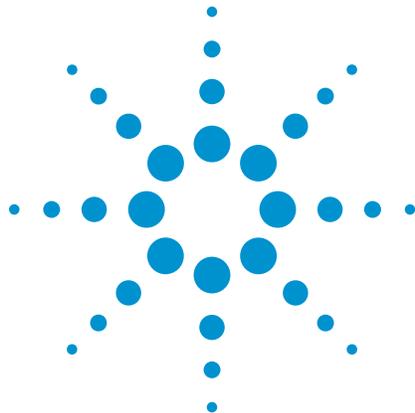


Flexible Signal Conditioning with the Help of the Agilent 81134A Pulse Pattern Generator

Application Note

Version 1.0



Introduction

The 81134A provides the ultimate timing accuracy and signal performance. The high signal quality, low intrinsic jitter and fast transition times enable you to perform quick and reliable measurements with accurate and repeatable results.

Compliance and interoperability is key in complex systems which require an accurate and versatile instrument.

The flexibility of the instrument allows you to generate

- Doubled data rate up to 6 Gb/s by using the RZ signal
- Multiple levels to test lossy transmission media
- Multiple data rate combined with multiple levels whereby the low speed signalling can be used to initialize the high speed transmission.
- Out-of-band signalling for link initialisation
- De-emphasized signals used for characterization of lossy transmission media.

This application note describes how to set up the Agilent 81134A 3.35 GHz Pulse Pattern Generator for different signal conditions.

Figure 1 shows the 81134A connected to two power dividers 11636B, which are used to combine the two channels. Normal output channel 1 connects with normal output channel 2 and same for the complement outputs. The cabling into the power dividers shall be kept short and there are 6 dB attenuators attached to all the output connectors.

This setup is used for all the experiments described in this document.



Figure 1: the Agilent 81134A Pulse Pattern Generator connected to two times 11636B power dividers.

Data rate doubling

Data rate doubling is achieved with help of the RZ mode. RZ means return to zero and allows to send the data bit for less than the whole period. This can be programmed as a width or as a duty cycle. What is needed here is a width or a duty cycle of 50 %. For the rest of the period the signal is always driven to zero, being low at the normal output (high at the complement).

As shown in figure 2 both channels are set to 50% duty cycle and channel 2 is delayed by 50% of the period. So while one channel generates the data the other channel is low at its time. Adding a bit to a low level is basically the bit. The result is a bit stream of twice the data rate, see figure 2.

The 81134A is set to 3 Gb/s. The resulting signal of 6 Gb/s is shown in figure 3 as an eye diagram. Two parameters of the 81134A help to make this happen: the low intrinsic jitter and the fast transition time. Both are good enough to achieve a reasonable signal at nearly twice the instrument's original maximum data rate.

Additional information

The pattern used in both channels is a PRBS 2^7-1 . A shift of at least 1 period is needed to get a pattern toggling with 6 Gb/s. Without that shift the same bit is consecutively generated two times, resulting in a PRBS of same type but looking like 3 GB/s.

Therefore the delay of channel 2 is one plus half a period based on 3 G ($1.5 * 333.3 \text{ ps} = 500 \text{ ps}$). As a consequence the signal at 6 Gb/s repeats with 508 bits (equals 4x 127 bit).

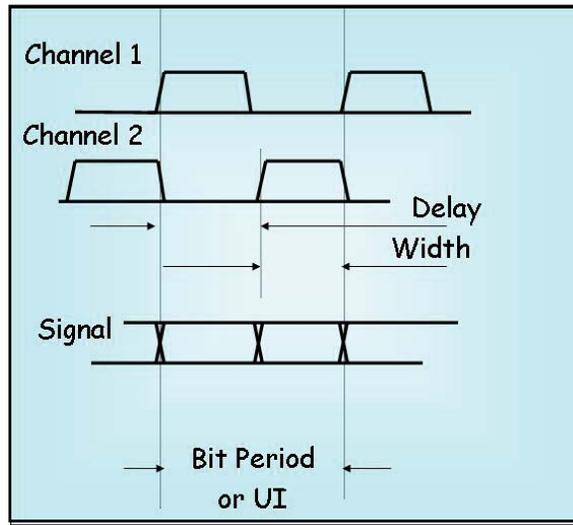


Figure 2: How to setup data rate doubling.

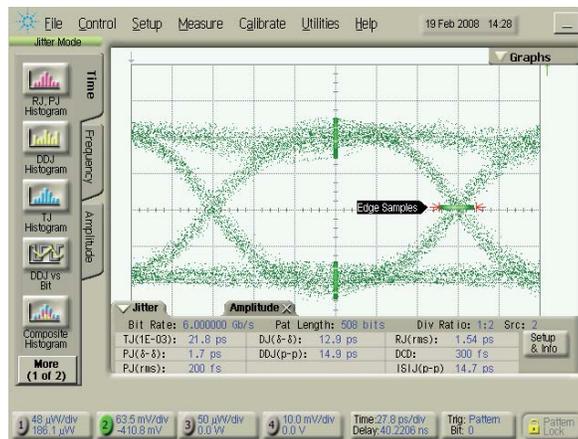


Figure 3: The resulting waveform at 6 Gb/s viewed with 86100C DCA-J in jitter mode.

	Data	Format	Duty Cycle	Delay
Channel 1	PRBS 2^7-1	RZ	50%	0 ps
Channel 2	PRBS 2^7-1	RZ	50%	500 ps

Table 1: Programming values for the 81134A to double the data rate at 3 Gb/s basic setting.

Multiple Levels

Multiple levelling is used to transmit more than one bit per data cycle. This helps to lower the bit period which can be an advantage when dealing with lossy transmission media.

This example is achieved by running data from both channels with NRZ format and same levels in both channels. This creates a signal with two eyes on top of each other, so the data transmission is achieved by 3 states, see figure 4. The low level results from both ,0's in both channels. The high level is achieved from both ,1's in both channels. The mid level results from either ,10' or ,01' in the channels. This is a transmission of 1.5 bit per bit period. However, if it is tracked so that the mid level results from the high or low state, a true 2 bit transmission is possible per bit period with this method.

Additional information

When using PRBS data in both channels, a delay shift of at least two periods is needed. With no shift we do not see two eyes as we get the state ,00' and ,11' only. With a shift of 1 period we see two eyes, but no transitions from ,00' to ,11'. The table lists a delay of 1ns, this represents a shift of 3 periods, which is just for convenience of value programming (for a shift of 2 periods the value of 667 ps needs to be used), see figure 5.

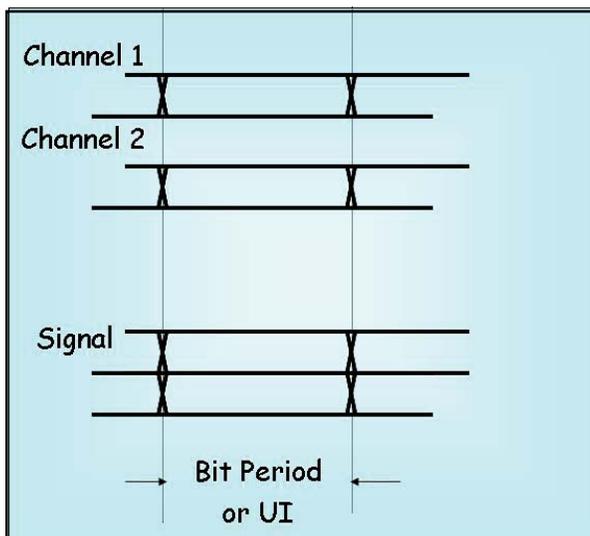


Figure 4: How to setup multiple levels.

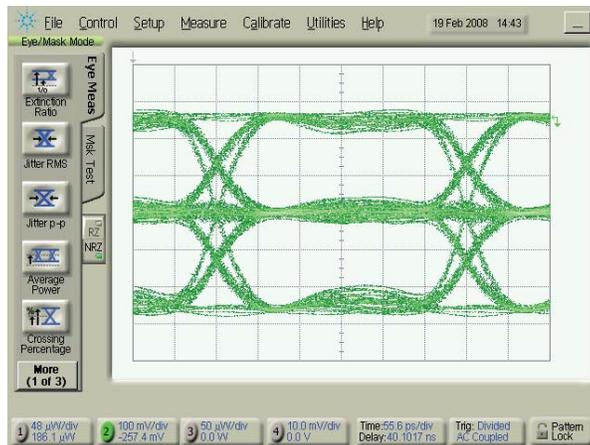


Figure 5: Resulting waveform of a three-level signal, viewed with 86100C DCA-J in eye mode.

	Data	Format	Levels	Delay
Channel 1	PRBS 2 ⁷ -1	NRZ	0 .. 500 mV	0 ps
Channel 2	PRBS 2 ⁷ -1	NRZ	0 .. 500 mV	1 ns

Table 2: Programming values for the 81134A to create multiple levels.

Multiple data rate combined with multiple levels

These are applications which combine low speed and high speed transmission over the same physical interface. The low speed signalling may be used to initialize the high speed transmission.

The frequency setting on the 81134A is according to the requirements of the high speed data generation. Therefore we need different patterns and levels in the two channels. Both patterns need to be structured for the low speed and high speed segments. Assuming that channel 2 is responsible for the low speed part, the pattern within the low speed part needs to be the way that every bit is multiplied n times consecutively to emulate the lower speed:

$n = \text{low speed bit period} / \text{high speed bit period}$

This may need a larger amount of the 81134A memory for high values of n . For the high speed transmission all bits have to be set to '0' in channel 2.

The pattern in channel 1 needs to be '0' during the low speed data generation and the desired pattern for the high speed transmission.

Additional information

The high speed transmission may be required differentially while the low speed is single ended only. In this case we need to modify the setup by disconnecting channel 2 complement output from the power divider and putting a 50 Ohm termination there. This ensures same amplitude on normal and complement signal for a device under test.

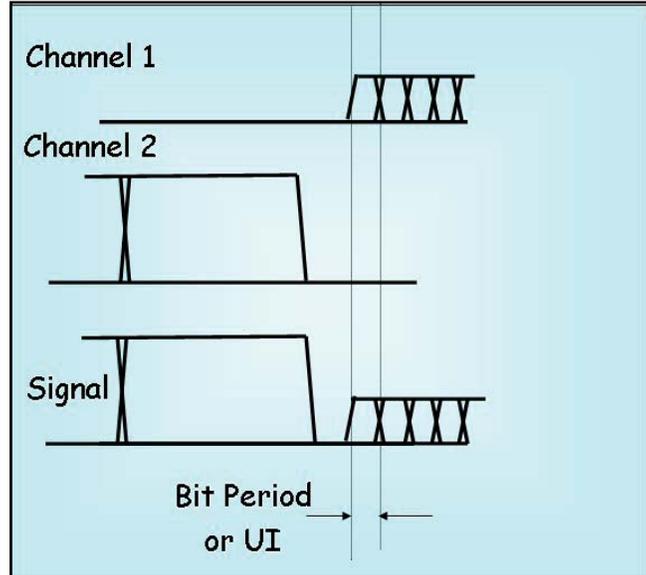


Figure 6: how to setup a signal with multiple data rate and three levels.

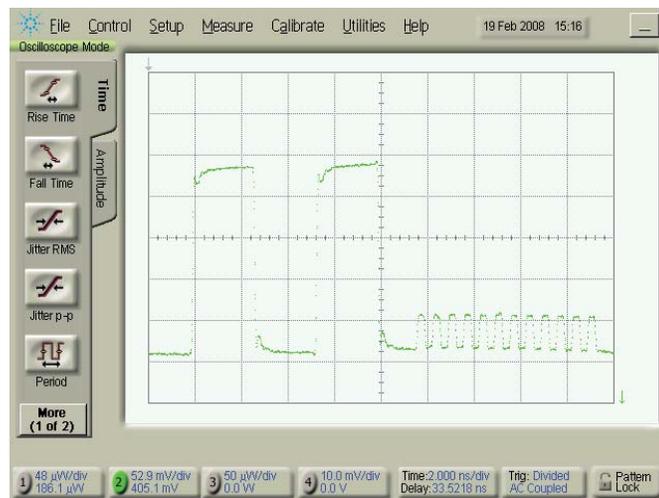


Figure 7 resulting waveform of a signal with multiple data rate and three levels viewed with 86100C DCA-J in scope mode.

	Data	Format	Levels	Delay
Channel 1	Pattern 1	NRZ	0 .. 200 mV	0 ps
Channel 2	Pattern 2	NRZ	0 .. 1 V	0 ps

Table 3: programming values for the 81134A to emulate a data signal with multiple data rate and three levels.

Out-of-band signalling

Out-of-band signalling is used with differential signals for link initialization.

During the out-of-band phase the amplitude of the differential signal has to be zero, as can be seen in figure 9.

An out-of-band signal can be obtained with the combination of two channels while there are different patterns needed for the two channels. For the out-of-band phase one channel drives continuously a ,0' , the other a ,1'. After the out-of-band phase both channels drive the same bit stream. Figure 8 shows how the channel addition establishes this kind of signalling on the single ended signal. The complement signal is composed accordingly.

Levels are the same in both channels and there are no specific delay requirements.

Figure 9 is the screen shot of the differential signals using two scope channels.

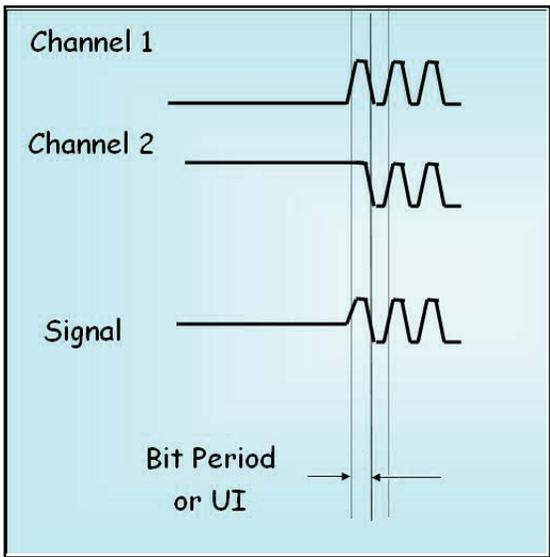


Figure 8: How to setup an out-of-band signalling, single ended view.

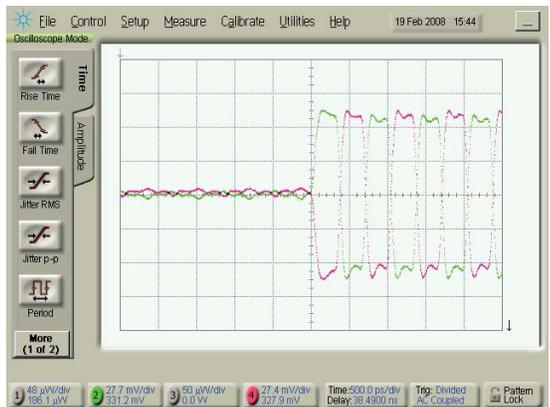


Figure 9: Resulting waveform of a differential signal with out-of-band signalling, normal and complement, viewed with the 86100C DCA-J in scope mode, the green signal corresponds to the combined signal in figure 8.

	Data	Format	Levels	Delay
Channel 1	Pattern 1	NRZ	0 .. 500 mV	0 ps
Channel 2	Pattern 2	NRZ	0 .. 500 mV	0 ps

Table 4: Programming values for the 81134A to create the out-of-band signalling.

De-emphasized signal

De-emphasized signals are used for characterization of lossy transmission media like backplanes and for testing receivers (RX) operating within lossy transmission media.

A de-emphasized differential signal can be obtained from the 81134A channel addition. This requires to load the inverted pattern from channel 1 to channel 2. Then it needs to delay channel 2 by one bit period (= 333 ps in case of a data rate of 3 Gb/s). Figure 10 shows this for a single ended signal. The amplitude of channel 2 defines the magnitude of the de-emphasis. The de-emphasis is defined as:

$$R = V_{pre} / V_{de}$$

$$\text{in dB: } R = 20 * \log (V_{pre} / V_{de})$$

Additional information

In the implementation with the 81134A, the amplitude of channel 2 is subtracted from the amplitude of channel 1. This is different to the typical definition of the standards. There we find the definition of the pre- and the de-emphasized amplitude V_{pre} , V_{de}) as shown in figure 11. This corresponds to the channel programming:

$$V_{pre} = \text{amp ch1}$$

$$V_{de} = \text{amp ch1} - \text{amp ch2}$$

For adjusting V_{pre} and V_{de} a pattern '00001111...' is recommended. After the adjustment any pattern may be used.

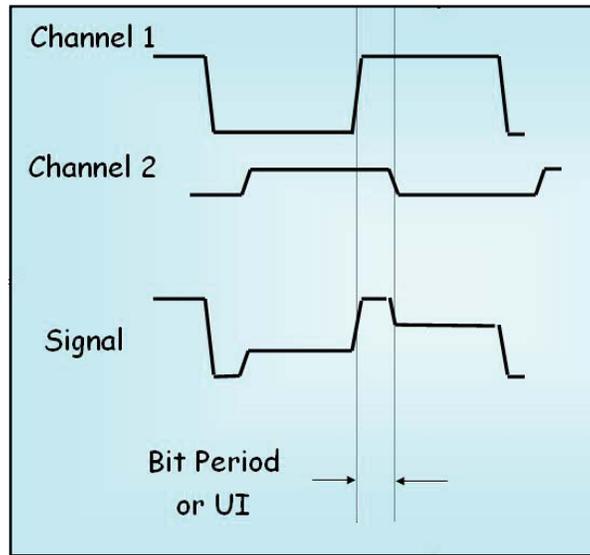


Figure 10: How to setup a de-emphasized signal, single ended view.

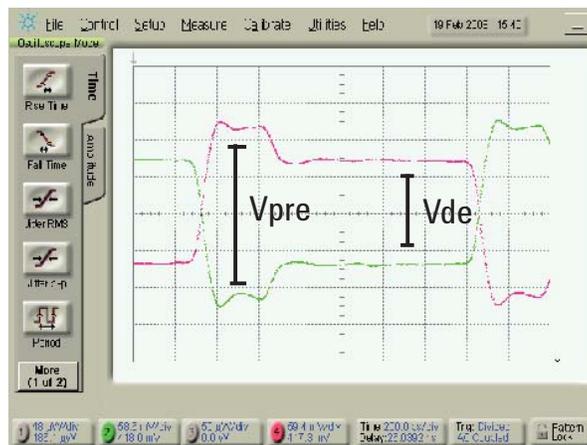


Figure 11: Resulting waveform for a differential signal with embedded de-emphasis, viewed with the 86100C DCA-J in scope mode, the green signal corresponds to the combined signal in figure 10

	Data	Format	Levels	Delay
Channel 1	Pattern	NRZ	0 .. 500 mV	0 ps
Channel 2	Pattern inv	NRZ	0 .. 100 mV	333 ps

Table 5: Programming values for the 81134A to create a de-emphasized signal.

Dynamic common mode

RX stress testing may require a dynamic change of the common mode offset in the running bit stream of a differential signal.

Such a dynamic common mode signal as shown in figure 13 and 14 can be achieved with the setup shown in figure 12 (modified from setup in figure 1).

The normal and complement data is taken from the same 81134A channel, while the second 81134A channel provides the dynamic offset signal.

The complement output of channel 2 is disabled and disconnected from the power divider. The divider leg is terminated with 50 Ohm. It is not recommended to omit the second power divider.

The pattern for the common mode channel depends on the common mode stress requirements. In case all logic '1's in the data stream shall get a positive offset, the same pattern as used for channel 1 shall be loaded to the channel 2.

This example adds channel 2 to channel 1, which generates a larger differential amplitude (sum of amplitude channel 1 and amplitude channel 2.)

If small amplitudes are desired for the data signals, it may be favorable to use the pattern inverted in channel 2, this turns to a subtraction of the channels.

	Data	Format	Levels	Delay
Channel 1	Pattern	NRZ	-/+ 200 mV	0 ps
Channel 2	Pattern inv	NRZ	-/+ 100 mV	0 ps

Table 6: Programming values for the 81134A to create the dynamic common mode signal.

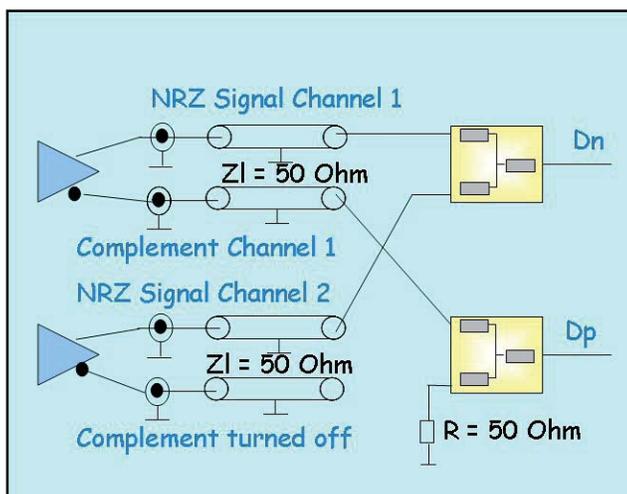


Figure 12: Setup for generating a signal with dynamic common mode voltage with help of the Agilent 81134A and two 11636B power divider, the setup differs from figure 1 by one input leg for Dp is disconnected from Channel 2 and terminated.

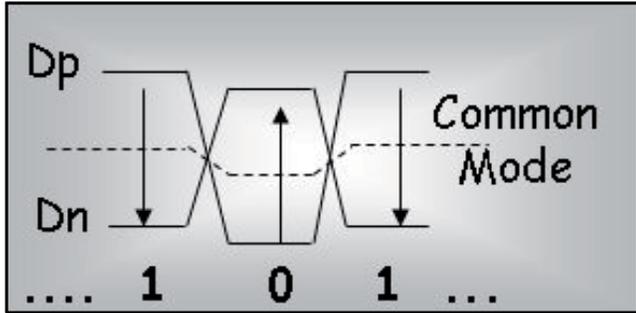


Figure 13: How to setup a differential signal with dynamic common mode.

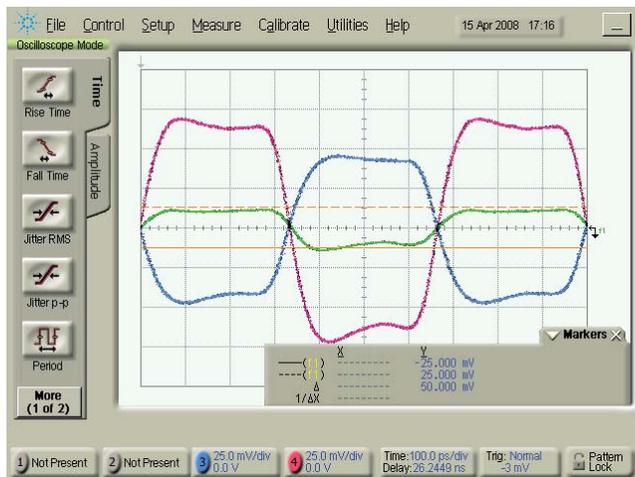


Figure 14: Resulting waveform of a differential data signal (red / blue) with dynamic common mode (green), viewed with the 86100C DCA-J in scope mode. The green signal is obtained by the 'math' function (ch1 add ch2) of the scope. The common mode voltage swing is 50 mV.

Dynamic differential skew

RX stress testing may require a dynamic change of the skew between the differential data D_p and D_n in the running bit stream.

Such a dynamic skewed signal as shown in figure 16 and 17 can be achieved from the setup shown in figure 15. The normal and complement data signal is taken from the two channels of the 81134A, while one of the two is modulated with the help of an Agilent 81150A Pulse Function Arbitrary Noise Generator.

The pattern in both 81134A channels has to be the same. The modulating signal can be any, from sine to noise, depending on the skew requirements. The amplitude of the 81150A output defines the magnitude of skew. The required amount of skew can be calibrated by using an oscilloscope. The pictures provided show the skew modulation on data D_p . This could be done on D_n or on both data lanes in a common or differential mode (using e.g. a 81150A with two channels).



Agilent 81150A

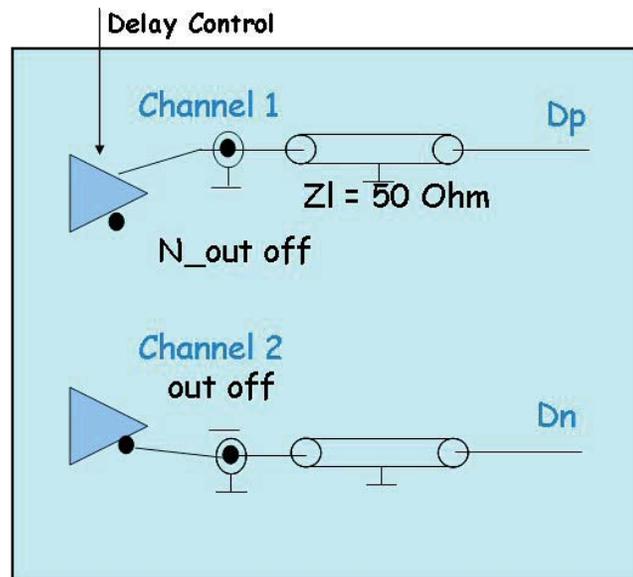


Figure 15: setup for the generation of a signal with dynamic differential skew with help of the Agilent 81134A and 3 times 11636B power divider

	Data	Format	Levels	Delay
Channel 1	Pattern	NRZ	-/+ 500 mV	0 ps
Channel 2	Pattern	NRZ	-/+ 500 mV	0 ps

Table 7: Programming values for the 81134A to create the dynamic differential skew signal.

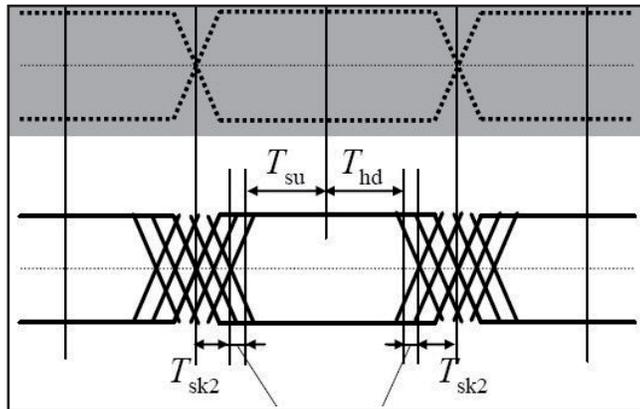


Figure 16: How to setup a signal with dynamic differential skew.

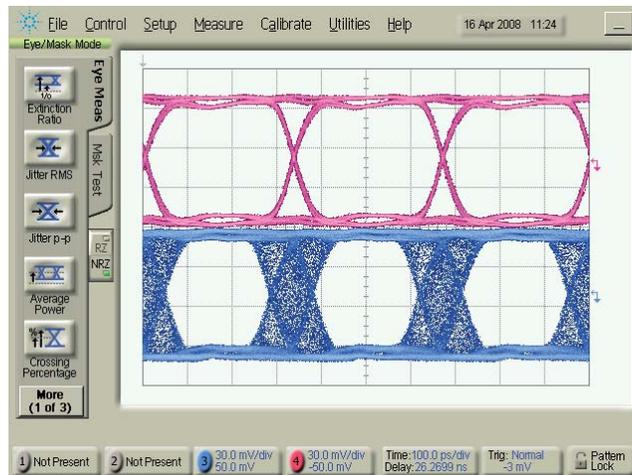


Figure 17: Resulting waveform of a differential signal with dynamic skew, normal and complement, viewed with the 86100C DCA-J in scope mode.

Related Literature	Pub. No.
Pulse Pattern and Data Generators Brochure	5980-0489EN
81133A and 81134A 3.35 GHz Pulse Pattern Generators Data Sheet	5988-5549EN
Advanced Jitter Generation and Analysis Product Note	5989-1650ENDE
Agilent 81133A/81134A 12 Mbit Product Note	5988-9591EN
81150A Pulse Function Arbitrary Noise Generator Data Sheet	5989-6433EN



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