tester, Version 1

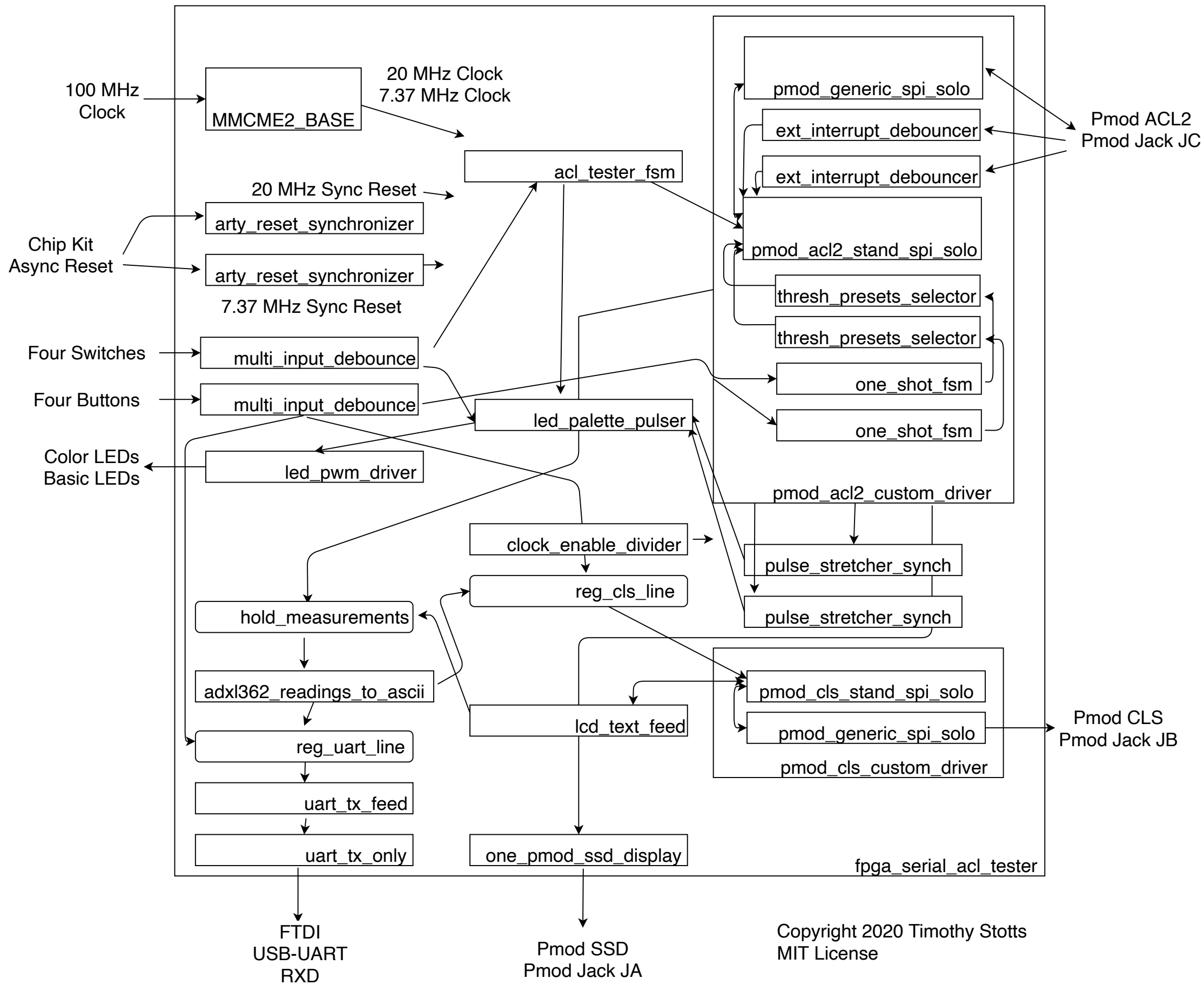
by Timothy Stotts

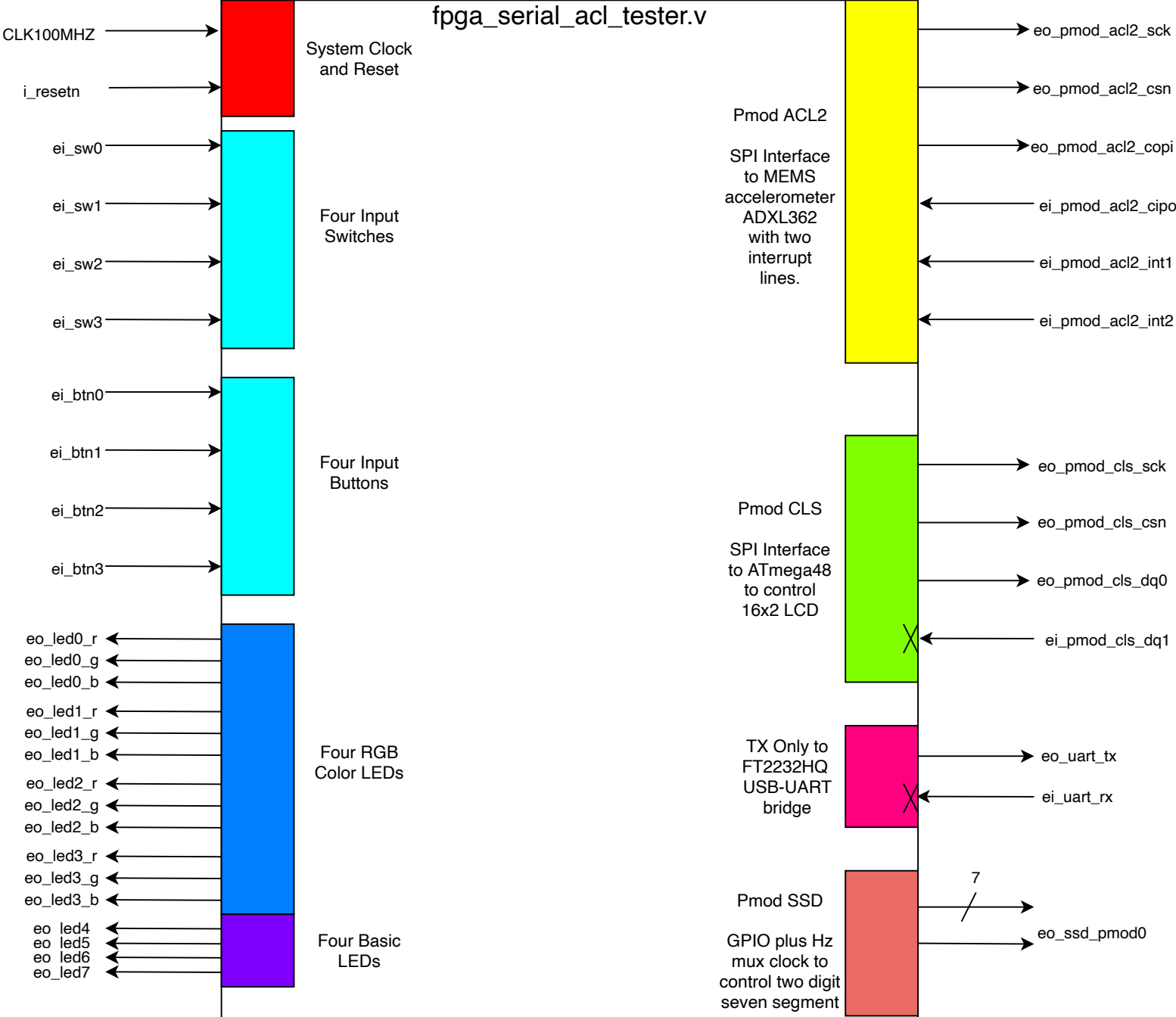
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Hosted at:

<https://github.com/timothystotts/fpga-serial-acl-tester-1>

ACL-Tester-Design-Diagrams document revision 2B



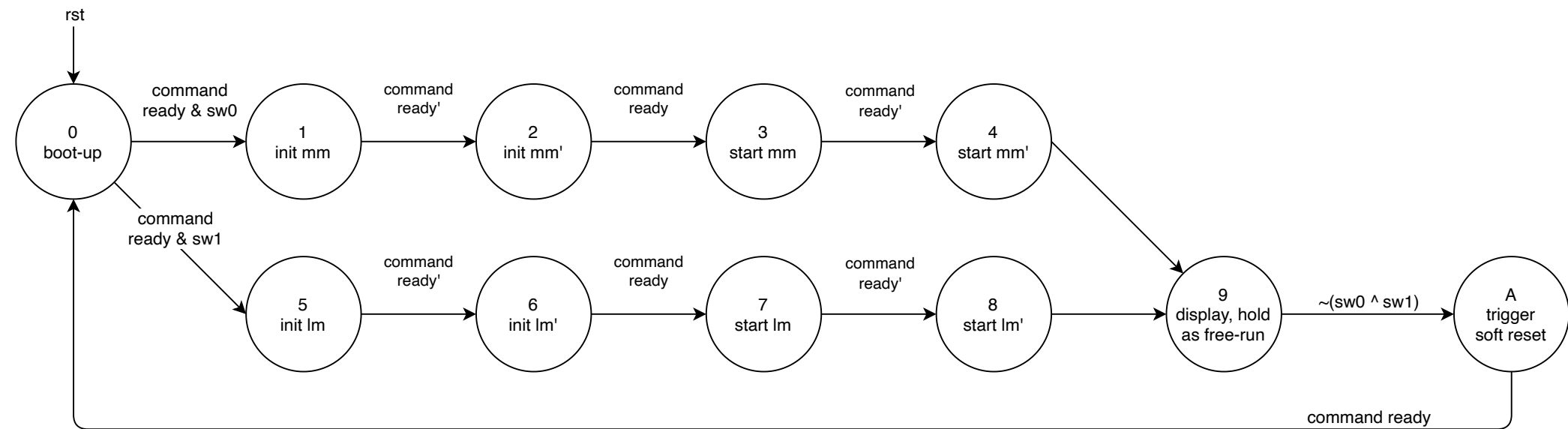


This top-level FPGA module operates the Pmod ACL2 to obtain measurement readings, converts these readings to ASCII data and text, and then outputs the ASCII data on the UART TX and the ASCII text on the Pmod CLS LCD. The switches select one of two possible operational modes: Stream Measurements to Display, or Detect Activity/Inactivity events and display event-trigger measurements. The event triggering is coded into the Pmod ACL2 driver with constants that define operation and preset inputs that define thresholds. The color LEDs LD0 and LD1 display information about internal FSM states to indicate mode of operation and if the top-level FSMs are perating data reception from the Pmod ACL2. The color LEDs LD2 ad LD3 indicate Activity Event and Inactivity Event respectively. The basic LED LD4 indicates Awake status of the Pmod ACL2; and basic LD6 and LD7 indicate selection of SW0 and SW1 respectively.

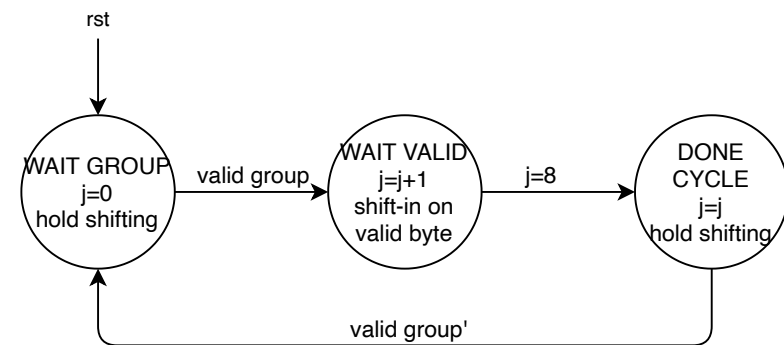
The Pmod CLS is selected to operate with SPI output and no SPI input, even though the Pmod CLS additionally supports UART and I2C modes.

Buttons 0 and 1 increment the threshold/timer presets for Activity and Inactivity respectively. The preset indexes, 0 through 9, are displayed on the Pmod SSD.

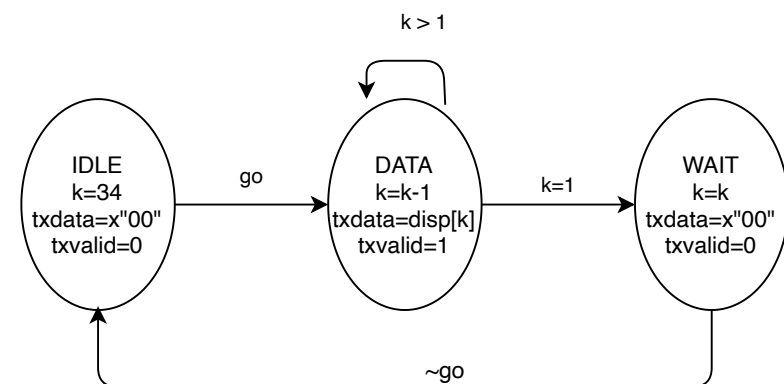
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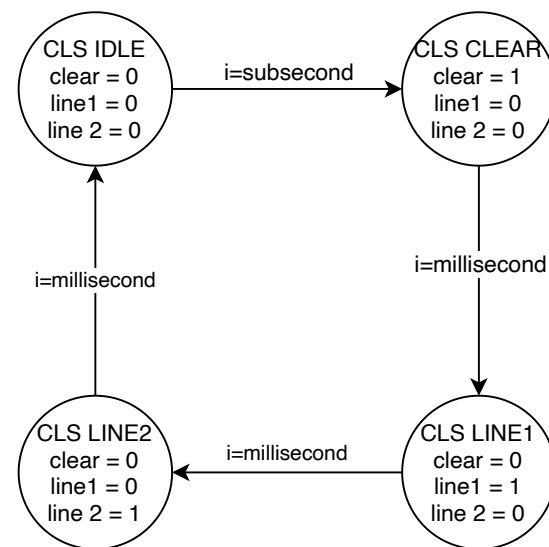
Tester FSM for operating the PMOD ACL2 driver commands.



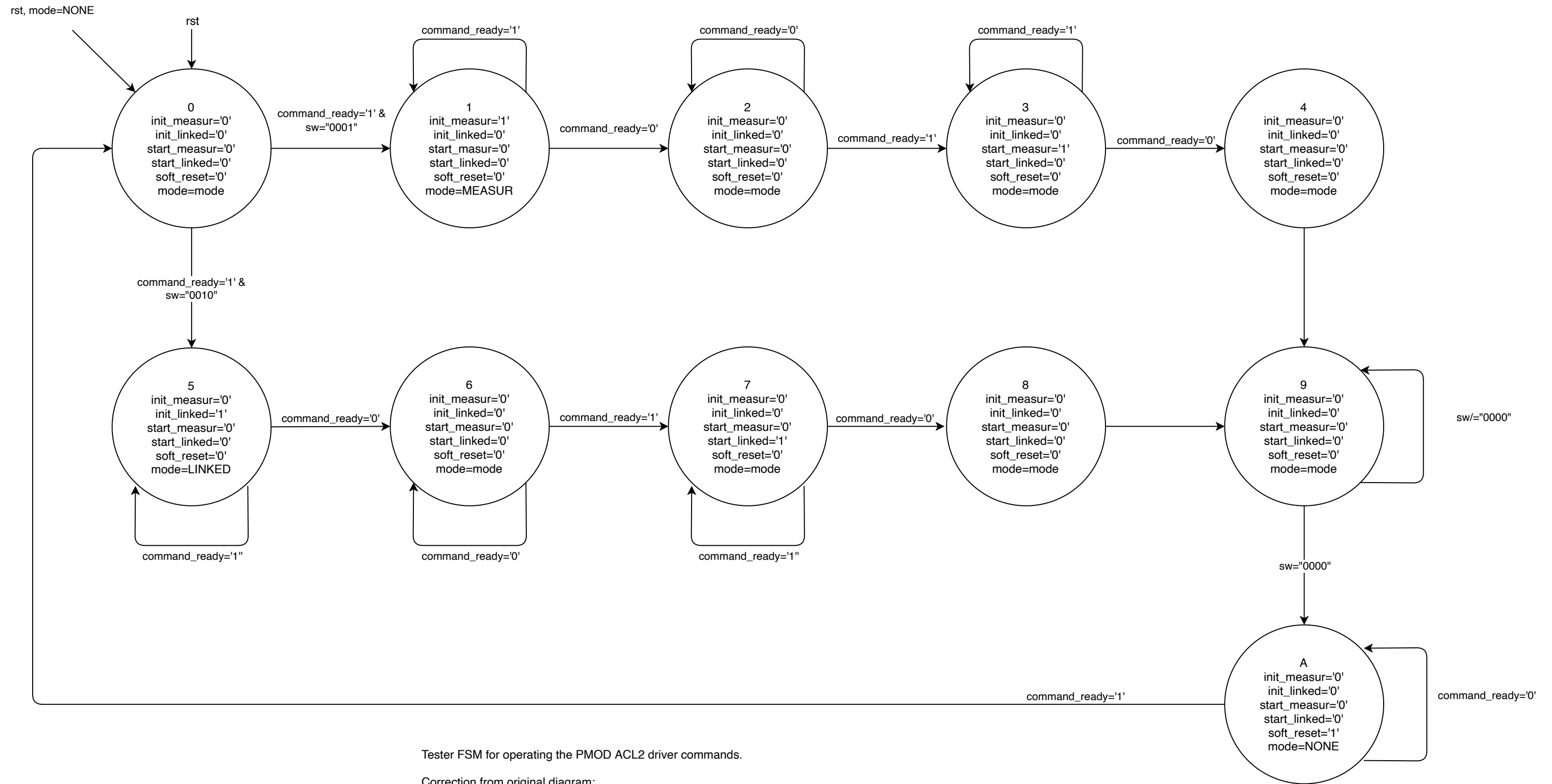
Tester FSM to receive the streamed measurements and shift them into a bit vector.



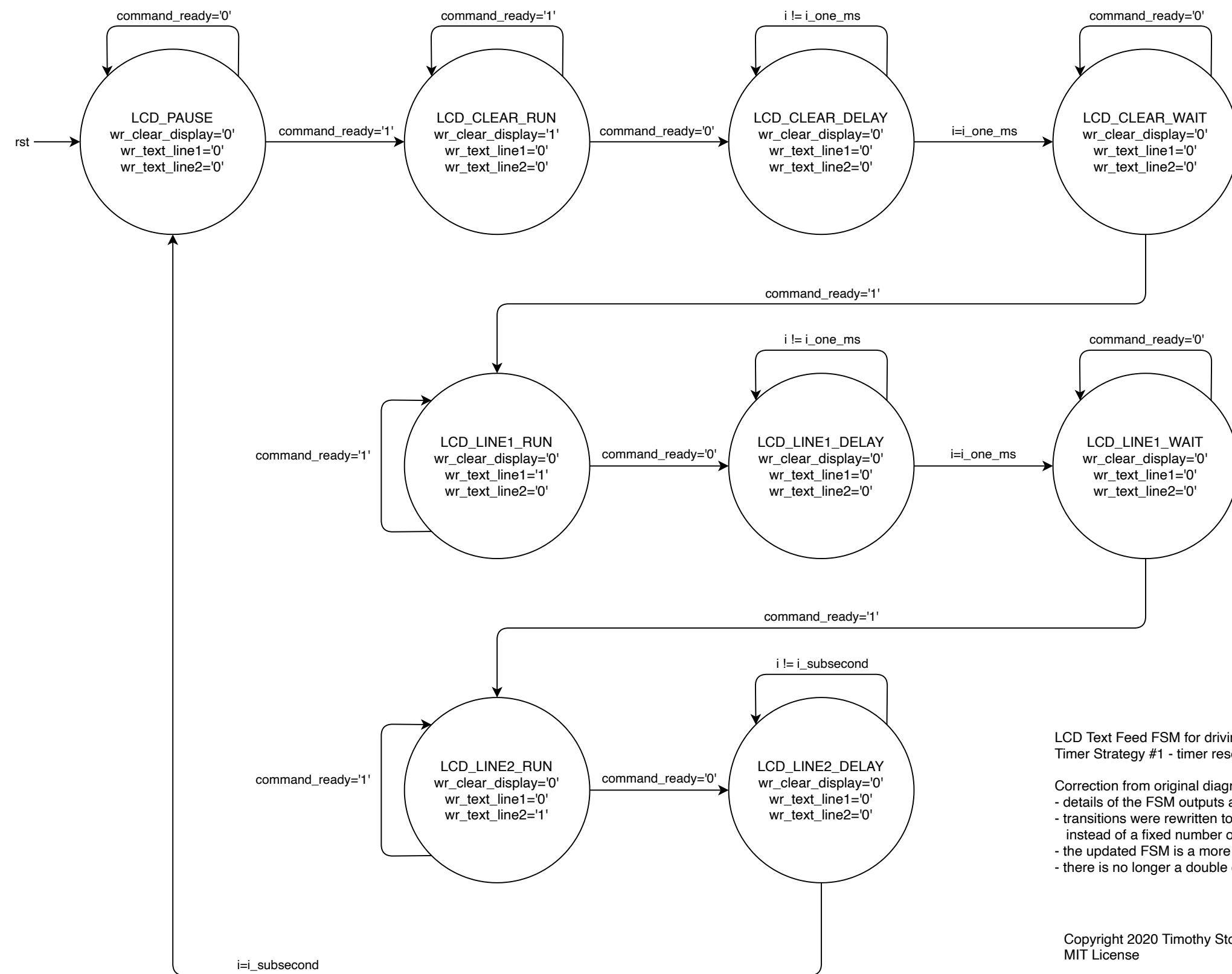
Tester FSM to load the TX ONLY UART with a 32 character text line, plus carriage return and new line.



Tester FSM for updating the PMOD CLS display.



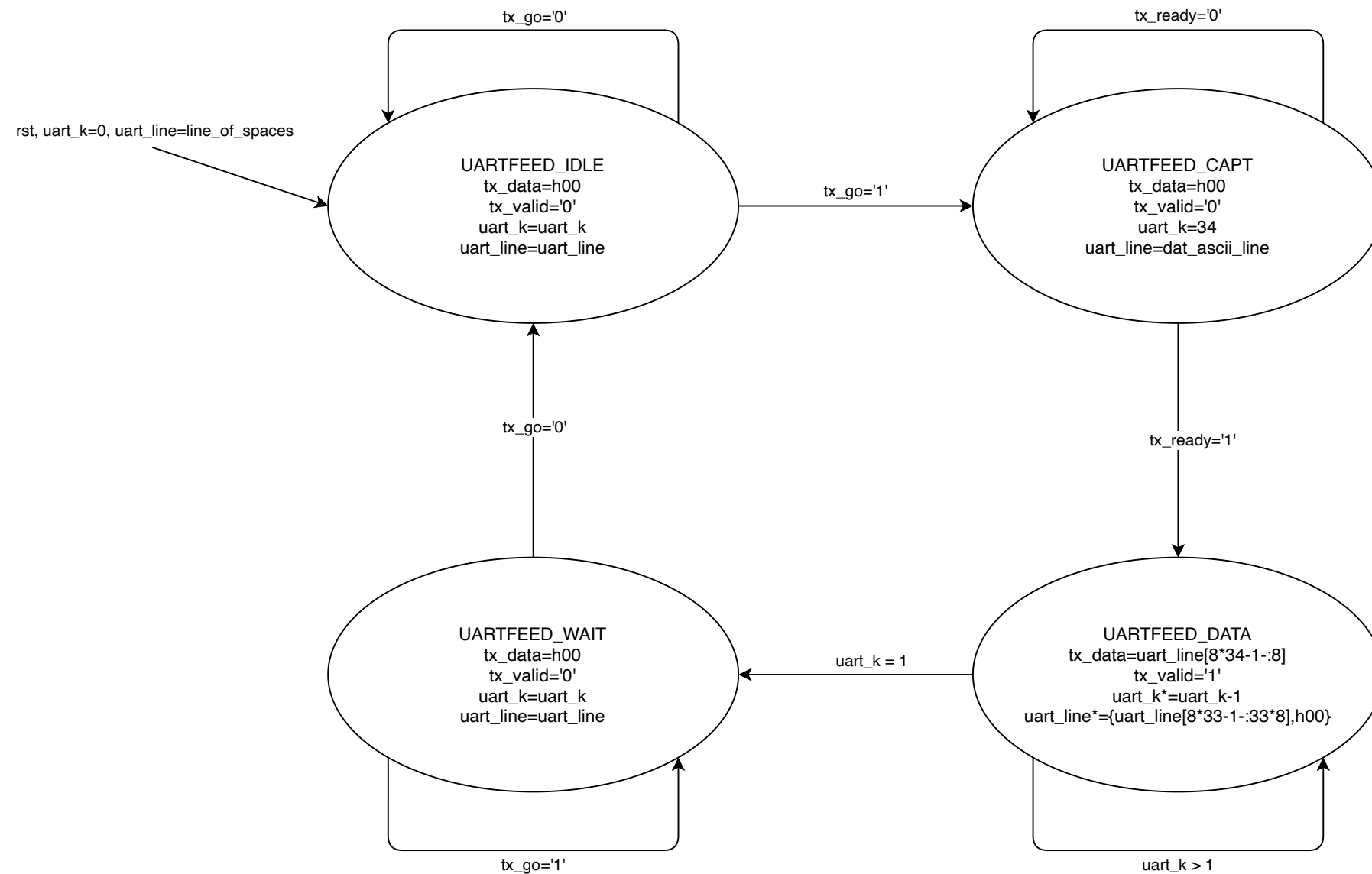
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LCD Text Feed FSM for driving the commands of the custom Pmod CLS driver.  
Timer Strategy #1 - timer resets on state change and runs from zero to `i_subsecond`.

Correction from original diagram:  
 - details of the FSM outputs and timer "i"  
 - transitions were rewritten to hold commands according to `command_ready` handshake instead of a fixed number of clock cycles during a state  
 - the updated FSM is a more proper FSM diagram design  
 - there is no longer a double delay between the end of Line 2 and the start of Clear.

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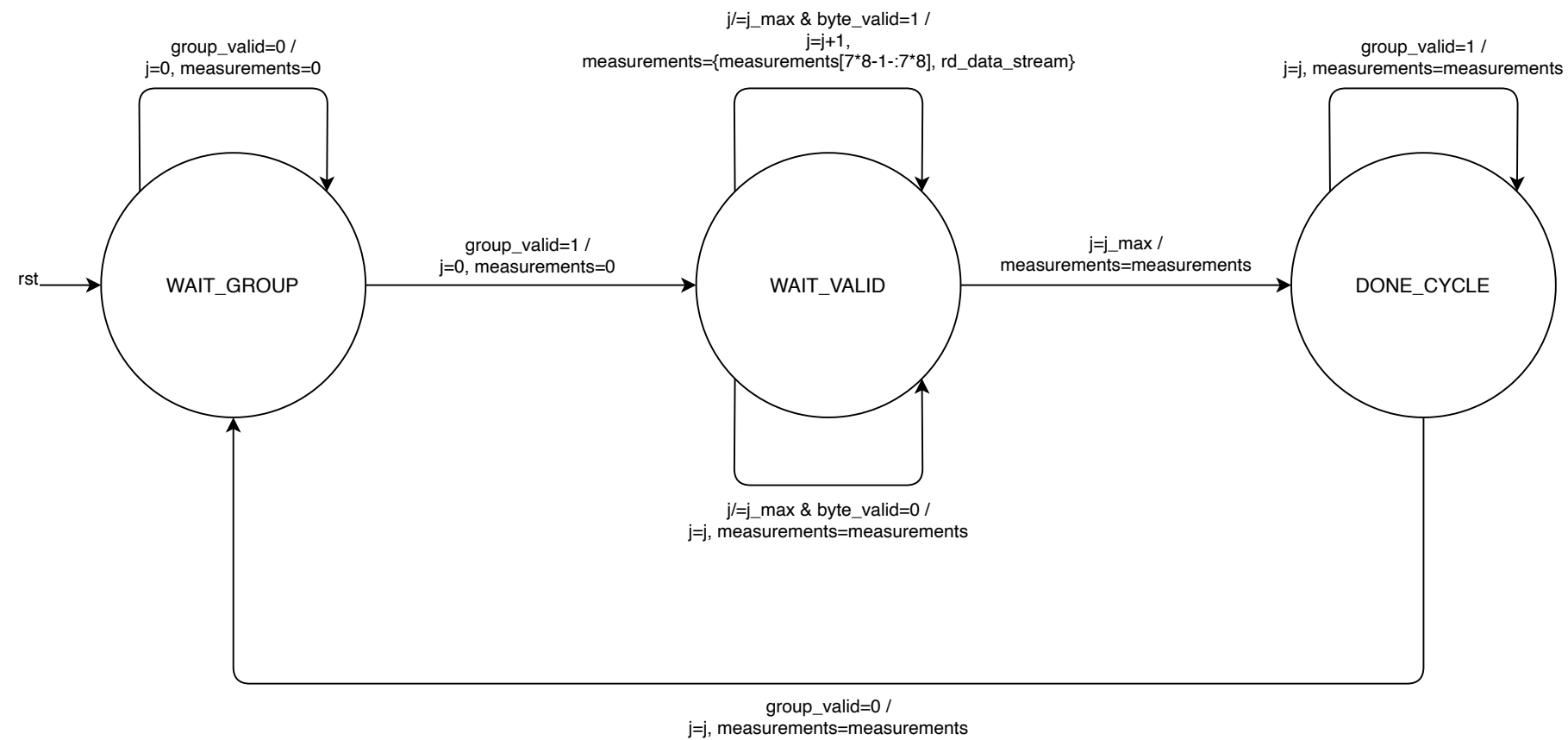
# UART TX Feed FSM

This FSM feeds the TX FIFO of the `uart_tx_only` module. The data to feed to the TX FIFO is always a 34 8-bit character line of ASCII text. The `tx_go` input is triggered by the corresponding `wr_clear_display` pulse on the Pmod CLS custom driver, such that the UART TX Feed occurs when the LCD is starting to update on the FSM cycle of that driver.

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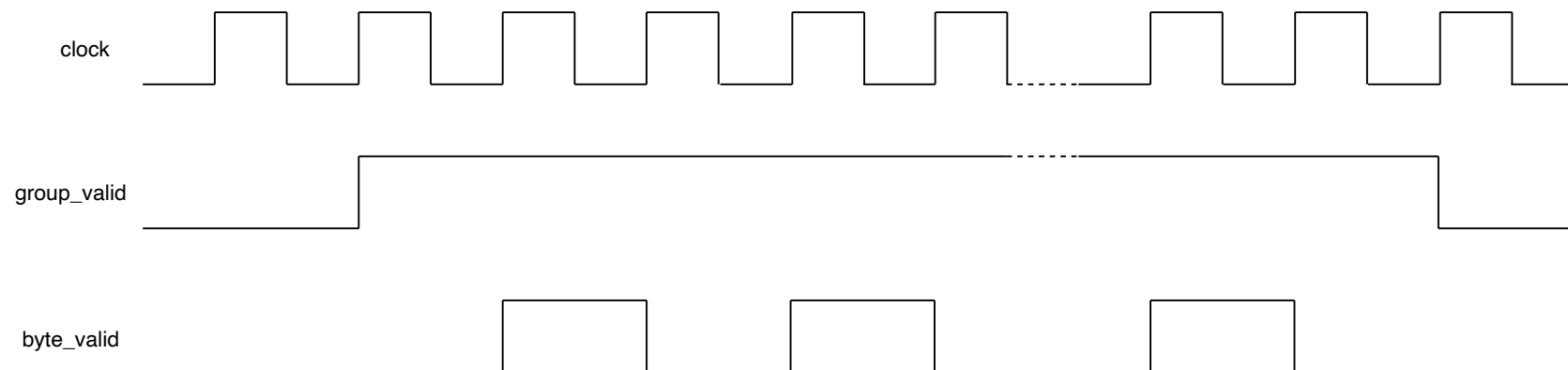






Stream FSM for capturing RX FIFO output from the ACL2 Custom Driver.  
 A group\_valid input signal is held high to indicate a set of measurement values.  
 A byte\_valid input signal is pulsed for each new byte to shift into the measurement register.

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Operational driver for the Digilent PMOD ACL2, that drives the Standard SPI FSM. This diagram is incomplete and does not show Soft Reset operation, or boot-time delay. Also, not all state-bypass preventions and not all iterations are show. This is the first design draft, and the complete FSM diagram is shown on another page.

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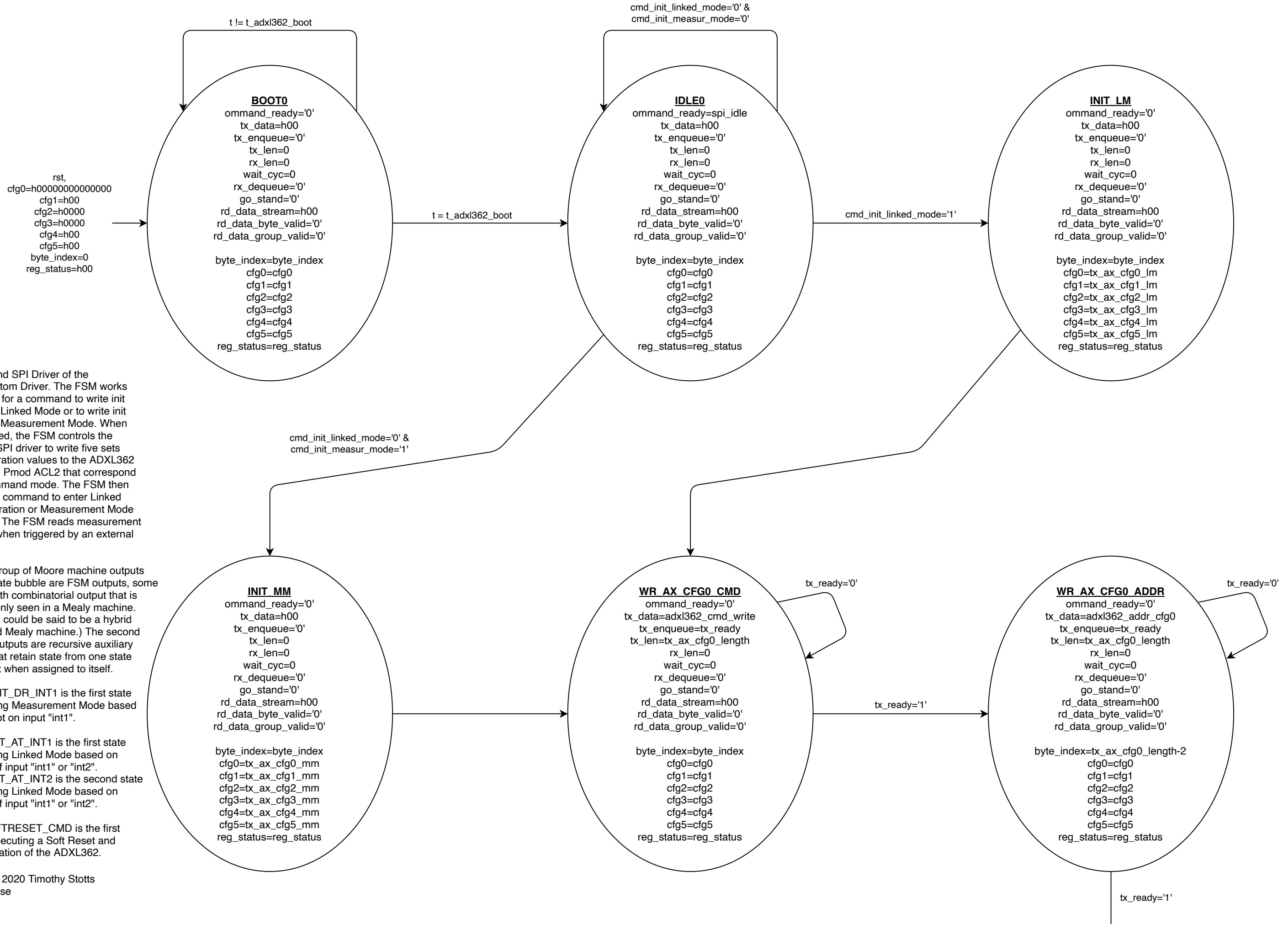
ACL2 Stand SPI Driver of the ACL2 Custom Driver. The FSM works by waiting for a command to write init values for Linked Mode or to write init values for Measurement Mode. When commanded, the FSM controls the standard SPI driver to write five sets of configuration values to the ADXL362 chip of the Pmod ACL2 that correspond to the command mode. The FSM then waits for a command to enter Linked Mode operation or Measurement Mode operation. The FSM reads measurement registers when triggered by an external interrupt.

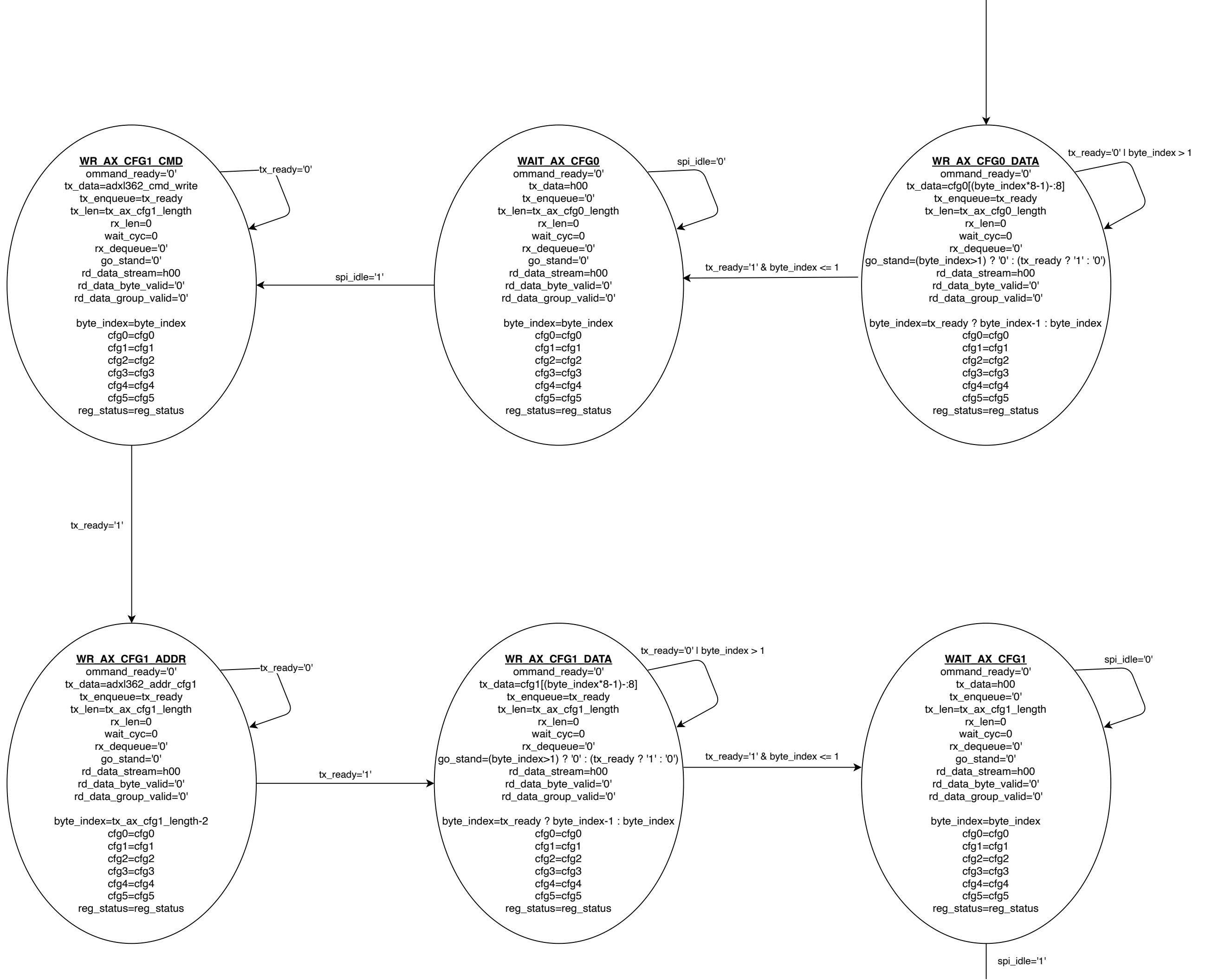
The first group of Moore machine outputs in each state bubble are FSM outputs, some of them with combinatorial output that is normally only seen in a Mealy machine. (This FSM could be said to be a hybrid Moore and Mealy machine.) The second group of outputs are recursive auxiliary outputs that retain state from one state to the next when assigned to itself.

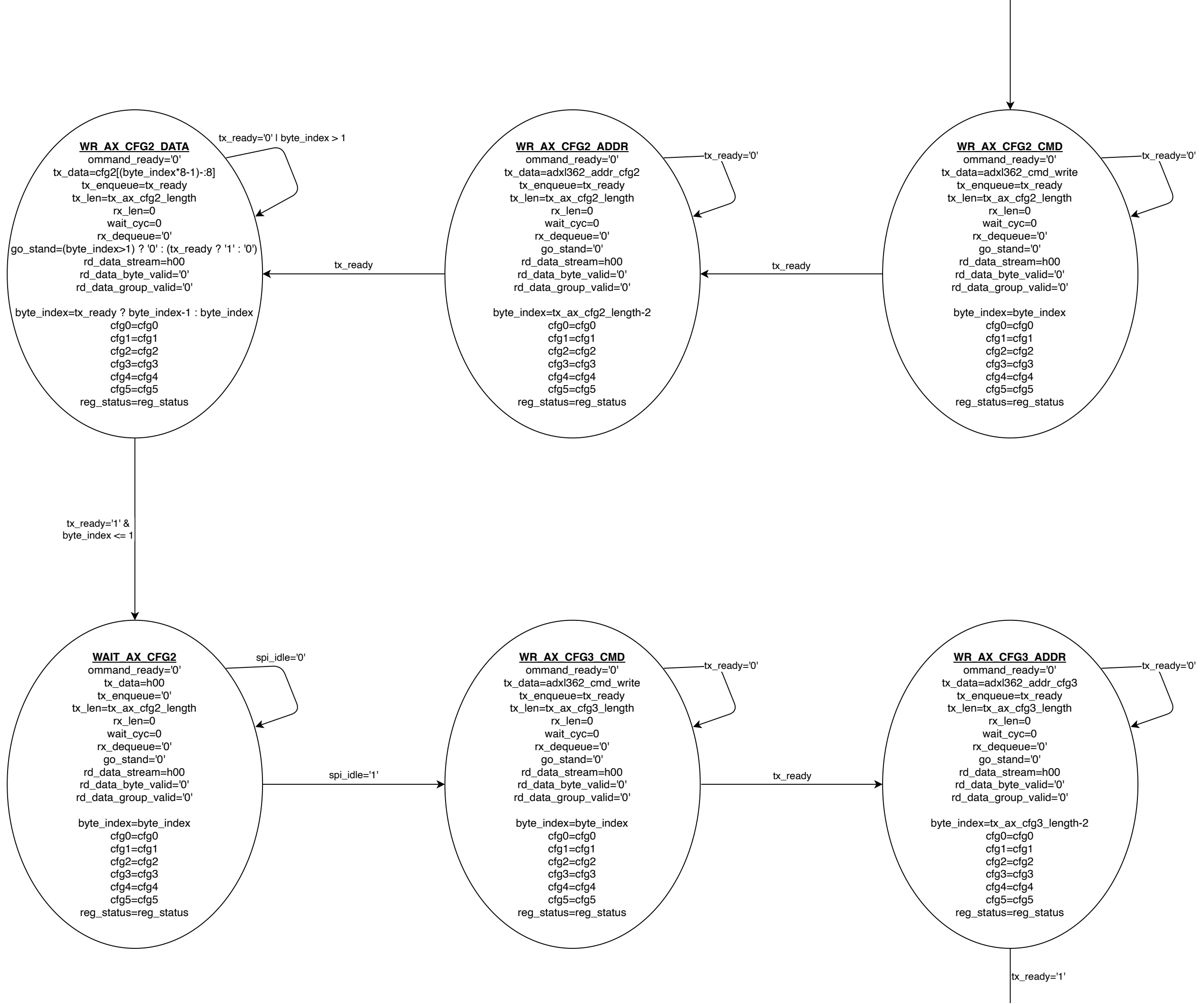
State WAIT\_DR\_INT1 is the first state of executing Measurement Mode based on interrupt on input "int1".

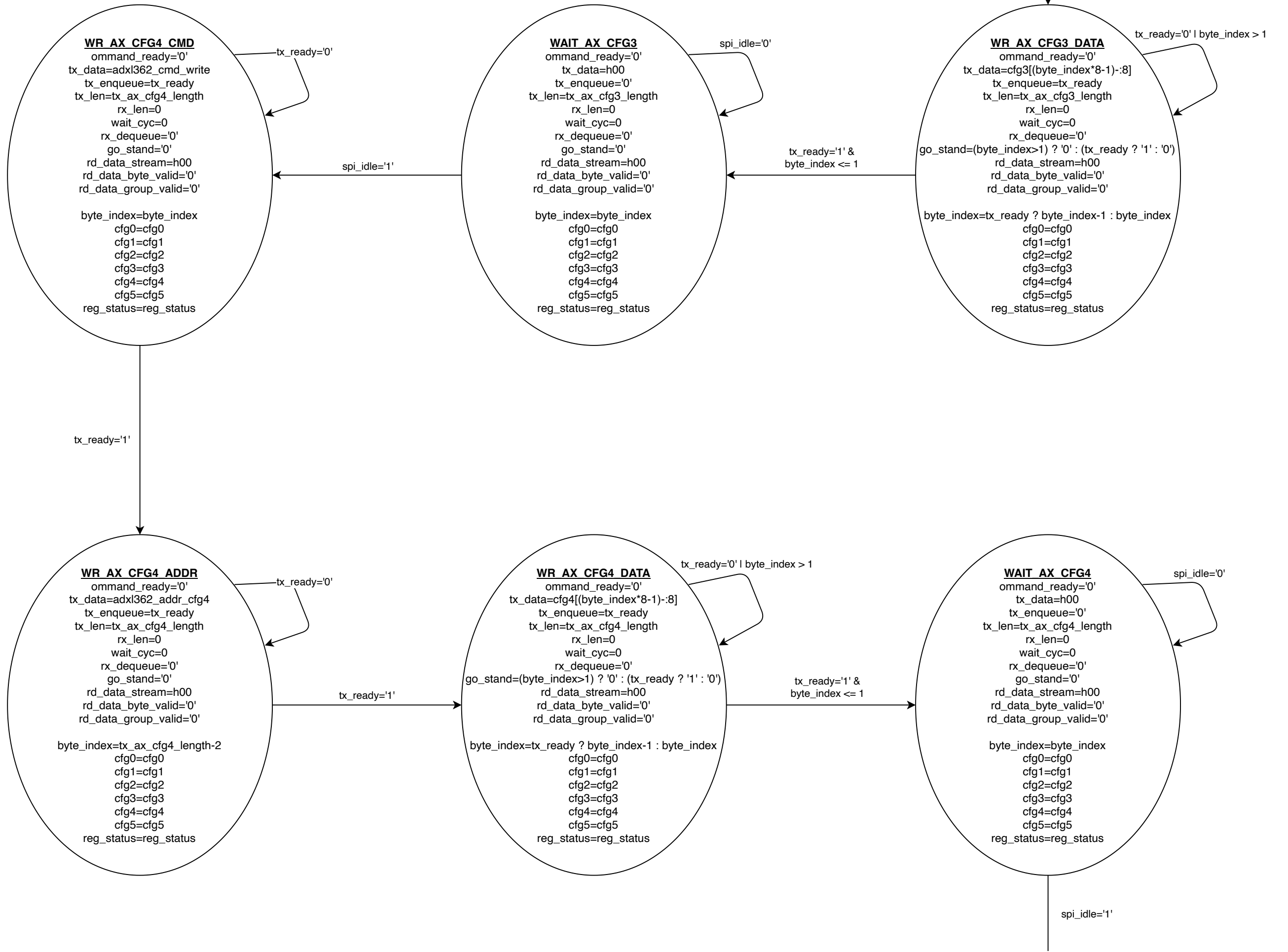
State WAIT\_AT\_INT1 is the first state of executing Linked Mode based on interrupt of input "int1" or "int2". State WAIT\_AT\_INT2 is the second state of executing Linked Mode based on interrupt of input "int1" or "int2".

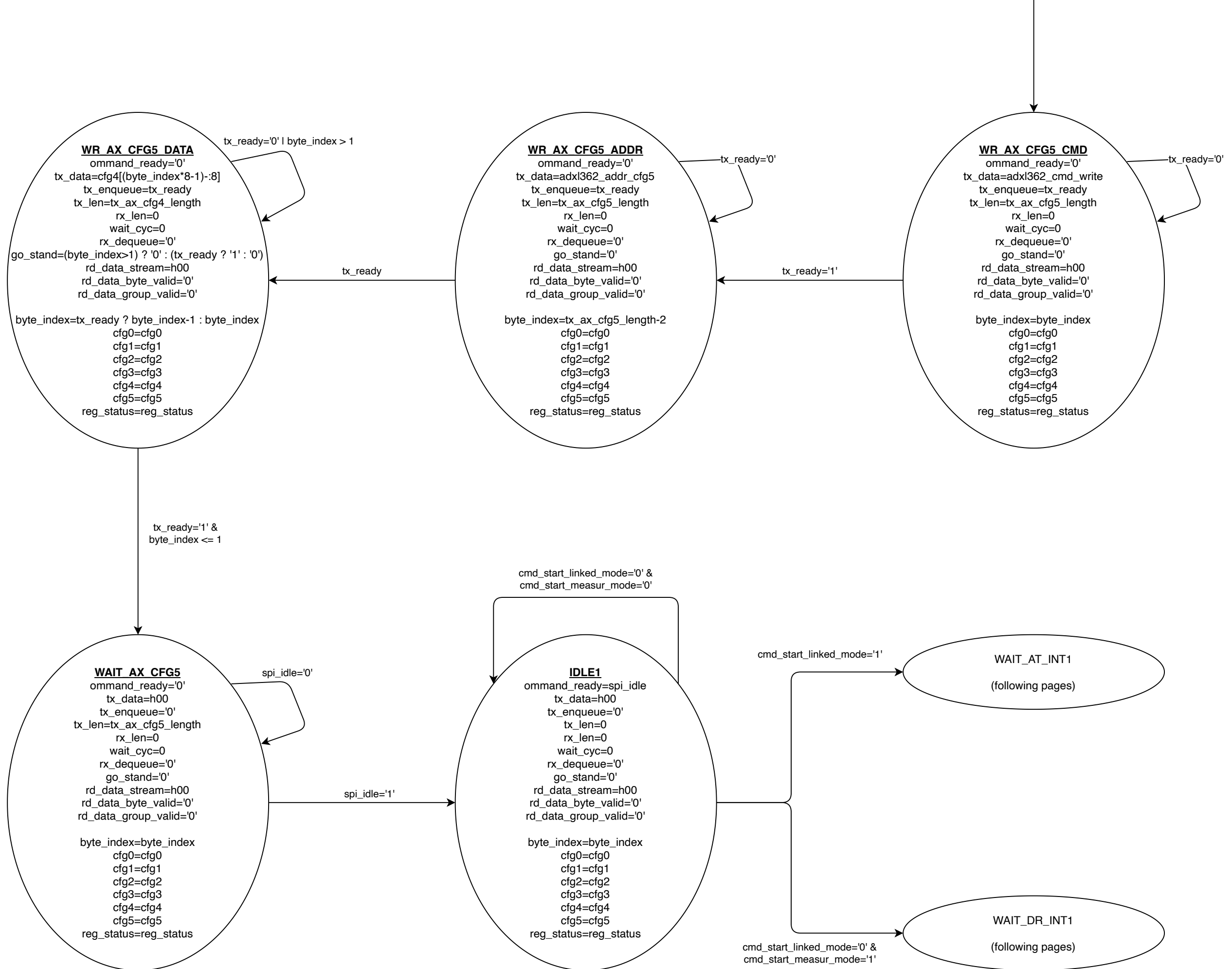
State SOFTRESET\_CMD is the first state of executing a Soft Reset and reconfiguration of the ADXL362.

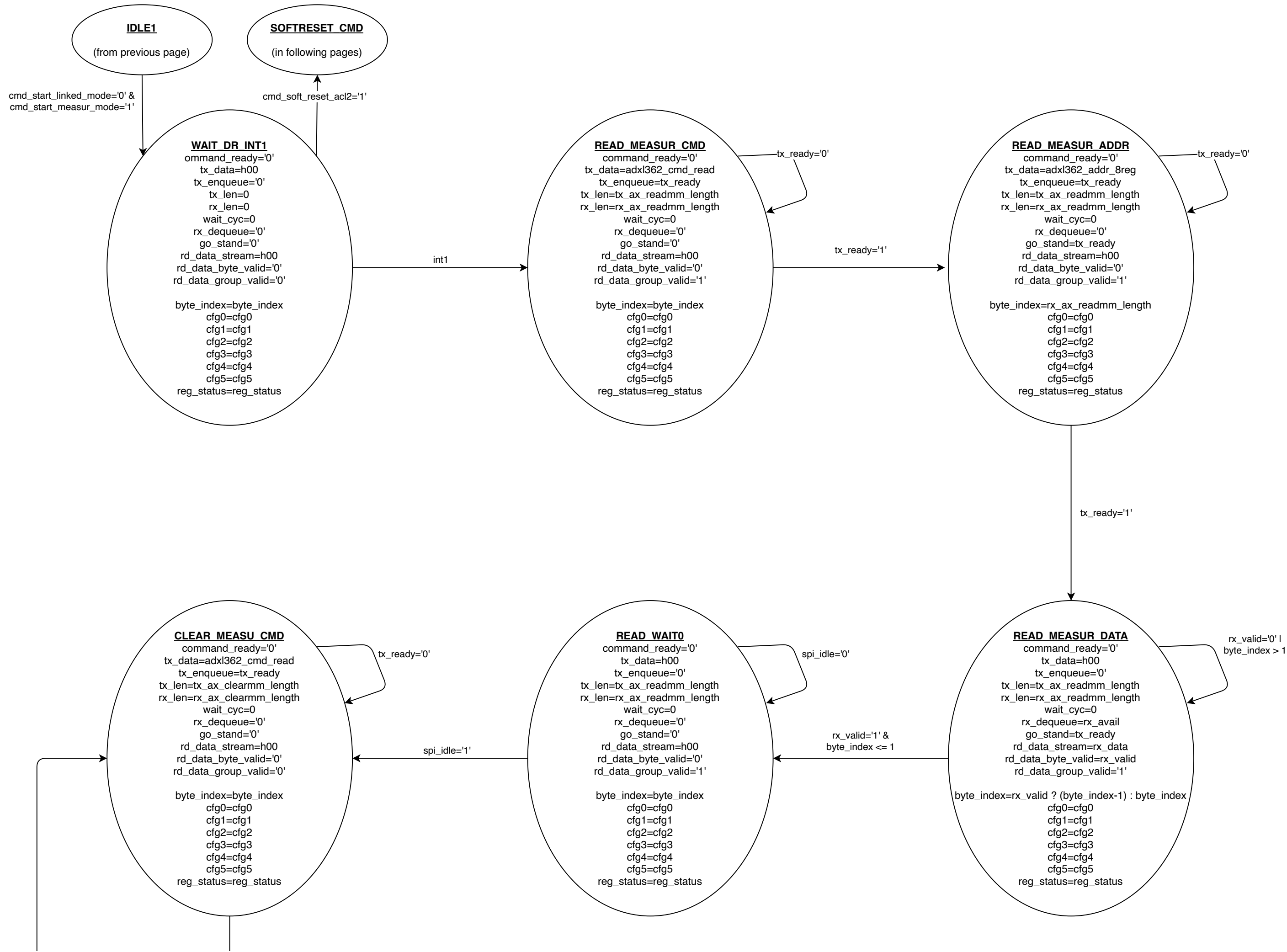




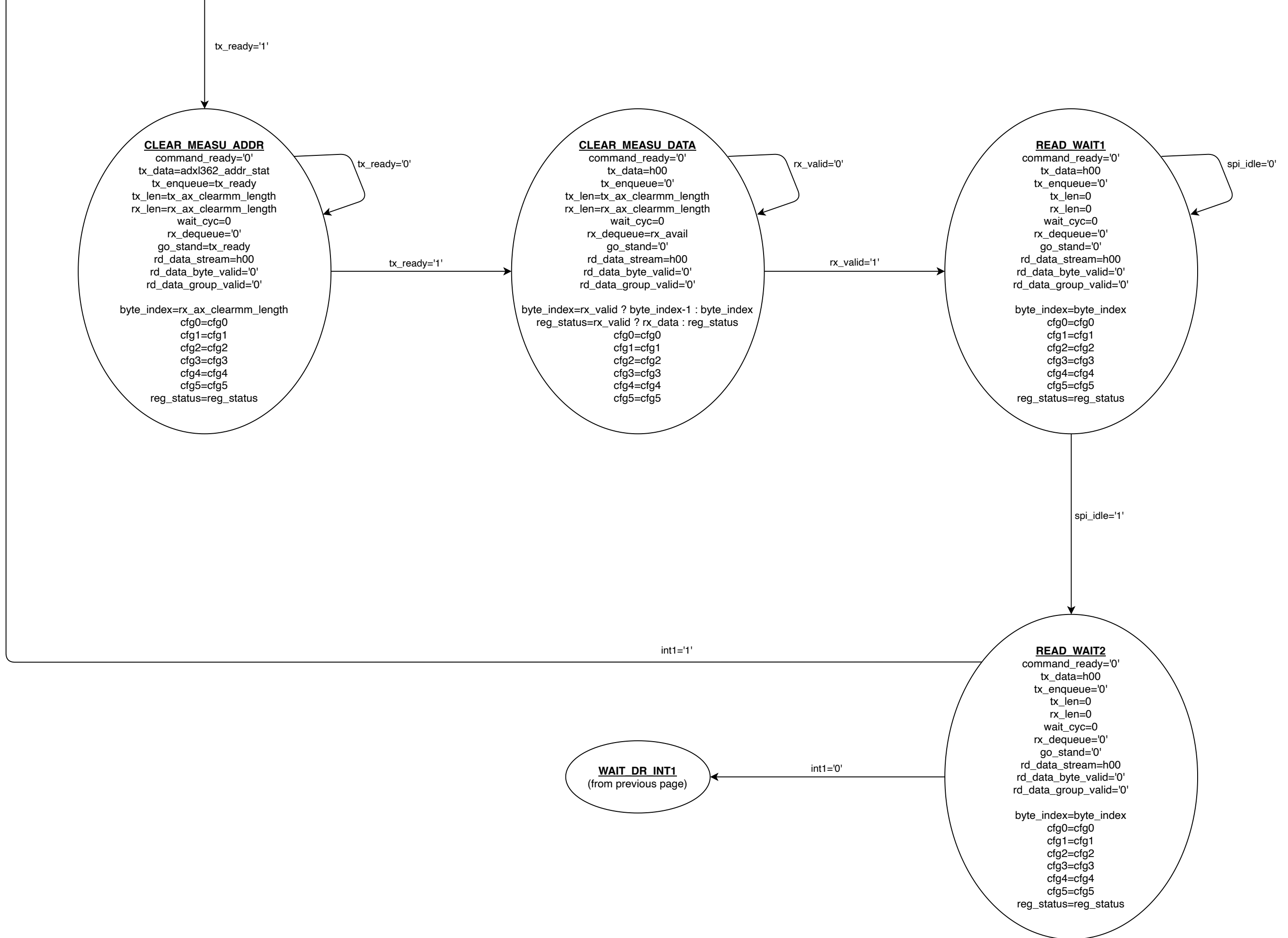




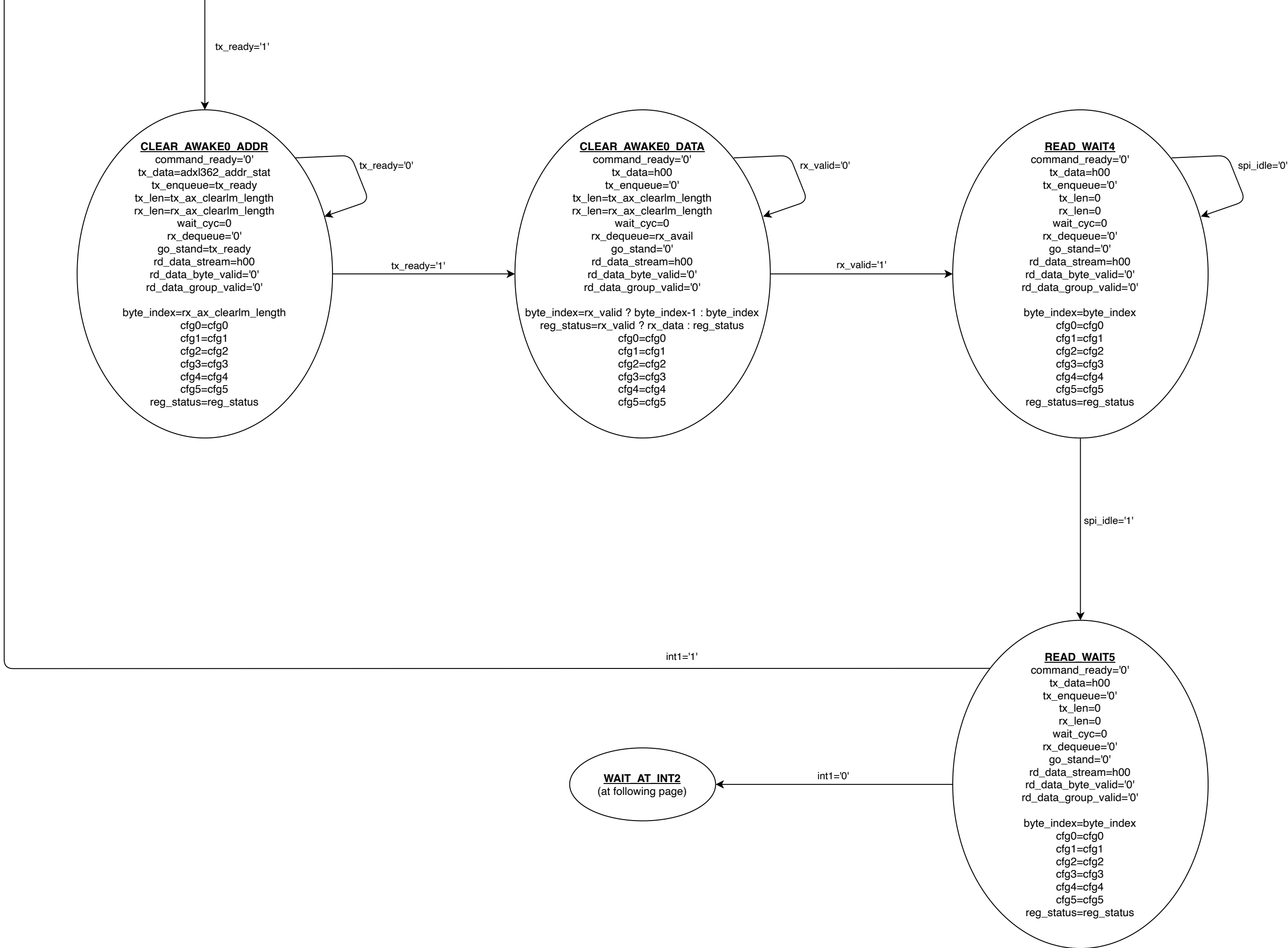


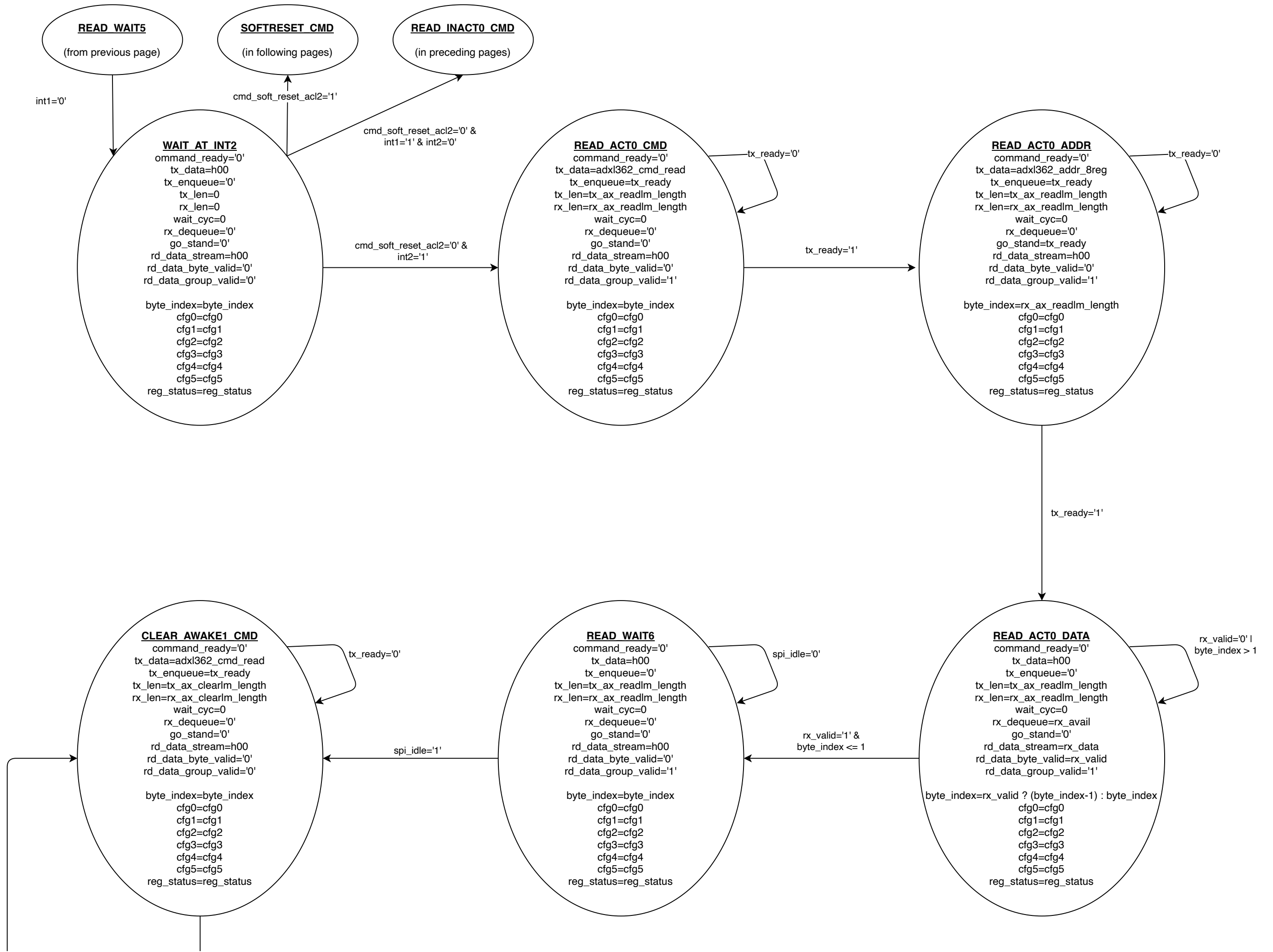


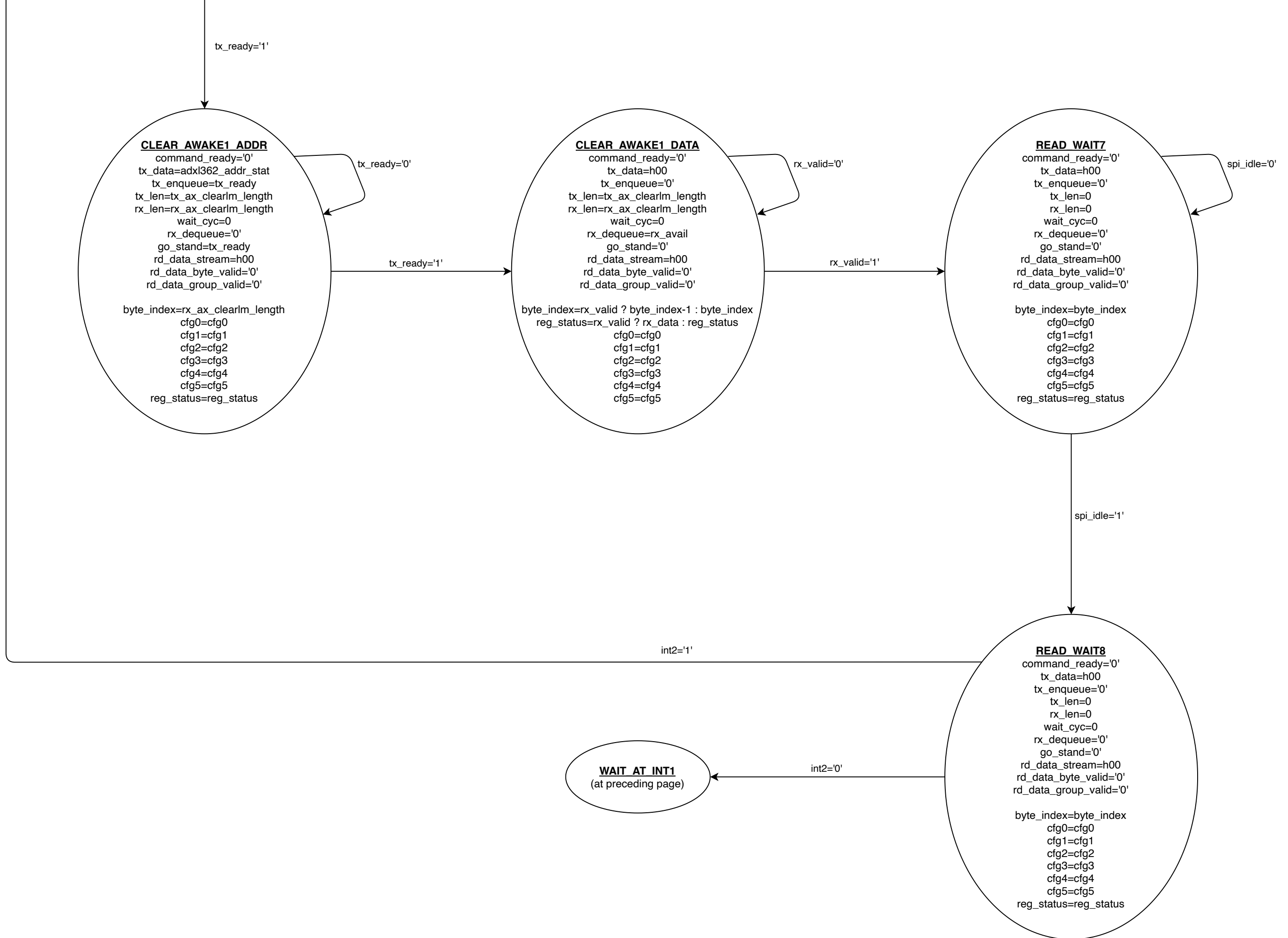




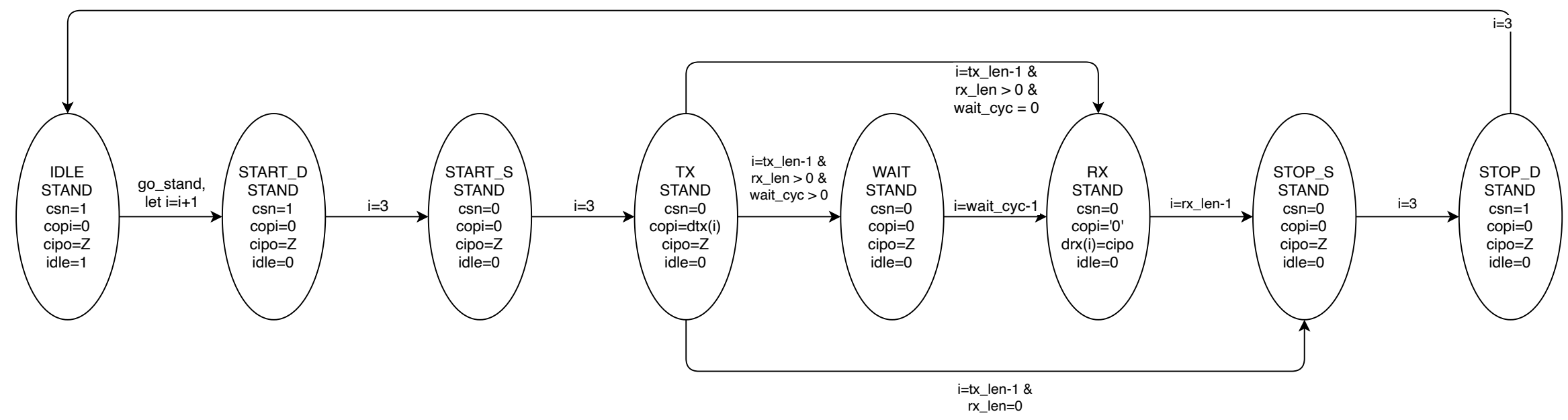












In each transition, tx\_len and rx\_len are to be multiplied by 8 from the FSM input signals, as it only makes sense to input into the FSM a byte count, while the FSM requires transitioning based upon a bit count.

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Generic SPI FSM, with only one SPI slave on the bus.

This diagram is incomplete and is shown as the first draft of designing the Standard SPI Single Slave Device driver.

Generic SPI FSM, with only one SPI  
slave on the bus.

In each transition, tx\_len and rx\_len are  
to be multiplied by 8 from the FSM input  
signals, as it only makes sense to input  
into the FSM a byte count, while the  
FSM requires transitioning  
based upon a bit count.

The main FSM combinatorial operates  
all states, but processes data on in the  
TX state when TX data is written out the  
copi port.

A side sequential process processes  
data only on the RX state when RX data  
is read from the cipo input port.

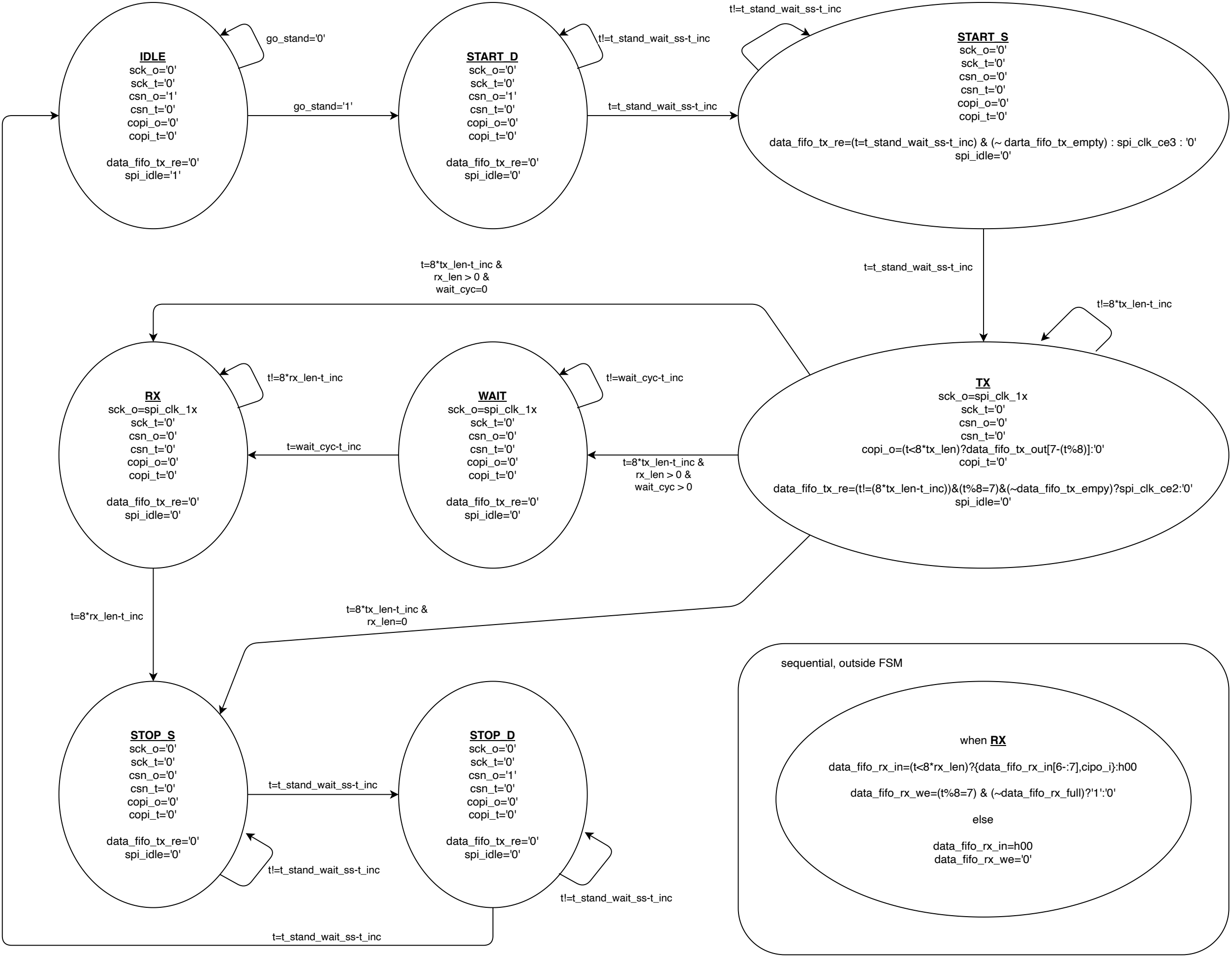
A general timer is used to time the SPI  
clock cycles (and thus bits). The timer  
is reset to zero at the transition from  
a state to a different state.

This machine could be considered a  
hybrid Moore and Mealy machine.  
The outputs during a state can  
change based upon timer and FIFO  
control inputs; but the diagram is  
drawn as a Moore machine.

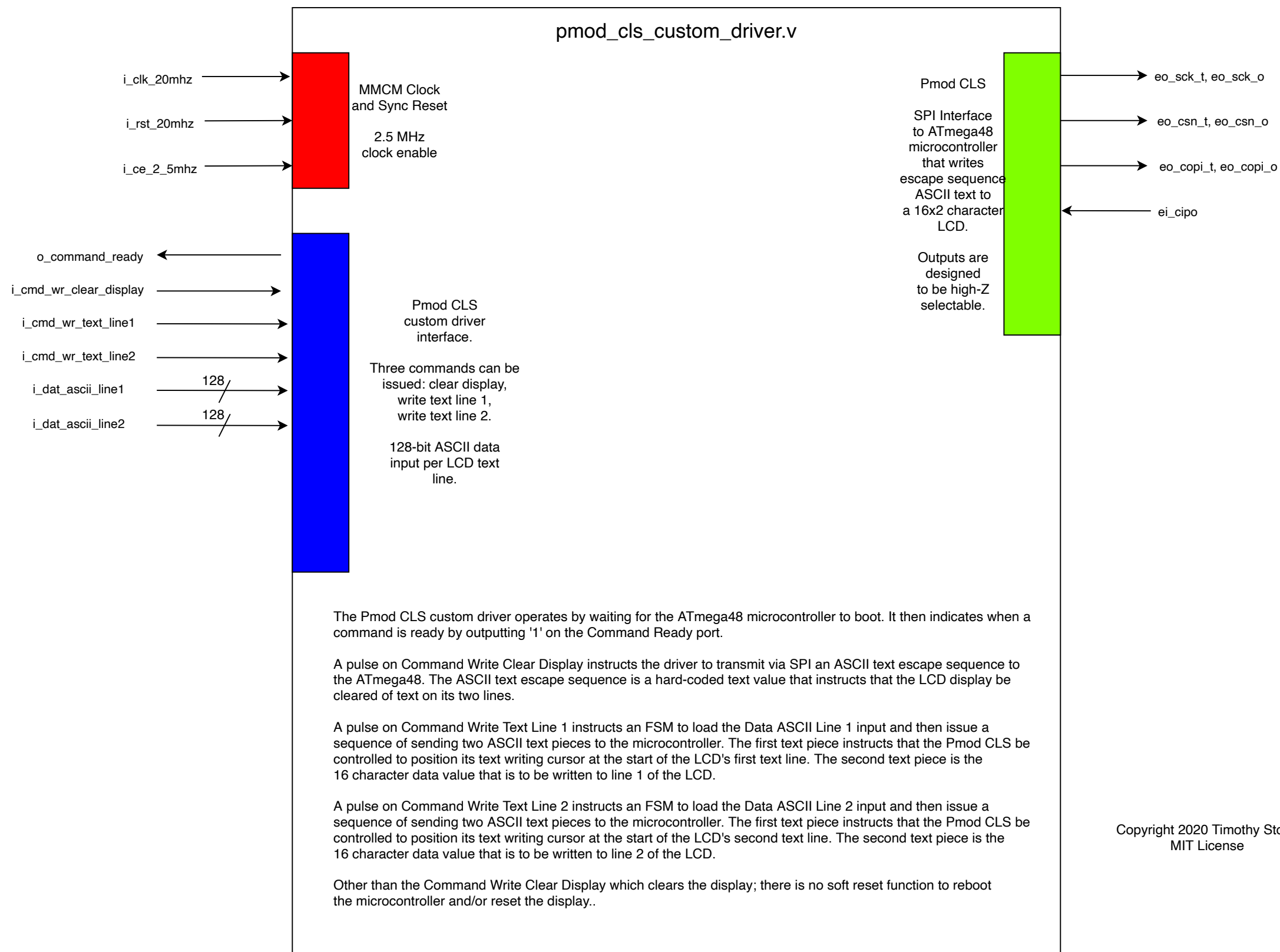
The TX state controls reading byte  
by byte from a TX fifo and write its  
bits to COPI until the timer has  
reached 8\*tx\_len cycles.

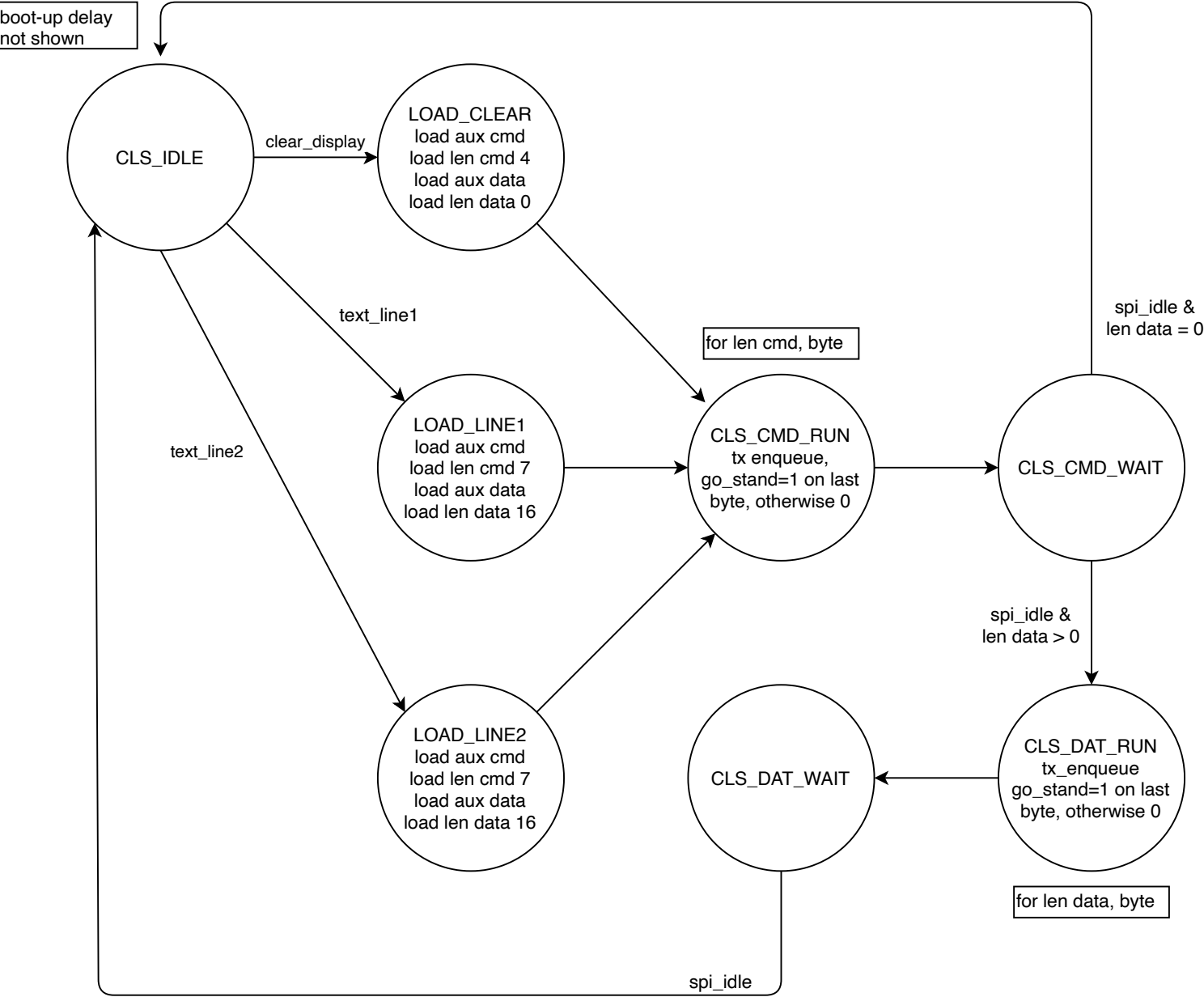
The RX standalone sequential  
controls reading a byte bit by bit  
from CIPO and then writing the  
full byte to a RX fifo when the  
full byte has been received.  
The main FSM still controls when  
the FSM is in the **RX** state or has  
transitioned to **STOP S** state.

Note that clock enables such as  
spi\_clk\_ce2 are omitted from most  
of the diagram, but are still required  
for proper function of the design to  
write data on the falling edge of the  
SPI clock output and read data on  
the rising edge of the SPI clock  
output. Refer to the source code.







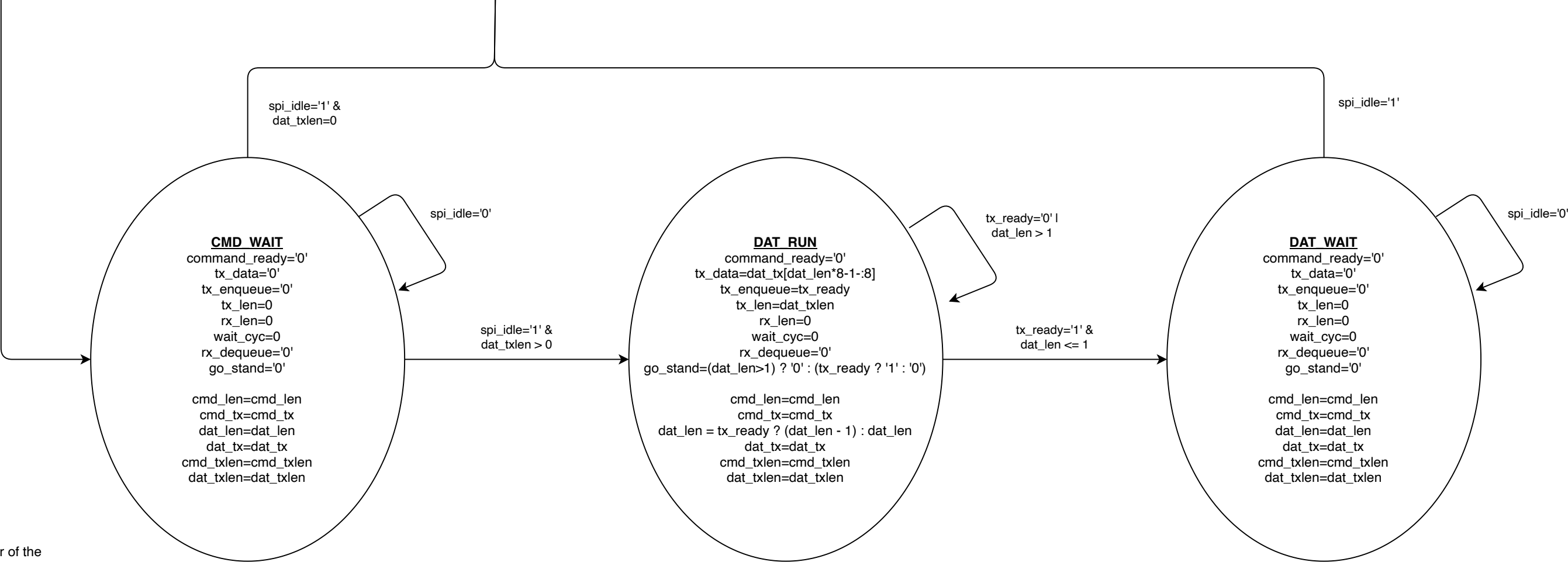


A FSM to operate the Digilent Inc. PMOD CLS LCD display communication via the single slave SPI-machine FSM of this document.

This diagram is incomplete and does not show boot-time delay. Also, some state-bypass preventions and iterations may not be shown. This is the first design draft, and the complete FSM diagram is shown on another page.

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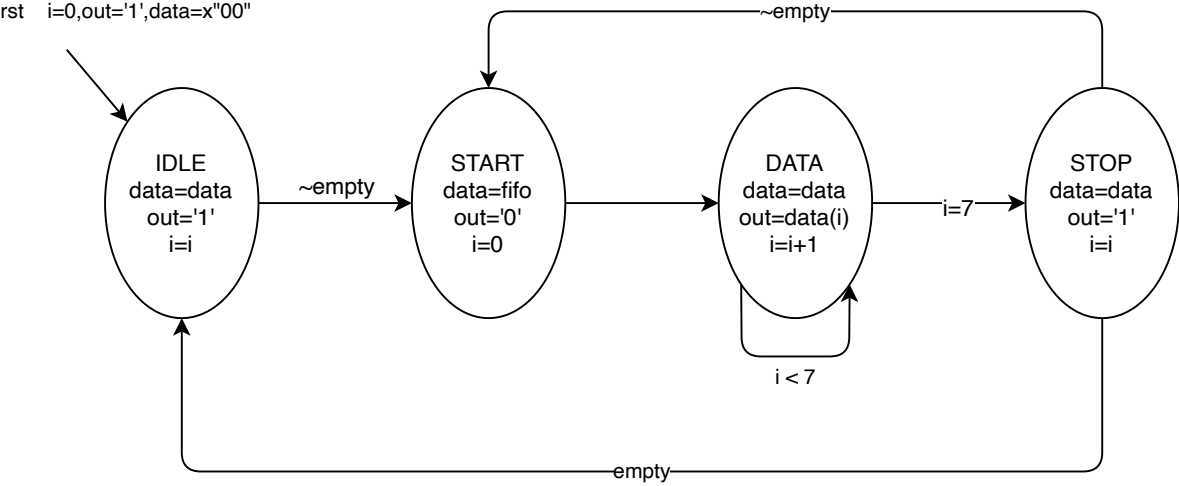




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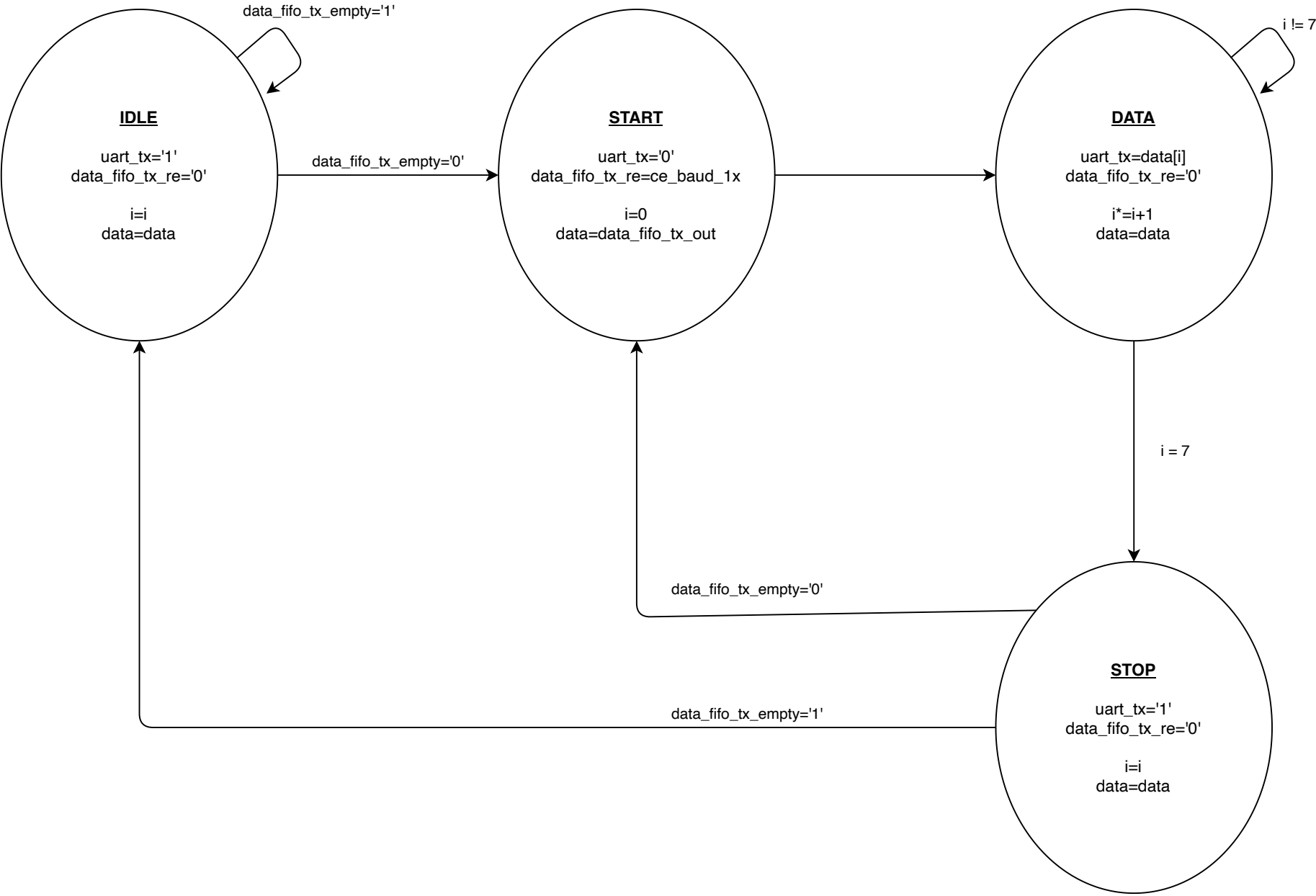
CLS Stand SPI Driver of the CLS Custom Driver. The FSM works by waiting for a command to (a) write a clear display command to the CLS, (b) write a 16-character line to the first line of the CLS, or (c) write a 16-character line to the second line of the CLS. The clear display command only writes an ANSI escape sequence with no textual data after it. The write line 1 and write line 2 commands write an ANSI escape sequence to position the cursor at the beginning of one of the two lines, and then 16 characters of text. The CLS microcontroller processes each command and line data. The clear display clears the 16x2 LCD; and the write line writes new text to the specified line of the 16x2 LCD.

The first group of Moore machine outputs in each state bubble are FSM outputs, some of them with combinatorial output that is normally only seen in a Mealy machine. (This FSM could be said to be a hybrid Moore and Mealy machine.) The second group of outputs are recursive auxiliary outputs that retain state from one state to the next when assigned to itself.



A TX ONLY UART output to UART chip from the FPGA, with the FSM executing at BAUD rate as its clock enable.

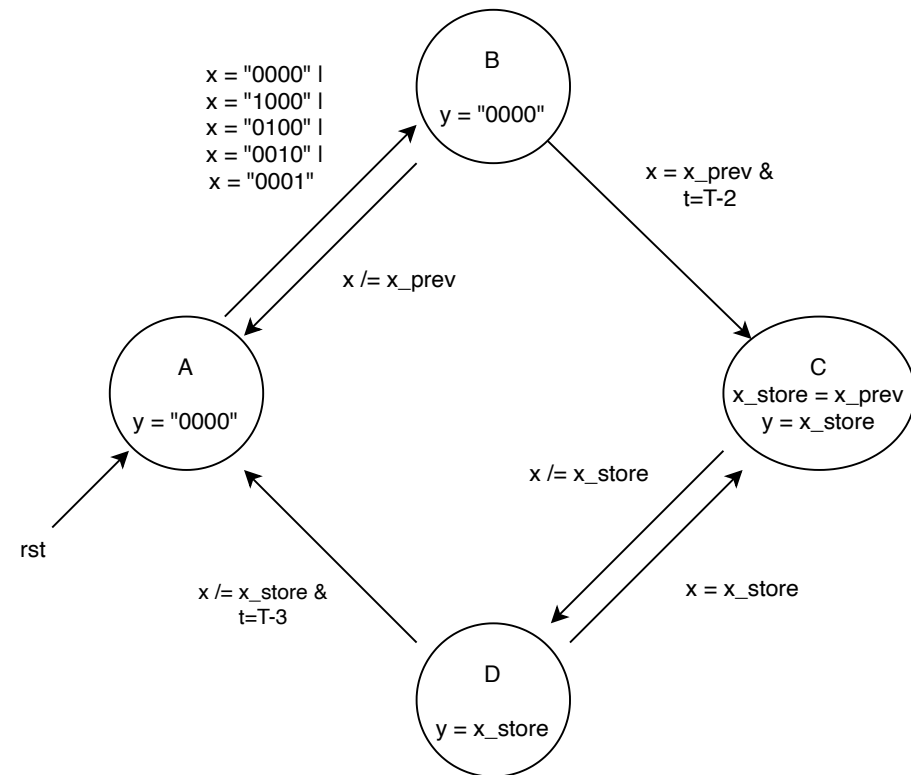
This is the first design draft,  
and the complete FSM diagram  
is shown on another page.



A TX ONLY UART output to UART chip from the FPGA, with the FSM executing at BAUD rate as its clock enable.

The FSM dequeues the UART TX FIFO when there is at least one more byte in the FIFO. No extra STOP/IDLE bits are generated except when the UART TX FIFO reaches empty.

The TX ONLY UART FSM generates a single START bit, 8 bits of DATA, a single STOP bit, and no parity bits.



Full 4-button combined debouncer.

x is defined as a four-bit value.

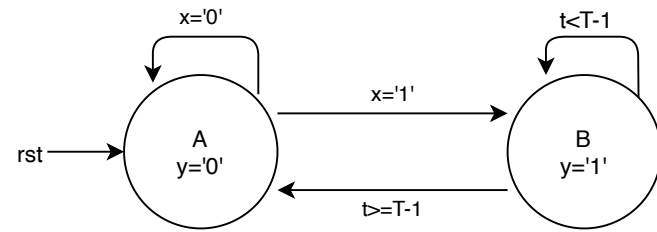
x\_prev is defined as a four-bit value that holds the previous clock cycle value of x.

x\_store is defined as a four-bit value that holds the value of x and updates the debouncer FSM entered state C during the transition BC..

The registers x\_prev and x\_store could be combined into one register, with its capture of X being a clock-enable during transitions and states of a more complex diagram.

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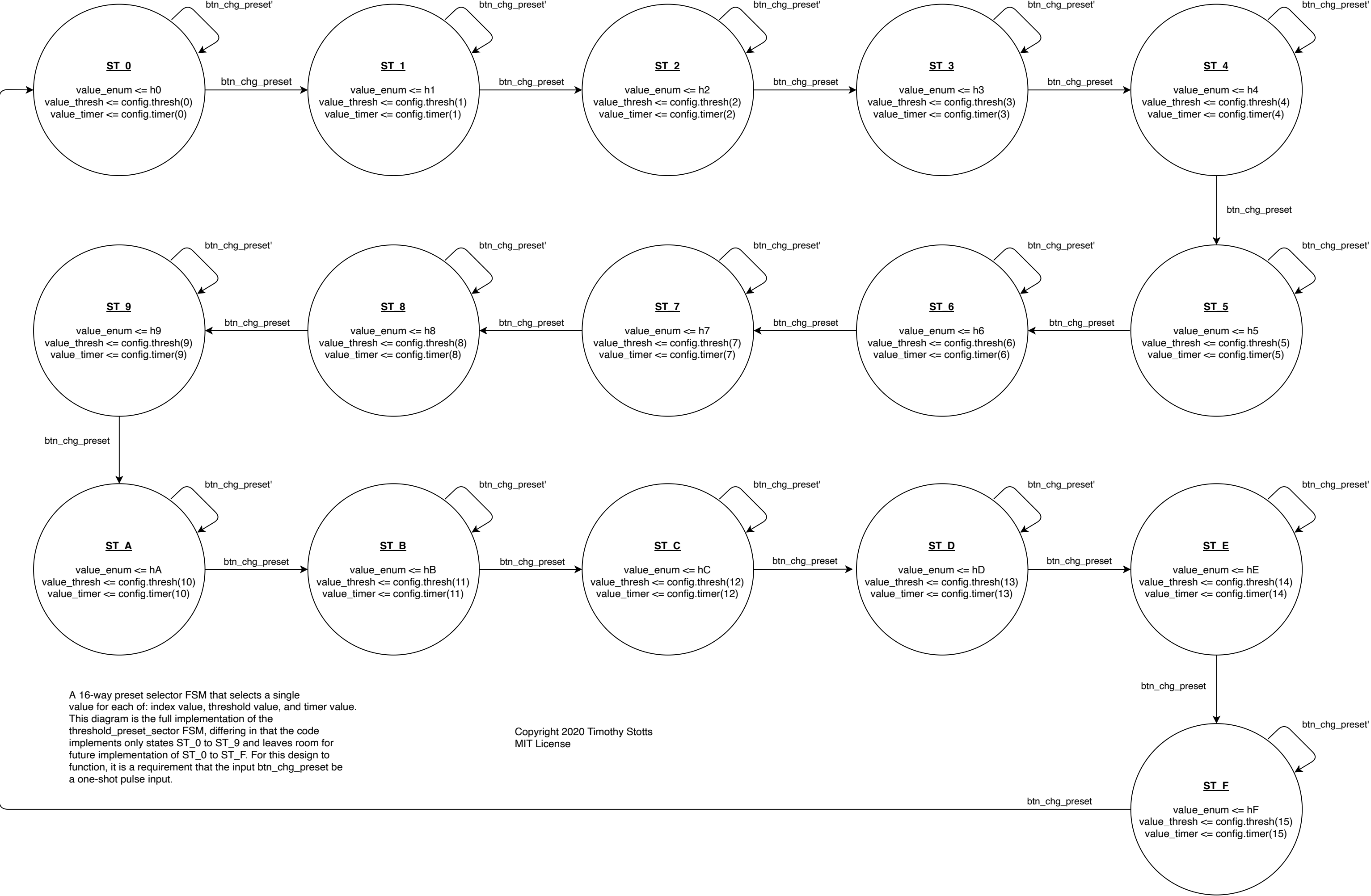


Moore FSM for a synchronous pulse stretcher of signal X that lasts for a duration less than T, with Y lasting exactly T cycles.

Textbook Figure 8.28. quoted from:

*Finite State Machines in Hardware: Theory and Design (with VHDL and SystemVerilog)*  
 by Volnei A. Pedroni,  
 reprinted courtesy of The MIT Press





A 16-way preset selector FSM that selects a single value for each of: index value, threshold value, and timer value. This diagram is the full implementation of the threshold\_preset\_sector FSM, differing in that the code implements only states ST\_0 to ST\_9 and leaves room for future implementation of ST\_0 to ST\_F. For this design to function, it is a requirement that the input btn\_chg\_preset be a one-shot pulse input.