

S5N8950

G.dmt ADSL Transceiver for CO and CPE

Preliminary Information Rev.0.1

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1 General Description

The **S5N8950** is an optimized chip of ADSL transceiver supporting G.992.1, G.992.2 and T1.413, and provides a total chipset solution with AFE chip (**S5N8951**) for both CO and CPE applications. The **S5N8950** consists of the ATM framer, DMT modem, and DSP core. It supports various interfaces of UTOPIA level 2 for ATM data and serial interface for Non-ATM data, and host controller compatible with Motorola and Intel. It is fully compatible with G.Lite and G.dmt standards to satisfy interoperability with compatible other chipsets. For CO/CPE application, evaluation tool kit shall be provided.

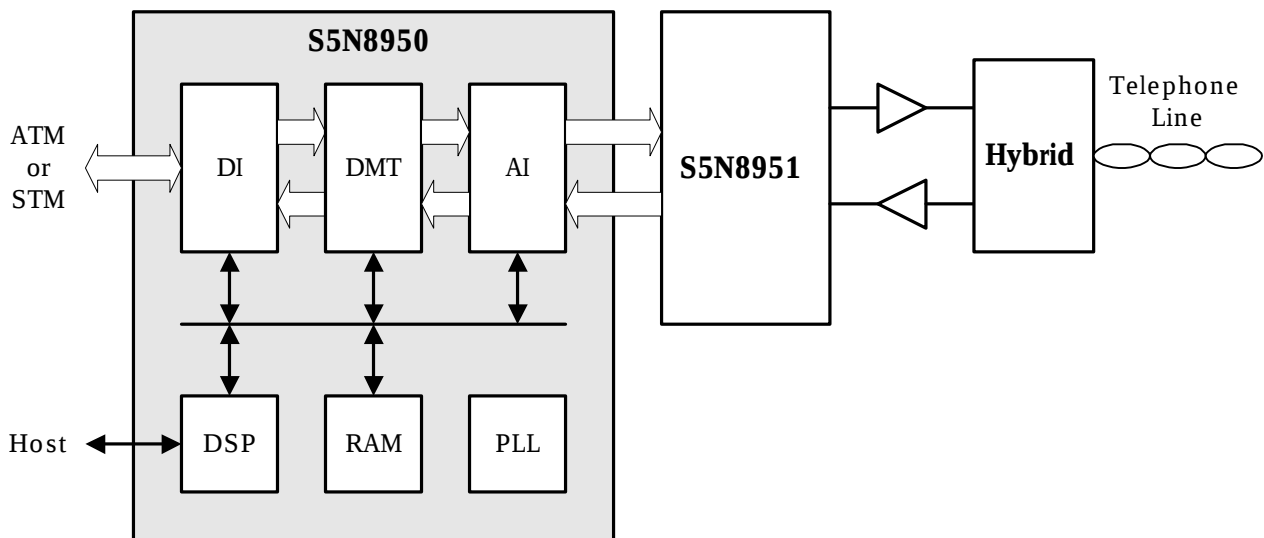


Figure 1: ADSL Transceiver configuration for S5N8950.

2 Main Features

- Power and performance optimized single port DMT.
- Supports ITU-T G.992.1 (G.dmt) , G.992.2 (G.Lite) and T1.413 standards.
- STM serial interface and ATM UTOPIA level 1 and level 2 interface.
- Supports both the FDM-based and EC-based DMT line coding.
- Analog and digital PLL modes.
- Adaptive frequency and time domain equalizing.
- Provides over 10 Mbps downstream data rate and over 640 Kbps upstream data rate
- Flexible host interface for Motorola and Intel Controller
- Reed-Solomon Forward Error Correction with Interleaving.
- 3-D trellis coding and Viterbi algorithm.
- Supports all of the framing modes.
- Supports Rate Adaptive Mode.
- 12-Bit ADC and DAC with Over-sampling
- Downloadable coefficients of rate-conversion filter banks.
- Low power consumption (less than 0.5 Watt).
- Power management
- Self-diagnostics
- 0.18 um 1.8 V CMOS technology.
- 3.3 V external interface.
- Operation Temperature : -40 C to 85 C
- Low Cost & Compact Package (160 QFP)

3 External Pin Description

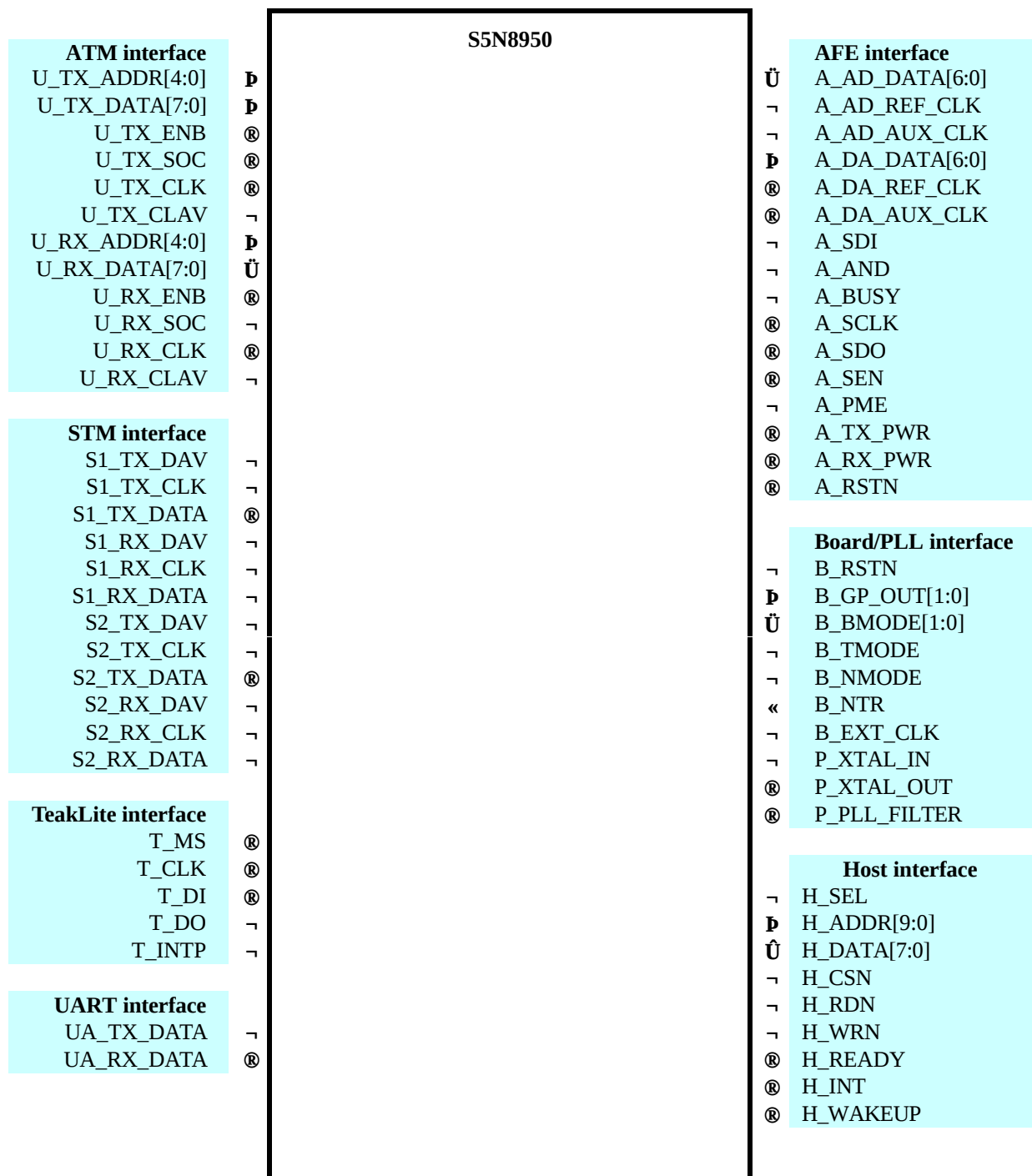


Figure 2: Pin diagram

U_RX_DATA_5	121	U_RX_DATA_4	120	U_RX_DATA_3	119	U_RX_DATA_2	118	U_RX_DATA_1	117	U_TX_CLK	116	VDD11	115	U_TX_CLAV	114	VSS11	113	U_TX_DATA_7	112	U_RX_DATA_0	111	U_TX_DATA_6	110	U_TX_SOC	109	U_TX_DATA_4	108	U_TX_DATA_5	107	T_INTP	106	U_TX_DATA_3	105	T_MS	104	U_TX_ENB	103	U_TX_DATA_2	102	VDD3P	101	T_DO	100	VSS3P	99	H_INT	98	U_TX_DATA_1	97	U_TX_DATA_0	96	U_TX_ADDR_4	95	U_TX_ADDR_3	94	VSS11	93	U_TX_ADDR_2	92	VDD11	91	U_TX_ADDR_1	90	B_EXT_CLK	89	U_TX_ADDR_0	88	VSS30	87	B_NTR	86	VDD30	85	T_CLK	84	B_GP_OUT_1	83	T_DI	82	B_GP_OUT_0	81	A_SDI	80	A_AND	79	A_SEN	78	VSS11	77	VDD11	76	A_SDO	75	A_SCLK	74	A_BUSY	73	A_RX_PWR	72	A_TX_PWR	71	A_PME	70	VSS3P	69	VDD3P	68	A_RSTN	67	A_AD_AUX_CLK	66	A_AD_REF_CLK	65	A_AD_DATA_6	64	A_AD_DATA_5	63	A_AD_DATA_4	62	VSS11	61	VDD11	60	A_AD_DATA_3	59	A_AD_DATA_2	58	A_AD_DATA_1	57	A_AD_DATA_0	56	A_DA_AUX_CLK	55	A_DA_REF_CLK	54	VSS30	53	VDD30	52	A_DA_DATA_6	51	A_DA_DATA_5	50	A_DA_DATA_4	49	A_DA_DATA_3	48	A_DA_DATA_2	47	A_DA_DATA_1	46	VSS11	45	VDD11	44	A_AD_DATA_0	43	UA_RX_DATA	42	UA_TX_DATA	41	H_SEL	1	H_CS_N	2	H_RDN	3	VDD30	4	H_WRN	5	VSS30	6	H_ADDR_0	7	H_ADDR_1	8	B_NMODE	9	H_ADDR_2	10	H_ADDR_3	11	VDD11	12	H_ADDR_4	13	VSS11	14	H_ADDR_5	15	H_ADDR_6	16	B_TMODE	17	H_ADDR_7	18	H_ADDR_8	19	VDD30P	20	H_ADDR_9	21	VSS30P	22	H_DATA_0	23	H_DATA_1	24	B_RSTN	25	H_DATA_2	26	H_DATA_3	27	VDD11	28	H_DATA_4	29	VSS11	30	H_DATA_5	31	B_MSC_CLK	32	H_DATA_6	33	B_BMODE_0	34	H_DATA_7	35	VDD3P	36	H_READY	37	VSS3P	38	H_WAKEUP	39	B_BMODE_1	40
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Figure 3: Pin configuration

Interface Type	Mnemonic	Type	Driver	Function
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ATM interface	U_TX_ADDR[4:0]	I	PHTICD	Utopia Tx Address
	U_TX_DATA[7:0]	I	PHTICD	Utopia Tx Data
	U_TX_ENB	I	PHTICD	Utopia Tx Enable
	U_TX_SOC	I	PHTICD	Utopia Tx Start of Cell
	U_TX_CLK	I	PHTICD	Utopia Tx Clock. 25 MHz
	U_TX_CLAV	OZ	PHTOT4	Utopia Tx Cell Available
	U_RX_ADDR[4:0]	I	PHTICD	Utopia Rx Address[4:0]
	U_RX_DATA[7:0]	OZ	PHTOT4	Utopia Rx Data[7:0]
	U_RX_ENB	I	PHTICD	Utopia Rx Enable
	U_RX_SOC	OZ	PHTOT4	Utopia Rx Start of Cell
	U_RX_CLK	I	PHTICD	Utopia Rx Clock. 25 MHz
	U_RX_CLAV	OZ	PHTOT4	Utopia Rx Cell Available

STM interface	S1_TX_DAV	O	PHOB4	Serial Tx data valid signal in the 1-st STM
	S1_TX_CLK	O	PHOB4	Serial Tx clock in the 1-st STM
	S1_TX_DATA	I	PHTICD	Serial Tx data in the 1-st STM
	S1_RX_DAV	O	PHOB4	Serial Rx data valid signal in the 1-st STM
	S1_RX_CLK	O	PHOB4	Serial Rx clock in the 1-st STM
	S1_RX_DATA	O	PHOB4	Serial Rx data in the 1-st STM
	S2_TX_DAV	O	PHOB4	Serial Tx data valid signal in the 2-nd STM
	S2_TX_CLK	O	PHOB4	Serial Tx clock in the 2-nd STM
	S2_TX_DATA	I	PHTICD	Serial Tx data in the 2-nd STM
	S2_RX_DAV	O	PHOB4	Serial Rx data valid in the 2-nd STM
	S2_RX_CLK	O	PHOB4	Serial Rx clock in the 2-nd STM
	S2_RX_DATA	O	PHOB4	Serial Rx data in the 2-nd STM

Host Interface	H_SEL	I	PHTICD	Host type : [0]=Motorola / [1]= Intel	
	H_ADDR[9:0]	I	PHTICD	Host address bus	
	H_DATA[7:0]	B	PHTBCDT6SM	Host data bus	
	H_CSN	I	PHTICD	Chip selection	
	H_RDN	I	PHTICD	Motorola	Not used.
				Intel	Read enable (active low)
	H_WRN	I	PHTICD	Motorola	[0]=write enable / [1]=read enable
				Intel	Write Enable (active low)
	H_READY	OZ	PHTOT4	Motorola	Host CPU DTACK (active low)
				Intel	Host CPU Ready (active high)
	H_INT	O	PHOB4	Motorola	Interrupt IRQ (active low)
				Intel	Interrupt INT (active high)
	H_WAKEUP	O	PHOB4	Host Wakeup	

AFE interface	A_AD_DATA[6:0]	I	PHICD	ADC data for 2 phase.
	A_AD_REF_CLK	I	PHICD	ADC data reference clock for DMT b2b test
	A_AD_AUX_CLK	I	PHICD	ADC data strobe clock for DMT b2b test
	A_DA_DATA[6:0]	O	PHOB2	DAC data for 2 phase
	A_DA_REF_CLK	O	PHOB2	DAC data reference clock
	A_DA_AUX_CLK	O	PHOB2	DAC data strobe clock
	A_SDI	I	PHICU	AFE serial input data
	A_AND	I	PHICD	Audible noise detection (active high)
	A_BUSY	I	PHICD	AFE busy (active high)
	A_SCLK	O	PHOB2	AFE serial clock
	A_SDO	O	PHOB2	AFE serial output data
	A_SEN	O	PHOB2	AFE serial enable (active low)
	A_PME	O	PHICD	AFE power management enable
	A_TX_PWR	O	PHOB2	TX line driver power enable (active high)
	A_RX_PWR	O	PHOB2	RX line driver power enable (active high)
	A_RSTN	O	PHOB2	AFE reset (active low)

Board / PLL interface	B_RSTN	I	PHIS	System reset (active low)
	B_GP_OUT[1:0]	O	PHOB2	General purpose output
	B_BMODE[1:0]	I	PHIC	TeakLite boot mode selection [0] = simple reset [1] = boot from Host CPU (normal mode) [2] = boot from JTAG (emulation mode) [3] = self-booting (test mode)
	B_TMODE	I	PHIC	Test Mode Enable (DSP view, Scan Test, Memory BIST, PLL Test) [0] Normal, [1] Test Mode
	B_NMODE	I	PHIC	NAND tree test mode [0] Normal, [1] NAND tree test mode
	B_NTR	B	PHTBCT4	ATM Network Timing Reference
	B_EXT_CLK	I	PHIC	external clock
	B_MSC_CLK	I	PHIC	misc. clock for BIRA test
	P_XTAL_IN	I	PHSOSCM26	XTAL input for clock.
	P_XTAL_OUT	O		XTAL output for clock.
	P_PLL_FILTER	O	POAR50_ABB	Internal PLL pump out connected to filter.

TeakLite Interface	T_MS	I	PHTICD	TeakLite JTAG test mode select
	T_CLK	I	PHTICD	TeakLite JTAG test clock
	T_DI	I	PHTICD	TeakLite JTAG test input data
	T_DO	OZ	PHTOT4	TeakLite JTAG test output data
	T_INTF	O	PHOB4	TeakLite TJAM interrupt to host

UART interface	UA_TX_DATA	O	PHOB4	UART Rx data
	UA_RX_DATA	I	PHTICD	UART Rx data

Power interface	P_VDD18A2	I	VDD1T_ABB	Digital power supply
	P_VSS18A2	I	VSS1T_ABB	Digital ground
	P_VDD18A1	I	VDD1T_ADD	Analog power supply
	P_VSS18A1	I	VSS1T_ABB	Analog ground
	P_VBBA	I	VBB1_ABB	bulk ground
	P_VDD1I	I	VDD1I	1.8 V internal power.
	P_VSS1I	I	VSS1I	1.8 V internal ground
	P_VDD3O	I	VDD3O	3.3 V output-driver power
	P_VSS3O	I	VSS3O	3.3 V output-driver ground
	P_VDD3P	I	VDD3P	3.3 V pre-driver power
	P_VSS3P	I	VSS3P	3.3 V pre-driver ground
	P_VDD3OP	I	VDD3OP	3.3 V output driver and pre-driver power
	P_VSS3OP	I	VSS3OP	3.3 V output driver and pre-driver ground

Table 1: Pin configuration

Pad	I/O	Description
PHTIC	I	5V tolerant for 3.3 V interface LVC MOS level input buffer
PHTICD	I	5V tolerant for 3.3 V interface LVC MOS level input buffer with pull-down register.
PHTOT4	OZ	5V tolerant for 3.3 V interface tri-state output buffer driving 4 mA
PHOB4	O	3.3 V LVC MOS normal output buffer driving 4 mA
PHOB2	O	3.3 V LVC MOS normal output buffer driving 2 mA
PHIC	I	3.3 V interface LVC MOS level input buffer
PHICD	I	3.3 V interface LVC MOS level input buffer with pull-down register.
PHICU	I	3.3 V interface LVC MOS level input buffer with pull-up resistor
PHICD	I	3.3 V interface LVC MOS level input buffer with pull-down resistor
PHIS	I	3.3 V interface LVC MOS Schmitt-trigger level input buffer
PHTBCT4	B	3.3 V interface 5 V tolerant LVC MOS level tri-state bi-directional buffer driving 4 mA
PHTBCT6SM	B	3.3 V interface 5 V tolerant LVC MOS level tri-state bi-directional buffer driving 6 mA medium slew rate control
PHTBCDT6SM	B	3.3 V interface 5 V tolerant LVC MOS level tri-state bi-directional buffer driving 6 mA medium slew rate control with pull-down register.
POAR50_ABB	O	Analog normal output pad for 1.8 V interface with resistor 50 Ohm and separated bulk bias
PHSOSCM26	I/O	Oscillator cell with enable and feedback resistor.
VDD1T_ABB	I	Power, 1.8 V total with separate bulk bias
VSS1T_ABB	I	Ground, 1.8 V total with separate bulk bias
VBB1_ABB	I	Ground, 1.8 V bulk bias
VDD1I	I	VDD for 1.8 V internal power
VSS1I	I	VSS for 1.8 V internal power
VDD3O	I	VDD for 3.3 V output driver power
VSS3O	I	VSS for 3.3 V output driver power
VDD3P	I	VDD for 3.3 V pre- driver power
VSS3P	I	VSS for 3.3 V pre- driver power
VDD3OP	I	VDD for 3.3 V output driver and pre- driver power
VSS3OP	I	VSS for 3.3 V output driver and pre- driver power

Table 2: Pad description

4 Functional Description

The G.dmt ADSL transceiver consists of two main chips; G.dmt ADSL transceiver chip (S5N8950) and Analog Front End chip (S5N8951). The AFE provides an analog interface with line driver and hybrid components to connect the PSTN. The G.dmt ADSL transceiver provides all the digital functional as depicted in Figure 4.

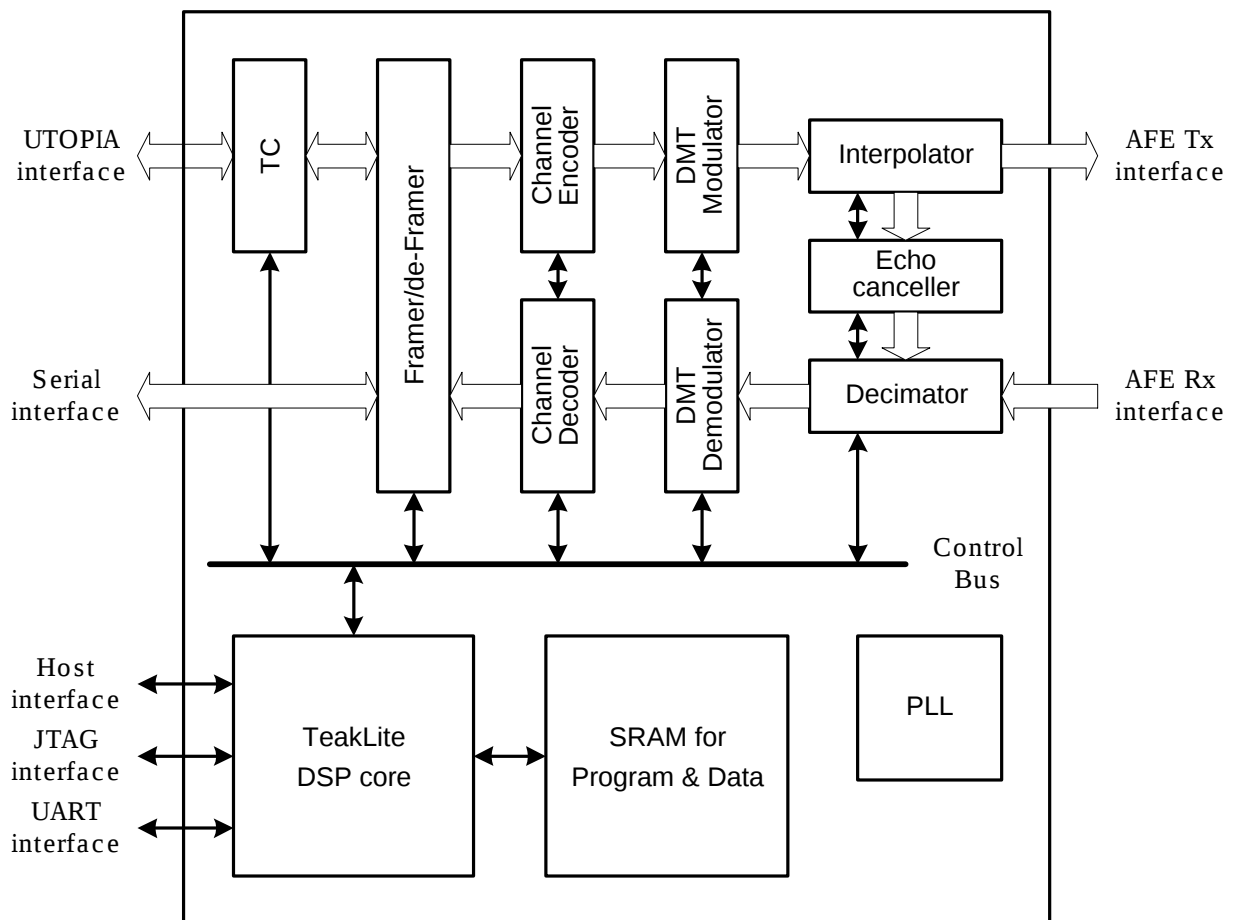


Figure 4: Block diagram

The input bit stream is divided into bit slices and they are fed into the QAM, which are allocated to 256 sub-channels according to the bit loading table. The bit slices are then converted to frequency-domain complex samples by the QAM encoder. The 256 complex samples are changed to 512 time-domain samples by IFFT. The Tx filter performs band separation and interpolation functions.

The received signals are attenuated and distorted in terms of both phase and amplitude. PLL fixes the phase errors within 4 samples using the 276 kHz pilot tone transmitted from the CO side. The ones over 4



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samples are fixed by the sync recovery algorithm using a known synchronization symbol. The TEQ is a filter that adaptively alters the channel so that the impulse response is reduced to the length of the cyclic prefix which will be removed prior to FFT. The FEQ is a one tap complex adaptive filter for each sub-channel, which adjusts the gains and phases of the received signals. The equalizers are adaptively updated due to the transmission channel environment.

In FDM-based DMT modulation, the frequency band, 0 to 1.104 MHz, is divided into 256 equi-spaced sub-channels, of which 26 KHz (#6) to 134 KHz (#31) is allocated for the upstream, and 142 KHz (#33) to 1.100 MHz (#255) for the downstream. The Nyquist rate, therefore, should be 2.208 MHz (276kHz).

DMT inherently transmits an optimized time-variable spectrum. This spectrum is adjusted according to the desired data rate and the transmission characteristics (transfer function and noise spectrum) on each and every sub-channel. For this, CO and CPE transmit 128.4 KHz wide tone downstream and upstream respectively to each other during initialization. They measure the quality of each of these received tones and then decided whether a tone has sufficient quality to be used for further transmission and, if so, how much data this tone should carry relative to the other tones that are used. They inform the bit loading result to each other.

5 I/O Timing Description

5.1 AFE Data Interface Timing Information

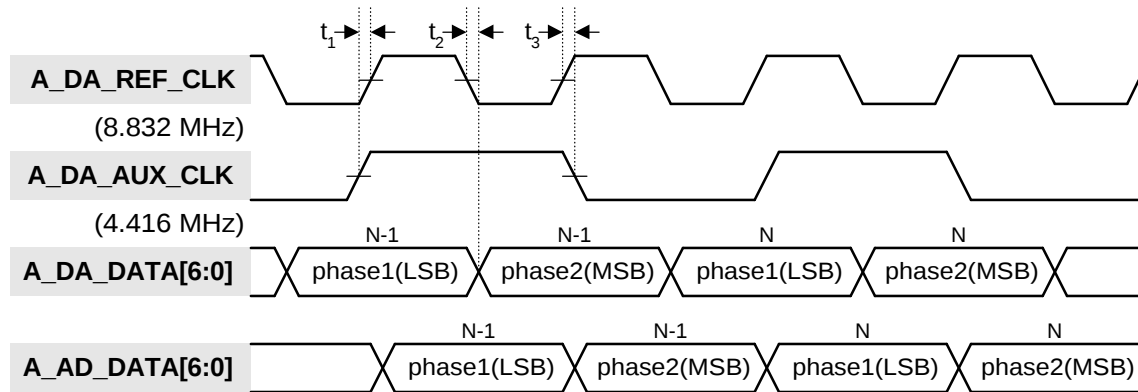


Table 3: AFE data interface timing diagram.

Parameter	Description	Min	Max	Unit
t_1	A_DA_AUX_CLK setup to A_DA_REF_CLK $\uparrow$		10	§ Å
t_2	DATA delay after A_DA_REF_CLK $\downarrow$		10	§ Å
t_3	A_DA_AUX_CLK hold to A_DA_REF_CLK $\uparrow$		10	§ Å

Table 4: AFE data interface timing table.

5.2 AFE Control Interface Timing Information

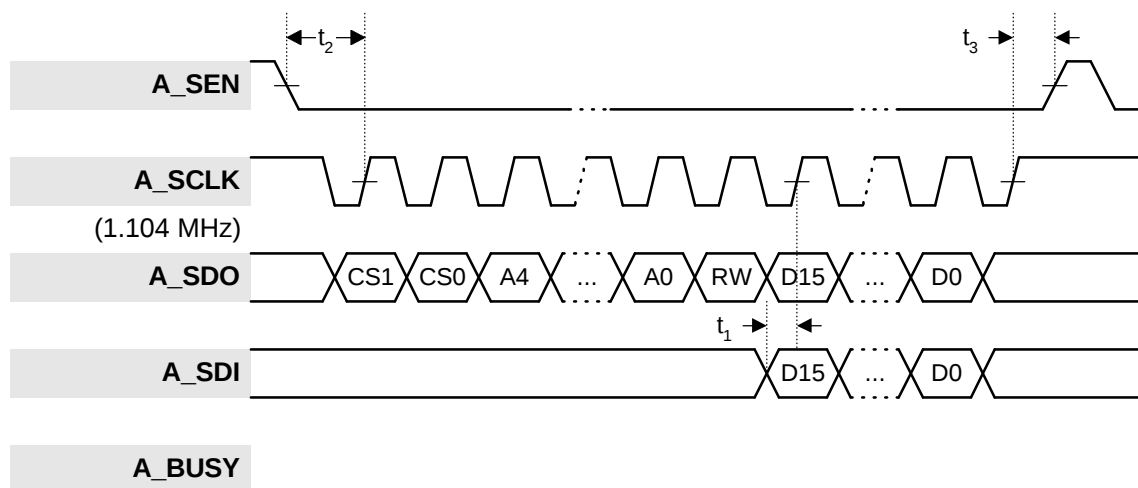


Figure 5: AFE control interface timing diagram.

Parameter	Description	Min	Max	Unit
t_1	A_SDI setup to A_SCLK $\uparrow$	30		μs
t_2	A_SEN $\downarrow$ before A_SCLK $\uparrow$	30		μs
t_3	A_SEN $\downarrow$ from A_SCLK $\uparrow$	15		μs

Table 5: AFE control interface timing table.

5.3 Motorola Read Cycle Timing Information

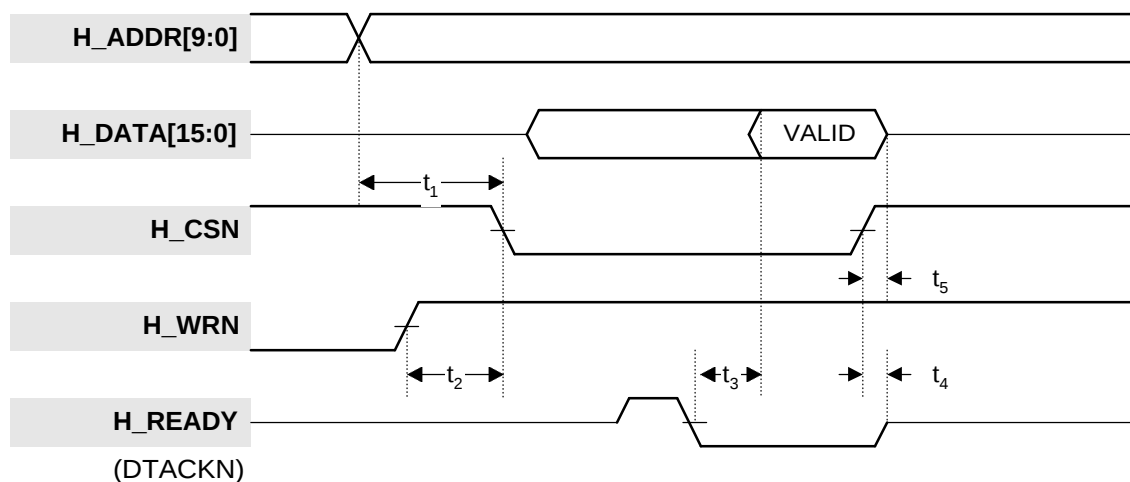


Figure 6: Motorola read cycle timing diagram.

Parameter	Description	Min	Max	Unit
t_1	H_ADDR setup to H_CSN $\downarrow$	0		μs
t_2	H_WRN $\uparrow$ before H_CSN $\downarrow$	0		μs
t_3	H_DATA valid from H_READY $\downarrow$		10	μs
t_4	H_READY hi-Z from H_CSN $\uparrow$	1	5	μs
t_5	H_DATA hold after H_CSN $\uparrow$		5	μs

Table 6: Motorola read cycle timing table.

5.4 Motorola Write Cycle Timing Information

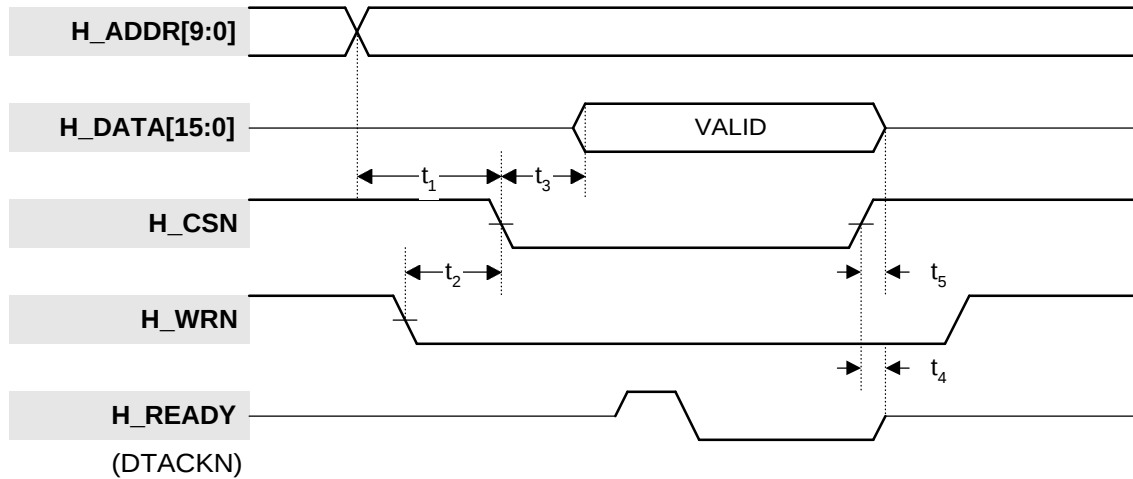


Figure 7: Motorola write cycle timing diagram.

Parameter	Description	Min	Max	Unit
t_1	H_ADDR setup to H_CSN ↓	0		§ Å
t_2	H_WRN ↓ before H_CSN ↓	0		§ Å
t_3	H_DATA valid from H_READY ↓		50	§ Å
t_4	H_READY hi-Z from H_CSN ↑	1	5	§ Å
t_5	H_DATA hold after H_CSN ↑	5		§ Å

Table 7: Motorola write cycle timing table.

5.5 Intel Read Cycle Timing Information

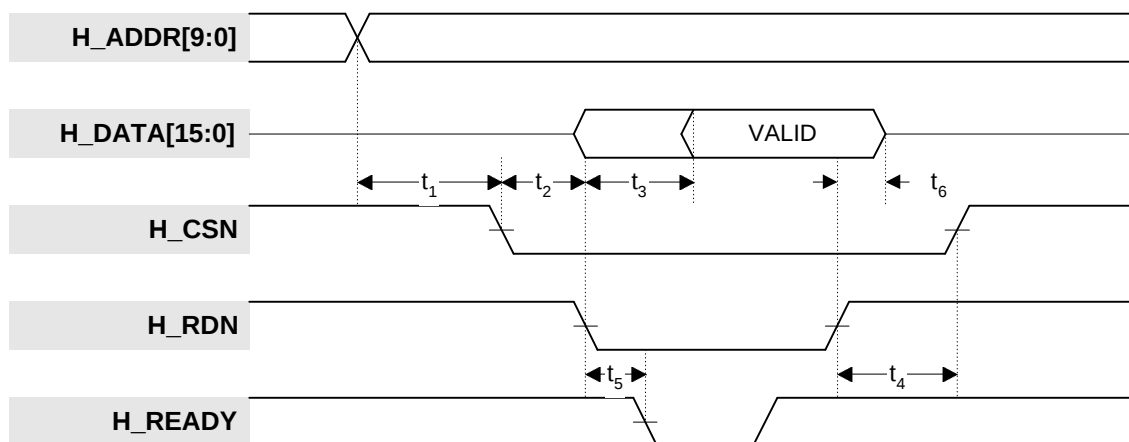


Figure 8: Intel read cycle timing diagram.

Parameter	Description	Min	Max	Unit
t_1	H_ADDR setup to H_CSN ↓	0		§ Å
t_2	H_CSN ↓ before H_RDN ↓	0		§ Å
t_3	H_DATA valid from H_RDN ↓		170	§ Å
t_4	H_CSN ↑ from H_RDN ↑	0		§ Å
t_5	H_READY ↓ from H_RDN ↓	0	20	§ Å
t_6	H_DATA hold after H_RDN ↑		5	§ Å

Table 8: Intel read cycle timing table.

5.6 Intel Write Cycle Timing Information

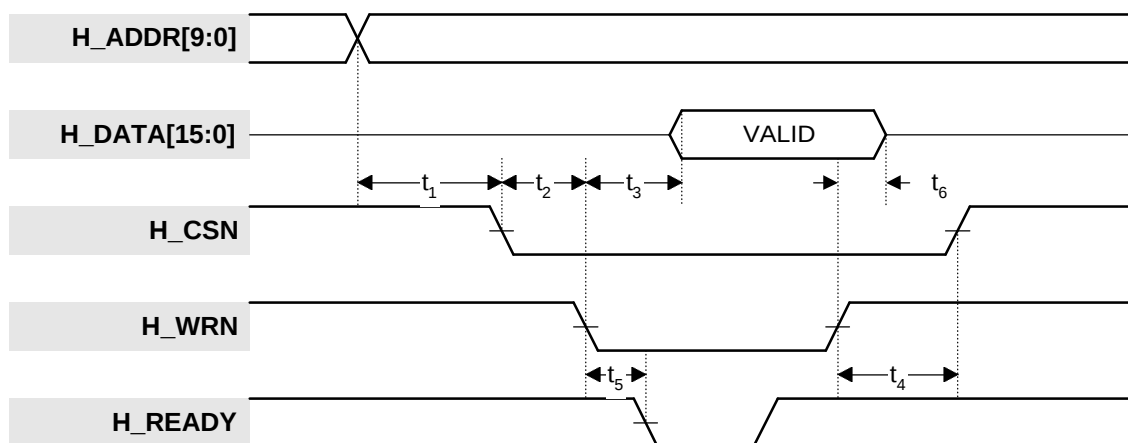


Figure 9: Intel write cycle timing diagram.

Parameter	Description	Min	Max	Unit
t_1	H_ADDR setup to H_CSN ↓	0		§ Å
t_2	H_CSN ↓ before H_WRN ↓	0		§ Å
t_3	H_DATA valid from H_WRN ↓		50	§ Å
t_4	H_CSN ↑ from H_WRN ↑	0		§ Å
t_5	H_READY ↓ from H_WRN ↓	0	20	§ Å
t_6	H_DATA hold after H_WRN ↑	5		§ Å

Table 9: Intel write cycle timing table.

5.7 Byte Mode Non-ATM Interface Timing Information.

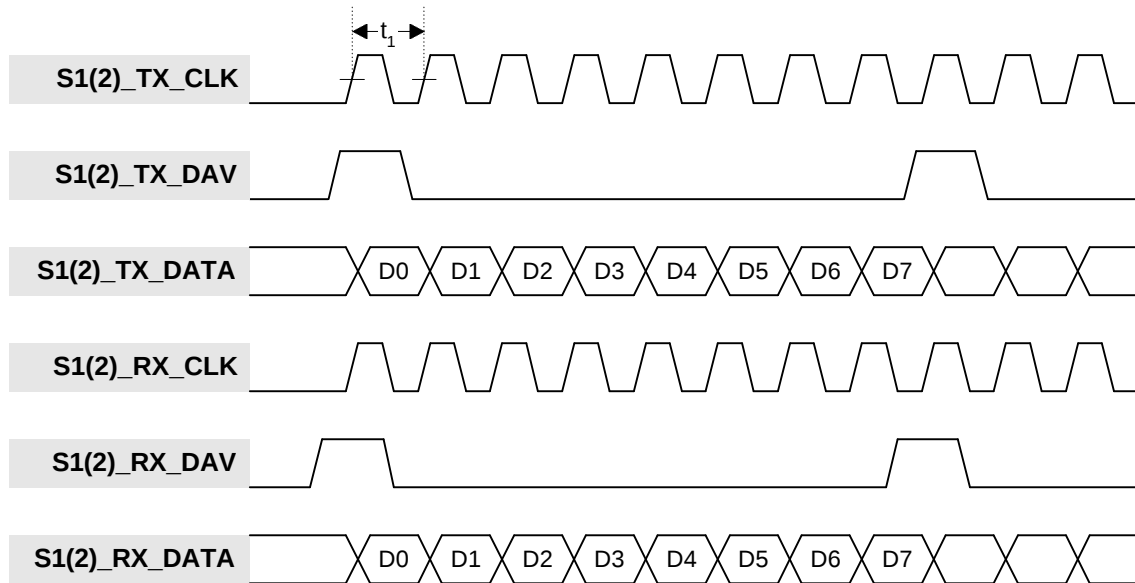


Figure 10: Byte mode non-ATM interface timing diagram.

Parameter	Description	Min	Max	Unit
t_1	S1(2)_TX_CLK frequency	1	25	MHz

Table 10: Byte mode non-ATM interface timing table.

5.8 Envelope Mode non-ATM Interface Timing Information

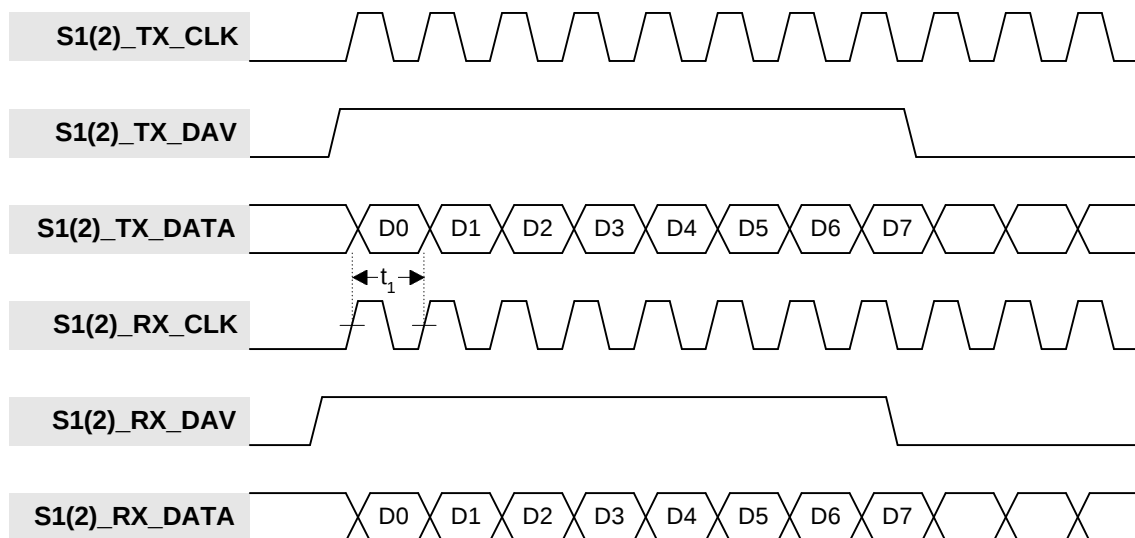


Figure 11: Envelope mode non-ATM interface timing diagram.

Parameter	Description	Min	Max	Unit
t_1	S1(2)_RX_CLK frequency	1	25	MHz

Table 11: Envelope mode non-ATM interface timing table.

5.9 UTOPIA-2 ATM Interface Timing Information

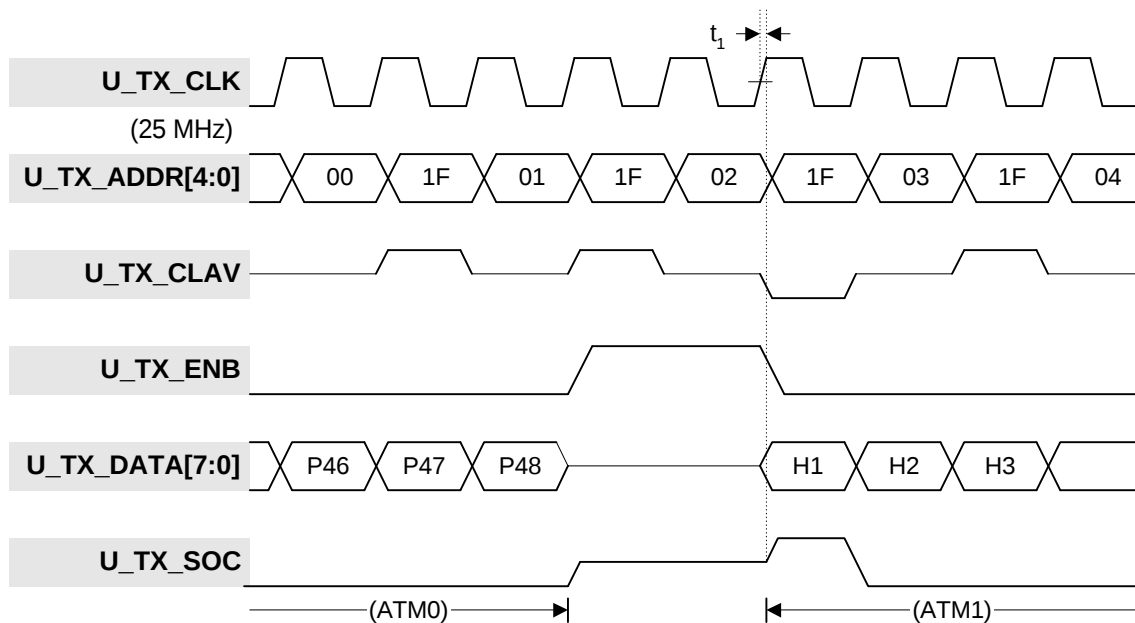


Figure 12: UTOPIA-2 ATM interface timing diagram.

Parameter	Description	Min	Max	Unit
t_1	Signal Hold after U_TX_CLK ↑	5	10	§ Å

Table 12: UTOPIA-2 ATM interface timing table.

5.10 UTOPIA-2 ATM Interface Timing Information

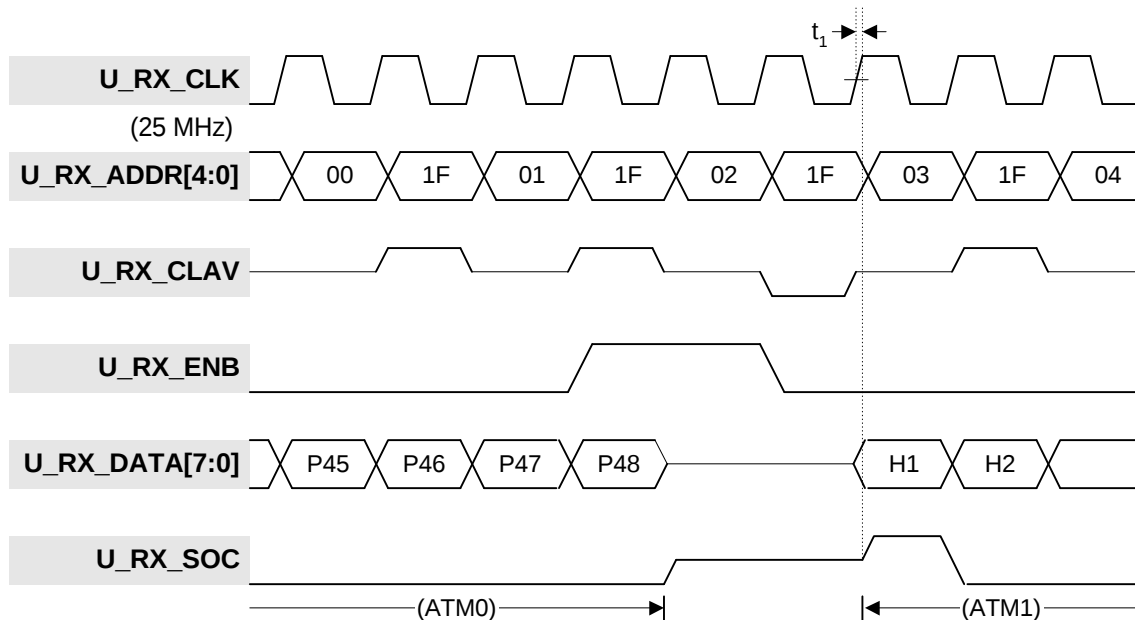


Figure 13: UTOPIA-2 ATM interface timing diagram.

Parameter	Description	Min	Max	Unit
t_1	Signal Hold after U_RX_CLK $\uparrow$	5	10	§ Å

Table 13: UTOPIA-2 ATM interface timing table.

6 Electrical Characteristics

Symbol	Parameter	Rating	Unit
I_{LATCH}	Latch-up Current	± 200	mA
T_{STG}	Storage Temperature	$-65 \sim 150$	$^{\circ}\text{C}$

Table 14: Absolute Maximum Ratings

Symbol	Parameter	Rating		Unit
V_{DD}	DC Input Voltage	1.8 V I/O	1.65 ~ 1.95	V
		3.3 V I/O	3.0 ~ 3.6	
		5V-tolerant I/O	3.0 ~ 3.6	
	Analog Core DC Supply Voltage	1.8 V Core	1.8 $\pm$ 5%	
T_A	Operating Temperature (Ambient)		-40 to 85	$^{\circ}\text{C}$

Table 15: Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit
P_D	Power Dissipation		716		W

Table 16: Power Dissipation

Symbol	Parameters	Min	Typ	Max	Unit
V_{IH}	Input High Voltage	2.0			V
V_{IL}	Input Low Voltage			0.8	
V_{OH}	Output High Voltage	2.4			
V_{OL}	Output Low Voltage			0.4	
V_T	Switching Threshold		1.4		
V_T^{+}	Schmitt Trigger, Positive-going Threshold			2.0	
V_T^{-}	Schmitt Trigger, Negative-going Threshold	0.8			μA
I_{IH}	Input High Current ($V_{IN}=V_{DD}$)	-10(10)	(33)	10(60)	
I_{IL}	Input Low Current ($V_{IN}=V_{SS}$)	-10(-60)	(-33)	10(-10)	
I_{OZ}	Tri-state Output Leakage Current	-10		10	
I_{DD}	Quiescent Supply Current			100	pF
C_{IN}	Input Capacitance			4	
C_{OUT}	Output Capacitance			4	

NOTE: () – Input buffer with pull-down

Table 17: DC Characteristics