Keysight Technologies
81133A and 81134A
3.35 GHz Pulse Pattern Generators
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The need for pulse and pattern generation is fundamental to digital device characterization tasks. The ability to emulate the pulse and pattern conditions to which the device will encounter in its final application, is essential. This emulation should include both typical and worst case conditions. Accurate emulation requires superlative signal integrity and timing performance along with full control over parameters that allow specific worst case testing.

Setting Standards

The Keysight Technologies, Inc. 81133A and 81134A 3.35 GHz Pulse Pattern Generators provide programmable pulse periods from 15 MHz (66.6 ns) to 3.35 GHz (298.5 ps) on all channels. With frequency ranges this fast, the transition time performance becomes critical; the Keysight 81133A and 81134A perform at less than 60 ps transition. The Delay Control Input and the Variable Crossover Point functionalities allow fast and easy Signal Integrity measurements, including emulation of real world signals by adding jitter to clock or data signals or by distorting the ‘eye’ for eye diagram measurements.

Key Features

- Pulse, Data Pattern and PRBS generation from 15 MHz up to 3.35 GHz
- Data formats NRZ, RZ and R1
- 12 Mbit pattern memory per channel
- Low jitter, high accuracy
- Fast transition times
- PRBS generation from 25 -1...231 -1
- Delay control input for pre-defined jitter input
- Jitter emulation up to ± 250 ps
- Easy-to-use graphical user interface
- 50 mV to 2 Vpp output amplitude
- Differential outputs
- 1 or 2 channels

Connectors

Front panel connectors

All signal outputs and inputs are accessible at the front panel. These are:
- 2 (or 4) output connectors for the 1 (or 2) differential channel(s)
- Trigger output
- Clock input
- Start input
- 1 (or 2) delay control input(s) for the 1 (or 2) channel(s)

Rear panel connectors

Remote programming interfaces: GPIB, LAN, USB 2.0 (see also 'Additional Features')

Clock Source

Selecting the clock source determines the origin of the time base. All other timing parameters are derived from it.

There are two choices:

Internal

The Clock is derived from the internal oscillator.

External

The Clock is derived from the external input. The ext. frequency is measured once and is thereafter used to maintain the calculated frequency dependant values including the pulse width or phase if set to duty cycle mode or phase mode respectively.

External 10 MHz reference

A 10 MHz reference clock can be applied to the clock input. This clock is used as a reference for all timing parameters.

Direct mode (direct internal/ direct external)

The direct modes allow changes of frequency without dropouts in the range of 1:2. This can be used for applications, where dropouts would make a measurement impossible (e.g.: PLL frequency sweep, micro processor clock sweep). In both direct modes, the delay and deskew of all channels is set to zero (deskewed at the connectors) and can’t be changed. Square mode, data mode (NRZ only) and PRBS mode (NRZ only) are available. In ‘Direct External’ mode the PLL is bypassed and the instrument exactly follows the externally attached frequency.
Frequency/Period

The main frequency is set for all channels. The frequency can also be set as period length. The frequency range is 15 Hz to 3.35 GHz, equal to 66.6μ to 298.5 ps period. The frequency range can also be further divided individually for each channel.

Available dividers are 1, 2, 4, 8, 16, 32, 64, 128.

Main Modes

Pulse pattern mode

In Pulse Pattern mode, each channel can be set independently to one of the channel modes described in 'Channel Modes'.

Burst mode

Burst mode enables the output of a burst consisting of data repeated n times followed by continuous zero data. It can be started either by:

- applying a signal at the start input.
- the start button.
- sending a command through the remote connections.

Repetitive burst mode

This command selects a repeated burst consisting of data repeated n times followed by a pause of p times zeros of the same length as the data before the data is repeated.

Channel Modes

The following channel modes are available, if the instrument main mode is set to pulse/pattern.

NOTE: The frequency of each channel can be optionally divided by 1, 2, 4, 8, 16, 32, 64, 128.

Square

Generates a square wave (clock) of fixed width (50% duty cycle)

Pulse

Generates pulses with selectable width or duty cycle.

Data

Generates data in either RZ, R1 or NRZ format. In RZ and R1 mode, the pulse width can be selected as either width or duty cycle.

PRBS

Outputs a selectable PRBS (Pseudo Random Binary Sequence) polynomial of either RZ, R1 or NRZ format. In RZ and R1 mode, the pulse width can be selected as either width or duty cycle.

Timing

Delay

The delay can be set:

- as an absolute value in nano seconds or pico seconds. The delay remains unchanged as the frequency or the period is modified.
- as phase (degrees relative to period). The phase remains unchanged as the frequency or the period is modified.

Deskew

The deskew adjustment allows for the compensation of e.g. cable delays. Deskew adjustment is not available in Direct Mode. In this case, all channels are factory deskewed at the front panel connectors.

Width

There are two ways to set the pulse width:

- as absolute value in nano seconds or pico seconds. In absolute mode, the pulse width stays constant when the frequency or period is changed.
- as duty cycle (percentage of period). In duty cycle mode, the duty cycle stays constant when the frequency or period is changed.

NOTE: Width adjustment is not available if data mode is set to NRZ.

Pulse Format

RZ

Return to zero pulse format. On 0 bit patterns, the signal remains at the low level. On 1 bit patterns, the signal goes high and back to the low level after the time specified by the pulse width or the duty cycle parameter.

R1

Return to one pulse format. On 1 bit patterns, the signal remains at the high level. On 0 bit patterns, the signal goes low and back to the high level after the time specified by the pulse width or the duty cycle parameter.

NRZ

Non-return to zero pulse format. The signal remains at the low level or high level according to the bit level of the pattern for the entire period.

NOTE: The pulse format selection is only available when operating the instrument in the data/pattern modes.
Variable Crossover

For each channel, the cross over of the NRZ signal in PRBS or data mode can be adjusted. This is used to artificially close the eye pattern simulating distortion. Figure 1 shows the normal and complement output with cross over point set to 50% and 70% respectively.

**NOTE:** Variable Crossover feature is available in NRZ mode only.

Pattern

There are two types of patterns available:

**Data**

Arbitrary data up to the maximum available memory per channel can be setup as pattern data.

**PRBS**

Predefined PRBS of 25-1 to 231-1 can be setup as pattern data.

Data Polarity

In pattern mode the polarity of the data can be set to either normal or inverted. When set to inverted, a logical ‘1’ will become a logical ‘0’ at the output and vice versa.

Levels

**Pre-defined levels**

Pre-defined levels allow the easy setup of the channels for commonly used logic families. These are: ECL, ECLGND, LVT, LVPCL and LVDS.

**Custom levels**

Levels can be set to custom values in either of two ways:

- low level and high level
- amplitude and offset

Level protection

Output levels can be limited to a user defined range to protect the device under test. Level protection can be switched on and off.

Level polarity

Level polarity can be set to either normal or inverted. Set to inverted, the low level and the high level values are interchanged.

Outputs enable/disable

Outputs can be switched on and off independently for each channel and for each normal/complement connector.
Auxiliary Channels

Outputs

Trigger output
The trigger output can be enabled or disabled. The levels of the trigger output can be set as high level or low level pair.

The trigger output can be set to one of the following modes:
- Trigger on clock The frequency of the trigger output is identical to the system frequency. It can be further divided by n (n= 1, 2, 3, 4, 5, 6, 7,...231-1).
- Trigger on data One Trigger pulse occurs on the first part of the repetitive data pattern.

Inputs

NOTE: The built-in input and output terminations eliminate the need for external bias networks and prevent a degrading of the input/output sensitivity

Clock input
The clock input can be ‘AC’ or ‘DC’ terminated. The ‘DC’ termination voltage can be set. See also ‘Clock Source – external’.

Start input
The start input can be used to start the instrument. After being armed, the instrument waits for the selected edge of the applied signal.

Parameters:
- Threshold (voltage)
- Edge (rising/falling)
- Termination voltage

Store/Recall

Allows permanent storage of instrument settings, including all signal parameters and data settings. Data patterns up to 8K bit length are also stored. The instrument provides memory for 9 different settings.

In addition, the 81133A and 81134A stores the current settings at shutdown and restored them on next power-on.

For data patterns with more than 8K Bit length, it is recommended to use the special PC-based pattern editor.

Overprogramming

Many parameters can be programmed to values that exceed the specified ranges.
Specifications

Specifications describe the instrument’s warranted performance. Non-warranted values are described as typical. All specifications apply after a 30 min warm-up with 50 Ohm source/load resistance. All specifications are valid from 0 to 55 °C ambient temperature if not stated otherwise.

### Internal clock generation

<table>
<thead>
<tr>
<th>Specification</th>
<th>Range/Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period range</td>
<td>298.5 ps - 66.6 ns</td>
</tr>
<tr>
<td>Period resolution</td>
<td>6 digits, 0.001 ps best case</td>
</tr>
<tr>
<td>Frequency range</td>
<td>15 MHz - 3.35 GHz</td>
</tr>
<tr>
<td>Frequency resolution</td>
<td>1 Hz</td>
</tr>
<tr>
<td>Accuracy</td>
<td>50 ppm</td>
</tr>
</tbody>
</table>

### Jitter

<table>
<thead>
<tr>
<th>Jitter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random jitter (clock mode)</td>
<td>&lt; 4 ps RMS typical&lt;sup&gt;1,2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total jitter (data mode)</td>
<td>&lt; 40 ps pp&lt;sup&gt;1,3&lt;/sup&gt;</td>
</tr>
<tr>
<td>(30 ps typical for frequencies &lt; 3 GHz)</td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> Measured on a 86100 Infiniium DCA-J Wideband Oscilloscope by using the Enhanced Jitter Analysis Software
<sup>2</sup> Clock pattern
<sup>3</sup> PRBS 2<sup>7</sup>-1, BER 10<sup>-9</sup>

### Transition Times

The transition times can be modified by the ‘Pulse Performance’ selector:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Description</th>
<th>Typical transition times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>Provides faster rise and fall times</td>
<td>60 to 75 ps</td>
</tr>
<tr>
<td>Normal</td>
<td>Standard setting with guaranteed</td>
<td>70 to 80 ps</td>
</tr>
<tr>
<td>Smooth</td>
<td>Provides slower rise and fall times</td>
<td>80 to 120 ps</td>
</tr>
</tbody>
</table>

### Human Interface

The graphical user interface enables the user to operate the instrument as simply as possible. All parameters are displayed on a color coordinated display. The instrument setup is intuitive. All important parameters can be easily accessed and modified with numeric keys, cursor keys or the twist and push button. A content sensitive online help enables users to set up their test configurations quickly and easily.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel output timing</td>
<td></td>
</tr>
<tr>
<td>Number of channels</td>
<td>1, (81133A), 2 (81134A)</td>
</tr>
<tr>
<td>Transition times</td>
<td>(10 % to 90 %) &lt; 90 ps</td>
</tr>
<tr>
<td>Transition times</td>
<td>(20 % to 80 %) &lt; 60 ps</td>
</tr>
<tr>
<td>Delay variation</td>
<td>-5 ns to 230 ns</td>
</tr>
<tr>
<td>Delay resolution</td>
<td>1 ps</td>
</tr>
<tr>
<td>Delay accuracy</td>
<td>± 20 ps</td>
</tr>
<tr>
<td>Phase</td>
<td>-6000 to +279000°</td>
</tr>
<tr>
<td>Phase resolution</td>
<td>0.01°, or 1 ps</td>
</tr>
<tr>
<td>Skew between differential outputs</td>
<td>&lt; 20 ps nominal</td>
</tr>
<tr>
<td>Maximum skew range</td>
<td>± 10 ns</td>
</tr>
<tr>
<td>Width range</td>
<td>100 ps to (period - 100 ps)</td>
</tr>
<tr>
<td>Width resolution</td>
<td>1 ps</td>
</tr>
<tr>
<td>Width accuracy</td>
<td>± 40 ps</td>
</tr>
<tr>
<td>Duty cycle range</td>
<td>0.15 - 99.85%</td>
</tr>
<tr>
<td>Duty cycle resolution</td>
<td>0.002%, or 1 ps</td>
</tr>
<tr>
<td>Divide by</td>
<td>1, 2, 4, 8, 16, 32, 64, 128</td>
</tr>
</tbody>
</table>

**NOTE:** Timing specifications are valid after auto calibration with a maximum temperature variation of ±10 °C.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel output levels</td>
<td></td>
</tr>
<tr>
<td>Amplitude</td>
<td>50 mV to 2.00 V</td>
</tr>
<tr>
<td>Level window</td>
<td>-2.00 to +3.00 V</td>
</tr>
<tr>
<td>Level resolution</td>
<td>10 mV</td>
</tr>
<tr>
<td>Level accuracy</td>
<td>2% of setting ±20 mV</td>
</tr>
<tr>
<td>Amplitude accuracy</td>
<td>2% ± 20 mV</td>
</tr>
<tr>
<td>Setting time</td>
<td>1 ns</td>
</tr>
<tr>
<td>Overshoot, ringing</td>
<td>&lt; 10 % ± 10 mV differential outputs</td>
</tr>
<tr>
<td>Impedance</td>
<td>50 Ohm nominal</td>
</tr>
<tr>
<td>Variable crossover</td>
<td>30 to 70% typical</td>
</tr>
<tr>
<td>Maximum external termination voltage</td>
<td>-2.00 to +3.00 V</td>
</tr>
<tr>
<td>Short circuit current</td>
<td>-80 mA &lt;= I&lt;sub&gt;sc&lt;/sub&gt; &lt;= 120 mA nominal</td>
</tr>
<tr>
<td>Limit</td>
<td>High and low levels into 50 Ohm can be limited.</td>
</tr>
<tr>
<td>Normal/complement</td>
<td>Selectable</td>
</tr>
<tr>
<td>Disable</td>
<td>Yes (relay)</td>
</tr>
</tbody>
</table>
Pulse Pattern and Data Functionality

The 81133A and 81134A can generate an 8 KBit digital pattern in NRZ, RZ and R1 mode. Furthermore, the 81133A and 81134A can provide a hardware generated pseudo random binary sequence (PRBS) from $2^5 - 1$ to $2^{31} - 1$.

Jitter Emulation (Delay Control Input)

Full control over the signal quality of pulse and data signals provides the Delay Control Input. With an external modulation source (e.g. Keysight 33250A) the amount and shape of signal jitter can be varied for stress tests or to emulate real world signals. The external source for jitter modulation is applied to this input. Jitter modulation can be turned on and off individually for each channel. Either one of two fixed sensitivities can be selected ± 25 ps or ± 250 ps resulting in a total of 50 ps or 500 ps. The amplitude of the modulated jitter is set by the voltage level of the signal applied to the Delay Control Input. The Variable Crossover Point feature provides additional control over the signal quality.

### Data generation

<table>
<thead>
<tr>
<th>Memory depth</th>
<th>8 Kbit per channel/12 Mbit extended memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data format</td>
<td>RZ/NRZ/R1</td>
</tr>
<tr>
<td>PRBS</td>
<td>$2^n - 1$, $n = 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 23, 31$</td>
</tr>
<tr>
<td>PRBS</td>
<td>Polynomial</td>
</tr>
<tr>
<td>Comment</td>
<td>ITU-T V.29</td>
</tr>
<tr>
<td>$2^5 - 1$</td>
<td>$X^0 + X^4 + X^5 + X^6 + 1$</td>
</tr>
<tr>
<td>$2^6 - 1$</td>
<td>$X^0 + X^6 + X^7 + X^8 + 1$</td>
</tr>
<tr>
<td>$2^7 - 1$</td>
<td>$X^0 + X^7 + X^8 + X^9 + 1$</td>
</tr>
<tr>
<td>$2^8 - 1$</td>
<td>$X^1 + X^9 + 1$</td>
</tr>
<tr>
<td>$2^9 - 1$</td>
<td>$X^1 + X^{13} + 1$</td>
</tr>
<tr>
<td>$2^{10} - 1$</td>
<td>$X^1 + X^{19} + 1$</td>
</tr>
<tr>
<td>$2^{11} - 1$</td>
<td>$X^{11} + X^{19} + 1$</td>
</tr>
<tr>
<td>$2^{12} - 1$</td>
<td>$X^{12} + X^8 + X^9 + X^{10} + 1$</td>
</tr>
<tr>
<td>$2^{13} - 1$</td>
<td>$X^{13} + X^{18} + X^8 + X^9 + 1$</td>
</tr>
<tr>
<td>$2^{14} - 1$</td>
<td>$X^{14} + X^{19} + X^{21} + X^9 + 1$</td>
</tr>
<tr>
<td>$2^{15} - 1$</td>
<td>$X^{15} + X^{19} + 1$</td>
</tr>
<tr>
<td>$2^{23} - 1$</td>
<td>$X^{23} + X^{18} + 1$</td>
</tr>
<tr>
<td>$2^{31} - 1$</td>
<td>$X^{31} + X^{28} + 1$</td>
</tr>
</tbody>
</table>

### Trigger output

| Amplitude          | 50 mV to 2.00 V                        |
| Level window       | $-2.00 \text{ V } ... +3.00 \text{ V}$ |
| Resolution         | 10 mV                                 |
| Format fixed duty cycle | 50% nominal                           |
| Maximum external voltage | $-2.00 \text{ V } ... +3.00 \text{ V}$ |
| Transition times (20% to 80% of amplitude) | < 100 ps (< 70 ps typical) |
| Minimum output frequency | 15 MHz/divider factor                 |
| Mode clock clock divided by $1, 2$, $3$, ... | $2^{31} - 1$ or trigger on bit 0 of data |
| Disable            | Yes (relay)                           |

### Delay control input

| Interface          | dc-coupled                             |
| Impedance          | 50 Ohm nominal                         |
| Input levels for full modulation range | ±500 mV                             |
| Max input levels   | ±2.5 V                                 |
| Delay modulation range | ±250 ps, ±25 ps, selectable          |
| Modulation frequency | 0 Hz - 200 MHz                         |

Figure 2. Modulated Delay (Jitter) vs Voltage Level at Delay-Control-Input for ±250 ps and ±25 ps settings
### Start input

<table>
<thead>
<tr>
<th>Modes</th>
<th>Start</th>
<th>Interface</th>
<th>Impedance</th>
<th>Termination voltage</th>
<th>Transitions</th>
<th>Threshold</th>
<th>Max. level window</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>dc-coupled</td>
<td>50 Ohm</td>
<td>−2.0 V...+3.0 V</td>
<td>&lt; 1 ns</td>
<td>−1.8 to +4 V</td>
<td>−2 to +5 V</td>
</tr>
</tbody>
</table>

1. No fixed latency between assertion of start signal and start of output signal

### General information

<table>
<thead>
<tr>
<th>Operating temperature</th>
<th>0 to +55 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage temperature</td>
<td>−40 to +70 °C</td>
</tr>
<tr>
<td>Humidity</td>
<td>95% R.H. (0 to +40 °C)</td>
</tr>
<tr>
<td>Warm up</td>
<td>30 Minutes</td>
</tr>
<tr>
<td>EMC</td>
<td>Class A</td>
</tr>
<tr>
<td>Power</td>
<td>100V to 240V AC nom.; 200 VA max.; 47 Hz to 63 Hz</td>
</tr>
<tr>
<td>Net weight</td>
<td>14.8 kg (32.6 lbs)</td>
</tr>
<tr>
<td>Shipping weight</td>
<td>19 kg (41.9 lbs)</td>
</tr>
<tr>
<td>Dimensions</td>
<td>145 x 426 x 553 (mm) 5.7 x 16.75 x 21.75 (in)</td>
</tr>
<tr>
<td>Recalibration period</td>
<td>3 years recommended</td>
</tr>
</tbody>
</table>
Ordering Information

Keysight 81133A  3.35 GHz 1-channel pulse/pattern generator
Keysight 81134A  3.35 GHz 2-channel pulse/pattern generator

Options
Keysight 8113xA-UK6  Commercial Calibration Certificate with Test Data
Keysight 8113xA-1CP  Rackmount and Handle Kit
Keysight 1494-0059  Rack Slide Kit
Keysight N4871A  Cable Kit: SMA matched pair, tt=50 ps (Recommended for high performance and differential applications)

Accessories
Keysight 15435A  Transition Time Converter 150 ps
Keysight 15432B  Transition Time Converter 250 ps
Keysight 15433B  Transition Time Converter 500 ps
Keysight 15434B  Transition Time Converter 1000 ps
Keysight 15438A  Transition Time Converter 2000 ps

Complimentary products
DSO 91xxxA/DCA-X  1/20 GHz
DSO 90604A/90804A  6/8 GHz
DSO 90404A  4 GHz

Related literature

- Pulse Pattern and Function Arbitrary Generators and Arbitrary Waveform Generator, Brochure 5980-0489E
- Generating and Measuring Jitter, Application Note 5988-9411EN
- Keysight 81133A/81134A Extended Pattern Memory, Product Fact Sheet 5988-9591EN

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