Analyze Märklin track signal

Get complementary signals from digitizing car

Load file

```
Directory[]
```

```
/home/cmaier/scad/Maerklin/analysis
```

```
Dimensions[raw = Import["TTL.10ms.5V.csv"]]
```

```
{524 290, 4}
```

```
Take[raw, 12]
```

```
{{X, CH1, CH2, }, {Second, Volt, Volt, }, {-0.131112, 5.4, 0., },
 {-0.131112, 5.4, 0., }, {-0.131111, 5.4, 0., }, {-0.131111, 5.4, 0., },
 {-0.13111, 5.4, 0., }, {-0.13111, 5.4, 0., }, {-0.131109, 5.4, 0., },
 {-0.131109, 5.4, 0., }, {-0.131108, 5.4, 0., }, {-0.131108, 5.4, 0., }}
```

Convert into two time series

```
Dimensions[
 timeseries = Transpose[{{#[[1]], #[[2]]}, {#[[1]], #[[3]]}} & /@ Drop[raw, 2], {2, 1, 3}]]
```

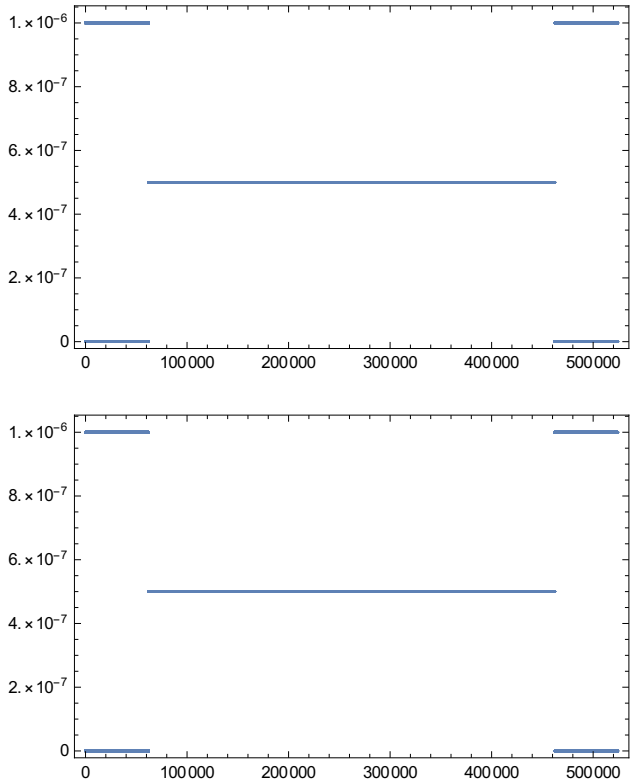
```
{2, 524 288, 2}
```

Calculate time step

```
Dimensions[ListConvolve[{1, -1}, First /@ #] & /@ timeseries]
```

```
{2, 524 287}
```

```
GraphicsGrid[
 {ListPlot[ListConvolve[{1, -1}, First /@ #], Frame → True, PlotRange → All]} & /@
  timeseries]
```

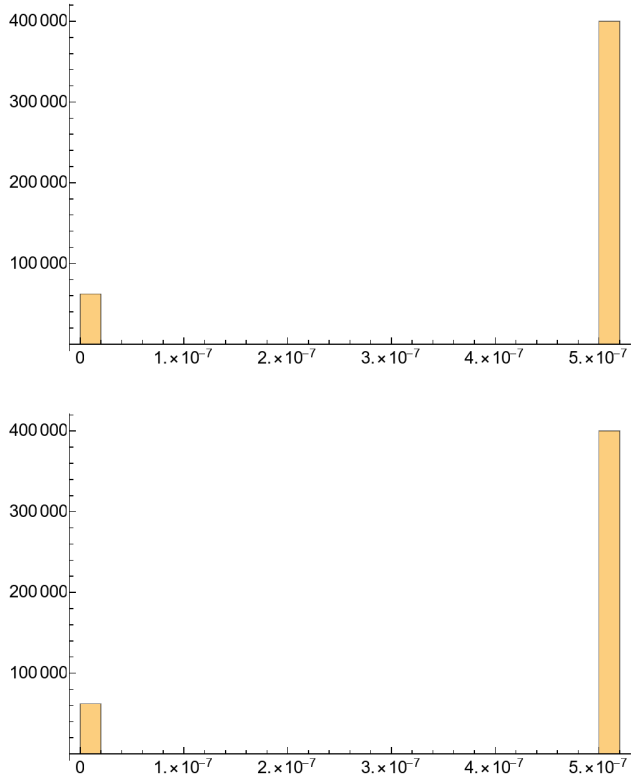



```
{Min[#], Max[#]} &[ListConvolve[{1, -1}, First /@ #]] & /@ timeseries
```

$$\{\{0., 1. \times 10^{-6}\}, \{0., 1. \times 10^{-6}\}\}$$

The time stamps have a quantization error because the precision at the beginning and end is only 1μs.

```
GraphicsGrid[
 {Histogram[ListConvolve[{1, -1}, First /@ #, PlotRange → All]]} & /@ timeseries]
```

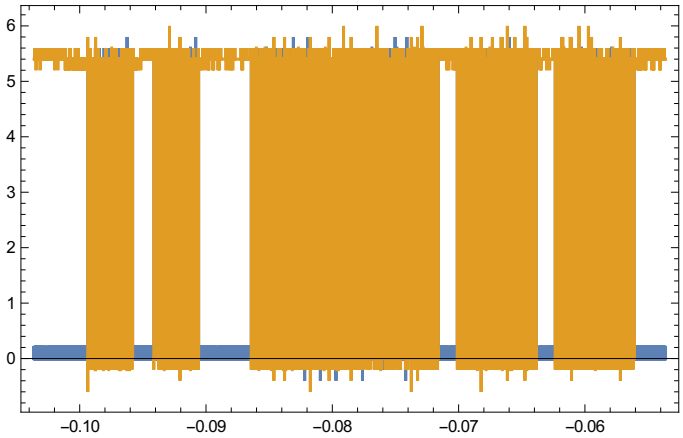



```
timestep = Mean[Median[ListConvolve[{1, -1}, First /@ #]] & /@ timeseries]
```

$5. \times 10^{-7}$

Display

```
ListPlot[Take[#, {55 000, 155 000}] & /@ timeseries, Frame → True, Joined → True]
```



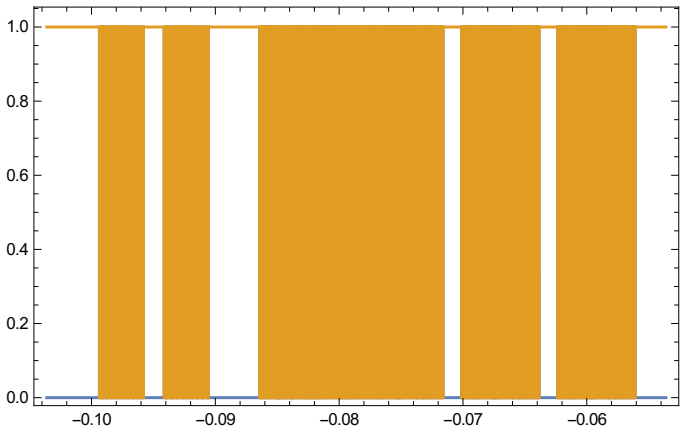
Digitize time series

```
Dimensions[digitized = Map[{#[[1]], HeavisideTheta[#[[2]] - 3.0001]} &, timeseries, {2}]]
```

```
{2, 524 288, 2}
```

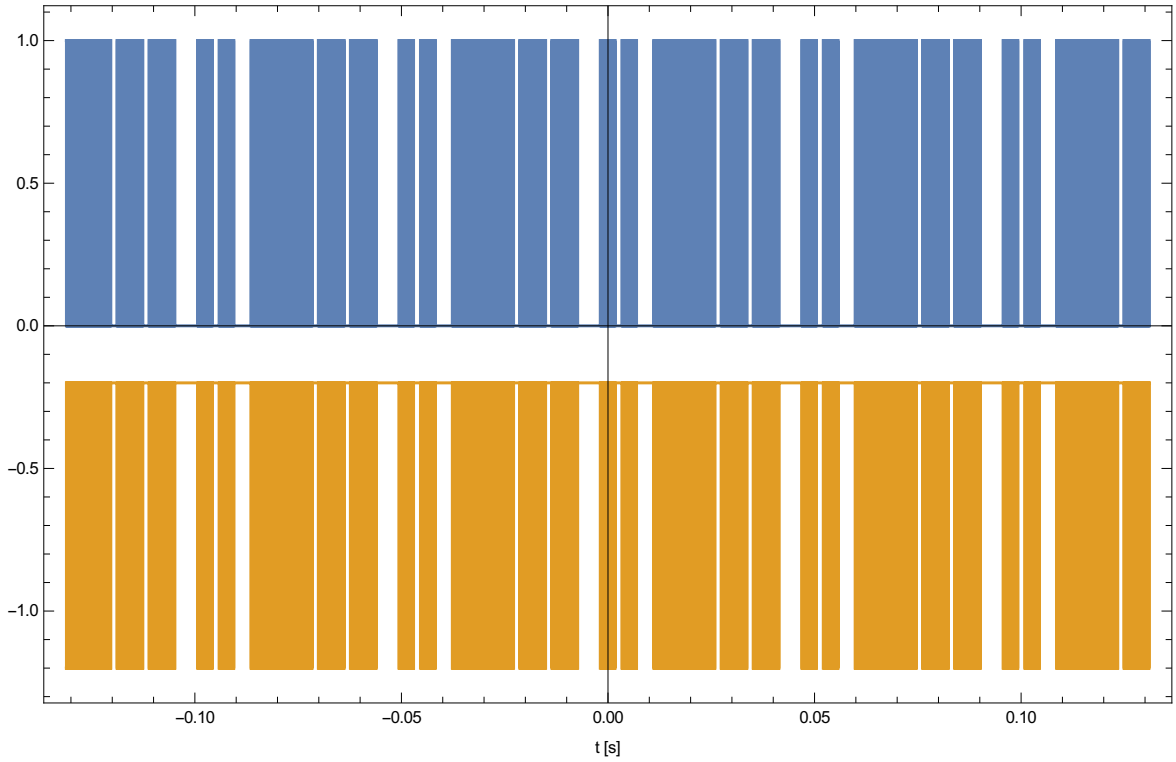
Display

```
ListPlot[Take[#, {55 000, 155 000}] & /@ digitized, Frame → True, Joined → True]
```



Display complementary phases

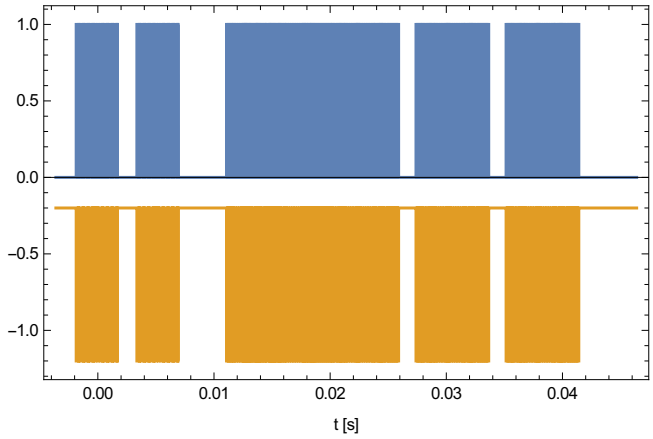
```
ListPlot[MapThread[
  Function[{series, offset}, # + {0, offset} & /@ series], {digitized, {0, -1.2}}],
 Frame → True, Joined → True, PlotRange → All, FrameLabel → {"t [s]", ""}]
```



The data sent repeats every 50ms

Display one 50ms data transmission

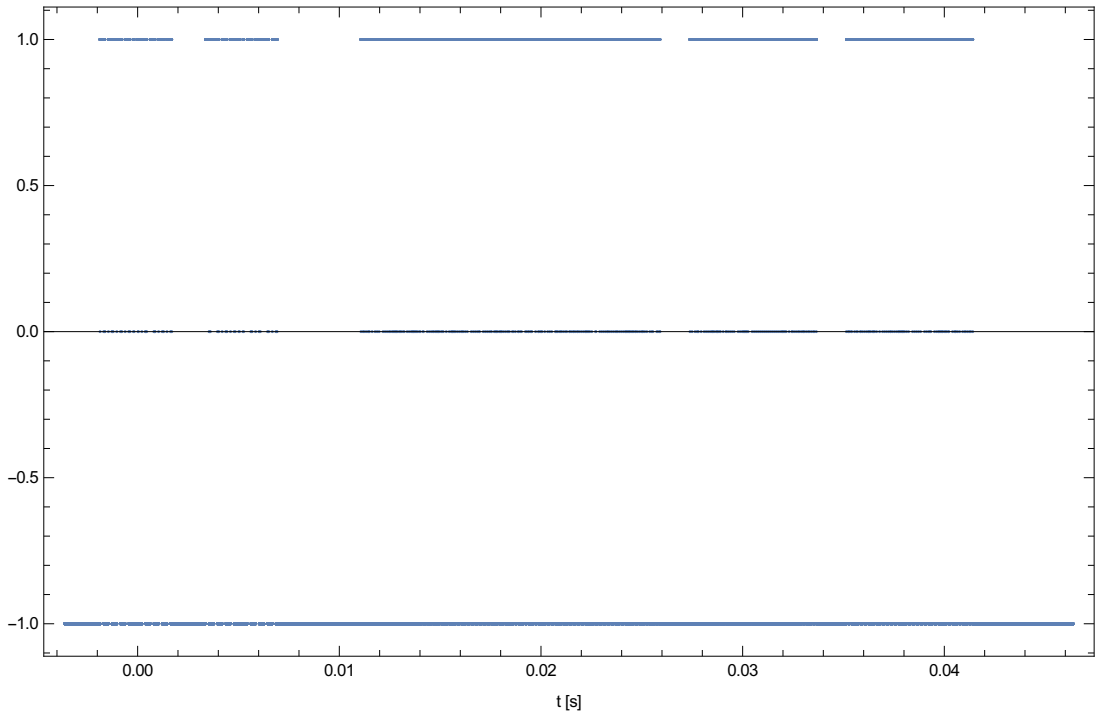
```
ListPlot[Take[#, {255 000, 355 000}] & /@ MapThread[
    Function[{series, offset}, # + {0, offset} & /@ series], {digitized, {0, -1.2}}],
 Frame → True, Joined → True, PlotRange → All, FrameLabel → {"t [s]", ""}]
```



Difference of time series

The zeros show where the phases do not overlap

```
ListPlot[Take[MapThread[{(#1[[1]] + #2[[1]])/2, #1[[2]] - #2[[2]]} &, digitized], {255 000, 355 000}],
 Frame → True, Joined → False, PlotRange → All, FrameLabel → {"t [s]", ""}]
```



Runs of identical values for difference series

```
Dimensions /@ (diffruns = SplitBy[Take[
      MapThread[{(#1[[1]] + #2[[1]])/2, #1[[2]] - #2[[2]]} &, digitized], {255 000, 355 000}], Last])
```

```
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```
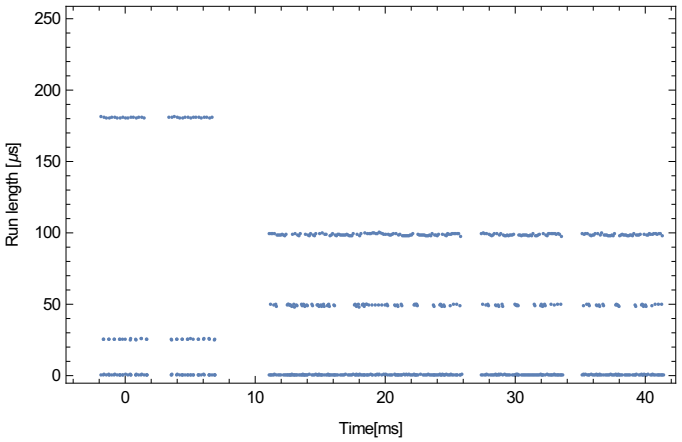

```
ListPlot[{10^3 First[First[#]], 10^6 timestep Length[#]} & /@ diffruns,
 Frame → True, FrameLabel → {"Time[ms]", "Run length [μs]"}]
```



In the difference series, the short run lengths of the phase non-overlaps are visible.

Runs of identical values for each series

```
Map[Dimensions, runs = SplitBy[Take[#, {255 000, 355 000}], Last] & /@ digitized, {2}]
```

```
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 {198, 2}, {197, 2}, {198, 2}, {199, 2}, {101, 2}, {97, 2}, {199, 2}, {197, 2},
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 {197, 2}, {199, 2}, {199, 2}, {200, 2}, {98, 2}, {201, 2}, {199, 2}, {101, 2},
 {199, 2}, {200, 2}, {100, 2}, {201, 2}, {199, 2}, {102, 2}, {196, 2}, {9961, 2}}}
```
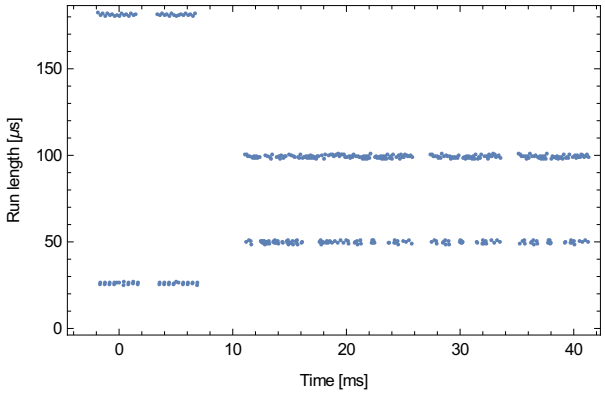
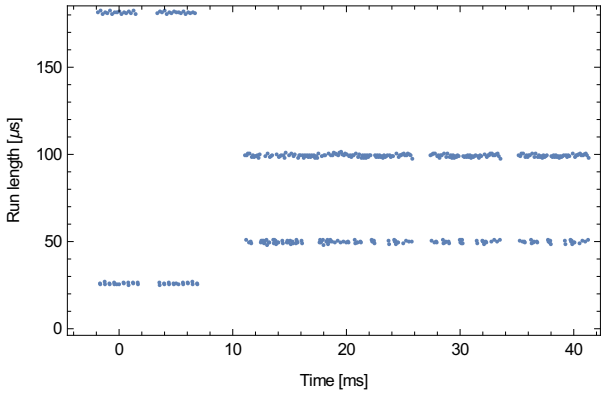

Length /@ runs

```
{421, 421}
```

```
GraphicsGrid[{ListPlot[{10^3 First[First[#]], 10^6 timestep Length[#]} & /@ #,
    Frame → True, FrameLabel → {"Time [ms]", "Run length [μs]"}]} & /@ runs]
```





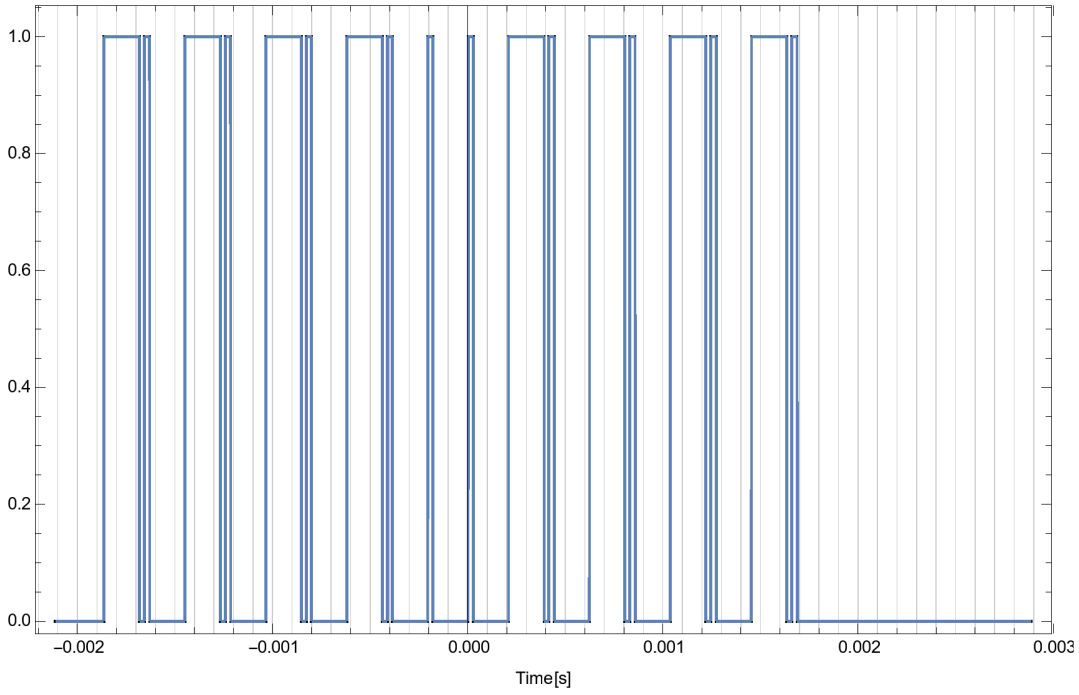
It is clearly apparent that the short modulation bursts have a different encoding timing than the remaining long and medium length bursts.

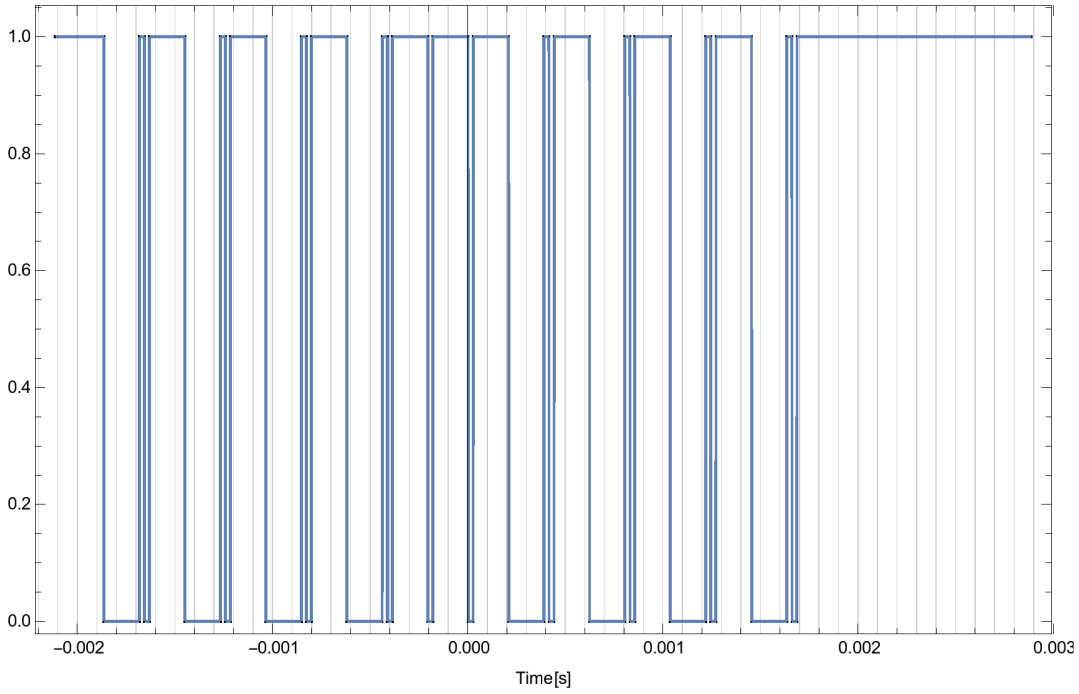
Packets within the time series

Short data packets

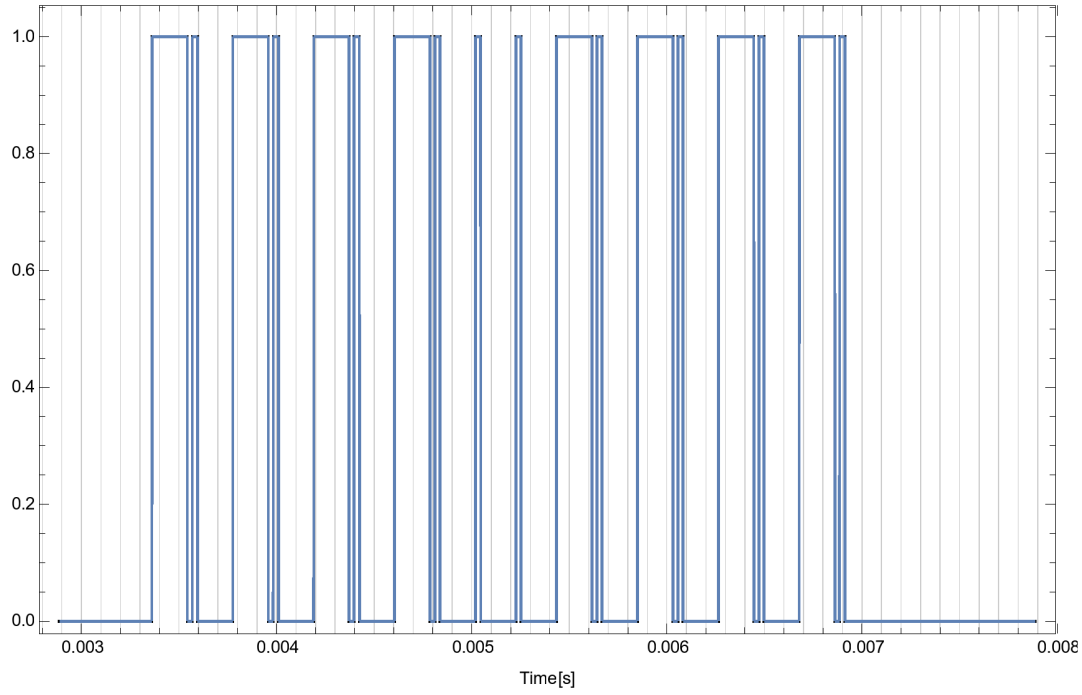
MM format, see 2.2.9 Einbettung von Steuerbefehlen im MM-Format

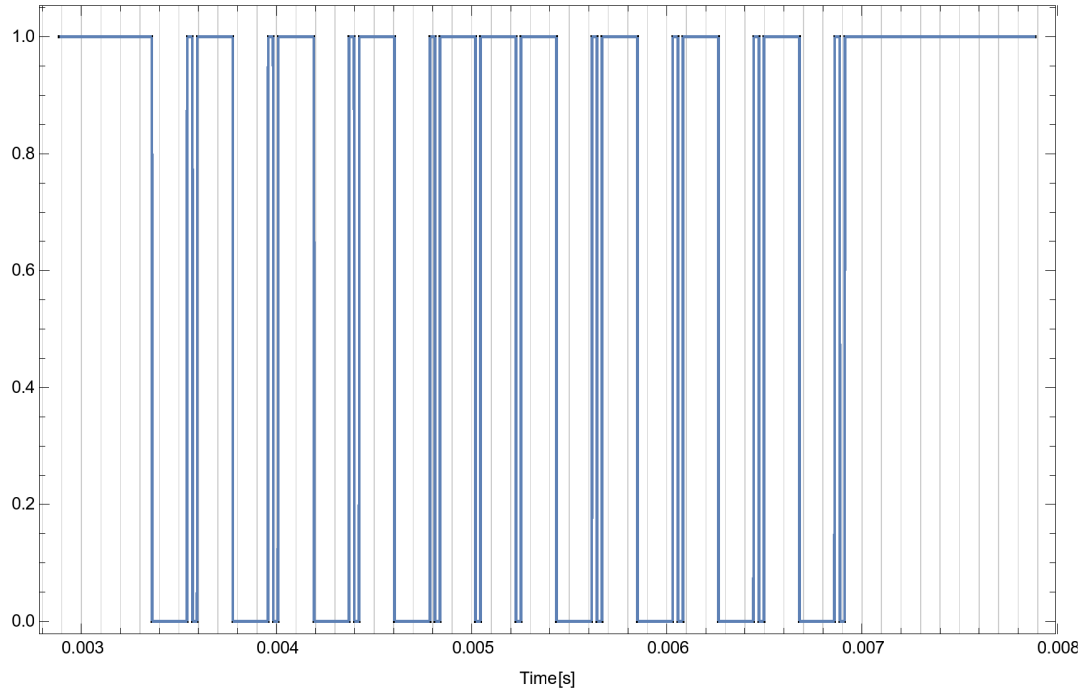
```
GraphicsGrid[
 {ListPlot[Take[#, {258 000, 268 000}], Frame → True, Joined → True, FrameLabel →
       {"Time [s]", ""}, GridLines → {Range[-.15, .15, 1.*^-4], None}]} & /@ digitized]
```





```
GraphicsGrid[
 {ListPlot[Take[#, {268 000, 278 000}], Frame → True, Joined → True, FrameLabel →
       {"Time [s]", ""}, GridLines → {Range[-.15, .15, 1.*^-4], None}]} & /@ digitized]
```

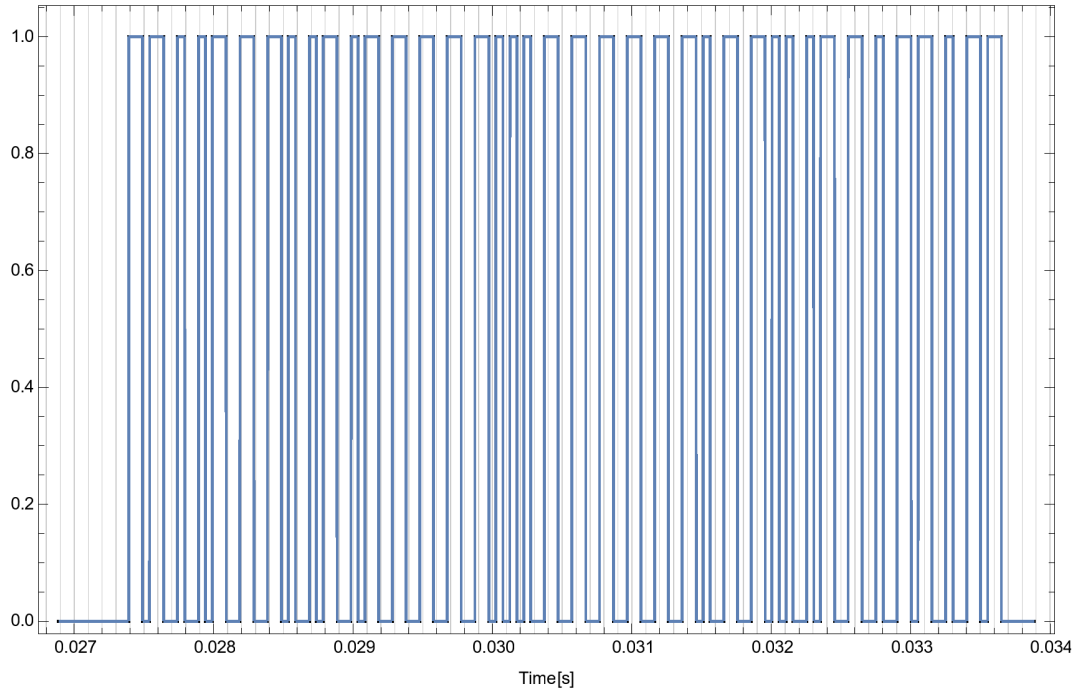


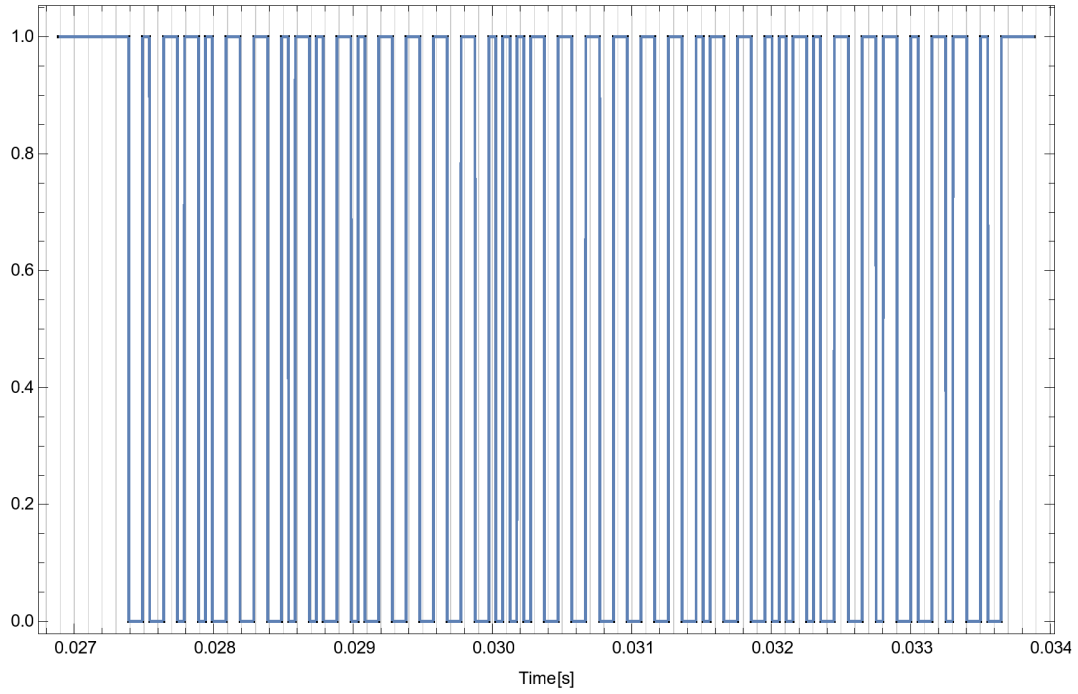


Medium length data packets

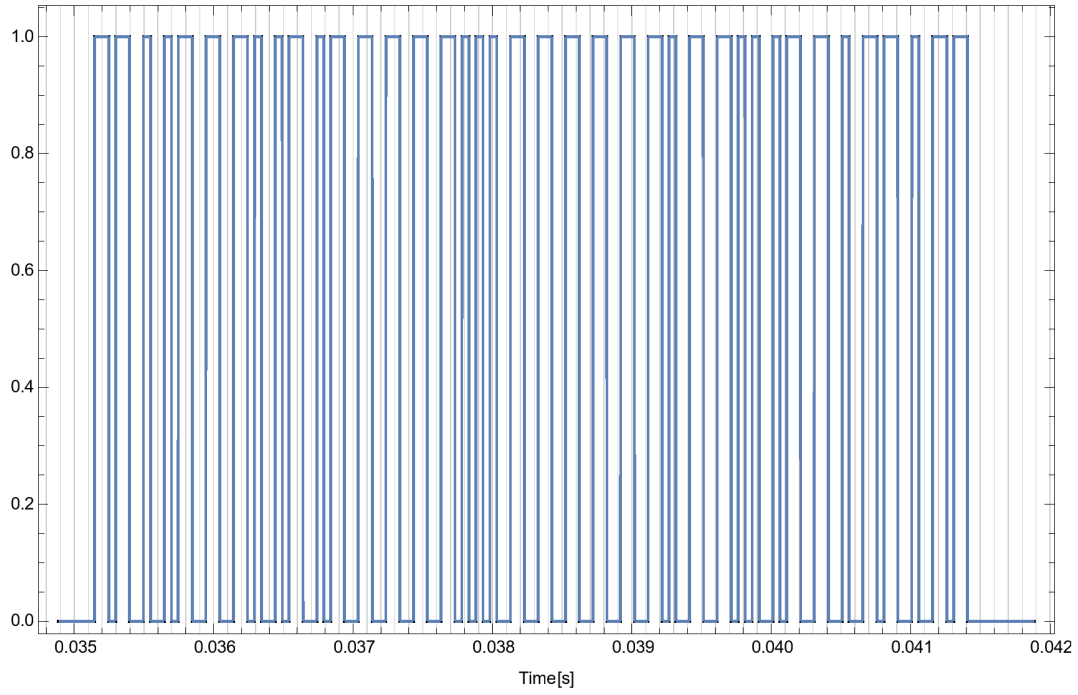
mfx signal

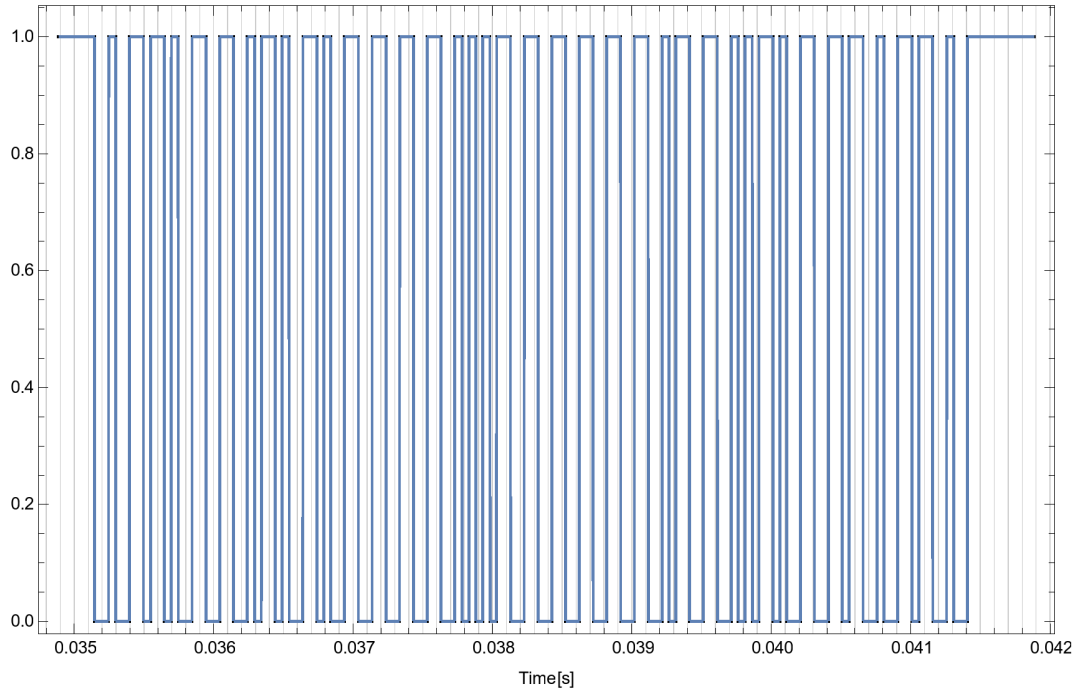
```
GraphicsGrid[
 {ListPlot[Take[#, {316 000, 330 000}], Frame → True, Joined → True, FrameLabel →
       {"Time [s]", ""}, GridLines → {Range[-.15, .15, 1.*^-4], None}]} & /@ digitized]
```





```
GraphicsGrid[
 {ListPlot[Take[#, {332 000, 346 000}], Frame → True, Joined → True, FrameLabel →
       {"Time [s]", ""}, GridLines → {Range[-.15, .15, 1.*^-4], None}]} & /@ digitized]
```

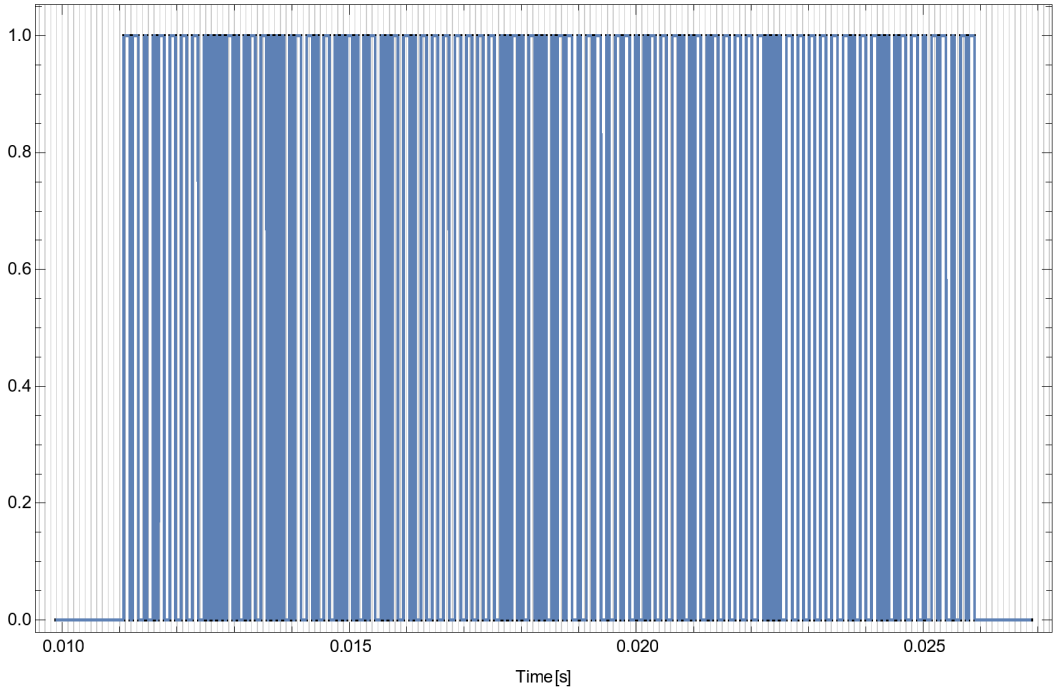


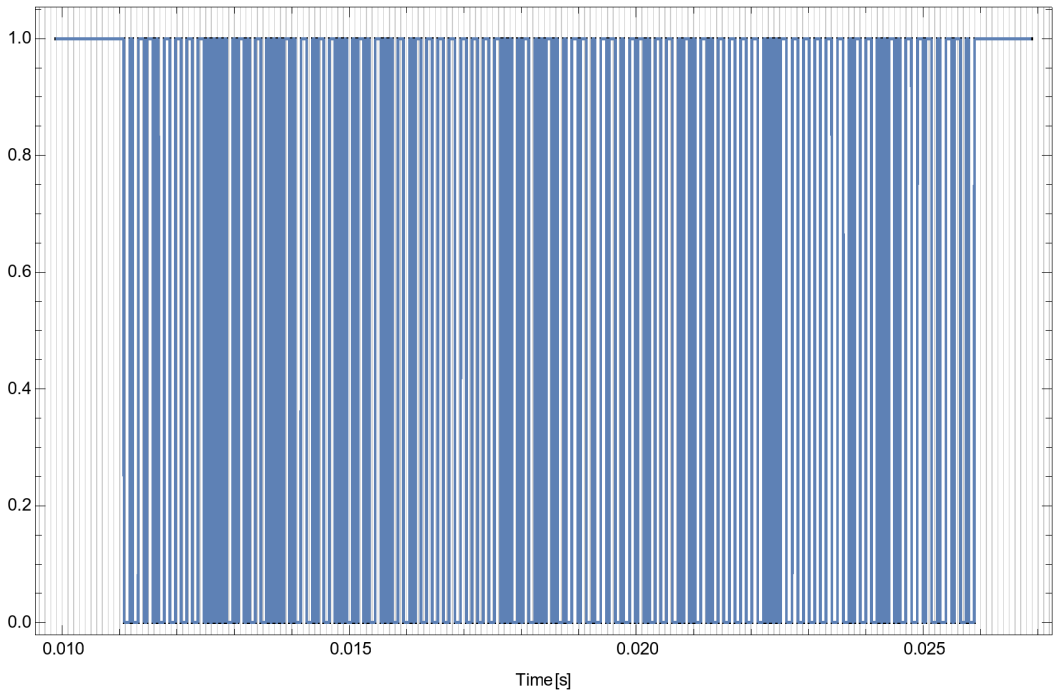


manually:
SYNC, 7'A:5, drive fwd 7'0, func 16' F3 on, CRC8'b01101000, SYNC, SYNC

Long data packet

```
GraphicsGrid[
 {ListPlot[Take[#, {282 000, 316 000}], Frame → True, Joined → True, FrameLabel →
      {"Time [s]", ""}, GridLines → {Range[-.15, .15, 1.*^-4], None}]} & /@ digitized]
```





Run length decoding

bit frame (100μs) per sampling step

```
timestep
   10^-4
```

```
0.005
```

Get run lengths of full traces

```
Length /@ (fullruns = SplitBy[#, Last] & /@ digitized)
```

```
{2312, 2312}
```

Run lengths in bit frames

```
rlbits = Map[timestep/10^-4 Length[#] &, fullruns, {2}]
```

```
{{0.275, 0.995, 0.51, 0.48, 1., 0.99, 0.5, 0.5, 0.51, 0.485, 0.99, 0.985, 1.005, 0.495,
  0.5, 0.985, 0.995, 0.98, 0.99, 0.985, 0.99, 0.98, 0.995, 0.98, 0.995, 0.985, 0.995,
  0.985, 0.995, 0.995, 0.51, 0.49, 0.51, 0.49, 1.005, 0.495, 0.495, 0.985, 1., 0.495,
  0.51, 0.495, 0.5, 0.995, 0.505, 0.495, 1.005, 0.5, 1., 0.99, 0.505, 0.995, 1.005,
  0.5, 1.005, 0.995, 0.505, 1.005, 1.005, 0.5, 1.005, 0.995, 0.505, 0.99, 0.505,
  0.49, 0.995, 0.985, 0.99, 0.98, 1.005, 0.495, 0.495, 0.995, 0.505, 0.49, 0.995,
  0.99, 0.51, 0.485, 0.995, 0.98, 0.995, 0.985, 0.995, 0.98, 0.995, 0.985, 1.005,
  0.495, 0.505, 0.495, 0.51, 0.5, 0.495, 0.98, 0.99, 0.98, 0.995, 0.985, 0.99, 0.985,
  0.995, 0.98, 0.995, 0.98, 1., 0.495, 0.495, 0.985, 0.995, 0.985, 1., 0.5, 0.505,
  0.5, 0.49, 0.995, 0.505, 0.49, 0.995, 0.98, 1.005, 0.99, 0.51, 0.995, 1., 0.495,
  1.005, 0.995, 0.51, 0.995, 1.005, 0.5, 0.99, 14.95, 1.005, 0.495, 1.005, 0.995,
  0.505, 0.995, 0.505, 0.48, 0.995, 0.985, 0.99, 0.985, 1.005, 0.5, 0.5, 0.995, 0.505,
  0.485, 0.995, 0.99, 0.51, 0.485, 0.995, 0.98, 0.995, 0.98, 0.995, 0.985, 0.995,
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  0.995, 0.985, 0.99, 0.985, 0.99, 0.985, 1.005, 0.495, 0.495, 0.985, 0.995, 0.98,
  1.01, 0.495, 0.505, 0.5, 0.495, 0.995, 0.51, 0.485, 0.99, 0.99, 1.005, 0.99, 0.505,
  0.995, 1.01, 0.495, 1., 0.99, 0.505, 0.995, 1.01, 0.495, 0.99, 14.955, 1.005, 0.495,
  1.005, 0.99, 0.505, 0.995, 0.51, 0.485, 0.995, 0.985, 0.995, 0.98, 1.005, 0.5,
  0.495, 0.995, 0.505, 0.49, 0.995, 0.995, 0.51, 0.485, 0.995, 0.985, 0.99, 0.985,
  0.995, 0.98, 0.995, 0.98, 1.005, 0.495, 0.51, 0.5, 0.505, 0.495, 0.49, 0.985, 0.995,
  0.985, 0.995, 0.98, 0.99, 0.985, 0.995, 0.98, 0.995, 0.98, 1.005, 0.495, 0.495,
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  0.99, 0.505, 0.995, 1.01, 0.495, 1.005, 0.99, 0.51, 0.995, 1., 0.495, 0.99, 54.78,
  1.815, 0.255, 0.265, 1.805, 1.825, 0.255, 0.265, 1.81, 1.82, 0.255, 0.265, 1.805,
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  1.82, 0.255, 0.265, 1.805, 1.825, 0.25, 0.27, 1.81, 1.82, 0.255, 0.27, 16.745,
```

1.815, 0.255, 0.265, 1.81, 1.82, 0.26, 0.26, 1.81, 1.82, 0.255, 0.27, 1.81, 1.82,
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0.98, 1.005, 0.495, 0.505, 0.495, 0.51, 0.495, 0.5, 0.98, 0.99, 0.98, 0.995, 0.985,
0.99, 0.985, 0.995, 0.98, 0.995, 0.98, 1., 0.495, 0.495, 0.98, 1., 0.985, 1.005,
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1., 0.5, 1.005, 0.99, 0.51, 0.995, 1.005, 0.5, 0.985, 14.95, 1.005, 0.495, 1.01,
0.995, 0.5, 0.995, 0.51, 0.485, 0.995, 0.98, 0.995, 0.98, 1.005, 0.495, 0.5, 0.995,
0.505, 0.485, 0.995, 0.99, 0.51, 0.485, 0.995, 0.985, 0.99, 0.98, 0.995, 0.985,
0.995, 0.985, 1., 0.5, 0.51, 0.495, 0.51, 0.495, 0.5, 0.985, 0.995, 0.985, 0.99,
0.985, 1., 0.98, 0.99, 0.98, 0.99, 0.985, 1.005, 0.49, 0.5, 0.985, 0.99, 0.985,
1.01, 0.495, 0.505, 0.495, 0.5, 0.99, 0.505, 0.485, 0.995, 0.985, 1.005, 0.99, 0.5,
0.995, 1.005, 0.495, 1., 0.995, 0.505, 0.995, 1.01, 0.495, 0.99, 14.955, 1.005,
0.5, 1.005, 0.995, 0.51, 0.995, 0.505, 0.49, 0.99, 0.98, 0.99, 0.985, 1.005, 0.495,
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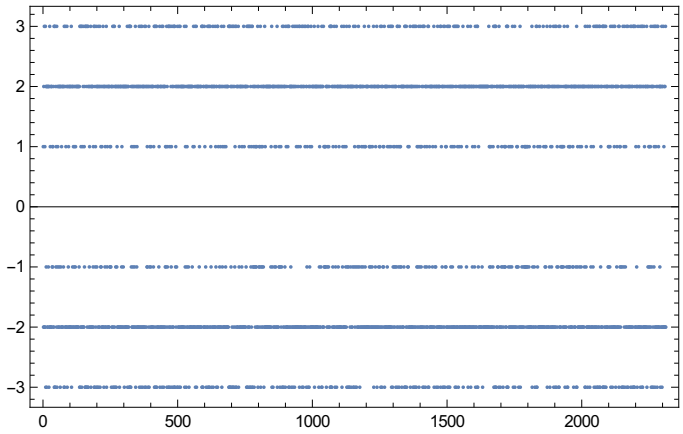
0.995, 1.005, 0.49, 1.005, 0.995, 0.505, 0.995, 1.005, 0.495, 1., 0.99, 0.305}}

Difference in run lengths of opposite polarities in sampling steps

$$\texttt{ListPlot}\left[\texttt{MapThread}\left[\frac{\#1-\#2}{\frac{\texttt{timestep}}{10^{-4}}}\&,\ \texttt{rlbits}\right],\ \texttt{Frame}\to\texttt{True},\ \texttt{PlotRange}\to\texttt{All}\right]$$



Run length encoded data packets separated by run length >2 bits

```
rlruns = SplitBy[#, # > 2 &] & /@ rlbits
```

```
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{0.995, 0.505, 1., 1.005, 0.495, 1.005, 0.5, 0.495, 0.99, 0.995, 0.98, 0.995,
0.995, 0.51, 0.49, 1.005, 0.495, 0.5, 0.985, 1.005, 0.5, 0.49, 0.985, 0.995, 0.98,
0.995, 0.98, 0.99, 0.985, 0.995, 0.99, 0.51, 0.495, 0.51, 0.49, 0.51, 0.49, 0.99,
0.985, 0.99, 0.985, 0.995, 0.985, 0.995, 0.98, 0.99, 0.985, 0.99, 0.995, 0.505,
0.49, 0.99, 0.98, 0.995, 0.99, 0.505, 0.5, 0.5, 0.485, 1., 0.5, 0.495, 0.985, 0.995,
0.995, 1.005, 0.5, 1.005, 0.995, 0.51, 0.995, 1., 0.5, 1.005, 0.99, 0.51, 0.975},

{14.96}, {0.995, 0.505, 0.99, 1.005, 0.5, 1.005, 0.5, 0.495, 0.985, 0.995,
 0.985, 0.995, 0.995, 0.51, 0.49, 1.005, 0.495, 0.5, 0.985, 1.005, 0.5,
 0.495, 0.985, 0.995, 0.985, 0.99, 0.98, 0.995, 0.985, 0.99, 0.995, 0.51, 0.5,
 0.505, 0.495, 0.505, 0.485, 0.99, 0.985, 0.995, 0.985, 0.995, 0.985, 0.99,
 0.98, 0.99, 0.985, 0.99, 0.995, 0.505, 0.485, 0.995, 0.985, 0.995, 0.99,
 0.51, 0.5, 0.505, 0.485, 1.005, 0.495, 0.495, 0.985, 0.995, 0.995, 1., 0.49,
 1.005, 0.995, 0.505, 0.995, 1., 0.5, 1.005, 0.995, 0.51, 0.98}, {54.79},
{1.81, 0.265, 0.26, 1.815, 1.81, 0.265, 0.255, 1.825, 1.805, 0.265, 0.255,
 1.815, 1.81, 0.27, 0.255, 1.82, 0.255, 1.82, 0.255, 1.815, 1.81, 0.265, 0.255,
 1.82, 1.805, 0.27, 0.255, 1.82, 1.805, 0.265, 0.26, 1.815, 1.81, 0.265, 0.25},
{16.75}, {1.81, 0.265, 0.255, 1.82, 1.81, 0.265, 0.255, 1.82, 1.805, 0.265,
 0.255, 1.82, 1.81, 0.26, 0.255, 1.82, 0.25, 1.82, 0.255, 1.815, 1.81, 0.265, 0.255,
 1.82, 1.805, 0.265, 0.255, 1.815, 1.81, 0.27, 0.255, 1.82, 1.81, 0.265, 0.255},
{41.655}, {0.995, 0.51, 0.995, 1.005, 0.5, 1., 0.495, 0.5, 0.985, 0.99, 0.985,
 0.99, 0.985, 0.995, 0.985, 1., 0.5, 0.505, 0.495, 0.5, 0.495, 0.51, 0.495, 0.5,
 0.995, 0.5, 0.485, 1.005, 0.495, 0.49, 0.985, 0.99, 0.995, 0.505, 0.5, 0.51,
 0.495, 0.5, 0.485, 1.005, 0.495, 0.5, 0.985, 0.99, 0.995, 0.505, 0.485, 0.99,
 0.98, 1.005, 0.495, 0.505, 0.495, 0.5, 0.995, 0.51, 0.485, 1.01, 0.495, 0.5,
 0.985, 1., 0.495, 0.505, 0.5, 0.495, 0.985, 0.995, 0.995, 0.505, 0.485, 0.995,
 0.985, 0.995, 0.98, 0.995, 0.985, 0.99, 0.99, 0.99, 0.98, 0.995, 0.985, 1.,
 0.985, 1.005, 0.5, 0.505, 0.5, 0.49, 1., 0.505, 0.49, 0.995, 0.995, 0.51, 0.49,
 0.51, 0.485, 1.01, 0.495, 0.51, 0.995, 0.505, 0.995, 1., 0.495, 1.005, 0.99,
 0.505, 1., 1., 0.495, 1.015, 0.995, 0.505, 0.995, 1.005, 0.495, 1., 0.5, 0.5,
 0.985, 0.995, 0.985, 0.995, 0.995, 0.505, 0.49, 1.005, 0.5, 0.495, 0.98, 1.,
 0.495, 0.495, 0.985, 0.995, 0.985, 0.99, 0.985, 1., 0.98, 0.995, 0.995, 0.51,
 0.495, 0.51, 0.5, 0.505, 0.49, 0.995, 0.985, 0.995, 0.99, 0.995, 0.985, 0.995,
 0.985, 0.99, 0.985, 0.99, 0.995, 0.505, 0.485, 0.995, 0.985, 0.99, 0.995,
 0.51, 0.495, 0.505, 0.485, 1.005, 0.5, 0.5, 0.985, 0.995, 0.995, 1.005, 0.5,
 1.005, 0.995, 0.51, 0.995, 1.005, 0.5, 1.005, 0.995, 0.51, 0.975}, {14.965},
{0.995, 0.505, 0.995, 1., 0.495, 1.005, 0.5, 0.495, 0.985, 0.995, 0.985, 0.995,
 1., 0.505, 0.485, 1.005, 0.495, 0.5, 0.985, 1., 0.5, 0.5, 0.985, 0.995, 0.985, 0.99,
 0.985, 0.99, 0.985, 0.99, 0.995, 0.505, 0.495, 0.505, 0.495, 0.505, 0.49, 0.995,
 0.985, 0.995, 0.985, 0.995, 0.99, 0.995, 0.985, 0.99, 0.98, 0.99, 0.995, 0.5, 0.49,
 0.995, 0.985, 0.99, 0.995, 0.51, 0.495, 0.505, 0.49, 1.005, 0.495, 0.495, 0.985,
 0.99, 0.995, 1.005, 0.495, 1.005, 0.995, 0.5, 1., 1., 0.5, 1., 0.995, 0.505, 0.98},
{14.965}, {0.995, 0.51, 0.995, 1.005, 0.495, 1.005, 0.495, 0.5, 0.98, 0.995, 0.985,
 0.995, 0.995, 0.505, 0.485, 1.005, 0.5, 0.49, 0.985, 1.005, 0.495, 0.5, 0.98, 1.,
 0.98, 0.99, 0.985, 0.995, 0.98, 0.99, 1., 0.505, 0.5, 0.505, 0.5, 0.51, 0.485, 0.99,
 0.99, 0.995, 0.98, 0.995, 0.985, 0.995, 0.985, 0.99, 0.985, 0.995, 0.995, 0.505,
 0.485, 0.995, 0.98, 0.995, 0.995, 0.505, 0.5, 0.51, 0.485, 1., 0.5, 0.49, 0.985, 0.995,
 0.99, 1., 0.495, 1.005, 1., 0.505, 0.995, 1., 0.495, 1.005, 0.995, 0.505, 0.98},
{54.79}, {1.805, 0.265, 0.255, 1.815, 1.81, 0.265, 0.255, 1.825, 1.805, 0.265,
 0.255, 1.815, 1.81, 0.27, 0.255, 1.815, 0.26, 1.815, 0.255, 1.815, 1.81, 0.265,
 0.26, 1.815, 1.81, 0.26, 0.255, 1.82, 1.805, 0.265, 0.26, 1.82, 1.81, 0.265, 0.255},
{16.75}, {1.81, 0.26, 0.255, 1.82, 1.805, 0.265, 0.26, 1.815, 1.81, 0.265, 0.255,

```
    1.82, 1.805, 0.265, 0.255, 1.82, 0.255, 1.82, 0.255, 1.82, 1.805, 0.265, 0.255,
    1.815, 1.81, 0.26, 0.255, 1.82, 1.81, 0.265, 0.255, 1.82, 1.81, 0.26, 0.255},
   {41.655}, {0.995, 0.51, 0.995, 1.005, 0.495, 1.005, 0.495, 0.5, 0.98, 0.995,
    0.98, 0.995, 0.98, 0.995, 0.98, 1.005, 0.495, 0.505, 0.495, 0.505, 0.495,
    0.51, 0.495, 0.5, 0.99, 0.5, 0.485, 1., 0.495, 0.5, 0.985, 0.99, 0.99, 0.51,
    0.495, 0.51, 0.495, 0.505, 0.485, 1.005, 0.495, 0.495, 0.98, 0.99, 0.99, 0.51,
    0.485, 0.995, 0.98, 1.005, 0.5, 0.51, 0.495, 0.495, 0.995, 0.505, 0.49, 1.005,
    0.5, 0.495, 0.985, 1.005, 0.495, 0.51, 0.495, 0.495, 0.985, 0.995, 0.99,
    0.51, 0.49, 0.99, 0.985, 0.99, 0.98, 0.995, 0.99, 0.99, 0.985, 0.995, 0.985,
    0.995, 0.985, 0.995, 0.98, 1., 0.495, 0.51, 0.495, 0.495, 0.99, 0.505, 0.485,
    0.995, 0.99, 0.505, 0.5, 0.505, 0.49, 1.005, 0.495, 0.5, 0.995, 0.51, 0.99, 1.,
    0.495, 1.005, 0.99, 0.51, 0.995, 1.005, 0.5, 1.01, 0.995, 0.51, 0.99, 1., 0.5,
    1., 0.5, 0.495, 0.985, 1., 0.985, 0.99, 0.99, 0.51, 0.49, 1.005, 0.495, 0.5,
    0.98, 1., 0.495, 0.495, 0.985, 0.995, 0.985, 0.995, 0.98, 0.995, 0.985, 0.995,
    0.99, 0.505, 0.495, 0.51, 0.49, 0.51, 0.48, 0.995, 0.985, 0.99, 0.98, 0.99,
    0.985, 0.995, 0.98, 0.99, 0.98, 0.995, 0.995, 0.51, 0.48, 0.995, 0.99, 0.995,
    0.995, 0.51, 0.5, 0.505, 0.485, 1.01, 0.495, 0.495, 0.985, 0.995, 0.99, 1.01,
    0.49, 1.01, 0.995, 0.5, 0.995, 1.005, 0.495, 1., 0.995, 0.51, 0.98}, {14.965},
   {0.995, 0.51, 0.995, 1.005, 0.495, 1.005, 0.495, 0.5, 0.985, 0.99, 0.985, 0.99,
    0.995, 0.505, 0.49, 1.005, 0.495, 0.495, 0.99, 1.005, 0.495, 0.5, 0.98, 0.995, 0.985,
    0.995, 0.985, 0.995, 0.985, 0.995, 0.995, 0.5, 0.5, 0.51, 0.495, 0.51, 0.485, 0.995,
    0.985, 0.995, 0.98, 0.995, 0.98, 1., 0.98, 0.995, 0.98, 0.995, 0.995, 0.505, 0.485,
    0.99, 0.985, 0.99, 0.995, 0.51, 0.5, 0.505, 0.49, 1., 0.495, 0.495, 0.98, 0.995,
    0.995, 1.005, 0.49, 1.005, 0.995, 0.505, 0.995, 1.005, 0.495, 1., 0.99, 0.305}}}
```

Dimensions[rlruns]

```
{2, 53}
```

Map[Length, rlruns, {2}]

```
{{135, 1, 77, 1, 77, 1, 35, 1, 35, 1, 191, 1, 77, 1,
   77, 1, 35, 1, 35, 1, 191, 1, 77, 1, 77, 1, 35, 1, 35, 1, 191, 1, 77, 1,
   77, 1, 35, 1, 35, 1, 191, 1, 77, 1, 77, 1, 35, 1, 35, 1, 191, 1, 76},
  {135, 1, 77, 1, 77, 1, 35, 1, 35, 1, 191, 1, 77, 1, 77, 1, 35, 1, 35,
   1, 191, 1, 77, 1, 77, 1, 35, 1, 35, 1, 191, 1, 77, 1, 77, 1,
   35, 1, 35, 1, 191, 1, 77, 1, 77, 1, 35, 1, 35, 1, 191, 1, 76}}
```

Length of packet separators in 100μs bit frames

```
TableForm[Transpose[Select[#, Length[#] ≤ 1 &] & /@ rlruns]]
```

```
14.95     14.965
14.955    14.96
54.78     54.785
16.745    16.75
41.645    41.66
14.95     14.96
14.955    14.965
54.78     54.785
16.735    16.745
41.635    41.65
14.955    14.965
14.955    14.965
54.775    54.79
16.735    16.74
41.645    41.655
14.955    14.97
14.95     14.96
54.785    54.79
16.735    16.75
41.645    41.655
14.95     14.965
14.955    14.965
54.78     54.79
16.74     16.75
41.645    41.655
14.955    14.965
```

Run length encoded packets

Display number of runs per packet

```
TableForm[
 Transpose[Map[Length, packetruns = Select[#, Length[#] > 1 &] & /@ rlruns, {2}]]]
```

```
135    135
77     77
77     77
35     35
35     35
191    191
77     77
77     77
35     35
35     35
191    191
77     77
77     77
35     35
35     35
191    191
77     77
77     77
35     35
35     35
191    191
77     77
77     77
35     35
35     35
191    191
76     76
```

Runs in 25μs time unit multiples

```
RoundRunTime = Round[4 #] &
```

```
Round[4 #1] &
```

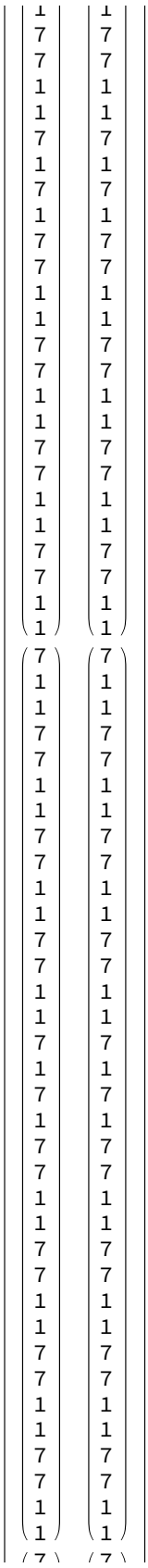
```
MatrixForm[Transpose[mmruns = RoundRunTime[Select[#, Length[#] == 35 &] & /@ packetruns]]]
```

$$\begin{pmatrix} \begin{pmatrix} 7 \\ 1 \\ 1 \\ 7 \\ 7 \\ 1 \\ 1 \\ 7 \\ 7 \\ 1 \\ 1 \\ 7 \\ 7 \\ 1 \\ 1 \\ 7 \\ 1 \\ 7 \\ 1 \\ 7 \end{pmatrix} & \begin{pmatrix} 7 \\ 1 \\ 1 \\ 7 \\ 7 \\ 1 \\ 1 \\ 7 \\ 7 \\ 1 \\ 1 \\ 7 \\ 7 \\ 1 \\ 1 \\ 7 \\ 1 \\ 7 \\ 1 \\ 7 \end{pmatrix} \end{pmatrix}$$

$$\left\{\begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix}, \begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix}\right\}$$

$$\left\{\begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix}, \begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix}\right\}$$

$$\left\{\begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix}, \begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix}\right\}$$



$$\left\{\begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\end{pmatrix}, \begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\end{pmatrix}\right\}$$

$$\left\{\left\{\begin{pmatrix}1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix},\begin{pmatrix}1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix}\right\},\left\{\begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix},\begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix}\right\},\left\{\begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix},\begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix}\right\}\right\}$$

$$\left\{\left\{\begin{pmatrix}1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix},\begin{pmatrix}1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix}\right\},\left\{\begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix},\begin{pmatrix}7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\1\\7\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\\7\\7\\1\\1\end{pmatrix}\right\},\left\{\begin{pmatrix}7\\1\\1\\7\\7\\1\end{pmatrix},\begin{pmatrix}7\\1\\1\\7\\7\\1\end{pmatrix}\right\}\right\}$$

1	1
7	7
7	7
1	1
1	1
7	7
7	7
1	1
1	1
7	7
1	1
7	7
1	1
7	7
7	7
1	1
1	1
7	7
7	7
1	1
1	1
7	7
7	7
1	1
1	1
7	7
7	7
1	1
1	1

```
MatrixForm[
 Transpose[mediumruns = RoundRunTime[Select[#, Length[#] == 77 &] & /@ packetruns]]]
```

4	4
2	2
4	4
4	4
2	2
4	4
2	2
2	2
4	4
4	4
4	4
4	4
4	4
2	2
2	2
4	4
2	2
2	2
4	4
4	4
2	2
2	2
4	4
4	4
4	4
4	4
4	4
4	4

$$\left\{\begin{pmatrix}4\\4\\4\\4\\2\\2\\2\\2\\2\\2\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\4\\4\\4\\4\\2\\2\\2\\2\\4\\2\\2\\4\\4\\4\\4\\2\\4\\4\\2\\4\\4\\2\\4\\4\\2\\4\end{pmatrix}\begin{pmatrix}4\\4\\4\\4\\2\\2\\2\\2\\2\\2\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\4\\4\\4\\4\\2\\2\\2\\2\\4\\2\\2\\4\\4\\4\\4\\2\\4\\4\\2\\4\\4\\2\\4\\4\\2\\4\end{pmatrix}\right\}$$

$$\left\{\begin{pmatrix}4\\2\\4\\4\\2\\4\\2\\2\\4\\4\\4\end{pmatrix}\begin{pmatrix}4\\2\\4\\4\\2\\4\\2\\2\\4\\4\\4\end{pmatrix}\right\}$$

	4		4	
	4		4	
	2		2	
	2		2	
	4		4	
	2		2	
	2		2	
	4		4	
	4		4	
	2		2	
	2		2	
	4		4	
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	2		2	
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	4		4	
	4		4	
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	4		4	
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	4		4	
	4		4	
	4		4	
	4		4	
	2		2	
	4		4	
	4		4	
	2		2	
	4		4	

$$\left\{\left\{\begin{pmatrix}4\\2\\4\\4\\2\\4\end{pmatrix}\begin{pmatrix}4\\2\\4\\4\\2\\4\end{pmatrix}\right\},\left\{\begin{pmatrix}4\\2\\4\\4\\2\\4\\2\\2\\4\\4\\4\\4\\4\\2\\2\\4\\2\\2\\4\\4\\2\\2\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\2\\2\\2\\2\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\4\\4\\4\end{pmatrix}\begin{pmatrix}4\\2\\4\\4\\2\\4\\2\\2\\4\\4\\4\\4\\4\\2\\2\\4\\2\\2\\4\\4\\2\\2\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\2\\2\\2\\2\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\4\\4\\4\end{pmatrix}\right\}\right\}$

4	4
2	2
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2	2
2	2
2	2
2	2
2	2
2	2
4	4

$$\left\{\left\{\begin{matrix}4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\4\\4\\4\\4\\2\\2\\2\\2\\4\\2\\2\\4\\4\\4\\4\\2\\4\\4\\2\\4\\4\\2\end{matrix}\right\},\left\{\begin{matrix}4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\4\\4\\4\\4\\2\\2\\2\\2\\4\\2\\2\\4\\4\\4\\4\\2\\4\\4\\2\\4\\4\\2\end{matrix}\right\}\right\}$$

$$\left\{\left\{\begin{matrix}4\\2\\4\\4\\2\\4\\2\\2\\4\\4\\4\\4\\2\\2\\4\\2\\2\\4\\4\\4\\4\\2\\4\\4\\2\\4\\4\\2\end{matrix}\right\},\left\{\begin{matrix}4\\2\\4\\4\\2\\4\\2\\2\\4\\4\\4\\4\\2\\2\\4\\2\\2\\4\\4\\4\\4\\2\\4\\4\\2\\4\\4\\2\end{matrix}\right\}\right\}$$

$$\left\{\left\{\begin{pmatrix}2\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\2\\2\\2\\2\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\4\\4\\4\\4\\2\\2\\2\\2\\4\\2\\2\\4\\4\\4\\4\\2\\4\\4\\2\\4\\4\\2\\4\\4\\2\\4\end{pmatrix}\quad\begin{pmatrix}2\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\2\\2\\2\\2\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\4\\2\\2\\4\\4\\4\\4\\2\\2\\2\\2\\4\\2\\2\\4\\4\\4\\4\\2\\4\\4\\2\\4\\4\\2\\4\\4\\2\\4\end{pmatrix}\right\}\quad\left\{\begin{pmatrix}4\\2\\4\\4\end{pmatrix}\quad\begin{pmatrix}4\\2\\4\\4\end{pmatrix}\right\}\right\}$$

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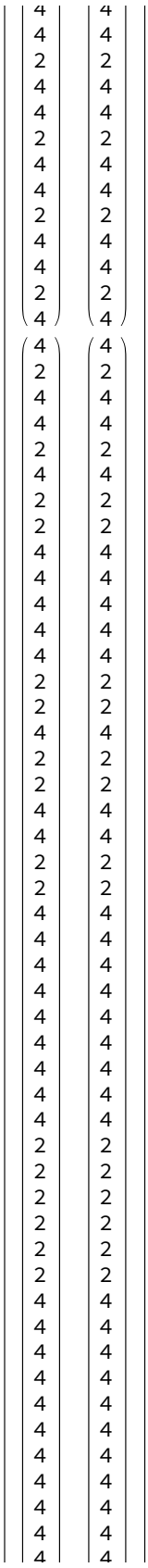

$$\left\{\left\{\begin{matrix}4\\2\\2\\4\\4\\4\\4\\2\\2\\2\\2\\4\\2\\2\\4\\4\\4\\4\\2\\4\\4\\2\\4\\4\\2\\4\end{matrix}\right\},\left\{\begin{matrix}4\\2\\2\\4\\4\\4\\4\\2\\2\\2\\2\\4\\2\\2\\4\\4\\4\\4\\2\\4\\4\\2\\4\\4\\2\\4\end{matrix}\right\}\right\}$$

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	4		4	
	4		4	
	4		4	
	4		4	
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	4		4	
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	4		4	
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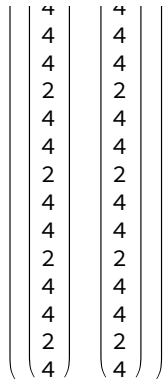
	2		2	
	2		2	
	2		2	
	2		2	
	4		4	
	2		2	
	2		2	
	4		4	
	4		4	



```
truncruns = RoundRunTime[
  Select[#, Function[l, And @@ (l ≠ # & /@ {1, 35, 77, 191})][Length[#]] &] & /@ packetruns]
```

```
{{{1, 4, 2, 2, 4, 4, 2, 2, 2, 2, 4, 4, 4, 2, 2, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4,
    4, 4, 4, 2, 2, 2, 2, 4, 2, 2, 4, 4, 2, 2, 2, 2, 4, 2, 2, 4, 2, 4, 4, 2, 4, 4, 2,
    4, 4, 2, 4, 4, 2, 4, 4, 2, 4, 2, 2, 4, 4, 4, 4, 4, 2, 2, 4, 2, 2, 4, 4, 2, 2, 4,
    4, 4, 4, 4, 4, 4, 4, 4, 2, 2, 2, 2, 2, 2, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 2,
    2, 4, 4, 4, 4, 2, 2, 2, 2, 4, 2, 2, 4, 4, 4, 4, 2, 4, 4, 2, 4, 4, 2, 4, 4, 2, 4},
   {4, 2, 4, 4, 2, 4, 2, 2, 4, 4, 4, 4, 4, 2, 2, 4, 2, 2, 4, 4, 2, 2, 4, 4, 4, 4,
    4, 4, 4, 4, 4, 2, 2, 2, 2, 2, 2, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 2, 2,
    4, 4, 4, 4, 2, 2, 2, 2, 4, 2, 2, 4, 4, 4, 4, 2, 4, 4, 2, 4, 4, 2, 4, 4, 1}},
  {{1, 4, 2, 2, 4, 4, 2, 2, 2, 2, 4, 4, 4, 2, 2, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4,
    4, 4, 4, 2, 2, 2, 2, 4, 2, 2, 4, 4, 2, 2, 2, 2, 4, 2, 2, 4, 2, 4, 4, 2, 4, 4, 2,
    4, 4, 2, 4, 4, 2, 4, 4, 2, 4, 2, 2, 4, 4, 4, 4, 4, 2, 2, 4, 2, 2, 4, 4, 2, 2, 4,
    4, 4, 4, 4, 4, 4, 4, 4, 2, 2, 2, 2, 2, 2, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 2,
    2, 4, 4, 4, 4, 2, 2, 2, 2, 4, 2, 2, 4, 4, 4, 4, 2, 4, 4, 2, 4, 4, 2, 4, 4, 2, 4},
   {4, 2, 4, 4, 2, 4, 2, 2, 4, 4, 4, 4, 4, 2, 2, 4, 2, 2, 4, 4, 2, 2, 4, 4, 4, 4,
    4, 4, 4, 4, 4, 2, 2, 2, 2, 2, 2, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 2, 2,
    4, 4, 4, 4, 2, 2, 2, 2, 4, 2, 2, 4, 4, 4, 4, 2, 4, 4, 2, 4, 4, 2, 4, 4, 1}}}
```

```
Function[l, And @@ (l ≠ # & /@ {1, 35, 77, 191})][35]
```

```
False
```

Parse runs

Shotgun mfx parser

```
mfxparser = Function[{in, out},
  If[Length[in] ≥ 6 ∧ {4, 2, 4, 4, 2, 4} == Take[in, 6], {Drop[in, 6], Append[out, SYNC]},
   If[Length[in] ≥ 2 ∧ {2, 2} == Take[in, 2], {Drop[in, 2], Append[out, 1]},
    If[{4} == Take[in, 1],
     {Drop[in, 1], Append[out, 0]}, {Drop[in, 1], Append[out, ⚠]}]]]
 ]
```

```
Function[{in, out},
 If[Length[in] ≥ 6 && {4, 2, 4, 4, 2, 4} == Take[in, 6], {Drop[in, 6], Append[out, SYNC]},
  If[Length[in] ≥ 2 && {2, 2} == Take[in, 2], {Drop[in, 2], Append[out, 1]},
   If[{4} == Take[in, 1], {Drop[in, 1], Append[out, 0]}, {Drop[in, 1], Append[out, ⚠]}]]]]
```

Parse by iteration over run length encoded input

```
NestWhile[mfxparser @@ # &, {mediumruns[[1, 1]], {}}, Length[First[#]] > 0 &]
```

```
{{}, {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC}}
```

Shotgun MM parser

```
MMparser = Function[{in, out},
  If[Length[in] ≥ 2,
   Which[{1, 7} == Take[in, 2], {Drop[in, 2], Append[out, 0]},
    {7, 1} == Take[in, 2], {Drop[in, 2], Append[out, 1]},
    True, {Drop[in, 1], Append[out, ⚠]}],
   If[Length[in] == 1, Which[{1} == Take[in, 1],
     {Drop[in, 1], Append[out, 0]}, {7} == Take[in, 1], {Drop[in, 1], Append[out, 1]},
     True, {Drop[in, 1], Append[out, ⚠]}], {Drop[in, 1], Append[out, ⚠]}]]
 ]
```

```
Function[{in, out}, If[Length[in] ≥ 2,
  Which[{1, 7} == Take[in, 2], {Drop[in, 2], Append[out, 0]}, {7, 1} == Take[in, 2],
   {Drop[in, 2], Append[out, 1]}, True, {Drop[in, 1], Append[out, ⚠]}],
  If[Length[in] == 1, Which[{1} == Take[in, 1], {Drop[in, 1], Append[out, 0]},
    {7} == Take[in, 1], {Drop[in, 1], Append[out, 1]}, True,
    {Drop[in, 1], Append[out, ⚠]}], {Drop[in, 1], Append[out, ⚠]}]]]
```

Parse by iteration over run length encoded input

```
NestWhile[MMparser @@ # &, {mmruns[[1, 1]], {}}, Length[First[#]] > 0 &]
```

```
{{}, {1, 0, 1, 0, 1, 0, 1, 0, 0, 0, 1, 0, 1, 0, 1, 0, 1, 0}}
```

Apply parsers

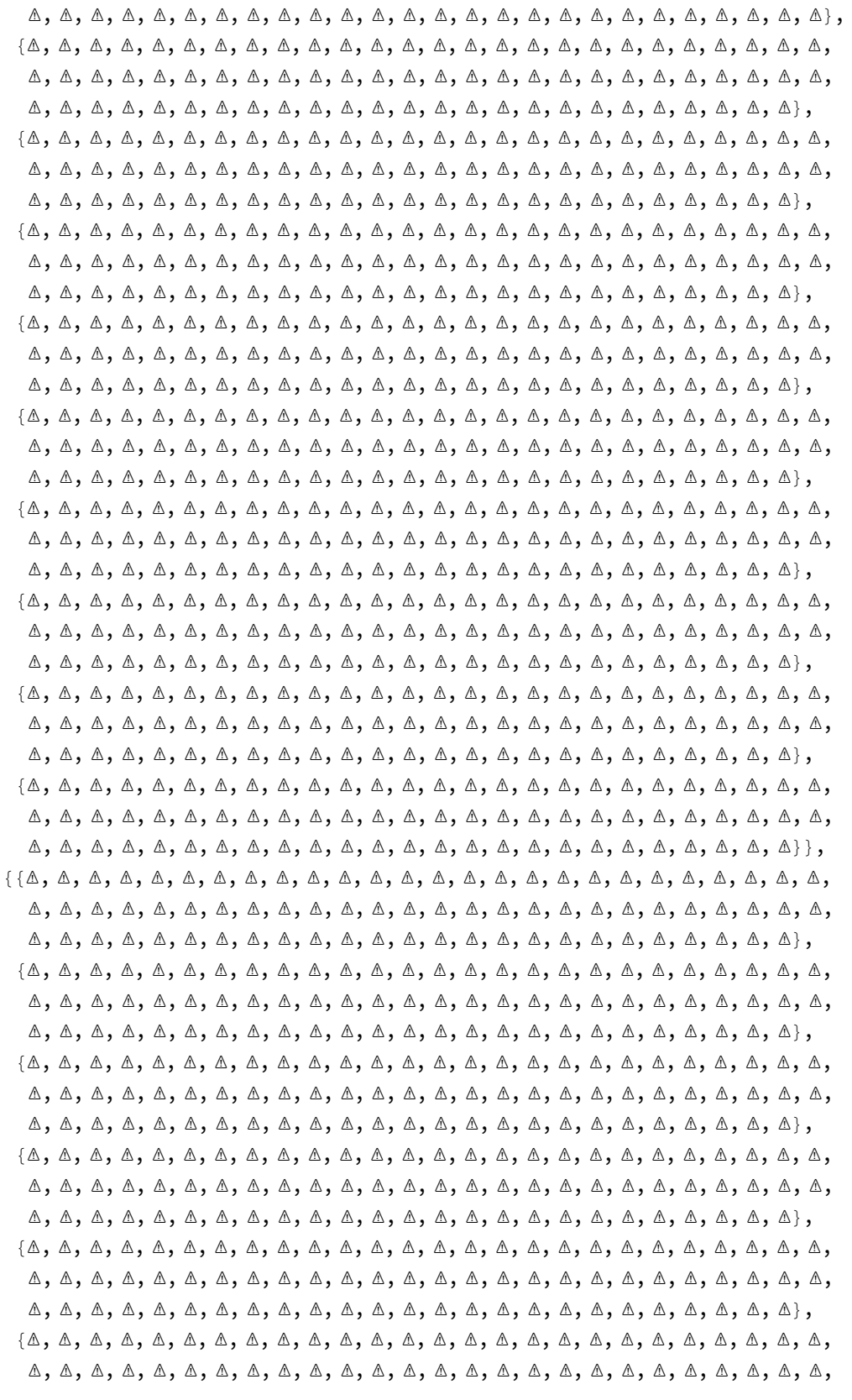
Parse over medium length runs

```
Map[Last[NestWhile[mfxparser @@ # &, {#, {}}, Length[First[#]] > 0 &]] &, mediumruns, {2}]
```

```
{{{SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC}},
 {{SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC}}}
```

```
Map[Last[NestWhile[MMparser @@ # &, {#, {}}, Length[First[#]] > 0 &]] &, mediumruns, {2}]
```

```
{{{⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠,
   ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠,
```



```
 ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠},
{⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠,
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{⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠,
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```

Parse over long runs

```
Map[Last[NestWhile[mfxparser @@ # &, {#, {}}, Length[First[#]] > 0 &]] &, longruns, {2}]
```

```
{{{SYNC, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 0, 0, 1, 1, 1, 0,
    1, 0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 1, SYNC, SYNC, SYNC,
    1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
   {SYNC, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 0, 0, 1, 1, 1, 0, 1,
    0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 1, SYNC, SYNC, SYNC,
    1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
   {SYNC, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 0, 0, 1, 1, 1, 0, 1,
    0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 1, SYNC, SYNC, SYNC,
    1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
   {SYNC, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 0, 0, 1, 1, 1, 0, 1,
    0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 1, SYNC, SYNC, SYNC,
    1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC},
   {SYNC, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 0, 0, 1, 1, 1, 0, 1,
    0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 1, SYNC, SYNC, SYNC,
    1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, SYNC}},
  {{SYNC, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 0, 0, 1, 1, 1, 0, 1,
    0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0,
```

```
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 1, 1, 0, 1, SYNC, SYNC, SYNC,
    1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0,
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Map[Last[NestWhile[MMparser @@ # &, {#, {}}, Length[First[#]] > 0 &]] &, longruns, {2}]
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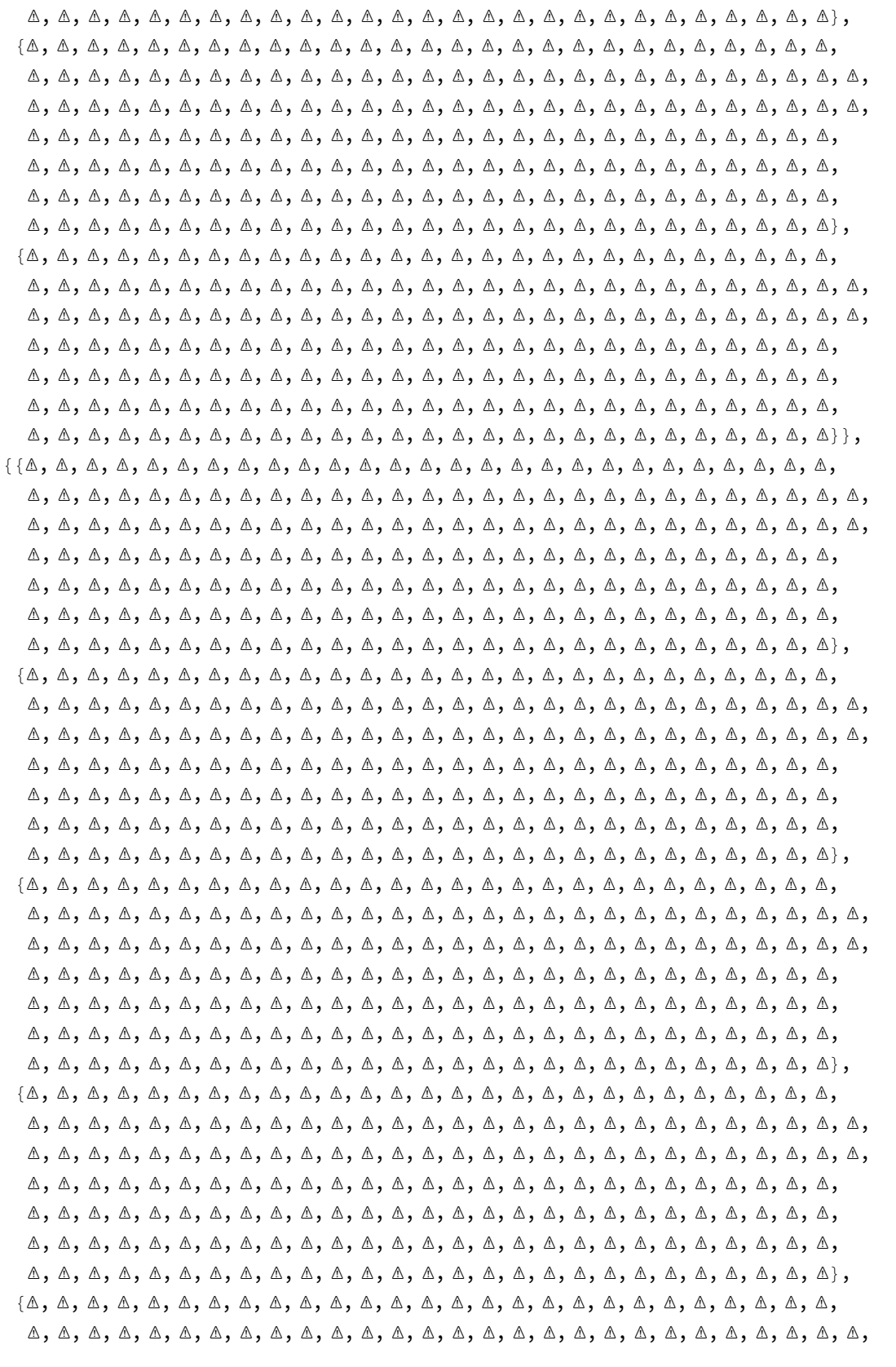

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Parse over MM runs

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Map[Last[NestWhile[mfxparser @@ # &, {#, {}}, Length[First[#]] > 0 &]] &, mmruns, {2}]
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  {{⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠, ⚠,
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Map[Last[NestWhile[MMparser @@ # &, {#, {}}, Length[First[#]] > 0 &]] &, mmruns, {2}]
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Parse over truncated runs

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Map[Last[NestWhile[mfxparser @@ # &, {#, {}}, Length[First[#]] > 0 &]] &, truncruns, {2}]
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  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, 0, ⚠, 0, 0, ⚠}},
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   1, 1, 0, 1, SYNC, SYNC, SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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  {SYNC, 1, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0,
   0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0, 0, SYNC, 0, ⚠, 0, 0, ⚠}}}
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Map[Last[NestWhile[MMparser @@ # &, {#, {}}, Length[First[#]] > 0 &]] &, truncruns, {2}]
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