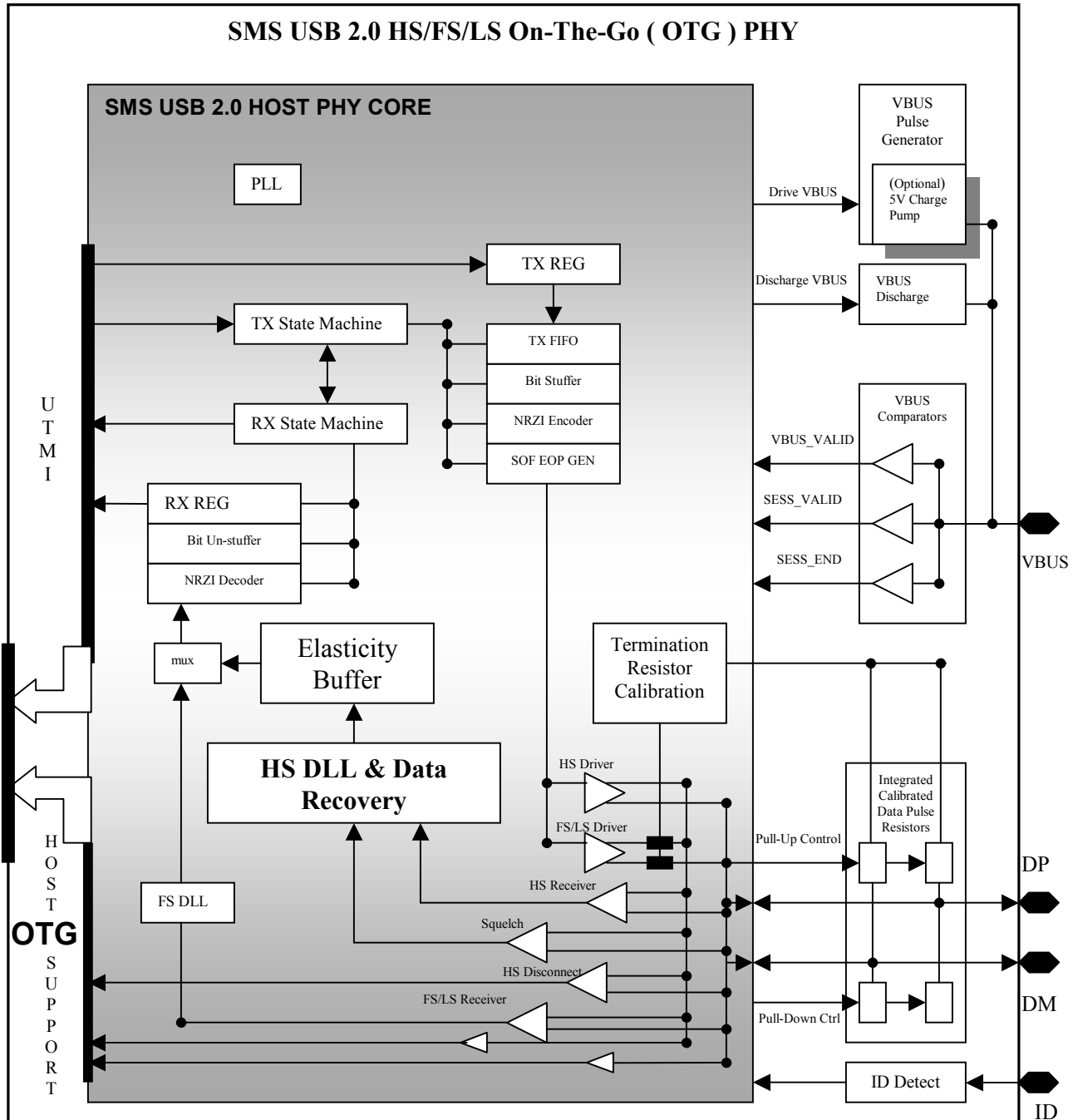


**SMS2300 USB 2.0 Host/Device Transceiver With On-The-Go ( OTG )**



**FEATURES**

- Fully compliant with latest USB 2.0
- Innovative technique to recover clock from 480 Mbps data.
- High frequency PLL.
- Advanced High-Speed Transmitter and Receiver.
- On-The-Go ( OTG ) Functionality
- Optional Charge Pump
- Support High Speed HS, Full Speed FS, Low Speed LS modes.
- Integrated/Calibrated/Switchable 1.5K & 15Kohm resistors on DP, DM in addition to Integrated/Calibrated Termination Resistors
- Full UTMI+ 1.0 Level 3 Support

**GENERAL DESCRIPTION**

USB 2.0 HOST/DEVICE/OTG Transceiver is a fully integrated PHY Core which is a super-set of HOST and DEVICE PHY with High Speed (HS), Full-Speed (FS) and Low-Speed Transceivers integrated with On-The-Go Functionality and is compliant with the USB 2.0 Specification and latest Revision of the On-The-Go and UTMI+ Specifications (UTMI+ Version 1.0 Level 3). It includes Data Pulsing, VBUS Pulsing, VBUS Comparators for Session Detection to support HNP (Host Negotiation Protocol) and SRP (Session Request Protocol), Clock/Data Recovery, on-chip PLL, Integrated & Calibrated Termination and Pull-Up/Down Resistors with full Analog Transceiver functionality for the Complete USB 2.0 PHY as illustrated in the figure.

USB2 Host/Device/OTG transceiver has standard UTMI with SIE so that ASIC vendors are isolated from the high speed and analog circuitry associated with the transceiver, thus reducing the design risk and fastening the design cycle.

The core’s main blocks are clock/data recovery for FS/HS, PLL, transceiver state machines, data encoder/decoder and high-speed analog transceiver as can be seen in the main block diagram above.

**Functional Description**

As shown in main block diagram, the USB2 transceiver’s main responsibility is to transmit data onto the line and to receive data and to recover clock correctly from the receive data. The front interface of USB2 transceiver is the cable, the back interface of USB2 transceiver is the UTMI to the serial interface engine that handles packet recognition, transaction sequencing, serialization/de-serialization, bit stuffing/unstuffing and other relevant functionality needed by a USB 2.0 Device PHY.

**Table 1: System Interface Signals**

Name	Direction	Active	Description
CLK	Output	Rising-Edge	<b>Clock.</b> This output is used for clocking receive and transmit parallel data. 60 MHz HS/FS or HS Only, with 8-bit interface 30 MHz HS/FS or HS Only, with 16-bit interface
Reset	Input	High	<b>Reset.</b> Reset all state machines in the UTM. Reset doesn’t stop the CLK output. Reset Signal Should be activated simultaneously with SuspendM signal and It should be deactivated 1ms after SuspendM signal. See Figure 2.
XcvrSelect(1:0)	Input	N/A	<b>Transceiver Select.</b> This signal selects between the LS, FS and HS transceivers: 00: HS transceiver enabled 01: FS transceiver enabled 10: LS transceiver enabled 11: Send LS Packet on FS bus, Receive LS packet
TermSelect	Input	N/A	<b>Termination Select.</b> This signal selects between the FS and HS terminations: 0: HS termination enabled 1: FS termination enabled
SuspendM	Input	Low	<b>SuspendM.</b> Places the Macrocell in a mode that draws minimal power from supplies. Shuts down all blocks not necessary for Suspend/Resume operation. While suspended, <b>TermSelect</b> must always be in FS mode to ensure that the 1.5K pull-up on <b>DP</b> remains powered. Suspend signal stops the CLK. When Suspend is activated, CLK stops at its low level. After Suspend is deactivated, CLK starts with at least 40% Duty Cycle in less than 4ms. 0: Macrocell circuitry drawing suspend current 1: Macrocell circuitry drawing normal current

LineState(0,1)	Output	N/A	<p><b>Line State.</b> These signals reflect the current state of the single-ended receivers. They are combinatorial until a "usable" <b>CLK</b> is available then they are synchronized to <b>CLK</b>. <b>DP=LineState[0]</b> &amp; <b>DM=LineState[1]</b></p> <p>DM DP Description  0 0 0: SE0  0 1 1: 'J' State  1 0 2: 'K' State  1 1 3: SE1</p>
OpMode(0-1)	Input	N/A	<p><b>Operational Mode.</b> These signals select between various operational modes:</p> <p>[1] [0] Description  0 0 0: Normal Operation  0 1 1: Non-Driving  1 0 2: Disable Bit Stuffing and NRZI encoding  1 1 3: Normal operation without generating SYNC and EOP. Bitstuffing depends on TxBitstuffEnable and TXBitStuffEnableH signals. NRZI encoding is always enabled. Only valid when XcvrSel is 00.</p>

**Table 2: Host/OTG Specific USB Interface Signals**

Name	Direction	Active	Description
HostDisconnect	Output	High	USB2 host transceiver notifies host SIE of disconnection from USB2 device.
Dppulldown	Input	High	Enable pull-down resistor on DP wire in Host mode
Dmpulldown	Input	High	Enable pull-down resistor on DM wire in Host mode
IDDig	Output	High	Indicates whether mini-A plug (0) or mini-B (1) plug is attached
IdPullup	Input	High	Enables IDDig Detection.
AValid	Output	High	Indicates if the session for an A-peripheral is valid by using VBUS comparators.
BValid	Output	High	Indicates whether the session is valid for a B-peripheral by using VBUS comparators.
VbusValid	Output	High	Indicates if voltage on VBUS is valid for operation
SessEnd	Output	High	Indicates if Vbus voltage is below B session End Threshold.
DrvVbus	Input	High	Enables to drive 5V on VBUS
ChrgVbus	Input	High	Enables charging VBUS
DischrgVbus	Input	High	Enables discharging VBUS
TxBitStuffEnable	Input	High	Indicates if the data on the DataOut(7:0) lines needs to be bit-stuffed or not. 0 : Bit-stuffing is disabled 1 : Bit-stuffing is enabled
TxBitStuffEnableH	Input	High	Indicates if the data on the DataOut(15:8) lines needs to be bit-stuffed or not. 0 : Bit-stuffing is disabled 1 : Bit-stuffing is enabled This signal is only required when the 16 bit mode is selected.
FsLsSerialMode	Input	High	Indicates whether the serial interface for FS/LS packets should be used. 0: FS/LS packets are sent using parallel interface. 1: FS/LS packets are sent using serial interface.

Tx_Enable_N	Input	Low	Output Enable for Full/Low Speed during Serial Mode
Rx_RCV	Output	N/A	Differential Receiver Output For Serial Mode
Rx_DM	Output	N/A	Single Ended Receiver Output For Serial Mode
Rx_DP	Output	N/A	Single Ended Receiver Output For Serial Mode
Tx_Dat	Input	N/A	Differential data for DP/DM
Tx_Se0	Input	N/A	Force Single Ended Zero at DP/DM

**Table 3: USB Interface Signals**

Name	Direction	Active	Description
DP	Bidir	N/A	USB data pin Data+
DM	Bidir	N/A	USB data pin Data-
VBUS	Bidir	N/A	Power pin for USB. Sourced By A-Device
ID	Input	N/A	ID Pin on the USB Mini Receptacle

**Table 4: Data Interface Signals (Transmit)**

Name	Direction	Active	Description
DataIn0-7	Input	N/A	<b>DataIn.</b> 8-bit parallel USB data input bus. When <b>DataBus16_8 = 1</b> this bus transfers the low byte of 16-bit transmit data. When <b>DataBus16_8 = 0</b> all transmit data is transferred over this bus.
DataIn8-15	Input	N/A	<b>DataIn.</b> An 8-bit parallel USB data input bus that transfers the high byte of 16-bit transmit data. These signals are only valid when <b>DataBus16_8 = 1</b> .
TXValid	Input	High	<b>Transmit Valid.</b> Indicates that the <b>DataIn</b> bus is valid. The assertion of Transmit Valid initiates SYNC on USB. The negation of Transmit Valid initiates EOP on USB.
TXValidH	Input	High	<b>Transmit Valid High.</b> When <b>DataBus16_8 = 1</b> , this signal indicates that the <b>DataIn(8:15)</b> bus contains valid transmit data. This signal is ignored when <b>DataBus16_8 = 0</b> .
TXReady	Output	High	<b>Transmit Data Ready.</b> If <b>TXValid</b> is asserted, the SIE must always have data available for clocking in to the TX Holding Register on the rising edge of <b>CLK</b> . <b>TXReady</b> is an acknowledgement to the SIE that the UTM has clocked the data from the bus. This acknowledgement also indicates to the SIE that it must present the data for the next transfer on the bus. If <b>TXValid</b> is negated, <b>TXReady</b> can be ignored by SIE.

**Table 5: Data Interface Signals (Receive)**

Name	Direction	Active	Description
DataOut0-7	Output	N/A	<b>DataOut.</b> 8-bit parallel USB data output bus. When <b>DataBus16_8 = 1</b> this bus transfers the low byte of 16-bit receive data. When <b>DataBus16_8 = 0</b> all receive data is transferred over this bus.
DataOut8-15	Output	N/A	<b>DataOut.</b> An 8-bit parallel USB data output bus that transfers the high byte of 16-bit receive data. These signals are only valid when <b>DataBus16_8 = 1</b> .
RXValid	Output	High	<b>Receive Data Valid.</b> Indicates that the <b>DataOut</b> bus has valid data. The Receive Data Holding Register is full and ready to be unloaded. The SIE is expected to latch the

			<b>DataOut</b> bus on the clock edge.
RXValidH	Output	High	<b>Receive Data Valid High.</b> When <b>DataBus16_8</b> = 1 this signal indicates that the <b>DataOut(8-15)</b> bus is presenting valid receive data. This signal is ignored when <b>DataBus16_8</b> = 0.
RXActive	Output	High	<b>Receive Active.</b> Indicates that the receive state machine has detected SYNC and is active. <b>RXActive</b> is negated after a Bit Stuff Error or an EOP is detected.
RXError	Output	High	<b>Receive Error.</b> 0 Indicates no error. 1 Indicates that a receive error has been detected.

**Table 6: Data Interface Signals (Other)**

Name	Direction	Active	Description
DataBus16_8	Input	High	<b>DataBus16_8</b> Selects between 8 and 16 bit data transfers. 1 16-bit data path enabled. DataIn(15:8), DataOut(15:8), TxValidH and RxValidH operational. CLK=30 MHz 0 8-bit data path enabled. DataIn(15:8), DataOut(15:8), TxValidH and RxValidH are undefined. CLK=60 MHz.

**Table 7: System Interface Signals**

Name	Direction	Active	Description
RefClk	Input	Pos-Edge	Reference Clock For PLL Input 48 MHz or 24 MHz (12 MHz is available if required)
Rext	Input	N/A	Bias Resistor Pin Should be connected to 12.3K %1
VoREF	Output	N/A	Voltage Reference output
Atest0	Output	N/A	Analog Test Output 0
Atest1	Output	N/A	Analog Test Output 1

**Table 8: Powers**

Name	Direction	Active	Description
AVDDR <sub>X</sub>	Input	N/A	Analog VDD for Receive
AVSSR <sub>X</sub>	Input	N/A	Analog VSS for Receive
AVDDT <sub>X</sub>	Input	N/A	Analog VDD for Transmit
AVSST <sub>X</sub>	Input	N/A	Analog VSS for Transmit
AVDDC	Input	N/A	Analog VDD for Common
AVSSC	Input	N/A	Analog VSS for Common
DVDD	Input	N/A	Digital VCC From Core
DVSS	Input	N/A	Digital VSS From Core

Note: Receive & Transmit Powers can be merged if necessary.

## USB ON-THE-GO DESCRIPTIONS AND SPECIFICATIONS

### VBUS Comparator Description:

There are four comparators which are required for VBUS level detection: Vbus\_Valid, ASession\_Valid, BSession\_Valid and Session\_End. The Vbus\_Valid comparator indicates that VBUS is valid when  $VBUS > 4.4V$ . The ASession\_Valid comparator indicates that an A Device USB session is valid ( $VBUS > 0.8V$ ), BSession\_Valid comparator indicates that an B Device USB session is valid ( $VBUS > 2.0V$ ) and Session\_End comparator indicates when a USB session has ended ( $VBUS < 0.8V$ ).

The A Device uses the Vbus\_Valid signal to detect if the B Device is a supported device by checking if the B Device is consuming too much current. The Session\_Valid signal is used to detect a valid Data Session and Session\_End signal is used to detect the end of the session when VBUS falls below 0.5V.

### COMPARATOR SPECIFICATION

Parameter	Min	Typ	Max	Unit
Vbus_Valid comparator threshold	4.40			V
ASession_Valid comparator threshold	0.8		2.0	V
BSession_Valid comparator threshold	2.0		4.0	V
Session_End comparator threshold	0.2		0.8	V

### Charge-Pump Description:

The OTG compliant Charge-Pump uses an input voltage VCC from 3.0V to 3.6V and generates an OTG compliant VBUS source with the ability to source 8 mA (minimum) of output current. When the VBUS is providing power, the rise time on the VBUS wire from 0V to 4.4V is no more than 100 ms when driving 8 mA on to an external load capacitance of 10 uF as specified by the OTG specification.

### CHARGE-PUMP SPECIFICATION

Parameter	Min	Typ	Max	Unit
VBUS Output Voltage	4.63		5.25	V
VBUS Output Current	8			mA

### Data-Line Pulsing Using Pull-up/Pull-down resistors:

To request for a new session using the Data-Pulsing SRP, the B Device uses its pull-up resistors (either D+ or D-pull-up) for 5mS to 10mS. A dual-role B Device can only initiate SRP at Full Speed so it will only use D+ pull-up resistor to initiate SRP. An A Device, which supports the Data-Pulsing SRP, detects the voltage level on D+ or D-going high and indicates an SRP detection.

### PULL-UP/PULL-DOWN RESISTOR SPECIFICATIONS

Parameter	Min	Typ	Max	Unit
Pull-Up Resistor on D+	1.425		1.575	KOhm
Pull-Up Resistor on D-	1.425		1.575	KOhm
Pull-Down Resistor on D+	14.25		15.75	KOhm
Pull-Down Resistor on D-	14.25		15.75	KOhm

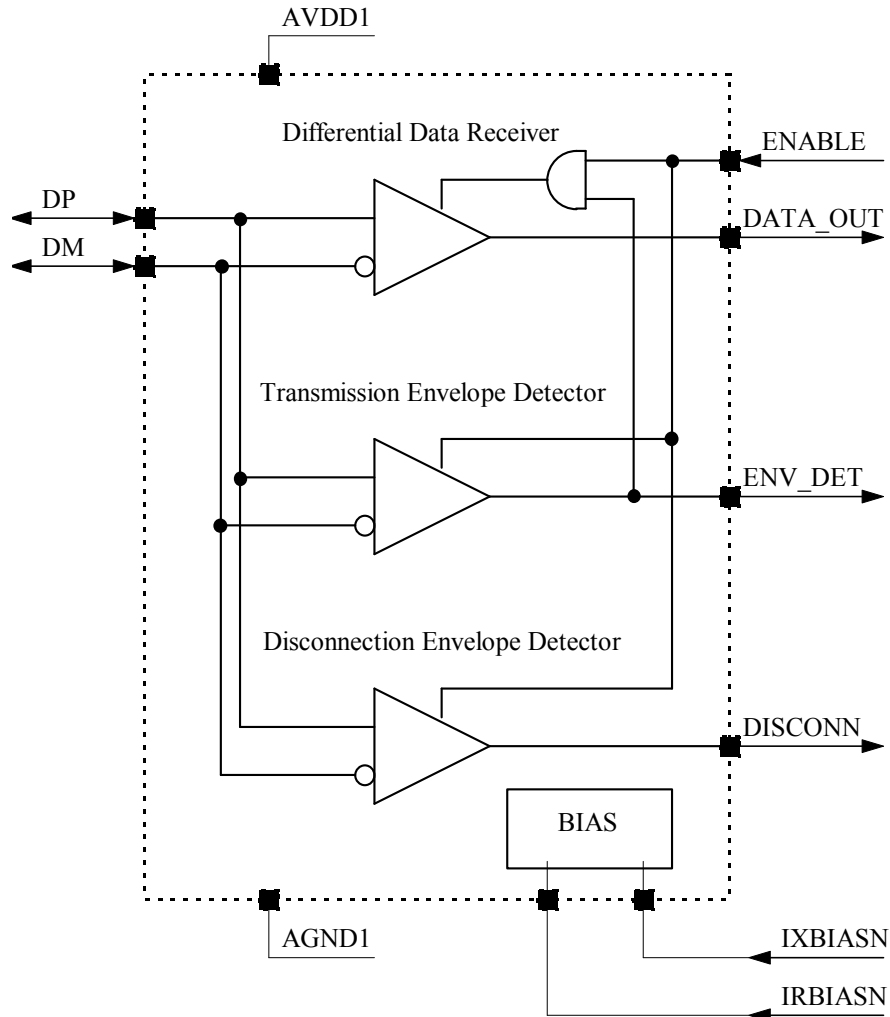
### ID Detect Description:

The ID Detect feature checks whether the ID pin is shorted to ground with a resistor less than 10 Ohm when a mini-A plug is connected and the OTG controller becomes an A Device which is a HOST by default. If a mini-B plug is connected, the ID pin is either left open or it is connected to ground with a resistor larger than 100 KOhm in which case the OTG controller becomes a B Device that is a PERIPHERAL by default.

## USB2FE

Analog front end USB2FE includes high-speed differential driver and envelope detection/disconnection differential receiver.

### HIGH-SPEED RECEIVER—Data Sheet



**Fig. 3: Block diagram of high-speed receiver**

The high-speed receiver primarily consists of three functional elements:

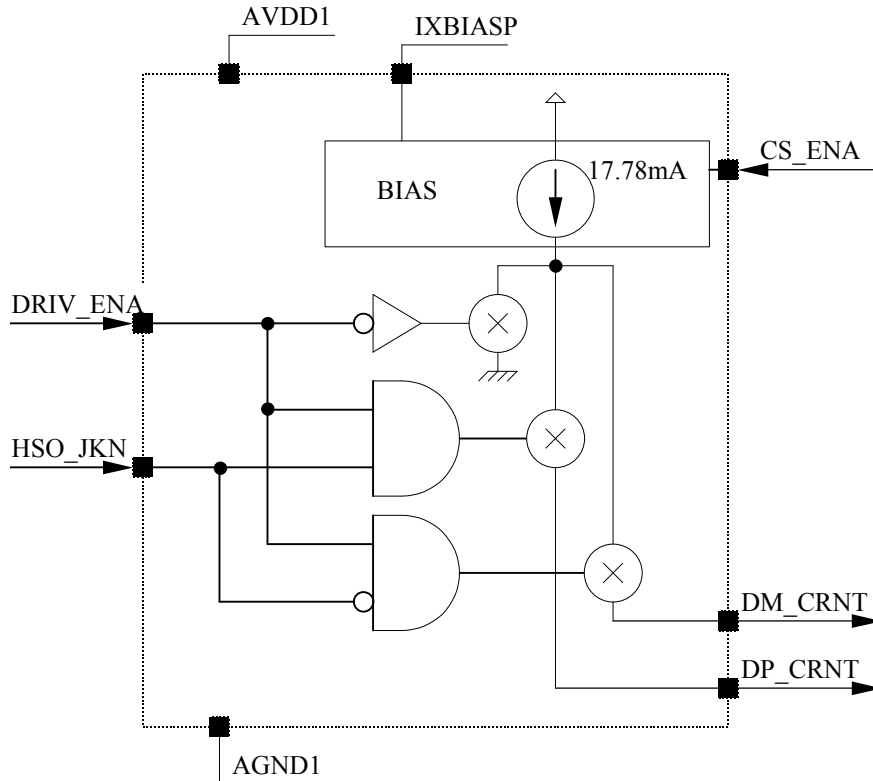
- 1) A differential data receiver.
- 2) A transmission envelope detector.
- 3) A disconnection envelope detector.

The differential data receiver receives the high-speed (480Mb/s) differential data from the USB and converts it to a single-ended NRZI signal (DATA\_OUT) suitable for use as an input to standard CMOS digital cells. The receiver is disabled and powered down (with digital output forced to "0") when either the ENABLE input to the high-speed receiver is set to "0" or the output of the transmission envelope detector is "0".

The transmission envelope detector monitors the amplitude of the high-speed differential data signal from the USB. A differential amplitude greater than 150mVp, indicating valid data, sets the digital output ENV\_DET to "1," while an amplitude less than 100mVp, indicating invalid data, resets ENV\_DET to "0."

The disconnection envelope detector also monitors the amplitude of the differential data signal from the USB, albeit with a somewhat different operation and different signal levels of interest. A differential signal amplitude greater than 625mV, indicating disconnection, forces output DISCONN to “1,” while a differential amplitude less than 525mV causes DISCONN to remain at “0.” The disconnection envelope detector is powered down (with DISCONN forced to “0”) when the ENABLE input is set to “0.”

**HIGH-SPEED CURRENT DRIVER—Data Sheet**



**Fig. 4: Block diagram of high-speed current driver**

The high-speed current driver is used for high-speed data transmission. For those times when the driver is not transmitting, a standby mode (set by DRIV\_ENA=0) is available which allows the 17.78mA current to be directed internally to ground (AGND1) and places the driver in a high-output-impedance state. The transition between standby and non-standby modes does not exhibit much delay, and use of the standby/non-standby modes ensures that the driver meets the required accuracy starting with the first symbol of a packet.

**HSDLL**

The HS DLL is a delay line, characterized to sample data at 480Mhz to detect the data transition. This information is used by a HSDLL state machine to position recover clock at the midpoint of the data pulse to assure optimal setup and hold time. To further correct the clock discrepancy, which can be up to 500ppm between transmitter and receiver, a 24-bit elasticity buffer is used to store enough data in it to avoid overflow or underflow. A 12-bit threshold is reached before the receiver state machine starts using the data.

**FSDLL**

FS DLL is a 4-time over-sampling clock recovery at 48Mhz to recover 12Mbps data. The HS detection circuit detects what speed the downstream port is. Once detected, either FS data or HS data are multiplexed to be NRZI-decoded back into NRZ data for receive state machine.



**RECEIVER:**

The Receiver includes the HS and FS Receive Portions of the Analog Front End and the Receive Portion of the Digital Block which includes HS Clock & Data Recovery, Elasticity Buffer, FS DLL, Receive FIFO and Receive State Machine Implementation which includes NRZI Decoding, Bit Un-Stuffing, UTMI Control Signal Generation.

The receive path functions as follows:

- 1) AFE continuously monitors the line state for activity.
- 2) The digital block detects SYNC and strips it, at the same time turns on RxActive.
- 3) Received and Recovered Data is de-serialized, after being converted to NRZ and bit stuffing additions have been removed to generate individual bytes
- 4) Received bytes are put into Receive FIFO
- 5) Bytes are extracted from FIFO and given to UTMI with the control of RxValid and RxValidh signals

**RECEIVE STATE MACHINE**

**RESET:** The assertion of reset signal forces the Receive State Machine into RESET state.

**RXWAIT:** When reset signal is gone, the Receive State Machine goes to RXWAIT state to wait for SYNC pattern.

**STRIP SYNC:** When SYNC is detected, STRIP SYNC filters out SYNC pattern until the first valid data.

**RXWAIT:** When reset signal is gone, the Receive SM goes to RXWAIT state to wait for SYNC pattern.

**RXDATA:** After 8 bits of valid serial data is received the state machine enters the RXDATA state, where the data is loaded into the RX Holding Register on the rising edge of **CLK** and **rxvalid** is asserted. The SIE must clock the data out on the next rising edge of **CLK**.

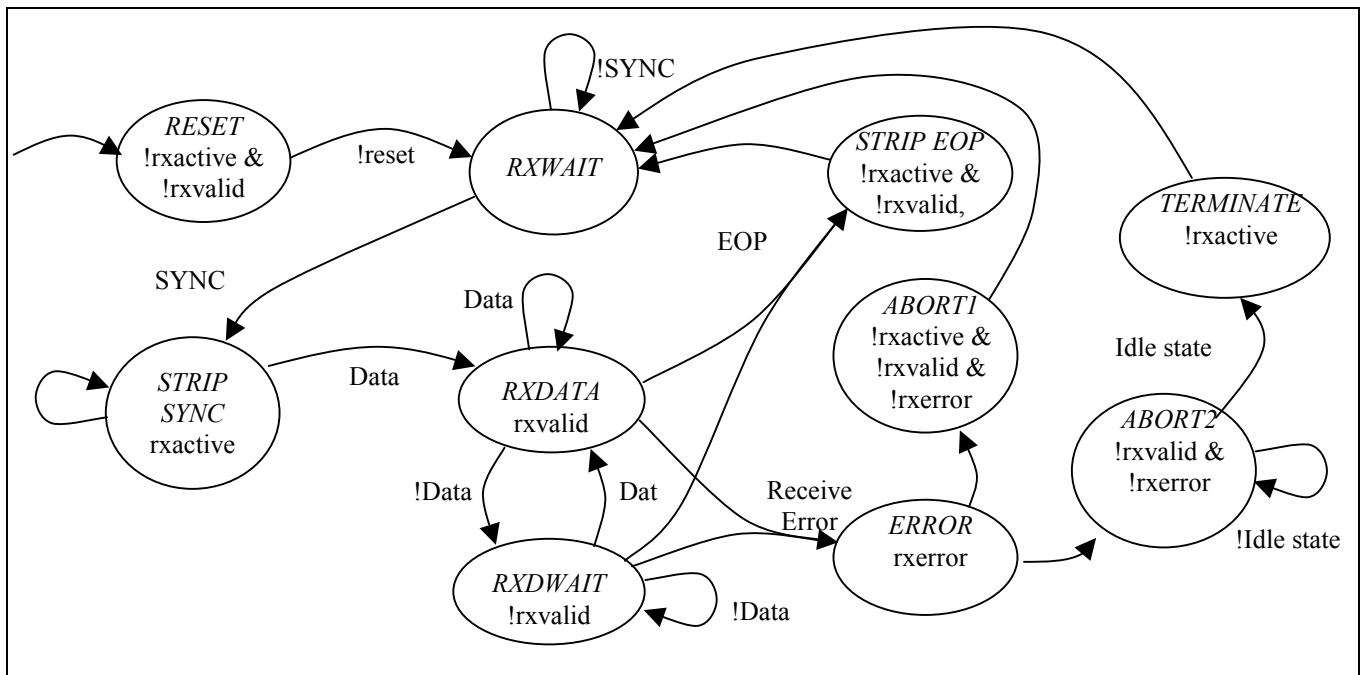
**RXDWAIT:** Each time 8 stuffed bits are accumulated the state machine will enter the RXDWAIT state, negating **rxvalid** thus skipping a byte time.

**STRIP EOP:** When the EOP is detected the state machine will enter the STRIP EOP state and negate **rxactive** and **rxvalid**. After the EOP has been stripped the Receive State Machine will reenter the RXWAIT state and begin looking for the next packet.

**ERROR:** At any time if there's an error due to bit stuff error, buffer overflow, buffer underflow, loss of sync, alignment error, ... the state machine will enter ERROR state.

**ABORT:** Abort current packet due to receive error.

**Figure 5: Receive State Diagram**



**TRANSMITTER**

The transmitter receives data from the UTMI under the control of TxReady, TxValid, TxValidh signals and drives the AFE to generate the correct form of signaling on the USB wire.

The Transmitter functions as follows:

- 1) The Device Function puts the transmit data on DataIn bus and turns on TxValid and/or TxValidh as appropriate.
- 2) The PHY samples TxValid and generates TxReady after putting the initial data into the Transmit FIFO
- 3) Individual bytes are taken from the TX FIFO and serialized for transmission while being NRZI encoded and Bit-Stuffed at the same time.
- 4) If, because of Bit-Stuffing, the TX FIFO becomes full, TxReady gets turned off which signals the Device Function to stop sending more data
- 5) The PHY drives turns on the appropriate Front End to generate the necessary Electrical signaling on the USB wire
- 6) As appropriate the PHY generates the SOF EOP and does the Disconnect Detection at the end of the packet

**TRANSMIT STATE MACHINE**

**RESET:** The assertion of reset signal forces the Transmit State Machine into RESET state.

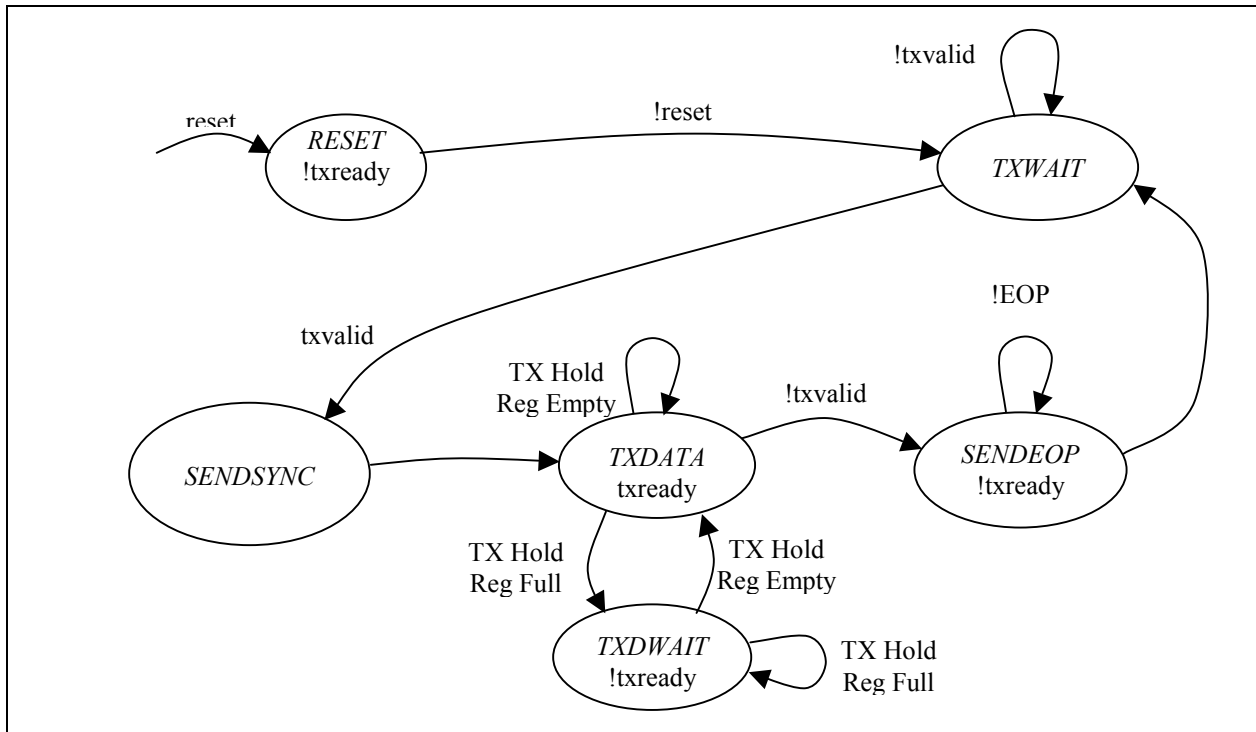
**TXWAIT:** When reset signal is gone, the Transmit State Machine goes to TXWAIT state to wait for txvalid.

**SENDSYNC:** When txvalid is detected, SENDSYNC starts sending out SYNC pattern.

**TXDATA:** When the transmitter is ready for the first byte of the packet (PID), it will enter the TXDATA state, assert txready and load the TX Holding Register.

**TXDWAIT:** When there is no more data, the state machine goes to TXDWAIT and remains there until the TX Data Holding register is available for more data.

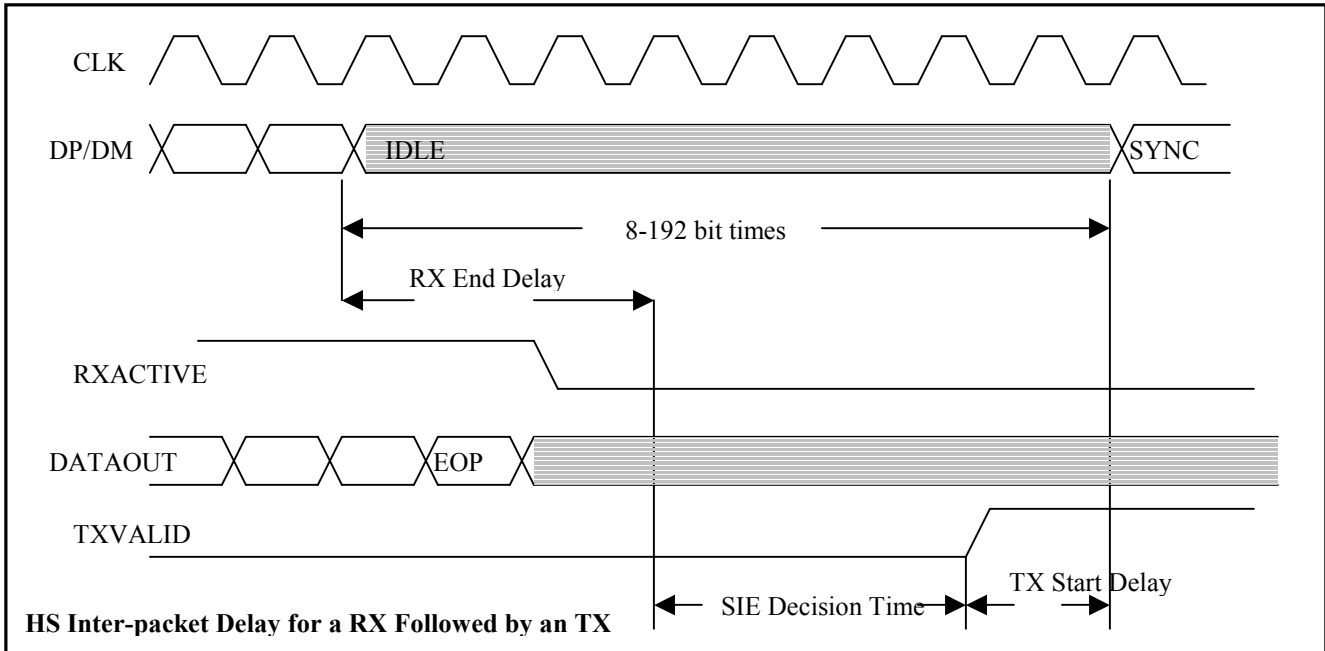
**SENDEOP:** When txvalid is negated the transmit state machine enters the SENDEOP state where it sends the EOP. After the EOP is transmitted the Transmit State Machine returns to the TXWAIT state, looking for more data.



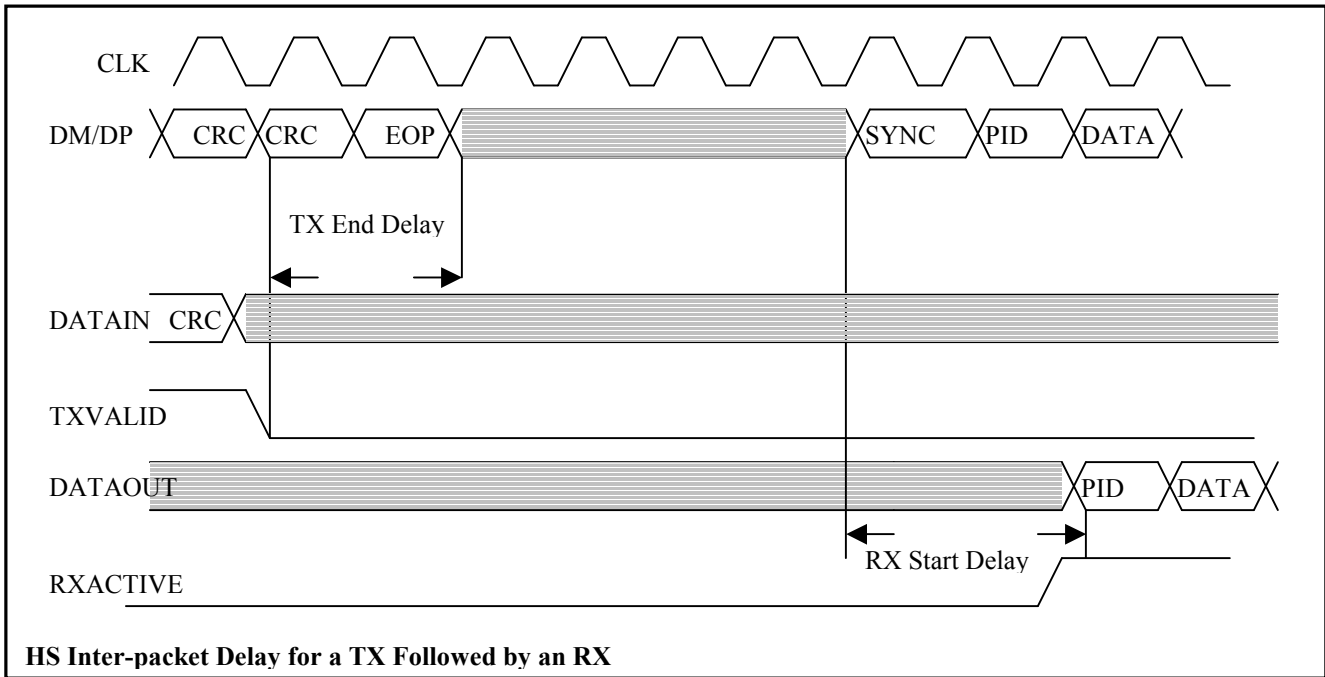
**Figure 6: Transmit State Diagram**

**TIMING CONSTRAINTS:**

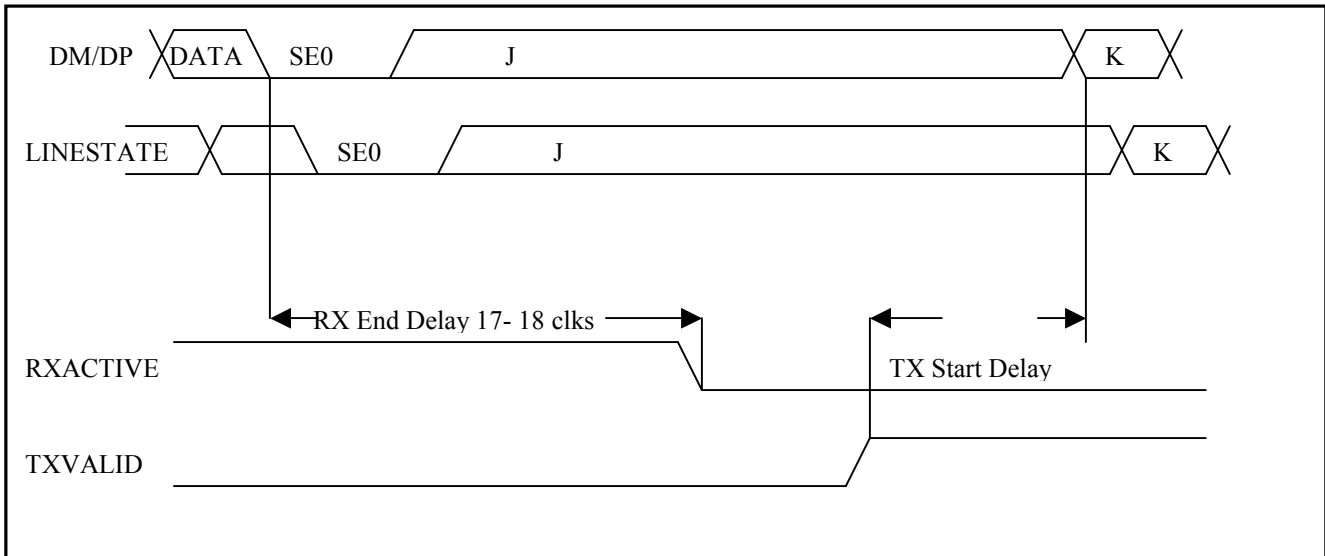
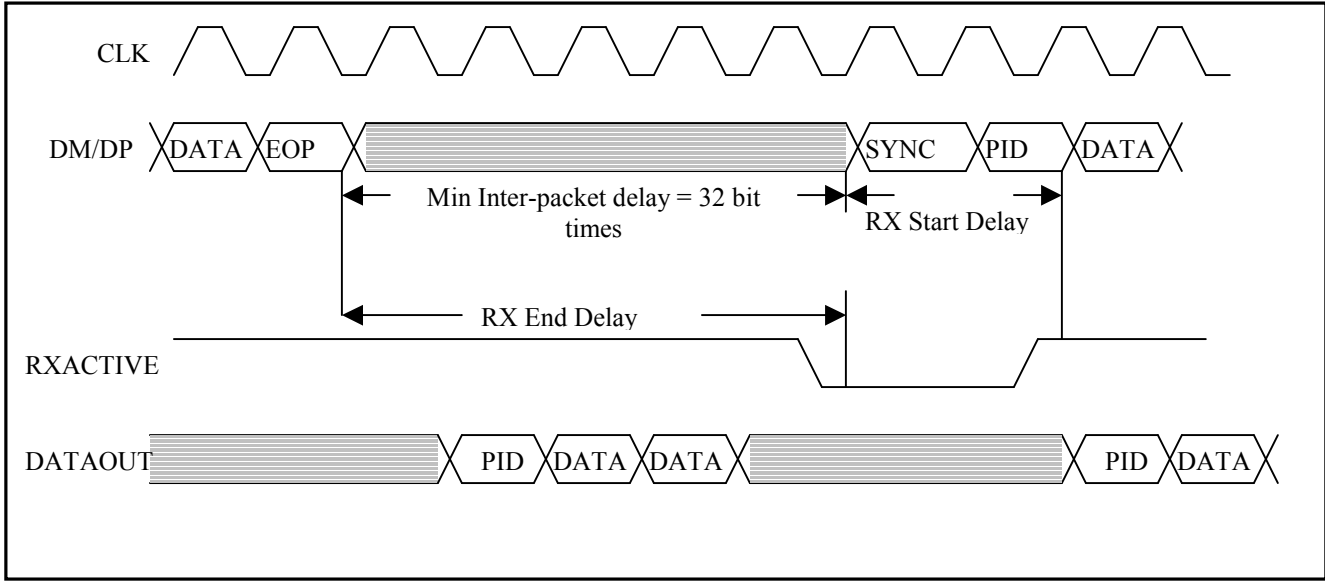
INTER-PACKET DELAY TIMING VALUES:



SMS2300 RX End Delay is 44 bit times to 63 bit times for 8-bit UTMI and 52 to 71 bits in 16-bit UTMI mode. The Maximum TX Start Delay for SMS2300 is 16 bit times.

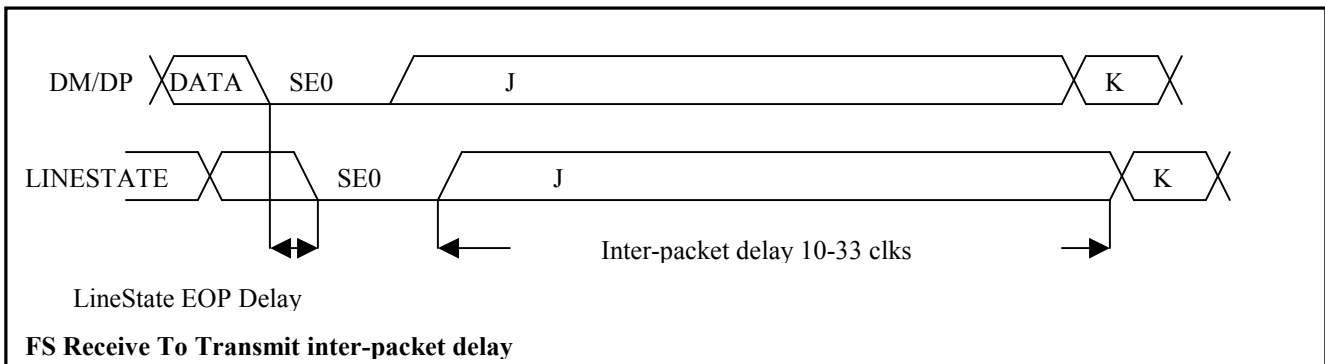


SMS2300 TX End Delay is 18 bit times to 40 bit times.  
SMS2300 RX Start Delay is 40 bit times to 63 bit times.

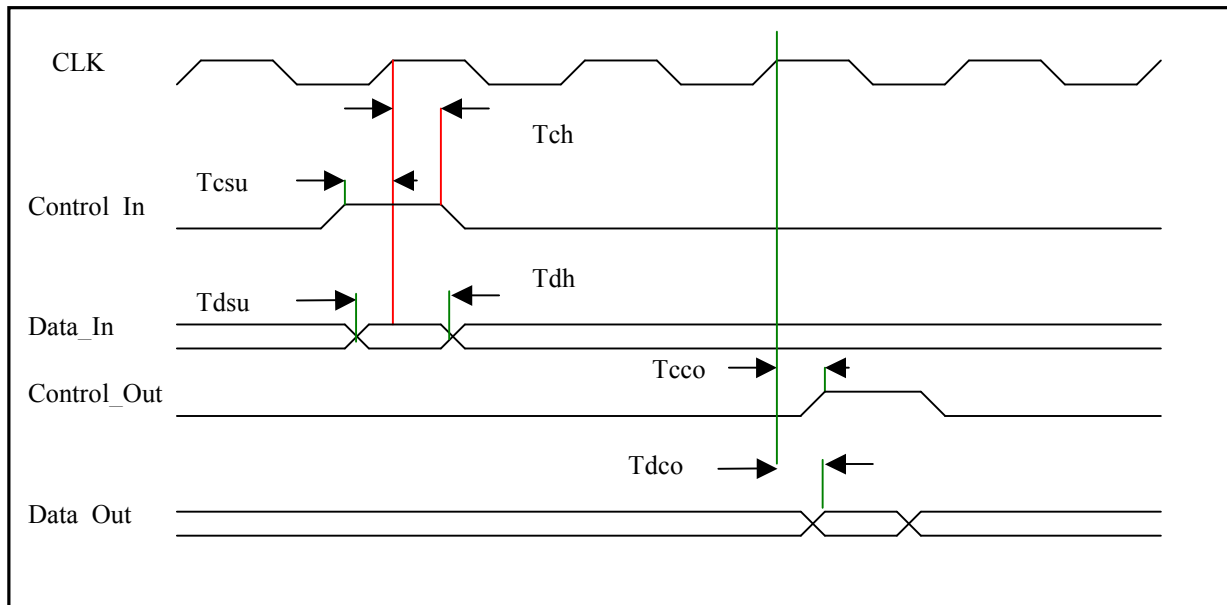


The SIE must utilize the LineState to determine the EOP transition from SE0 to the J-State.

FS SIE Decision time must be between 7 to 9 clks to ensure that 6.5 bit times FS inter-packet gap is met.



UTMI CONTROL SIGNAL TIMING VALUES:



- Tcsu: 3ns**
- Tch: 1ns**
- Tdsu: 3ns**
- Tdh: 1ns**
- Tcco: 2ns min, 4ns max**
- Tdco: 2ns min, 4ns max**