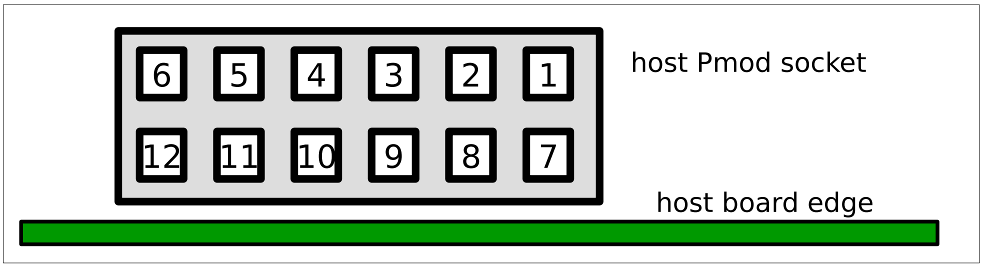
Test Report: SMA2 Plug v2 nr 001

Design:	SMA2 Plug v2
Serial number:	001
Date tested:	2020-07-23
Tested by:	joris
Report date:	2020-07-23

Pmod pinout

This test report refers to Pmod pins according to the non-standard pin number assignments used in the Digilent Pmod specification.

Looking away from the peripheral board, into the Pmod connector on the host board, the pin numbers are as follows:



The SMA2_Plug_v2 board uses the pinout of Digilent Pmod Interface Type 1 (GPIO).

Pin nr	function	in/out
1	IN2	output from peripheral
2	OUT2	input to peripheral
3	OE2	input to peripheral
7	IN1	output from peripheral
8	OUT1	input to peripheral
9	OE1	input to peripheral
4, 10	not connected	
5, 11	GND	
6, 12	+3.3 V	

Sanity checks

1.1. Remove jumpers JP1 and JP2 (to select 50 Ω output resistance).

1.2. Use a multimeter to measure the resistance between Pmod pins 5 and 11.

1.3. Use a multimeter to measure the resistance between Pmod pins 6 and 12.

Measurement	Expected	Result
1.2. Pmod pin 5 to pin 11	< 0.1 Ω	0.0 Ω OK
1.3. Pmod pin 6 to pin 12	< 0.1 Ω	0.0 Ω OK

1.4. Use a multimeter to measure the resistance between Pmod pin 5 and the shell of SMA connector J1.

1.5. Use a multimeter to measure the resistance between Pmod pin 5 and the shell of SMA connector J2.

Measurement	Expected	Result
1.3. Pmod pin 5 to J1 shell	< 0.1 Ω	0.0 Ω OK
1.4. Pmod pin 5 to J2 shell	< 0.1 Ω	0.0 Ω OK

1.6. Set a DC voltage source to +3.3 V, limited to 100 mA.
Connect the negative supply terminal to pin 5.
Connect the positive supply terminal to pin 6.
Leave the other Pmod pins unconnected.

1.7. Use a multimeter to measure the supply voltage.

1.8. Use a multimeter to measure the supply current.

1.9. Additionally connect Pmod pin 9 (OE1) to +3.3 V and measure the supply current.

1.10. Connect both Pmod pin 8 (OUT1) and Pmod pin 9 (OE1) to +3.3 V and measure the supply current.

1.11. Disconnect Pmod pins 8 and 9.
Connect Pmod pin 3 (OE2) to +3.3 V and measure the supply current.

1.12. Connect both Pmod pin 2 (OUT2) and Pmod pin 3 (OE2) to +3.3 V and measure the supply current.

Measurement	Expected	Result
1.7. Supply voltage	min 3.2 V, max 3.4 V	3.30 V OK
1.8. Supply current	< 1 mA	0.0 mA OK
1.9. Supply current, OE1=+3.3V	< 3 mA	0.3 mA OK
1.10. Supply current, OE1=OUT1=+3.3V	< 3 mA	1.0 mA OK
1.11. Supply current, OE2=+3.3V	< 3 mA	0.3 mA OK
1.12. Supply current, OE2=OUT2=+3.3V	< 3 mA	1.0 mA OK

1.13. Disconnect Pmod pins 2 and 3. Disconnect the power supply.

Functional test

2.1. Remove jumpers JP1 and JP2 (to select 50 Ω output resistance).
Attach the SMA2 Plug to a Pmod type 1 (GPIO) connector on a suitable Digilent host board (for example Basys or Atlys).
Make sure the Pmod connector on the host board is configured for 3.3 Volt operation.

2.2. Program the host board to drive logic '0' to OUT1, OE1, OUT2, OE2.

2.3. Use the host board to read the logic levels from IN1, IN2.

2.4. Connect a +3.3 Volt input signal to SMA connector J1.
Use the host board to read the logic levels from IN1, IN2.

2.5. Disconnect the input signal from J1.
Connect a +3.3 Volt input signal to SMA connector J2.
Use the host board to read the logic levels from IN1, IN2.

Measurement	**Expected**	**Result**
2.3. Input not connected	IN1=0, IN2=0	OK
2.4. J1 = 3.3 V	IN1=1, IN2=0	OK
2.5. J2 = 3.3 V	IN1=0, IN2=1	OK

2.6. Disconnect the input signal from J2.
Connect a multimeter to measure the output voltage from J1.
Use the host board to drive the following logic patterns and measure the output voltage from J1 for each pattern.

Measurement	**Expected**	**Result**
OUT1=0, OE1=0, OUT2=0, OE2=0	J1 ≥ 0.0 V, J1 < 0.2 V	0.00 V OK
OUT1=0, OE1=0, OUT2=1, OE2=1	J1 ≥ 0.0 V, J1 < 0.2 V	0.00 V OK
OUT1=1, OE1=0, OUT2=0, OE2=0	J1 ≥ 0.0 V, J1 < 0.2 V	0.00 V OK
OUT1=0, OE1=1, OUT2=0, OE2=0	J1 ≥ 0.0 V, J1 < 0.2 V	0.00 V OK
OUT1=1, OE1=1, OUT2=0, OE2=0	J1 > 3.1 V, J1 < 3.4 V	3.26 V OK

2.7. Disconnect the input signal from J1.
Connect a multimeter to measure the output voltage from J2.
Use the host board to drive the following logic patterns and measure the output voltage from J2 for each pattern.

Measurement	**Expected**	**Result**
OUT1=0, OE1=0, OUT2=0, OE2=0	J2 ≥ 0.0 V, J2 < 0.2 V	0.00 V OK
OUT1=1, OE1=1, OUT2=0, OE2=0	J2 ≥ 0.0 V, J2 < 0.2 V	0.00 V OK
OUT1=0, OE1=0, OUT2=1, OE2=0	J2 ≥ 0.0 V, J2 < 0.2 V	0.00 V OK
OUT1=0, OE1=0, OUT2=0, OE2=1	J2 ≥ 0.0 V, J2 < 0.2 V	0.00 V OK
OUT1=0, OE1=0, OUT2=1, OE2=1	J2 > 3.1 V, J2 < 3.4 V	3.26 V OK

2.8. Use the host board to drive OE1 = 1, OUT1 = 1, OE2 = 1, OUT2 = 1.
Use a multimeter to measure the output voltage from J1 and J2.
Then connect a 50 Ohm resistor in parallel to the multimeter (use an SMA T-joint).
Again measure the output voltage from J1 and J2.

Measurement	**Expected**	**Result J1**	**Result J2**
high output level, high-Z	> 3.1 V, < 3.4 V	3.257 V	3.257 V
high output level, 50 Ohm	> 1.5 V, < 1.7 V	1.648 V	1.656 V

2.9. Place jumpers JP1 and JP2 in the "15 Ω output" position.
Use the host board to drive OE1 = 1, OUT1 = 1, OE2 = 1, OUT2 = 1.
Use a multimeter to measure the output voltage from J1 and J2.
Then connect a 50 Ohm resistor in parallel to the multimeter (use an SMA T-joint).
Again measure the output voltage from J1 and J2.

Measurement	**Expected**	**Result J1**	**Result J2**
high output level, high-Z	> 3.1 V, < 3.4 V	3.268 V	3.268 V
high output level, 50 Ohm	> 2.4 V, < 2.6 V	2.474 V	2.480 V

2.10. Remove jumpers JP1 and JP2.
Use the host board to drive OE1 = 0, OUT1 = 0, OE2 = 0, OUT2 = 0.

Use a multimeter to measure the input resistance of J1 and J2.
Then place jumpers JP1 and JP2 in the "50 Ω input" position.
Again measure the input resistance of J1 and J2.

Measurement	**Expected**	**Result J1**	**Result J2**
input resistance, high-Z	> 9 kΩ , < 11 kΩ	10.00 kΩ	10.00 kΩ
input resistance, 50 Ohm	> 48 Ω, < 52 Ω	50.8 Ω	50.8 Ω

Input performance test

3.1. Remove jumpers JP1 and JP2.
Attach the SMA2 Plug to a Pmod type 1 (GPIO) connector on a suitable Digilent host board (for example Basys or Atlys).

3.2. Connect a signal generator to SMA connector J1.
Usa an SMA T-joint to also measure the voltage with a multimeter.

Configure the signal generator for high-Z load.
Set the signal generator to 0.0 Volt DC output.
Use the host board to check that the IN1 logic level is '0'.

3.3. Slowly tune up the DC output voltage from 0.0 Volt to +3.3 Volt.
Verify that the multimeter follows the configured output voltage.

While tuning up the input voltage, monitor the IN1 logic level with the host board.
Note the voltage where the IN1 logic level changes from '0' to '1'.
Then tune down the input voltage and note where IN1 changes from '1' to '0'.

Measurement	**Expected**	**Result J1**	**Result J2**
3.2. Jx = 0.0 V	INx=0	OK	OK
3.3. 0-to-1 threshold	> 0.8 V, < 2.0 V	1.70 V	1.69 V
3.3. 1-to-0 threshold	> 0.8 V, < 2.0 V	1.64 V	1.64 V

3.4. Set the signal generator to +3.3 Volt DC output.
Check that the multimeter shows +3.3 Volt.

3.5. Place jumper JP1 in the "50 Ω input" position.
Configure the signal generator for 50 Ohm load.
Set the signal generator to +3.3 Volt DC output.
Check that the multimeter shows +3.3 Volt.
Check that the IN1 logic level is '1'.

Measurement	**Expected**	**Result J1**	**Result J2**
3.4. voltage at +3.3V, high-Z	> 3.2 V, < 3.4 V	3.273 V	3.274 V
3.5. voltage at +3.3 V, 50 Ohm	> 3.2 V, < 3.4 V	3.322 V	3.324 V
3.5. INx at +3.3 V, 50 Ohm	INx=1	OK	OK

3.6. Remove the T-joint and multimeter.
Connect the signal generator directly to J1, using a coax cable of at least 10 m length.

Leave jumper JP1 in the "50 Ω input" position.
Configure the signal generator for 50 Ohm load.
Set the signal generator to square wave output, 1 MHz, 50% duty cycle, 0.0 Volt to +2.5 Volt (2.5 Vpp with +1.25 V offset).

Use the host board to sample the IN1 signal at a sample rate of 500 MS/s.
Record the min/max/avg pulse high duration and the min/max/avg pulse low duration.

Calculate the square wave frequency from the average pulse durations:
freq = 1 / (avg_pulse_low + avg_pulse_high)

Calculate the duty cycle from the average pulse lengths:
duty_cycle = avg_pulse_high / (avg_pulse_low + avg_pulse_high)

Calculate the peak-to-peak jitter:
jitter = max(max_pulse_high - min_pulse_high, max_pulse_low - min_pulse_low)

Measurement	**Expected**	**Result J1**	**Result J2**
pulse low: min/max/avg (ns)		500 / 504 / 501.9	500 / 504 / 502.0
pulse high: min/max/avg (ns)		496 / 500 / 498.1	496 / 500 / 498.0
frequency	1 MHz +/- 0.01 MHz	1.000 MHz	1.000 MHz
duty cycle	> 49%, < 51%	50.2 %	50.2 %
jitter	< 5 ns	4 ns	4 ns

3.7. Configure the signal generator for high-Z load.
Set the signal generator to 1 MHz square wave output, 0.0 Volt to +2.5 Volt.
Remove jumper JP1.
Repeat the measurements of 3.6., this time in high-Z configuration.

Measurement	**Expected**	**Result J1**	**Result J2**
pulse low: min/max/avg (ns)		500 / 504 / 502.0	500 / 504 / 502.0
pulse high: min/max/avg (ns)		496 / 500 / 498.0	496 / 500 / 498.0
frequency	1 MHz +/- 0.01 MHz	1.000 MHz	1.000 MHz
duty cycle	> 49%, < 51%	50.2 %	50.2 %
jitter	< 5ns	4 ns	4 ns

3.8. Use the host board to generate cross-talk on the other channel:
Set OE2 = '1' and send a random sequence of bits to OUT2 at 100 Mbit/s.
Repeat the jitter measurements of step 3.7 under these conditions.

Measurement	**Expected**	**Result J1**	**Result J2**
jitter	< 5ns	4 ns	4 ns

3.9. Disconnect the signal generator from J1.
Repeat steps 3.2. to 3.8. but this time use input J2, jumper J2, monitor IN2 and generate cross-talk through OE1, OUT1.

Output performance test

4.1. Remove jumpers JP1 and JP2 to select 50 Ω output resistance.
Attach the SMA2 Plug to a Pmod type 1 (GPIO) connector on a suitable Digilent host board (for example Basys or Atlys).

4.2. Connect SMA connector J1 to an oscilloscope with at least 200 MHz analog bandwidth.
Use a coax cable of at most 2 m length.
Set the scope to DC coupling, 1 MOhm input impedance, full bandwidth.

4.3. Set the host board to drive OE1 = 1, OUT1 = 0, OE2 = 0, OUT2 = 0.
Analyze the J1 waveform on the scope.
It should be a DC voltage. Note mean level and noise.

4.4. Set the host board to drive OE1 = 1, OUT1 = 0, OE2 = 1 and send a random sequence of bits to OUT2 at 100 Mbit/s.
Analyze the J1 noise on the scope.

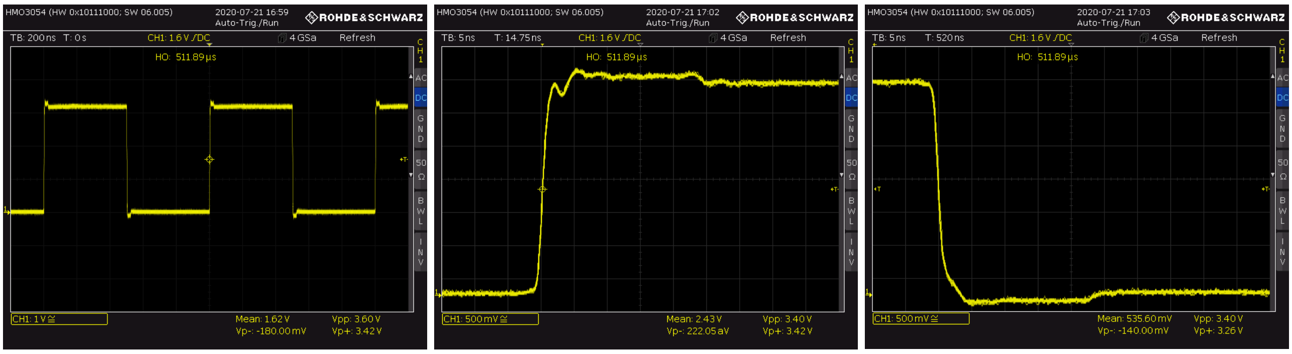
4.5. Set the host board to drive OE1 = 1, OUT1 = 1, OE2 = 0, OUT2 = 0.
Analyze the J1 waveform on the scope.
It should be a DC voltage. Note mean level and noise.

4.6. Set the host board to drive OE1 = 1, OUT1 = 1, OE2 = 1 and send a random sequence of bits to OUT2 at 100 Mbit/s.
Analyze the J1 noise on the scope.

Measurement	**Expected**	**Result J1**	**Result J2**
4.3. mean output signal	≥ 0.0 V, < 0.2 V	0.0 V	
4.3. noise (other channel silent)	< 0.2 V pp	0.03 V pp	
4.4. noise (other channel busy)	< 0.2 V pp	0.03 V pp	
4.5. mean output signal	> 3.1 V, < 3.4 V	3.24 V	
4.5. noise (other channel silent)	< 0.2 V pp	0.02 V pp	
4.6. noise (other channel busy)	< 0.2 V pp	0.02 V pp	

4.7. Set the host board to drive OE1 = 1, OE2 = 0, OUT2 = 0 and drive a 1 MHz square wave to OUT1.
Analyze the J1 waveform on the oscilloscope.
It should be a 1 MHz square wave. Note the mean high and low levels.
Note the rise time and fall time. Note the overshoot.
Note the interval between successive rising edges.
Note the peak-to-peak jitter: the interval between longest and shortest period (use the persistent display mode of the scope).

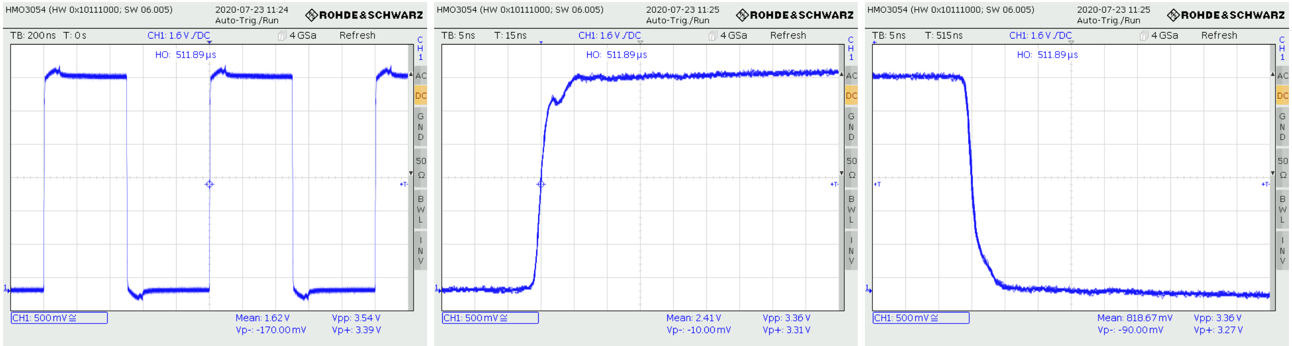
Measurement	**Expected**	**Result J1**	**Result J2**
mean low level	> −0.1 V, < 0.2 V	0.02 V	
mean high level	> 3.1 V, < 3.4 V	3.22 V	
rise time from 0.8 V to 2.0 V	< 5 ns	< 1 ns	
fall time from 2.0 V to 0.8 V	< 5 ns	< 1 ns	
rising edge overshoot	< 0.2 V	0.20 V	
falling edge overshoot	< 0.2 V	0.16 V	
no ringing (repeated overshoot)		OK	
period	1 µs ± 10 ns	1.000 us	
jitter	< 5 ns pp	< 1 ns pp	



1 MHz waveform from J1 output, 50 Ω output, 2 meter cable, 1 MΩ input on scope

4.8. Reconnect the oscilloscope to J1 using a coax cable of at least 10 m length.
Repeat the measurement of 4.7.

Measurement	**Expected**	**Result J1**	**Result J2**
mean low level	> −0.1 V, < 0.2 V	0.02 V	0.03 V
mean high level	> 3.1 V, < 3.4 V	3.23 V	3.22 V
rise time from 0.8 V to 2.0 V	< 5 ns	1 ns	1 ns
fall time from 2.0 V to 0.8 V	< 5 ns	< 2 ns	< 2 ns
rising edge overshoot	< 0.2 V	0.18 V	0.18 V
falling edge overshoot	< 0.2 V	0.17 V	0.18 V
no ringing (repeated overshoot)		OK	OK
jitter	< 5 ns pp	< 1 ns pp	< 1 ns pp



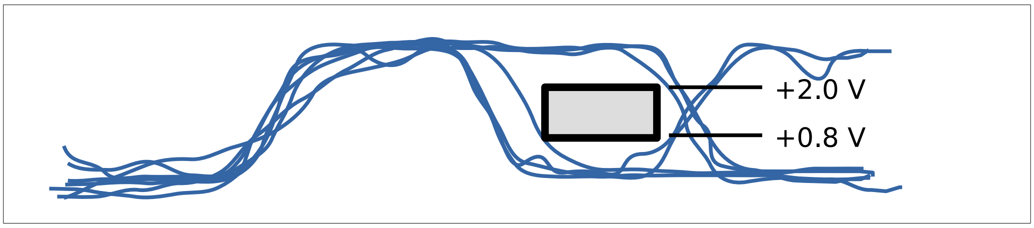
1 MHz waveform from J1 output, 50 Ω output, 10 meter cable, 1 MΩ input on scope

4.9. Set the host board to drive OE = 1, OE2 = 1, drive a 1 MHz square wave to OUT1, and send a random sequence of bits to OUT2 at 100 Mbit/s.
Check the jitter on the oscilloscope.

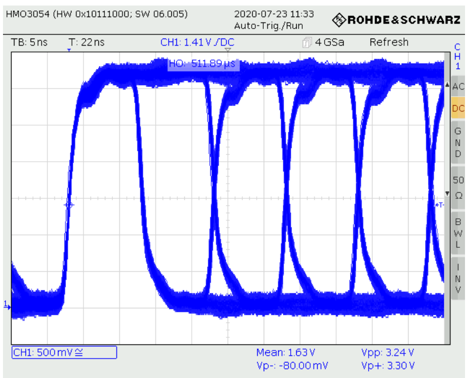
Measurement	Expected	Result J1	Result J2
jitter	< 5 ns pp	< 1 ns pp	< 1 ns pp

4.10. Set the host board to drive OE1 = 1, OE2 = 1 and send independent random sequences of bits to OUT1 and OUT2 at 100 Mbit/s.
Set the oscilloscope time base to 5 ns.
Trigger on rising edge with trigger level +1.4 V.
Enable persistence and collect at least 10000 traces.

Analyze the resulting eye pattern. Note the duration of the interval where the signal is either below +0.8 V or above +2.0 V in each collected trace.



Measurement	Expected	Result J1	Result J2
eye pattern clear duration	> 5 ns	7 ns	7 ns

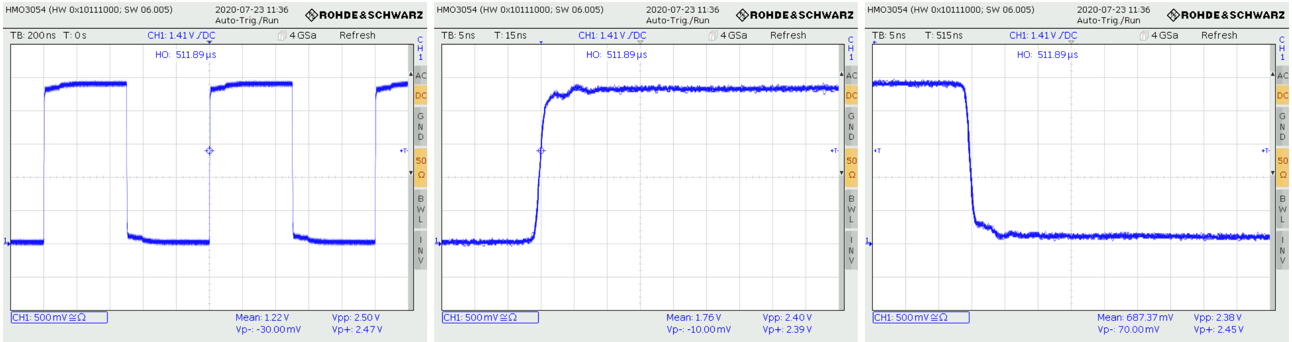


100 Mbit random data from J1 output, 50 Ω output, 10 meter cable, 1 MΩ input on scope

4.11. Switch the oscilloscope to 50 Ω input.
Place jumpers JP1 and JP2 in the "15 Ω output" position.
Repeat the measurements of 4.8, 4.9 and 4.10.

1 MHz square signal, other channel silent, 10 m cable, 15 Ω output, 50 Ω scope:

Measurement	Expected	Result J1	Result J2
mean low level	> −0.1 V, < 0.2 V	0.02 V	0.03 V
mean high level	> 2.4 V, < 2.6 V	2.42 V	2.42 V
rise time from 0.8 V to 2.0 V	< 5 ns	1 ns	1 ns
fall time from 2.0 V to 0.8 V	< 5 ns	1 ns	1 ns
rising edge overshoot	< 0.2 V	0.0 V	0.0 V
falling edge overshoot	< 0.2 V	0.0 V	0.0 V
no ringing (repeated overshoot)		OK	OK
jitter	< 5 ns pp	< 1 ns pp	< 1 ns pp



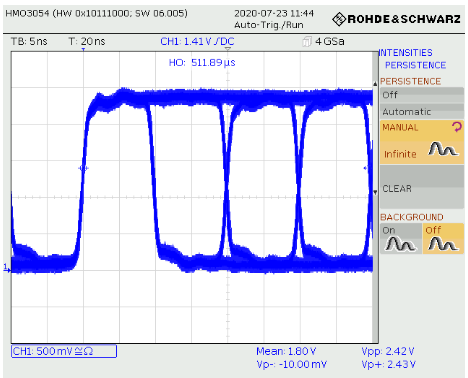
1 MHz waveform from J1 output, 15 Ω output, 10 meter cable, 50 Ω input on scope

1 MHz square signal, other channel busy, 10 m cable, 15 Ω output, 50 Ω scope:

Measurement	Expected	Result J1	Result J2
jitter	< 5 ns pp	< 1 ns pp	< 1 ns pp

random 100 Mbit/s signal on both channels, 10 m cable, 15 Ω output, 50 Ω scope, eye pattern:

Measurement	Expected	Result J1	Result J2
eye pattern clear duration	> 5 ns	7 ns	8 ns



100 Mbit random data from J1 output, 15 Ω output, 10 meter cable, 50 Ω input on scope

4.12. Disconnect the oscilloscope from J1. Repeat steps 4.3 to 4.11, but this time connect the oscilloscope to J2 and switch the roles of OE1,OUT1 with OE2,OUT2.

Output jitter

5.1. Remove jumpers JP1 and JP2 to select 50 Ω output resistance.
Attach the SMA2 Plug to a Pmod type 1 (GPIO) connector on a suitable Digilent host board (for example Basys or Atlys).

5.2. Use a coax cable of at least 10 m length to connect SMA connector J1 to the input of a frequency counter (Pendulum CNT-91 or similar).
Configure the timer input to DC coupling, high input impedance.
Trigger on rising edge at +1.6 V.

5.3. Set the host board to drive OE1 = 1, OE2 = 0, OUT2 = 0 and drive a 1 MHz square wave to OUT1.

Set Settings, measurement time = 10 seconds.
Use function Freq A to measure frequency.
Set Settings, Stat, N = 10000.
Use function Period, Single, A and enable Stat/Plot to measure jitter.

Measurement	**Expected**	**Result J1**	**Result J2**
average frequency	1 MHz ± 0.001 MHz	1.0000 MHz	1.0000 MHz
jitter peak-to-peak	< 1 ns pp	0.36 ns pp	0.36 ns pp
jitter RMS	< 0.3 ns rms	47 ps rms	48 ps rms

5.4. Set the host board to drive OE = 1, OE2 = 1, drive a 1 MHz square wave to OUT1, and send a random sequence of bits to OUT2 at 100 Mbit/s.
Measure jitter under these conditions.

Measurement	**Expected**	**Result J1**	**Result J2**
jitter peak-to-peak	< 1 ns pp	0.48 ns pp	0.50 ns pp
jitter RMS	< 0.3 ns rms	57 ps rms	58 ps rms

5.5. Place jumpers JP1 and JP2 in the "15 Ω output" position.
Reconfigure the timer input to 50 Ω input impedance.
Repeat measurement steps 5.3 and 5.4.

Measurement	**Expected**	**Result J1**	**Result J2**
average frequency	1 MHz ± 0.001 MHz	1.0000 MHz	1.0000 MHz
jitter peak-to-peak (other channel silent)	< 1 ns pp	0.37 ns pp	0.42 ns pp
jitter RMS (other channel silent)	< 0.3 ns rms	47 ps rms	48 ps rms
jitter peak-to-peak (other channel busy)	< 1 ns pp	0.47 ns pp	0.43 ns pp
jitter RMS (other channel busy)	< 0.3 ns rms	56 ns rms	56 ps rms

5.6. Disconnect J1. Connect J2 to the frequency counter and repeat steps 5.3 and 5.5 but switch the roles of OE1,OUT1 with OE2,OUT2.