

# The `tikz`-`timing` package

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<http://www.ctan.org/indexes/graphics/pgf/contrib/tikz-timing/>

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**Note to Advanced Users:** This is a new package which internal macros might still change. Please only rely on the user macros for now.

## 1 Introduction

This package uses the `tikz`<sup>1</sup> package to produce timing diagrams inside text or `{tikzpicture}` environments. Also a tabular-like environment is provided to produce a larger timing diagram with multiple labeled signals and the possibility to add own drawing material.


The signal levels of the timing diagram can be given by corresponding characters/letters like ‘H’ for *Logical High* or ‘L’ for *Logical Low*. So e.g. ‘{HLZXD}’ gives ‘’. Lowercase characters only produce a signal with half the width while uppercase characters produce one with the “full” width, called the ‘period width’ in this document and which is by default identical to there height, called ‘signal height’, which defaults to 1.6ex (about the height of the uppercase ‘X’ of the current font). Table 1 shows all by default defined logic characters. Additional functionality is provided by the “modifiers” shown in Table 2.

Table 1: Timing Characters

Character	Description	Full Width (Uppercase)	Half Width (Lowercase)	Transition Example
H	High			
L	Low			
Z	High Impedance			
X	Undefined / Don't Care			
D	Data / Double			
U	Unknown Data			
T	Toggle			
C	Clock (no slope)			
M	Metastable Condition			
G	Glitch (zero width)			
S	Space (nothing)			

<sup>1</sup>Part of the `pgf` package, CTAN: <http://www.ctan.org/pkg/pgf>

## 2 Usage

### 2.1 Macro for use in Text Mode

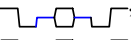
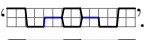
`\texttiming[<initial character>]{<characters>}`

This macro places a single timing diagram line into the current text. The signals have the same height as a uppercase letter (like ‘X’) of the current font, i.e. they scale with the font size.

The macro argument must contain only valid logic characters which define the logical levels of the diagram line.

An initial character can be given as an optional argument. No logic level will be drawn for this character. Instead it will be used to define the initial position of the signal so that the diagram line will start with a transition from the initial to the first character.

*Examples:*

`\texttiming{HLZDZLH}` gives ‘’, with grid: .



`\texttiming[L]{HLZDZLH}` gives ‘’, with grid: .

Table 2: Modifiers for Timing Characters




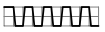





Modifier Syntax	Description	Example Usage	Example Result
<code>D{D}</code>	Produces transition between two data values.	<code>D{D}</code>	
<code>D{<i>&lt;Text&gt;</i>}</code>	Adds text material into a data signal using a node.	<code>D{A}D{B}</code>	
<code>D[<i>&lt;TikZ Settings&gt;</i>]{<i>&lt;Text&gt;</i>}</code>	Adds text material into a data signal using the given settings.	<code>D[blue]A</code>	
<code><i>&lt;integer&gt;</i>{<i>&lt;characters&gt;</i>}</code>	Repeats the given characters by the given number.	<code>5{h1}</code>	
<code><i>&lt;number&gt;</i><i>&lt;character&gt;</i></code>	Sets width of next signal to given number. Half of it if character is in lower case.	<code>2.6H5.21</code>	
<code>N[<i>&lt;Settings&gt;</i>](<i>&lt;Name&gt;</i>){<i>&lt;Content&gt;</i>}</code>	Adds node at current position. All three arguments are optional.	<code>H N(a1) L</code>	
<code>[<i>&lt;TikZ Settings&gt;</i>]</code>	Executes given TikZ settings.	<code>H[blue]LH</code>	
<code>;</code>	Renews the internal drawing path which ends the scope of all options given by [ <i>&lt;TikZ Settings&gt;</i> ].	<code>H; [blue]L;H</code>	
<code>,</code>	Same as ‘;’, but timing specific options (atm.: slopes and line width) are restored for the new path.	<code>H, [lw=1pt]L;H</code>	
<code>!{<i>&lt;code&gt;</i>}</code>	Places given code into the internal {tikzpicture}.	See Example 1 on page 8.	

Table 3: Overview over all transitions.

$\begin{smallmatrix} \nearrow \text{to} \\ \text{from} \end{smallmatrix}$	H	L	Z	X	D	U	M	G	S	T	C
H											
L											
Z											
X											
D											
U											
M											
G											
S											
T											
C											

`\texttimingbefore` (defaults to: `\empty`)

`\texttimingafter` (defaults to: `\empty`)

This two macros are executed before and after every timing diagram line created by `\texttiming` macro inside the same `{tikzpicture}` environment and can be used to add drawing macros. The argument of the `\texttiming` macro is already processed before any of these macros are expanded, therefore this macros can access the width of the diagram.

Example: `\let\texttimingbefore\texttiminggrid` adds a grid into the background of the `\texttiming` diagram. A more L<sup>A</sup>T<sub>E</sub>X-stylish way to do this is `\renewcommand*\textttimingbefore{\texttiminggrid}`.

`\texttiminggrid`

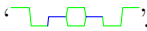
This macro should only be used inside `\texttimingbefore` or `\texttimingafter` and draws a grid of the full size of the `\texttiming` diagram.

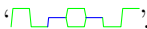
## 2.2 Macro for use inside TikZ-Pictures

```
\timing[TikZ Settings] (TikZ Coordinate) {[initial character]}(characters);
```

This macro does the same as `\texttiming` but is designed to be used inside a `{tikzpicture}` environment and only there. Like normal TikZ macros (`\path`, `\draw`, `\node`) it allows an optional argument with TikZ settings and an optional TikZ-coordinate (which may start with + or ++). However, a own argument parser, not the one used by TikZ, is used to detect and read these optional arguments. Therefore the order of the arguments is mandatory and might not be reversed. This small limitation might be overcome in future versions of this package.

Please note that the optional initial character may be given *inside* and at the very start of the mandatory argument, not before it. This is necessary because of several technical reasons.

Example: `\tikz \timing [green] (1,2) {HLZDZLH};` gives .

Example: `\tikz \timing [green] (1,2) {[L]HLZDZLH};` gives .

## 2.3 Table for Timing Diagrams

```
\begin{tikztimingtable}[TikZ settings]  
  Signal Name & Characters \\  
  ...  
  \extracode % Optional  
  additional code  
\end{tikztimingtable}
```

This environment can be used to typeset multi-line timing diagrams. The syntax is like the one for a `{tabular}` environment with two columns. The first column is for the signal name and the second one for the logic characters which would be placed inside the argument of a `\texttiming` or `\timing` macro. The whole table will be drawn inside a `{tikzpicture}` environment using multiple `\timing` and `\node` macros for the timing signals and their names, respectively. Additional `tikz` drawing code can be inserted at the end of the table using `\extracode`.

`\extracode`

This macro is only defined inside a `{tikztimingtable}` environment and can only be used after the last table line (i.e. after a `\\`). If used all code between it and the `\end{tikztimingtable}` will be placed inside the same `{tikzpicture}`. This allows to add some drawing lines or a grid to the picture. It is also possible to draw something behind the timing diagram by using the PGF background layer: `\begin{pgfonlayer}{background}... \end{pgfonlayer}`.

### 2.3.1 Macros for `\extracode` Section

The following macros are only defined inside a `{tikztimingtable}` after the macro `\extracode`. They are useful for drawing additional material.

`\tablegrid[<TikZ Settings>]`

`\fulltablegrid[<TikZ Settings>]`

After `\extracode` this macros draw a grid in the background of the table. The first one draws a separate grid for each row and the second one a big grid over all rows.

`\rowdist`

`\colldist`

This macros return the row and column distance. There are useful for drawing additional material relative to the rows and columns. This values can be set (e.g. in the optional argument of the table) using the `timing/rowdist` and `timing/colldist` settings which are explained in Section 3.

`\nrows`

Returns the number of rows in the current table. Useful for use in `\horlines`.

`\twidth`

Returns the width (as multiple of the ‘period width’) of the longest timing diagram line in the table.

Example: If the longest line would be ‘H 2.3L z’ than `\twidth` would be  $1 + 2.3 + 0.5 = 3.8$ .

`\horlines[<TikZ Settings>]{<list>}`

Draws horizontal lines, optionally with the given *<Settings>*, at the base line of the rows given by *<list>*. The PGF macro `\foreach`<sup>2</sup> is internally used so the list can include not only row numbers as integer but also fractional numbers and the ‘...’ operator to auto-increment the numbers. Please note that all numbers in the list are multiplied by `\rowdist`. If the list is empty the default ‘1,2,...,\nrows’ is used which draws lines for all rows.

`\vertlines[<TikZ Settings>]{<list>}`

Like `\horlines` but draws vertical lines and the listed numbers a relative to the basic width. If the list is empty the default ‘0,1,...,\twidth’ is used which draws lines after every period width.

---

<sup>2</sup>See the `pgf` manual for more details.

`\tablerules[TikZ Settings]`

This macro adds top and bottom rules to the table in the same (or at least very similar) way as the `booktabs` package is doing it for normal `tabulars`. The current bounding box is used to calculate the needed rule length, which makes this macro position dependent if further code is changing the bounding box.

### Positions & Scalings inside the Table

The first row starts at  $y = 0$  and the next rows are each `-1*\rowdist` lower than the previous one. The vertical unit is 1 `signal height` and the default row distance is ‘2’ ( $=2 \times \text{signal height}$ ). This means that a normal table with three rows goes from  $y = +1$  (base line at  $0 + 1 \text{ signal height}$ ) to  $y = -4$  (first row:  $+0$ , second row:  $-2$ , third row:  $-4$ ). This are relative to the middle of the drawn lines, i.e. the bounding box is  $2 \times \frac{\text{line width}}{2} = 1 \cdot \text{line width}$  higher.

The timing column starts at  $x = 0$  and goes into the positive range while scaled using the period width. Example: `HHHh` has a width of 3.5.

The label column starts at  $x = -\text{coldist}$  and the text is right align with the right border at this position.

### 3 Styles

The generated logic signals are drawn using the style mechanism provided by **tikz** (which is based on **pgfkeys**<sup>3</sup>). These styles are defined and can be redefined using `\tikzset{<style name>/.style=<value>},}`. They can also be used in all places where *<TikZ Settings>* is mentioned. Please note that path/draw specific settings might not survive the transition to characters which have their own color, because these start a new drawing path. For a more detailed explanation why this is necessary see the **tikz** manual. However, timing specific settings are saved and restored between internal paths.

The package follows the directory structures approach used by TikZ/PGF and places all styles and other settings under the “subdirectory” ‘**timing**’ in the main “directory” ‘**tikz**’, which is the default when `\tikzset` is used.

Example: The slope of the transitions can be changed using the key ‘**timing/slope**’, which can also be written in the absolute form ‘**/tikz/timing/slope**’.

The Table 4 lists all styles defined by this package.

Table 4: TikZ Styles and Settings provided and used by this Package.

Style/Setting	Description
<b>timing</b>	Base settings like signal height & period width.
<b>timing/intext</b>	Used for <code>\texttiming</code> . Depends on <b>timing</b> .
<b>timing/grid</b>	Used for grids. Depends on <b>help lines</b> and <b>timing</b> .
<b>timing/table</b>	Used for <code>{tikztimingtable}</code> . Depends on <b>timing</b> .
<b>timing/table/grid</b>	Used for table grid. Depends on <b>timing/grid</b> .
<b>timing/table/lines</b>	Used for <code>\horlines</code> and <code>\vertlines</code> .
<b>timing/table/rules</b>	Used for <code>\tablerules</code> .
<b>timing/inline node</b>	Used for nodes created by the N character. Default to coordinate.
<b>timing/&lt;lowercase char&gt;</b>	Style for character <i>&lt;char&gt;</i> . Not used for ‘H’ and ‘L’.
<b>timing/&lt;lc char&gt;/background</b>	Background style for characters ‘D’ and ‘U’.
<b>timing/&lt;lc char&gt;/text</b>	Text style for character <i>&lt;char&gt;</i> . Only defined for ‘D’.
<b>timing/slope=&lt;0.0–1.0&gt;</b>	Sets slope for logic transitions. This also sets <code>dslope=2*slope</code> , <code>zslope=slope/2</code> .
<b>timing/lslope=&lt;0.0–1.0&gt;</b>	Sets slope for logic transitions only. Default: 0.1
<b>timing/dslope=&lt;0.0–1.0&gt;</b>	Sets slope for data transitions. Default: 0.2
<b>timing/zslope=&lt;0.0–1.0&gt;</b>	Sets slope for Z transitions. Default: 0.05
<b>timing/rowdist=&lt;distance&gt;</b>	Sets (baseline) distance between rows in a <code>tikztimingtable</code> . Default: 2 (=2×signal height)
<b>timing/coldist=&lt;distance&gt;</b>	Sets distance between columns in a <code>tikztimingtable</code> . Default: 1 (=1×period width)

<sup>3</sup>Part of the **pgf** package, CTAN: <http://www.ctan.org/pkg/pgf>

## 4 Examples

This section shows some examples by putting either the full source code or only the needed characters beside the graphical result. Please note that the displayed syntax is the one of `\timing` where the initial character is declared as optional argument (`[<char>]`) *inside/together* with the logic characters. The syntax of `\texttttiming` is identical except the initial character is given as a normal optional argument before the characters argument. All examples except Example 1 are attached in compilable form to this PDF.

Example 1: Initial Characters, Modifiers, TikZ Settings

Characters	Resulting Diagram
HLZXDU TC	
cccc	
tttt	
[c]cccc	
4{c}	
4c4c	
4{1.8c}	
[d] 4{5D{Text}} 0.2D	
3.4H 0.6L	
DDUUUDD	
DD{ }DUUDD	
8{2D{\hexcountmacro }} 08 09 0A 0B 0C 0D 0E 0F	
3{2{0.25X 2.5D .25Z}} 0.25X 0.25D 0.25Z	
DD{ } 3{0.2D{}} DDD	
DD{ } 3{0.2D{}} 0.4D{ } 0.6D{ } DDD	
HHLLH SSS HLLHHL	
HHGHHGGHLLGLLGH	
ZZ G ZZ G XX G X	
LLL 2{0.1H 0.1L} 0.6H HH	
LLL [timing/slope=0.05] 4{.05H .05L} 0.6H HH	
LLL 0.4U 0.6H HH	
[L] [timing/slope=1.0] HL HL HL HL HL	
LLLLL !{-- +(.5,.5) -- ++(1,0)} HHHHHH	
LLLLL [/utils/exec={\somemacro \code }] HHHHHH	
LL [green] HH [brown] XX LL ZZ [orange] HH	
[ ] [line width=1pt] HLXZDU [line width=0.1pt] HLXZDU	
[ ] [line width=1pt] HLXZDU ; [line width=0.1pt] HLXZDU	


Note: Optional argument must be placed before macro argument if `\texttttiming` is used.





```

\begin{tikztimingtable}
  <<Name>> & hLLLLh      \\
  Clock    & 10{c}       \\
  Signal   & z4D{Text}z      \\
\end{tikztimingtable}

```

«Name» 

Clock 


Signal 


Example 2: `{tikztimingtable}` without `\extracode`.


```

\begin{tikztimingtable}
  <<Name>> & hLLLLh      \\
  Clock    & 10{c}       \\
  Signal   & z4D{Text}z      \\
\extracode
  \draw (0,0) circle (0.2pt); % Origin
  \begin{pgfonlayer}{background}
    \vertlines[help lines]{0.5,4.5}
  \end{pgfonlayer}
\end{tikztimingtable}

```

«Name» 

Clock 

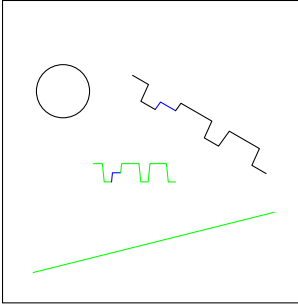
Signal 

Example 3: `{tikztimingtable}` with `\extracode`.

```

\begin{tikzpicture}[x=4cm,y=4cm]
  \draw (0,0) rectangle (1,1);
  \draw (0.2,0.7) circle (10pt);
  \begin{scope}[green]
    \draw (0.1,0.1) -- +(0.8,0.2);
    \timing (0.3,0.4) {hlzhhlhhl};
  \end{scope}
  \timing [rotate=-30]
    (0.4,0.7) {HLZHHLHHL};
\end{tikzpicture}

```

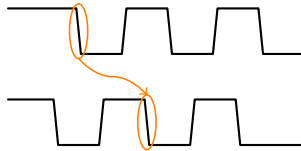


Example 4: `\timing` inside general `{tikzpicture}`.

```

\Huge
\begin{tikzpicture}[timing,thick,
  timing/inline node/.style={coordinate,
    shift={(0.05,-.5)}}]
\timing (0,2) {hH N(A) LHLHL};
\timing (0,0) {HLH N(B) LHLl};
\draw [orange,semithick]
  (A) ellipse (.2 and .6) +(0,-0.6) coordinate (Ax)
  (B) ellipse (.2 and .6) +(0,+0.6) coordinate (Bx);
\draw [orange,semithick,->]
  (Ax) parabola[bend pos=0.5] (Bx);
\end{tikzpicture}

```

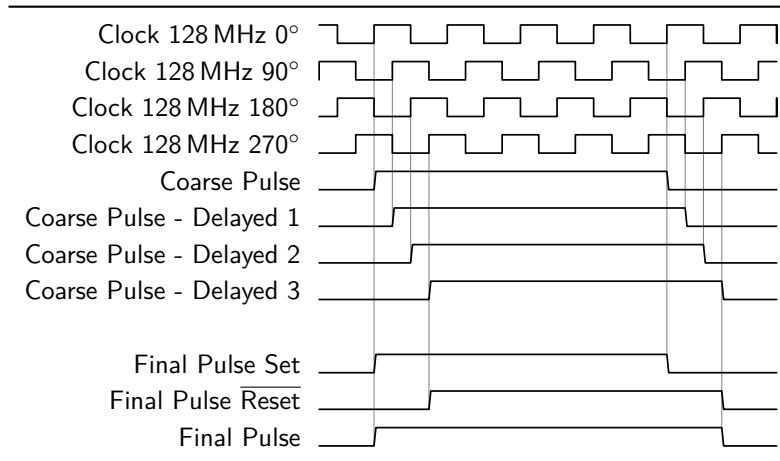


Example 5: Using In-Line Nodes to draw Relationships.

```

\def\degr{${}^\circ}
\begin{tikztimingtable}
  Clock 128\,MHz 0\degr      & H 2C N(A1) 8{2C} N(A5) 3{2C} G\\
  Clock 128\,MHz 90\degr    & [C] 2{2C} N(A2) 8{2C} N(A6) 2{2C} C\\
  Clock 128\,MHz 180\degr   & C 2{2C} N(A3) 8{2C} N(A7) 2{2C} G\\
  Clock 128\,MHz 270\degr   & 3{2C} N(A4) 8{2C} N(A8) 2C C\\
  Coarse Pulse              & 3L 16H 6L \\
  Coarse Pulse - Delayed 1  & 4L N(B2) 16H N(B6) 5L \\
  Coarse Pulse - Delayed 2  & 5L N(B3) 16H N(B7) 4L \\
  Coarse Pulse - Delayed 3  & 6L 16H 3L \\
  \\
  Final Pulse Set           & 3L 16H N(B5) 6L \\
  Final Pulse  $\overline{\text{Reset}}$  & 6L N(B4) 16H 3L \\
  Final Pulse               & 3L N(B1) 19H N(B8) 3L \\
\extracode
\tablerules
\begin{pgfonlayer}{background}
  \foreach \n in {1,...,8}
    \draw [help lines] (A\n) -- (B\n);
\end{pgfonlayer}
\end{tikztimingtable}

```

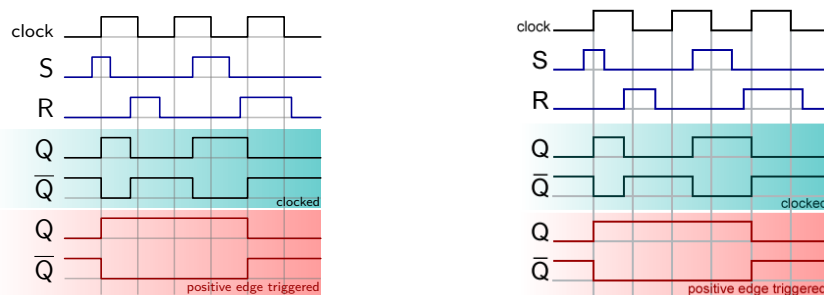


Example 6: Using In-Line Nodes to draw Marker Lines.

```

\definecolor{bgblue}{rgb}{0.41961,0.80784,0.80784}
\definecolor{bgred}{rgb}{1,0.61569,0.61569}
\definecolor{fgblue}{rgb}{0,0,0.6}
\definecolor{fgred}{rgb}{0.6,0,0}
\begin{tikztimingtable}[timing/slope=0,
  timing/coldist=2pt,xscale=2,yscale=1.1,semithick]
  \scriptsize clock & 7{C}\
  S & .75L h 2.25L H LL [fgblue]\
  R & 1.8L .8H 2.2L 1.4H 0.8L [fgblue]\
  Q & L .8H 1.7L 1.5H LL\
  $\overline{\mbox{Q}}$ & H .8L 1.7H 1.5L HH\
  Q & LHHHLL [fgred]\
  $\overline{\mbox{Q}}$ & HLLLLHH [fgred]\
\extracode
\begin{pgfonlayer}{background}
  \shade [right color=bgblue,left color=white]
    (7,-8.45) rectangle (-2,-4.6);
  \shade [right color=bgred,left color=white]
    (7,-12.8) rectangle (-2,-8.6);
\begin{scope}[gray,semitransparent,semithick]
  \horlines{}
  \foreach \x in {1,...,6}
    \draw (\x,1) -- (\x,-12.8);
  % similar: \vertlines{1,...,6}
\end{scope}
\node [anchor=south east,inner sep=0pt]
  at (7,-8.45) {\tiny clocked};
\node [anchor=south east,inner sep=0pt,fgred]
  at (7,-12.8) {\tiny positive edge triggered};
\end{pgfonlayer}
\end{tikztimingtable}
\insertoriginalimageforcomparisionifpresent

```

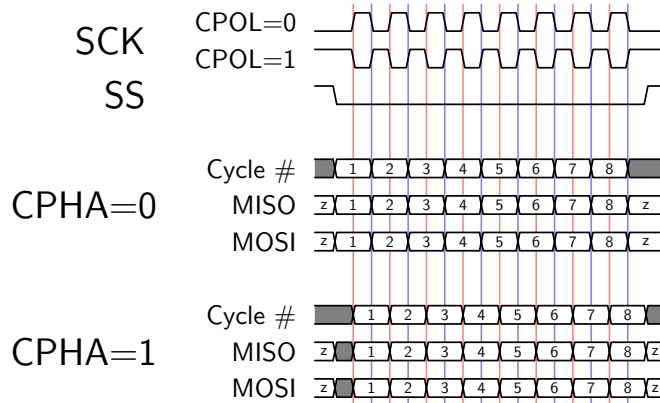


Example 7: SR flip-flop timing diagram (left). Redrawn from image (right)  
[http://commons.wikimedia.org/wiki/File:SR\\_FF\\_timing\\_diagram.png](http://commons.wikimedia.org/wiki/File:SR_FF_timing_diagram.png)

```

\newcounter{countup}
\newcommand*{\countup}{\addtocounter{countup}{1}\thecountup}
\newcommand*{\crst}{\setcounter{countup}{0}}
\begin{tikztimingtable}
[timing/d/background/.style={fill=white},
 timing/lslope=0.2]
CPOL=0 & LL 15{T} LL \\\
CPOL=1 & HH 15{T} HH \\\
        & & H 17L H \\\
\\
\crst Cycle \# & U      8{2D{\countup}} 2U \\\
\crst MISO & D{z} 8{2D{\countup}} 2D{z} \\\
\crst MOSI & D{z} 8{2D{\countup}} 2D{z} \\\
\\
\crst Cycle \# & UU      8{2D{\countup}} U \\\
\crst MISO & D{z}U 8{2D{\countup}} D{z} \\\
\crst MOSI & D{z}U 8{2D{\countup}} D{z} \\\
\extracode
\begin{pgfonlayer}{background}
\begin{scope}[semitransparent,semithick]
\vertlines[red]{2.1,4.1,...,17.1}
\vertlines[blue]{3.1,5.1,...,17.1}
\end{scope}
\end{pgfonlayer}
\begin{scope}
[font=\sffamily\Large,shift={(-6em,-0.5)},anchor=east]
\node at ( 0, 0) {SCK}; \node at ( 0,-3 ) {SS};
\node at (1ex,-9) {CPHA=0}; \node at (1ex,-17) {CPHA=1};
\end{scope}
\end{tikztimingtable}%

```



Example 8: SPI Interface Timing. Redrawn from image  
[http://en.wikipedia.org/wiki/File:SPI\\_timing\\_diagram.svg](http://en.wikipedia.org/wiki/File:SPI_timing_diagram.svg)

## 5 Implementation

### 5.1 Package Header

```
1 \langle*package\rangle
2 \RequirePackage{tikz}
3 \usetikzlibrary{calc}
4 \usetikzlibrary{backgrounds}
5 \RequirePackage{environ}
6
7 \def\tikztimingwidth{0.0}
8 \newcount\tikztiming@numint
9 \newcount\tikztiming@numfrac
10 \def\tikztiming@num{1.0}%
11 %%\def\tikztiming@num{\the\tikztiming@numint.\the\tikztiming@numfrac}
12
13 \newcounter{tikztiming@nrows}%
14 \def\tikztiming@rowdist{2}%
15 \def\tikztiming@colldist{1}%
16 \def\tikztiminglabel#1{#1}%
17
18 \def\tikztiming@prefix{tikztiming@trans@}
```

### 5.2 TikZ Style Settings

```
19 \tikzset{timing/.style={%
20     x=1.6ex, y=1.6ex,
21     line cap=round, line join=round,
22 }%
23 }
24 \tikzset{%
25     timing/.cd,
26     grid/.style={timing,help lines},
27     intext/.style={timing,line width=0.15ex},
28     inline node/.style={shape=coordinate},
29     table/.style={timing,line width=0.15ex,font=\sffamily},
30     coord/.style={inner sep=0pt,outer sep=0pt},
31     save/.style={inner sep=0pt,outer sep=0pt,/utils/exec=\tikztiming@savesettings},
32     restore/.style={/utils/exec=\tikztiming@restoresettings},
33     name/.style={inner sep=0pt,outer sep=0pt},
34     d/text/.style={timing,scale=0.6,font=\sffamily},
35     d/background/.style={},
36     h/.style={},
37     l/.style={},
38     d/.style={},
39     m/.style={black!40!brown},
40     u/background/.style={fill=gray},
41     u/.style={},
42     o/background/.style={},
43     o/.style={timing/d,line width=0.10ex,dotted},
44     z/.style={blue},
```

```

45 t/.style={},
46 c/.style={timing/slope=0.0},
47 x/.style={red},
48 table/grid/.style={timing/grid},
49 table/lines/.style={},
50 table/rules/.style={line width=0.08em,line cap=butt},
51 slope/.code={%
52   \tikztimingsetslope{#1}%
53   \tikztimingsetdslope{2*#1}%
54   \tikztimingsetzslope{#1/2}%
55 },
56 lslope/.code={\tikztimingsetslope{#1}},
57 dslope/.code={\tikztimingsetdslope{#1}},
58 zslope/.code={\tikztimingsetzslope{#1}},
59 coldist/.store in=\tikztiming@coldist,
60 rowdist/.store in=\tikztiming@rowdist,
61 }

```

### 5.3 Macros

#### `\texttimingbefore`

This macro is executed inside the tikzpicture environment of `\texttiming` before the timing diagram is drawn.

```
62 \def\texttimingbefore{}
```

#### `\texttimingafter`

This macro is executed inside the tikzpicture environment of `\texttiming` after the timing diagram is drawn.

```
63 \def\texttimingafter{}
```

#### `\texttiminggrid`

Draws a background grid with the ‘timing/grid’ setting. Should be used inside `\texttimingbefore`.

```

64 \def\texttiminggrid{%
65   \draw[xstep={\timingwidth/2.},ystep={\timingheight/2.},timing/grid] (0,0) grid
66   (\timingwidth*\tikztimingwidth,\timingheight);
67 }

```

#### `\texttiming`

#1: Optional initial character

#2: Timing characters

```

68 \DeclareRobustCommand*\texttiming[2] []{%
69   \begingroup
70   \tikztiming@init
71   \uppercase{\def\lastchar{#1}}%
72   \@ifundefined{tikztiming@initcode@\lastchar}%
73   {}%

```

```

74     {\@nameuse{tikztiming@initcode@\lastchar}}%
75     \ifx\lastchar\empty\else
76     \@ifundefined{tikztiming@prefix\lastchar @start}%
77     {\PackageWarning{tikz-timing}{Start value for timing character '\lastchar'
78     is not defined and will be ignored!}}{}{}{}%
79     {\tikztiming@nameaddtostr{\lastchar @start}{}{}}%
80     \fi
81     \tikztiming@#2\relax
82     %\message{^^Jmeaning\tikztiming@str^^J}%
83     \begin{tikzpicture}[timing/intext]%
84         \path[use as bounding box] (0,0) rectangle
85         (\timingwidth*\tikztimingwidth,\timingheight);%
86         \texttimingbefore
87         \tikztiming@str;%
88         \texttimingafter
89     \end{tikzpicture}%
90 \endgroup
91 }

```

#### **\tikztiming@init**

```

92 \def\tikztiming@init{%
93     \def\lastchar{}%
94     \let\currentchar\empty
95     \def\tikztimingwidth{0.0}%
96     \setcounter{tikztimingtrans}{-1}%
97     \def\tikztiming@str{\draw (0,0) coordinate (timing/start base) }%
98 }

```

#### **\timing**

```

99 \def\timing{%
100     \@ifnextchar{[]}%
101     {\timing@}%
102     {\timing@[]}%
103 }

```

#### **\timing@**

#1: Optional TikZ Settings

```

104 \def\timing@[#1]{%
105     \@ifnextchar{+}%
106     {\timing@@{#1}}%
107     {\@ifnextchar(}%
108     {\timing@@{#1}}%
109     {\timing@@{#1}+(0,0)}%
110     }%
111 }

```

#### **\timing@@**

#1: Optional TikZ Settings



#2: Potential '+' or empty

#3: Coordinate

```
112 \def\timing@@#1#2(#3){%
113   \timing@@@{#1}{#2(#3)}%
114 }
```

#### **\timing@@@**

#1: Optional TikZ Settings

#2: Coordinate

#3: Timing Characters

```
115 \def\timing@@@#1#2#3{%
116   \begingroup
117     \tikztiming@init
118     \@ifnextchar{[]}%
119       {\timing@@@init}%
120       {\timing@@@init[]}%
121     #3\relax
122     %\message{^^J\meaning\tikztiming@str^^J}%
123     \begin{scope}[shift={#2},timing,#1]%
124       \tikztiming@str;%
125     \end{scope}%
126   \endgroup
127   \timing@@@end
128 }
```

#### **\timing@@@end**

#1: Token behind \timing macro.

```
129 \def\timing@@@end#1;%
130   \ifx;#1;\else
131     \PackageError{tikz-package}{Can not parse timing path}{-}{-}{-}%
132   \fi
133 }
134 %
```

#### **\timing@@@init**

#1: Initial character.

```
135 \def\timing@@@init[#1]{%
136   \uppercase{\def\lastchar{#1}}%
137   \@ifundefined{tikztiming@initcode@\lastchar}%
138     {}%
139     {\@nameuse{tikztiming@initcode@\lastchar}}%
140   \ifx\lastchar\empty\else
141     \@ifundefined{\tikztiming@prefix\lastchar @start}%
142     {\PackageWarning{tikz-timing}{Start value for timing character '\lastchar'
143       is not defined and will be ignored!}{-}{-}{-}}%
144     {\tikztiming@nameaddtostr{\lastchar @start}{-}}%
145   \fi
```

```

146 \tikztiming@
147 }

\tikztiming@trans@
    The empty transition gets defined to avoid errors if it is used by the generic
    code, e.g. if a non-combinable character like ‘C’ is the last one.
148 \let\tikztiming@trans@\@gobble

\tikztiming@aftercode@T
149 \def\tikztiming@aftercode@T{%
150 \tikztiming@output@flush
151 }

\tikztiming@aftercode@t
152 \def\tikztiming@aftercode@t{%
153 \tikztiming@aftercode@T
154 }

\tikztiming@aftercode@C
155 \def\tikztiming@aftercode@C{%
156 \tikztiming@output@flush
157 }

\tikztiming@aftercode@c
158 \def\tikztiming@aftercode@c{%
159 \tikztiming@aftercode@C
160 }

\tikztiming@aftercode@G
161 \def\tikztiming@aftercode@G{%
162 \let\lastchar\secondlastchar
163 \let\tikztimingwidth\lasttikztimingwidth
164 }

\tikztiming@aftercode@g
165 \def\tikztiming@aftercode@g{%
166 \let\lastchar\secondlastchar
167 \let\tikztimingwidth\lasttikztimingwidth
168 }

\tikztiming@aftercode@S
169 \def\tikztiming@aftercode@S{%
170 \let\lastchar\secondlastchar
171 }

```

**\tikztiming@aftercode@s**

```
172 \def\tikztiming@aftercode@s{%
173   \let\lastchar\secondlastchar
174 }
```

**\tikztiming@beforenextcode@D@edge@**

```
175 \def\tikztiming@beforenextcode@D@edge@{%
176   \if D\currentchar\else
177     \if d\currentchar\else
178       \def\lastchar{D}%
179     \fi
180   \fi
181 }
```

**\tikztiming@beforecode@d@edge@**

```
182 \def\tikztiming@beforenextcode@d@edge@{%
183   \if D\currentchar\else
184     \if d\currentchar\else
185       \def\lastchar{D}%
186     \fi
187   \fi
188 }
```

**\tikztiming@initcode@D**

```
189 \def\tikztiming@initcode@D{%
190   \def\lastchar{D@edge@}%
191 }
```

**\tikztiming@initcode@d**

```
192 \def\tikztiming@initcode@d{%
193   \def\lastchar{d@edge@}%
194 }
```

**\tikztiming@**

The `\@ifnextchar\bgroup` is a trick to remove following spaces which would break the number test.

```
195 \def\tikztiming@{%
196   \@ifnextchar\bgroup
197     {\tikztiming@testfornum}%
198     {\tikztiming@testfornum}%
199 }
```

**\tikztiming@eaddtostr**

**#1:** Tokens to add to string.

```
200 \def\tikztiming@eaddtostr#1{%
201   \begingroup
202     \tikztiming@internaldefs{}%

```

```

203 \temptokena\expandafter{\tikztiming@str}%
204 \xdef\tikztiming@str{%
205     \the\temptokena
206     #1%
207 }%
208 \endgroup
209 }

\tikztiming@addtostr

210 \def\tikztiming@addtostr{%
211     \g@addto@macro\tikztiming@str
212 }

\tikztiming@output

#1: Character 1
#2: Character 2

213 \def\tikztiming@output#1#2{%
214     \ifx\relax#2\relax
215         \tikztiming@nameaddtostr{#1}%
216     \else
217         \ifcase0%
218             \ifx\tikztiming@output@bufchara\empty
219                 \ifx\tikztiming@output@bufcharb\empty
220                     1%
221                 \fi
222             \fi\relax
223             % not empty
224             \edef\tikztiming@output@currentchar{#2}%
225             \ifcase0%
226                 \expandafter\ifx\cename tikztiming@nocombine@#2\endcsname\relax
227                 \ifx\tikztiming@output@currentchar\tikztiming@output@bufcharb
228                     1%
229                 \fi\fi
230             \relax
231             \tikztiming@output@flush
232             \edef\tikztiming@output@bufchara{#1}%
233             \edef\tikztiming@output@bufcharb{#2}%
234         \or
235             \pgfmathparse{\tikztiming@output@bufnum + \tikztiming@num}%
236             \let\tikztiming@output@bufnum\pgfmathresult
237             \def\tikztiming@num{1.0}%
238         \fi
239     \else % empty
240         \edef\tikztiming@output@bufchara{#1}%
241         \edef\tikztiming@output@bufcharb{#2}%
242         \let\tikztiming@output@bufnum\tikztiming@num
243         \def\tikztiming@num{1.0}%
244     \fi
245 \fi

```

```
246 }
```

Init buffer macros:

```
247 \def\tikztiming@output@bufchara{}%
248 \def\tikztiming@output@bufcharb{}%
249 \def\tikztiming@output@bufnum{0}%
```

#### **\tikztiming@output@flush**

```
250 \def\tikztiming@output@flush{%
251   \begingroup
252     \let\tikztiming@num\tikztiming@output@bufnum
253     \tikztiming@nameaddtostr{%
254       \tikztiming@output@bufchara
255       \tikztiming@output@bufcharb
256     }%
257   \endgroup%
258   \gdef\tikztiming@output@bufchara{}%
259   \gdef\tikztiming@output@bufcharb{}%
260   \global\let\tikztiming@output@bufnum\tikztiming@num
261   \gdef\tikztiming@num{1.0}%
262 }
```

#### **\tikztiming@nameaddtostr**

#1: Name of macro without prefix to add

```
263 \def\tikztiming@nameaddtostr#1{%
264   \begingroup
265     \edef\@tempa{\tikztiming@num}%
266     \expandafter\g@addto@macro
267     \expandafter\tikztiming@str
268     \expandafter{\csname\tikztiming@prefix#1\expandafter\endcsname
269     \expandafter{\@tempa} }%
270   \endgroup
271   \def\tikztiming@num{1.0}%
272 }
```

#### **\tikztiming@nameedef**

#1: Optional character to indicate character case

#2: Macro name to be defined (without prefix)

#3: Content of macro

Defines internal tikztiming macro with name `\<prefix>\<name (#2)>`. The macro definition (`#3`) is expanded while the internal drawing definitions are active.

```
273 \newcommand\tikztiming@nameedef[3][A]{%
274   \def\@gtempa##1{#3}%
275   \expandafter\let\csname\tikztiming@prefix#2@general\endcsname\@gtempa
276   \begingroup
277     \tikztiming@internaldefs{#1}%
278     \xdef\@gtempa##1{\@gtempa{\width}}%
279   \endgroup
```

```

280 \expandafter\let\csname\tikztiming@prefix#2\endcsname\@gtempa
281 \let\@gtempa\empty
282 }

```

#### **\tikztiming@namelet**

#1: Original Characters

#2: New Characters

Only execute \let if the original macro is defined or the destination macro is defined and would now set to undefined.

```

283 \newcommand\tikztiming@namelet[2]{%
284 \ifcase0%
285 \ifundefined{\tikztiming@prefix#2}%
286 {\ifundefined{\tikztiming@prefix#1}%
287 {0}{1}%
288 }%
289 {1}%
290 \relax
291 \else
292 \expandafter\let
293 \csname\tikztiming@prefix#1\endcsname\expandafter\endcsname
294 \csname\tikztiming@prefix#2\endcsname
295 \fi
296 }

```

#### **\tikztiming@@end**

```

297 \def\tikztiming@@end{%
298 \tikztiming@output@flush
299 \global\let\tikztimingwidth\tikztimingwidth
300 \tikztiming@addtostr{ coordinate (timing/end)
301 let \p1 = (timing/start base), \p2 = (timing/end) in
302 coordinate (timing/end base) at (\x2,\y1)
303 coordinate (timing/end top) at (\x2,1+\y1)
304 }%
305 }

```

#### **\tikztiming@@**

#1: Next Character

```

306 \def\tikztiming@@#1{%
307 \ifx\relax#1\empty
308 \expandafter\tikztiming@@end
309 \else
310 \let\lasttikztimingwidth\tikztimingwidth
311 \tikztiming@iflower{#1}%
312 {\pgfmathparse{\tikztiming@num/2.0}\let\tikztiming@num\pgfmathresult}%
313 {}%
314 \pgfmathparse{\tikztimingwidth + \tikztiming@num}%
315 \let\tikztimingwidth\pgfmathresult
316 \def\currentchar{#1}%

```

```

317 \uppercase{\def\currentcharuc{#1}}%
318 \ifundefined{tikztiming@beforenextcode@\lastchar}%
319 {}%
320 {\@nameuse{tikztiming@beforenextcode@\lastchar}}%
321 \ifundefined{tikztiming@beforecode@\currentchar}%
322 {}%
323 {\@nameuse{tikztiming@beforecode@\currentchar}}%
324 \ifundefined{\tikztiming@prefix\lastchar\currentchar}%
325 {\ifundefined{\tikztiming@prefix\lastchar\currentcharuc}%
326 {\PackageWarning{tikz-timing}{Timing transition '\lastchar\currentchar'
327 is not defined and will be ignored!}}{}{}%
328 {\tikztiming@output{\lastchar}{\currentcharuc}}%
329 }%
330 {\tikztiming@output{\lastchar}{\currentchar}}%
331 \let\secondlastchar\lastchar
332 \let\lastchar\currentcharuc
333 \ifundefined{tikztiming@aftercode@\currentcharuc}%
334 {}%
335 {\@nameuse{tikztiming@aftercode@\currentcharuc}}%
336 \expandafter
337 \tikztiming@testfortext
338 \fi
339 }

```

#### **\tikztiming@testfortext**

```

340 \def\tikztiming@testfortext{%
341 \ifnextchar\bgroup
342 {\tikztiming@handletext}%
343 {\tikztiming@}%
344 }

```

#### **\tikztiming@handletext**

#1: Text

```

345 \def\tikztiming@handletext#1{%
346 \ifnextchar{[]}%
347 {\tikztiming@handletext@}%
348 {\tikztiming@handletext@[]}%
349 #1\relax
350 }

```

#### **\tikztiming@handletext@**

#1: Optional Settings

#2: Text

```

351 \def\tikztiming@handletext@[#1]#2\relax{%
352 \begingroup
353 \expandafter\lowercase\expandafter{%
354 \expandafter\def\expandafter\currentcharlc
355 \expandafter{\currentchar}%

```

```

356 }%
357 \pgfkeysifdefined{/tikz/timing/\currentcharlc/text/.@cmd}%
358 {%
359 \tikztiming@output@flush
360 \tikztiming@eaddtostr{%
361     node (timing@dend) at +(\dslope/2.0,\height/2.0) {}
362     node [%]
363         shift={($ (timing@dstart)!0.5!(timing@dend) $)},%
364     timing/\currentcharlc/text,%
365 }%
366 \endgroup
367 \tikztiming@addtostr{[%
368     #1%
369     ] {#2}%
370 }%
371 \def\lastchar{D@edge@}%
372 }{%
373     \endgroup
374     \PackageWarning{tikz-timing}{Ignoring text for character
375         '\currentchar'!}{-}{-}{-}%
376 }%
377 \tikztiming@
378 }

```

#### **\tikztiming@stoppath**

#1: Character to gobble

```

379 \def\tikztiming@stoppath#1{%
380     \tikztiming@output@flush
381     \tikztiming@eaddtostr{%
382         \newdraw
383     }%
384     \tikztiming@
385 }

```

#### **\tikztiming@stoppath@nosave**

#1: Character to gobble

```

386 \def\tikztiming@stoppath@nosave#1{%
387     \tikztiming@output@flush
388     \tikztiming@eaddtostr{%
389         \newdraws
390     }%
391     \tikztiming@
392 }

```

#### **\tikztiming@addnode**

#1: Character to gobble

```

393 \def\tikztiming@addnode#1{%
394     \@ifnextchar{[]}%

```



```

395     {\tikztiming@addnode@getoptions}%
396     {\tikztiming@addnode@getoptions[]}%
397 }

```

#### **\tikztiming@addnode**

#1: Options

```

398 \def\tikztiming@addnode@getoptions[#1]{%
399   \@ifnextchar{({}%
400     {\tikztiming@addnode@getname{#1}}%
401     {\tikztiming@addnode@getname{#1}({}%
402 }

```

#### **\tikztiming@addnode@getname**

#1: Previous read options

#2: Node name

```

403 \def\tikztiming@addnode@getname#1(#2){%
404   \@ifnextchar\bgroup
405     {\tikztiming@addnode@{#1}{#2}}%
406     {\tikztiming@addnode@{#1}{#2}{}}%
407 }

```

#### **\tikztiming@addnode@**

#1: Options

#2: Node name

#3: Node text

```

408 \def\tikztiming@addnode@#1#2#3{%
409   \tikztiming@output@flush
410   \begingroup
411     \def\@tempa{#2}%
412     \ifx\@tempa\empty
413       \def\@tempa{ node [timing/inline node,#1] }%
414     \else
415       \def\@tempa{ node [timing/inline node,#1] (#2) }%
416     \fi
417     \expandafter\tikztiming@addtostr\expandafter{\@tempa {#3} }%
418   \endgroup
419   \tikztiming@
420 }

```

#### **\tikztiming@testforcode**

```

421 \def\tikztiming@testforcode{%
422   \@ifnextchar{!}%
423     {\tikztiming@testforcode@}%
424     {\@ifnextchar{[%
425       {\tikztiming@handleoption}%
426       {\@ifnextchar{;%
427         {\tikztiming@stoppath@nosave}%

```

```

428      {\@ifnextchar{,}%
429      {\tikztiming@stoppath}%
430      {\@ifnextchar{N}%
431      {\tikztiming@addnode}%
432      {\tikztiming@@}%
433      }%
434      }%
435      }%
436      }%
437 }

```

#### **\tikztiming@testforcode@**

#1: Character to gobble

```

438 \def\tikztiming@testforcode#1{%
439   \@ifnextchar\bgroup
440   {\tikztiming@handlecode}%
441   {%
442     \PackageWarning{tikz-timing}{Missing braces after '!' character. Ignoring
443     this character}{-}{-}}%
444   \tikztiming@
445   }%
446 }

```

#### **\tikztiming@handlecode**

#1: Code to add to string

```

447 \def\tikztiming@handlecode#1{%
448   \tikztiming@output@flush
449   \tikztiming@addtostr{ #1 }%
450   \tikztiming@
451 }

```

#### **\tikztiming@handleoption**

#1: Options to add to string

```

452 \def\tikztiming@handleoption[#1]{%
453   \tikztiming@addtostr{ [#1] }%
454   \tikztiming@
455 }

```

#### **\tikztiming@testfornum**

```

456 \def\tikztiming@testfornum{%
457   \let\tikztiming@numchars\empty
458   \tikztiming@numfrac0\relax
459   \afterassignment
460   \tikztiming@testfornum@
461   \tikztiming@numint0%
462 }

```

**\tikztiming@testfornumfrac**

```
463 \def\tikztiming@testfornumfrac{%
464   \afterassignment
465   \tikztiming@testfornum@@@
466   \tikztiming@numfrac1%
467 }
```

**\tikztiming@numloop**

```
468 \def\tikztiming@numloop{%
469   \ifnum\tikztiming@numint>0%
470     \toks@\expandafter\tikztiming@numchars}%
471     \xdef\tikztiming@numchars{%
472       \the\toks@
473       \the\@temptokena
474     }%
475     \advance\tikztiming@numint by -1\relax
476     \expandafter\tikztiming@numloop
477   \fi
478 }
```

**\tikztiming@testfornum@**

```
479 \def\tikztiming@testfornum@{%
480   \ifnum0<\tikztiming@numint
481     \let\tikztiming@next\tikztiming@testfornum@@
482   \else
483     \def\tikztiming@next{%
484       \@ifnextchar{.}%
485       {\expandafter\tikztiming@testfornumfrac\@gobble}%
486       {%
487         \tikztiming@numint1\relax
488         \tikztiming@numfrac0\relax
489         \def\tikztiming@num{1.0}%
490         \expandafter\tikztiming@testforcode
491       }%
492     }%
493   \fi
494   \tikztiming@next
495 }
```

**\tikztiming@testfornum@@**

```
496 \def\tikztiming@testfornum@@{%
497   \@ifnextchar{.}%
498   {\expandafter\tikztiming@testfornumfrac\@gobble}%
499   {\tikztiming@testfornum@@@}%
500 }
```

**\tikztiming@testfornum@@@**

```
501 \def\tikztiming@testfornum@@@{%
```

```

502 \xdef\tikztiming@num{\the\tikztiming@numint.\expandafter\@gobble\the\tikztiming@numfrac}%
503 \@ifnextchar\bgroup
504 {%
505   \expandafter\tikztiming@numfrac\expandafter0\expandafter
506   \@gobble\the\tikztiming@numfrac\relax
507   \ifnum0=\tikztiming@numfrac\else
508     \pgfmathparse{round(\tikztiming@num)}%
509     \PackageWarning{tikz-timing}%
510       {Can not repeat group by a non-integer factor!^^J%
511       Rounding '\tikztiming@num' to '\pgfmathresult'.}{-}{-}{-}%
512     \let\tikztiming@num\pgfmathresult
513   \fi
514   \tikztiming@testfornum@@@
515 }%
516 {%
517   \tikztiming@testforcode
518 }%
519 }

```

**\tikztiming@testfornum@@@**

#1: Characters and other tokens to repeat

```

520 \def\tikztiming@testfornum@@@#1{%
521   \begingroup
522   \@temptokena{#1}%
523   \tikztiming@numloop%
524   \endgroup
525   \tikztiming@numint1\relax
526   \tikztiming@numfrac0\relax
527   \expandafter\tikztiming@\tikztiming@numchars
528 }

```

## 5.4 Table environment

```

529 %\usetikzlibrary{backgrounds}
530 \newcounter{tikztimingrows}

```

**\tikztiming@extracode**

```

531 \def\tikztiming@extracode{\@gobble{EXTRACODE}}%

```

**tikztimingtable**

#1: Optional settings

```

532 \NewEnviron{tikztimingtable}[1][]{%
533   \begingroup
534   \setcounter{tikztiming@nrows}{0}%
535   \def\tikztiming@maxwidth{0.0}%
536   \let\extracode\tikztiming@extracode
537   \let\tablegrid\tikztiming@tablegrid
538   \let\fulltablegrid\tikztiming@fulltablegrid

```

```

539 \let\horlines\tikztiming@horlines
540 \let\vertlines\tikztiming@vertlines
541 \let\ablerules\tikztiming@ablerules
542 \def\rowdist{\tikztiming@rowdist}%
543 \def\coldist{\tikztiming@coldist}%
544 \def\nrows{\the\c@tikztiming@nrows}%
545 \def\twidth{\tikztiming@maxwidth}%
546 \begin{tikzpicture}[timing/table,#1]%
547   \coordinate (last row) at (0,\rowdist);
548   \coordinate (label pos) at (-1*\coldist,0);
549   \coordinate (timing/table/top left) at (0,1);
550   \coordinate (timing/table/bottom right) at (0,0);
551   \expandafter\tikztimingtable@row\BODY\endtikztimingtable@
552 \end{tikzpicture}
553 \endgroup
554 }
555
556 \def\endtikztimingtable@{\@gobble{ENDTIKSTIMING}}

```

#### **\tikztimingextracode**

#1: Token to gobble

#2: Extra drawing code

```

557 \long\def\tikztimingextracode#1#2\endtikztimingtable@{%
558   \path let
559     \p1 = (timing/table/top left),
560     \p2 = (timing/table/bottom right)
561   in
562     coordinate (timing/table/bottom left) at (\x1,\y2)
563     coordinate (timing/table/top right) at (\x2,\y1)
564     coordinate (timing/table/size) at (\x2-\x1,\y1-\y2)
565   ;
566   #2%
567 }

```

#### **\tikztiming@emptycell**

Just used as marker. Needs unique definition.

```

568 \def\tikztiming@emptycell{%
569   \@gobble{tikztiming@emptycell}%
570 }

```

#### **\tikztimingtable@row**

#1: Row content

```

571 \def\tikztimingtable@row#1\\{%
572   \tikztimingtable@row@#1&\tikztiming@emptycell&\\
573 }

```

#### **\tikztimingtable@row@**

#1: Cell 1

#2: Cell 2 or empty  
 #3: Potential further cells

```

574 \def\tikztimingtable@row@#1&#2&#3\\{%
575   \ifx\\#3\\else
576     \begingroup
577       \def\@tempa{\tikztiming@emptycell&}%
578       \def\@tempb{#3}%
579       \ifx\@tempa\@tempb\else
580         \PackageWarning{tikz-timing}{%
581           To many columns in tikztimingtable row! Only two are allowed%
582         }{}{}%
583       \fi
584     \endgroup
585   \fi
586   \ifx\tikztiming@emptycell#2%
587     \def\next{\tikztimingtable@row@@{#1}{}}%
588   \else
589     \def\next{\tikztimingtable@row@@{#1}{#2}}%
590   \fi
591   \next
592 }%

```

#### `\tikztimingtable@row@@`

#1: Name/Label  
 #2: Timing characters

```

593 \def\tikztimingtable@row@@#1#2{%
594   \addtocounter{tikztiming@nrows}{1}%
595   \path ($ (last row) + (0,-1*\rowdist) $) coordinate (last row);
596   \path ($ (last row) + (-1*\colldist,0) $) node [anchor=base east, timing/name]
597     {\tikztiminglabel{#1}};
598   \timing (last row) {#2};
599   \path let \p1 = (timing/table/bottom right), \p2 = (timing/end base) in
600     coordinate (timing/table/bottom right) at ({max(\x1,\x2)},\y2);
601   %
602   \pgfmathparse{max(\tikztiming@maxwidth,\tikztimingwidth)}%
603   \let\tikztiming@maxwidth\pgfmathresult
604   \@ifnextchar\extracode
605   {%
606     \let\extracode\relax
607     \tikztimingextracode
608   }%
609   {%
610     \@ifnextchar\endtikztimingtable@
611     {\@gobble}{\tikztimingtable@row}%
612   }%
613 }

```

#### `\tikztiming@fulltablegrid`

#1: Optional settings

```

614 \newcommand*\tikztiming@fulltablegrid[1] [] {%
615   \begin{pgfonlayer}{background}
616     \scope[xstep={\timingwidth/2.},ystep={\timingheight/2.},
617       shift={(\timing/table/bottom left)},timing/table/grid,#1]
618       \draw (0,0) grid
619         ($ (\timing/table/top right) - (\timing/table/bottom left) $);
620     \endscope
621   \end{pgfonlayer}
622 }

```

### **\tikztiming@tablegrid**

#1: Optional settings

```

623 \newcommand*\tikztiming@tablegrid[1] [] {%
624   \begin{pgfonlayer}{background}
625     \scope[xstep={\timingwidth/2.},ystep={\timingheight/2.},timing/table/grid,#1]
626       \foreach \y in {1,...,\nrows} {%
627         \draw {[shift={($ (\timing/table/bottom left) + (0,\y*\rowdist) -
628           (0,\rowdist) $)}] let \p1 = (\timing/table/bottom right) in (0,0) grid
629           (\x1,1)};
630       }%
631     \endscope
632   \end{pgfonlayer}
633 }

```

### **\tikztiming@tablerules**

#1: Optional Settings

```

634 \newcommand*\tikztiming@tablerules[1] [] {%
635   \draw [timing/table/rules,#1] let
636     \p1 = (current bounding box.north west),
637     \p2 = (current bounding box.south east),
638     \p3 = (last row)
639   in
640     (\x1-\tabcolsep,\rowdist) -- (\x2+\tabcolsep,\rowdist)
641     ($ (\x1-\tabcolsep,\y3) - (0,\rowdist-1) $) --
642     ($ (\x2+\tabcolsep,\y3) - (0,\rowdist-1) $)
643   ;
644 }

```

### **\tikztiming@horlines**

#1: Optional Settings

#2: Row numbers

```

645 \newcommand*\tikztiming@horlines[2] [] {%
646   \begingroup
647     \def\list{#2}%
648     \ifx\list\empty
649       \def\list{1,2,...,\nrows}%
650     \fi
651     \foreach \row in \list%

```

```

652      \draw [timing/table/lines,#1] let
653          \p1 = (timing/table/bottom right)
654      in
655          (0,\rowdist-\row*\rowdist) -- +(\x1,0);
656  \endgroup
657 }

```

### **\tikztiming@vertlines**

#1: Optional Settings

#2: Column numbers

```

658 \newcommand*\tikztiming@vertlines[2][]{%
659   \begingroup
660   \def\list{#2}%
661   \ifx\list\empty
662     \def\list{0,1,...,\twidth}%
663   \fi
664   \draw [timing/table/lines,#1] let
665       \p1 = ($ (timing/table/bottom right) - (0,2) $)
666   in
667       \foreach \clk in \list {
668         (\clk,+1.5) -- +(0,\y1)
669       }
670   ;
671 \endgroup
672 }

```

## **5.5 Other Macros**

### **\tikztiming@iflower**

#1: Character

```

673 \def\tikztiming@iflower#1{%
674   \begingroup
675   \edef\@tempa{‘#1}%
676   \ifnum\@tempa=\lccode\@tempa
677     \endgroup
678     \expandafter
679     \@firstoftwo
680   \else
681     \endgroup
682     \expandafter
683     \@secondoftwo
684   \fi
685 }

```

### **\timingwidth**

### **\timingheight**

```

686 \def\timingwidth{1}%
687 \def\timingheight{1}%

```



## `\tikztiming@internaldefs`

#1: Character

```
688 \def\tikztiming@internaldefs#1{%
689   \def\draw{\noexpand\draw}%
690   \def\path{\noexpand\path}%
691   \def\fill{\noexpand\fill}%
692   \def\width{###1*\noexpand\timingwidth}%
693   \def\fwidht{\noexpand\timingwidth}%
694   \def\height{\noexpand\timingheight}%
695   \def\slope{\noexpand\timingslope}%
696   \def\zslope{\noexpand\timingzslope}%
697   \def\dslope{\noexpand\timingdslope}%
698   \def\gslope{0}%
699   \lowercase{%
700     \def\style{timing/#1}%
701     \def\bgstyle{timing/#1/background}%
702   }%
703   \def\newdraw{\tikztiming@newdraw}%
704   \def\newdrawns{\tikztiming@newdraw@nosave}%
705   \def\code##1{ [/utils/exec={\unexpanded{##1}}] }%
706 }
```

## `\tikztimingsetslope`

#1: Slope value

```
707 \def\tikztimingsetslope#1{%
708   \pgfmathparse{min(1.0,{max(0.0,#1)})}%
709   \let\tikztiming@slope\pgfmathresult
710   \edef\timingslope{\tikztiming@slope*\noexpand\timingwidth}%
711 }
```

## `\tikztimingsetdslope`

#1: Slope value

```
712 \def\tikztimingsetdslope#1{%
713   \pgfmathparse{min(1.0,{max(0.0,#1)})}%
714   \let\tikztiming@dslope\pgfmathresult
715   \edef\timingdslope{\tikztiming@dslope*\noexpand\timingwidth}%
716 }
```

## `\tikztimingsetzslope`

#1: Slope value

```
717 \def\tikztimingsetzslope#1{%
718   \pgfmathparse{min(1.0,{max(0.0,#1)})}%
719   \let\tikztiming@zslope\pgfmathresult
720   \edef\timingzslope{\tikztiming@zslope*\noexpand\timingwidth}%
721 }

722 \tikztimingsetslope{0.10}%
```

```

723 \tikztimingsetdslope{0.20}%
724 \tikztimingsetzslope{0.05}%

\tikztiminguse
#1: Character(s)

725 \def\tikztiminguse#1{%
726   \ifundefined{\tikztiming@prefix#1@general}%
727     {\PackageWarning{Can not use transition macro for '#1'.}{-}{-}}%
728     {\@nameuse{\tikztiming@prefix#1@general}}%
729 }

\tikztimingdef
#1: One or two characters

730 \def\tikztimingdef#1{%
731   \tikztimingdef@#1\relax%
732 }

\tikztimingdef@
#1: First character
#2: Second character or empty
#3: Definition code

733 \def\tikztimingdef@#1#2\relax#3{%
734   \ifx\relax#2\relax
735     \tikztiming@nameedef[#1]{#1}{#3}%
736   \else
737     \tikztiming@nameedef[#2]{#1#2}{#3}%
738   \fi
739 }

\tikztiminglet
#1: Original characters
#2: New characters

740 \def\tikztiminglet#1#2{%
741   \tikztiminglet@#1\relax#2\relax
742 }

\tikztiminglet@
#1: First original character
#2: Second original character
#3: First new character
#4: Second new character

743 \def\tikztiminglet@#1#2\relax#3#4\relax{%
744   \tikztiming@namelet{#1#2}{#3#4}%
745   \tikztiming@namelet{#1#2@general}{#3#4@general}%
746   \tikztiming@iflower{#1}{}%
747     {\tikztiming@iflower{#2}%

```

```

748      {%
749      \lowercase{\tikztiminglet@{#1}{#2}\relax{#3}{#4}}\relax
750      }%
751      {%
752      \uppercase{\lowercase{%
753      \uppercase{\lowercase{\tikztiminglet@{#1}{#2}}\relax{#3}{#4}}\relax
754      \lowercase{\uppercase{%
755      \lowercase{\uppercase{\tikztiminglet@{#1}{#2}}\relax{#3}{#4}}\relax
756      }%
757      }%
758 }

```

### **\tikztiming@chars**

#1: Comma to gobble

Initial definition of character list. Will gobble the separation comma in front of the first character which is added to the list.

```

759 \def\tikztiming@chars#1{}

```

### **\tikztiming@ifcharexists**

#1: Character to check if in list

```

760 \def\tikztiming@ifcharexists#1{%
761   \def\tikztiming@ifcharexists@##1,#1,##2\relax{%
762     \ifx\relax##2\relax%
763       \expandafter\@firstoftwo
764     \else
765       \expandafter\@secondoftwo
766     \fi
767   }%
768   \expandafter\tikztiming@ifcharexists@
769   \expandafter,\tikztiming@chars,#1,\relax%
770 }

```

### **\tikztiming@addchar**

#1: Character

```

771 \def\tikztiming@addchar#1{%
772   \tikztiming@ifcharexists{#1}{%
773     \edef\tikztiming@chars{\tikztiming@chars,#1}%
774   }{}%
775 }

```

### **\tikztimingchar**

#1: New character

```

776 \def\tikztimingchar#1{%
777   \uppercase{%
778     \tikztiming@addchar{#1}%
779     \tikztimingchar@{#1}}%
780 }

```

```

781 \expandafter\def\csname\tikztiming@prefix @start\endcsname#1{%

\tikztimingchar@
#1: Character
#2: Start position
#3: Character drawing code

782 \def\tikztimingchar#1#2#3{%
783 \tikztiming@nameedef[#1]{#1@start}{#2 coordinate (timing/start) }%
784 \tikztiming@nameedef[#1]{#1}{#2 coordinate (timing/start) #3}%
785 \tikztimingdef{#1#1}{#3}%
786 }

\tikztimingalias
#1: Original character
#2: New character

787 \def\tikztimingalias#1#2{%
788 \uppercase{\tikztimingalias@{#1}{#2}}%
789 }

\tikztimingalias@
#1: New character
#2: Original character

790 \def\tikztimingalias@#1#2{%
791 \tikztiming@namelet{#1}{#2}%
792 \tikztiming@namelet{#1@start}{#2@start}%
793 \lowercase{%
794 \tikztiming@namelet{#1}{#2}%
795 \tikztiming@namelet{#1@start}{#2@start}%
796 }%
797 \tikztiminglet{#1#1}{#2#2}%
798 \@for\@tempa:=\tikztiming@chars\do{%
799 \expandafter\tikztiminglet@@
800 \expandafter{\@tempa}{#1}{#2}%
801 }%
802 }

\tikztimingecopy
#1: New character
#2: Original character

803 \def\tikztimingecopy#1#2{%
804 \uppercase{\tikztimingecopy@{#1}{#2}}%
805 }

\tikztimingecopy@
#1: New character
#2: Original character

```

```

806 \def\tikztimingecopy@#1#2{%
807   \tikztimingchar{#1}{}%
808   \tikztimingdef{#1}{\tikztiminguse{#2}{##1}}%
809   \tikztiming@nameedef[#1]{#1@start}{\tikztiminguse{#2@start}{##1}}%
810   \lowercase{%
811     \ifundefined{\tikztiming@prefix#2}{}%
812     \tikztimingdef{#1}{\tikztiminguse{#2}{##1}}%
813     \tikztiming@nameedef[#1]{#1@start}{\tikztiminguse{#2@start}{##1}}%
814   }%
815 }%
816 \tikztimingdef{#1#1}{\tikztiminguse{#2#2}{##1}}%
817 \@for\@tempa:=\tikztiming@chars\do{%
818   \expandafter\tikztimingdef@@
819   \expandafter{\@tempa}{#1}{#2}%

```

Handle lowercase macros:

```

820   \expandafter\lowercase\expandafter{\expandafter\def\expandafter\@tempb
821   \expandafter{\@tempa}}%
822   \@ifundefined{\tikztiming@prefix#2\@tempb}{}%
823   \expandafter\tikztimingdef@@
824   \expandafter{\@tempb}{#1}{#2}%
825 }%
826 }%
827 }

```

#### **\tikztiminglet@@**

#1: Character from list  
 #2: New character  
 #3: Original character

```

828 \def\tikztiminglet@@#1#2#3{%
829   \tikztiminglet@@@#1#2#3%
830   % Should stay, cause no harm:
831   \lowercase{\tikztiminglet@@@#1}{#2#3}%
832   \lowercase{\tikztiminglet@@@#1#2#3}%
833   \lowercase{\uppercase{\tikztiminglet@@@#1}{#2#3}}%
834 }

```

#### **\tikztiminglet@@@**

#1: Character from list  
 #2: New character  
 #3: Original character

```

835 \def\tikztiminglet@@@#1#2#3{%
836   \tikztiminglet{#1#2}{#1#3}%
837   \tikztiminglet{#2#1}{#3#1}%
838 }

```

#### **\tikztimingdef@@**

#1: Character from list

#2: New character  
 #3: Original character

```
839 \def\tikztimingdef@@#1#2#3{%
840   \tikztimingdef{#1#2}{\tikztiminguse{#1#3}{##1}}%
841   \tikztimingdef{#2#1}{\tikztiminguse{#3#1}{##1}}%
842 }
```

#### **\tikztiming@savesettings**

```
843 \def\tikztiming@savesettings{%
844   \xdef\tikztiming@saved@settings{%
845     {\tikztiming@slope}%
846     {\tikztiming@dslope}%
847     {\tikztiming@zslope}%
848     {\the\pgflinewidth}%
849   }%
850 }
```

#### **\tikztiming@restoresettings**

```
851 \def\tikztiming@restoresettings{%
852   \expandafter\tikztiming@restoresettings@
853   \tikztiming@saved@settings\relax
854 }
```

#### **\tikztiming@restoresettings@**

#1: Slope  
 #2: D-Slope  
 #3: Z-Slope  
 #4: Line width

```
855 \def\tikztiming@restoresettings@#1#2#3#4\relax{%
856   \tikztimingsetslope{#1}%
857   \tikztimingsetdslope{#2}%
858   \tikztimingsetzslope{#3}%
859   \pgfsetlinewidth{#4}%
860 }
```

#### **\tikztiming@newdraw**

```
861 \def\tikztiming@newdraw{%
862   node [timing/save] (timing@save) {};%
863   \draw [timing/restore] (timing@save) ++(0,0)
864 }
```

#### **\tikztiming@newdraw**

```
865 \def\tikztiming@newdraw@nosave{%
866   node [timing/coord] (timing@save) {};%
867   \draw (timing@save) ++(0,0)
868 }
```

## 5.6 Definition of Timing Characters

```

869 \tikztimingchar{H}{++(0,\height)}{-- ++(#1,0)}
870
871 \tikztimingchar{L}{++(0,0)}{-- ++(#1,0)}
872
873 \tikztimingchar{Z}{++(0,\height/2.)}{%
874   \newdraw [\style]
875   -- ++(#1,0)
876 }
877
878 \tikztimingchar{X}{}{}%
879 \tikztimingchar{D}{}{}%
880 \tikztimingchar{U}{}{}%
881 %\tikztimingchar{O}{}{}%
882 \tikztimingchar{M}{}{}%
883
884 \tikztimingchar{G}{++(0,0)}{-- ++(\gslope,\height) -- ++(\gslope,-\height)}
885 \tikztimingchar{S}{++(0,0)}{++(#1,0)}
886
887 \tikztimingdef{DD}{
888   node [timing/save] (timing@save) {}; \path [\bgstyle] (timing@save) ++(0,0)
889     +(0.5*\dslope,0.5*\height) -- +(\dslope,0)
890     -- +(#1,0)
891     -- +($ (#1,0) + 0.5*(\dslope,\height) $)
892     -- +(#1,\height)
893     -- +(\dslope,\height) -- cycle;
894   \draw [timing/restore,\style] (timing@save) ++(0,0)
895     node [timing/save] (timing@dstart) at +(\dslope/2.,\height/2.) {}
896     -- +(\dslope,+\height) -- +(#1,+\height) ++(0,+\height)
897     -- +(\dslope,-\height) -- ++(#1,-\height)
898 }
899 \tikztiming@namelet{D@edge@D}{DD}
900 \tikztiming@namelet{D@edge@D@general}{DD@general}
901
902 \tikztimingchar{D}{++(0,0)}{
903   node [timing/save] (timing@save) {}; \path [\bgstyle] (timing@save) ++(0,0)
904     -- +(#1,0)
905     -- +($ (#1,0) + 0.5*(\dslope,\height) $)
906     -- +(#1,\height)
907     -- +(0,\height)
908     -- cycle;
909   \draw [timing/restore,\style] (timing@save) ++(0,0)
910     node [timing/save] (timing@dstart) at +(-\dslope/2.,\height/2.0) {}
911     -- +(#1,0) ++(0,+\height)
912     -- ++(#1,0) ++(0,-\height)
913 }
914
915 \tikztimingdef{DD}{
916   node [timing/save] (timing@save) {}; \path [\bgstyle] (timing@save) ++(0,0)

```

```

917 -- +(#1,0)
918 -- +($ (#1,0) + 0.5*(\dslope,\height) $)
919 -- +(#1,\height)
920 -- +(0,\height)
921 -- cycle;
922 \newdraw [\style]
923 -- +(#1,0) ++(0,+\height)
924 -- ++(#1,0) ++(0,-\height)
925 }
926
927 \tikztiming@namelet{D@edge@@start}{D@start}
928 \tikztiming@namelet{d@edge@@start}{d@start}
929

\tikztiming@trans@D@fill
#1: Original width
#2: Width to subtract

930 \def\tikztiming@trans@D@fill#1#2{%
931   node [timing/save] (timing@save) {}; \path [\bgstyle] (timing@save) ++(0,0)
932   -- +(0.5*\dslope,-0.5*\height)
933   -- ++($ (#1,-0.5*\height) - (#2,0) $)
934   -- +(0.5*\dslope,0.5*\height)
935   -- +(0,\height)
936   -- ++($ (#2,\height) - (#1,0) + (0.5*\dslope,0) $)
937   -- cycle;
938   \draw [timing/restore,\style] (timing@save) ++(0,0)
939   node [timing/save] (timing@dstart) {}
940 }

941 \tikztimingdef{HH}{-- ++(#1,0)}
942 \tikztimingdef{LL}{-- ++(#1,0)}
943 \tikztimingdef{HL}{-- ++(\slope,-\height) \tikztiminguse{HH}{#1-\slope}}
944 \tikztimingdef{LH}{-- ++(\slope, \height) \tikztiminguse{LL}{#1-\slope}}
945
946 \tikztimingdef{HG}{-- ++(\gslope,-\height) -- ++(\gslope,+\height)}
947 \tikztimingdef{LG}{-- ++(\gslope,+\height) -- ++(\gslope,-\height)}
948 \tikztimingdef{ZG}{
949   -- ++(\gslope,-\height/2.0)
950   -- ++(\gslope,+\height)
951   -- ++(\gslope,-\height/2.0)
952 }
953 \tikztiminglet{DG}{LG}
954 \tikztiminglet{MG}{ZG}
955
956 \tikztiminglet{HS}{S}
957 \tikztiminglet{LS}{S}
958 \tikztiminglet{ZS}{S}
959 \tikztiminglet{DS}{S}
960 \tikztiminglet{TS}{S}
961

```



```

962 \tikztimingdef{LZ}{
963   \newdraw [\style]
964   -- ++(\zslope,+\height/2.) -- ++($ (#1,0) - (\zslope,0) $)
965 }
966 \tikztimingdef{HZ}{%
967   \newdraw [\style]
968   -- ++(\zslope,-\height/2.) -- ++($ (#1,0) - (\zslope,0) $)
969 }
970 \tikztimingdef{ZH}{
971   \newdraw
972   -- ++(\zslope,+\height/2.) -- ++($ (#1,0) - (\zslope,0) $)
973 }
974 \tikztimingdef{ZL}{%
975   \newdraw
976   -- ++(\zslope,-\height/2.) -- ++($ (#1,0) - (\zslope,0) $)
977 }
978
979 \tikztimingdef{DZ}{
980   -- ++( \dslope/2.,+\height/2.)
981   ++(-\dslope/2.,+\height/2.)
982   -- ++( \dslope/2.,-\height/2.)
983   \newdraw [\style]
984   -- ++($ (#1,0) - (\dslope/2.,0) $)
985 }
986
987 \tikztimingdef{ZD}{
988   \tikztiming@trans@D@fill{#1}{0}%
989   -- ++(\dslope/2.,\height/2.) -- ++($ (#1,0) - (\dslope/2.,0) $)
990   ++($ -1*(#1,0) + (0,-\height/2.) $)
991   -- ++(\dslope/2.,-\height/2.) -- ++($ (#1,0) - (\dslope/2.,0) $)
992 }
993
994 \tikztimingdef{LD}{
995   -- ++(0.5*\dslope,0.5*\height)
996   \tikztiming@trans@D@fill{#1}{0.5*\dslope}%
997   -- ++(0.5*\dslope,0.5*\height)
998   -- ++($ (#1,0) - (\dslope,0) $)
999   ++($ -1*(#1,0) + (0,-\height) $) ++(\dslope/2.,+\height/2.)
1000  -- ++(\dslope/2.,-\height/2.) -- ++($ (#1,0) - (\dslope,0) $)
1001 }
1002
1003 \tikztimingdef{DL}{
1004   -- ++( \dslope/2.,+\height/2.)
1005   ++(-\dslope/2.,+\height/2.)
1006   -- ++(\dslope/2.,-\height/2.)
1007   \newdraw [\style]
1008   -- ++(\dslope/2.,-\height/2.)
1009   -- ++($ (#1,0) - (\dslope,0) $)
1010 }
1011

```

```

1012 \tikztimingdef{HD}{
1013   -- ++(0.5*\dslope,-0.5*\height)
1014   \tikztiming@trans@D@fill{#1}{0.5*\dslope}%
1015   -- ++(0.5*\dslope,-0.5*\height)
1016   -- ++($ (#1,0) - (\dslope,0) $)
1017       ++($ -1*(#1,0) + (0,+\height) $)          ++(\dslope/2.,-\height/2.)
1018   -- ++(\dslope/2.,+\height/2.) -- ++($ (#1,0) - (\dslope,0) $)
1019       ++(0,-\height)
1020 }
1021
1022 \tikztimingdef{DH}{
1023   ++(0,+\height)
1024   -- ++(+\dslope/2.,-\height/2.)
1025       ++(-\dslope/2.,-\height/2.)
1026   -- ++(\dslope/2.,+\height/2.)
1027   \newdraw [\style]
1028   -- ++(\dslope/2.,+\height/2.)
1029   -- ++($ (#1,0) - (\dslope,0) $)
1030 }
1031
1032
1033 \tikztimingalias{M}{Z}
1034 \tikztimingchar{M}{++(0,\height/2.)}{
1035   [\style]
1036   -- ++($ 1/16.*(#1,0) + (0,+\height*.225) $)
1037   -- ++($ 1/8.*(#1,0) + (0,-\height*.45) $)
1038   -- ++($ 1/8.*(#1,0) + (0,+\height*.45) $)
1039   -- ++($ 1/8.*(#1,0) + (0,-\height*.45) $)
1040   -- ++($ 1/8.*(#1,0) + (0,+\height*.45) $)
1041   -- ++($ 1/8.*(#1,0) + (0,-\height*.45) $)
1042   -- ++($ 1/8.*(#1,0) + (0,+\height*.45) $)
1043   -- ++($ 1/8.*(#1,0) + (0,-\height*.45) $)
1044   -- ++($ 1/16.*(#1,0) + (0,+\height*.225) $)
1045 }
1046
1047 \tikztimingdef{MZ}{
1048   \newdraw [\style]
1049   -- ++(#1,0)
1050 }
1051
1052 \tikztimingdef{m}{
1053   [\style]
1054   ++(0,+\height/2.)
1055   -- ++($ 1/8.*(#1,0) + (0,+\height*.225) $)
1056   -- ++($ 1/4.*(#1,0) + (0,-\height*.45) $)
1057   -- ++($ 1/4.*(#1,0) + (0,+\height*.45) $)
1058   -- ++($ 1/4.*(#1,0) + (0,-\height*.45) $)
1059   -- ++($ 1/8.*(#1,0) + (0,+\height*.225) $)
1060 }
1061

```

```

1062 \tikztimingdef{ZM}{
1063   \newdraw [\style]
1064   -- ++($ 1/16.*(#1,0) + (0,+\height*.075) $)
1065   -- ++($ 1/8.*(#1,0) + (0,-\height*.20) $)
1066   -- ++($ 1/8.*(#1,0) + (0,+\height*.25) $)
1067   -- ++($ 1/8.*(#1,0) + (0,-\height*.30) $)
1068   -- ++($ 1/8.*(#1,0) + (0,+\height*.35) $)
1069   -- ++($ 1/8.*(#1,0) + (0,-\height*.40) $)
1070   -- ++($ 1/8.*(#1,0) + (0,+\height*.45) $)
1071   -- ++($ 1/8.*(#1,0) + (0,-\height*.45) $)
1072   -- ++($ 1/16.*(#1,0) + (0,+\height*.225) $)
1073 }
1074
1075 \tikztimingdef{Zm}{
1076   \newdraw [\style]
1077   -- ++($ 1/8.*(#1,0) + (0,+\height*.075) $)
1078   -- ++($ 1/4.*(#1,0) + (0,-\height*.20) $)
1079   -- ++($ 1/4.*(#1,0) + (0,+\height*.25) $)
1080   -- ++($ 1/4.*(#1,0) + (0,-\height*.30) $)
1081   -- ++($ 1/8.*(#1,0) + (0,+\height*.175) $)
1082 }
1083
1084 \tikztimingdef{Mm}{
1085   -- ++($ 1/8.*(#1,0) + (0,+\height*.225) $)
1086   -- ++($ 1/4.*(#1,0) + (0,-\height*.45) $)
1087   -- ++($ 1/4.*(#1,0) + (0,+\height*.45) $)
1088   -- ++($ 1/4.*(#1,0) + (0,-\height*.45) $)
1089   -- ++($ 1/8.*(#1,0) + (0,+\height*.225) $)
1090 }
1091
1092 \tikztimingdef{LM}{
1093   \newdraw [\style]
1094   -- ++($ 1/16.*(#1,0) + (0,+\height*.60) $)
1095   -- ++($ 1/8.*(#1,0) + (0,-\height*.20) $)
1096   -- ++($ 1/8.*(#1,0) + (0,+\height*.25) $)
1097   -- ++($ 1/8.*(#1,0) + (0,-\height*.30) $)
1098   -- ++($ 1/8.*(#1,0) + (0,+\height*.35) $)
1099   -- ++($ 1/8.*(#1,0) + (0,-\height*.40) $)
1100   -- ++($ 1/8.*(#1,0) + (0,+\height*.45) $)
1101   -- ++($ 1/8.*(#1,0) + (0,-\height*.45) $)
1102   -- ++($ 1/16.*(#1,0) + (0,+\height*.20) $)
1103 }
1104 \tikztimingdef{HM}{
1105   \newdraw [\style]
1106   -- ++($ 1/16.*(#1,0) + (0,-\height*.40) $)
1107   -- ++($ 1/8.*(#1,0) + (0,-\height*.20) $)
1108   -- ++($ 1/8.*(#1,0) + (0,+\height*.25) $)
1109   -- ++($ 1/8.*(#1,0) + (0,-\height*.30) $)
1110   -- ++($ 1/8.*(#1,0) + (0,+\height*.35) $)
1111   -- ++($ 1/8.*(#1,0) + (0,-\height*.40) $)

```

```

1112 -- ++($ 1/8.*(#1,0) + (0,+\height*.45) $)
1113 -- ++($ 1/8.*(#1,0) + (0,-\height*.45) $)
1114 -- ++($ 1/16.*(#1,0) + (0,+\height*.20) $)
1115 }
1116 \tikztimingdef{DM}-{
1117     ++($ -1/16.*(#1,0) + (0,0) $)
1118 -- ++($ 1/16.*(#1,0) + (0,0) $)
1119 -- ++($ 1/16.*(#1,0) + (0,+\height*.50) $)
1120     ++($ -1/8.*(#1,0) + (0,+\height*.50) $)
1121 -- ++($ 1/16.*(#1,0) + (0,0) $)
1122 -- ++($ 1/16.*(#1,0) + (0,-\height*.50) $)
1123 \newdraw [\style]
1124 -- ++($ 1/8.*(#1,0) + (0,-\height*.10) $)
1125 -- ++($ 1/8.*(#1,0) + (0,+\height*.25) $)
1126 -- ++($ 1/8.*(#1,0) + (0,-\height*.30) $)
1127 -- ++($ 1/8.*(#1,0) + (0,+\height*.35) $)
1128 -- ++($ 1/8.*(#1,0) + (0,-\height*.40) $)
1129 -- ++($ 1/8.*(#1,0) + (0,+\height*.45) $)
1130 -- ++($ 1/8.*(#1,0) + (0,-\height*.45) $)
1131 -- ++($ 1/16.*(#1,0) + (0,+\height*.20) $)
1132 }
1133
1134 \tikztimingdef{Lm}-{
1135 \newdraw [\style]
1136 -- ++($ 1/8.*(#1,0) + (0,+\height*.575) $)
1137 -- ++($ 1/4.*(#1,0) + (0,-\height*.20) $)
1138 -- ++($ 1/4.*(#1,0) + (0,+\height*.25) $)
1139 -- ++($ 1/4.*(#1,0) + (0,-\height*.30) $)
1140 -- ++($ 1/8.*(#1,0) + (0,+\height*.175) $)
1141 }
1142 \tikztimingdef{Hm}-{
1143 \newdraw [\style]
1144 -- ++($ 1/8.*(#1,0) + (0,-\height*.425) $)
1145 -- ++($ 1/4.*(#1,0) + (0,-\height*.20) $)
1146 -- ++($ 1/4.*(#1,0) + (0,+\height*.25) $)
1147 -- ++($ 1/4.*(#1,0) + (0,-\height*.30) $)
1148 -- ++($ 1/8.*(#1,0) + (0,+\height*.175) $)
1149 }
1150 \tikztimingdef{Dm}-{
1151     ++($ -1/8.*(#1,0) + (0,0) $)
1152 -- ++($ 1/8.*(#1,0) + (0,0) $)
1153 -- ++($ 1/8.*(#1,0) + (0,+\height*.50) $)
1154     ++($ -1/4.*(#1,0) + (0,+\height*.50) $)
1155 -- ++($ 1/8.*(#1,0) + (0,0) $)
1156 -- ++($ 1/8.*(#1,0) + (0,-\height*.50) $)
1157 \newdraw [\style]
1158 -- ++($ 1/4.*(#1,0) + (0,-\height*.10) $)
1159 -- ++($ 1/4.*(#1,0) + (0,+\height*.25) $)
1160 -- ++($ 1/4.*(#1,0) + (0,-\height*.30) $)
1161 -- ++($ 1/8.*(#1,0) + (0,+\height*.15) $)

```

```

1162 }
1163
1164 \newcounter{tikztimingtrans}
1165 \newcounter{tikztimingtranspos}
1166
1167 \tikztimingchar{T}{++(0,0)}{
1168   -- ++(#1,0)
1169 }
1170
1171 \tikztimingdef{HT}{%
1172   {[\style]
1173     \code{\setcounter{tikztimingtrans}{-1}}
1174     -- ++(\slope,\value{tikztimingtrans}*\height) -- ++($ (#1,0) - (\slope,0) $)
1175   }
1176 }
1177
1178 \tikztimingdef{LT}{%
1179   {[\style]
1180     \code{\setcounter{tikztimingtrans}{+1}}
1181     -- ++(\slope,\value{tikztimingtrans}*\height) -- ++($ (#1,0) - (\slope,0) $)
1182   }
1183 }
1184
1185 \tikztimingdef{TL}{%
1186   \code{\setcounter{tikztimingtranspos}{\value{tikztimingtrans}}}%
1187   \addtocounter{tikztimingtranspos}{+1}}
1188   -- ++(\slope, -0.5*\value{tikztimingtranspos}*\height) -- ++($ (#1,0) - (\slope,0) $)
1189 }
1190
1191 \tikztimingdef{TH}{%
1192   \code{\setcounter{tikztimingtranspos}{\value{tikztimingtrans}}}%
1193   \addtocounter{tikztimingtranspos}{-1}}
1194   -- ++(\slope, -0.5*\value{tikztimingtranspos}*\height) -- ++($ (#1,0) - (\slope,0) $)
1195 }
1196
1197 \tikztimingdef{TZ}{%
1198   \newdraw [ \style]
1199   \code{\setcounter{tikztimingtrans}{-\value{tikztimingtrans}}}%
1200   -- ++(\slope,\value{tikztimingtrans}*\height/2.)
1201   -- ++($ (#1,0) - (\slope,0) $)
1202 }
1203
1204 \tikztimingdef{TG}{%
1205   -- +(\gslope,-1*\value{tikztimingtrans}*\height)
1206   -- +(\gslope,0)
1207 }
1208
1209 \tikztimingdef{ZT}{%
1210   \newdraw
1211   {[\style]

```

```

1212 node [timing/save] {\setcounter{tikztimingtrans}{-\value{tikztimingtrans}}}
1213 -- ++(\slope,\value{tikztimingtrans}*\height/2.)
1214 -- ++($ (#1,0) - (\slope,0) $)
1215 }
1216 }
1217
1218 \tikztimingdef{TT}{%
1219 {[\style]
1220 \code{\setcounter{tikztimingtrans}{-\value{tikztimingtrans}}}
1221 -- ++(\slope,\value{tikztimingtrans}*\height) -- ++($ (#1,0) - (\slope,0) $)
1222 }
1223 }
1224
1225 \tikztimingdef{TD}{
1226 \code{\setcounter{tikztimingtrans}{-\value{tikztimingtrans}}}
1227 \code{\setcounter{tikztimingtranspos}{\value{tikztimingtrans}}}%
1228 \addtocounter{tikztimingtranspos}{-1}}
1229 -- ++(0.5*\dslope,+0.5*\value{tikztimingtrans} * \height)
1230 \tikztiming@trans@D@fill{#1}{0.5*\dslope}%
1231 -- ++(0.5*\dslope,+0.5*\value{tikztimingtrans} * \height)
1232 -- ++($ (#1,0) - (\dslope,0) $)
1233 ++($ -1*(#1,\value{tikztimingtrans}*\height) $)
1234 ++(\dslope/2.,+1*\value{tikztimingtrans}*\height/2.)
1235 -- ++(\dslope/2.,-1*\value{tikztimingtrans}*\height/2.)
1236 -- ++($ (#1,0) - (\dslope,0) $)
1237 ++(0,\value{tikztimingtranspos}*\height/2.)
1238 }
1239
1240 \tikztimingdef{DT}{
1241 \code{\setcounter{tikztimingtrans}{-1}}
1242 \tikztiminguse{DL}{#1}%
1243 }
1244
1245 \tikztimingdef{MT}{%
1246 \newdraw
1247 {[\style]
1248 -- ++(\slope,\value{tikztimingtrans}*\height/2.) -- ++($ (#1,0) - (\slope,0) $)
1249 }
1250 }
1251
1252 \tikztimingdef{TM}{%
1253 \newdraw [\style]
1254 \code{\setcounter{tikztimingtrans}{-\value{tikztimingtrans}}}
1255 -- ++($ 1/16.*(#1,0) + (0,\value{tikztimingtrans}*\height*.50+\height*.10) $)
1256 -- ++($ 1/8.*(#1,0) + (0,-\height*.20) $)
1257 -- ++($ 1/8.*(#1,0) + (0,+\height*.25) $)
1258 -- ++($ 1/8.*(#1,0) + (0,-\height*.30) $)
1259 -- ++($ 1/8.*(#1,0) + (0,+\height*.35) $)
1260 -- ++($ 1/8.*(#1,0) + (0,-\height*.40) $)
1261 -- ++($ 1/8.*(#1,0) + (0,+\height*.45) $)

```

```

1262 -- ++($ 1/8.*(#1,0) + (0,-\height*.45) $)
1263 -- ++($ 1/16.*(#1,0) + (0,+\height*.20) $)
1264 }
1265
1266 \tikztimingdef{Tm}{%
1267 \newdraw [\style]
1268 \code{\setcounter{tikztimingtrans}{-\value{tikztimingtrans}}}%
1269 -- ++($ 1/8.*(#1,0) + (0,\value{tikztimingtrans}*\height*.50+\height*.075) $)
1270 -- ++($ 1/4.*(#1,0) + (0,-\height*.20) $)
1271 -- ++($ 1/4.*(#1,0) + (0,+\height*.25) $)
1272 -- ++($ 1/4.*(#1,0) + (0,-\height*.30) $)
1273 -- ++($ 1/8.*(#1,0) + (0,+\height*.175) $)
1274 }
1275
1276 \tikztimingecopy{C}{T}%
1277 \def\tikztiming@nocombine@T{%
1278 \def\tikztiming@nocombine@C{%
1279 \def\tikztiming@nocombine@t{%
1280 \def\tikztiming@nocombine@c{%
1281 \def\tikztiming@nocombine@M{%
1282 \def\tikztiming@nocombine@m{%
1283
1284
1285 \tikztimingecopy{U}{D}
1286 \tikztimingdef{UD}{\tikztiminguse{D@edge@D}{#1}}
1287 \tikztimingdef{DU}{\tikztiminguse{D@edge@D}{#1}}
1288
1289 \tikztimingecopy{O}{D}
1290 \tikztimingecopy{X}{Z}

```

## Change History

v0.3		In-line Nodes, e.g. to mark positions inside the diagram. . . . .	1
General:	First released version . . .		1
v0.4		Released as v0.4 . . . . .	1
General:	Added output routine which combines successive occurrences of the same character. This improves screen display quality and reduces rendering time and file size. . . . .	Removed own macros for lowercase characters. They are now handled by the uppercase macros which receive half of the width. Exceptions are possible like for the ‘m’ character. . . .	1
Added parser for rows in <code>\tikztimingtable</code> . This makes the syntax much more stable. Also replaced row counter with TikZ coordinates which is more user-friendly. . .		User macros to draw grids and lines inside table. . . . .	1
		v0.4a	
General:	Added <code>\ablerules</code> macro. Changed default style of inline nodes to <code>coordinate</code> . . .		1