Team09 Lab3 Report

b11901003 方嘉麟
b11901091 鄭淳芸
b11901148 李承彥

1. File Structure

```
team09_lab3
| - team09_lab3_report.pdf
| - src/
    | - DE2_115/
        | - DE2_115.sv
        | - Debounce.sv
        | - SevenHexDecoder.sv
    | - Altpll/
        | - Altpll.v
    | - AudDSP.sv
    | - AudPlayer.sv
    | - AudRecorder.sv
    | - AudPlayer.sv
    | - I2cInitializer.sv
    | - Top.sv
```

2. System Architecture

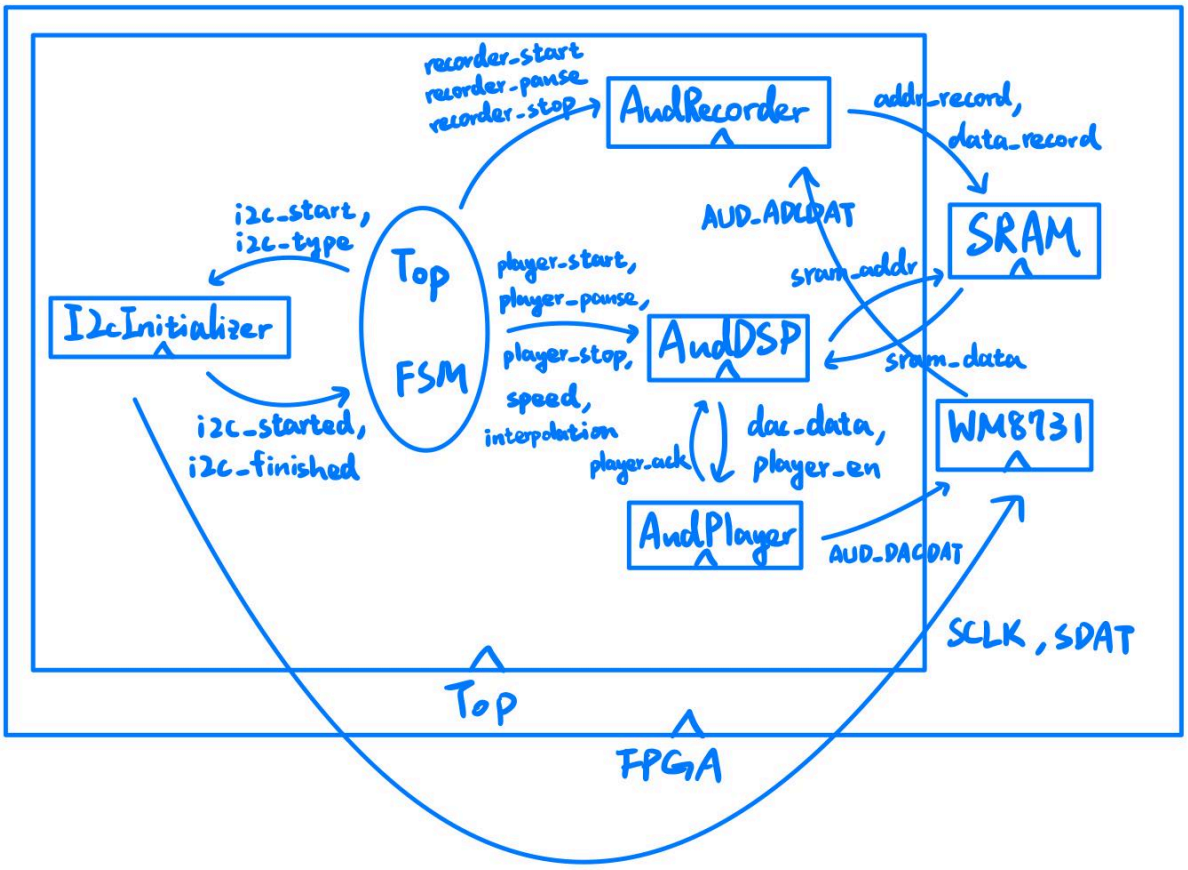


Figure 1: System Architecture

3. Hardware Scheduling
    a. FSM
        i. Top

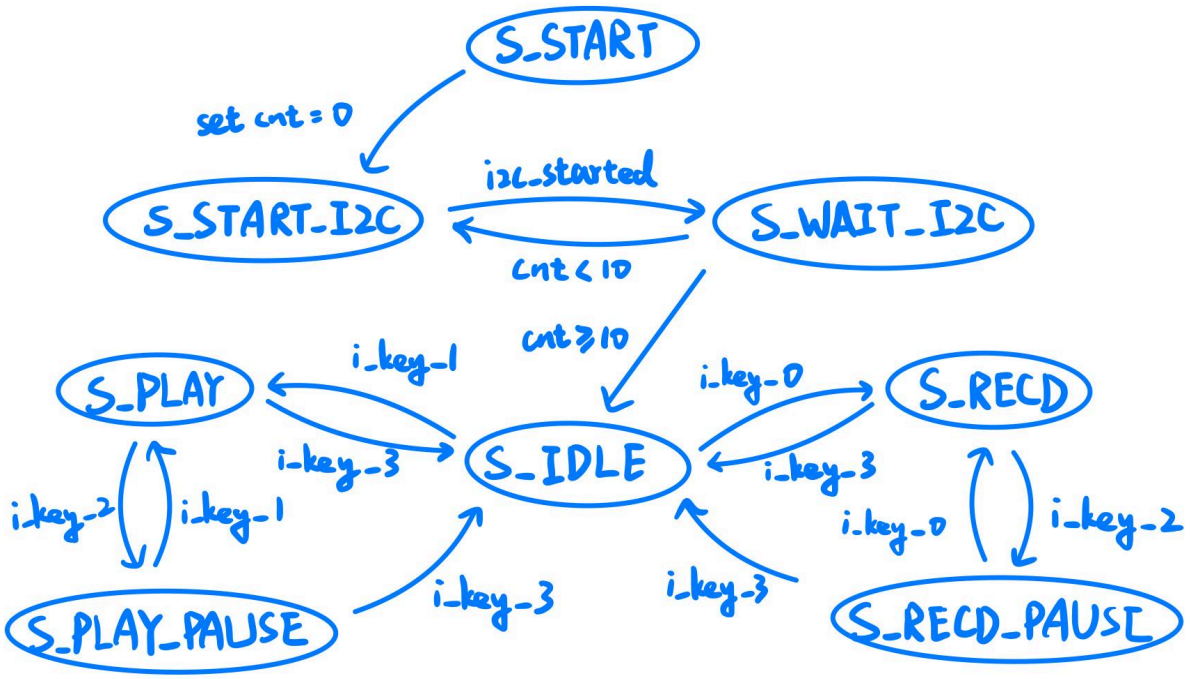


Figure 2: FSM of Top.

ii. I2cInitializer

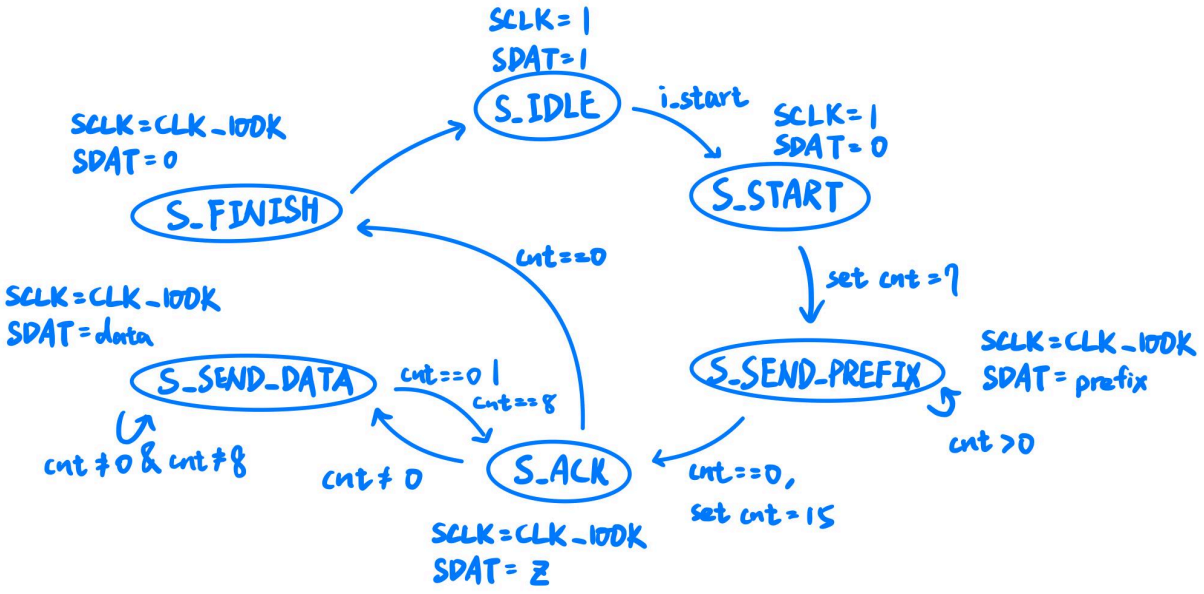


Figure 2: FSM of I2cInitializer.

iii. AudRecorder

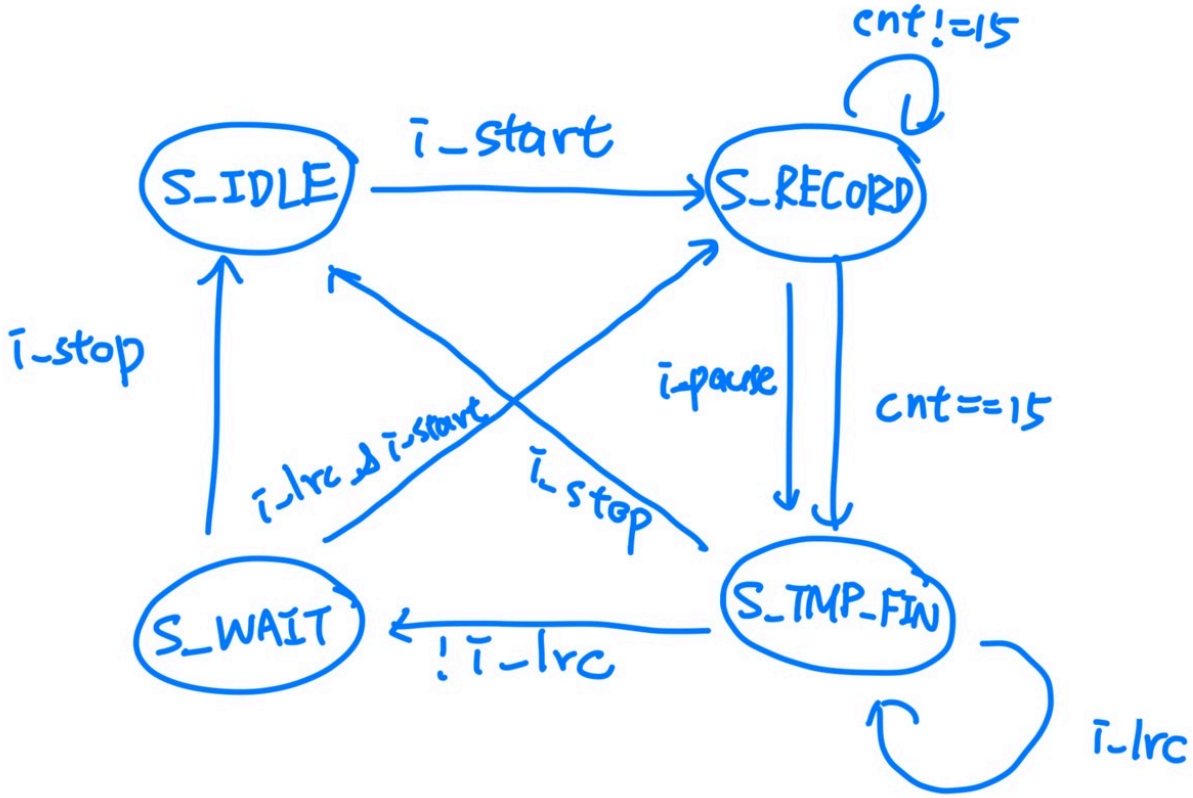


Figure 4: FSM of AudRecorder.

IDLE: set output data and SRAM address to 0 and wait for *i_start* to start recording.

RECORD: record input data for 16 cycles
TMP_FIN: temporarily pause and wait for the next i_LRC to be the opposite channel and go to WAIT.
WAIT: wait for the next i_LRC signal to be the desired channel and start recording
PAUSE: pause the recording, and keep the same SRAM address

iv. AudDSP

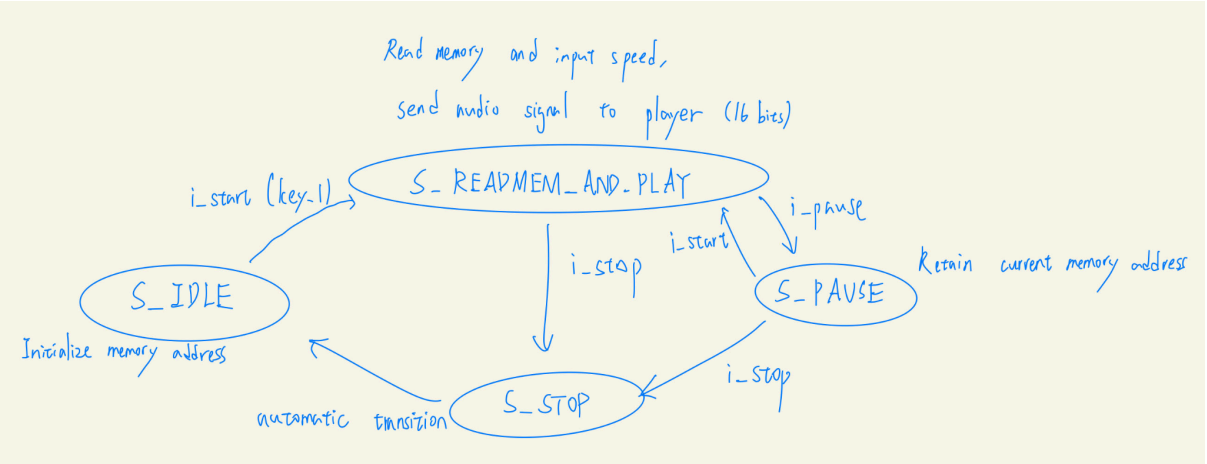
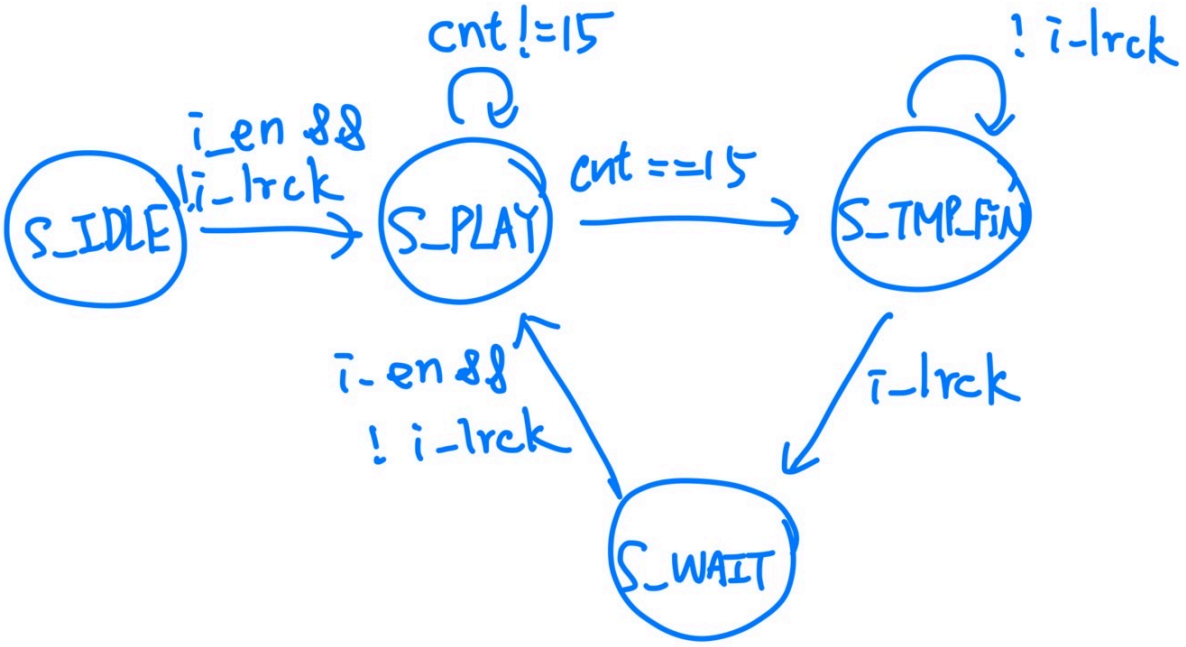


Figure 5: FSM of AudDSP

v. AudPlayer



IDLE, WAIT: wait for *i_en* and *i_LRC* to start playing and load data before switching to wait
PLAY: load input data and transfer the data into I2S format
TMP_FIN: finish the transfer of the current data and wait for the i_lrc signal to change.

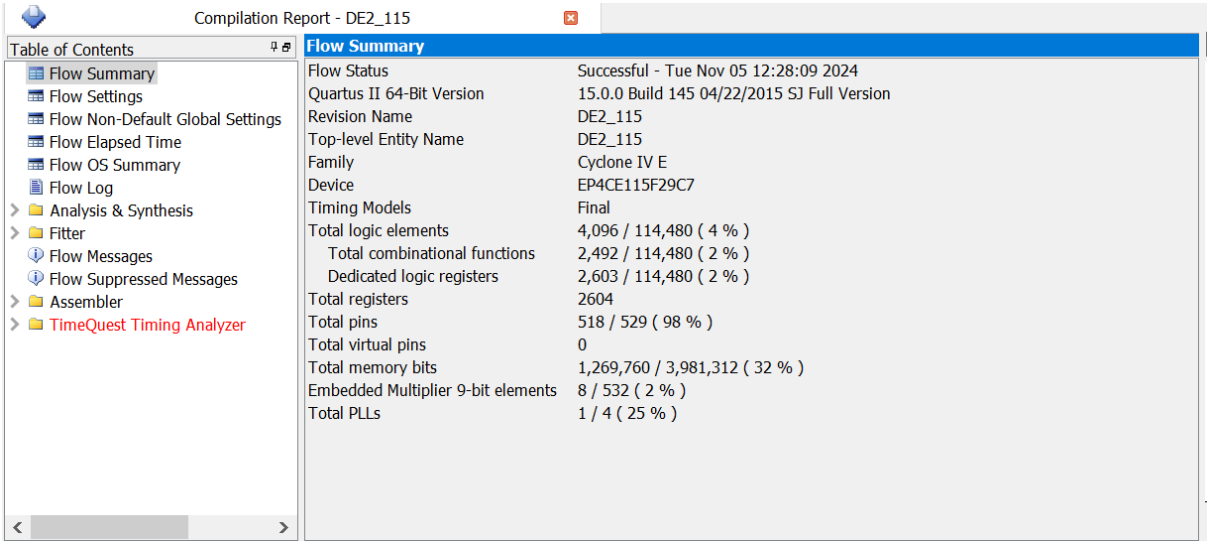
b. DSP functions

i. play speed determination:A table is established to be looked up when a speed signal is sent from DE2_115.sv -> Top.sv -> AudDSP.sv, which will then control the speed of the update of sram address and thus present the effect of playing music with different speed.

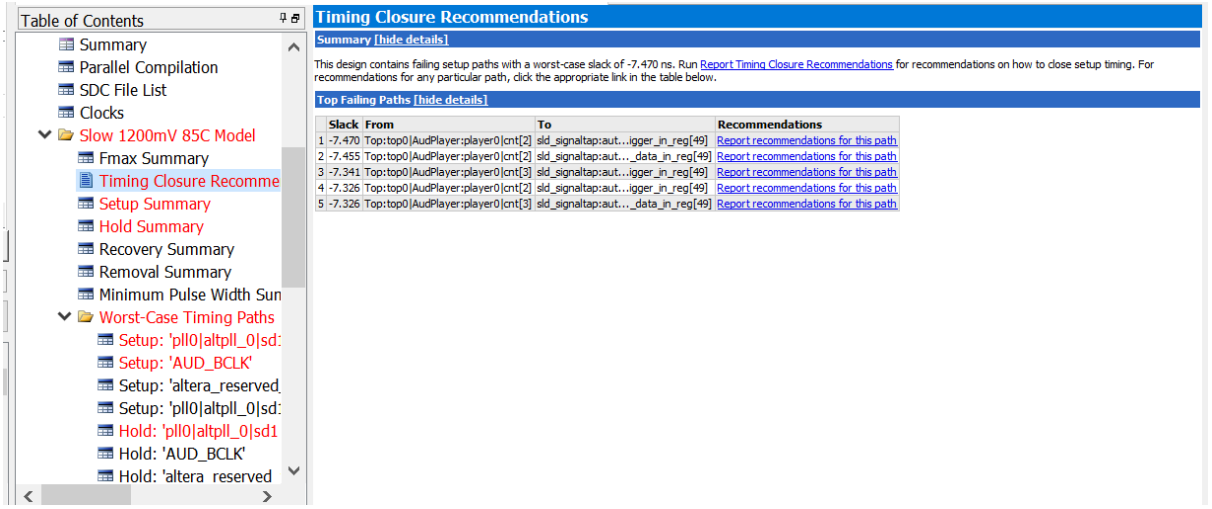
ii. interpolation method:Based on the input interpolation decision signal, different interpolation methods will be activated when playing music with slower speed. A counter will decide when to get a new audio signal and the weight of different data to form a linear combination of audio signals. 1/2 , 1/4 ,1/8 play speed are easily attained by shifting the combined signals, while 1/3 play speed is achieved by an approximated division. 1/5,1/6,1/7 play speed are using similar methods of 1/4, 1/8, 1/8 respectively and the reasons will be discussed later.

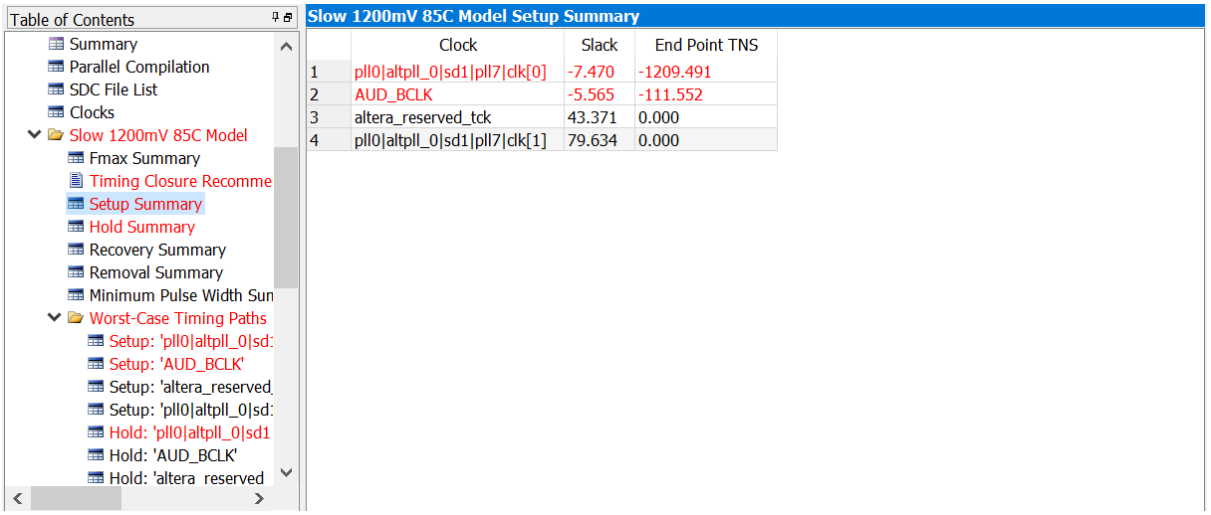
iii. communicate with player:Since signal are sent on specific moments according to I2S protocol, DSP needs to control when to enable and send right signals to the player. This is achieved by following DACLRCK and requesting for memory data right after the opposite edge of DACLRCK.

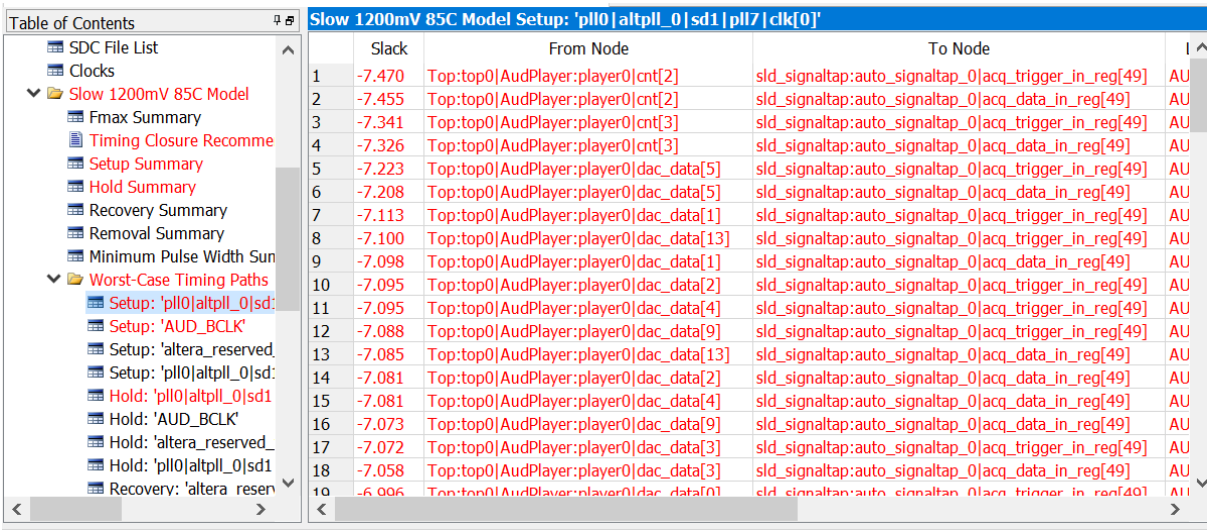
4. Fitter Summary 截圖



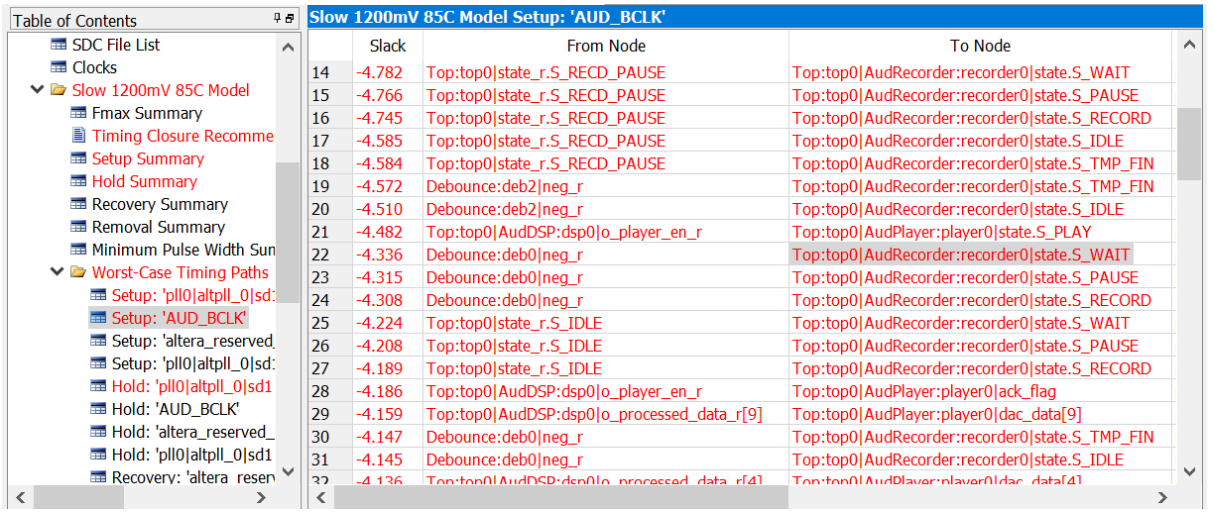
5. Timing Analyzer截圖



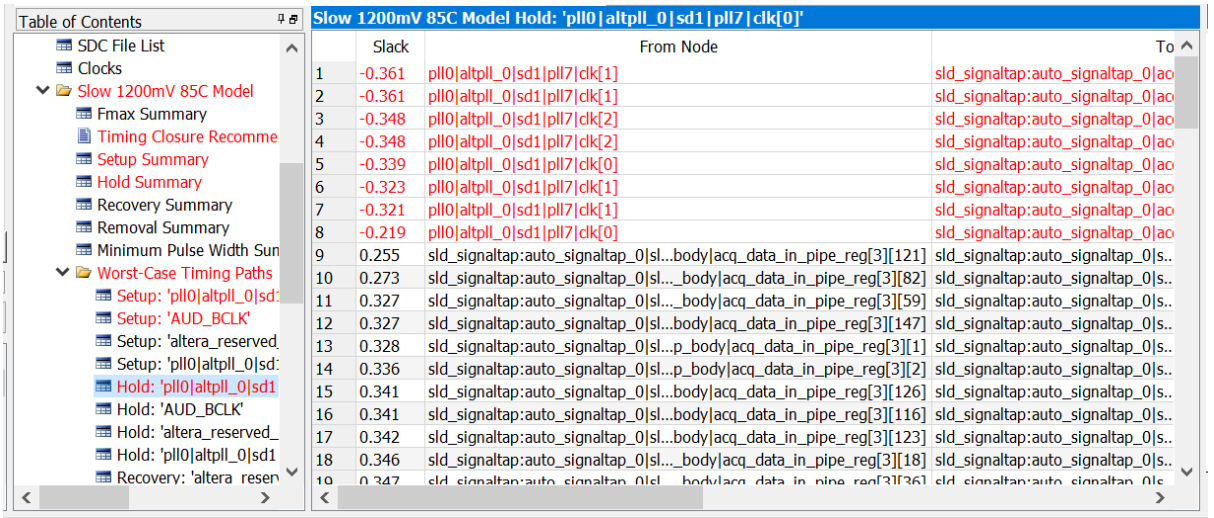




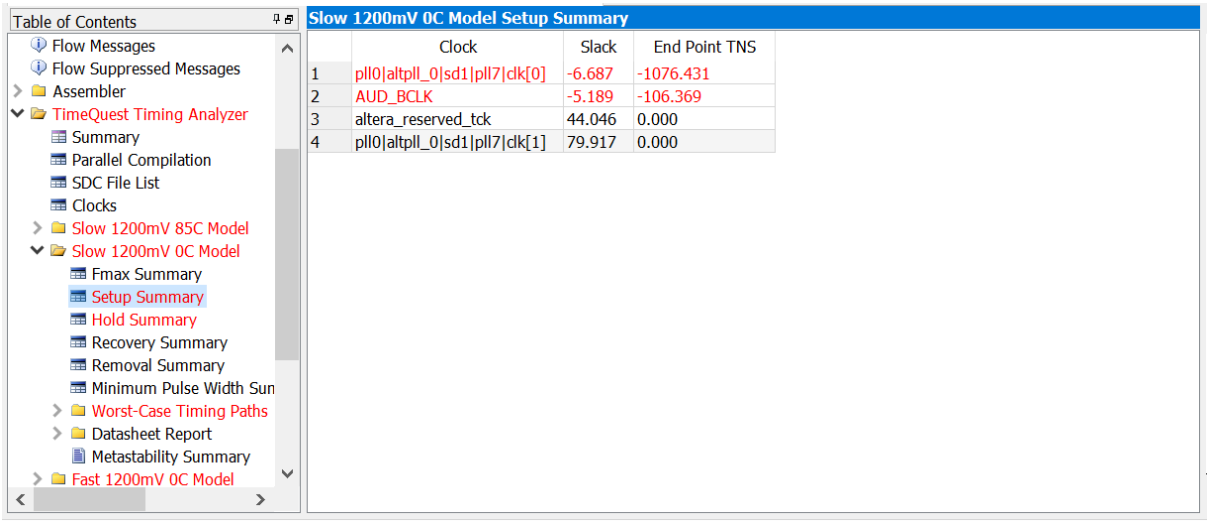
	Slack	From Node	To Node	I
1	-7.470	Top:top0|AudPlayer:player0|cnt[2]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
2	-7.455	Top:top0|AudPlayer:player0|cnt[2]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
3	-7.341	Top:top0|AudPlayer:player0|cnt[3]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
4	-7.326	Top:top0|AudPlayer:player0|cnt[3]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
5	-7.223	Top:top0|AudPlayer:player0|dac_data[5]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
6	-7.208	Top:top0|AudPlayer:player0|dac_data[5]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
7	-7.113	Top:top0|AudPlayer:player0|dac_data[1]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
8	-7.100	Top:top0|AudPlayer:player0|dac_data[13]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
9	-7.098	Top:top0|AudPlayer:player0|dac_data[1]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
10	-7.095	Top:top0|AudPlayer:player0|dac_data[2]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
11	-7.095	Top:top0|AudPlayer:player0|dac_data[4]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
12	-7.088	Top:top0|AudPlayer:player0|dac_data[9]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
13	-7.085	Top:top0|AudPlayer:player0|dac_data[13]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
14	-7.081	Top:top0|AudPlayer:player0|dac_data[2]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
15	-7.081	Top:top0|AudPlayer:player0|dac_data[4]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
16	-7.073	Top:top0|AudPlayer:player0|dac_data[9]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
17	-7.072	Top:top0|AudPlayer:player0|dac_data[3]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
18	-7.058	Top:top0|AudPlayer:player0|dac_data[3]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
19	-6.996	Top:top0|AudPlayer:player0|dac_data[0]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU



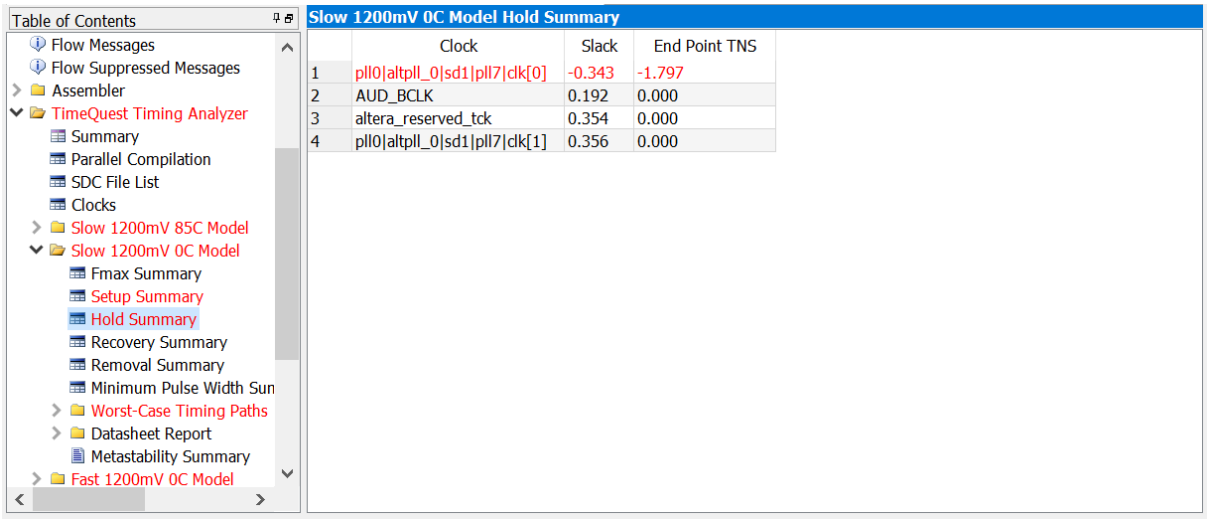
	Slack	From Node	To Node
14	-4.782	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_WAIT
15	-4.766	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_PAUSE
16	-4.745	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_RECORD
17	-4.585	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_IDLE
18	-4.584	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
19	-4.572	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
20	-4.510	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_IDLE
21	-4.482	Top:top0|AudDSP:dsp0|o_player_en_r	Top:top0|AudPlayer:player0|state.S_PLAY
22	-4.336	Debounce:deb0|neg_r	Top:top0|AudRecorder:recorder0|state.S_WAIT
23	-4.315	Debounce:deb0|neg_r	Top:top0|AudRecorder:recorder0|state.S_PAUSE
24	-4.308	Debounce:deb0|neg_r	Top:top0|AudRecorder:recorder0|state.S_RECORD
25	-4.224	Top:top0|state_r.S_IDLE	Top:top0|AudRecorder:recorder0|state.S_WAIT
26	-4.208	Top:top0|state_r.S_IDLE	Top:top0|AudRecorder:recorder0|state.S_PAUSE
27	-4.189	Top:top0|state_r.S_IDLE	Top:top0|AudRecorder:recorder0|state.S_RECORD
28	-4.186	Top:top0|AudDSP:dsp0|o_player_en_r	Top:top0|AudPlayer:player0|ack_flag
29	-4.159	Top:top0|AudDSP:dsp0|o_processed_data_r[9]	Top:top0|AudPlayer:player0|dac_data[9]
30	-4.147	Debounce:deb0|neg_r	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
31	-4.145	Debounce:deb0|neg_r	Top:top0|AudRecorder:recorder0|state.S_IDLE
32	-4.136	Top:top0|AudDSP:dsp0|o_processed_data_r[4]	Top:top0|AudPlayer:player0|dac_data[4]



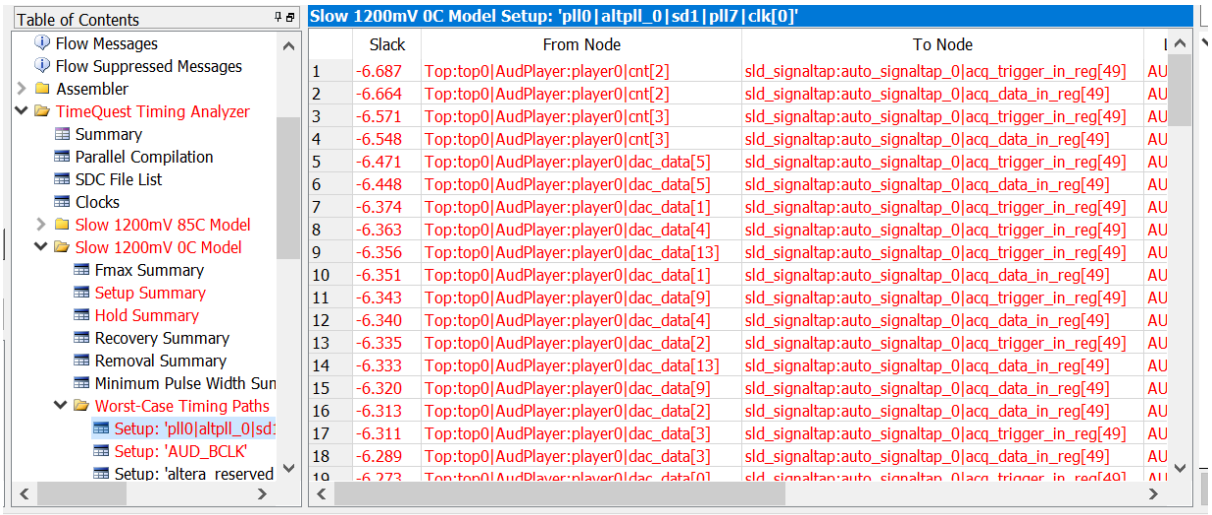
	Slack	From Node	To
1	-0.361	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
2	-0.361	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
3	-0.348	pll0|altpll_0|sd1|pll7|clk[2]	sld_signaltap:auto_signaltap_0|ac
4	-0.348	pll0|altpll_0|sd1|pll7|clk[2]	sld_signaltap:auto_signaltap_0|ac
5	-0.339	pll0|altpll_0|sd1|pll7|clk[0]	sld_signaltap:auto_signaltap_0|ac
6	-0.323	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
7	-0.321	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
8	-0.219	pll0|altpll_0|sd1|pll7|clk[0]	sld_signaltap:auto_signaltap_0|ac
9	0.255	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][121]	sld_signaltap:auto_signaltap_0|s..
10	0.273	sld_signaltap:auto_signaltap_0|sl..._body|acq_data_in_pipe_reg[3][82]	sld_signaltap:auto_signaltap_0|s..
11	0.327	sld_signaltap:auto_signaltap_0|sl..._body|acq_data_in_pipe_reg[3][59]	sld_signaltap:auto_signaltap_0|s..
12	0.327	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][147]	sld_signaltap:auto_signaltap_0|s..
13	0.328	sld_signaltap:auto_signaltap_0|sl...p_body|acq_data_in_pipe_reg[3][1]	sld_signaltap:auto_signaltap_0|s..
14	0.336	sld_signaltap:auto_signaltap_0|sl...p_body|acq_data_in_pipe_reg[3][2]	sld_signaltap:auto_signaltap_0|s..
15	0.341	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][126]	sld_signaltap:auto_signaltap_0|s..
16	0.341	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][116]	sld_signaltap:auto_signaltap_0|s..
17	0.342	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][123]	sld_signaltap:auto_signaltap_0|s..
18	0.346	sld_signaltap:auto_signaltap_0|sl..._body|acq_data_in_pipe_reg[3][18]	sld_signaltap:auto_signaltap_0|s..
19	0.347	sld_signaltap:auto_signaltap_0|sl..._body|acq_data_in_pipe_reg[3][36]	sld_signaltap:auto_signaltap_0|s



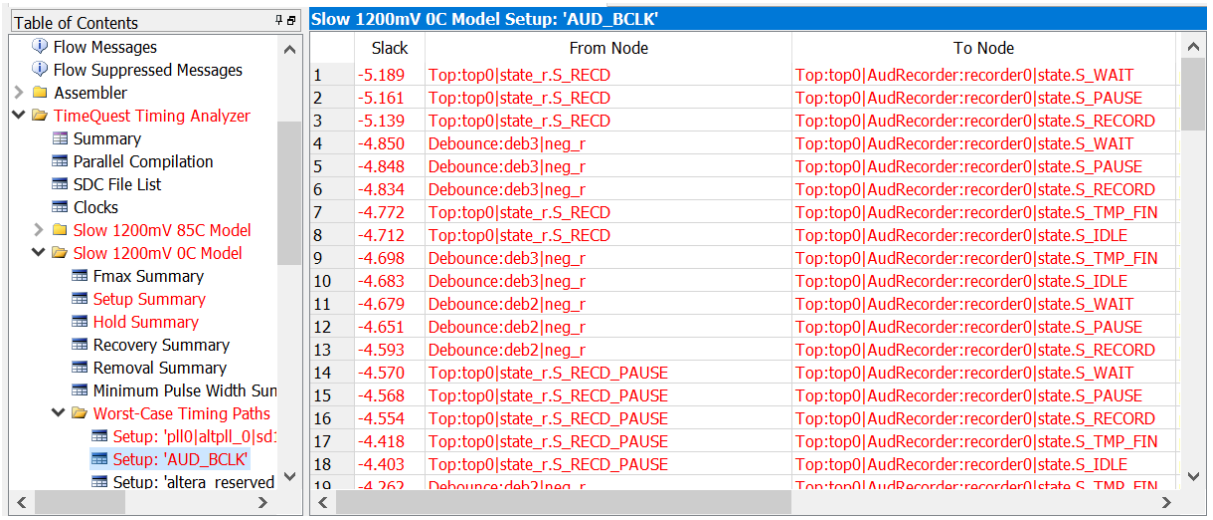
	Clock	Slack	End Point TNS
1	pll0|altpll_0|sd1|pll7|clk[0]	-6.687	-1076.431
2	AUD_BCLK	-5.189	-106.369
3	altera_reserved_tck	44.046	0.000
4	pll0|altpll_0|sd1|pll7|clk[1]	79.917	0.000



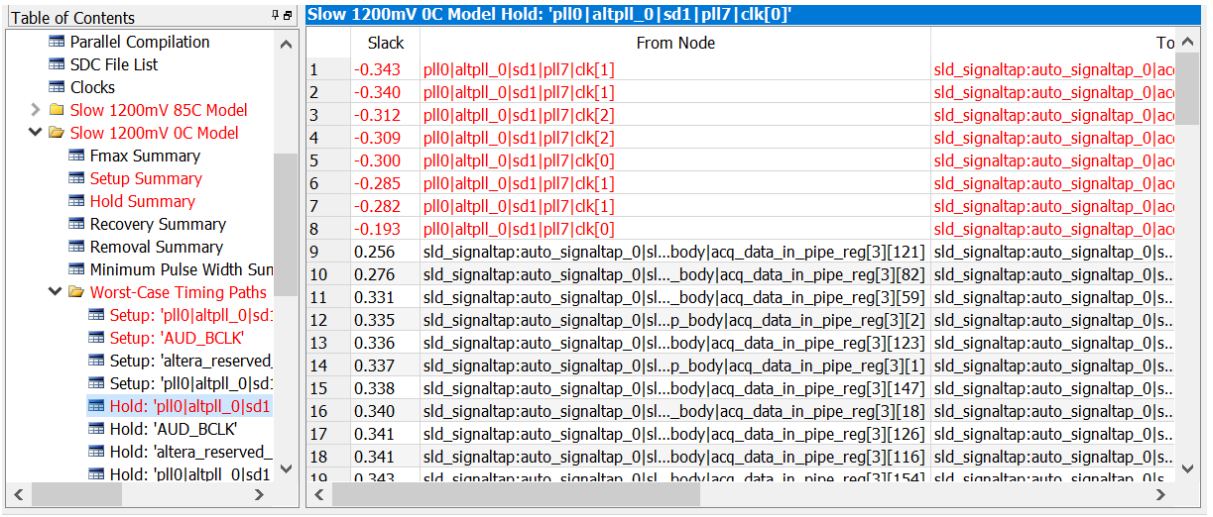
	Clock	Slack	End Point TNS
1	pll0|altpll_0|sd1|pll7|clk[0]	-0.343	-1.797
2	AUD_BCLK	0.192	0.000
3	altera_reserved_tck	0.354	0.000
4	pll0|altpll_0|sd1|pll7|clk[1]	0.356	0.000



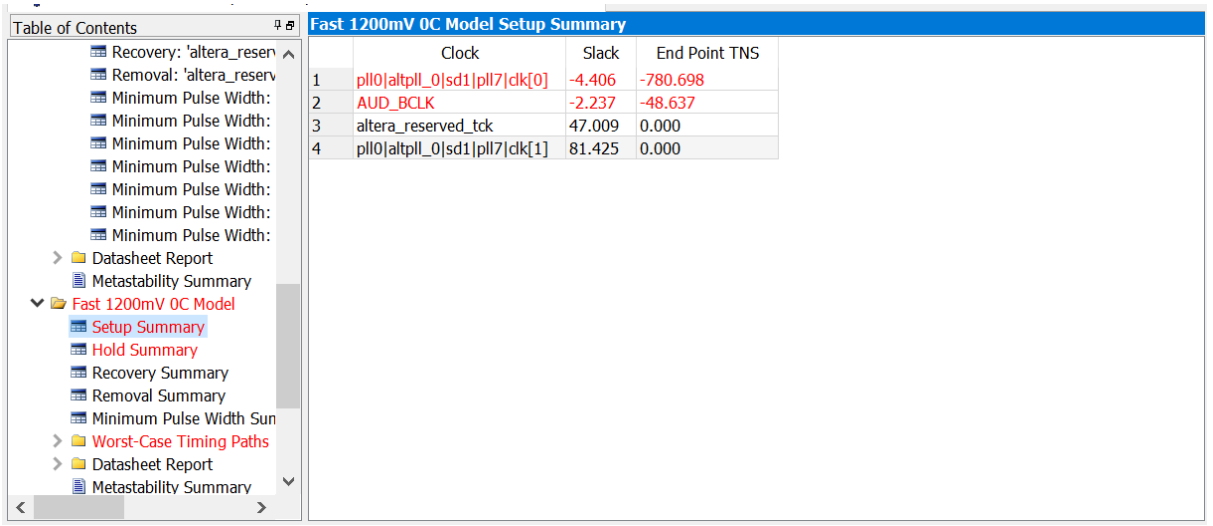
	Slack	From Node	To Node	I
1	-6.687	Top:top0|AudPlayer:player0|cnt[2]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
2	-6.664	Top:top0|AudPlayer:player0|cnt[2]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
3	-6.571	Top:top0|AudPlayer:player0|cnt[3]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
4	-6.548	Top:top0|AudPlayer:player0|cnt[3]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
5	-6.471	Top:top0|AudPlayer:player0|dac_data[5]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
6	-6.448	Top:top0|AudPlayer:player0|dac_data[5]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
7	-6.374	Top:top0|AudPlayer:player0|dac_data[1]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
8	-6.363	Top:top0|AudPlayer:player0|dac_data[4]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
9	-6.356	Top:top0|AudPlayer:player0|dac_data[13]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
10	-6.351	Top:top0|AudPlayer:player0|dac_data[1]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
11	-6.343	Top:top0|AudPlayer:player0|dac_data[9]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
12	-6.340	Top:top0|AudPlayer:player0|dac_data[4]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
13	-6.335	Top:top0|AudPlayer:player0|dac_data[2]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
14	-6.333	Top:top0|AudPlayer:player0|dac_data[13]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
15	-6.320	Top:top0|AudPlayer:player0|dac_data[9]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
16	-6.313	Top:top0|AudPlayer:player0|dac_data[2]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
17	-6.311	Top:top0|AudPlayer:player0|dac_data[3]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
18	-6.289	Top:top0|AudPlayer:player0|dac_data[3]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
19	-6.273	Top:top0|AudPlayer:player0|dac_data[0]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU



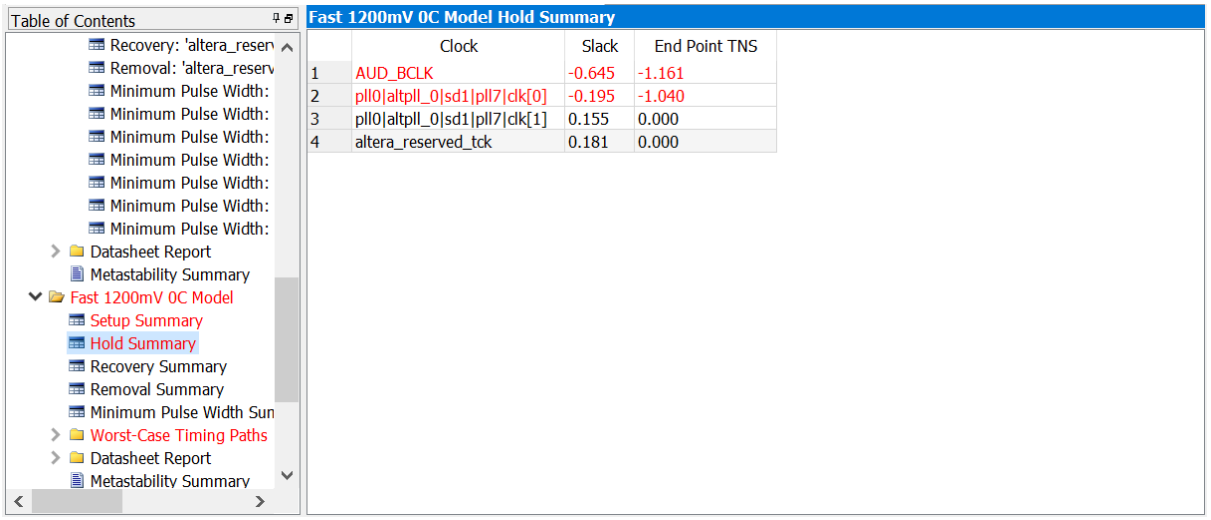
	Slack	From Node	To Node
1	-5.189	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_WAIT
2	-5.161	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_PAUSE
3	-5.139	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_RECORD
4	-4.850	Debounce:deb3|neg_r	Top:top0|AudRecorder:recorder0|state.S_WAIT
5	-4.848	Debounce:deb3|neg_r	Top:top0|AudRecorder:recorder0|state.S_PAUSE
6	-4.834	Debounce:deb3|neg_r	Top:top0|AudRecorder:recorder0|state.S_RECORD
7	-4.772	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
8	-4.712	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_IDLE
9	-4.698	Debounce:deb3|neg_r	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
10	-4.683	Debounce:deb3|neg_r	Top:top0|AudRecorder:recorder0|state.S_IDLE
11	-4.679	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_WAIT
12	-4.651	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_PAUSE
13	-4.593	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_RECORD
14	-4.570	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_WAIT
15	-4.568	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_PAUSE
16	-4.554	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_RECORD
17	-4.418	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
18	-4.403	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_IDLE
19	-4.262	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN



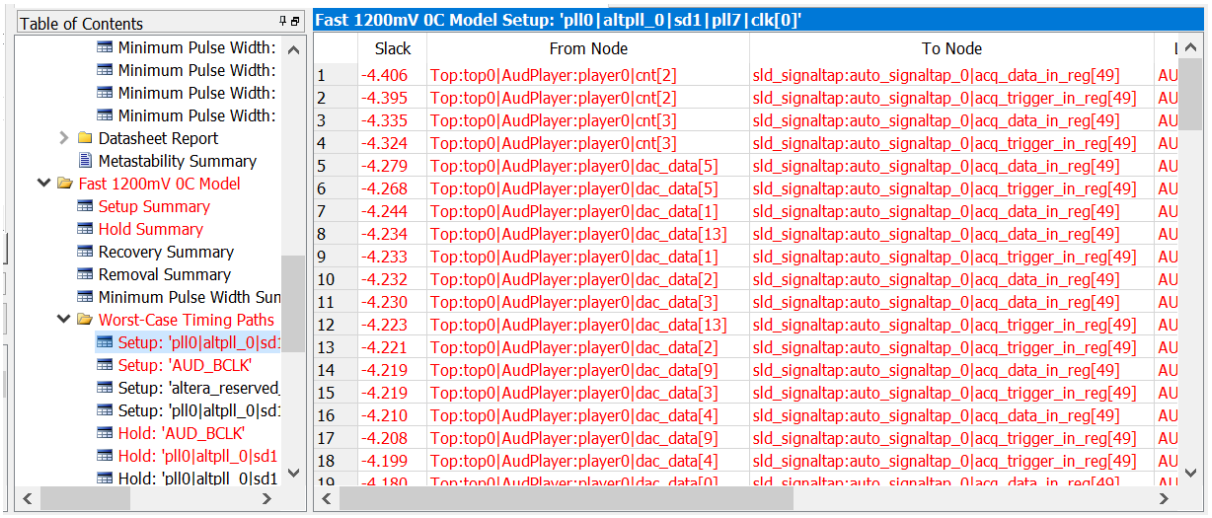
	Slack	From Node	To
1	-0.343	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
2	-0.340	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
3	-0.312	pll0|altpll_0|sd1|pll7|clk[2]	sld_signaltap:auto_signaltap_0|ac
4	-0.309	pll0|altpll_0|sd1|pll7|clk[2]	sld_signaltap:auto_signaltap_0|ac
5	-0.300	pll0|altpll_0|sd1|pll7|clk[0]	sld_signaltap:auto_signaltap_0|ac
6	-0.285	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
7	-0.282	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
8	-0.193	pll0|altpll_0|sd1|pll7|clk[0]	sld_signaltap:auto_signaltap_0|ac
9	0.256	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][121]	sld_signaltap:auto_signaltap_0|s..
10	0.276	sld_signaltap:auto_signaltap_0|sl..._body|acq_data_in_pipe_reg[3][82]	sld_signaltap:auto_signaltap_0|s..
11	0.331	sld_signaltap:auto_signaltap_0|sl..._body|acq_data_in_pipe_reg[3][59]	sld_signaltap:auto_signaltap_0|s..
12	0.335	sld_signaltap:auto_signaltap_0|sl...p_body|acq_data_in_pipe_reg[3][2]	sld_signaltap:auto_signaltap_0|s..
13	0.336	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][123]	sld_signaltap:auto_signaltap_0|s..
14	0.337	sld_signaltap:auto_signaltap_0|sl...p_body|acq_data_in_pipe_reg[3][1]	sld_signaltap:auto_signaltap_0|s..
15	0.338	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][147]	sld_signaltap:auto_signaltap_0|s..
16	0.340	sld_signaltap:auto_signaltap_0|sl..._body|acq_data_in_pipe_reg[3][18]	sld_signaltap:auto_signaltap_0|s..
17	0.341	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][126]	sld_signaltap:auto_signaltap_0|s..
18	0.341	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][116]	sld_signaltap:auto_signaltap_0|s..
19	0.343	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][154]	sld_signaltap:auto_signaltap_0|s..



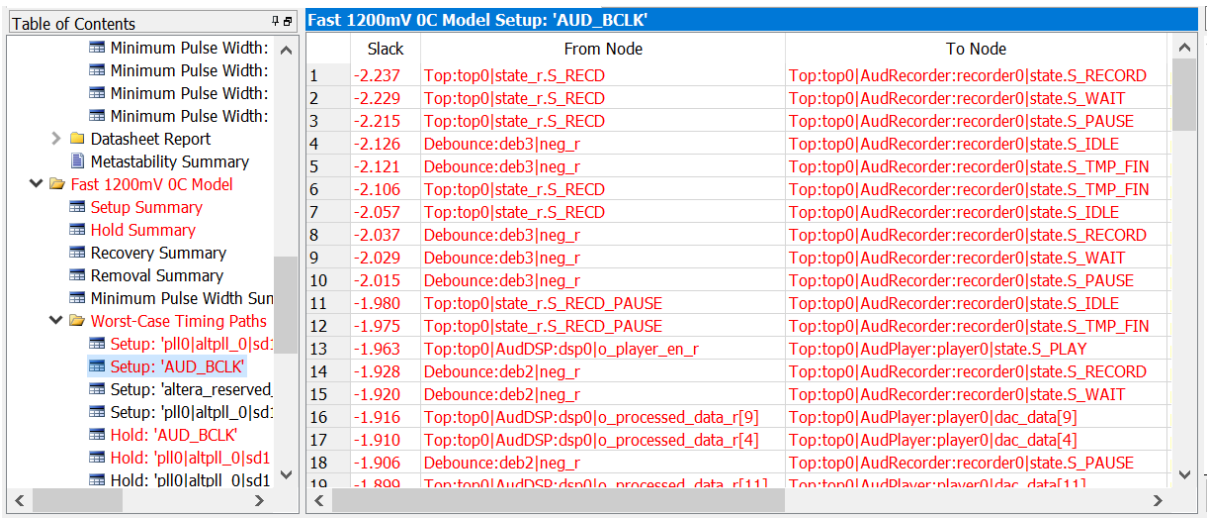
	Clock	Slack	End Point TNS
1	pll0|altpll_0|sd1|pll7|clk[0]	-4.406	-780.698
2	AUD_BCLK	-2.237	-48.637
3	altera_reserved_tck	47.009	0.000
4	pll0|altpll_0|sd1|pll7|clk[1]	81.425	0.000



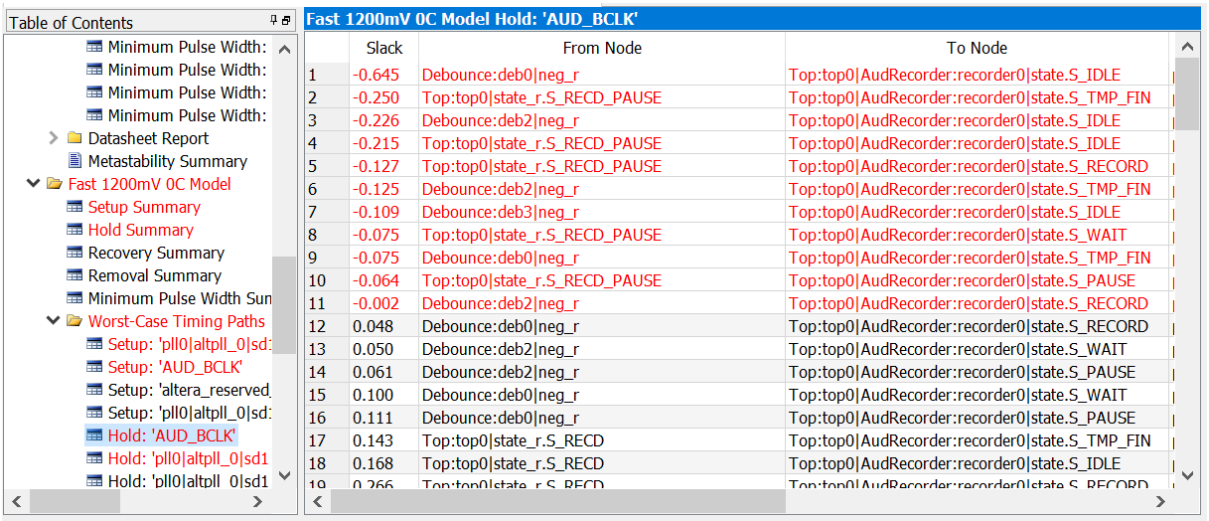
	Clock	Slack	End Point TNS
1	AUD_BCLK	-0.645	-1.161
2	pll0|altpll_0|sd1|pll7|clk[0]	-0.195	-1.040
3	pll0|altpll_0|sd1|pll7|clk[1]	0.155	0.000
4	altera_reserved_tck	0.181	0.000



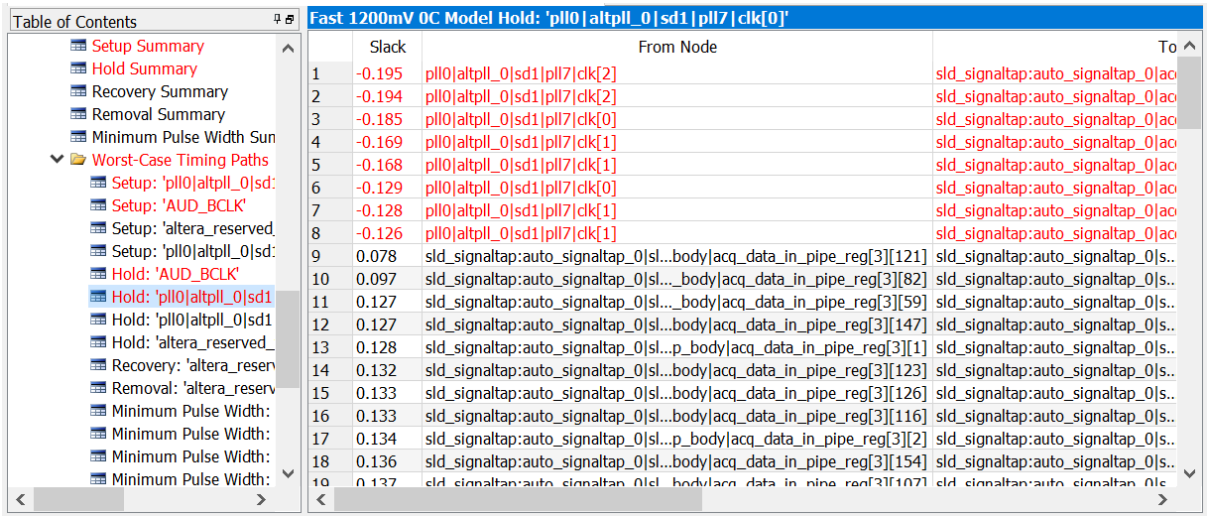
	Slack	From Node	To Node	I
1	-4.406	Top:top0|AudPlayer:player0|cnt[2]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
2	-4.395	Top:top0|AudPlayer:player0|cnt[2]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
3	-4.335	Top:top0|AudPlayer:player0|cnt[3]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
4	-4.324	Top:top0|AudPlayer:player0|cnt[3]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
5	-4.279	Top:top0|AudPlayer:player0|dac_data[5]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
6	-4.268	Top:top0|AudPlayer:player0|dac_data[5]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
7	-4.244	Top:top0|AudPlayer:player0|dac_data[1]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
8	-4.234	Top:top0|AudPlayer:player0|dac_data[13]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
9	-4.233	Top:top0|AudPlayer:player0|dac_data[1]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
10	-4.232	Top:top0|AudPlayer:player0|dac_data[2]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
11	-4.230	Top:top0|AudPlayer:player0|dac_data[3]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
12	-4.223	Top:top0|AudPlayer:player0|dac_data[13]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
13	-4.221	Top:top0|AudPlayer:player0|dac_data[2]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
14	-4.219	Top:top0|AudPlayer:player0|dac_data[9]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
15	-4.219	Top:top0|AudPlayer:player0|dac_data[3]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
16	-4.210	Top:top0|AudPlayer:player0|dac_data[4]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU
17	-4.208	Top:top0|AudPlayer:player0|dac_data[9]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
18	-4.199	Top:top0|AudPlayer:player0|dac_data[4]	sld_signaltap:auto_signaltap_0|acq_trigger_in_reg[49]	AU
19	-4.180	Top:top0|AudPlayer:player0|dac_data[0]	sld_signaltap:auto_signaltap_0|acq_data_in_reg[49]	AU



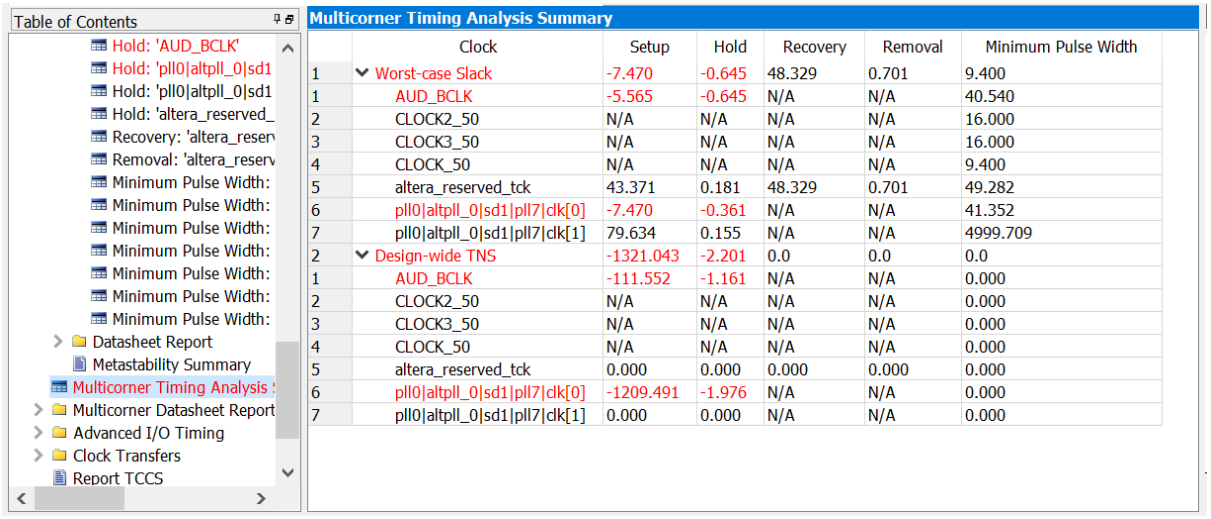
	Slack	From Node	To Node
1	-2.237	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_RECORD
2	-2.229	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_WAIT
3	-2.215	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_PAUSE
4	-2.126	Debounce:deb3|neg_r	Top:top0|AudRecorder:recorder0|state.S_IDLE
5	-2.121	Debounce:deb3|neg_r	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
6	-2.106	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
7	-2.057	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_IDLE
8	-2.037	Debounce:deb3|neg_r	Top:top0|AudRecorder:recorder0|state.S_RECORD
9	-2.029	Debounce:deb3|neg_r	Top:top0|AudRecorder:recorder0|state.S_WAIT
10	-2.015	Debounce:deb3|neg_r	Top:top0|AudRecorder:recorder0|state.S_PAUSE
11	-1.980	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_IDLE
12	-1.975	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
13	-1.963	Top:top0|AudDSP:dsp0|o_player_en_r	Top:top0|AudPlayer:player0|state.S_PLAY
14	-1.928	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_RECORD
15	-1.920	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_WAIT
16	-1.916	Top:top0|AudDSP:dsp0|o_processed_data_r[9]	Top:top0|AudPlayer:player0|dac_data[9]
17	-1.910	Top:top0|AudDSP:dsp0|o_processed_data_r[4]	Top:top0|AudPlayer:player0|dac_data[4]
18	-1.906	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_PAUSE
19	-1.899	Top:top0|AudDSP:dsp0|o_processed_data_r[11]	Top:top0|AudPlayer:player0|dac_data[11]

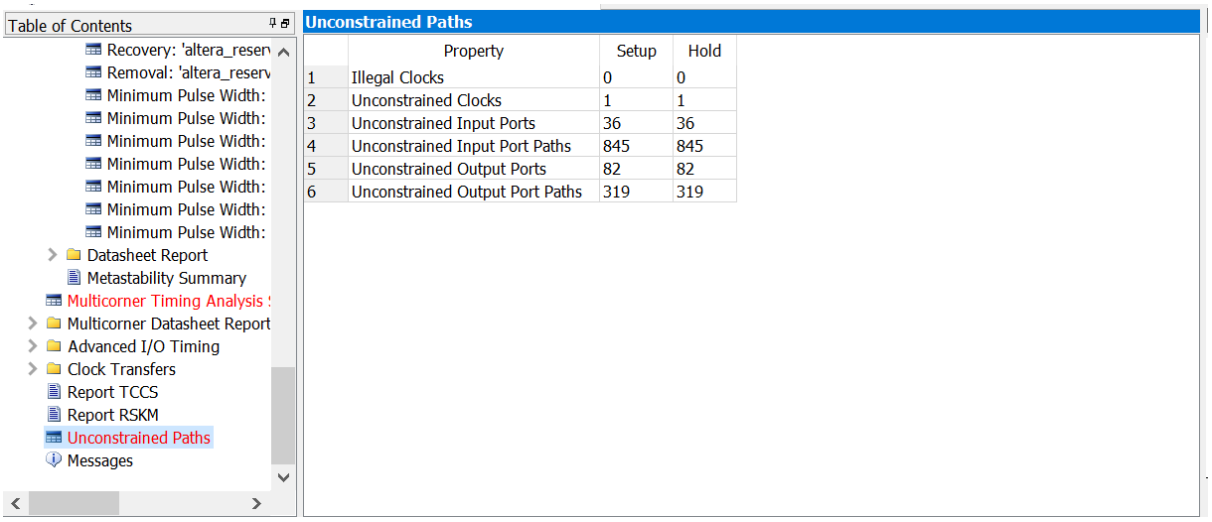


	Slack	From Node	To Node
1	-0.645	Debounce:deb0|neg_r	Top:top0|AudRecorder:recorder0|state.S_IDLE
2	-0.250	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
3	-0.226	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_IDLE
4	-0.215	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_IDLE
5	-0.127	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_RECORD
6	-0.125	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
7	-0.109	Debounce:deb3|neg_r	Top:top0|AudRecorder:recorder0|state.S_IDLE
8	-0.075	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_WAIT
9	-0.075	Debounce:deb0|neg_r	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
10	-0.064	Top:top0|state_r.S_RECD_PAUSE	Top:top0|AudRecorder:recorder0|state.S_PAUSE
11	-0.002	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_RECORD
12	0.048	Debounce:deb0|neg_r	Top:top0|AudRecorder:recorder0|state.S_RECORD
13	0.050	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_WAIT
14	0.061	Debounce:deb2|neg_r	Top:top0|AudRecorder:recorder0|state.S_PAUSE
15	0.100	Debounce:deb0|neg_r	Top:top0|AudRecorder:recorder0|state.S_WAIT
16	0.111	Debounce:deb0|neg_r	Top:top0|AudRecorder:recorder0|state.S_PAUSE
17	0.143	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_TMP_FIN
18	0.168	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_IDLE
19	0.266	Top:top0|state_r.S_RECD	Top:top0|AudRecorder:recorder0|state.S_RECORD



	Slack	From Node	To
1	-0.195	pll0|altpll_0|sd1|pll7|clk[2]	sld_signaltap:auto_signaltap_0|ac
2	-0.194	pll0|altpll_0|sd1|pll7|clk[2]	sld_signaltap:auto_signaltap_0|ac
3	-0.185	pll0|altpll_0|sd1|pll7|clk[0]	sld_signaltap:auto_signaltap_0|ac
4	-0.169	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
5	-0.168	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
6	-0.129	pll0|altpll_0|sd1|pll7|clk[0]	sld_signaltap:auto_signaltap_0|ac
7	-0.128	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
8	-0.126	pll0|altpll_0|sd1|pll7|clk[1]	sld_signaltap:auto_signaltap_0|ac
9	0.078	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][121]	sld_signaltap:auto_signaltap_0|s..
10	0.097	sld_signaltap:auto_signaltap_0|sl..._body|acq_data_in_pipe_reg[3][82]	sld_signaltap:auto_signaltap_0|s..
11	0.127	sld_signaltap:auto_signaltap_0|sl..._body|acq_data_in_pipe_reg[3][59]	sld_signaltap:auto_signaltap_0|s..
12	0.127	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][147]	sld_signaltap:auto_signaltap_0|s..
13	0.128	sld_signaltap:auto_signaltap_0|sl...p_body|acq_data_in_pipe_reg[3][1]	sld_signaltap:auto_signaltap_0|s..
14	0.132	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][123]	sld_signaltap:auto_signaltap_0|s..
15	0.133	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][126]	sld_signaltap:auto_signaltap_0|s..
16	0.133	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][116]	sld_signaltap:auto_signaltap_0|s..
17	0.134	sld_signaltap:auto_signaltap_0|sl...p_body|acq_data_in_pipe_reg[3][2]	sld_signaltap:auto_signaltap_0|s..
18	0.136	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][154]	sld_signaltap:auto_signaltap_0|s..
19	0.137	sld_signaltap:auto_signaltap_0|sl...body|acq_data_in_pipe_reg[3][107]	sld_signaltap:auto_signaltap_0|s..





6. 遇到的問題與解決辦法
   a. 我們原本 I2C 的 SDAT 是在 posedge 更新的，結果發現 WM8732 不會產生 LRCK，後來才發現因為 WM8732 是在 posedge 讀資料，所以資料應該要提早準備好，於是我們把 SDAT 改成在 negedge 更新。
   b. 雜音問題：
      i.一般雜音問題的話除了dsp裡面signed的問題之外，I2S的傳遞差一個bit也會影響，還是聽得出來錄製內容，只是會有背景噪音，因此寫的時候要注意I2S的傳遞。
      ii.慢速播放奇數分母1次插值雜音問題的部分，我們有用過除法及近似除法來解決過，但都無法有效解決問題。最後我們參考在1/2,1/4,1/8倍速聲音較乾淨的case，做了一次插值上的近似。以1/7倍速為例，將其近似成1/8的線性組合，因此會以8:0, 7:1, 6:2, 5:3, 4:4, 3:5, 2:6的方式填補空缺。
   c. debug工具：採用Quartus內的signal tap功能，可以即時了解訊號在FPGA上傳遞的情況。

7. Bonus
   a. 錄音機state顯示：顯示錄音機處於錄製,播放,暫停等狀態，以七段顯示器顯示
   b. 播放倍速顯示：顯示錄音機播放倍速

c. 錄音與播放秒數:可隨播放速度變化，於Top.sv內處理
d. 倒帶播放:將錄製內容倒著播放出來，會從錄製結束的位置開始往回播放，避免播出雜音

8. 心得

這次的lab雖然不像上次有演算法的部分需要理解一下，但因為開始需要在實作上與FPGA板上其他晶片溝通，因此處理protocol的部分花了不少時間。除此之外，因為整體系統逐漸擴大，因此在分工時需要更詳細討論各部分的溝通方式，也同時滿足各protocol的要求。這次最大的收穫之一應該是debug工具的使用，可以了解FPGA上面訊號的正確性，不再只是自己寫tb猜訊號的正確性，為之後final project增加一大利多。