When saving or printing, disable Automatic Calculation.

WAVEFORMS SPECTRA

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INDEX

INTRODUCTION

The subscript "gd" is the acronym of "Global Data.xmcd"
The subscript "fs" is the acronym of "Fourier series.xmcd"
The subscript "sl" is the acronym of "Signal List.xmcd"
The subscript "dp" is the acronym of "Dirac Pulse - formulas.xmcd"

INDEX

Periodic Waveforms Frequency Spectra

FILES REFERENCES

Reference:E:\Pulses And Waveforms\Pulses and Waveforms formulae.xmcd(R)
Reference:E:\Pulses And Waveforms\Pulse Train Data.xmcd(R)
Reference:E:\Pulses And Waveforms\staircase pulse data.xmcd(R)
Reference:E:\Pulses And Waveforms\staircase 2 pulse data.xmcd(R)
Reference:E:\Pulses And Waveforms\staircase 3 pulse data.xmcd(R)
Reference:E:\Pulses And Waveforms\staircase 4 pulse data.xmcd(R)
Reference:E:\Pulses And Waveforms\sawtooth pulse data.xmcd(R)
Reference:E:\Pulses And Waveforms\FM data.xmcd(R)
Reference:E:\Pulses And Waveforms\PM data.xmcd(R)
Reference:E:\Pulses And Waveforms\Signal's Bandwidth Calculation.xmcd(R)

INTRODUCTION

This worksheet is a collection of some common (and not), signals used in electronics. It deals with the harmonic analysis of periodic signals satisfying the Dirichlet conditions. For each one first, it is plotted a graph, then is calculated its bandwidth in order to do a correct sampling of it. The Fourier harmonics and phase, are plotted in two graphs. Then, the sampled signal is rebuilt with the Shannon interpolation formula. Given the sampled signal, the fft function is applied and plotted to compare the result (first 18 functions only). The previous procedure is repeated for each signal (43). The numerical results are compared with the analytical one only for example 3 and 18. In some cases, calculating the signal bandwidth takes a long time.
To simplify the realization of this file (this worksheet) and to make more agile and immediate viewing of signal's graphics, the data, for some signal, are defined in other worksheets as listed in the references just above this introduction.
Hence, to change the data, one must open the relative file and modify them. Then one should save and close both files (relative file data and this one) to store the data variations done, then one can reopen "Waveforms & Spectra".

Units: Mrads and Grads stand for $10^6 \cdot rad$ and $10^9 \cdot rad$

PERIODIC WAVEFORMS' FREQUENCY SPECTRA

TEST Waveforms

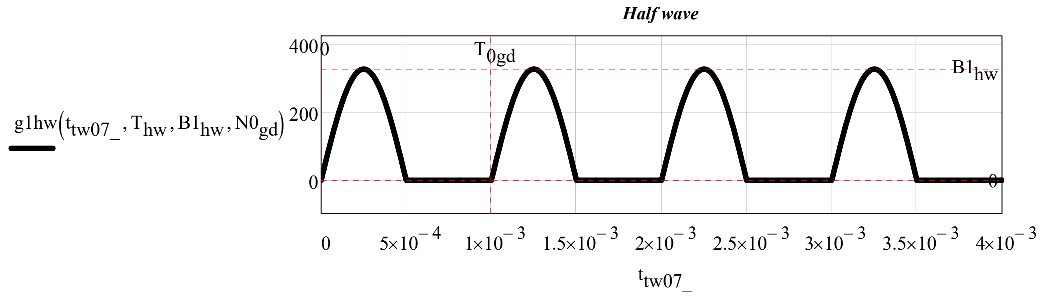
Periodic Waveforms ***Periodic Waveforms*** ***Periodic Waveforms***

1) Half wave

Data file " general data.xmcd"

Amplitude: $B1_{hw} := 230 \cdot \sqrt{2} \cdot V$

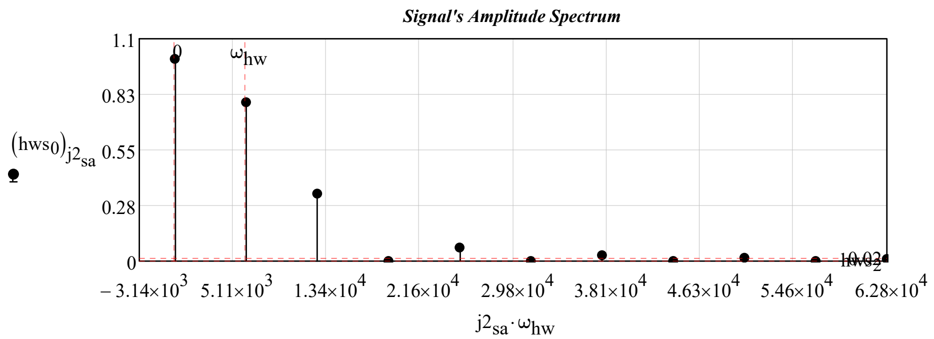
$f_{hw} := \frac{1}{T_{0gd}}$ $T_{hw} := T_{0gd}$ Angular frequency: $\omega_{hw} := \frac{2 \cdot \pi}{T_{0gd}}$ $T_{hw} = 1 \cdot ms$

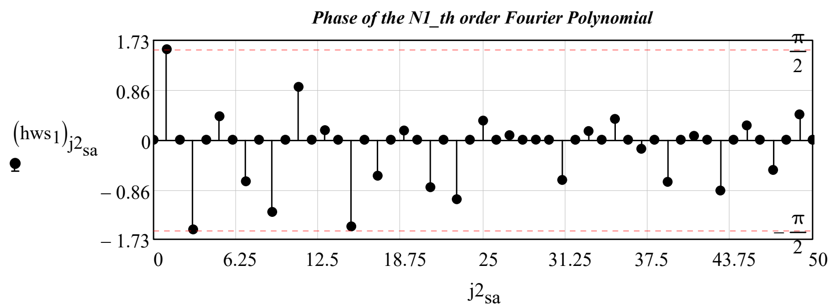


$V_{hw}(t) := g1hw(t, T_{hw}, B1_{hw}, N0_{gd})$ $B1_{hw} = 325.269\,V$

$hws := SPCT(V_{hw}, rt_{gd}, N1\_, 0 \cdot sec, T_{hw})$ $N1\_ = 50$

$j2_{sa} := 0 .. rows(hws_0) - 1$





$Bw_{sa} := hws_3 \cdot Hz$ $Bw_{sa} = 0.019 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $fpt_{so} = 0.038 \cdot MHz$

$relerr := hws_7$ $relerr = 10 \cdot \%$

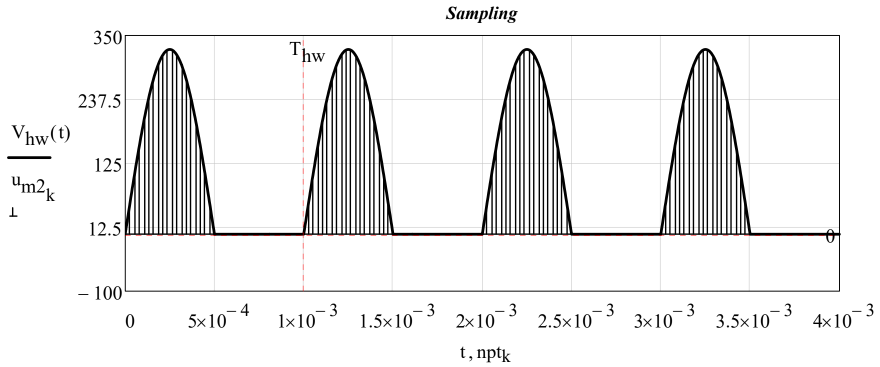
$k := 0 .. 2^8 - 1$ $npt_k := \frac{k}{fpt_{so}}$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{hw}} = 6.737$

Signal sampling: $u_{m2_k} := V_{hw}(npt_k)$

$u_{m2}^T =$

	0	1	2	3	4
0	0	53.538	105.615	154.811	...



$relerr = 10 \cdot \%$ $\omega_{bw} := 2 \cdot \pi \cdot Bw_{sa}$ $\omega_{bw} = 0.119 \cdot \frac{Mrads}{sec}$ $n \cdot \frac{\pi}{\omega_{bw}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

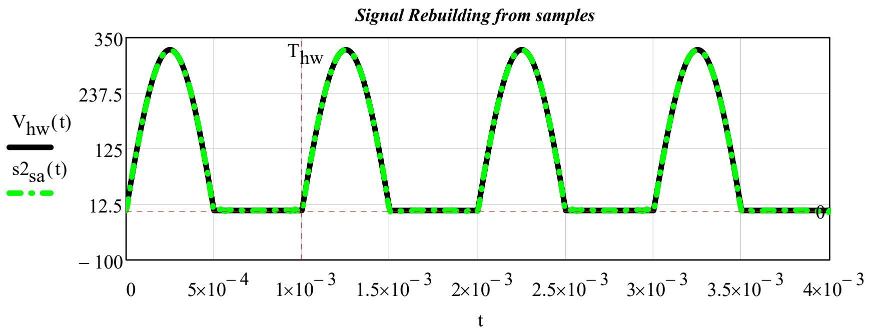
Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s2_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m2_n} \cdot \text{sinc}(\omega_{bw} \cdot t - n \cdot \pi) \right) \right]$

$N0_{gd} - 1 = 255$ $u_{m2_{12}} = 297.873$

$\text{rows}(u_{m2}) = 256$

$relerr = 10 \cdot \%$

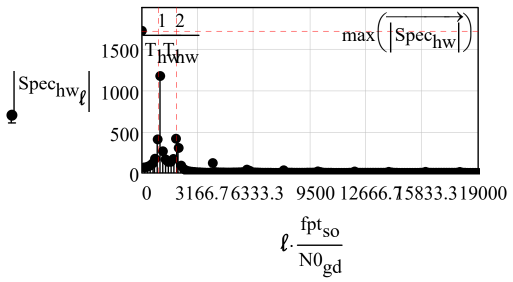


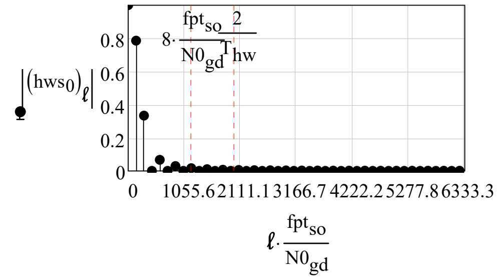
$\text{length}(u_{m2}) = 256$

$fpt_{so} = 38 \cdot kHz$

$Spec_{hw} := \text{fft}(u_{m2})$ $\text{length}(Spec_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

2 Half wave filtered (Capacitive)

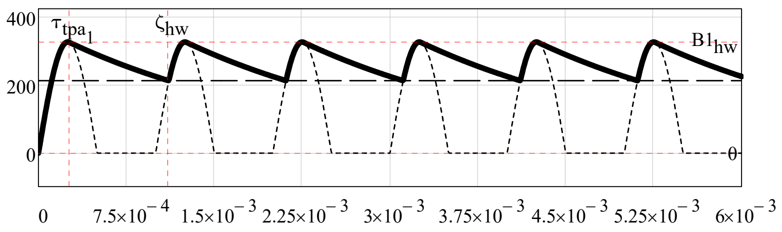
Max half wave amplitude: $B1_{hw} = 325.269 \cdot V$,
Amplitude of the decreasing exponential for t=0: V_{pp},
Exponential Time constant: $\tau_{hw1} := 2 \cdot T_{0gd}$
Period: , $T_{hw} = 1 \times 10^{3} \cdot \mu s$,
Pulsation: $\omega_{hw} := \frac{2 \cdot \pi}{T_{hw}} = 6.283 \cdot \frac{krads}{sec}$,
Intersection abscissa between half wave and exponential: ζ (scalar),
Tangent points abscissas between half wave and exponential: τ_{tpa} (vector)

$$\tau_{tpa_{k_{sl}}} := \frac{atan(-\omega_{hw} \cdot \tau_{hw1}) + k_{sl} \cdot \pi}{\omega_{hw}}$$

$$V_{tpv} := B1_{hw} \cdot \sin(\omega_{hw} \cdot \tau_{tpa_1}) \cdot e^{\frac{\tau_{tpa_1}}{\tau_{hw1}}} \qquad V_{tpv} = 369.746\,V$$

$$\zeta_{hw} := Z01(\tau_{hw1}, \omega_{hw}, B1_{hw}, V_{tpv})$$

Ripple

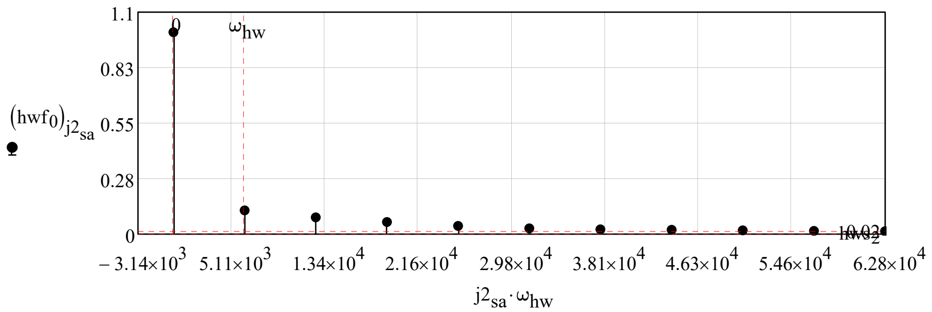


$B1_{hw} = 325.269\,V \qquad V_{hwf}(t) := g2hw(t, \tau_{hw1}, \tau_{tpa}, \zeta_{hw}, \omega_{hw}, B1_{hw}, V_{tpv}, N0_{gd})$

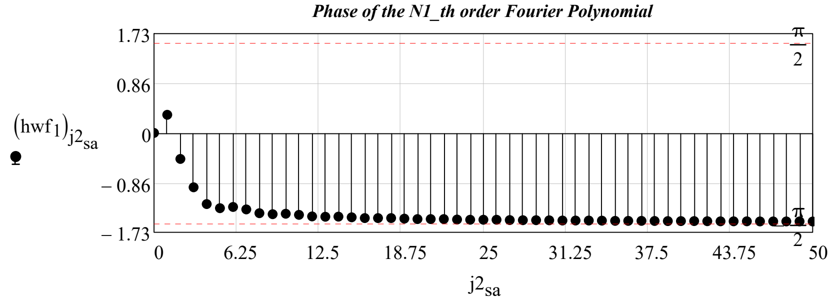
$hwf := SPCT(V_{hwf}, rt_{gd}, N1\_, 0 \cdot sec, T_{0gd}) \qquad N1\_ = 50$

$j2_{sa} := 0 .. rows(hws_0) - 1$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := hwf_3 \cdot Hz$

$Bw_{sa} = 0.048 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa} \qquad fpt_{so} = 0.096 \cdot MHz$

$$npt_k := \frac{k}{fpt_{so}}$$

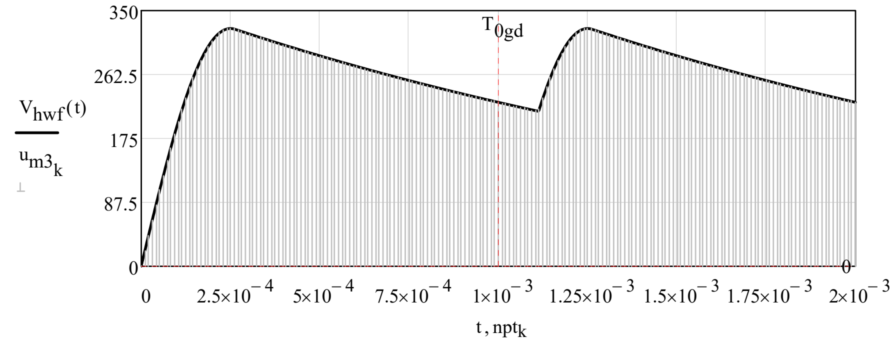
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{0gd}} = 2.667$

$$u_{m3_k} := V_{hwf}(npt_k)$$

$u_{m3}^{T} =$

	0	1	2	3	4	5	6	7	8	9
0	0	21.274	42.456	63.457	84.186	104.554	124.475	143.863	162.635	...

Sampling

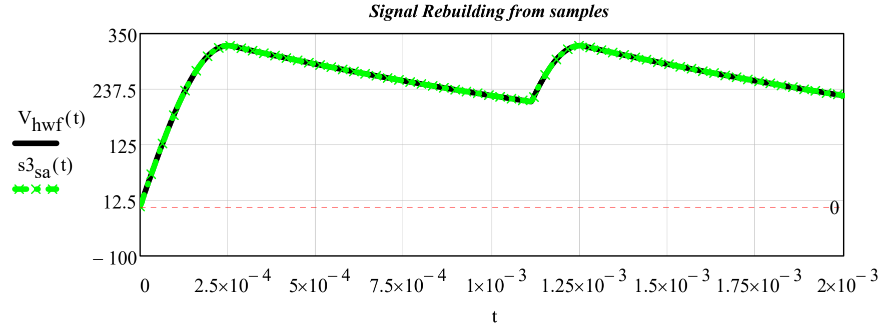


relerr = 10·% $\qquad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa} \qquad \omega_{bwr} = 0.302 \cdot \frac{Mrads}{sec} \qquad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s3_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m3_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi)\right)\right] \qquad N0_{gd} - 1 = 255 \qquad$ relerr = 10·%

Signal Rebuilding from samples



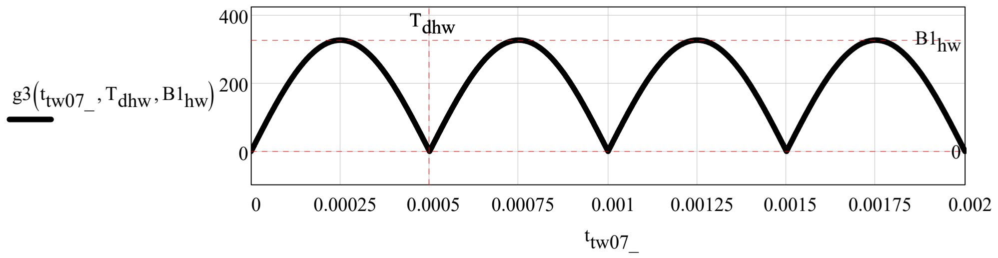
Symbol frequency:

Periodic Waveforms

3 Double Half wave

$T_{dhw} := \frac{T_{hw}}{2}$ $\quad \omega_{dhw} := \frac{\pi}{T_{dhw}}$ $\quad g3(t_{sl}, T_{dhw}, B1_{hw}) := \frac{B1_{hw}}{V} \cdot \left| \sin\left(\frac{2\cdot\pi}{T_{hw}} \cdot t_{sl}\right) \right|$

Double Half wave



Dirichlet conditions

A periodic function s(t)=s(t+T), can be expressed by the Fourier series provided that (Dirichlet conditions):
(1) it is discontinuous and presents a finite number of discontinuities in the period T;
(2) has a limited average value in the period T;
(3) it has a finite number of maximum positive or negative.
If these conditions are met, the considered function can be developed in Fourier series in trigonometric form.

The Dirichlet conditions apply to:

1) signals of energy for which holds: $\int_{-\infty}^{\infty} \left(\left|s_{fs}(t)\right|\right)^2 dt < \infty$,

2) power signals for which holds: $\lim_{T \to \infty} \left[\frac{1}{T} \cdot \int_{-T}^{T} \left(\left|s_{fs}(t)\right|\right)^2 dt\right] < \infty$

Fourier series definition $\quad s_{fs}(t) = \frac{a_0}{2} + \sum_{k=1}^{\infty} \left(a_k \cos(\omega \cdot k \cdot t) + b_k \cdot \sin(\omega \cdot k \cdot t)\right)$

The coefficients are defined as follows:

$$\frac{a_0}{2} = A_{fs} = \frac{1}{T} \cdot \int_{t_0}^{t_0+T} s_{fs}(t)\, dt$$

$$a_k = \frac{2}{T} \cdot \int_{t_0}^{t_0+T} s_{fs}(t) \cdot \cos(\omega \cdot k \cdot t)\, dt$$

$$b_k = \frac{2}{T} \cdot \int_{t_0}^{t_0+T} s_{fs}(t) \cdot \sin(\omega \cdot k \cdot t)\, dt$$

$B1_{hw} = 325.269\,V$ $\qquad s_{fs}(t) := \frac{B1_{hw}}{V} \cdot \left| \sin\left(\frac{2\cdot\pi}{T_{hw}} \cdot t\right) \right|$

$T_{dhw} := T_{dhw}$ $\quad t := t$ $\quad T_{hw} := T_{hw}$

$$\frac{a_0}{2} = A_{fs} = \frac{2}{T_{hw}} \cdot \frac{B1_{hw}}{V} \cdot \int_{0}^{\frac{T_{hw}}{2}} \sin\left(\frac{2\cdot\pi}{T_{hw}} \cdot t\right) dt = \frac{2 \cdot B1_{hw}}{\pi \cdot V}$$

$$a_k = \frac{4}{T_{hw}} \cdot \frac{B1_{hw}}{V} \cdot \int_0^{\frac{T_{hw}}{2}} \sin\left(\frac{2\cdot\pi}{T_{hw}}\cdot t\right)\cdot\cos\left(\frac{2\cdot\pi}{T_{hw}}\cdot k\cdot t\right) dt = \frac{2\cdot B1_{hw}\cdot(\cos(\pi\cdot k)+1)}{-\pi\cdot V\cdot(k^2-1)}$$

$$b_k = \frac{4}{T_{hw}} \cdot \frac{B1_{hw}}{V} \cdot \int_0^{\frac{T_{hw}}{2}} \sin\left(\frac{2\cdot\pi}{T_{hw}}\cdot t\right)\cdot\sin\left(\frac{2\cdot\pi}{T_{hw}}\cdot k\cdot t\right) dt = -\frac{2\cdot B1_{hw}\cdot\sin(\pi\cdot k)}{\pi\cdot V\cdot(k^2-1)}$$

$$s_{fs}(t) = \frac{2\cdot B1_{hw}}{\pi\cdot V}\cdot\left[1+\sum_{k=1}^{\infty}\left[\frac{(\cos(\pi\cdot k)+1)}{-(k^2-1)}\cdot\cos(\omega\cdot k\cdot t)+\frac{\sin(\pi\cdot k)}{(k^2-1)}\cdot\sin(\omega\cdot k\cdot t)\right]\right] \qquad \cos[k\cdot(\pi+\omega\cdot t)] = (-1)^k\cdot\cos(k\cdot\omega\cdot t)$$

$$\frac{2\cdot B1_{hw}}{\pi\cdot V}\cdot\left[1+\sum_{k=1}^{\infty}\frac{\cos(\omega\cdot k\cdot t)+\cos[k\cdot(\pi+\omega\cdot t)]}{1-k^2}\right] = \frac{2\cdot B1_{hw}}{\pi\cdot V}\cdot\left[1+\sum_{k=1}^{\infty}\frac{\cos(\omega\cdot k\cdot t)+(-1)^k\cdot\cos(k\cdot\omega\cdot t)}{1-k^2}\right]$$

$$\frac{2\cdot B1_{hw}}{\pi\cdot V}\cdot\left[1+\sum_{k=1}^{\infty}\frac{\cos(\omega\cdot k\cdot t)+(-1)^k\cdot\cos(k\cdot\omega\cdot t)}{1-k^2}\right] = \frac{2\cdot B1_{hw}}{\pi\cdot V}\cdot\left[1+\frac{\pi\cdot\cos(\omega\cdot t)\cdot i}{2}+\sum_{k=2}^{\infty}\frac{\left[1+(-1)^k\right]\cdot\cos(k\cdot\omega\cdot t)}{1-k^2}\right]$$

$$\lim_{k\to 1^+}\frac{\left[1+(-1)^k\right]\cdot\cos(k\cdot\omega\cdot t)}{1-k^2} \to \frac{\pi\cdot\cos(\omega\cdot t)\cdot i}{2} \qquad \lim_{k\to 1^-}\frac{\left[1+(-1)^k\right]\cdot\cos(k\cdot\omega\cdot t)}{1-k^2} \to \frac{\pi\cdot\cos(\omega\cdot t)\cdot i}{2}$$

$$s_{dhw}(t) = \frac{2\cdot B1_{hw}}{\pi\cdot V}\cdot\left[1+\frac{\pi\cdot\cos\left(\frac{2\cdot\pi}{T_{hw}}\cdot t\right)\cdot i}{2}+\sum_{k=2}^{\infty}\frac{\left[1+(-1)^k\right]\cdot\cos\left(k\cdot\frac{2\cdot\pi}{T_{hw}}\cdot t\right)}{1-k^2}\right]$$

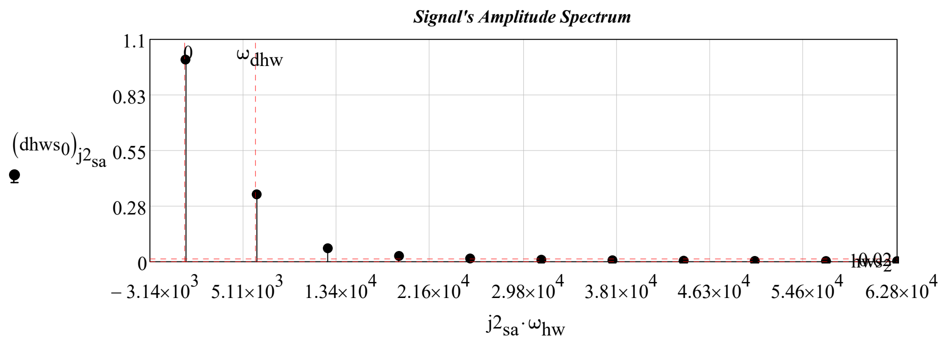
$$s_{dhw}(t) := \frac{2\cdot B1_{hw}}{\pi\cdot V}\cdot\left[1+\frac{\pi\cdot\cos\left(\frac{2\cdot\pi}{T_{hw}}\cdot t\right)\cdot i}{2}+\sum_{k=2}^{100}\frac{\left[1+(-1)^k\right]\cdot\cos\left(k\cdot\frac{2\cdot\pi}{T_{hw}}\cdot t\right)}{1-k^2}\right]$$

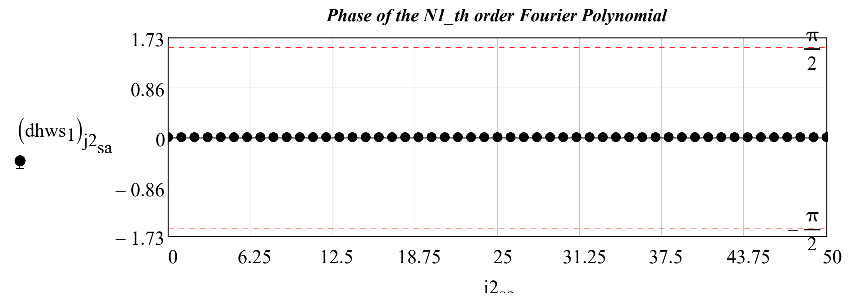
$s_{dhw}(0) = 2.05 + 325.269i$ $\quad \left|s_{dhw}(0)\right| = 325.276$ $\quad s_{dhw}\left(\frac{T_{dhw}}{2}\right) = 325.249$

$B1_{hw} = 325.269\,V$ $\quad V_{dhw}(t) := g3(t, T_{hw}, B1_{hw})$ $\quad \omega_{sa} := \omega_{dhw}$ $\quad 2\cdot\frac{B1_{hw}}{\pi\cdot V} = 207.073$

$dhws := SPCT(V_{dhw}, rt_{gd}, N1\_, 0\cdot sec, T_{dhw})$ $\quad N1\_ = 50$

$j2_{sa} := 0 .. rows(hws_0) - 1$





$Bw_{sa} := dhws_3\cdot Hz$

$Bw_{sa} = 0.03\cdot MHz$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa}$ $\quad fpt_{so} = 0.06\cdot MHz$

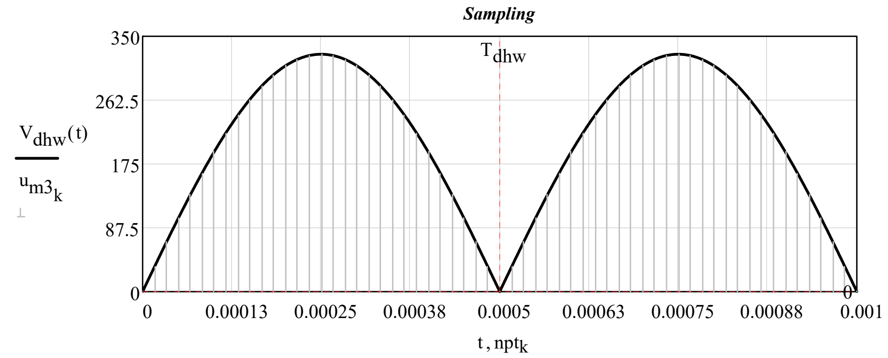
$k := 0 .. 2^8 - 1$ $\quad npt_k := \frac{k}{fpt_{so}}$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}}\cdot\frac{1}{T_{dhw}} = 8.533$

$u_{m3_k} := V_{dhw}(npt_k)$

$u_{m3}^T =$

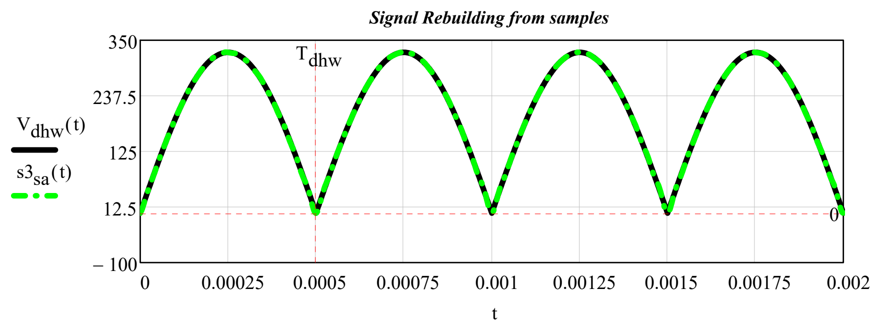
	0	1	2	3	4
0	0	34	67.627	100.514	...

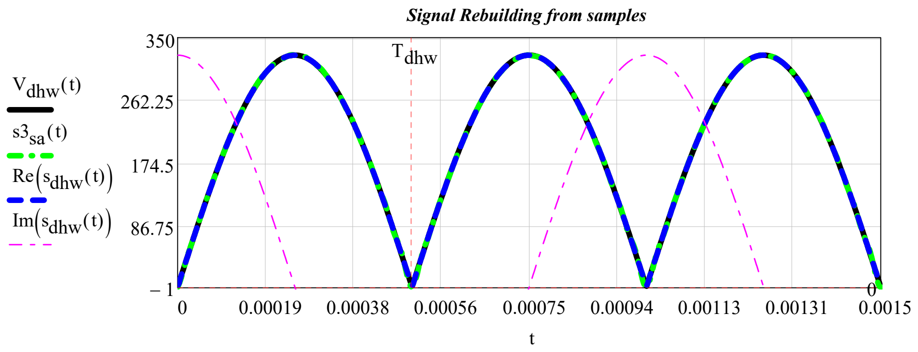


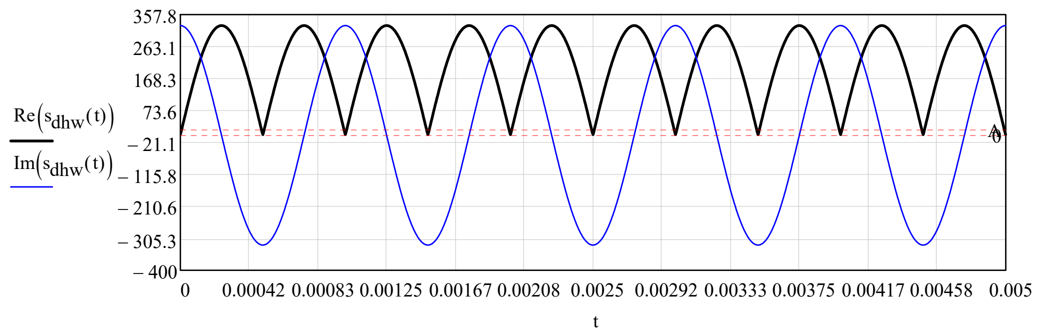
relerr = 10·% $\quad \omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\quad \omega_{bwr} = 0.188\cdot\frac{Mrads}{sec}$ $\quad n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula: $s3_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m3_n}\cdot sinc(\omega_{bwr}\cdot t - n\cdot\pi)\right)\right]$ $\quad N0_{gd} - 1 = 255$ $\quad$ relerr = 10·%





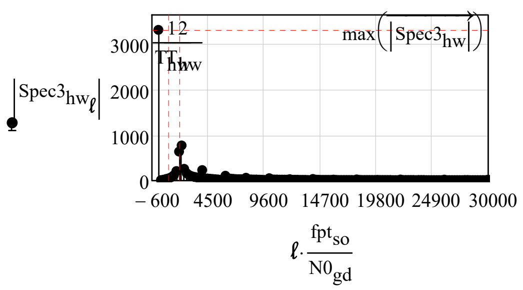


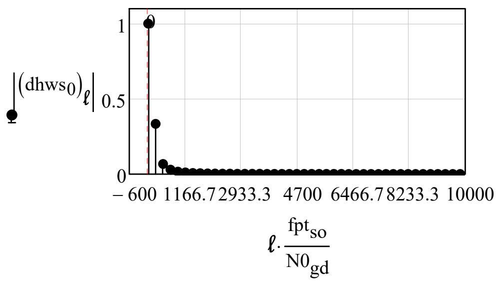
$length(u_{m2}) = 256$

$fpt_{so} = 60\cdot kHz$

$Spec3_{hw} := fft(u_{m3})$ $\quad length(Spec3_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\quad \frac{N0_{gd}}{2} = 128$





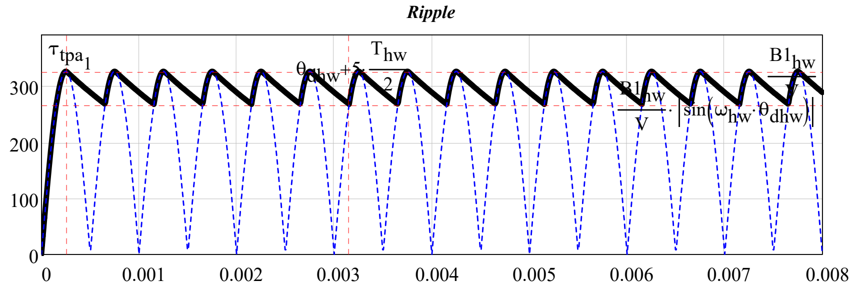
TEST Waveforms

Periodic Waveforms

4 Double Half wave filtered

$V_{ppt} := B1_{hw}\cdot\sin(\omega_{hw}\cdot\tau_{tpa_1})\cdot e^{\frac{\tau_{tpa_1}}{\tau_{hw1}}}$ $\quad \theta_{dhw} := Z1(\tau_{hw1}, \omega_{hw}, B1_{hw}, V_{ppt})$ $\quad rip1 := \frac{\frac{B1_{hw}}{V} - \frac{B1_{hw}}{V}\cdot|\sin(\omega_{hw}\cdot\theta_{dhw})|}{\frac{B1_{hw}}{V}}$

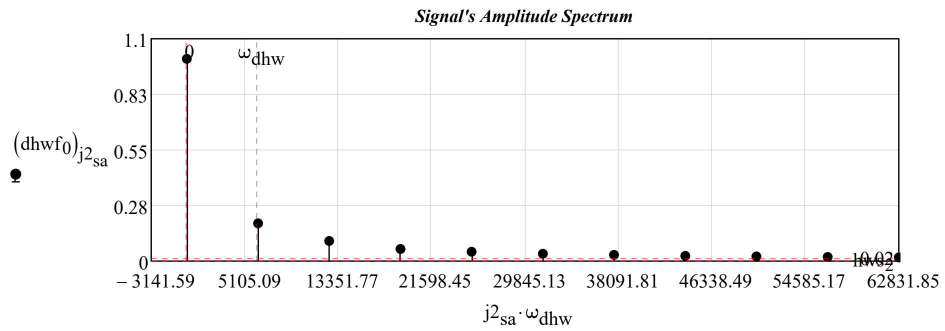
$V_{ppt} = 369.746\,V$

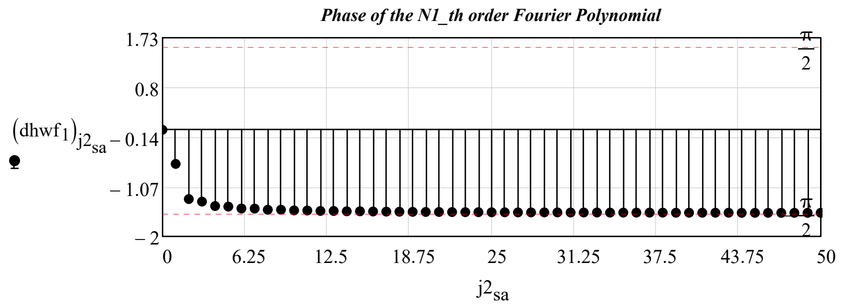


$B1_{hw} = 325.269\,V$ $\quad V_{dhwf}(t) := g4(t, \tau_{hw1}, \tau_{tpa}, \theta_{dhw}, \omega_{hw}, B1_{hw}, V_{ppt}, N0_{gd})$

$dhwf := SPCT(V_{dhwf}, rt_{gd}, N1\_, 0\cdot sec, T_{dhw})$ $\quad N1\_ = 50$

$j2_{sa} := 0 .. rows(dhws_0) - 1$





$Bw_{sa} := dhwf_3\cdot Hz$

$Bw_{sa} = 0.096\cdot MHz$

sampling frequency: $\quad fpt_{so} := 2\cdot Bw_{sa}$ $\quad fpt_{so} = 0.192\cdot MHz$

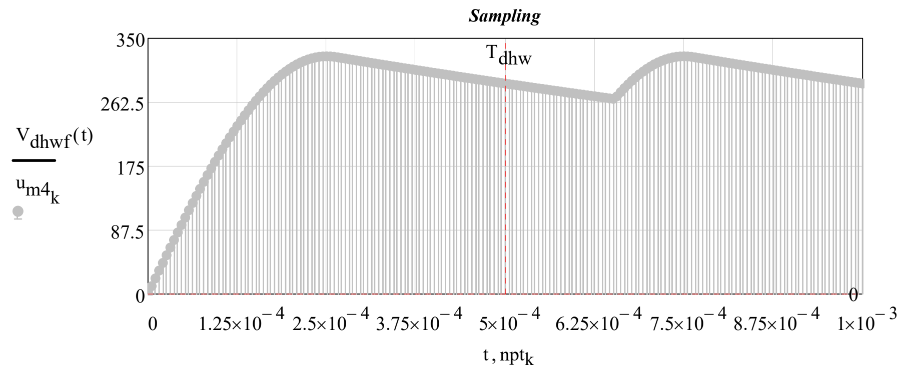
$npt_k := \frac{k}{fpt_{so}}$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{dhw}} = 2.667$

$u_{m4_k} := V_{dhwf}(npt_k)$

$u_{m4}^T =$

	0	1	2	3	4	5	6
0	0	10.643	21.274	31.882	42.456	52.985	...

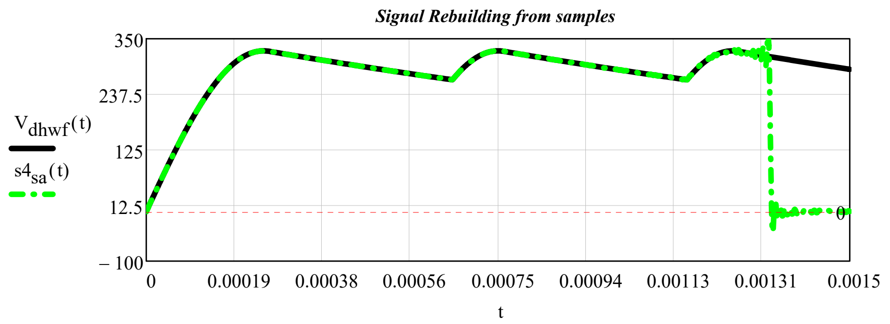


relerr = 10·%

$\omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\omega_{bwr} = 0.603\cdot\frac{Mrads}{sec}$ $n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s4_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m4_n}\cdot \mathrm{sinc}(\omega_{bwr}\cdot t - n\cdot\pi)\right)\right]$ $N0_{gd} - 1 = 255$ relerr = 10·%

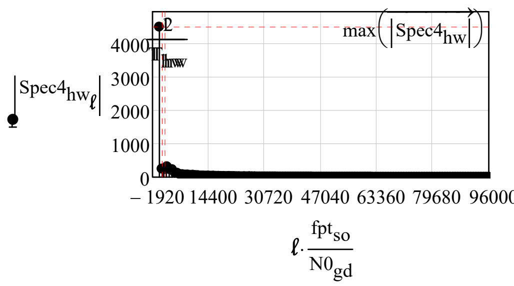


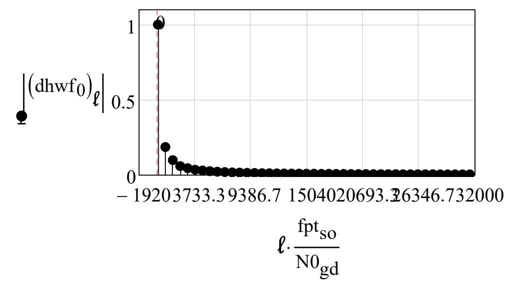
$\mathrm{length}(u_{m4}) = 256$

$fpt_{so} = 192\cdot kHz$

$Spec4_{hw} := \mathrm{fft}(u_{m4})$ $\mathrm{length}(Spec4_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\frac{N0_{gd}}{2} = 128$





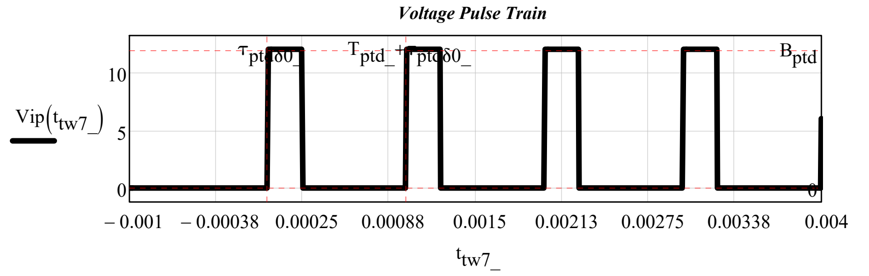
TEST Waveforms

Periodic Waveforms

5 Voltage Pulse Train

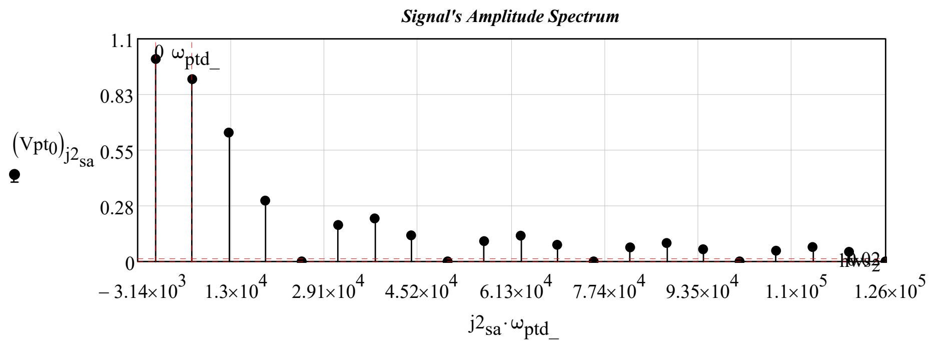
Data file " pulse train data.xmcd"

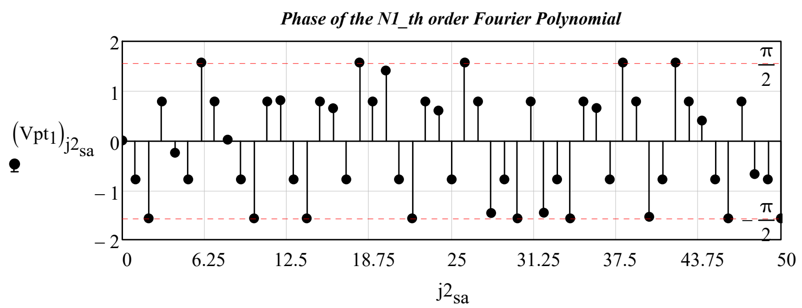
$Vip(t) := Vip1(t, T_{ptd\_}, \tau_{ptd\delta0\_}, \delta_{ptd\_}, B_{ptd}, N0_{gd})$



$Vpt := SPCT(Vip, rt_{gd}, N1\_, 0\cdot sec, T_{ptd\_})$ $N1\_ = 50$

$j2_{sa} := 0 .. \mathrm{rows}(dhws_0) - 1$ $\omega_{ptd\_} = 6.283\times10^{-3}\cdot\frac{Mrads}{s}$





$Bw_{sa} := Vpt_3\cdot Hz$

$Bw_{sa} = 0.048\cdot MHz$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa}$ $fpt_{so} = 0.096\cdot MHz$

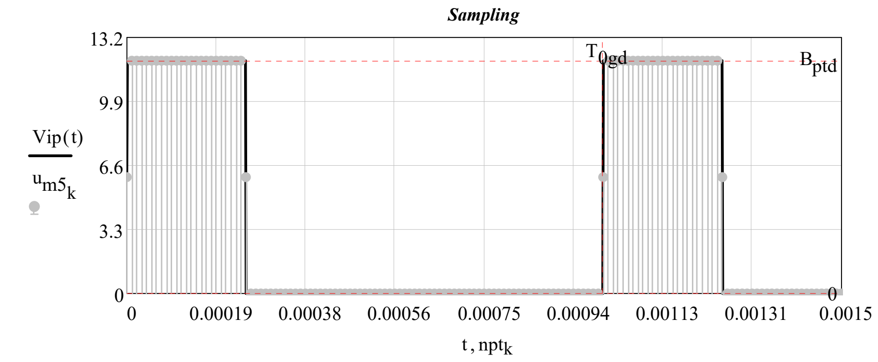
$$npt_k := \frac{k}{fpt_{so}}$$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{0gd}} = 2.667$

$$u_{m5_k} := Vip(npt_k)$$

$u_{m5}^T =$

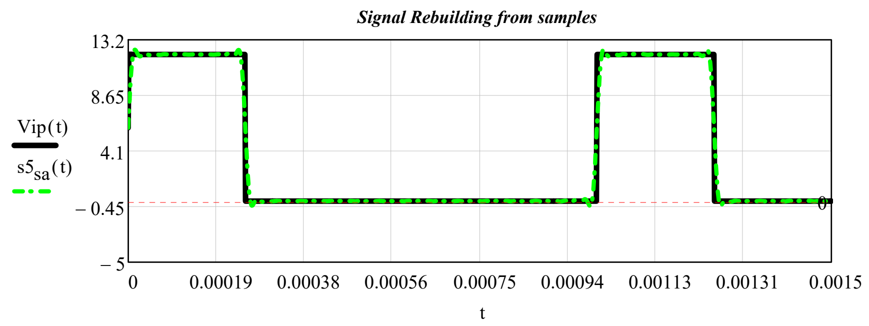
	0	1	2	3	4	5	6	7	8	9
0	6	12	12	12	12	12	12	12	12	...



relerr = 10·% $\omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\omega_{bwr} = 0.302 \cdot \frac{Mrads}{sec}$ $n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s5_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m5_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi)\right)\right]$ $N0_{gd} - 1 = 255$ relerr = 10·%

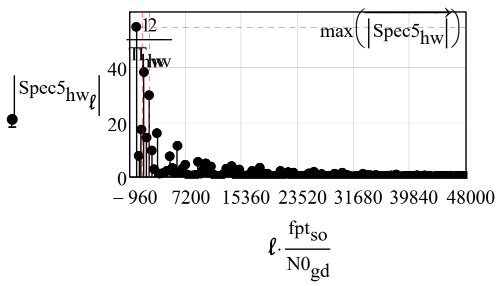


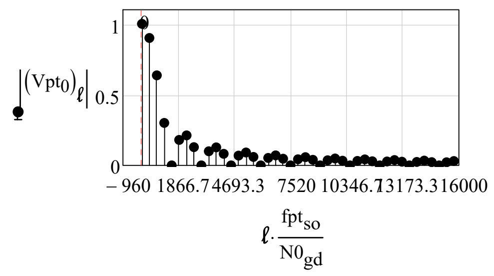
$length(u_{m5}) = 256$

$fpt_{so} = 96 \cdot kHz$

$Spec5_{hw} := fft(u_{m5})$ $length(Spec5_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

6 RF Pulse Train

Data file " rf pulse data.xmcd"

Step amplitude..............................: $V_{rfpd} := B_{ptd}$, $V_{rfpd} = 12 \cdot V$

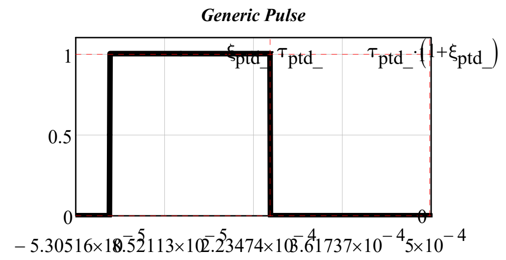
Signal frequency..........................: $f_{rfpd} := 30 \cdot f_{ptd\_}$,

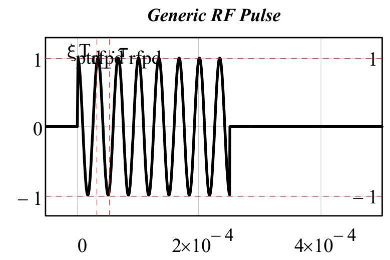
Signal period...............................: $T_{rfpd} := \frac{1}{f_{rfpd}}$

Signal angular frequency...............: $\omega_{rfpd} := 2 \cdot \pi \cdot f_{rfpd}$ $\omega_{rfpd} = 0.188 \cdot \frac{Mrads}{sec}$,

time constant..............................: $\tau_{rfpd} := \frac{10}{\omega_{rfpd}}$, $\tau_{rfpd} = 53.052 \cdot \mu s$

Rising edge delay ....: $\tau_{\delta rfpd} := 0 \cdot ns$

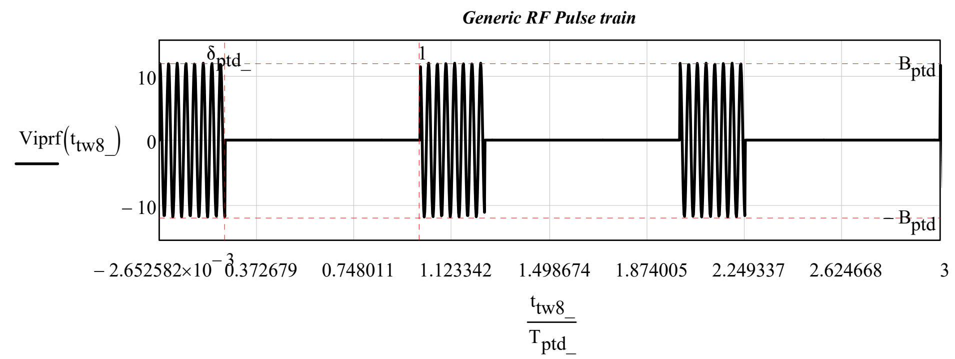




Average value: $v_{ptmrfsl} := B_{ptd} \cdot \delta_{ptd\_}$

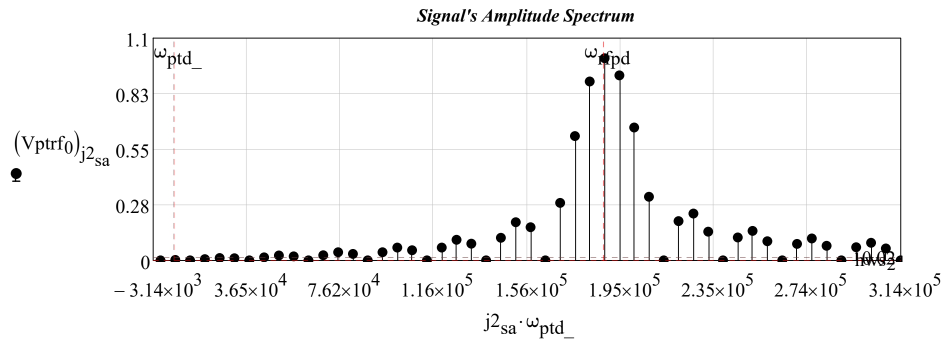
$$t_{tw8\_} := -1 \cdot \tau_{ptd\_}, -1 \cdot \tau_{ptd\_} + \frac{4 \cdot T_{ptd\_} + \tau_{ptd\_}}{2000} .. 4 \cdot T_{ptd\_}$$

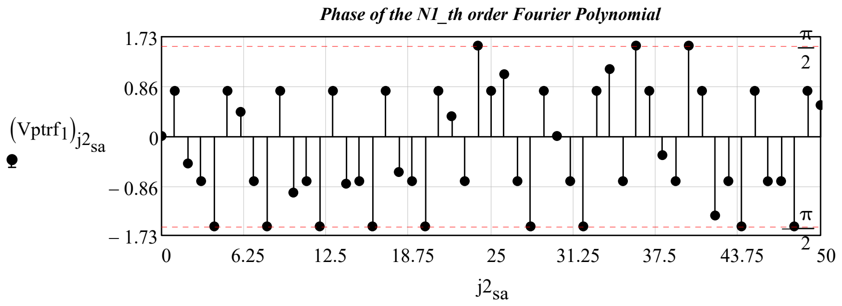
$$Viprf(t) := v_{ptrf}\left(t, T_{ptd\_}, \tau_{\delta rfpd}, \delta_{ptd\_}, \omega_{rfpd}, \frac{V_{rfpd}}{V}, N0_{gd}\right)$$



$Vptrf := SPCT(Viprf, rt_{gd}, N1\_, 0 \cdot sec, T_{ptd\_})$ $N1\_ = 50$

$\omega_{ptd\_} = 6.283 \cdot \frac{krads}{s}$ $j2_{sa} := 0 .. rows(dhws_0) - 1$ $\omega_{rfpd} = 188.496 \cdot \frac{krads}{s}$





$Bw_{sa} := Vptrf_3 \cdot Hz$

$Bw_{sa} = 0.048 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $fpt_{so} = 0.096 \cdot MHz$

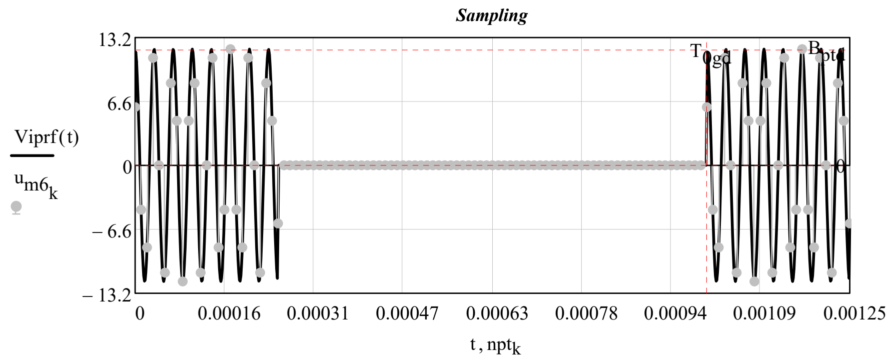
$npt_k := \frac{k}{fpt_{so}}$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{0gd}} = 2.667$

$u_{m6_k} := Vipr f(npt_k)$

$u_{m6}^T =$

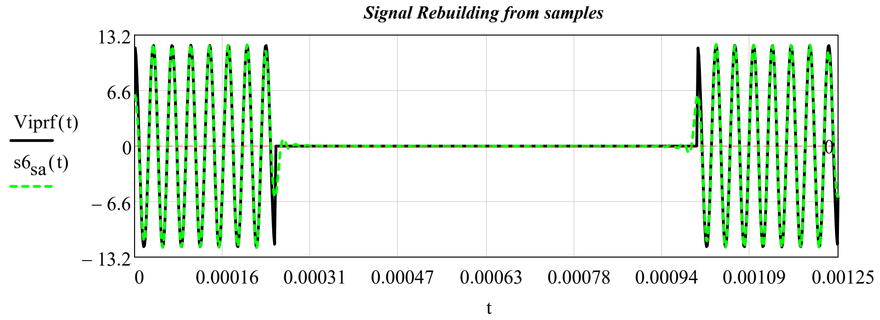
	0	1	2	3	4
0	6	-4.592	-8.485	11.087	...



relerr = 10·% $\omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\omega_{bwr} = 0.302 \cdot \frac{Mrads}{sec}$ $n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s6_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m6_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi) \right) \right]$ $N0_{gd} - 1 = 255$ relerr = 10·%

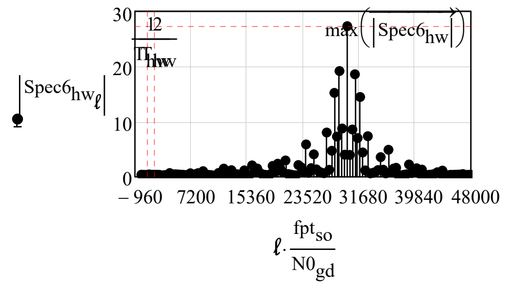


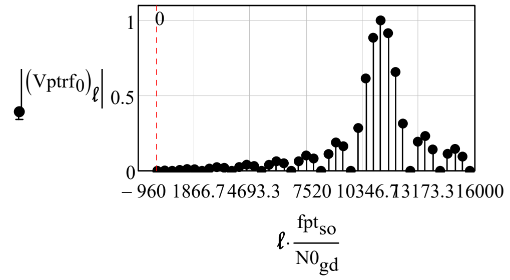
$length(u_{m6}) = 256$

$fpt_{so} = 96 \cdot kHz$

$Spec6_{hw} := fft(u_{m6})$ $length(Spec6_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\frac{N0_{gd}}{2} = 128$





Periodic Waveforms

7 Bipolar Square Wave

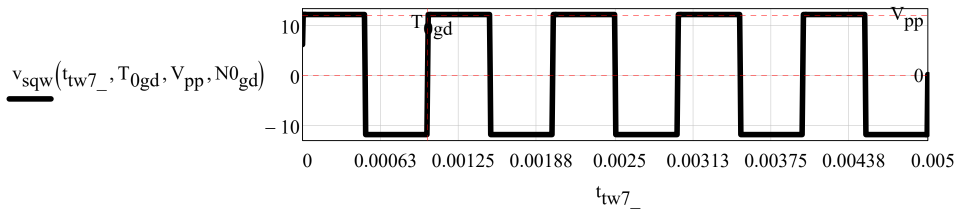
Data file " pulse train data.xmcd"

Signal amplitude: $V_{pp} = 12 \cdot V$

Square wave period: $T_{0gd} = 1 \times 10^{6} \cdot ns$

$\omega_{ptd\_} = 6.283 \times 10^{-6} \cdot \frac{Grads}{sec}$

Bipolar Square Wave

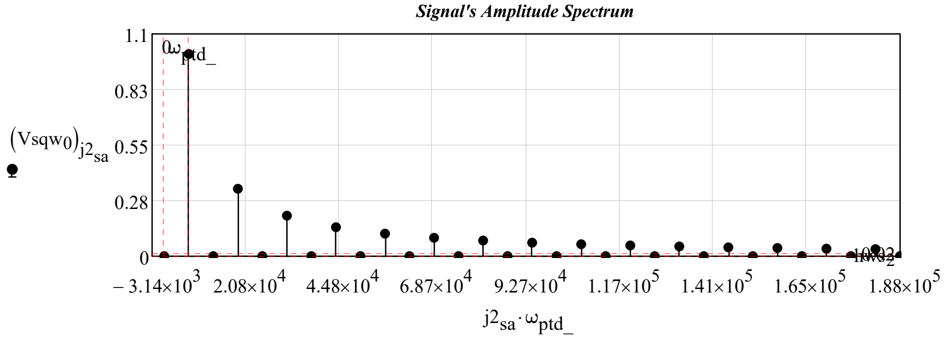


$V_{sqw}(t) := V^{-1} \cdot v_{sqw}(t, T_{0gd}, V_{pp}, N0_{gd})$

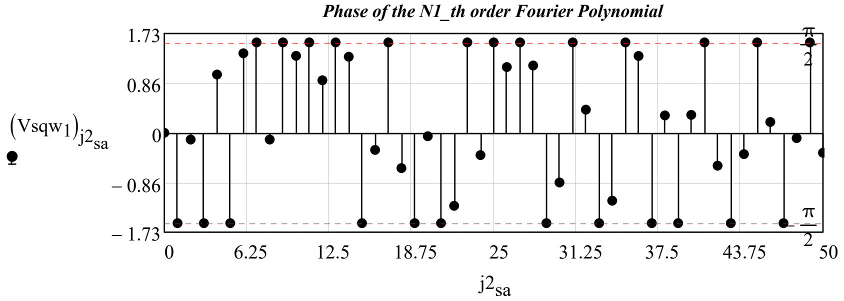
$Vsqw := SPCT(V_{sqw}, rt_{gd}, N1\_, 0 \cdot sec, T_{0gd})$ $\quad N1\_ = 50$

$j2_{sa} := 0 .. rows(dhws_0) - 1$ $\quad \omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := Vsqw_3 \cdot Hz$

$Bw_{sa} = 0.048 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 0.096 \cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

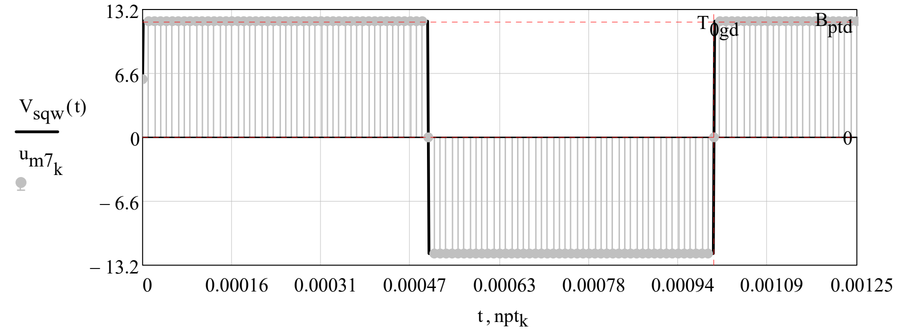
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{0gd}} = 2.667$

$u_{m7_k} := V_{sqw}(npt_k)$

$u_{m6}^{T} =$

	0	1	2	3	4
0	6	-4.592	-8.485	11.087	...

Sampling

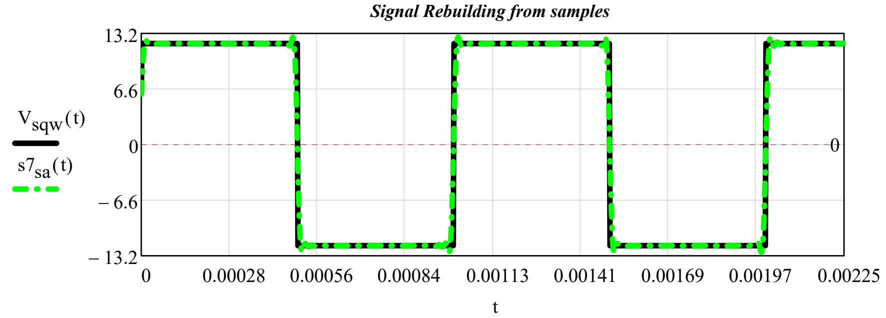


$relerr = 10 \cdot \%$ $\quad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\quad \omega_{bwr} = 0.302 \cdot \frac{Mrads}{sec}$ $\quad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s7_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m7_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi) \right) \right]$ $\quad N0_{gd} - 1 = 255$ $\quad relerr = 10 \cdot \%$

Signal Rebuilding from samples

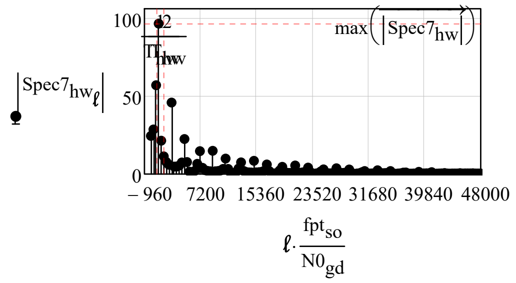


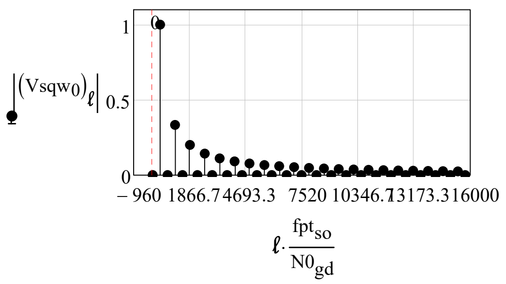
$length(u_{m7}) = 256$

$fpt_{so} = 96 \cdot kHz$

$Spec7_{hw} := fft(u_{m7})$ $\quad length(Spec7_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\quad \frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

8 Bipolar Square Wave 1

Data file " pulse train data.xmcd"

Signal amplitude: $V_{pp} = 12 \cdot V$

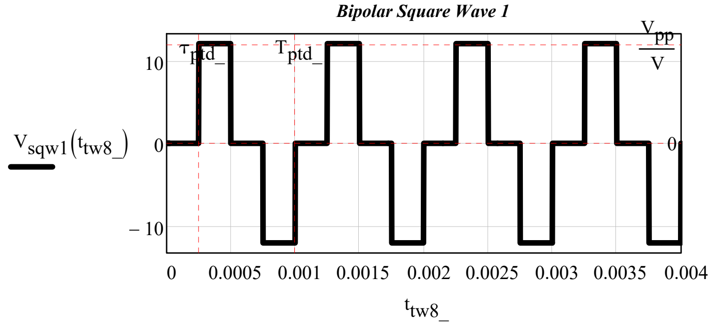
Square wave period: $T_{0gd} = 1 \times 10^{6} \cdot ns$ $\qquad \xi_{twsl} := \xi_{ptd\_}$

$\omega_{ptd\_} = 6.283 \times 10^{-6} \cdot \frac{Grads}{sec}$ $\qquad \tau_{\delta sl} := -\tau_{ptd\_} \cdot (1 - \xi_{twsl})$

$\tau_{ptd\_} = 2.5 \times 10^{-4} s$

$V_{sqw1}(t) := V_6(t, \tau_{\delta sl}, \tau_{ptd\_}, T_{ptd\_}, V_{pp}, N0_{gd})$

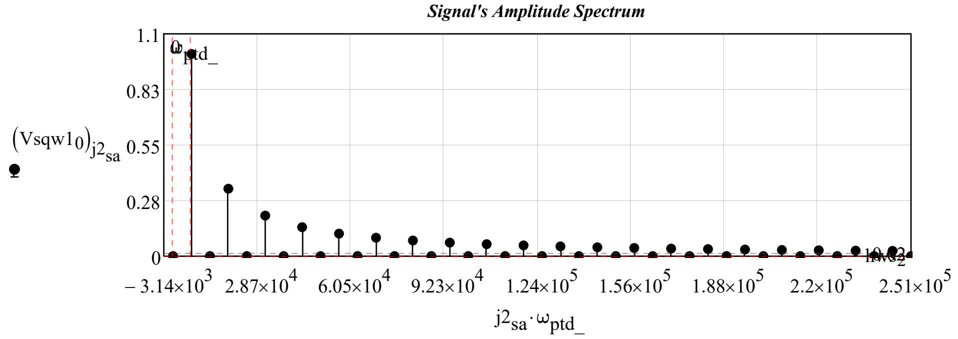
Bipolar Square Wave 1



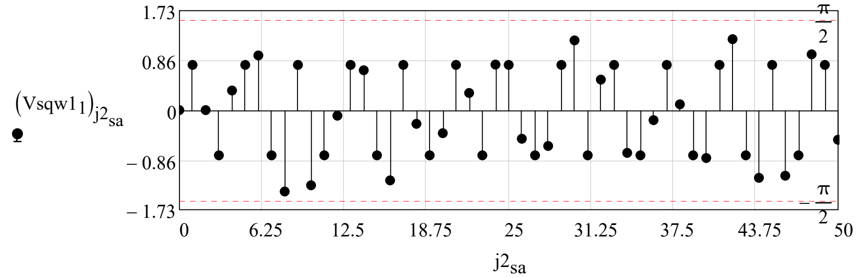
$Vsqw1 := SPCT(V_{sqw1}, rt_{gd}, N1\_, \tau_{ptd\_}, T_{ptd\_})$ $\qquad N1\_ = 50$

$j2_{sa} := 0 .. rows(Vsqw1_0) - 1$ $\qquad \omega_{ptd\_} = 6.283 \cdot \frac{krads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := Vsqw1_3 \cdot Hz$

$Bw_{sa} = 0.048 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\qquad fpt_{so} = 0.096 \cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

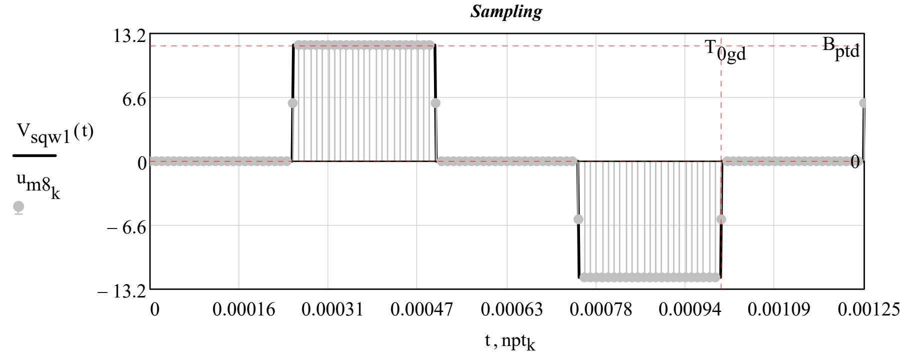
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{0gd}} = 2.667$

$u_{m8_k} := V_{sqw1}(npt_k)$

$u_{m8}^T =$

	0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	0	0	0	0	...

Sampling

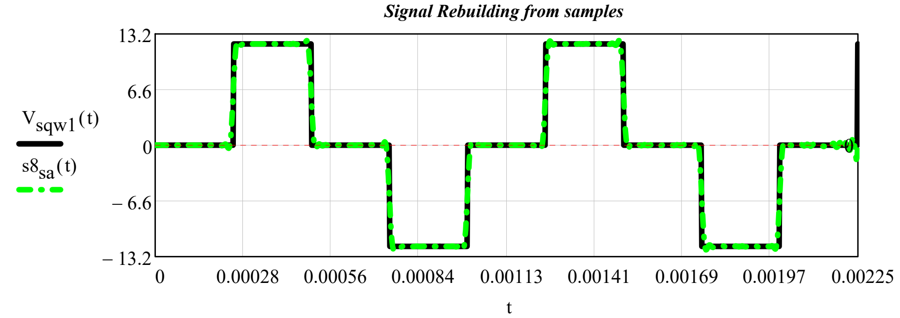


$relerr = 10 \cdot \%$ $\qquad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\qquad \omega_{bwr} = 0.302 \cdot \frac{Mrads}{sec}$ $\qquad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\qquad s8_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m8_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi)\right)\right]$ $\qquad N0_{gd} - 1 = 255$ $\qquad relerr = 10 \cdot \%$

Signal Rebuilding from samples

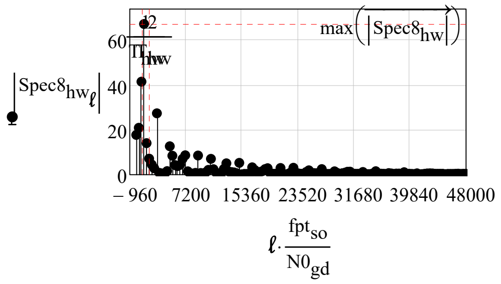


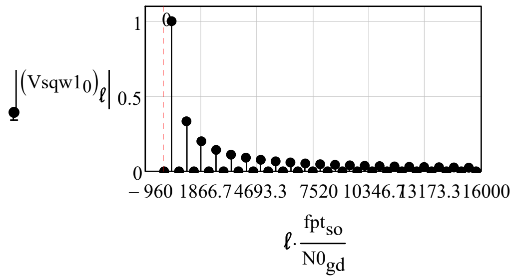
$length(u_{m8}) = 256$

$fpt_{so} = 96 \cdot kHz$

$Spec8_{hw} := fft(u_{m8}) \quad length(Spec8_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2} \quad \frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

9 Staircase 1 Voltage Pulse Train

***Description of the Function's parameters*:** $v_{stcp}(t_{sl}, period, signal\_amplitude, number\_of\_steps, max\_number\_of\_periods)$

$: v_{stc}(t_{sl}, step\_length, signal\_amplitude, number\_of\_steps, max\_number\_of\_periods)$

For data, see the worksheet *" staircase pulse data.xmcd"*

Period: $T_{stcpt} := (m1_{steps} + 1) \cdot T_{1stpl\_} \cdot 2$

Duty Cycle: $\delta_{stcpt} := \frac{m1_{steps} \cdot T_{1stpl\_}}{T_{stcpt}}$

Staircase frequency: $f_{stcpt} := \frac{1}{T_{stcpt}}$

$\omega_{stcpt} := 2 \cdot \pi \cdot f_{stcpt} \quad \omega_{1stpl} := \frac{2 \cdot \pi}{T_{1stpl\_}}$

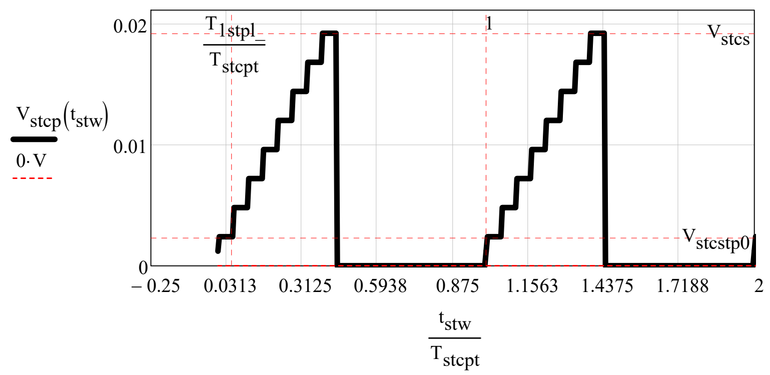
Number of periods shown: $n_p := 20$

$$v_{stcptasl} := \frac{V_{stcs}}{2 \cdot m1_{steps} \cdot (m1_{steps} + 1)} \cdot \sum_{k=1}^{m1_{steps}} (m1_{steps} - k + 1) = 4.8 \cdot mV$$

$$t_{stw} := 0 \cdot T_{stcpt}, 0 \cdot T_{stcpt} + \frac{10 \cdot T_{stcpt}}{2000} .. 10 \cdot T_{stcpt}$$

$$V_{stcp}(t) := \frac{v_{stcp}(t, T_{stcpt}, V_{stcs}, m1_{steps}, N0_{gd})}{V}$$

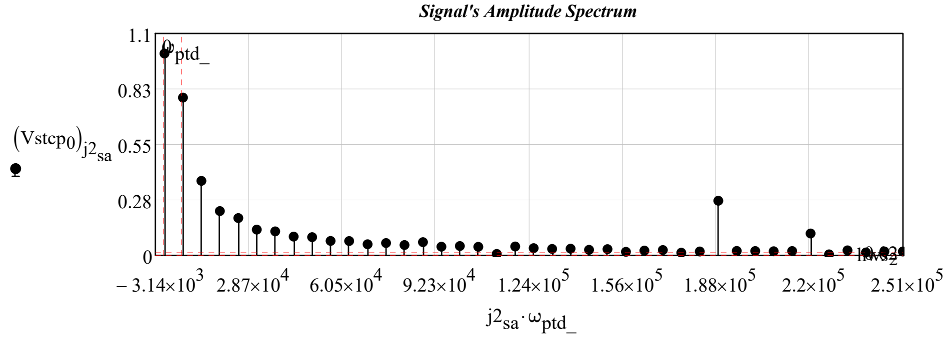
Periodic Staircase 1



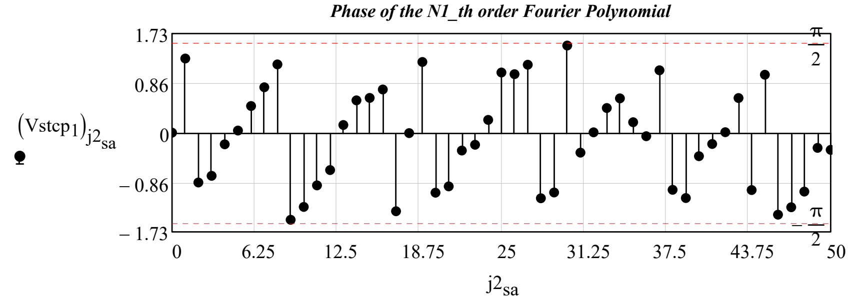
$Vstcp := SPCT(V_{stcp}, rt_{gd}, N1\_, 0 \cdot s, T_{stcpt}) \quad N1\_ = 50$

$j2_{sa} := 0 .. rows(Vstcp_0) - 1 \quad \omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := Vstcp_3 \cdot Hz$

$Bw_{sa} = 7.2 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa} \quad fpt_{so} = 14.4 \cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

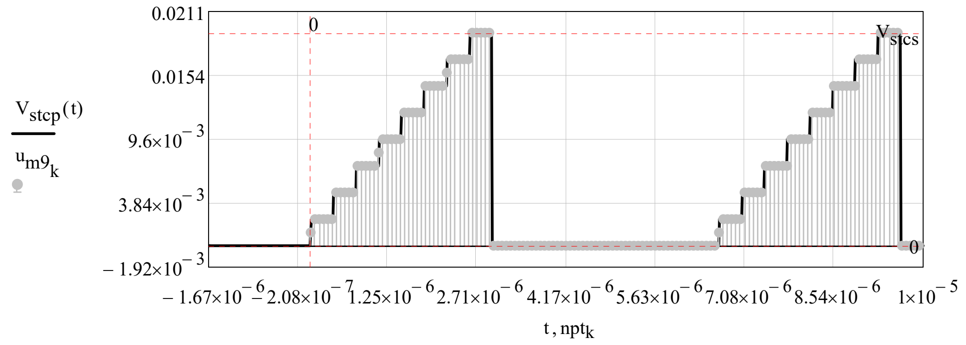
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{stcpt}} = 2.667$

$u_{m9_k} := V_{stcp}(npt_k)$

$u_{m9}^T =$

	0	1	2	3	4	5	6
0	$1.2 \cdot 10^{-3}$	$2.4 \cdot 10^{-3}$	$2.4 \cdot 10^{-3}$	$2.4 \cdot 10^{-3}$	$2.4 \cdot 10^{-3}$	$2.4 \cdot 10^{-3}$	...

Sampling

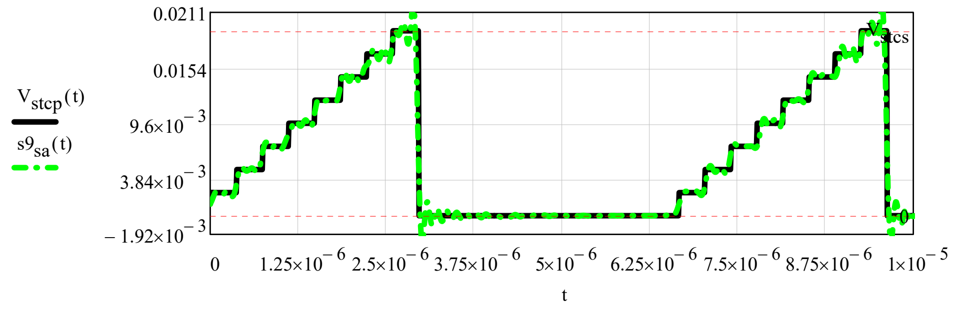


relerr = 10·% $\omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\omega_{bwr} = 45.239\cdot\frac{Mrads}{sec}$ $n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s9_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m9_n}\cdot \operatorname{sinc}(\omega_{bwr}\cdot t - n\cdot\pi)\right)\right]$ $N0_{gd} - 1 = 255$ relerr = 10·%

Signal Rebuilding from samples

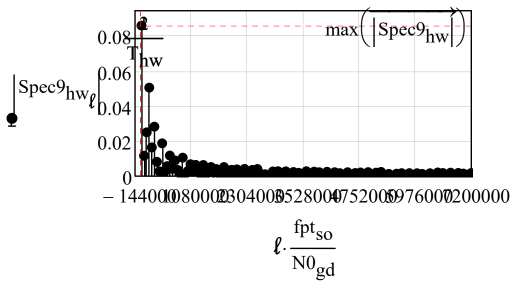


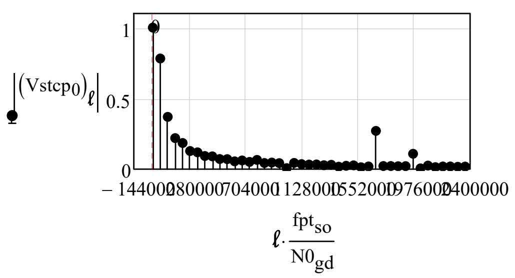
$\text{length}(u_{m9}) = 256$

$fpt_{so} = 1.44\times 10^{4}\cdot kHz$

$Spec9_{hw} := \text{fft}(u_{m9})$ $\text{length}(Spec9_{hw}) = 129$

$\ell := 0..\frac{N0_{gd}}{2}$ $\frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

10 Staircase 2 Voltage Pulse Train

Description of the Function's parameters: v_{stct}(time, period, max_amplitude, number_of_steps, max_number_of_periods)

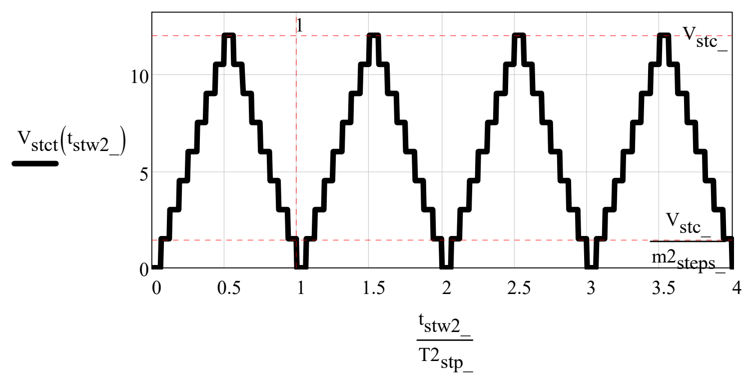
v_{stcc}(t_{sl}, step_length, signal_amplitude, number_of_steps, number_max_of_periods)

For data, see the worksheet " staircase 2 pulse data.xmcd"

$$t_{stw2\_} := 0\cdot T2_{stp\_}, 0\cdot T2_{stp\_} + \frac{10\cdot T2_{stp\_}}{2000} .. 10\cdot T2_{stp\_}$$

$$V_{stct}(t) := \frac{v_{stct}(t, T2_{stp\_}, V_{stc\_}, m2_{steps\_}, N0_{gd})}{V}$$

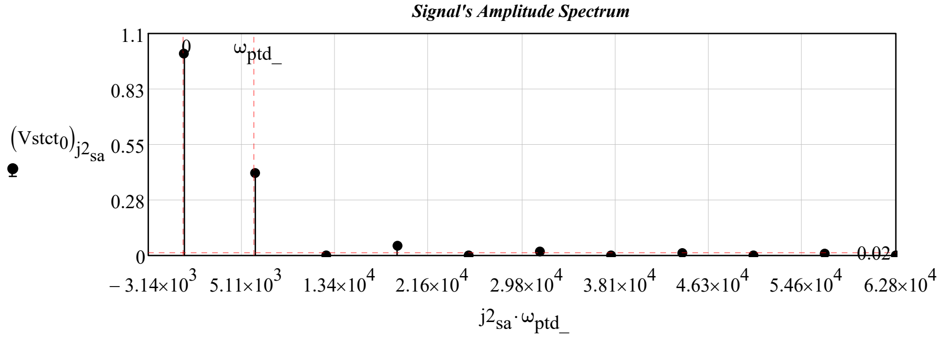
Staircase 2 Wave



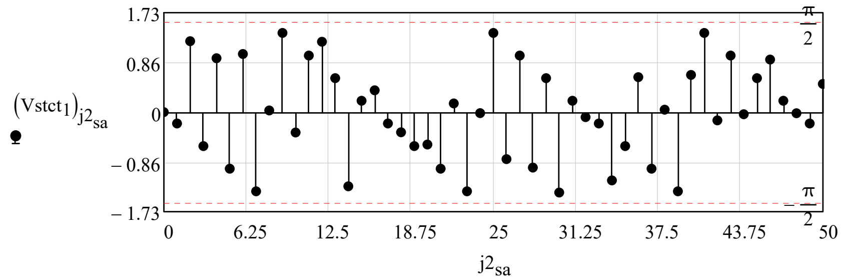
$Vstct := SPCT(V_{stct}, rt_{gd}, N1\_, 0\cdot s, T2_{stp\_})$ N1_ = 50

$j2_{sa} := 0..\text{rows}(Vstct_0) - 1$ $\omega_{ptd\_} = 6.283\times 10^{-3}\cdot\frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := Vstct_3\cdot Hz$

$Bw_{sa} = 0.667\cdot MHz$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa}$ $fpt_{so} = 1.333\cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

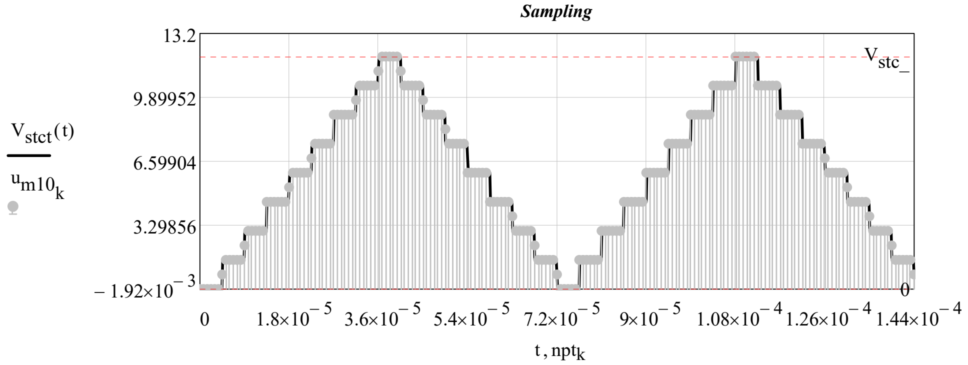
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T2_{stp\_}} = 2.667$

$u_{m10_k} := V_{stct}(npt_k)$

$u_{m10}{}^T =$

	0	1	2	3	4	5	6	7	8
0	0	0	0	0	0	0	0.75	1.5	...

Sampling

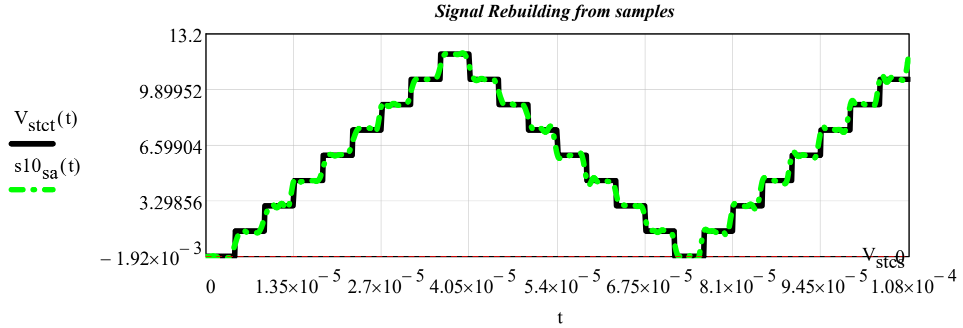


relerr = 10·% $\omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\omega_{bwr} = 4.189 \cdot \frac{Mrads}{sec}$ $n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s10_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m10_n} \cdot \mathrm{sinc}(\omega_{bwr} \cdot t - n \cdot \pi) \right) \right]$ $N0_{gd} - 1 = 255$ relerr = 10·%

Signal Rebuilding from samples

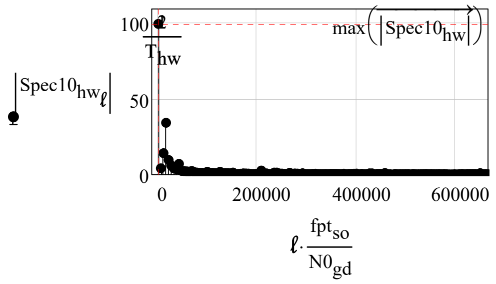


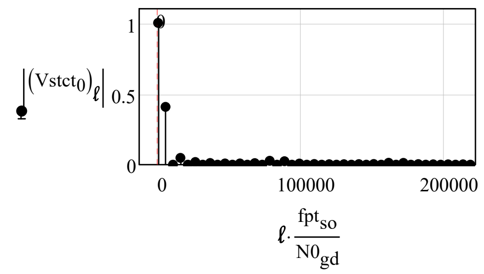
$\mathrm{length}(u_{m10}) = 256$

$fpt_{so} = 1.333 \times 10^3 \cdot kHz$

$Spec10_{hw} := \mathrm{fft}(u_{m10})$ $\mathrm{length}(Spec10_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

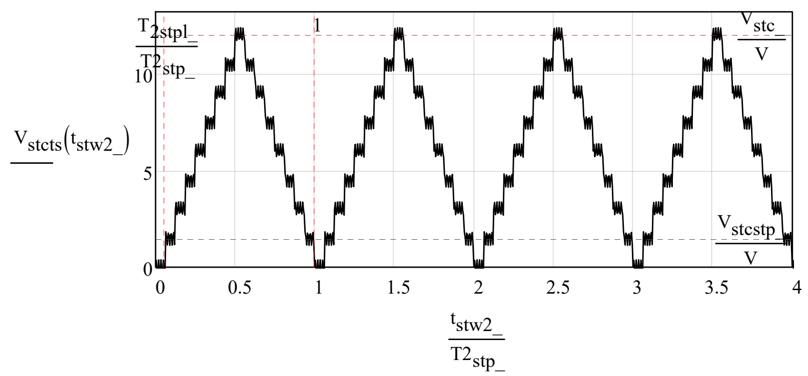
11 Staircase 2 Voltage Pulse Train + sinus

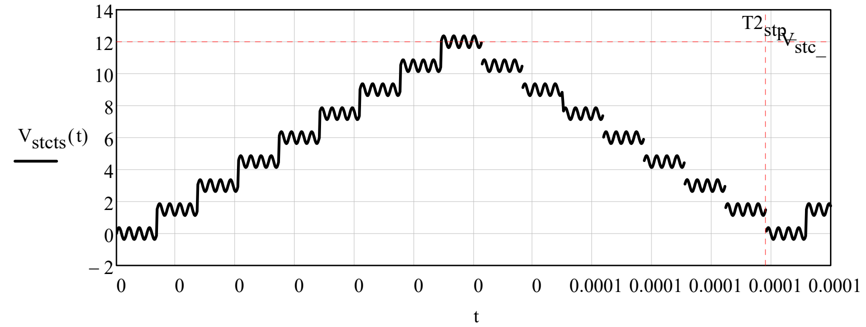
Description of the Function's parameters: Vstcsin(t_{sl}, period, max_amplitude, number_of_steps, max_number_of_periods)

For data, see the worksheet *" staircase 2 pulse data.xmcd"*

$V_{stcts}(t) := \mathrm{Vstcsin}(t, T2_{stp\_}, V_{stc\_}, m2_{steps\_}, N0_{gd})$

Staircase 2 Wave + sinus (adimensional)



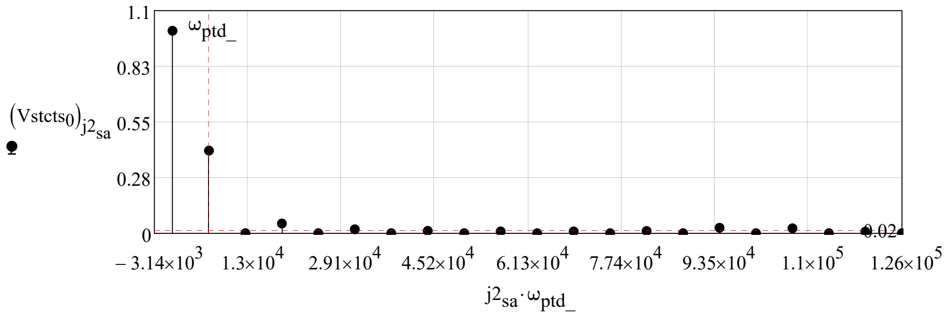


$N1 := 25$ $Vstcts := \mathrm{SPCT}(V_{stcts}, rt_{gd}, N1\_, 0 \cdot s, T2_{stp\_})$

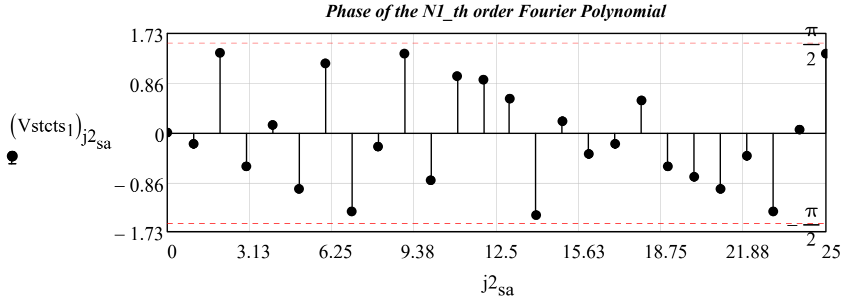
$N1\_ = 25$

$j2_{sa} := 0..\text{rows}(Vstcts_0) - 1$ $\qquad \omega_{ptd\_} = 6.283 \cdot \frac{krads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := Vstcts_3 \cdot Hz$

$Bw_{sa} = 0.319 \cdot MHz$

sampling frequency: $\quad fpt_{so} := 2 \cdot Bw_{sa} \qquad fpt_{so} = 0.639 \cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

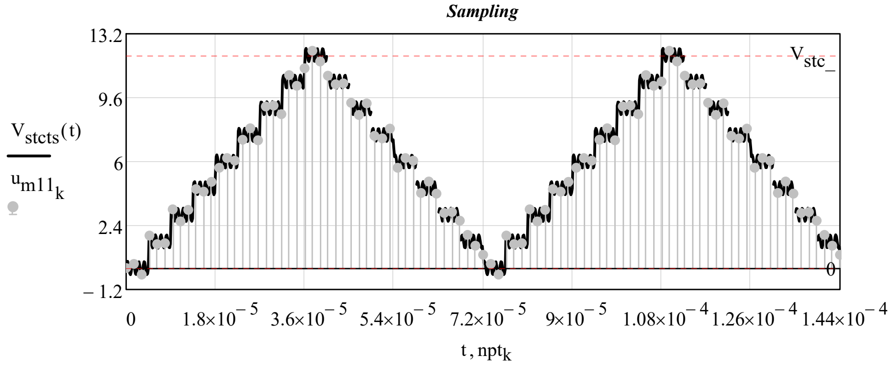
Frequency resolution: $\quad \frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T2_{stp\_}} = 5.565$

$u_{m11_k} := V_{stcts}(npt_k)$

$u_{m11}^T =$

	0	1	2	3	4
0	0	0.237	-0.367	1.833	...

Sampling



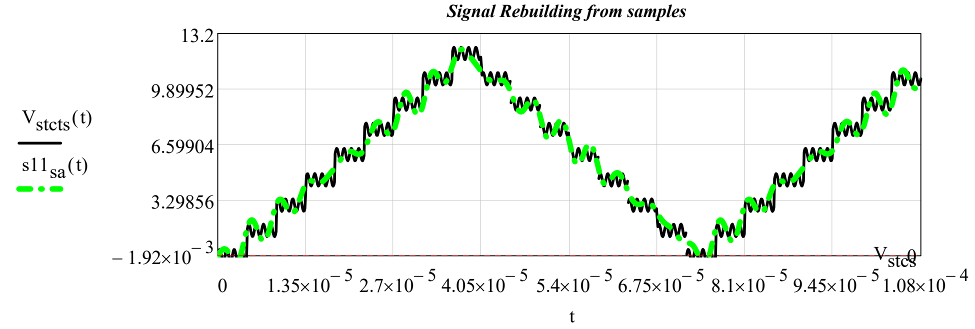
$relerr = 10 \cdot \%$ $\qquad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa} \qquad \omega_{bwr} = 2.007 \cdot \frac{Mrads}{sec} \qquad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s11_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m11_n} \cdot \text{sinc}(\omega_{bwr} \cdot t - n \cdot \pi) \right) \right] \qquad N0_{gd} - 1 = 255 \qquad relerr = 10 \cdot \%$

$N1\_ = 25$

Signal Rebuilding from samples

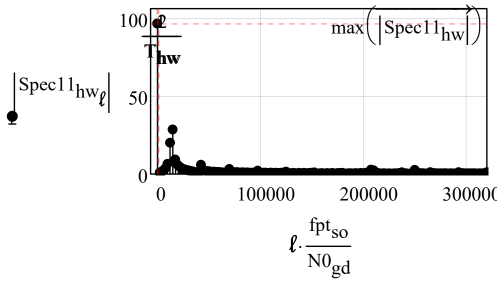


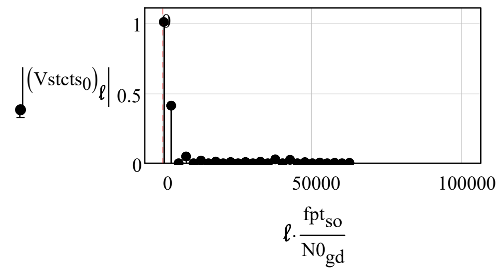
$\text{length}(u_{m11}) = 256$

$fpt_{so} = 638.889 \cdot kHz$

$Spec11_{hw} := \text{fft}(u_{m11}) \quad \text{length}(Spec11_{hw}) = 129$

$\ell := 0..\frac{N0_{gd}}{2} \qquad \frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

12 Staircase 3 Voltage Pulse Train

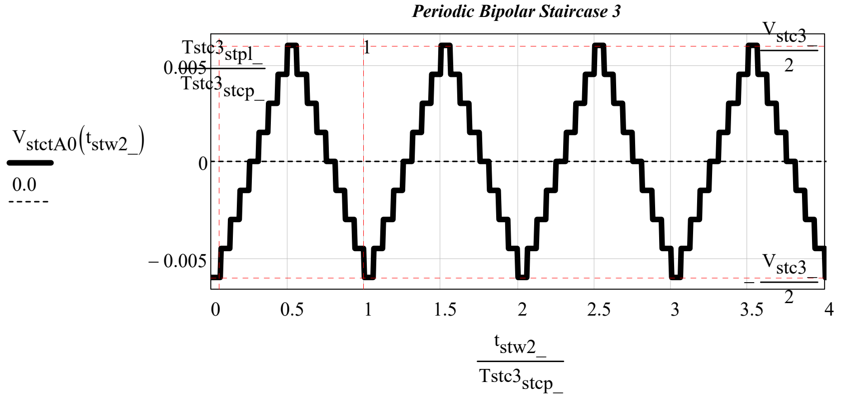
Description of the Function's parameters: $v_{stct}(t_{sl}, period, step\_amplitude, number\_of\_steps, max\_number\_of\_periods)$

: $v_{stctA0}[t_{sl}, (period, step\_amplitude, number\_of\_steps, max\_number\_of\_periods)]$

You can find the data in "*staircase 3 pulse data.xmcd*"

$$V_{stctA0}(t) := \frac{v_{stctA0}(t, Tstc3_{stcp\_}, V_{stc3\_}, mstc3_{steps\_}, N0_{gd})}{V} \qquad N1\_ := 25$$

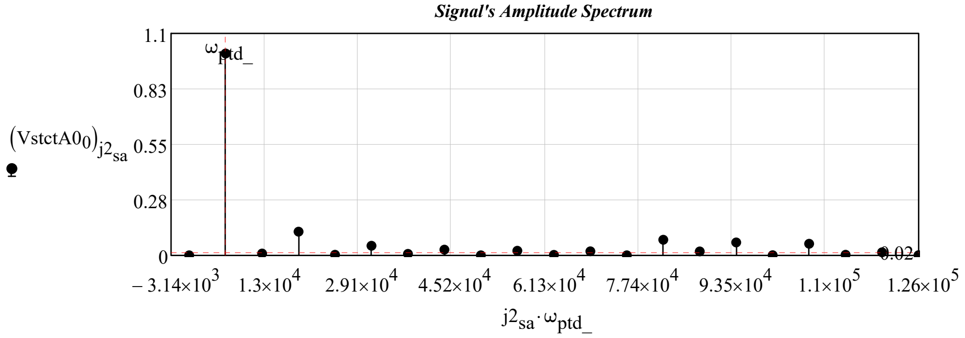
Periodic Bipolar Staircase 3



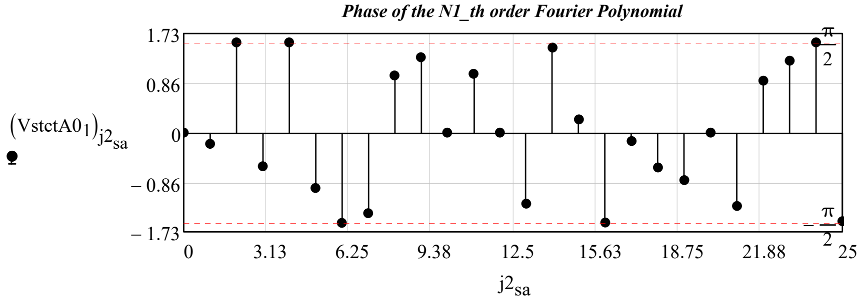
$$VstctA0 := SPCT(V_{stctA0}, rt_{gd}, N1\_, 0 \cdot s, Tstc3_{stcp\_}) \qquad N1\_ = 25$$

$$j2_{sa} := 0 .. rows(VstctA0_0) - 1 \qquad \omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \frac{Mrads}{s}$$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$$Bw_{sa} := VstctA0_3 \cdot Hz$$

$$Bw_{sa} = 0.328 \cdot MHz$$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\qquad fpt_{so} = 0.656 \cdot MHz$

$$npt_k := \frac{k}{fpt_{so}}$$

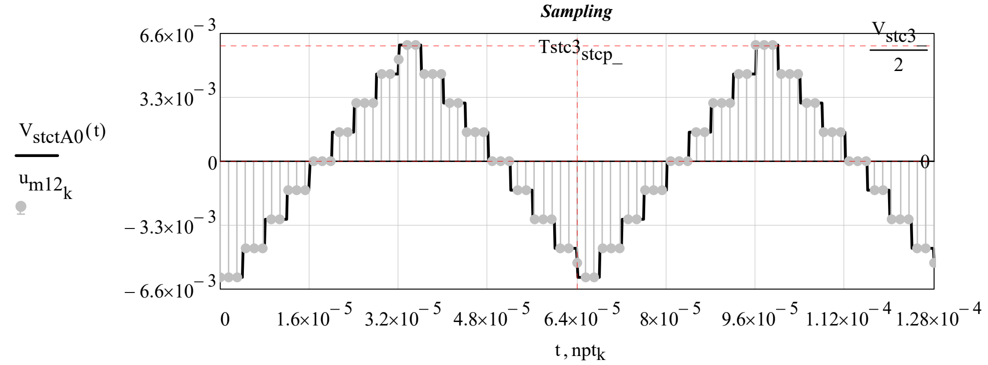
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T2_{stp\_}} = 5.418$

$$u_{m12_k} := V_{stctA0}(npt_k)$$

$u_{m12}^T =$

	0	1	2	3	4	5
0	-6·10-3	-6·10-3	-6·10-3	-4.5·10-3	-4.5·10-3	...

Sampling



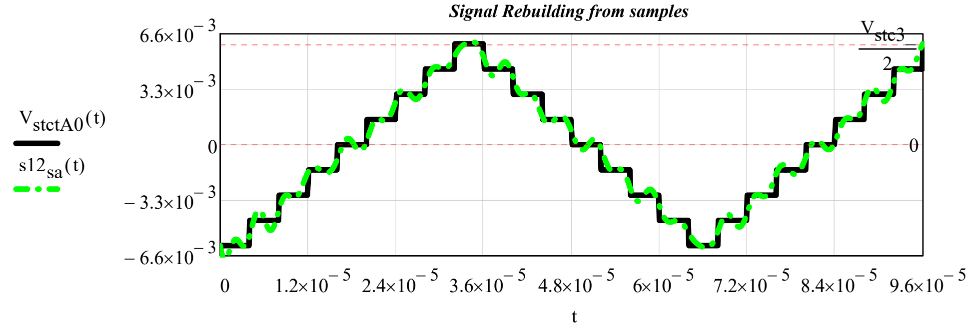
relerr = 10·% $\qquad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\qquad \omega_{bwr} = 2.062 \cdot \frac{Mrads}{sec}$ $\qquad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\qquad s12_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m12_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi)\right)\right]$ $\qquad N0_{gd} - 1 = 255$ $\qquad$ relerr = 10·%

Signal Rebuilding from samples

N1_ = 25

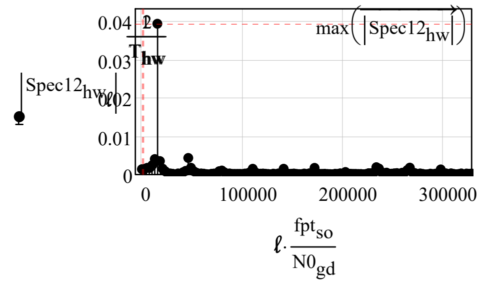


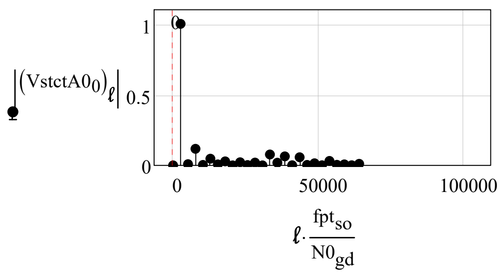
$$length(u_{m12}) = 256$$

$$fpt_{so} = 656.25 \cdot kHz$$

$$Spec12_{hw} := fft(u_{m12}) \qquad length(Spec12_{hw}) = 129$$

$$\ell := 0 .. \frac{N0_{gd}}{2} \qquad \frac{N0_{gd}}{2} = 128$$





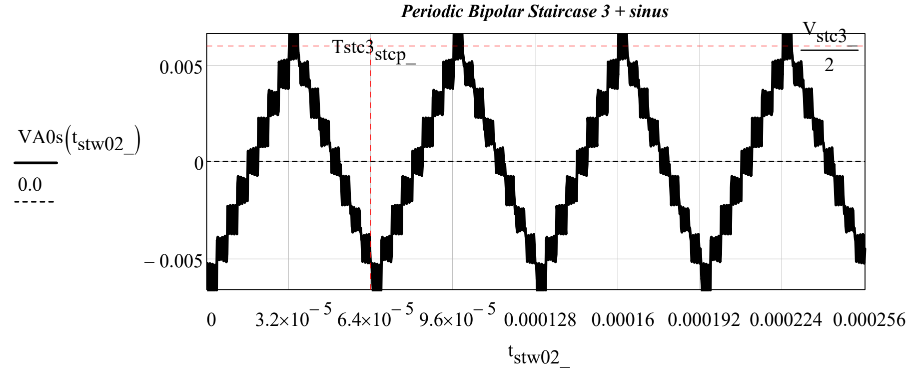
TEST Waveforms

Periodic Waveforms

13 Staircase 3 Voltage Pulse Train + sinus

$$VA0s(t) := VistctA0sin\left(t, Tstc3_{stcp\_}, V_{stc3\_}, mstc3_{steps\_}, N0_{gd}\right)$$

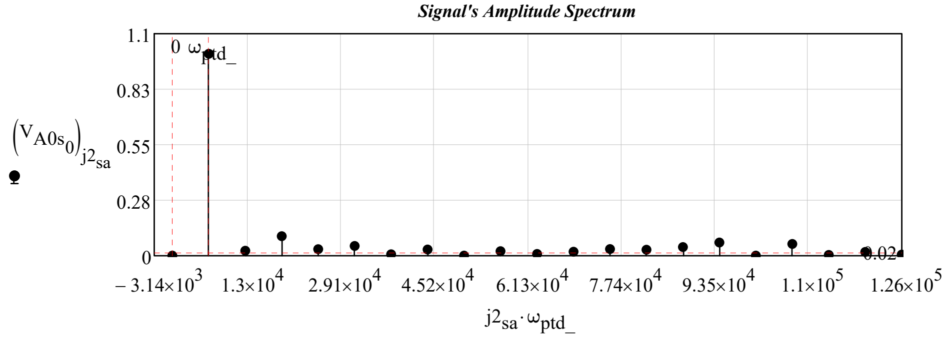
Periodic Bipolar Staircase 3 + sinus



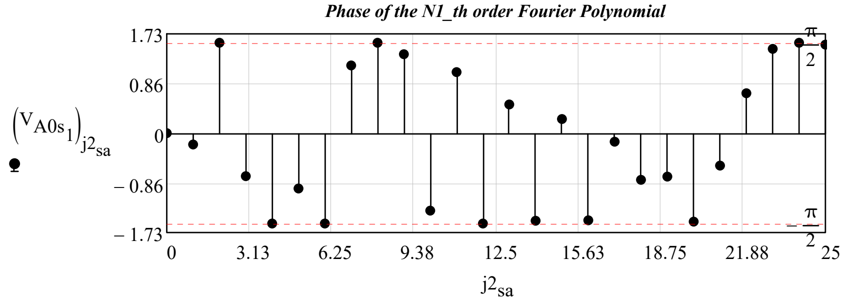
$$V_{A0s} := SPCT\left(VA0s, rt_{gd}, N1\_, 0\cdot s, Tstc3_{stcp\_}\right) \qquad N1\_ = 25$$

$$j2_{sa} := 0 .. rows\left(V_{A0s_0}\right) - 1 \qquad \omega_{ptd\_} = 6.283\times10^{-3}\cdot\frac{Mrads}{s}$$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$$Bw_{sa} := V_{A0s_3}\cdot Hz$$

$$Bw_{sa} = 0.344\cdot MHz$$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa}$ $\qquad fpt_{so} = 0.688\cdot MHz$

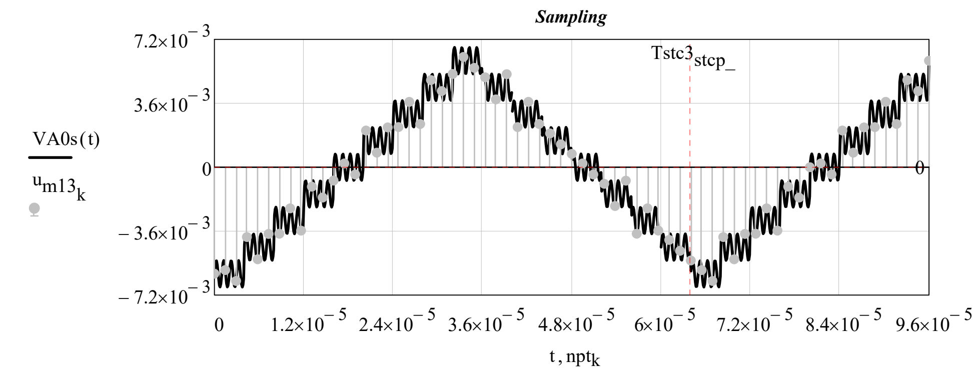
$$npt_k := \frac{k}{fpt_{so}}$$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}}\cdot\frac{1}{T2_{stp\_}} = 5.172$

$$u_{m13_k} := VA0s\left(npt_k\right)$$

$u_{m13}{}^T =$

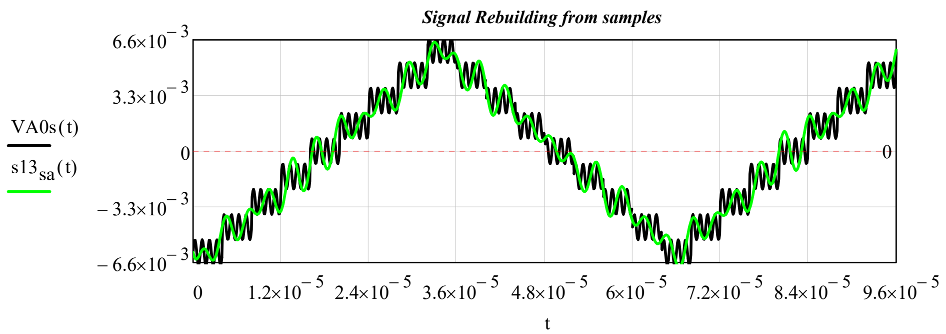
	0	1	2	3	4
0	$-6\cdot10^{-3}$	$-5.789\cdot10^{-3}$	$-6.405\cdot10^{-3}$	$-3.933\cdot10^{-3}$	...



relerr = 10·% $\omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\omega_{bwr} = 2.16\cdot\frac{Mrads}{sec}$ $n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s13_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m13_n}\cdot \text{sinc}\left(\omega_{bwr}\cdot t - n\cdot\pi\right)\right)\right]$ $N0_{gd} - 1 = 255$ relerr = 10·%

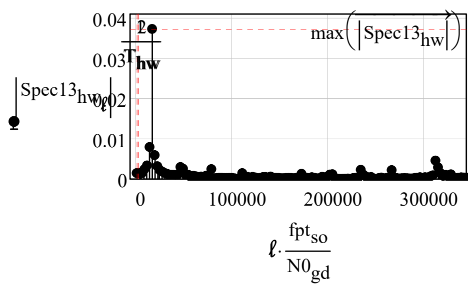


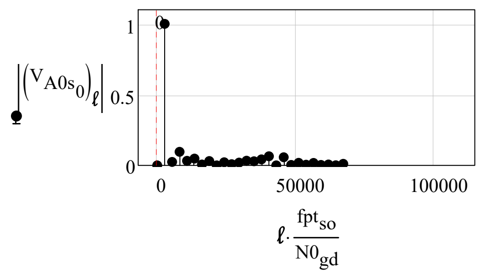
$\text{length}(u_{m13}) = 256$

$fpt_{so} = 687.5\cdot kHz$

$Spec13_{hw} := \text{fft}(u_{m13})$ $\text{length}(Spec13_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

14 Staircase 4 Voltage Pulse Train

Description of the Function's parameters : vstc1p(time, step length, max amplitude, number of steps, max number of periods)

To modify data, see the worksheet *"staircase 4 pulse data.xmcd"*

Step Amplitude: $V_{stc4} = 15\,V$

Step length: $T_{4stpl\_} = 1.481\cdot\mu s$

Number of steps: $m4_{steps} = 8$

Time constant: $\tau 4\_ = 74.074\cdot ns$

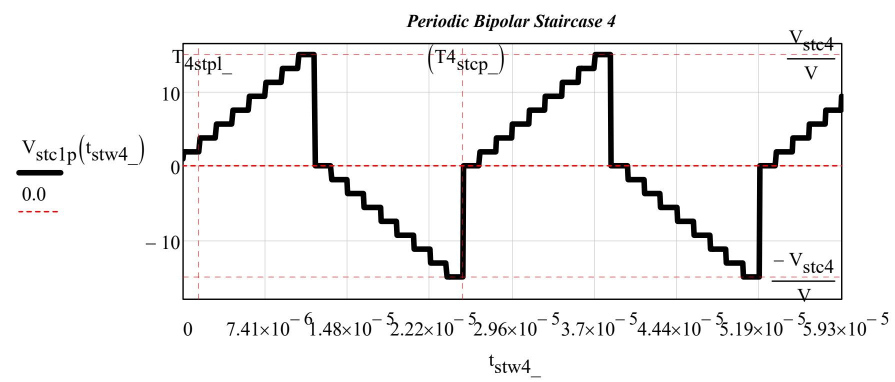
Period: $T4_{stcp\_} = 0.025\cdot ms$

Frequency: $f_{44stcp\_} = 3.971\times10^{4}\cdot Hz$

$\omega_{44stcp\_} = 2.495\times10^{5}\cdot\frac{rad}{sec}$

Description of the Function's parameters : vstc1p(time, step length, max amplitude, number of steps)

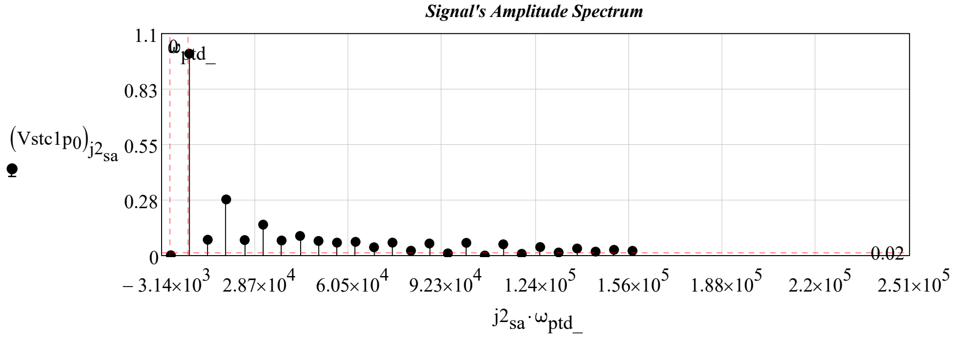
$$V_{stc1p}(t) := \frac{\text{vstc1p}\left(t, T_{4stpl\_}, V_{stc4}, m4_{steps}, N0_{gd}\right)}{V}$$



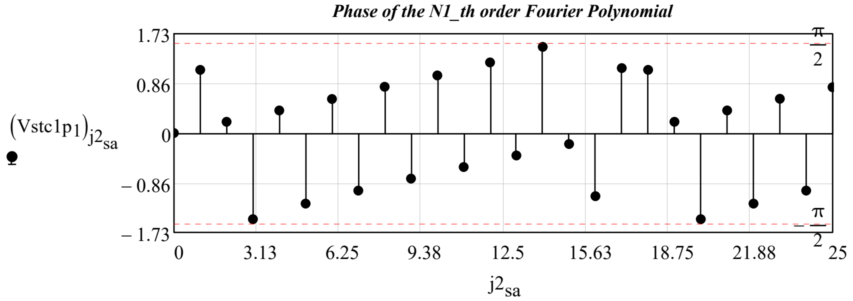
$Vstc1p := \text{SPCT}\left(V_{stc1p}, rt_{gd}, N1\_, 0\cdot s, T4_{stcp\_}\right)$ $N1\_ = 25$

$j2_{sa} := 0 .. \text{rows}\left(V_{A0s_0}\right) - 1$ $\omega_{ptd\_} = 6.283\times10^{-3}\cdot\frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := Vstc1p_3 \cdot Hz$

$Bw_{sa} = 0.913 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 1.826 \cdot MHz$

$$npt_k := \frac{k}{fpt_{so}}$$

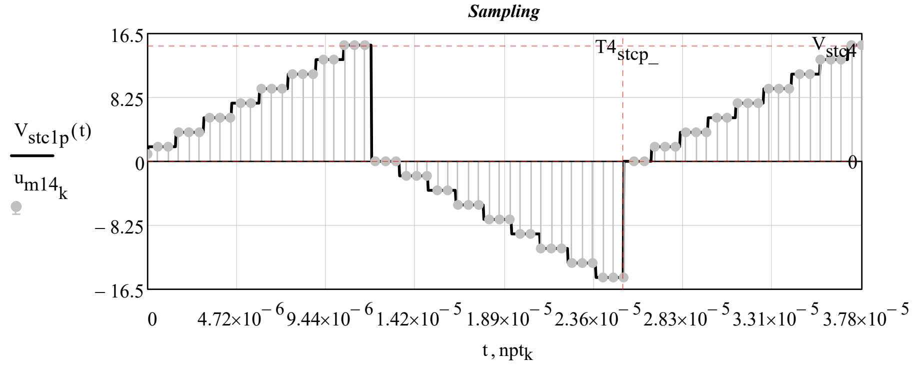
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T4_{stcp\_}} = 5.565$

$$u_{m14_k} := V_{stc1p}(npt_k)$$

$u_{m14}{}^T =$

	0	1	2	3	4	5	6
0	0.938	1.875	1.875	3.75	3.75	3.75	...

Sampling

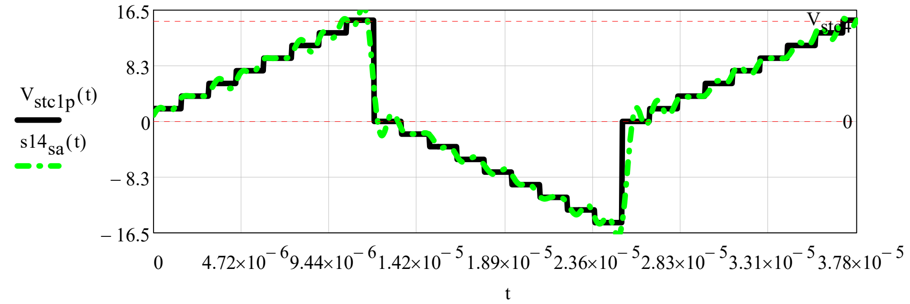


$relerr = 10 \cdot \%$ $\quad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\quad \omega_{bwr} = 5.738 \cdot \frac{Mrads}{sec}$ $\quad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s14_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m14_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi) \right) \right]$ $\quad N0_{gd} - 1 = 255$ $\quad relerr = 10 \cdot \%$

Signal Rebuilding from samples

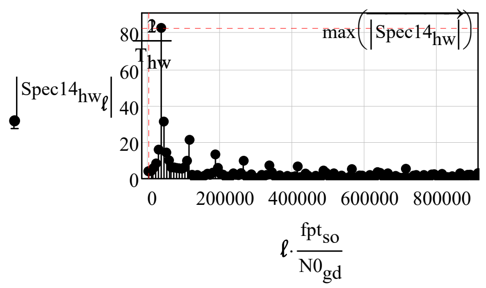


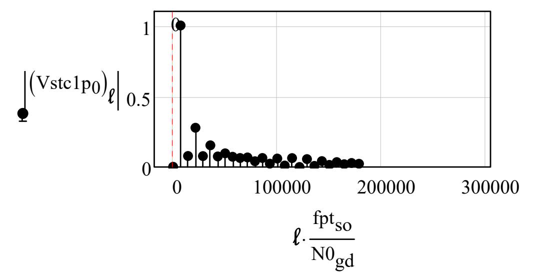
$length(u_{m14}) = 256$

$fpt_{so} = 1.826 \times 10^3 \cdot kHz$

$Spec14_{hw} := fft(u_{m14})$ $\quad length(Spec14_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\quad \frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

15 Bipolar Triangular Voltage Wave

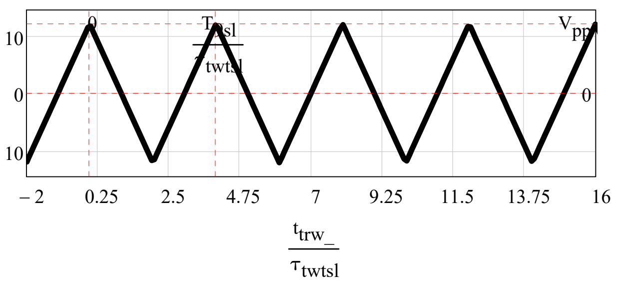
Description of the Function's parameters : Λ_V(time, triangle half base, triangle amplitude, max number of periods)

Time constant: $\tau_{twtsl} := 1 \cdot \mu s$

Period: $T_{9sl} := 4 \cdot \tau_{twtsl}$ $\quad f_{9sl} := \frac{1}{T_{9sl}}$

$$t_{trw\_} := -1 \cdot T_{9sl}, -1 \cdot T_{9sl} + \frac{20 \cdot T_{9sl} + 1 \cdot T_{9sl}}{1000} .. 20 \cdot T_{9sl}$$

$\Lambda_V(t_{trw\_}, \tau_{twtsl}, V_{pp}, N0_{gd})$



Bipolar Triangular Voltage Wave Built using the Step Function

Signal amplitude: $V_{pp} = 12 \cdot V$

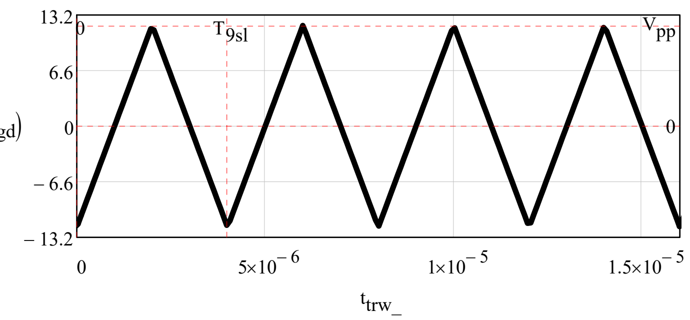
Time constant: $\tau_{twtsl} = 1 \cdot \mu s$

Period: $T_{9sl} = 4 \cdot \mu s$

$\omega_{9sl} := 2 \cdot \pi \cdot f_{9sl}$ $\quad \omega_{9sl} = 1.571 \times 10^6 \cdot \frac{rad}{sec}$

$N0_{gd} = 256$

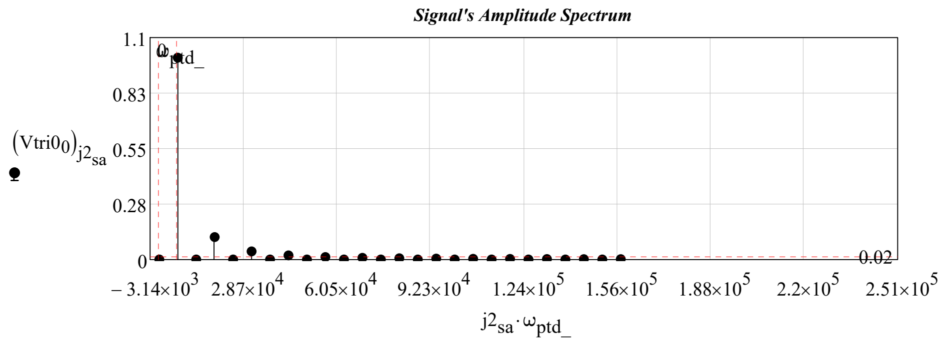
$v_{tri0}(t_{trw\_}, T_{9sl}, V_{pp}, N0_{gd})$

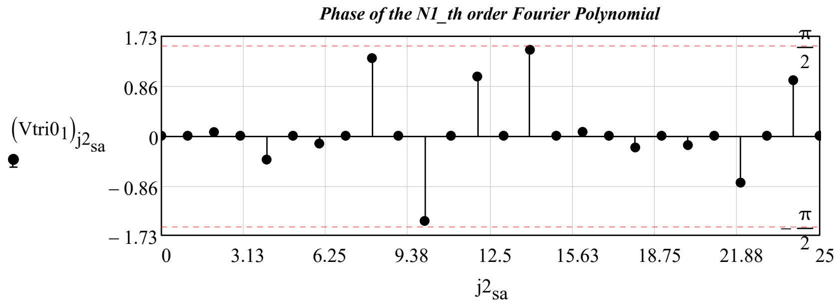


$$V_{tri0}(t) := \frac{v_{tri0}(t, T_{9sl}, V_{pp}, N0_{gd})}{V}$$

$Vtri0 := SPCT(V_{tri0}, rt_{gd}, N1\_, 0 \cdot s, T_{9sl})$ $\quad N1\_ = 25$

$j2_{sa} := 0 .. rows(Vtri0_0) - 1$ $\quad \omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \frac{Mrads}{s}$





$Bw_{sa} := Vtri0_3 \cdot Hz$

$Bw_{sa} = 3.5 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 7 \cdot MHz$

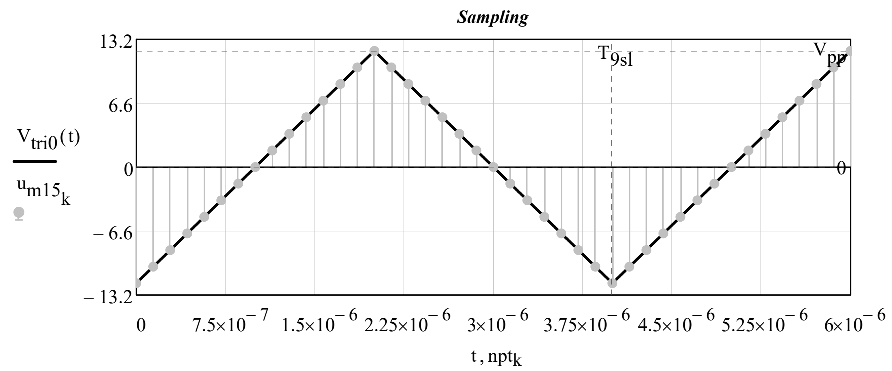
$$npt_k := \frac{k}{fpt_{so}}$$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T4_{stcp\_}} = 1.452$

$u_{m15_k} := V_{tri0}(npt_k)$

$u_{m15}{}^T =$

	0	1	2	3	4
0	-12	-10.286	-8.571	-6.857	...

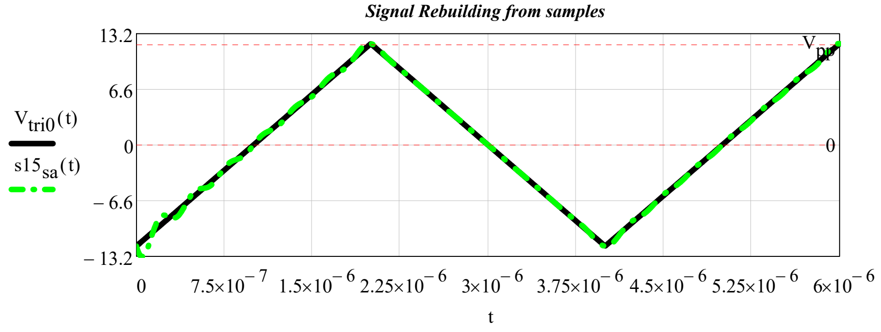


relerr = 10·% $\quad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\quad \omega_{bwr} = 21.991 \cdot \frac{Mrads}{sec}$ $\quad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s15_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m15_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi) \right) \right]$ $\quad N0_{gd} - 1 = 255$ $\quad$ relerr = 10·%

Signal Rebuilding from samples

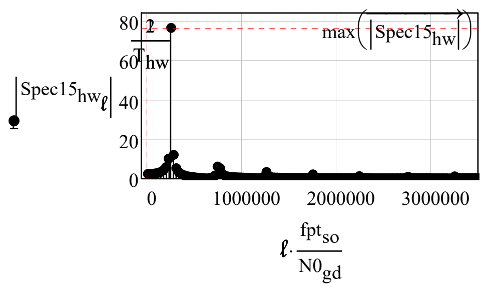


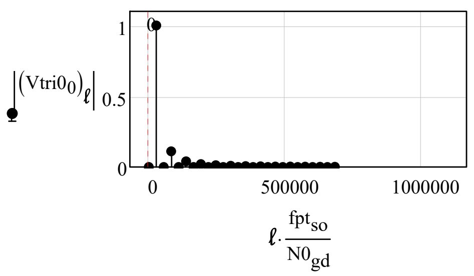
$\text{length}(u_{m15}) = 256$

$fpt_{so} = 7 \times 10^{3} \cdot \text{kHz}$

$Spec15_{hw} := \text{fft}(u_{m15}) \quad \text{length}(Spec15_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2} \qquad \frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

16 Triangular Cusps Voltage Pulse Train

Signal amplitude: $V_{pp} = 12 \cdot V$

Pulse width: $p_{wsl} := \tau_{ptd\_} \qquad p_{wsl} = 250 \cdot \mu s$

Max pulse amplitude and cusp ratio: $a_{psl} := \frac{1}{4} \qquad a_{psl} < 1$

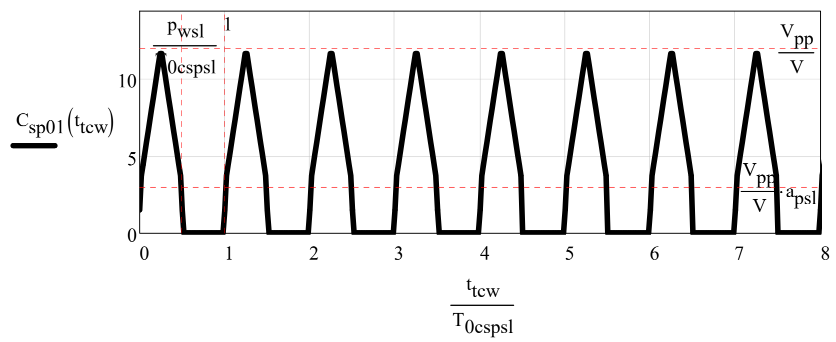
Cusp slope $c_{ssl} := V_{pp} \cdot \frac{2 \cdot (1 - a_{psl})}{p_{wsl}} \qquad c_{ssl} = 0.072 \cdot \frac{V}{\mu s}$

Period: $T_{0cspsl} := 2 \cdot p_{wsl}$

$$t_{tcw} := 0 \cdot T_{0cspsl}, 0 \cdot T_{0cspsl} + \frac{10 \cdot T_{0cspsl} - 0 \cdot T_{0cspsl}}{500} .. 10 \cdot T_{0cspsl}$$

$$C_{sp01}(t) := \frac{csp01(t, p_{wsl}, a_{psl}, T_{0cspsl}, V_{pp}, N0_{gd})}{V}$$

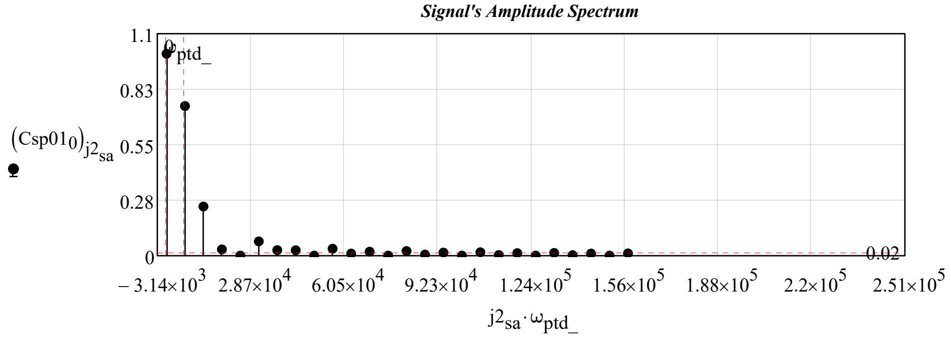
Cusp Pulses Train



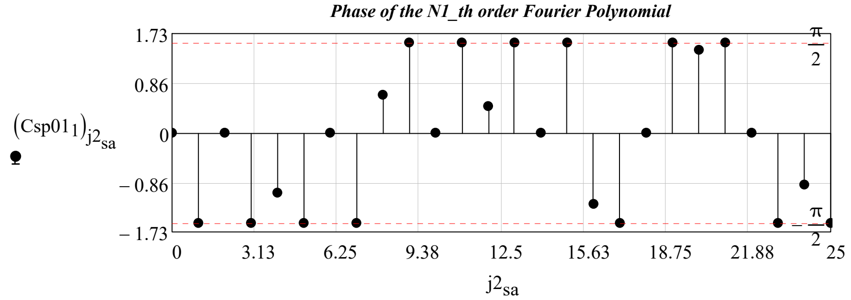
$Csp01 := \text{SPCT}(C_{sp01}, rt_{gd}, N1\_, 0 \cdot s, T_{0cspsl}) \qquad N1\_ = 25$

$j2_{sa} := 0 .. \text{rows}(Csp01_0) - 1 \qquad \omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := Csp01_3 \cdot Hz$

$Bw_{sa} = 0.046 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 0.092 \cdot MHz$

$$npt_k := \frac{k}{fpt_{so}}$$

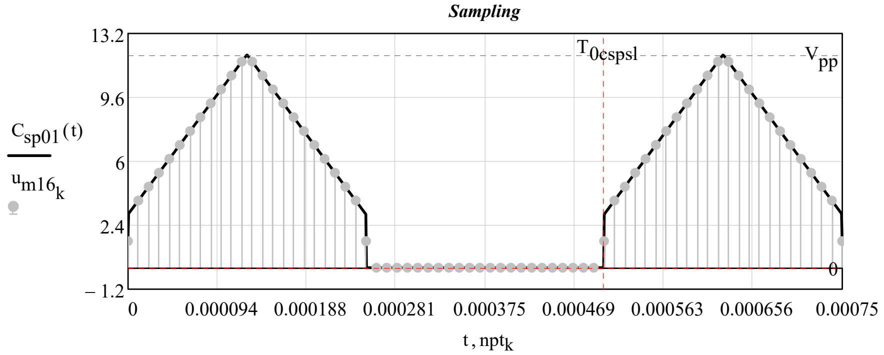
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T4_{stcp\_}} = 110.486$

$u_{m16_k} := C_{sp01}(npt_k)$

$u_{m16}^{T} =$

	0	1	2	3	4	5	6	7
0	1.5	3.783	4.565	5.348	6.13	6.913	7.696	...

Sampling

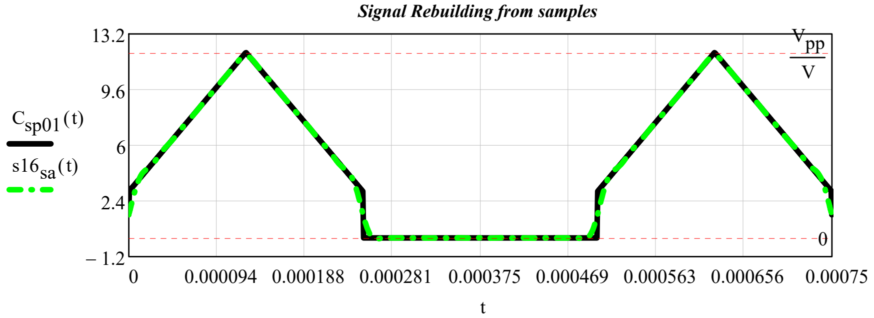


$relerr = 10 \cdot \%$ $\qquad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\qquad \omega_{bwr} = 0.289 \cdot \frac{Mrads}{sec}$ $\qquad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s16_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m16_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi)\right)\right]$ $\qquad N0_{gd} - 1 = 255$ $\qquad relerr = 10 \cdot \%$

Signal Rebuilding from samples

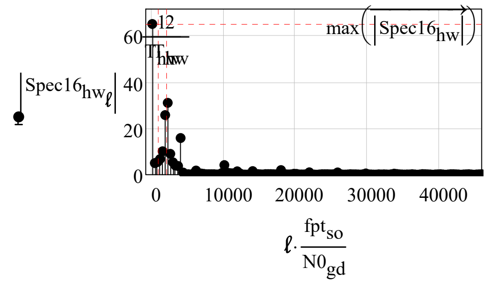


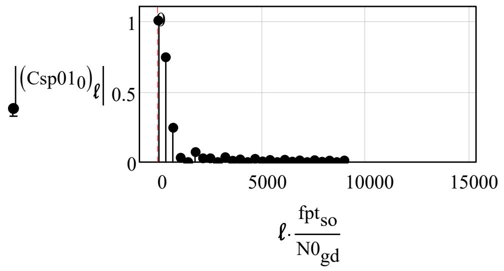
$length(u_{m16}) = 256$

$fpt_{so} = 92 \cdot kHz$

$Spec16_{hw} := fft(u_{m16})$ $\quad length(Spec16_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\quad \frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

17 Bipolar Sawtooth with positive slope Pulse Train

Period: $\quad T_{sawth\_} := 1 \cdot \delta_{sawth\_}$

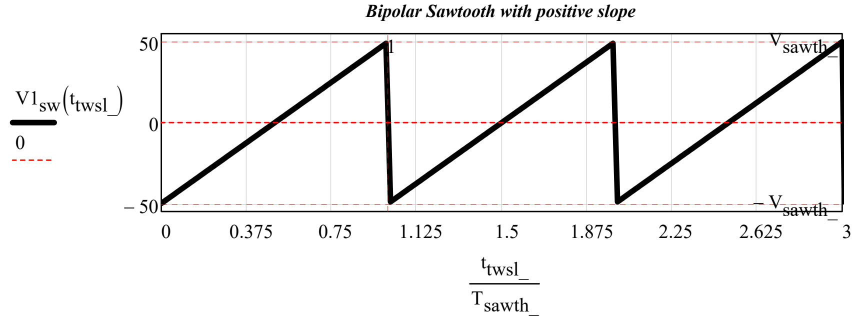
Frequency: $\quad f_{sawth\_} := \frac{1}{T_{sawth\_}}$ $\qquad f_{sawth\_} = 1 \cdot MHz$

$T_{sawth\_} = 1 \cdot \mu s$ $\qquad \omega_{sawth\_} := 2 \cdot \pi \cdot f_{sawth\_}$ $\qquad \omega_{sawth\_} = 6.283 \cdot \frac{Mrads}{sec}$

$t_{twsl\_} := 0, \frac{5 \cdot T_{sawth\_}}{500} .. 5 \cdot T_{sawth\_}$

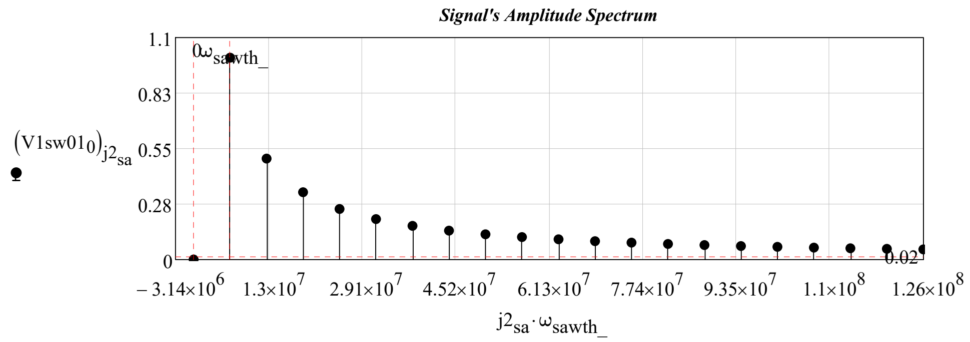
$$V1_{sw}(t) := \frac{v1_{sw}(t, T_{sawth\_}, V_{sawth\_}, N0_{gd})}{V}$$

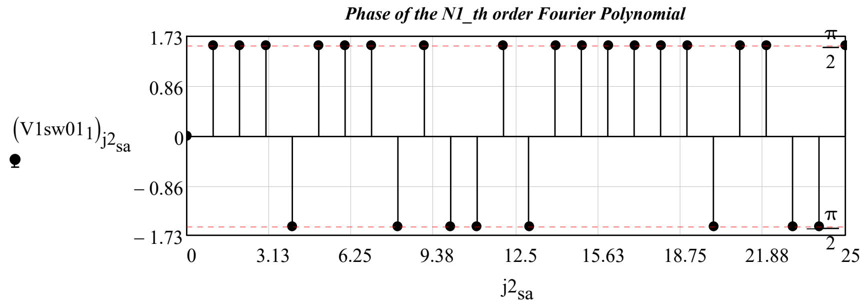
Bipolar Sawtooth with positive slope



$V1sw01 := SPCT(V1_{sw}, rt_{gd}, N1\_, 0 \cdot s, T_{sawth\_})$ $\qquad N1\_ = 25$

$j2_{sa} := 0 .. rows(V1sw01_0) - 1$ $\qquad \omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \frac{Mrads}{s}$





$Bw_{sa} := V1sw01_3 \cdot Hz$

$Bw_{sa} = 23 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 46 \cdot MHz$

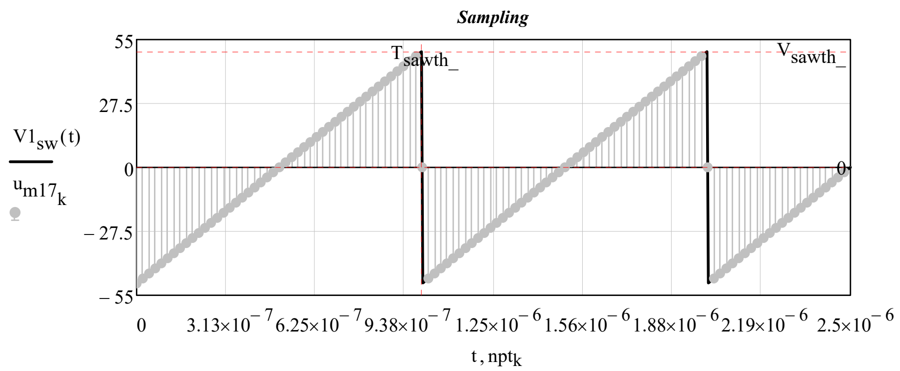
$npt_k := \frac{k}{fpt_{so}}$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{sawth\_}} = 5.565$

$u_{m17_k} := V1_{sw}(npt_k)$

$u_{m17}^T =$

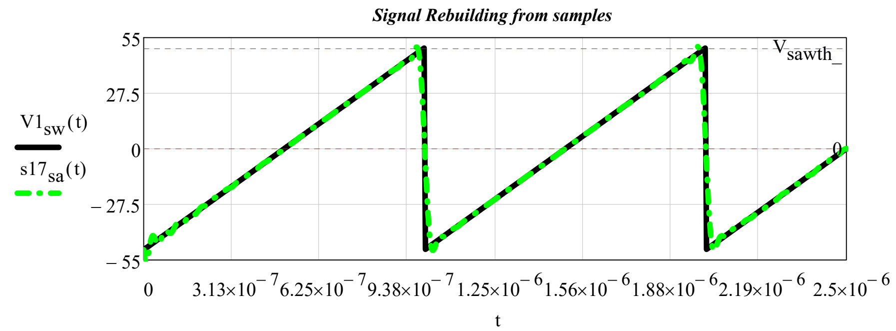
	0	1	2	3	4
0	-50	-47.826	-45.652	-43.478	...



relerr = 10·% $\quad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\quad \omega_{bwr} = 144.513 \cdot \frac{Mrads}{sec}$ $\quad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s17_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m17_n} \cdot \text{sinc}(\omega_{bwr} \cdot t - n \cdot \pi) \right) \right]$ $\quad N0_{gd} - 1 = 255$ $\quad$ relerr = 10·%

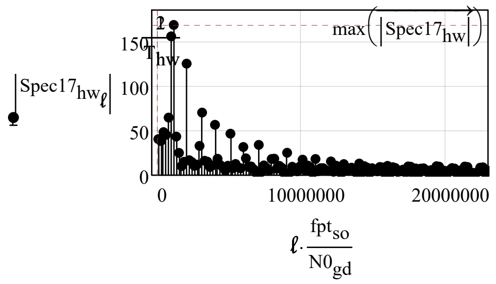


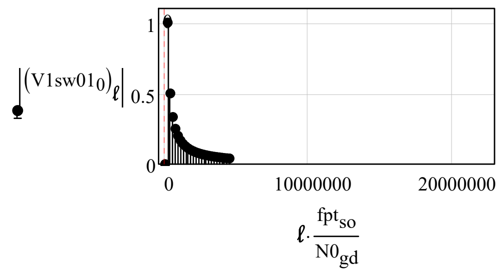
$\text{length}(u_{m17}) = 256$

$fpt_{so} = 46 \cdot MHz$

$Spec17_{hw} := \text{fft}(u_{m17})$ $\quad \text{length}(Spec17_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\quad \frac{N0_{gd}}{2} = 128$





Periodic Waveforms

18 Bipolar Sawtooth with negative slope Pulse Train

Amplitude: $V_{sawth\_} = 50 \cdot V$

Sawtooth length: $\delta_{sawth\_} = 1 \cdot \mu s$

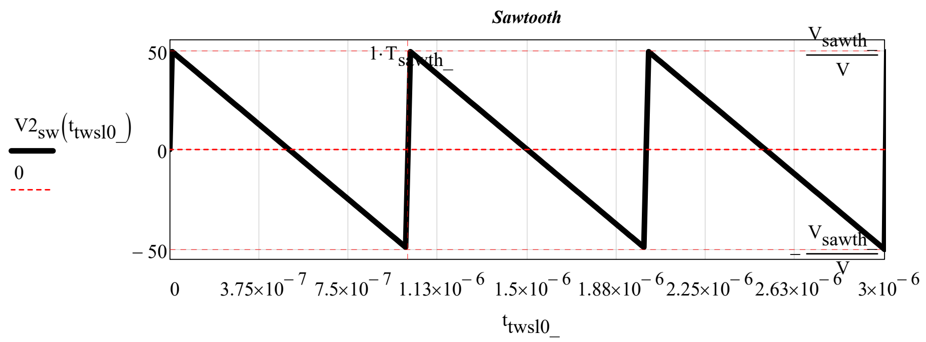
Slope: $sp_{sawth\_} = 50 \cdot \frac{V}{\mu s}$

Period: $T_{sawth\_} = 1 \cdot \mu s$

Frequency: $\frac{1}{T_{sawth\_}} = 1 \cdot MHz$

$$t_{twsl0\_} := -T_{sawth\_} \cdot 0, T_{sawth\_} \cdot 0 + \frac{5 \cdot T_{sawth\_} + T_{sawth\_} \cdot 0}{500} .. 5 \cdot T_{sawth\_}$$

$$V2_{sw}(t) := \frac{v2_{sw}\left(t, T_{sawth\_}, V_{sawth\_}, N0_{gd}\right)}{V}$$



Dirichlet conditions

A periodic function s(t)=s(t+T), can be expressed by the Fourier series provided that (Dirichlet conditions):
(1) it is discontinuous and presents a finite number of discontinuities in the period T;
(2) has a limited average value in the period T;
(3) it has a finite number of maximum positive or negative.
If these conditions are met, the considered function can be developed in Fourier series in trigonometric form.

The Dirichlet conditions apply to:

1) signals of energy for which holds: $\int_{-\infty}^{\infty} \left(\left|s_{fs}(t)\right|\right)^2 dt < \infty$,

2) power signals for which holds: $\lim_{T \to \infty} \left[\frac{1}{T} \cdot \int_{-T}^{T} \left(\left|s_{fs}(t)\right|\right)^2 dt\right] < \infty$

Fourier series definition

$$s_{fs}(t) = \frac{a_0}{2} + \sum_{k=1}^{\infty} \left(a_k \cos(\omega \cdot k \cdot t) + b_k \cdot \sin(\omega \cdot k \cdot t)\right)$$

The coefficients are defined as follows:

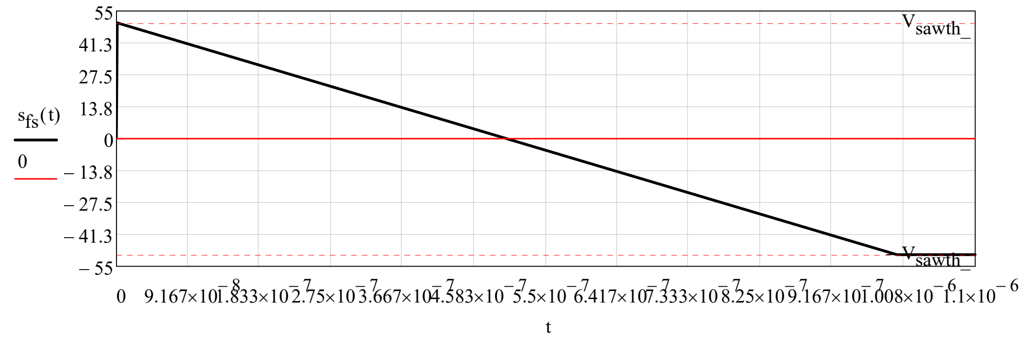
$$\frac{a_0}{2} = A_{fs} = \frac{1}{T} \cdot \int_{t_0}^{t_0+T} s_{fs}(t)\, dt$$

$$a_k = \frac{2}{T} \cdot \int_{t_0}^{t_0+T} s_{fs}(t) \cdot \cos(\omega \cdot k \cdot t)\, dt$$

$$b_k = \frac{2}{T} \cdot \int_{t_0}^{t_0+T} s_{fs}(t) \cdot \sin(\omega \cdot k \cdot t)\, dt$$

$V_{sawth\_} = 50\,V$

$$s_{fs}(t) := 2 \cdot V_{sawth\_} \cdot \left[\left(\frac{-t}{T_{sawth\_}} + 1\right) \cdot \left(\Phi(t) - \Phi\left(t - T_{sawth\_}\right)\right) - \frac{1}{2}\right]$$



$$\frac{a_0}{2} = A_{fs} = \frac{2 \cdot V_{sawth\_}}{T_{sawth\_}} \cdot \int_{t,0}^{t_0+T_{so}} \left(\frac{-t}{T_{sawth\_}} + 1\right) \cdot \left(\Phi(t) - \Phi\left(t - T_{sawth\_}\right)\right) - \frac{1}{2}\, dt = \frac{2 \cdot V_{sawth\_}}{T_{sawth\_}} \cdot \int_{0}^{T_{sawth\_}} \left(\frac{-t}{T_{sawth\_}} + \frac{1}{2}\right) dt$$

$$\frac{2 \cdot V_{sawth\_}}{T_{sawth\_}} \cdot \int_{0}^{T_{sawth\_}} \left(\frac{-t}{T_{sawth\_}} + \frac{1}{2}\right) dt = 0$$

$$a_k = \frac{2}{T} \cdot \int_{t_0}^{t_0+T} s_{fs}(t) \cdot \cos(\omega \cdot k \cdot t)\, dt = 2 \cdot \frac{2 \cdot V_{sawth\_}}{T_{sawth\_}} \cdot \int_{0}^{T_{sawth\_}} \left(\frac{-t}{T_{sawth\_}} + \frac{1}{2}\right) \cdot \cos(\omega \cdot k \cdot t)\, dt$$

$$2 \cdot \frac{2 \cdot V_{sawth\_}}{T_{sawth\_}} \cdot \int_{0}^{T_{sawth\_}} \left(\frac{-t}{T_{sawth\_}} + \frac{1}{2}\right) \cdot \cos(\omega \cdot k \cdot t)\, dt = \frac{2 \cdot V_{sawth\_} \cdot \left(4 \cdot \sin\left(\frac{T_{sawth\_} \cdot \omega \cdot k}{2}\right)^2 - T_{sawth\_} \cdot \omega \cdot k \cdot \sin\left(T_{sawth\_} \cdot \omega \cdot k\right)\right)}{T_{sawth\_}{}^2 \cdot \omega^2 \cdot k^2}$$

$$a_k = \frac{2 \cdot V_{sawth\_} \cdot \left(4 \cdot \sin\left(\frac{T_{sawth\_} \cdot \omega \cdot k}{2}\right)^2 - T_{sawth\_} \cdot \omega \cdot k \cdot \sin\left(T_{sawth\_} \cdot \omega \cdot k\right)\right)}{T_{sawth\_}{}^2 \cdot \omega^2 \cdot k^2}$$

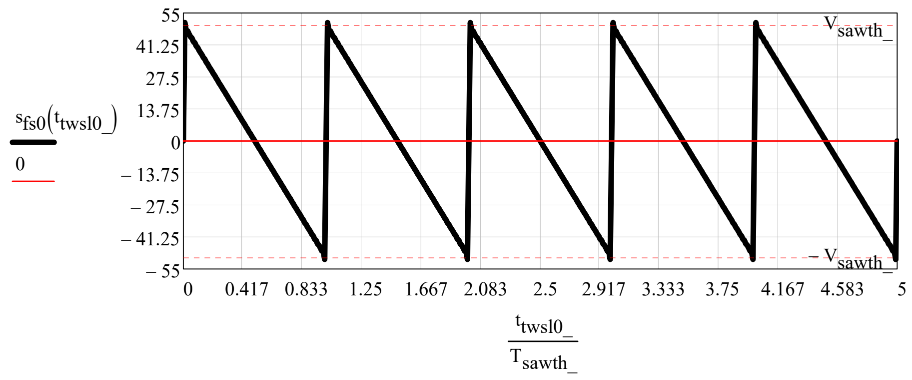
$$b_k = \frac{2}{T} \cdot \int_{t_0}^{t_0+T} s_{fs}(t) \cdot \sin(\omega \cdot k \cdot t)\, dt = 2 \cdot \frac{2 \cdot V_{sawth\_}}{T_{sawth\_}} \cdot \int_{t_0}^{t_0+T} \left(\frac{-t}{T_{sawth\_}} + \frac{1}{2}\right) \cdot \sin(\omega \cdot k \cdot t)\, dt$$

$$2 \cdot \frac{2 \cdot V_{sawth\_}}{T_{sawth\_}} \cdot \int_{t_0}^{t_0+T} \left(\frac{-t}{T_{sawth\_}} + \frac{1}{2}\right) \cdot \sin(\omega \cdot k \cdot t)\, dt = \left(\cos\left(\frac{T_{sawth\_} \cdot \omega \cdot k}{2}\right)^2 - \frac{\sin\left(T_{sawth\_} \cdot \omega \cdot k\right)}{T_{sawth\_} \cdot \omega \cdot k}\right) \cdot \frac{4 \cdot V_{sawth\_}}{\left(T_{sawth\_} \cdot \omega \cdot k\right)}$$

$$b_k = \left(\cos\left(\frac{T_{sawth\_} \cdot \omega \cdot k}{2}\right)^2 - \frac{\sin\left(T_{sawth\_} \cdot \omega \cdot k\right)}{T_{sawth\_} \cdot \omega \cdot k}\right) \cdot \frac{4 \cdot V_{sawth\_}}{\left(T_{sawth\_} \cdot \omega \cdot k\right)}$$

$\omega_{sf} := \omega_{sawth\_}$

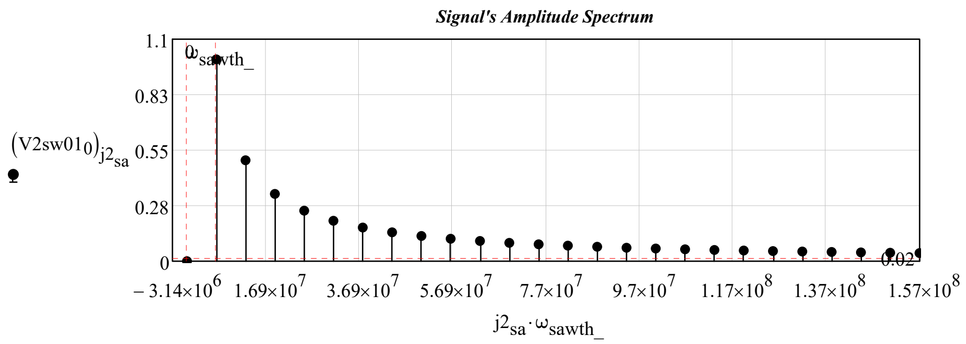
$$s_{fs0}(t) := \frac{2 \cdot V_{sawth\_}}{(T_{sawth\_} \cdot \omega_{sf})} \cdot \sum_{k=1}^{N0_{gd}} \left[\frac{4 \cdot \sin\left(\frac{T_{sawth\_} \cdot \omega_{sf} \cdot k}{2}\right)^2 - T_{sawth\_} \cdot \omega_{sf} \cdot k \cdot \sin(T_{sawth\_} \cdot \omega_{sf} \cdot k)}{T_{sawth\_} \cdot \omega_{sf} \cdot k} \cos(\omega_{sf} \cdot k \cdot t) \ldots \right. \\ \left. + \left(\cos\left(\frac{T_{sawth\_} \cdot \omega_{sf} \cdot k}{2}\right)^2 - \frac{\sin(T_{sawth\_} \cdot \omega_{sf} \cdot k)}{T_{sawth\_} \cdot \omega_{sf} \cdot k} \right) \cdot \frac{2}{k} \cdot \sin(\omega_{sf} \cdot k \cdot t) \right]$$

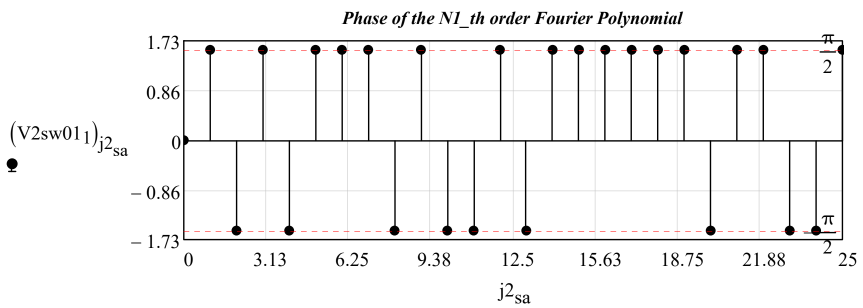


$V_{sawth\_} = 50\,V$

$V2sw01 := SPCT(V2_{sw}, rt_{gd}, N1\_, 0 \cdot s, T_{sawth\_})$ $\quad N1\_ = 25$

$j2_{sa} := 0 .. rows(V2sw01_0) - 1$ $\quad \omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \frac{Mrads}{s}$





$Bw_{sa} := V2sw01_3 \cdot Hz$

$Bw_{sa} = 23 \cdot MHz$

sampling frequency: $\quad fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 46 \cdot MHz$

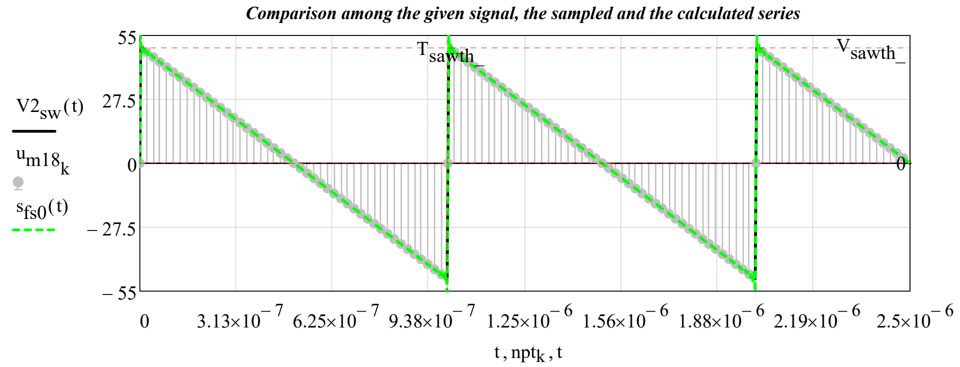
$npt_k := \frac{k}{fpt_{so}}$

Frequency resolution: $\quad \frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{sawth\_}} = 5.565$

$u_{m18_k} := V2_{sw}(npt_k)$

$u_{m18}^T =$

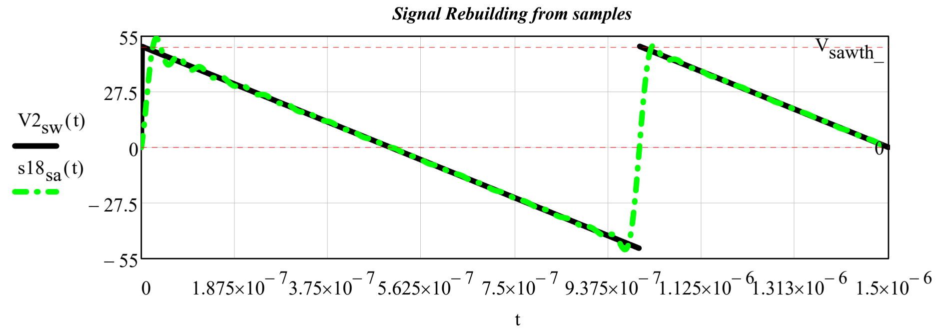
	0	1	2	3	4
0	0	47.826	45.652	43.478	...



$relerr = 10 \cdot \%$ $\quad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\quad \omega_{bwr} = 144.513 \cdot \frac{Mrads}{sec}$ $\quad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s18_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m18_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi) \right) \right]$ $\quad N0_{gd} - 1 = 255$ $\quad relerr = 10 \cdot \%$

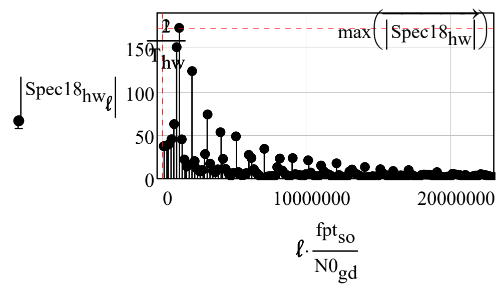


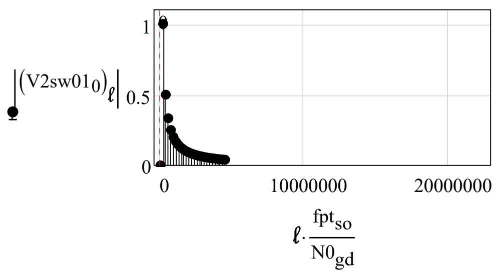
$length(u_{m18}) = 256$

$fpt_{so} = 46 \cdot MHz$

$Spec18_{hw} := fft(u_{m18})$ $\quad length(Spec18_{hw}) = 129$

$\ell := 0 .. \frac{N0_{gd}}{2}$ $\quad \frac{N0_{gd}}{2} = 128$





TEST Waveforms

Periodic Waveforms

19 Bipolar Sawtooth with adjustable rising and falling edges Pulse Train

$\delta_{cycl} \cdot T_{sl} = 200 \cdot ns$

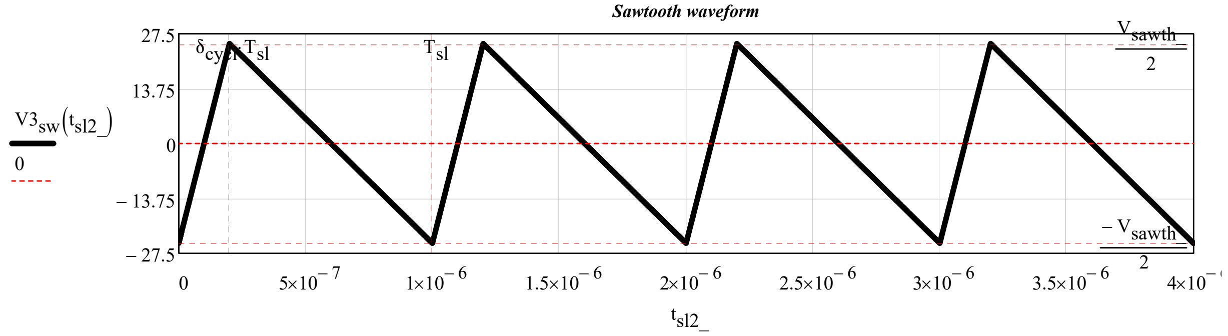
$T_{sl} = 1 \cdot \mu s$ $\qquad f_{3sw} := \frac{1}{T_{sl}} \qquad \omega_{3sw} := 2 \cdot \pi \cdot f_{3sw} \quad \omega_{3sw} = 6.283 \cdot \frac{Mrads}{sec}$

$\delta_{cycl} = 20 \cdot \%$

$$t_{sl2\_} := 0 \cdot T_{sl}, 0 \cdot T_{sl} + \frac{4 \cdot T_{sl}}{10000} .. 4 \cdot T_{sl}$$

$$V3_{sw}(t) := \frac{V_s\left(t \cdot sec^{-1}, T_{sl} \cdot sec^{-1}, \delta_{cycl}, V_{sawth\_}, N_{gd}\right)}{V}$$

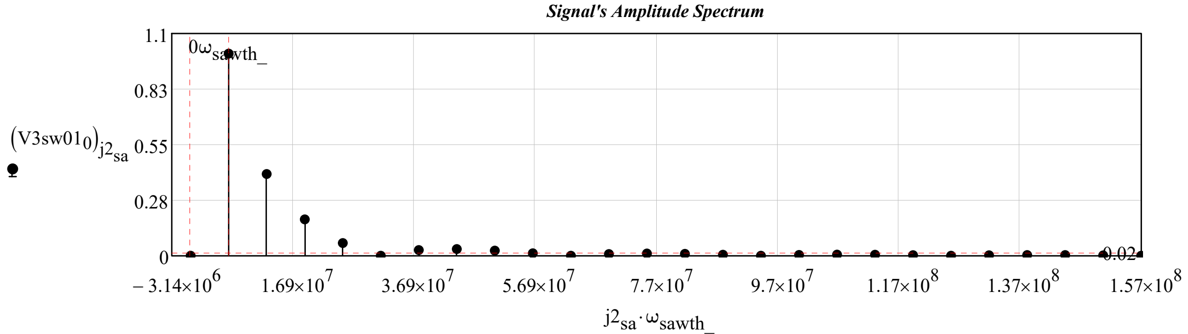
Sawtooth waveform



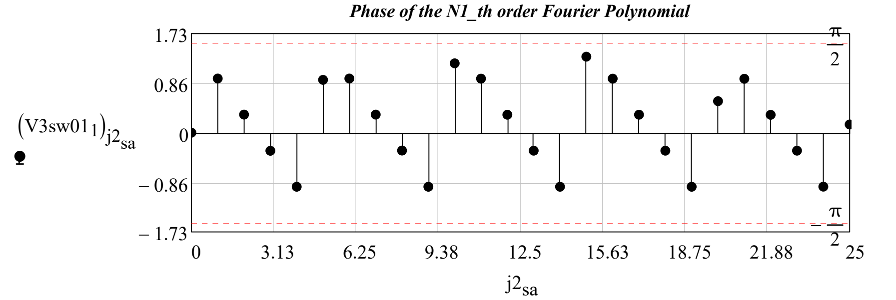
$V3sw01 := SPCT\left(V3_{sw}, rt_{gd}, N1\_, 0 \cdot s, T_{sawth\_}\right) \qquad N1\_ = 25$

$j2_{sa} := 0 .. rows(V3sw01_0) - 1 \qquad \omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := V3sw01_3 \cdot Hz$

$Bw_{sa} = 13 \cdot MHz$

sampling frequency: $\quad fpt_{so} := 2 \cdot Bw_{sa} \qquad fpt_{so} = 26 \cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

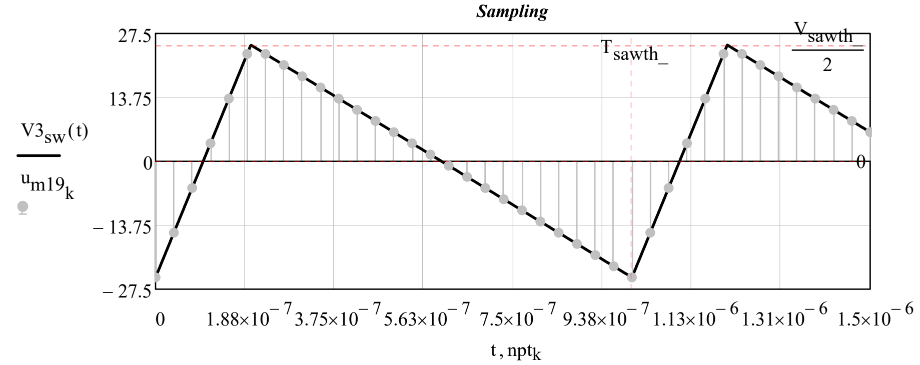
Frequency resolution: $\quad \frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{sawth\_}} = 9.846$

$u_{m19_k} := V3_{sw}(npt_k)$

$u_{m19}{}^T =$

	0	1	2	3	4	5	6
0	-25	-15.385	-5.769	3.846	13.462	23.077	...

Sampling

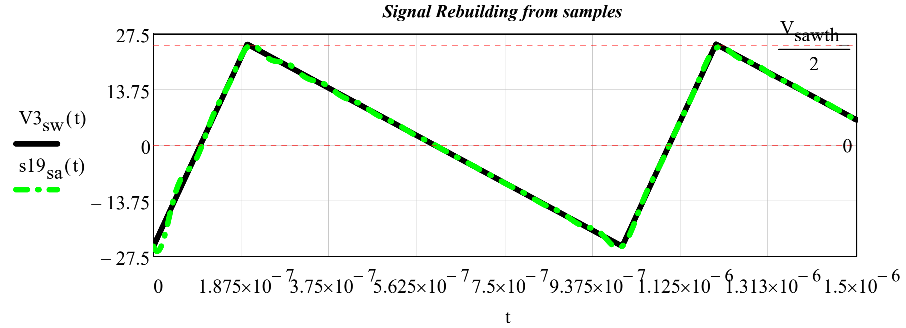


$relerr = 10 \cdot \%$ $\qquad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa} \qquad \omega_{bwr} = 81.681 \cdot \frac{Mrads}{sec} \qquad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s19_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m19_n} \cdot sinc\left(\omega_{bwr} \cdot t - n \cdot \pi\right)\right)\right] \qquad N0_{gd} - 1 = 255 \qquad relerr = 10 \cdot \%$

Signal Rebuilding from samples



Periodic Waveforms

20 Dimensionless (RC) Pulse Train

$T_{rcsl} := T_{0gd}$ $\quad \alpha_{rcsl} := 0.3$ $\quad Bw_{rcsl} := \dfrac{1+\alpha_{rcsl}}{2 \cdot T_{0gd}}$

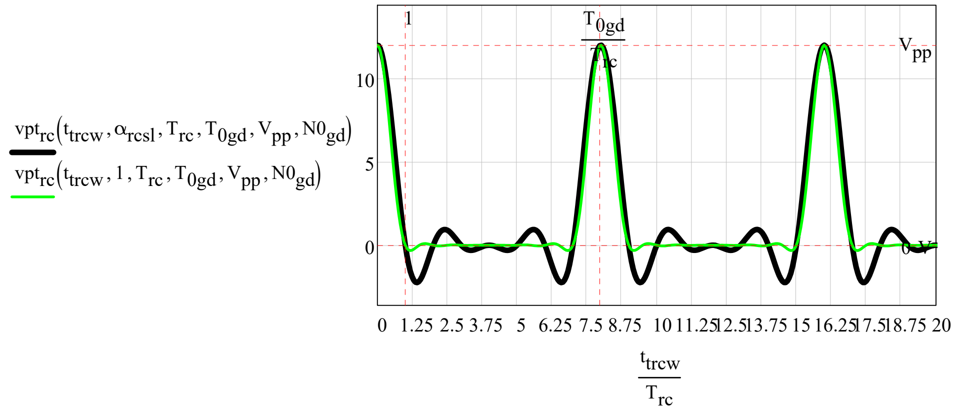
$T_{0gd} = 1 \times 10^{3} \cdot \mu s$ $\qquad Bw_{rcsl} = 650 \cdot Hz$

$$T_{rc} := \frac{T_{0gd}}{8}$$

$$Vpt0_{rc}(t) := \frac{vpt_{rc}(t, \alpha_{rcsl}, T_{rc}, T_{0gd}, V_{pp}, N0_{gd})}{V}$$

$\alpha_{rcsl} = 0.3$ $\qquad t_{rcw} := -20 \cdot T_{rc}, -20 \cdot T_{rc} + \dfrac{40 \cdot T_{rc} + 20 \cdot T_{rc}}{1000} .. 40 \cdot T_{rc}$

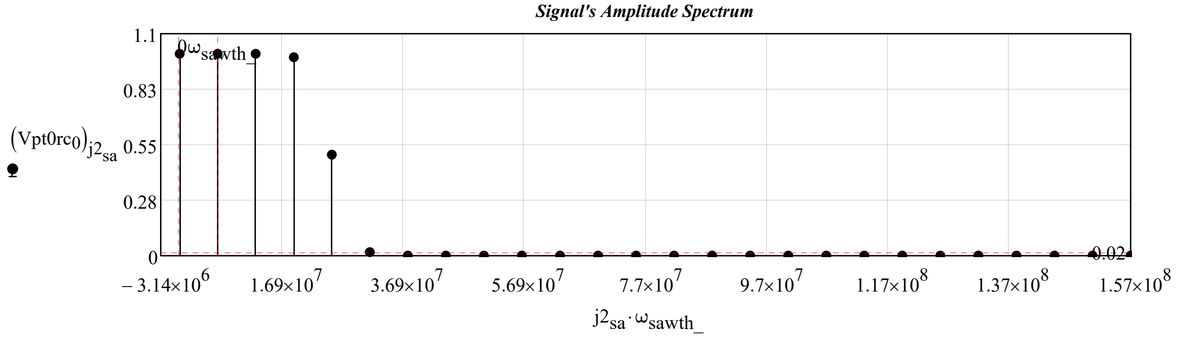
Raised-Cosine (RC) Pulse Train for α:0.3 and α=1



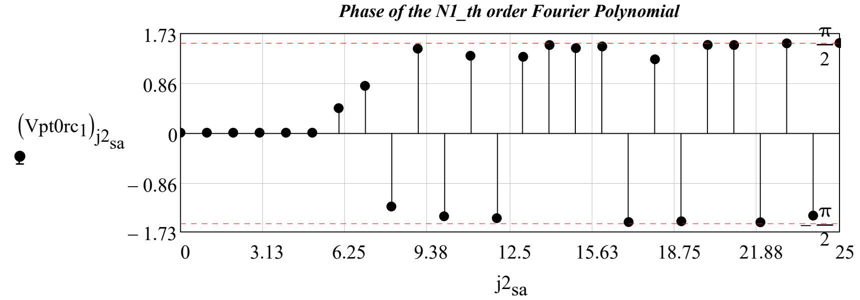
$\alpha_{rcsl} = 0.3$ $\quad Vpt0rc := SPCT(Vpt0_{rc}, rt_{gd}, N1\_, 0 \cdot s, T_{0gd})$ $\qquad N1\_ = 25$

$j2_{sa} := 0 .. rows(Vpt0rc_{0}) - 1$ $\qquad \omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \dfrac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := Vpt0rc_{3} \cdot Hz$

$Bw_{sa} = 5 \times 10^{-3} \cdot MHz$

sampling frequency: $\quad fpt_{so} := 2 \cdot Bw_{sa}$ $\qquad fpt_{so} = 0.01 \cdot MHz$

$$npt_{k} := \frac{k}{fpt_{so}}$$

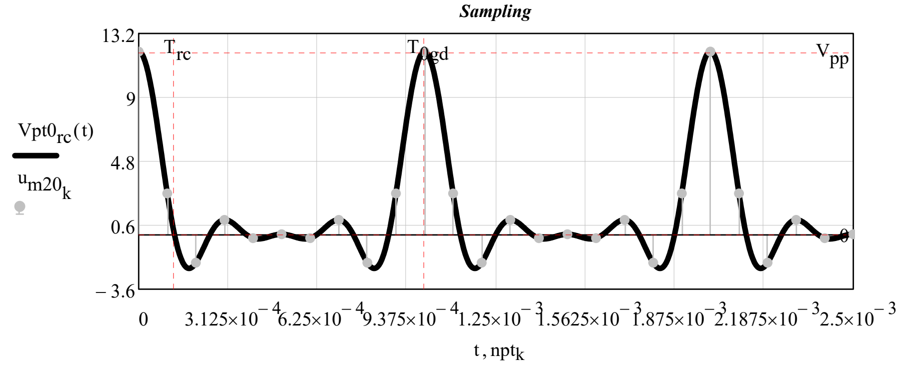
Frequency resolution: $\quad \dfrac{N0_{gd}}{fpt_{so}} \cdot \dfrac{1}{T_{rc}} = 204.8$

$$u_{m20_{k}} := Vpt0_{rc}(npt_{k})$$

$u_{m20}^{T} =$

	0	1	2	3	4
0	12	2.678	-1.871	0.944	...

Sampling

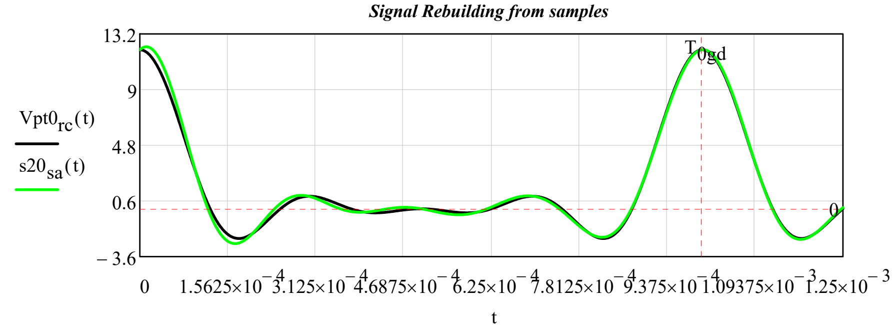


relerr = 10·% $\qquad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\quad \omega_{bwr} = 0.031 \cdot \dfrac{Mrads}{sec}$ $\qquad n \cdot \dfrac{\pi}{\omega_{bwr}} = n \cdot \dfrac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s20_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m20_{n}} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi)\right)\right]$ $\qquad N0_{gd} - 1 = 255$ $\qquad$ relerr = 10·%

Signal Rebuilding from samples



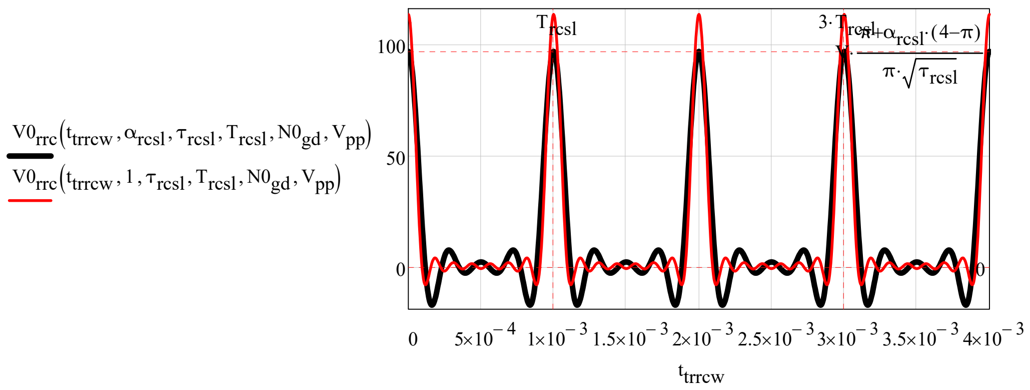
Periodic Waveforms

21 Root Raised-Cosine (RC) Pulse Train

$$\tau_{rcsl} := \frac{T_{0gd}}{8} \qquad T_{0gd} = 1\times10^{3}\cdot\mu s \qquad Bw_{rcsl} = 650\cdot Hz$$

$$V0_{rrc}\left(t_{trrcw},\alpha_{rcsl},\tau_{rcsl},T_{rcsl},N0_{gd},V_{pp}\right) := V_{rrc}\left(t_{trrcw},\alpha_{rcsl},\tau_{rcsl},T_{rcsl},N0_{gd},\frac{V_{pp}}{V}\right)$$

Root Raised-Cosine (RRC) Pulse Train



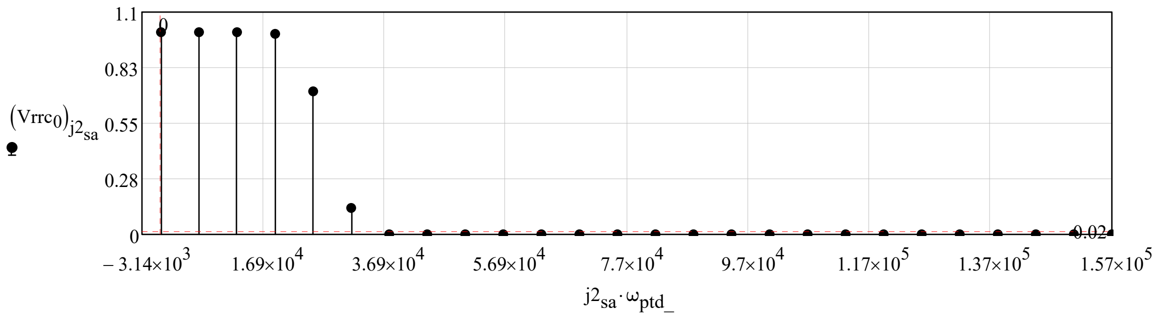
$$vrrc(t) := V_{rrc}\left(t,\alpha_{rcsl},\tau_{rcsl},T_{rcsl},N0_{gd},\frac{V_{pp}}{V}\right)$$

$$t_{trcw} := -20\cdot T_{rcsl}, -20\cdot T_{rcsl} + \frac{20\cdot T_{rcsl} + 20\cdot T_{rcsl}}{1000} .. 20\cdot T_{rcsl}$$

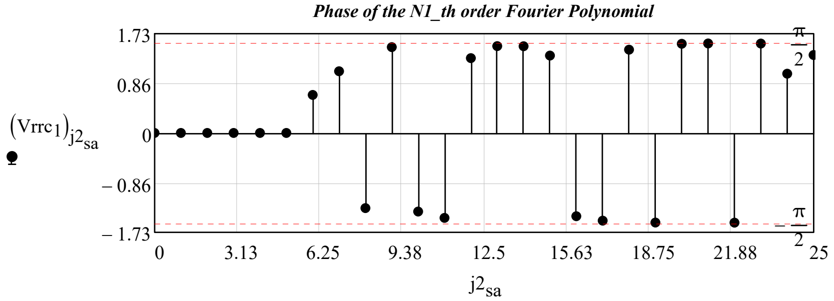
$$Vrrc := SPCT\left(vrrc, rt_{gd}, N1\_, 0\cdot s, T_{rcsl}\right) \qquad N1\_ = 25$$

$$j2_{sa} := 0 .. rows\left(Vpt0rc_0\right) - 1 \qquad \omega_{ptd\_} = 6.283\times10^{-3}\cdot\frac{Mrads}{s}$$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$$Bw_{sa} := Vrrc_3\cdot Hz$$

$$Bw_{sa} = 5\times10^{-3}\cdot MHz$$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa} \qquad fpt_{so} = 0.01\cdot MHz$

$$npt_k := \frac{k}{fpt_{so}}$$

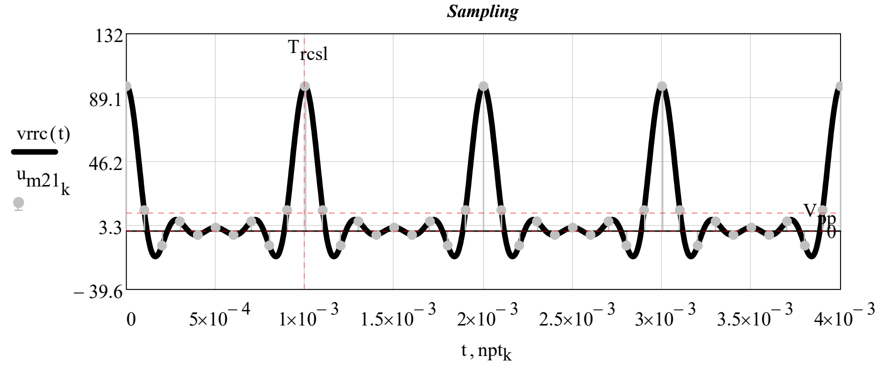
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}}\cdot\frac{1}{T_{rcsl}} = 25.6$

$$u_{m21_k} := vrrc\left(npt_k\right)$$

$u_{m21}{}^{T} =$

	0	1	2	3	4	5	6
0	96.801	13.619	-10.131	6.083	-3.022	1.904	...

Sampling

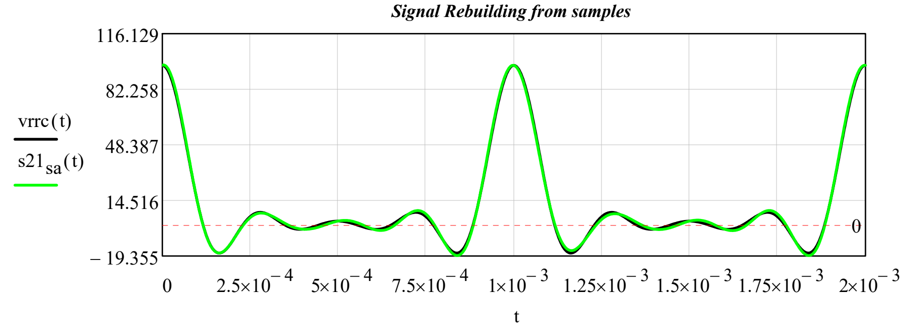


relerr = 10·% $\qquad \omega_{bwr} := 2\cdot\pi\cdot Bw_{sa} \qquad \omega_{bwr} = 0.031\cdot\frac{Mrads}{sec} \qquad n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\qquad s21_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m21_n}\cdot sinc\left(\omega_{bwr}\cdot t - n\cdot\pi\right)\right)\right] \qquad N0_{gd} - 1 = 255 \qquad relerr = 10\cdot\%$

Signal Rebuilding from samples



TEST Waveforms

Periodic Waveforms

22 AM test signal (single tone)

Carrier Amplitude: $A1_{sl} := 20\cdot volt$

Modulating signal's amplitude: $B1_{sl} := 12\cdot volt$ $\qquad \omega_{0gd} = 6.283\cdot\frac{krads}{s}$

$\omega1_{csl} := 15\cdot\omega_{0gd}$ $\quad T1_{csl} := \frac{2\cdot\pi}{\omega1_{csl}}$ $\quad \omega1_{msl} := \frac{\omega1_{csl}}{10}$ $\quad T1_{msl} := \frac{2\cdot\pi}{\omega1_{msl}}$ $\quad f1_{msl} := \frac{\omega1_{msl}}{2\cdot\pi}$ $\quad f_{15sl} := \frac{\omega1_{csl}}{2\cdot\pi}$

$\omega1_{csl} = 94.248\cdot\frac{krads}{sec}$ $\qquad \frac{\omega1_{csl}}{\omega1_{msl}} = 10$

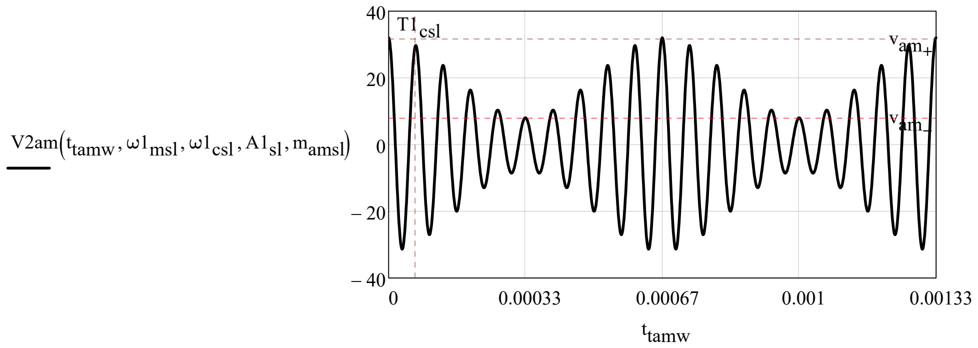
$v_{am_+} := A1_{sl} + B1_{sl}$ $\qquad v_{am\_} := A1_{sl} - B1_{sl}$ $\qquad A1_{sl} = v_{am_+} + v_{am\_}$ $\qquad B1_{sl} = v_{am_+} - v_{am\_}$

$v_{am_+} = 32\cdot volt$

$v_{am\_} = 8\cdot volt$ $\qquad m_{amsl} := \frac{v_{am_+} - v_{am\_}}{v_{am_+} + v_{am\_}}$ $\qquad m_{amsl} = 60\cdot\%$ $\qquad \frac{B1_{sl}}{A1_{sl}} = 60\cdot\%$

$t_{tamw} := -T_{0gd}\cdot 3, -T_{0gd}\cdot 3 + \frac{20\cdot T1_{csl} + T_{0gd}\cdot 3}{5000} .. 20\cdot T1_{csl}$

AM Waveform

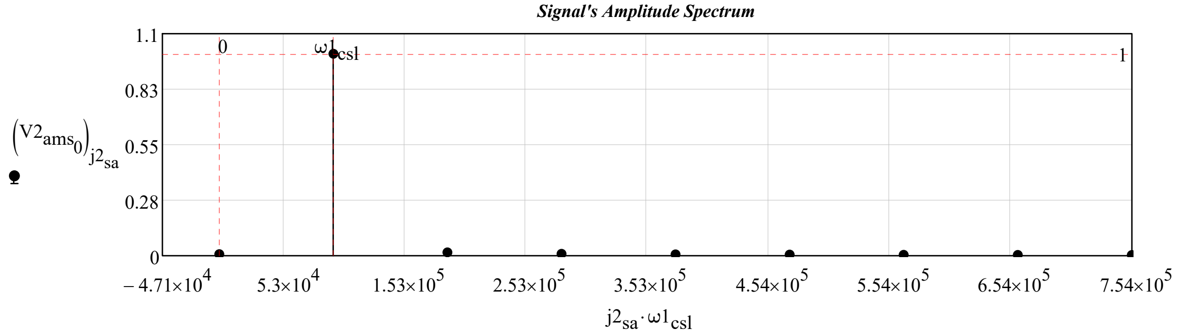


$N1\_ := 50$ $\qquad V2_{am}(t) := V2am(t, \omega1_{msl}, \omega1_{csl}, A1_{sl}, m_{amsl})$

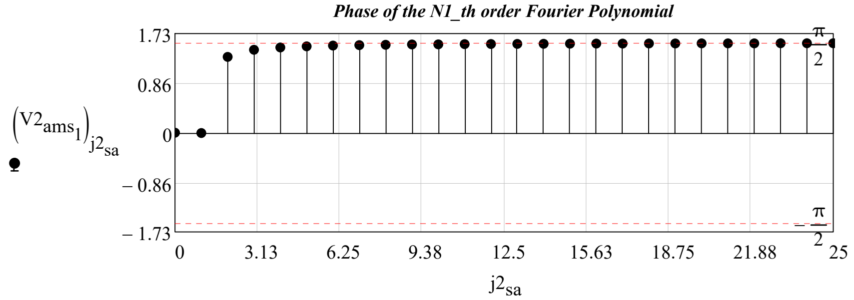
$V2_{ams} := SPCT(V2_{am}, rt_{gd}, N1\_, 0\cdot s, T1_{csl})$ $\qquad N1\_ = 25$

$j2_{sa} := 0 .. rows(Vpt0rc_0) - 1$ $\qquad \omega_{ptd\_} = 6.283\times10^{-3}\cdot\frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := V2_{ams_3}\cdot Hz$

$Bw_{sa} = 0.075\cdot MHz$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa}$ $\qquad fpt_{so} = 0.15\cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

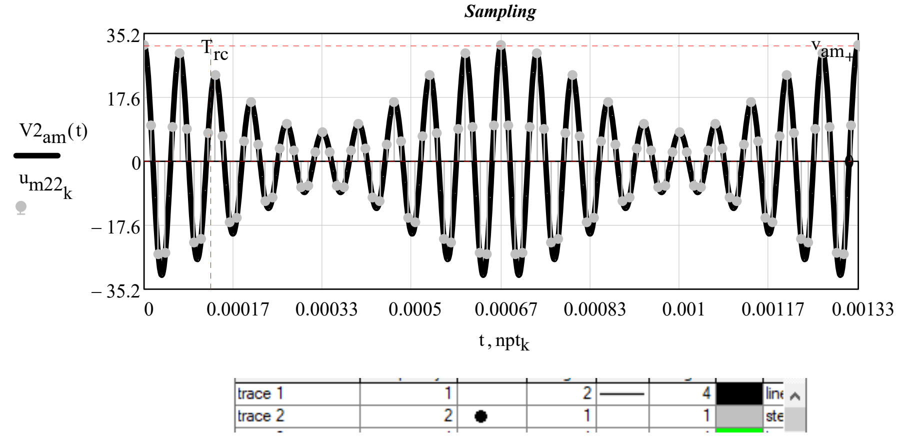
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}}\cdot\frac{1}{T_{rc}} = 13.653$

$u_{m22_k} := V2_{am}(npt_k)$

$u_{m22}^T =$

	0	1	2	3	4	5	6
0	32	25.869	9.859	-9.823	-25.584	-31.413	...

Sampling

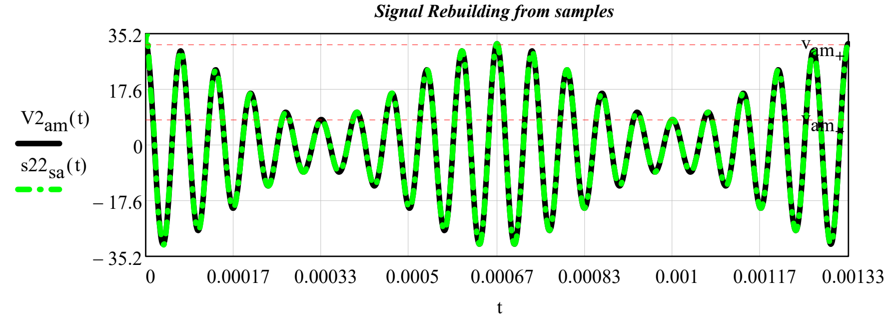


$relerr = 10\cdot\%$ $\qquad \omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\qquad \omega_{bwr} = 0.471\cdot\frac{Mrads}{sec}$ $\qquad n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\qquad s22_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m22_n}\cdot sinc(\omega_{bwr}\cdot t - n\cdot\pi)\right)\right]$ $\qquad N0_{gd} - 1 = 255$ $\qquad relerr = 10\cdot\%$

Signal Rebuilding from samples



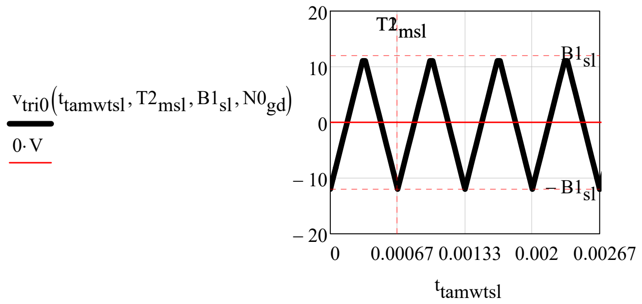
Periodic Waveforms

23 AM test signal (triangular wave)

$$\omega_{2msl} := \frac{\omega 1_{csl}}{10} \qquad T2_{msl} := \frac{2\cdot\pi}{\omega_{2msl}}$$

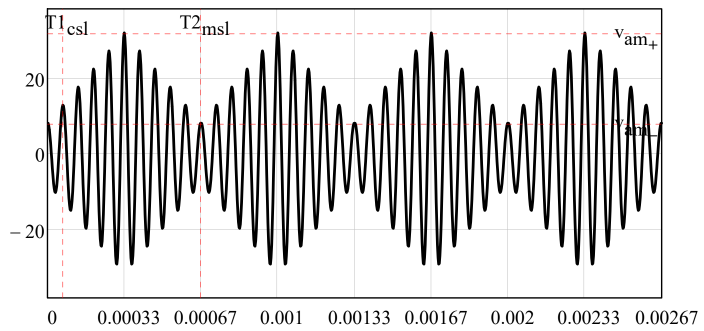
$$t_{tamwtsl} := 0\cdot sec, 40\cdot\frac{T2_{msl}}{1000} .. 40\cdot T2_{msl}$$

Madulating Signal



$$t_{twsl\_} := -T_{0gd}\cdot 3, -T_{0gd}\cdot 3 + \frac{8\cdot T2_{msl} + T_{0gd}\cdot 3}{500} .. 8\cdot T2_{msl}$$

AM Waveform

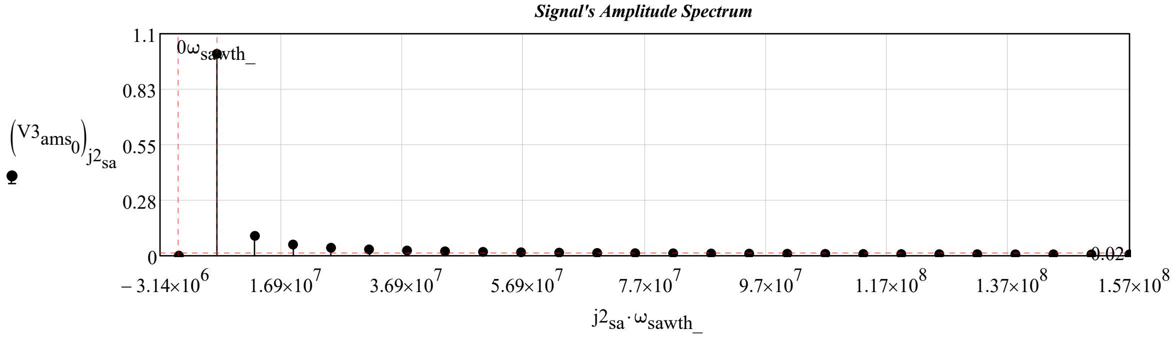


$$V3_{am}(t) := V3am\left(t, \omega 1_{msl}, \omega 1_{csl}, m_{amsl}, A1_{sl}, B1_{sl}, N0_{gd}\right)$$

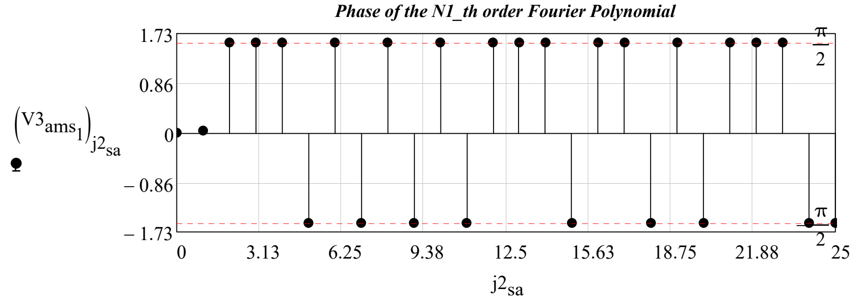
$$V3_{ams} := SPCT\left(V3_{am}, rt_{gd}, N1\_, 0\cdot s, T1_{csl}\right) \qquad N1\_ = 25$$

$$j2_{sa} := 0 .. rows\left(Vpt0rc_0\right) - 1 \qquad \omega_{ptd\_} = 6.283\times 10^{-3}\cdot\frac{Mrads}{s}$$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$$Bw_{sa} := V3_{ams_3}\cdot Hz$$

$$Bw_{sa} = 0.345\cdot MHz$$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa}$ $\qquad fpt_{so} = 0.69\cdot MHz$

$$npt_k := \frac{k}{fpt_{so}}$$

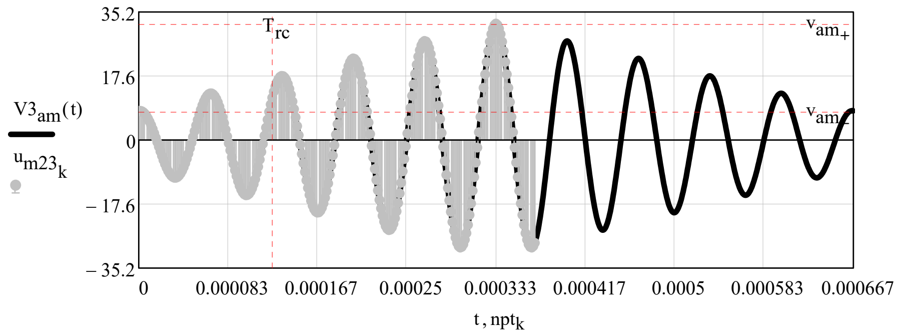
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}}\cdot\frac{1}{T_{rc}} = 2.968$

$$u_{m23_k} := V3_{am}\left(npt_k\right)$$

$u_{m23}{}^T =$

	0	1	2	3	4	5	6
0	8	8.029	7.904	7.625	7.192	6.61	...

Sampling

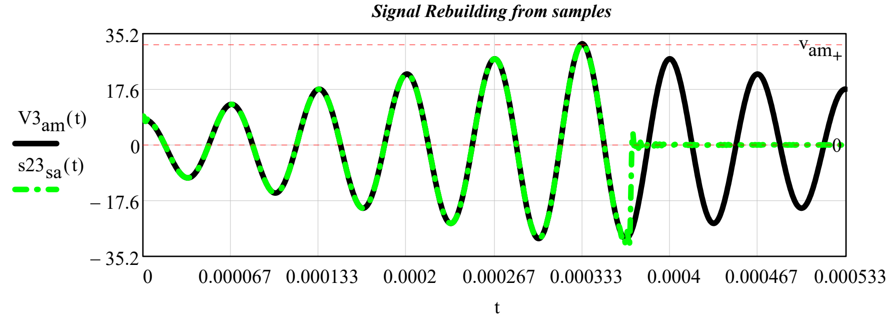


relerr = 10·% $\qquad \omega_{bwr} := 2\cdot\pi\cdot Bw_{sa} \qquad \omega_{bwr} = 2.168\cdot\frac{Mrads}{sec} \qquad n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\qquad s23_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m23_n}\cdot sinc\left(\omega_{bwr}\cdot t - n\cdot\pi\right)\right)\right] \qquad N0_{gd} - 1 = 255 \qquad$ relerr = 10·%

Signal Rebuilding from samples



TEST Waveforms

Periodic Waveforms

24 AM DSBSC test signal (single tone)

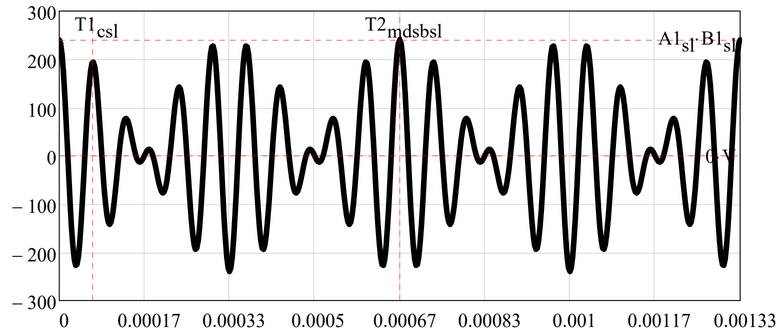
$\omega2_{msl} := \frac{\omega1_{csl}}{10}$ $T2_{mdsbsl} := \frac{2\cdot\pi}{\omega2_{msl}}$ $\omega2_{msl} = \frac{2\cdot\pi}{T2_{mdsbsl}}$ $\frac{A1_{sl}\cdot B1_{sl}}{2} = 120\cdot volt^2$

$\omega1_{csl} = 94.248\cdot\frac{krads}{sec}$ $\omega2_{msl} = 9.425\cdot\frac{krads}{sec}$ $f2_{msl} := \frac{1}{T2_{msl}}$ $f1_{csl} := \frac{\omega1_{csl}}{2\cdot\pi}$

$T_{1csl} := \frac{1}{f1_{csl}}$ $\nu_{sl} := 20$

$t_{tdsbw} := 0\cdot sec, \nu_{sl}\cdot\frac{T1_{csl}}{500} .. \nu_{sl}\cdot T1_{csl}$

DSBSC single tone

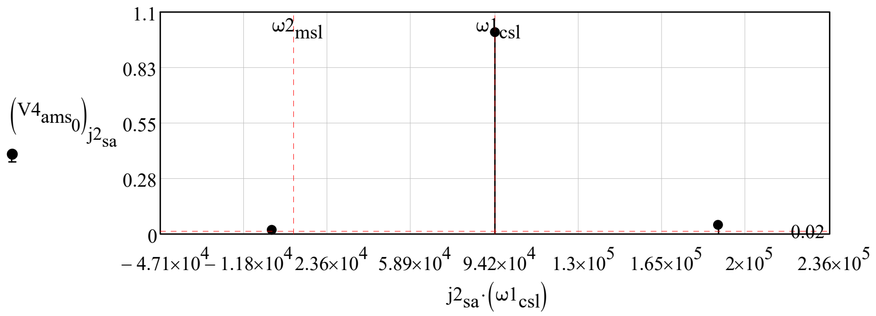


$V4_{am}(t) := V4dsbsc(t, f1_{csl}, f2_{msl}, A1_{sl}, B1_{sl})$

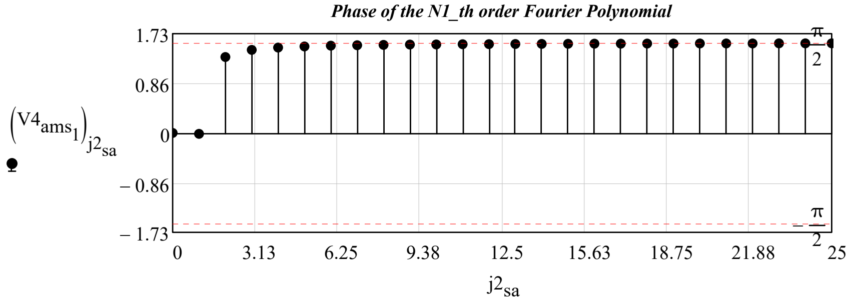
$V4_{ams} := SPCT(V4_{am}, rt_{gd}, N1\_, 0\cdot s, T1_{csl})$ $N1\_ = 25$

$j2_{sa} := 0 .. rows(V4_{ams_0}) - 1$ $\omega_{ptd\_} = 6.283\times10^{-3}\cdot\frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := V4_{ams_3}\cdot Hz$

$Bw_{sa} = 0.195\cdot MHz$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa}$ $fpt_{so} = 0.39\cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

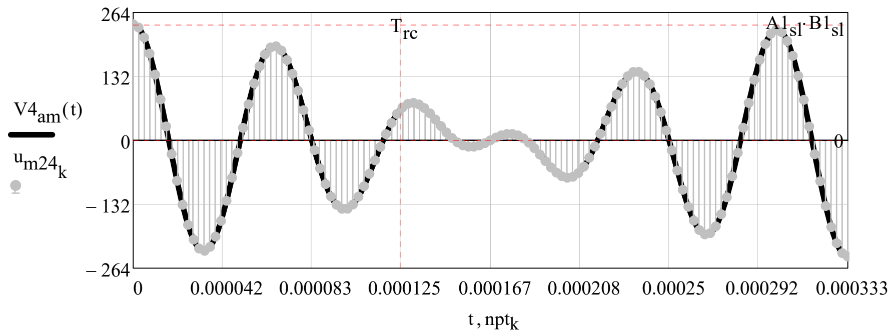
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}}\cdot\frac{1}{T_{rc}} = 5.251$

$u_{m24_k} := V4_{am}(npt_k)$

$u_{m24}^T =$

	0	1	2	3	4
0	240	232.958	212.261	179.171	...

Sampling

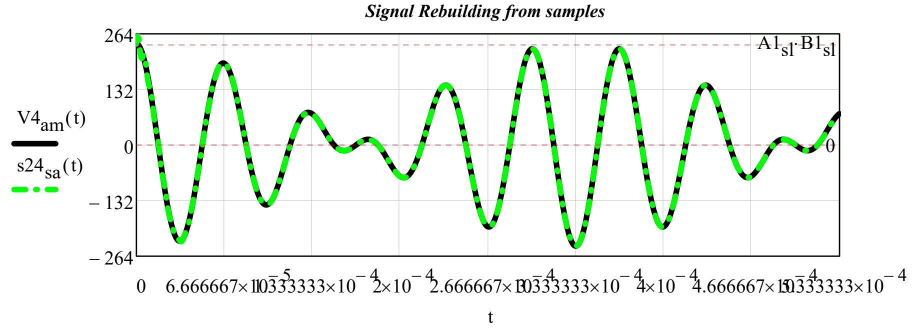


relerr = 10·% $\omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\omega_{bwr} = 1.225\cdot\frac{Mrads}{sec}$ $n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s24_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m24_n}\cdot sinc(\omega_{bwr}\cdot t - n\cdot\pi)\right)\right]$ $N0_{gd} - 1 = 255$ relerr = 10·%

Signal Rebuilding from samples



TEST Waveforms

Periodic Waveforms

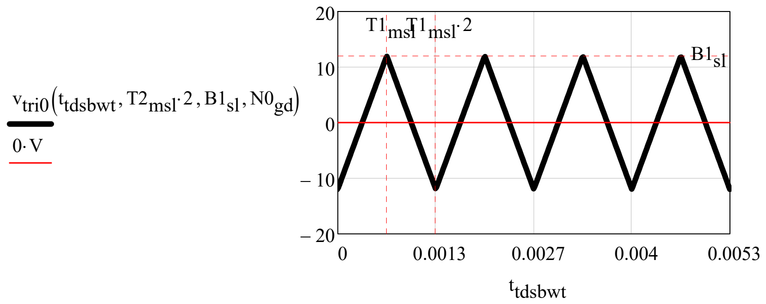
25 AM DSBSC test signal (triangular wave)

$T_{18} := T2_{mdsbsl}$

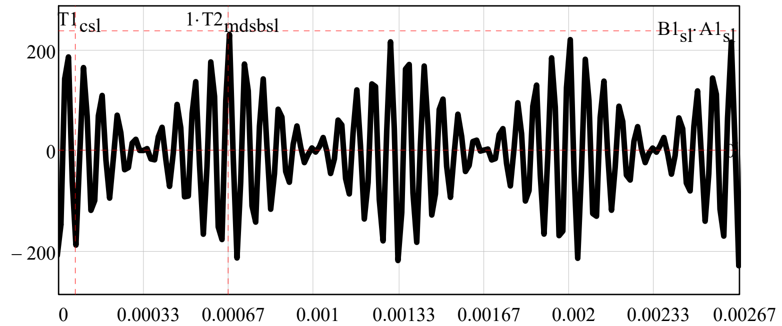
$f_{18} := \frac{1}{T_{18}}$

$t_{tdsbwt} := -T_{18}\cdot 3, -T_{18}\cdot 3 + \frac{8\cdot T_{18} + T_{18}\cdot 3}{500} .. 8\cdot T_{18}$

Modulating Signal



DSBSC Triangular wave modulated



$v5_{dsbsc}(t) := V5_{dsbsc}(t, T2_{mdsbsl}, f1_{csl}, f2_{msl}, A1_{sl}, B1_{sl}, N0_{gd})$ $v5_{dsbsc}(T2_{md}$

$N1\_ := 25$

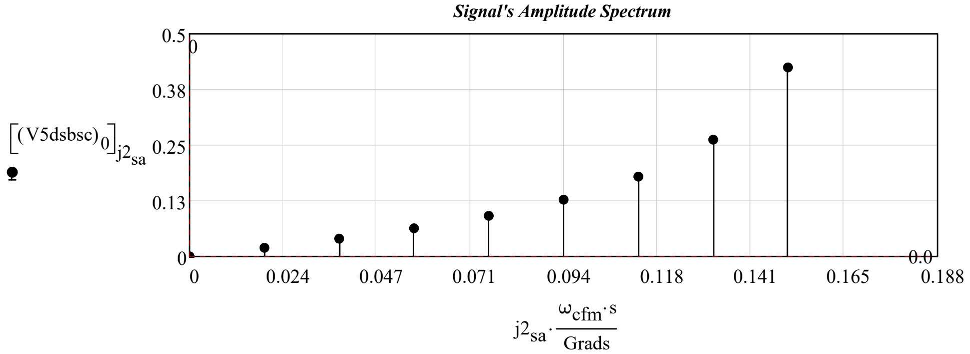
$f_{cfm} = 3\cdot MHz$

$V5dsbsc := SPCT(v5_{dsbsc}, rt_{gd}, N1\_, 0\cdot s, T2_{mdsbsl})$ $N1\_ = 25$

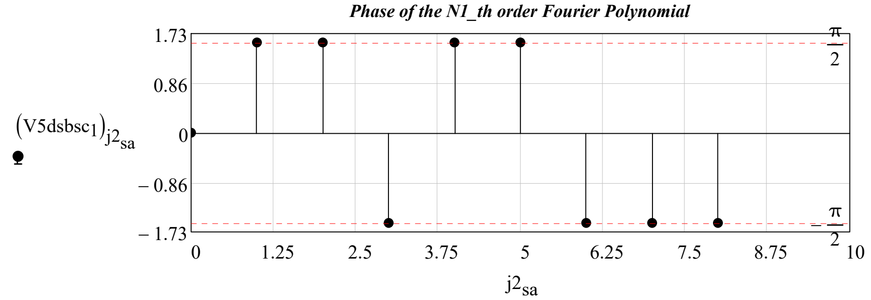
$\omega_{cfm} = 0.019\cdot\frac{Grads}{s}$

$j2_{sa} := 0 .. rows(V5dsbsc) - 1$ $\omega_{fmm} = 0.942\cdot\frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := V5dsbsc_3\cdot Hz$

$Bw_{sa} = 0.035\cdot MHz$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa}$ $fpt_{so} = 0.069\cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

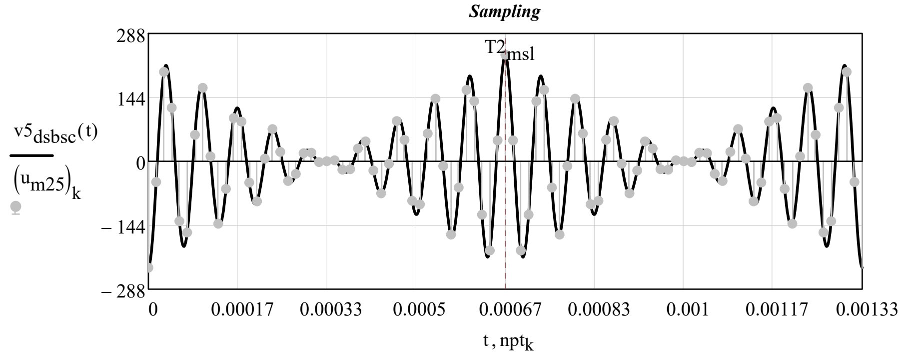
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}}\cdot\frac{1}{T2_{msl}} = 5.565$

$(u_{m25})_k := v5_{dsbsc}(npt_k)$

$u_{m25}^T =$

	0	1	2	3	4
0	-240	-46.706	200.989	120.351	...

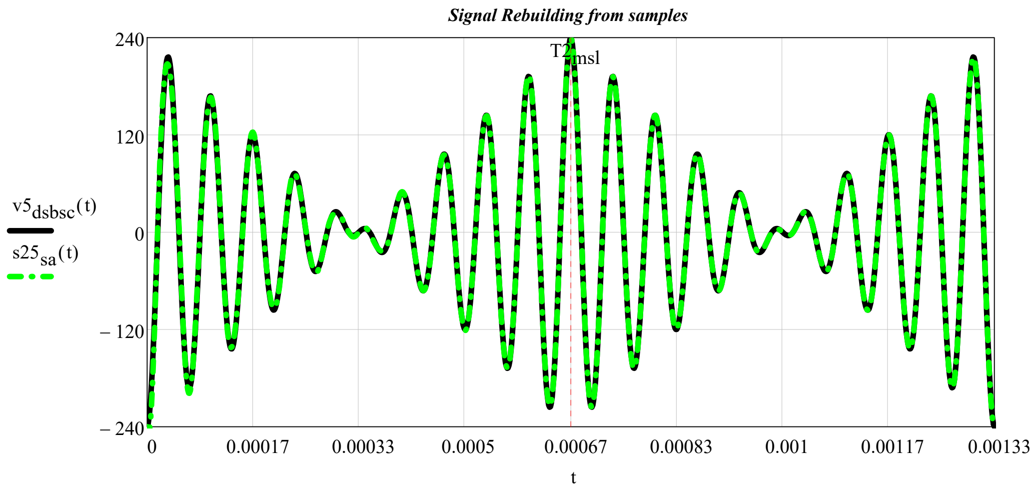
Sampling



$relerr = 10\cdot\%$ $\omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\omega_{bwr} = 0.217\cdot\frac{Mrads}{sec}$ $n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s25_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m25_n}\cdot sinc(\omega_{bwr}\cdot t - n\cdot\pi)\right)\right]$ $N0_{gd} - 1 = 255$ $relerr = 10\cdot\%$

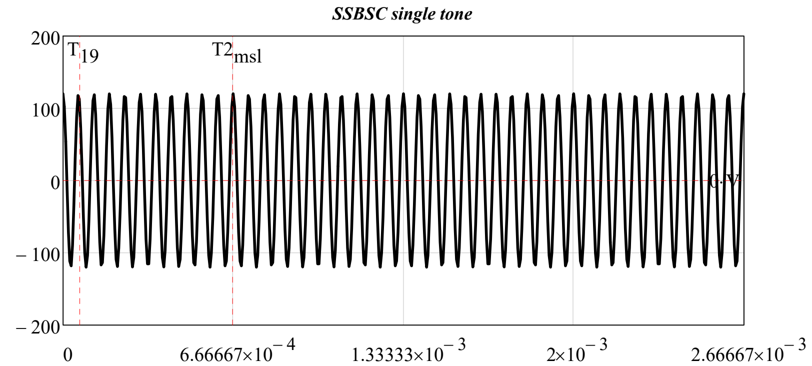


Periodic Waveforms

26 AM SSBSC test signal (single tone)

$f_{19} := \frac{\omega 1_{csl}}{2\cdot\pi}$ $\quad T_{19} := \frac{1}{f_{19}}$

$t_{ssbw} := 0\cdot sec, \frac{4\cdot T2_{msl}}{500} .. 4\cdot T2_{msl}$

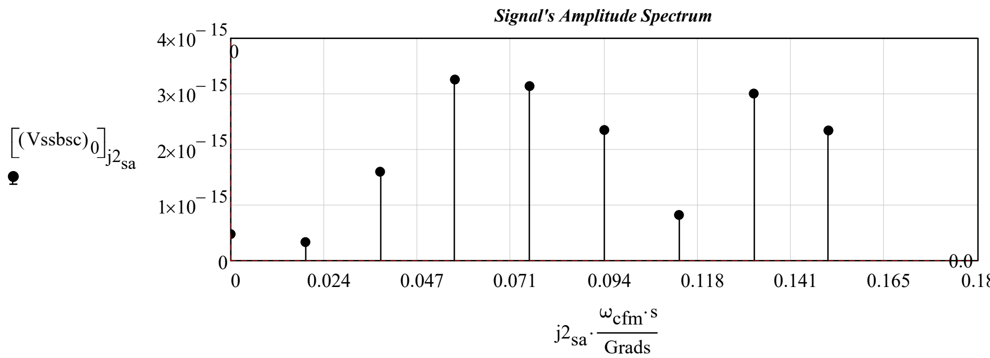


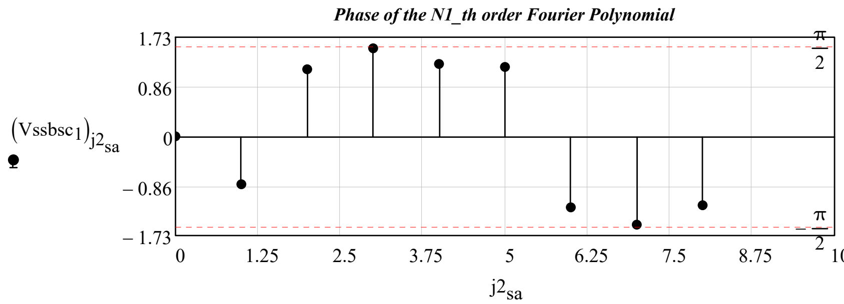
$v_{ssbsc}(t) := \frac{V_{ssbsc}(t, f1_{csl}, f2_{msl}, A1_{sl}, B1_{sl})}{V^2}$ $\quad v_{ssbsc}(T_{19}) = 97.082$

$N1\_ := 25$

$f_{cfm} = 3\cdot MHz$ $\quad Vssbsc := SPCT(v_{ssbsc}, rt_{gd}, N1\_, 0\cdot s, T2_{msl})$ $\quad N1\_ = 25$

$\omega_{cfm} = 0.019\cdot\frac{Grads}{s}$ $\quad j2_{sa} := 0 .. rows(Vssbsc) - 1$ $\quad \omega_{fmm} = 0.942\cdot\frac{Mrads}{s}$





$Bw_{sa} := Vssbsc_3\cdot Hz$

$Bw_{sa} = 0.023\cdot MHz$

sampling frequency: $\quad fpt_{so} := 2\cdot Bw_{sa}$ $\quad fpt_{so} = 0.045\cdot MHz$

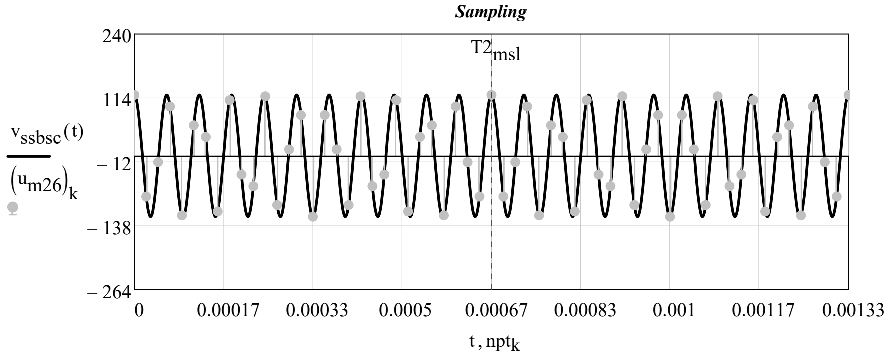
$npt_k := \frac{k}{fpt_{so}}$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T2_{msl}} = 8.533$

$\left(u_{m26}\right)_k := v_{ssbsc}\left(npt_k\right)$

$u_{m26}^T =$

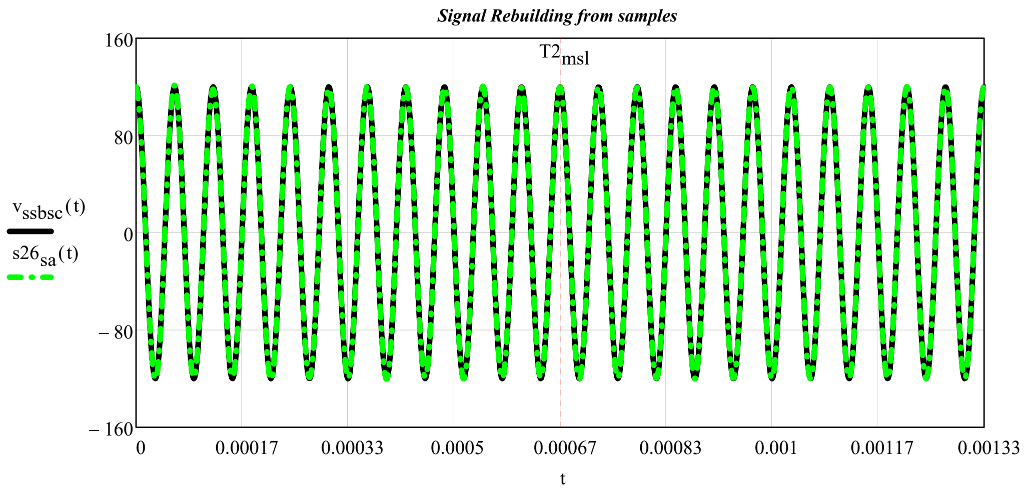
	0	1	2	3	4	5
0	120	-80.296	-12.543	97.082	-117.378	...



relerr = 10·% $\omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\omega_{bwr} = 0.141 \cdot \frac{Mrads}{sec}$ $n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

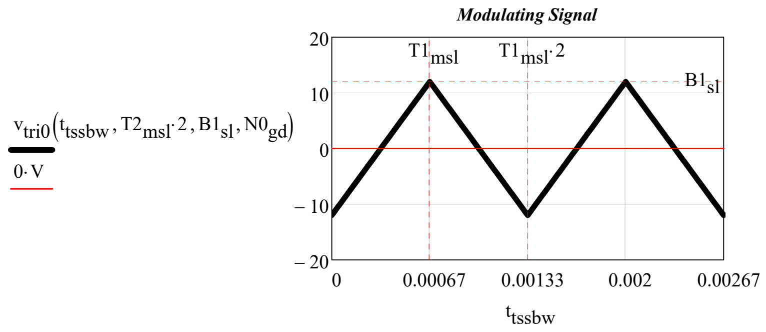
interpolation formula $s26_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m26_n} \cdot sinc\left(\omega_{bwr} \cdot t - n \cdot \pi\right)\right)\right]$ $N0_{gd} - 1 = 255$ relerr = 10·%



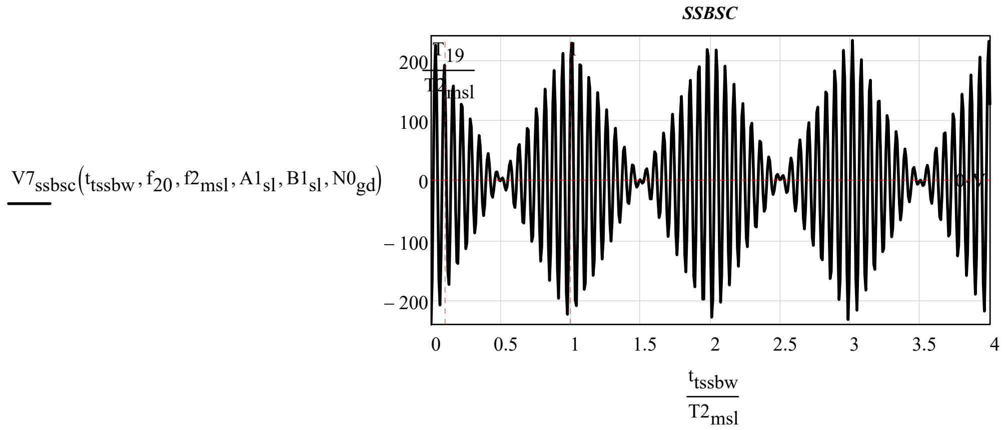
Periodic Waveforms

27 AM SSBSC test signal (triangular wave)

$f_{20} := \frac{10}{T1_{csl}}$



$\frac{A1_{sl} \cdot A1_{sl}}{2} = 200 V^2$

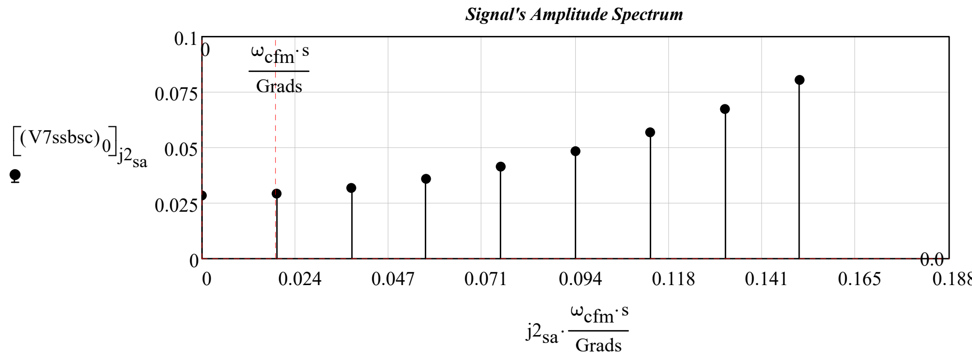


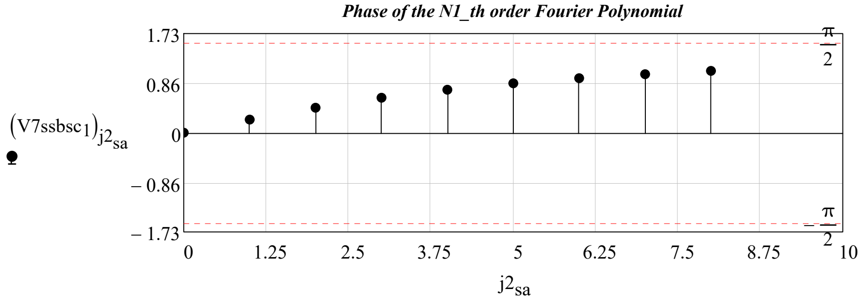
$N1\_ := 25$

$v7_{ssbsc}(t) := V7_{ssbsc}\left(t, f_{20}, f2_{msl}, A1_{sl}, B1_{sl}, N0_{gd}\right)$

$f_{cfm} = 3 \cdot MHz$ $V7ssbsc := SPCT\left(v7_{ssbsc}, rt_{gd}, N1\_, 0 \cdot s, T2_{msl}\right)$ $N1\_ = 25$

$\omega_{cfm} = 0.019 \cdot \frac{Grads}{s}$ $j2_{sa} := 0 .. rows(V7ssbsc) - 1$ $\omega_{fmm} = 0.942 \cdot \frac{Mrads}{s}$





$Bw_{sa} := V7ssbsc_3 \cdot Hz$

$Bw_{sa} = 0.035 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 0.069 \cdot MHz$

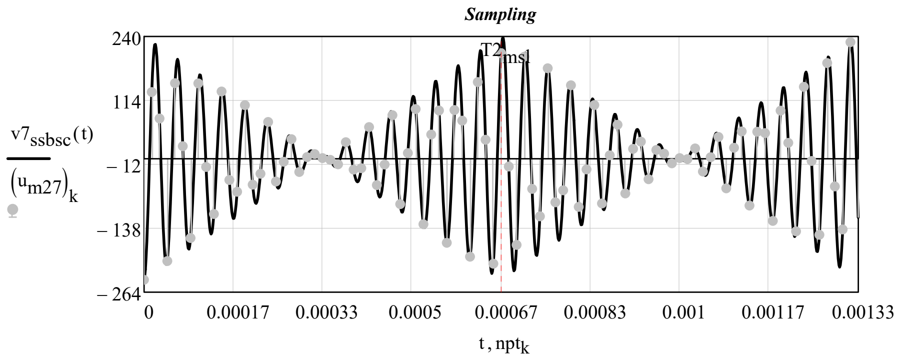
$npt_k := \frac{k}{fpt_{so}}$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T2_{msl}} = 5.565$

$(u_{m27})_k := v7_{ssbsc}(npt_k)$

$u_{m27}^T =$

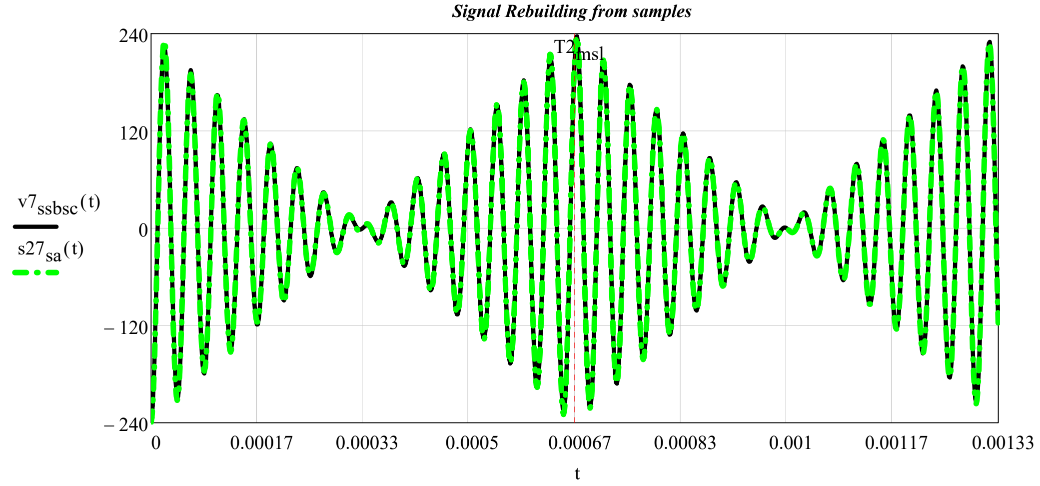
	0	1	2	3	4
0	-240	130.212	78.129	-202.786	...



relerr = 10·% $\quad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\quad \omega_{bwr} = 0.217 \cdot \frac{Mrads}{sec}$ $\quad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s27_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m27_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi)\right)\right]$ $\quad N0_{gd} - 1 = 255$ $\quad$ relerr = 10·%



Periodic Waveforms

28 FM test signal (single tone) (change data in FM data.xmcd)

Carrier Amplitude..: $A_{fm} = 200 \cdot mV$

Carrier Frequency..: $f_{cfm} = 3 \cdot MHz$

Carrier period..: $T_{cfm} = 0.333 \cdot \mu s$

Angular frequency of the carrier.....................................: $\omega_{cfm} = 18.85 \cdot \frac{Mrads}{sec}$

Amplitude of the single tone modulating signal............: $B_{fmm} = 15 \cdot V$

Period of the modulating signal...: $T_{fmm} = 6.667 \cdot \mu s$

Frequency of the single tone modulating signal........ .....: $f_{fmm} := \frac{1}{T_{fmm}}$

Angular frequency of the single tone modulating signal:

$\omega_{fmm} = 0.942 \cdot \frac{Mrads}{sec}$

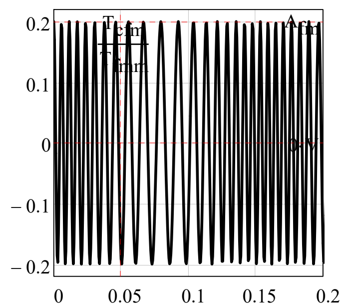
Frequency modulation index: $m_{fm} = 8$

$\frac{T_{fmm}}{T_{cfm}} = 20$ $\frac{\omega_{cfm}}{\omega_{fmm}} = 20$

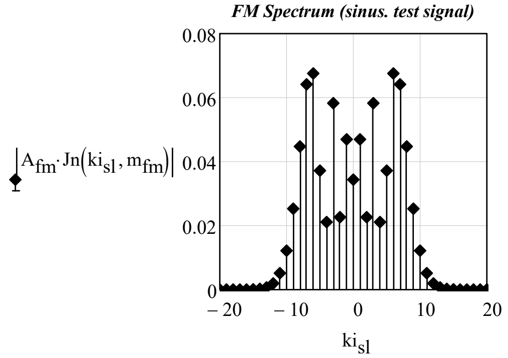
$m_{fm} = 8$ $ki_{sl} := -30 .. 30$

$$t_{fmsl} := T_{fmm} \cdot 0, T_{fmm} \cdot 0 + \frac{10 \cdot T_{fmm} - T_{fmm} \cdot 0}{20000} .. 10 \cdot T_{fmm}$$

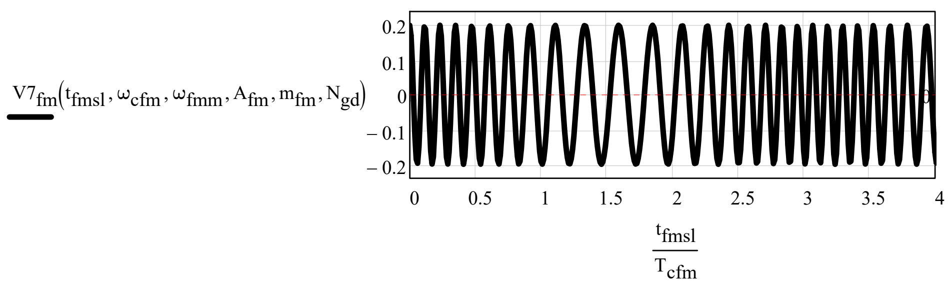
FM test signal



FM Spectrum (sinus. test signal)



FM Waveform



$m_{fm} = 8$

$A_{fm} = 0.2 V$

$B_{fmm} = 15 V$

$N1\_ := 25$

$v7_{fm}(t) := V7_{fm}(t, \omega_{cfm}, \omega_{fmm}, A_{fm}, m_{fm}, N_{gd})$

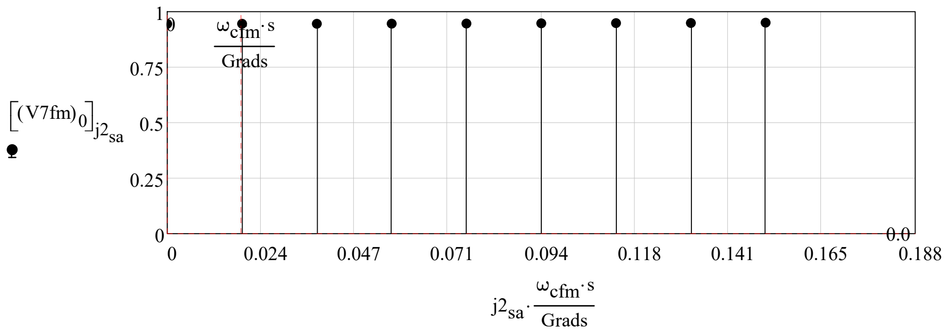
$f_{cfm} = 3 \cdot MHz$

$V7fm := SPCT(v7_{fm}, rt_{gd}, N1\_, 0 \cdot s, T_{fmm})$ $N1\_ = 25$

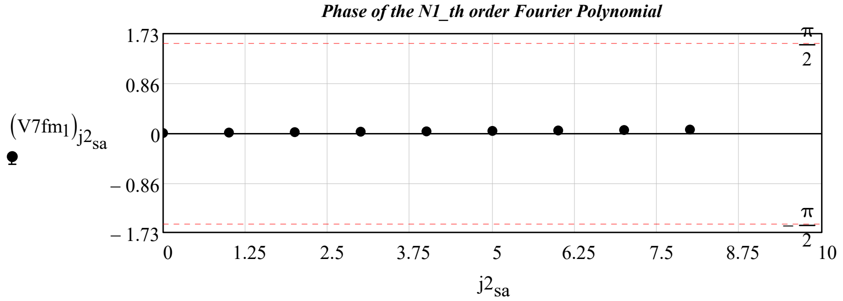
$\omega_{cfm} = 0.019 \cdot \frac{Grads}{s}$

$j2_{sa} := 0 .. rows(V7fm) - 1$ $\omega_{fmm} = 0.942 \cdot \frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := V7fm_3 \cdot Hz$

$Bw_{sa} = 3.45 \cdot MHz$

sampling frequency: $fpt_{so} := 40 \cdot Bw_{sa}$ $fpt_{so} = 138 \cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

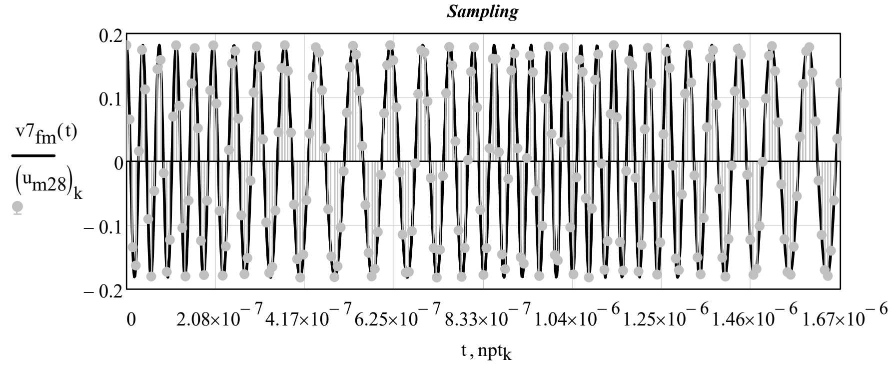
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{fmm}} = 0.278$

$(u_{m28})_k := v7_{fm}(npt_k)$

$u_{m28}^T =$

	0	1	2	3	4
0	0.2	0.072	-0.148	-0.179	...

Sampling



relerr = 10·%

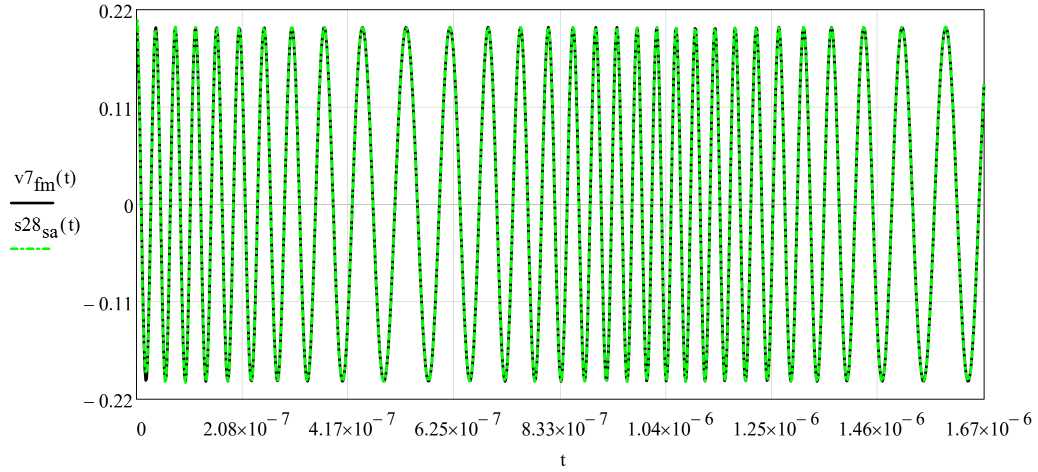
$\omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa} \cdot 20$ $\omega_{bwr} = 433.54 \cdot \frac{Mrads}{sec}$

$n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s28_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m28_n} \cdot \operatorname{sinc}(\omega_{bwr} \cdot t - n \cdot \pi)\right)\right]$ $N0_{gd} - 1 = 255$ $relerr = 10 \cdot \%$

Signal Rebuilding from samples

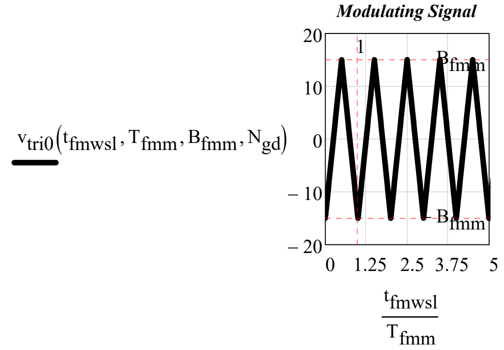


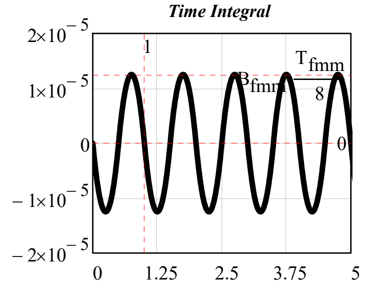
Periodic Waveforms

29 FM test signal (triangular wave)

$$t_{fmwsl} := 0 \cdot T_{fmm}, \frac{10 \cdot T_{fmm} - 0 \cdot T_{fmm}}{1000} .. 10 \cdot T_{fmm}$$

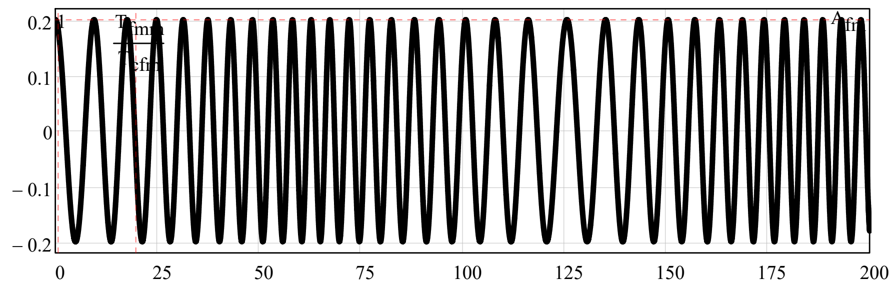
Modulating Signal ***Time Integral***





$$Kst_{fmsl} := \frac{m_{fm} \cdot \omega_{fmm}}{2 \cdot \pi \cdot B_{fmm}} \quad f_{fmm} := \frac{1}{T_{fmm}}$$

FM test Waveform



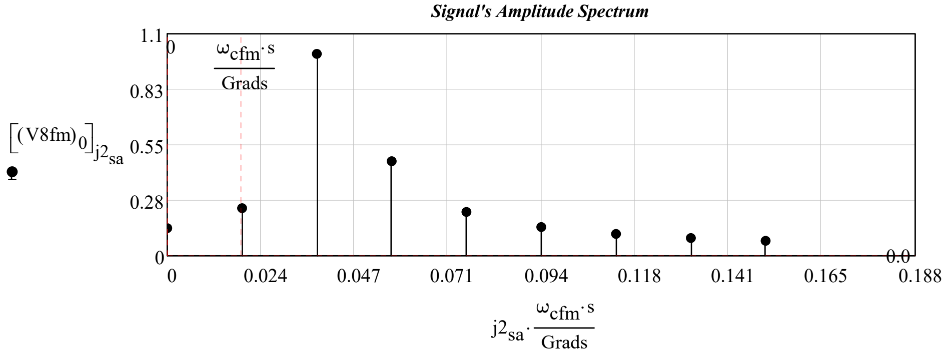
$N1\_ := 25$

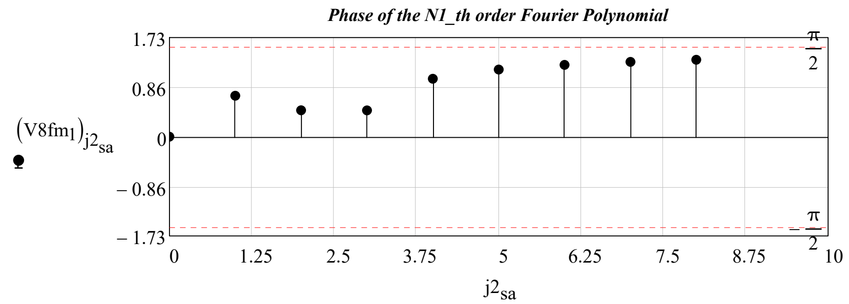
$$v8_{fm}(t) := V8_{fm}(t, T_{fmm}, f_{cfm}, f_{fmm}, A_{fm}, B_{fmm}, m_{fm}, Kst_{fmsl}, N0_{gd})$$

$f_{cpm} = 0.12 \cdot MHz$ $V8fm := SPCT(v8_{fm}, rt_{gd}, N1\_, 0 \cdot s, T_{fmm})$ $N1\_ = 25$

$\omega_{cpm} = 7.54 \times 10^{-4} \cdot \frac{Grads}{s}$ $j2_{sa} := 0 .. rows(V8fm) - 1$ $\omega_{pmm} = 0.075 \cdot \frac{Mrads}{s}$

Signal's Amplitude Spectrum





$Bw_{sa} := V8fm_3 \cdot Hz$

$Bw_{sa} = 3.45 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 6.9 \cdot MHz$

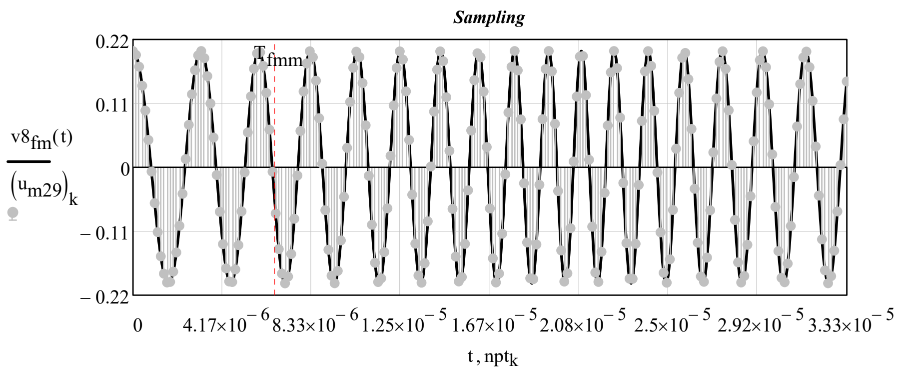
$npt_k := \frac{k}{fpt_{so}}$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{fmm}} = 5.565$

$(u_{m29})_k := v8_{fm}(npt_k)$

$u_{m29}^T =$

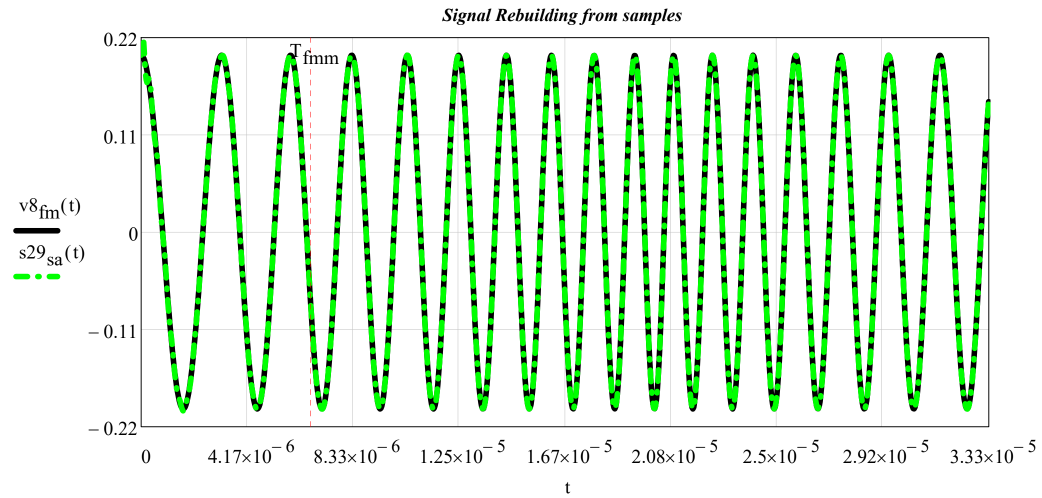
	0	1	2	3	4
0	0.2	0.193	0.173	0.14	...



relerr = 10·% $\quad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\quad \omega_{bwr} = 21.677 \cdot \frac{Mrads}{sec}$ $\quad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s29_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m29_n} \cdot \text{sinc}(\omega_{bwr} \cdot t - n \cdot \pi)\right)\right]$ $\quad N0_{gd} - 1 = 255$ $\quad$ relerr = 10·%



TEST Waveforms

Periodic Waveforms

30 PM test signal (single tone)

Carrier Amplitude...: $A_{pm} := 20 \cdot V$, $A_{pm} = 20 \cdot V$

Carrier Frequency...: $f_{cpm} = 0.12 \cdot MHz$,

Carrier period..: $T_{cpm} = 8.333 \times 10^3 \cdot ns$,

Angular frequency of the carrier................................: $\omega_{cpm} = 7.54 \times 10^{-4} \cdot \frac{Grads}{sec}$,

Amplitude of the modulating signal.................... ....: $B_{pm} = 5\,V$,

Modulating signal period...: $T_{pmm} = 83.333 \cdot \mu s$,

Frequency of the harmonic modulating signal.........: $f_{pmm} = 0.012 \cdot MHz$, $\frac{T_{pmm}}{T_{cpm}} = 10$,

Angular frequency of the modulating signal...........: $\omega_{pmm} = 0.075 \cdot \frac{Mrads}{sec}$.

Phase modulation index..: $m_{pm} = 5 \cdot rad$

Phase-sensitivity factor..: $k_{pm} = 1 \cdot \frac{rad}{V}$

$$k_{pm} = \frac{m_{pm}}{B_{pm}}$$

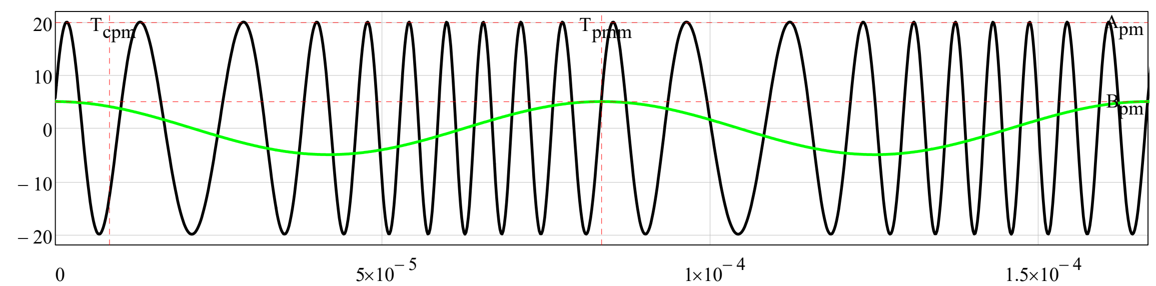
$$v_{pm}(t, f_{cpm}, f_{pmm}, A_{pm}, m_{pm}, N_{gd}) = Re\left[A_{pm} \cdot e^{j \cdot 2 \cdot \pi \cdot f_{cpm} \cdot t} \cdot \sum_{k=-N_{gd}}^{N_{gd}} \left(e^{j \cdot \frac{k \cdot \pi}{2}} \cdot Jn(k, m_{pm}) \cdot \cos(k \cdot 2 \cdot \pi \cdot f_{pmm} \cdot t)\right)\right]$$

Dimensionless function: $V9_{pm}(t, f_{cpm}, f_{pmm}, A_{pm}, m_{pm}, N_{gd}) = \frac{v_{pm}(t, f_{cpm}, f_{pmm}, A_{pm}, m_{pm}, N_{gd})}{V}$

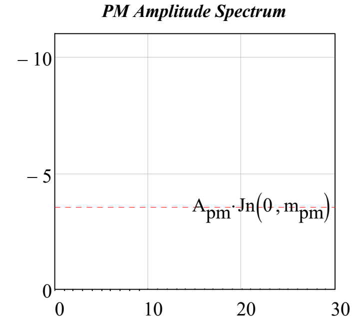
$f_{cpm} = 0.12 \cdot MHz$ $t_{pm} := T_{cpm} \cdot 0, T_{cpm} \cdot 0 + \frac{80 \cdot T_{cpm} - 0 \cdot T_{cpm}}{4000} .. 80 \cdot T_{cpm}$ $m_{pm} = 5$ $A_{pm} = 20\,V$

$f_{pmm} = 0.012 \cdot MHz$

PM (single tone) Waveform



PM Amplitude Spectrum



$N1\_ := 25$

$f_{cpm} = 0.12 \cdot MHz$

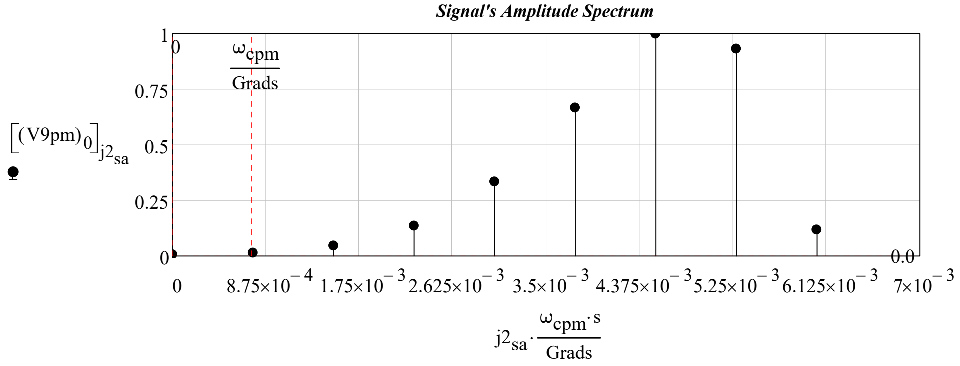
$\omega_{cpm} = 7.54 \times 10^{-4} \cdot \frac{Grads}{s}$

$v9_{pm}(t) := V9_{pm}(t, f_{cpm}, f_{pmm}, A_{pm}, m_{pm}, N_{gd})$

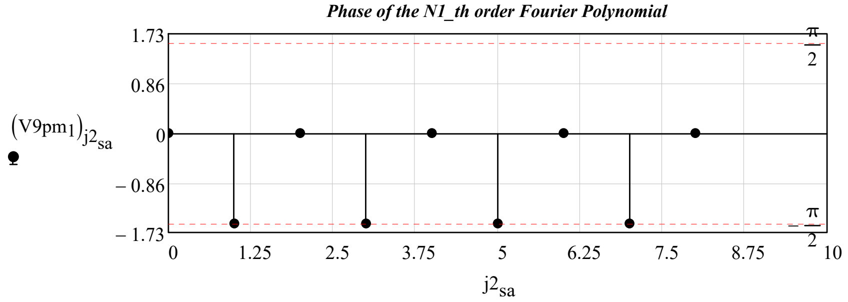
$V9pm := SPCT(v9_{pm}, rt_{gd}, N1\_, 0 \cdot s, T_{pmm})$ $N1\_ = 25$

$j2_{sa} := 0 .. rows(V9pm) - 1$ $\omega_{pmm} = 0.075 \cdot \frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := V9pm_3 \cdot Hz$

$Bw_{sa} = 0.216 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $fpt_{so} = 0.432 \cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

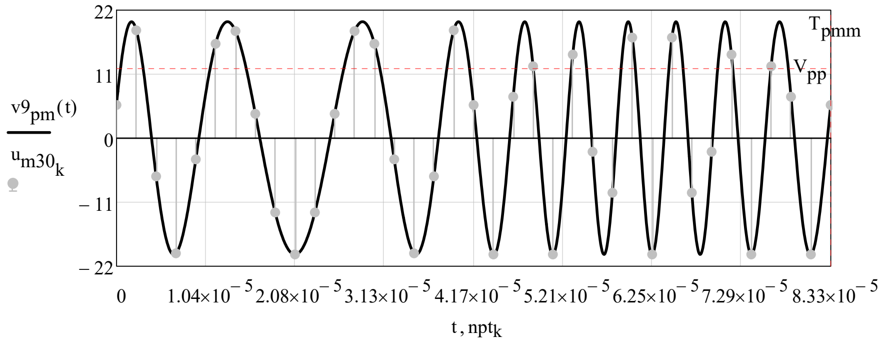
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{pmm}} = 7.111$

$(u_{m30})_k := v9_{pm}(npt_k)$

$u_{m30}^T =$

	0	1	2	3	4	5	6
0	5.673	18.527	-6.578	-19.801	-3.66	16.21	...

Sampling

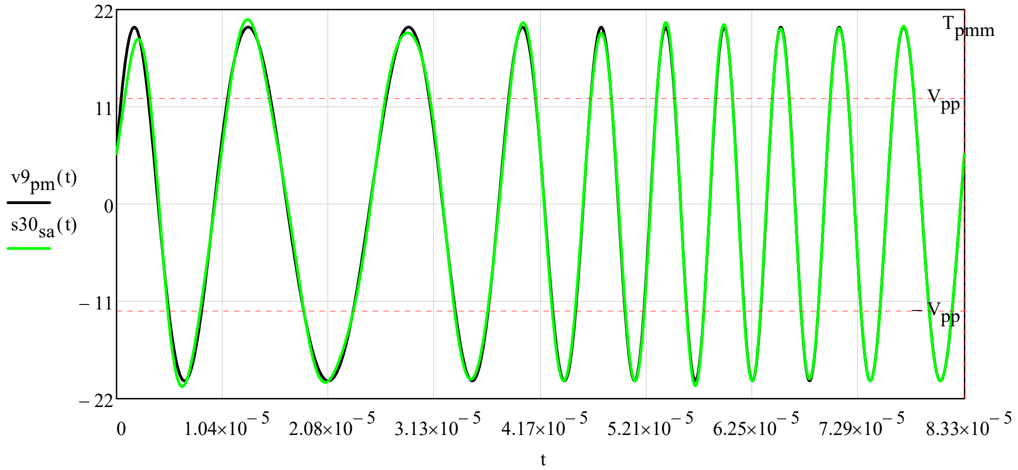


$relerr = 10\cdot\%$ $\qquad \omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\qquad \omega_{bwr} = 1.357\cdot\frac{Mrads}{sec}$ $\qquad n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\qquad s30_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m30_n}\cdot \mathrm{sinc}\left(\omega_{bwr}\cdot t - n\cdot\pi\right)\right)\right]$ $\qquad N0_{gd} - 1 = 255$ $\qquad relerr = 10\cdot\%$

Signal Rebuilding from samples



TEST Waveforms

Periodic Waveforms

31 PM test signal (triangular wave)

$T_{tri} := \frac{T_{pmm}}{2}$ $\qquad \omega_{cpm} := 0.377\,\frac{rad}{ns}$ $\qquad v_{mtri}(t_{sl}) := v_{tri0}(t_{sl}, T_{tri}, A_{pm}, N0_{gd})$

$v_{pmtri}(t_{sl}) := A_{pm}\cdot\cos\left(\omega_{cpm}\cdot t_{sl} + k_{pm}\cdot v_{mtri}(t_{sl})\right)$

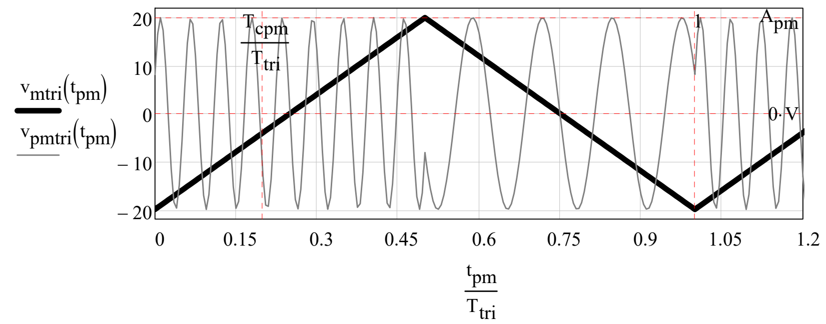
$k_{pm} = \frac{m_{pm}}{B_{pm}}$ $\qquad k_{pm} = 1\,\frac{1}{V}$

$v_{pmtri}(t, T_{pmm}, f_{cpm}, k_{pm}, A_{pm}, B_{pm}, N0_{gd}) = A_{pm}\cdot\cos\left(2\cdot\pi\cdot f_{cpm}\cdot t + k_{pm}\cdot v_{tri0}(t, T_{tri}, B_{pm}, N0_{gd})\right)$

$V10_{pm}(t, T_{pmm}, f_{cpm}, m_{pm}, A_{pm}, B_{pm}, N0_{gd}) = \frac{v_{pmtri}(t, T_{tri}, f_{cpm}, m_{pm}, A_{pm}, B_{pm}, N0_{gd})}{V}$

$t_{pm} := T_{tri}\cdot 0, T_{tri}\cdot 0 + \frac{5\cdot T_{tri} - 0\cdot T_{tri}}{1000} .. 5\cdot T_{tri}$

Carrier & Triangular Modulating Waveform

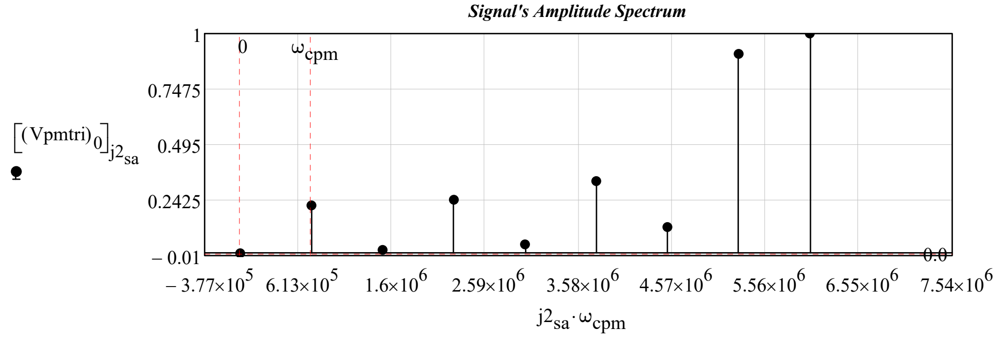


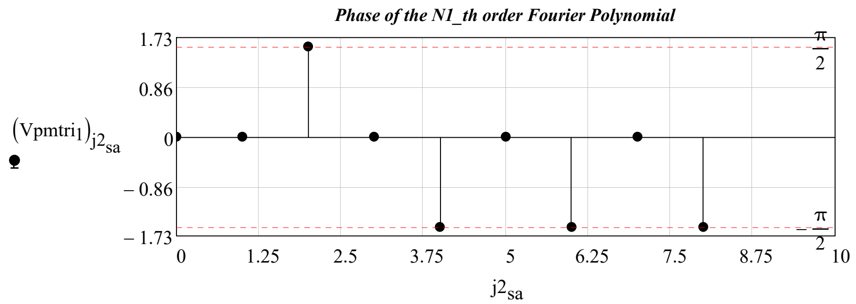
$N1\_ := 25$ $\qquad vpmtri(t) := \frac{v_{pmtri}(t)}{V}$

$Vpmtri := SPCT(vpmtri, rt_{gd}, N1\_, 0\cdot s, T_{tri})$ $\qquad N1\_ = 25$

$relerr := Vpmtri; j2_{sa} := 0 .. rows(Vpmtri) - 1$ $\qquad \omega_{pmm} = 0.075\cdot\frac{Mrads}{s}$

Signal's Amplitude Spectrum





$Bw_{sa} := Vpmtri_3 \cdot Hz$

$Bw_{sa} = 0.552 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $fpt_{so} = 1.104 \cdot MHz$

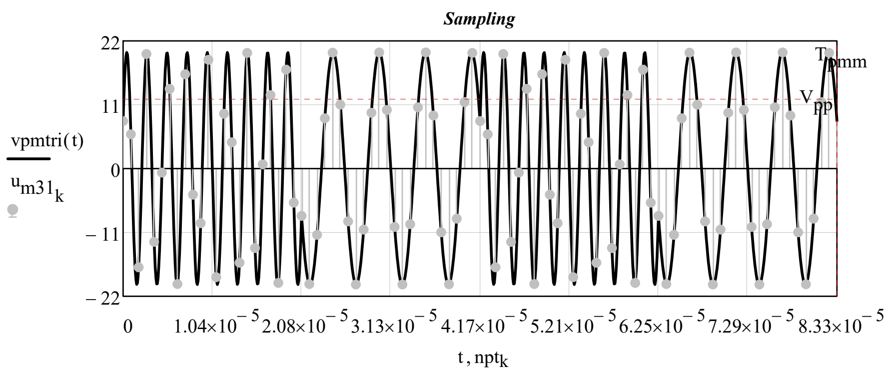
$k := 0 .. 2^8 - 1$ $npt_k := \frac{k}{fpt_{so}}$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{pmm}} = 2.783$

$(u_{m31})_k := vpmtri(npt_k)$

$u_{m31}^T =$

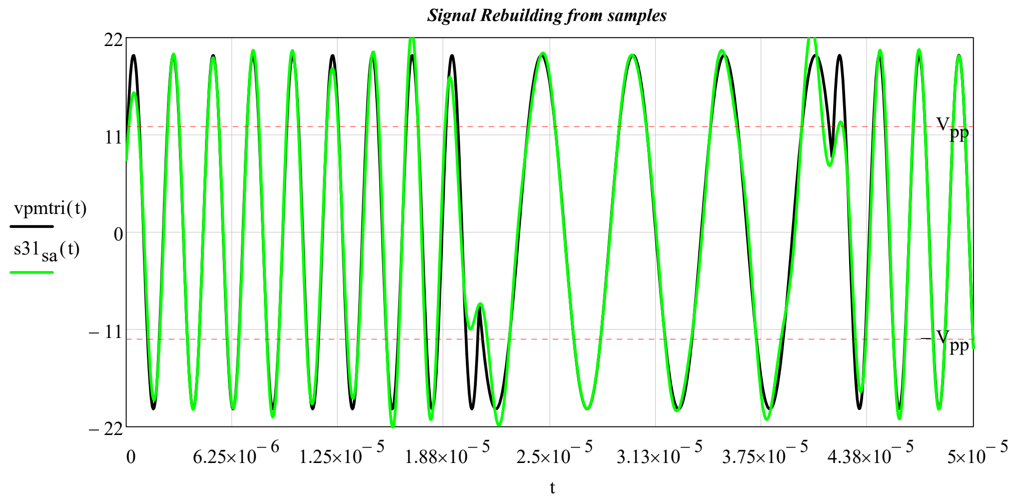
	0	1	2	3	4	5	6
0	8.162	5.894	-17.028	19.721	-12.637	-0.712	...



relerr = 10·% $\omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\omega_{bwr} = 3.468 \cdot \frac{Mrads}{sec}$ $n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s31_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m31_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi) \right) \right]$ $N0_{gd} - 1 = 255$ relerr = 10·%



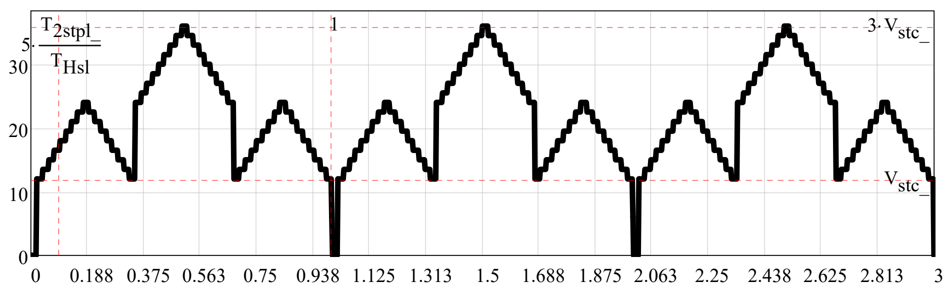
Periodic Waveforms

32 Staircase based test signal

$shift := 1$

$T_{Hsl} := \left(6 \cdot m2_{steps\_} + shift + 3\right) \cdot T_{2stpl\_}$ $\quad t_{tscbw} := 0 \cdot T_{Hsl}, 0 \cdot T_{Hsl} + \frac{5 \cdot T_{Hsl}}{2000} .. 5 \cdot T_{Hsl}$

Staircase based test signal...

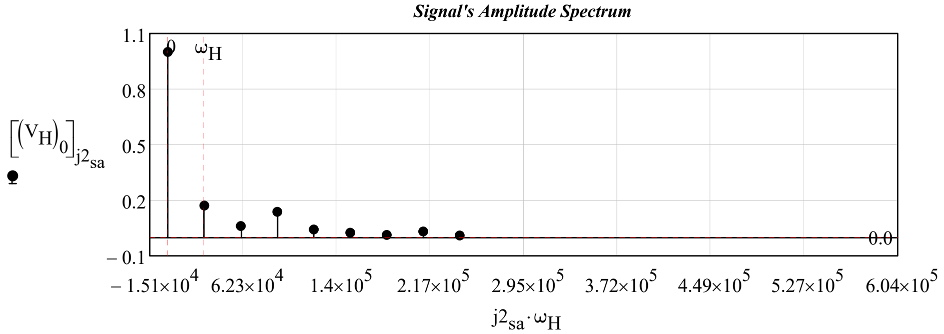


$N1\_ := 25$ $\quad \omega_H := \frac{2 \cdot \pi}{T_{Hsl}}$ $\quad VH(t) := V_H\left(t, T_{Hsl}, T_{2stpl\_}, V_{stc\_}, mstc3_{steps\_}, shift, N_{gd}\right)$

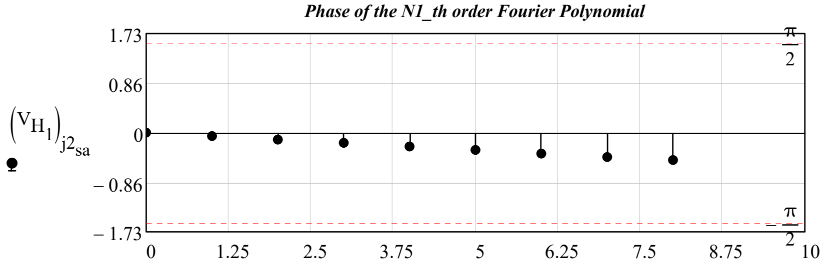
$5 \cdot T_{2stpl\_} = 20 \cdot \mu s$ $\quad V_H := SPCT\left(VH, rt_{gd}, N1\_, 5 \cdot T_{2stpl\_}, T_{Hsl}\right)$ $\quad N1\_ = 25$

$j2_{sa} := 0 .. rows\left(V_H\right) - 1$ $\quad \omega_H = 30.208 \cdot \frac{krads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := V_{H_3} \cdot Hz$

$Bw_{sa} = 0.111 \cdot MHz$

sampling frequency: $\quad fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 0.221 \cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

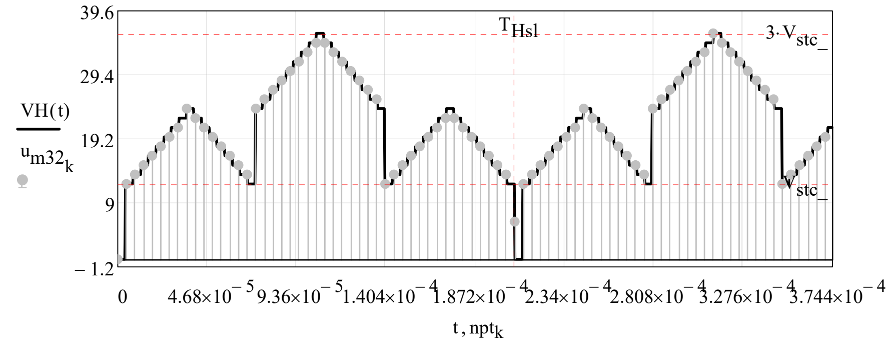
Frequency resolution: $\quad \frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{Hsl}} = 5.565$

$\left(u_{m32}\right)_k := VH\left(npt_k\right)$

$u_{m32}^T =$

	0	1	2	3	4	5	6	7	8	9
0	0	12	13.5	15	16.5	18	19.5	21	24	...

Sampling

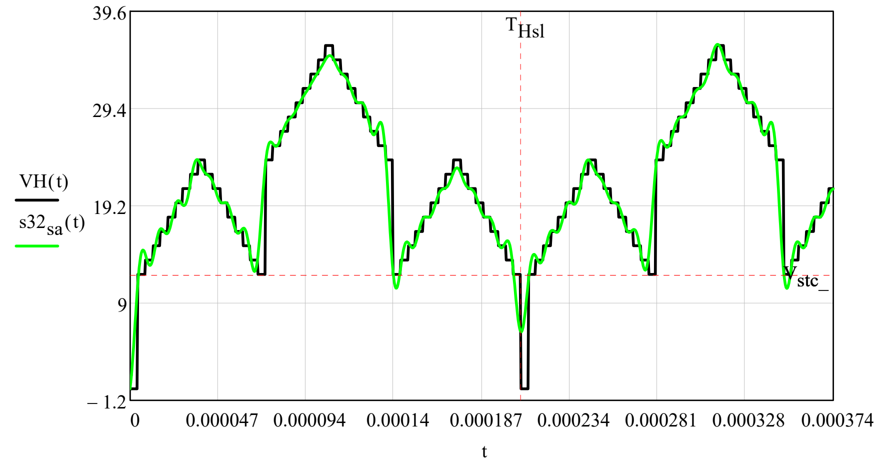


$relerr = 10 \cdot \%$ $\quad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\quad \omega_{bwr} = 0.695 \cdot \frac{Mrads}{sec}$ $\quad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s32_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m32_n} \cdot sinc\left(\omega_{bwr} \cdot t - n \cdot \pi\right)\right)\right]$ $\quad N0_{gd} - 1 = 255$ $\quad relerr = 10 \cdot \%$

Signal Rebuilding from samples



TEST Waveforms

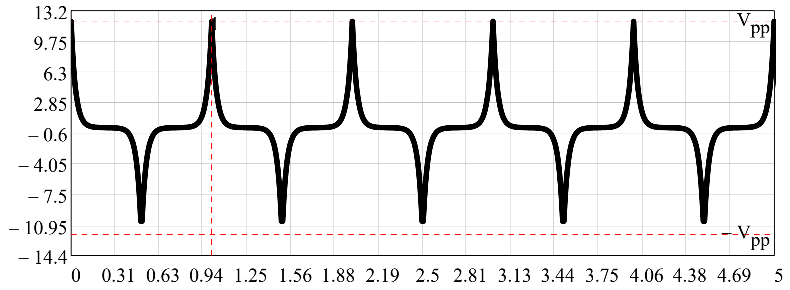
Periodic Waveforms

33 Bipolar Double Exponential Pulse Train

$$T_{bdep} := 32\cdot\tau_{ptd\_}$$

$$t_{tdewsl} := -20\cdot T_{bdep}, -20\cdot T_{bdep} + \frac{20\cdot T_{bdep} + 20\cdot T_{bdep}}{5000} \,..\, 20\cdot T_{bdep}$$

Bipolar Double Exponential Pulse Train



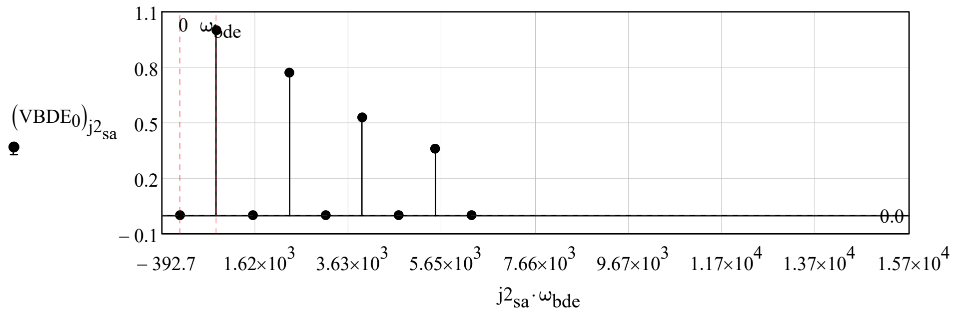
t.tdewsl/T.bdep

$N1\_ := 50$ $\quad \omega_{bde} := \frac{2\cdot\pi}{T_{bdep}}$ $\quad Vbdept(t) := \frac{V_{bdept}(t, \tau_{ptd\_}, T_{bdep}, V_{pp}, N0_{gd})}{V}$

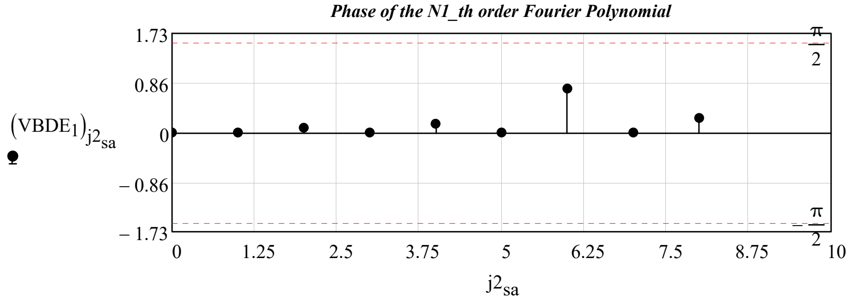
$VBDE := SPCT(Vbdept, rt_{gd}, N1\_, 0\cdot s, T_{bdep})$ $\quad N1\_ = 50$

$j2_{sa} := 0 \,..\, rows(VBDE) - 1$ $\quad \omega_{bde} = 0.785\cdot\frac{krads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := VBDE_3\cdot Hz$

$Bw_{sa} = 6\times10^{-3}\cdot MHz$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa}$ $\quad fpt_{so} = 0.012\cdot MHz$

$$npt_k := \frac{k}{fpt_{so}}$$

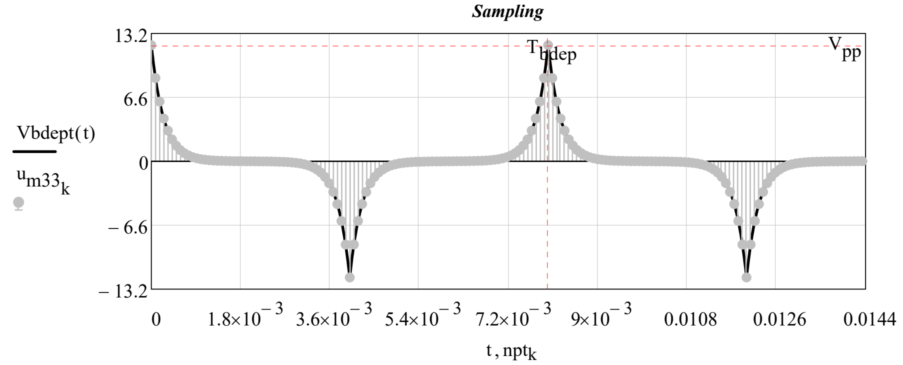
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}}\cdot\frac{1}{T_{bdep}} = 2.667$

$$\left(u_{m33}\right)_k := Vbdept\left(npt_k\right)$$

$u_{m33}^T =$

	0	1	2	3	4
0	12	8.598	6.161	4.415	...

Sampling

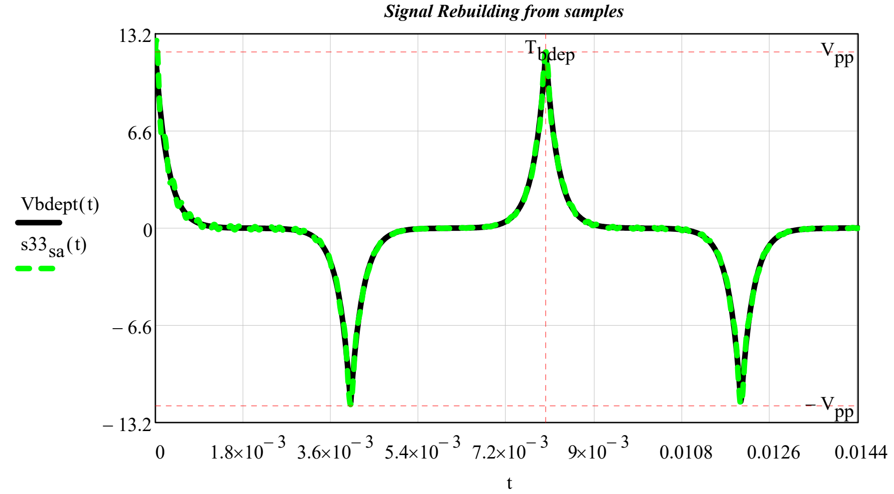


relerr = 10·% $\quad \omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\quad \omega_{bwr} = 0.038\cdot\frac{Mrads}{sec}$ $\quad n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s33_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m33_n}\cdot sinc\left(\omega_{bwr}\cdot t - n\cdot\pi\right)\right)\right]$ $\quad N0_{gd} - 1 = 255$ $\quad relerr = 10\cdot\%$

Signal Rebuilding from samples

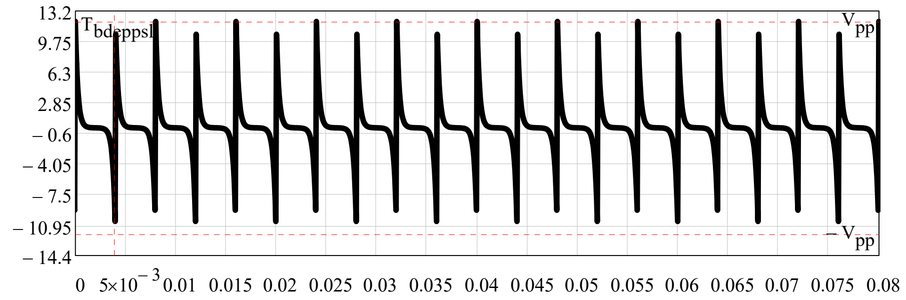


Periodic Waveforms

34 Bipolar Double Exponential Odd symmetric Pulse Train

$$T_{bdeppsl} := 16\cdot\tau_{ptd\_}$$

Bipolar Double Exponential Pulse Train

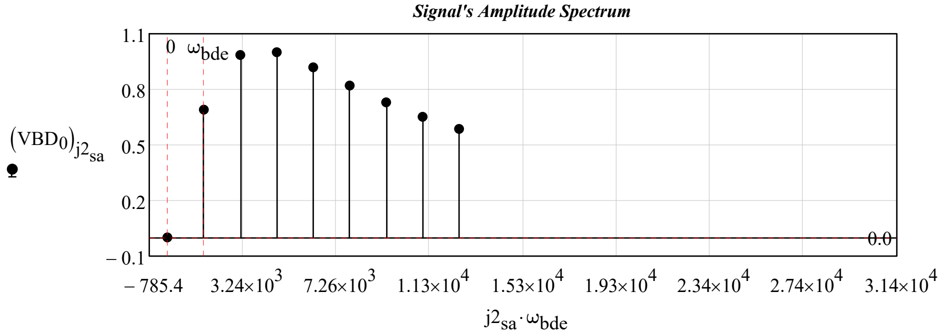


$N1\_ := 50$ $\quad \omega_{bde} := \dfrac{2\cdot\pi}{T_{bdeppsl}}$ $\quad Vbdeospp(t) := \dfrac{V_{bdeospp}\left(t,\tau_{ptd\_},T_{bdeppsl},V_{pp},N0_{gd}\right)}{V}$

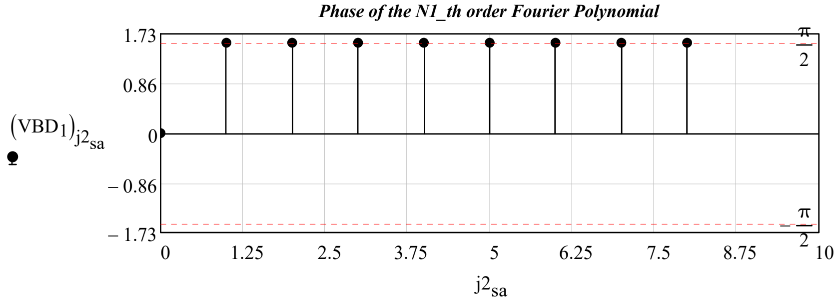
$VBD := SPCT\left(Vbdeospp, rt_{gd}, N1\_, 0\cdot s, T_{bdeppsl}\right)$ $\quad N1\_ = 50$

$j2_{sa} := 0 .. rows(VBD) - 1$ $\quad \omega_{bde} = 1.571\cdot\dfrac{krads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := VBD_3\cdot Hz$

$Bw_{sa} = 0.012\cdot MHz$

sampling frequency: $\quad fpt_{so} := 2\cdot Bw_{sa}$ $\quad fpt_{so} = 0.024\cdot MHz$

$npt_k := \dfrac{k}{fpt_{so}}$

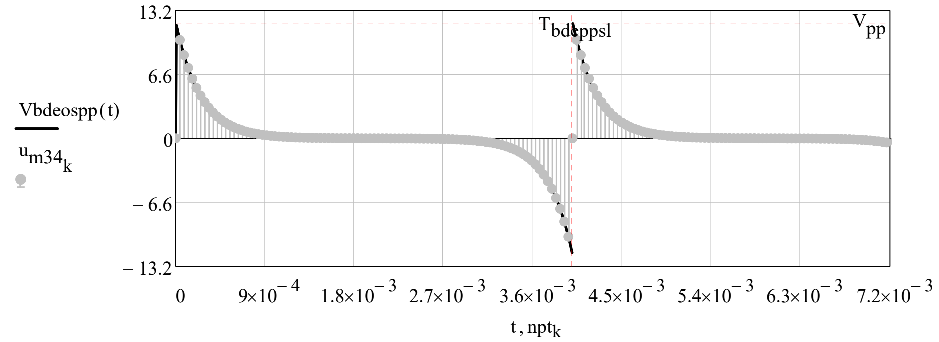
Frequency resolution: $\quad \dfrac{N0_{gd}}{fpt_{so}}\cdot\dfrac{1}{T_{bdeppsl}} = 2.667$

$\left(u_{m34}\right)_k := Vbdeospp\left(npt_k\right)$

$u_{m34}{}^T =$

	0	1	2	3	4
0	-1.35·10⁻⁶	10.158	8.598	7.278	...

Sampling

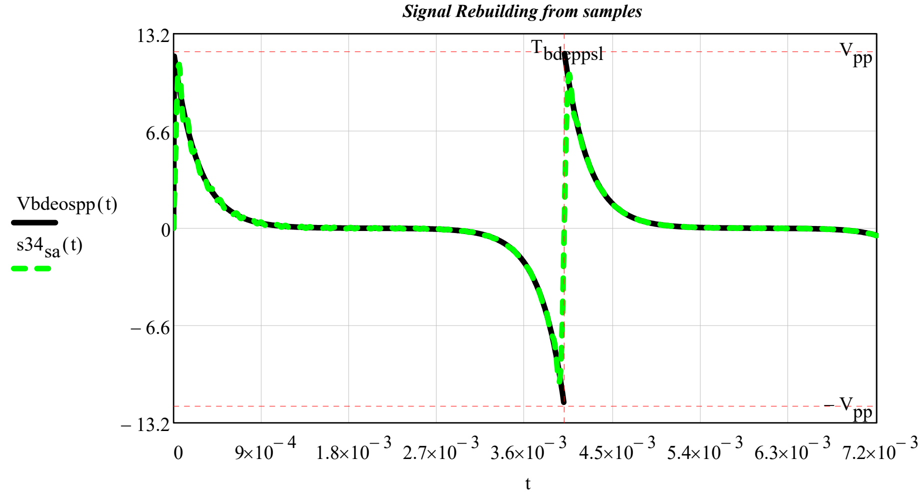


$relerr = 10\cdot\%$ $\quad \omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\quad \omega_{bwr} = 0.075\cdot\dfrac{Mrads}{sec}$ $\quad n\cdot\dfrac{\pi}{\omega_{bwr}} = n\cdot\dfrac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s34_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m34_n}\cdot sinc\left(\omega_{bwr}\cdot t - n\cdot\pi\right)\right)\right]$ $\quad N0_{gd} - 1 = 255$ $\quad relerr = 10\cdot\%$

Signal Rebuilding from samples

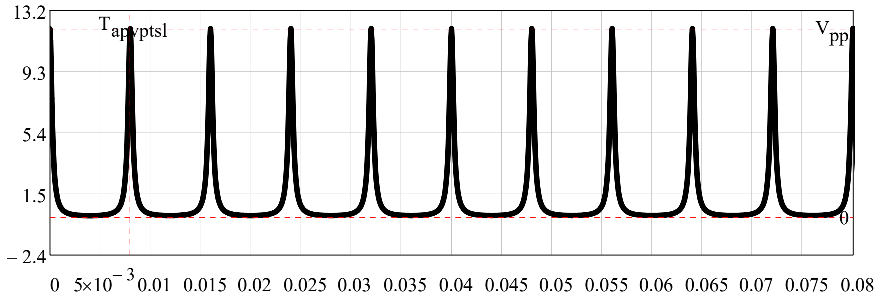


Periodic Waveforms

35 Agnesi Profile Voltage Pulse Train

$$T_{apvptsl} := 32 \cdot \tau_{ptd\_}$$

Agnesi Voltage Pulse Train

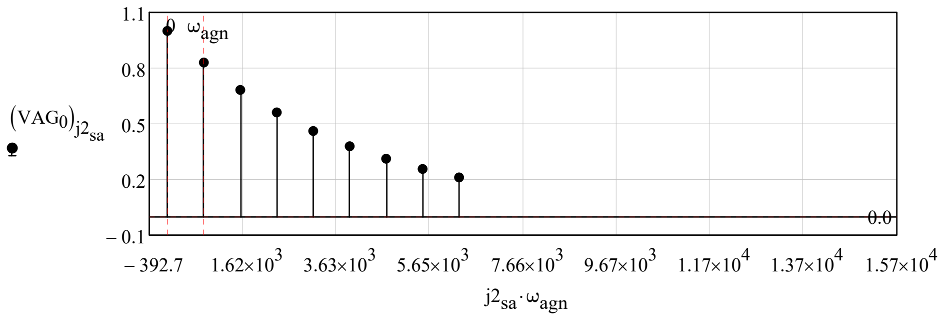


$N1\_ := 50$ $\qquad \omega_{agn} := \dfrac{2 \cdot \pi}{T_{apvptsl}}$ $\qquad Vagnp(t) := \dfrac{V_{agnp}\left(t, \tau_{ptd\_}, T_{apvptsl}, V_{pp}, N0_{gd}\right)}{V}$

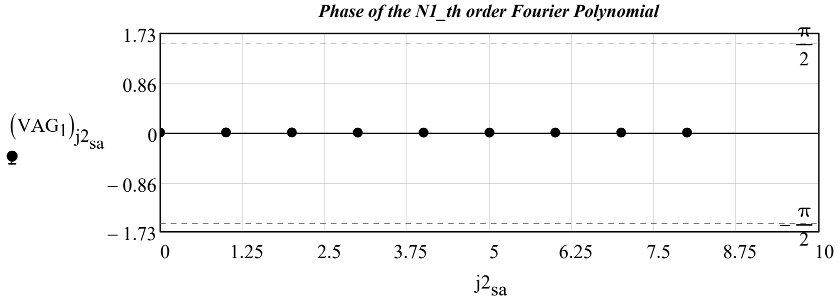
$VAG := SPCT\left(Vagnp, rt_{gd}, N1\_, 0 \cdot s, T_{apvptsl}\right)$ $\qquad N1\_ = 50$

$j2_{sa} := 0 .. rows(VAG) - 1$ $\qquad \omega_{agn} = 0.785 \cdot \dfrac{krads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := VAG_3 \cdot Hz$

$Bw_{sa} = 2.875 \times 10^{-3} \cdot MHz$

sampling frequency: $\quad fpt_{so} := 2 \cdot Bw_{sa}$ $\qquad fpt_{so} = 5.75 \times 10^{-3} \cdot MHz$

$npt_k := \dfrac{k}{fpt_{so}}$

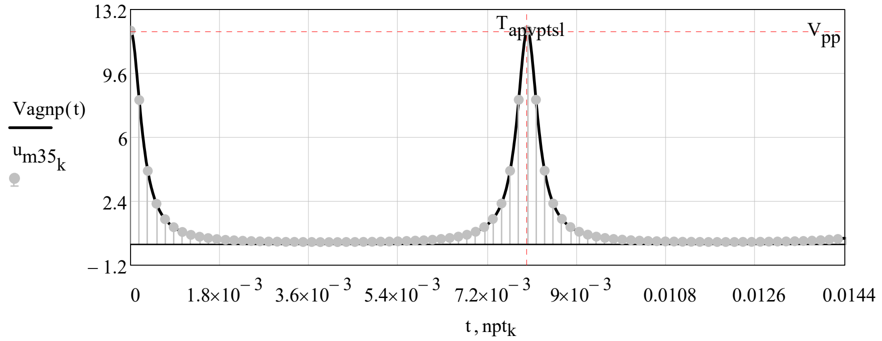
Frequency resolution: $\quad \dfrac{N0_{gd}}{fpt_{so}} \cdot \dfrac{1}{T_{bdeppsl}} = 11.13$

$\left(u_{m35}\right)_k := Vagnp\left(npt_k\right)$

$u_{m35}^{T} =$

	0	1	2	3	4	5	6	7
0	12.019	8.106	4.108	2.262	1.395	0.939	0.675	...

Sampling

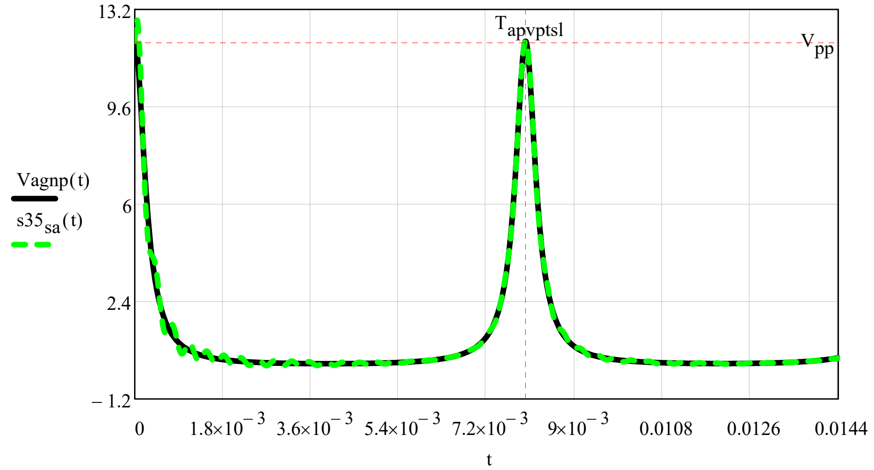


$relerr = 10 \cdot \%$ $\qquad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\qquad \omega_{bwr} = 0.018 \cdot \dfrac{Mrads}{sec}$ $\qquad n \cdot \dfrac{\pi}{\omega_{bwr}} = n \cdot \dfrac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s35_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m35_n} \cdot sinc\left(\omega_{bwr} \cdot t - n \cdot \pi\right)\right)\right]$ $\qquad N0_{gd} - 1 = 255$ $\qquad relerr = 10 \cdot \%$

Signal Rebuilding from samples

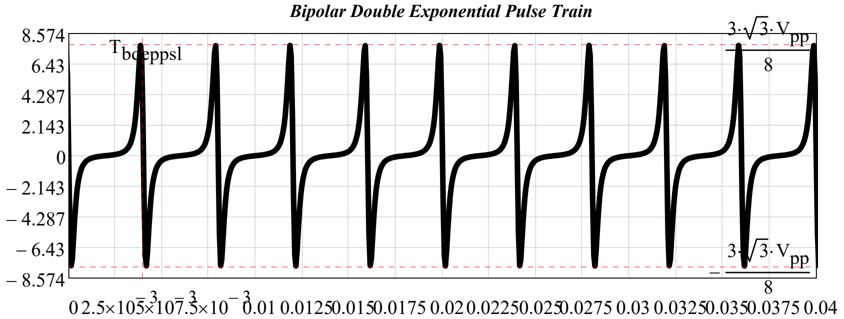


TEST Waveforms

Periodic Waveforms

36 Agnesi Derivative Profile Voltage Pulse Train

Bipolar Double Exponential Pulse Train

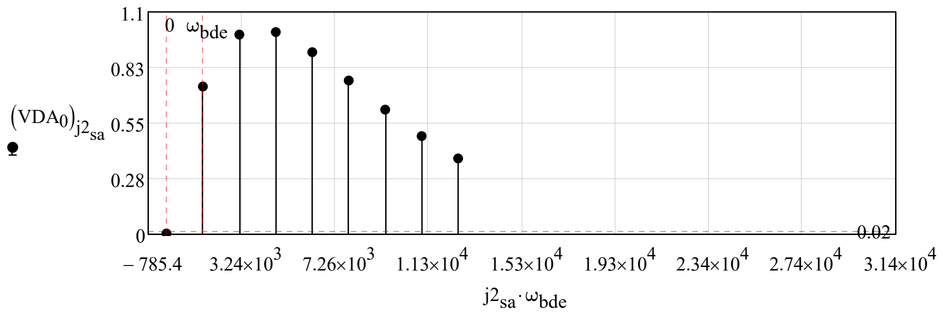


$N1\_ := 50$ $\quad \omega_{bde} := \frac{2\cdot\pi}{T_{bdeppsl}}$ $\quad VDagnp(t) := \frac{V_{Dagnp}(t, \tau_{ptd\_}, T_{bdeppsl}, V_{pp}, N0_{gd})}{V}$

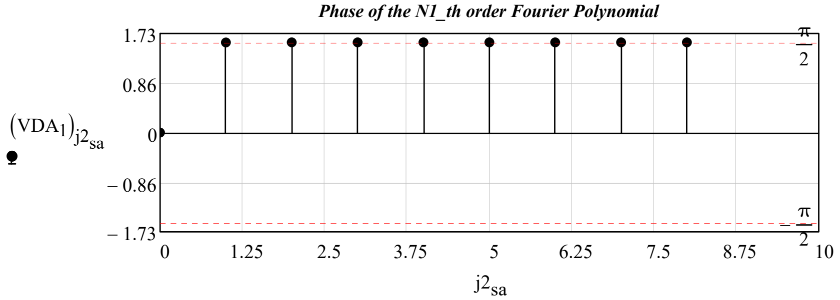
$VDA := SPCT(VDagnp, rt_{gd}, N1\_, 0\cdot s, T_{bdeppsl})$ $\quad N1\_ = 50$

$j2_{sa} := 0 .. rows(VDA) - 1$ $\quad \omega_{bde} = 1.571\cdot\frac{krads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := VDA_3\cdot Hz$

$Bw_{sa} = 4.5\times 10^{-3}\cdot MHz$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa}$ $\quad fpt_{so} = 9\times 10^{-3}\cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

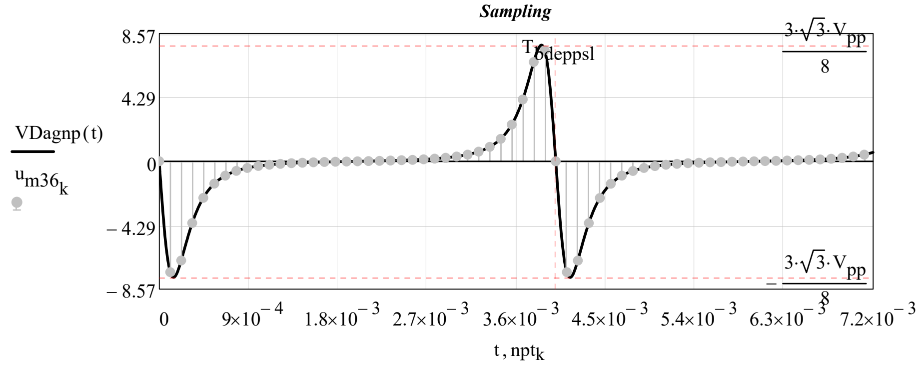
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}}\cdot\frac{1}{T_{bdeppsl}} = 7.111$

$(u_{m36})_k := VDagnp(npt_k)$

$u_{m36}^T =$

	0	1	2	3	4
0	6.996·10⁻³	-7.43	-6.649	-4.138	...

Sampling

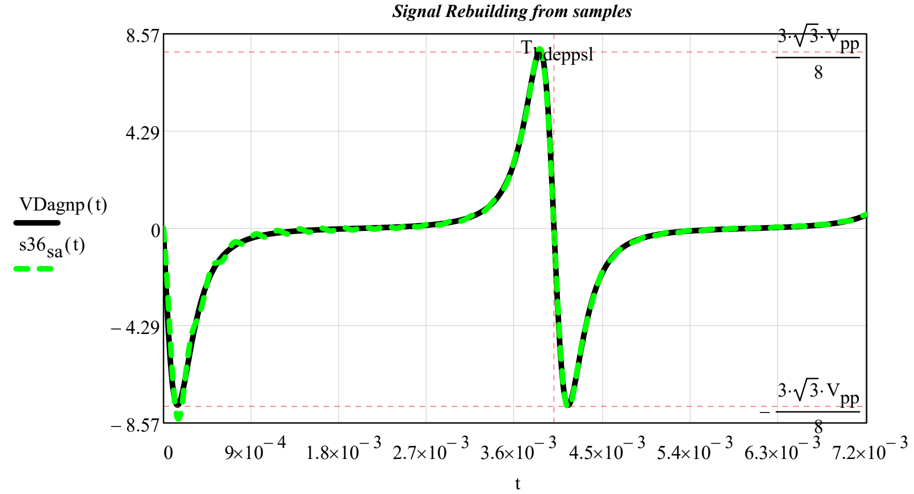


$relerr = 10\cdot\%$ $\quad \omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\quad \omega_{bwr} = 0.028\cdot\frac{Mrads}{sec}$ $\quad n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s36_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m36_n}\cdot sinc(\omega_{bwr}\cdot t - n\cdot\pi)\right)\right]$ $\quad N0_{gd} - 1 = 255$ $\quad relerr = 10\cdot\%$

Signal Rebuilding from samples

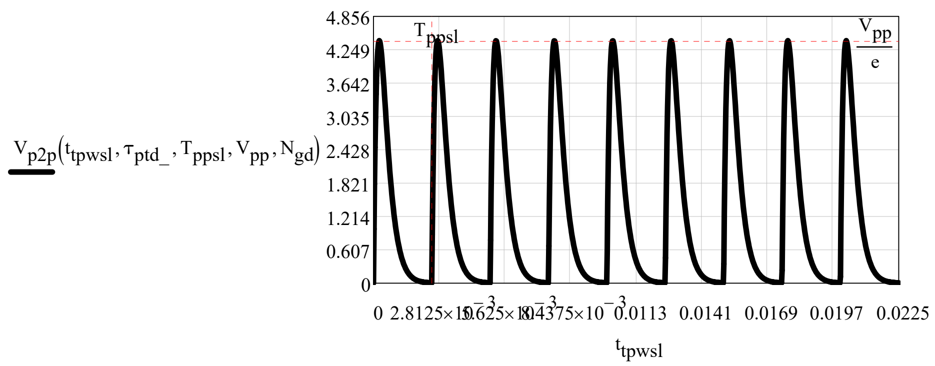


Periodic Waveforms

37 Poisson Profile Voltage Pulse Train

$$t_{tpw} := 0\cdot\tau_{ptd\_}, 0\cdot\tau_{ptd\_} + \frac{200\cdot\tau_{ptd\_}}{500} .. 200\cdot\tau_{ptd\_}$$

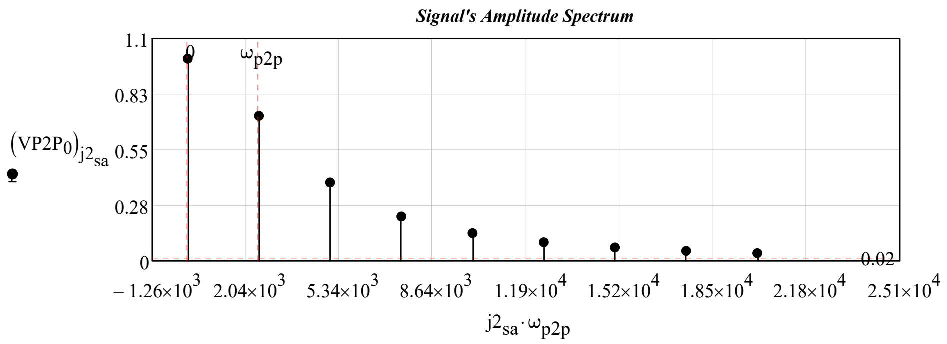
$$T_{ppsl} := 10\cdot\tau_{ptd\_}$$

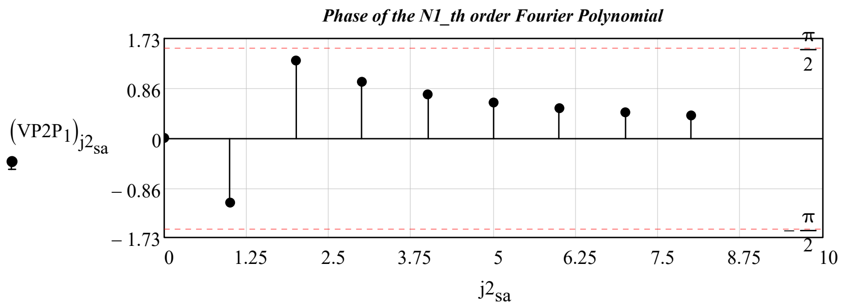


$$\omega_{p2p} := \frac{2\cdot\pi}{T_{ppsl}} \qquad V_{p2p}(t) := \frac{V_{p2p}(t, \tau_{ptd\_}, T_{ppsl}, V_{pp}, N_{gd})}{V}$$

$$VP2P := SPCT(V_{p2p}, rt_{gd}, N1\_, 0\cdot s, T_{ppsl}) \qquad N1\_ = 50$$

$$j2_{sa} := 0 .. rows(VP2P) - 1 \qquad \omega_{p2p} = 2.513\cdot\frac{krads}{s}$$





$$Bw_{sa} := VP2P_3\cdot Hz$$

$$Bw_{sa} = 0.01\cdot MHz$$

sampling frequency: $fpt_{so} := 2\cdot Bw_{sa}$ $\qquad fpt_{so} = 0.02\cdot MHz$

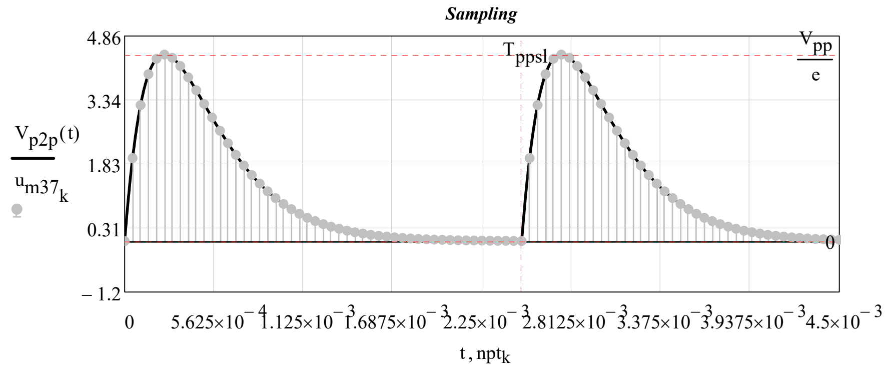
$$npt_k := \frac{k}{fpt_{so}}$$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}}\cdot\frac{1}{T_{ppsl}} = 5.12$

$$(u_{m37})_k := V_{p2p}(npt_k)$$

$u_{m37}{}^T =$

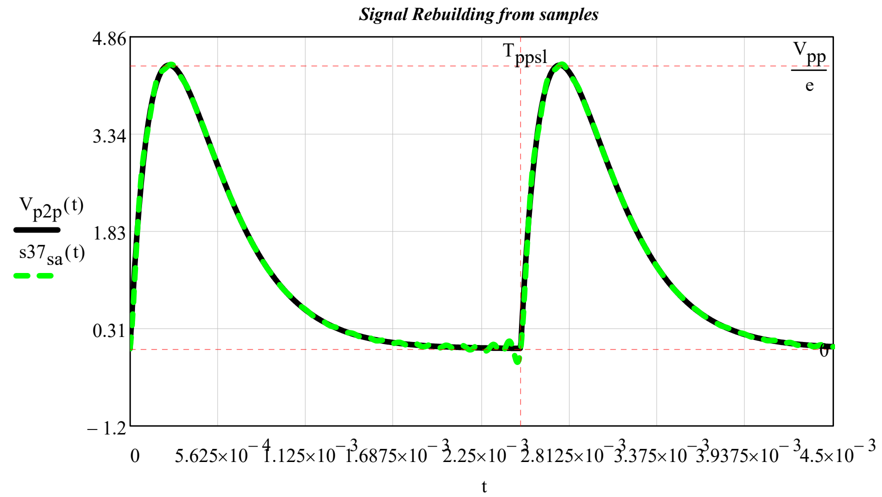
	0	1	2	3	4
0	0	1.965	3.218	3.951	...



relerr = 10·% $\qquad \omega_{bwr} := 2\cdot\pi\cdot Bw_{sa} \qquad \omega_{bwr} = 0.063\cdot\frac{Mrads}{sec} \qquad n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

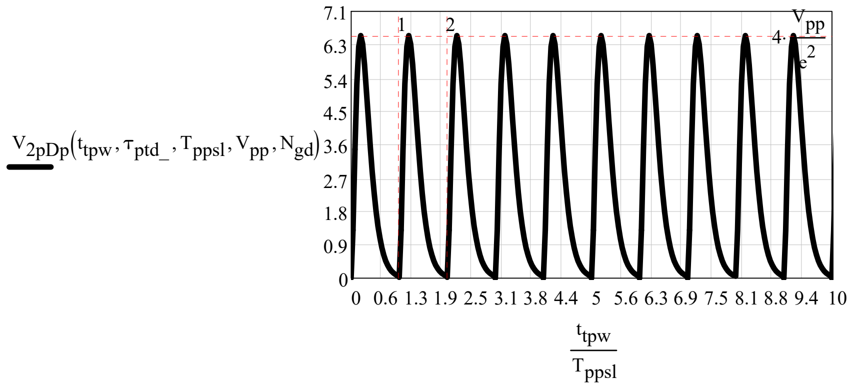
Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s37_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m37_n}\cdot sinc(\omega_{bwr}\cdot t - n\cdot\pi)\right)\right] \qquad N0_{gd} - 1 = 255 \qquad relerr = 10\cdot\%$



Periodic Waveforms

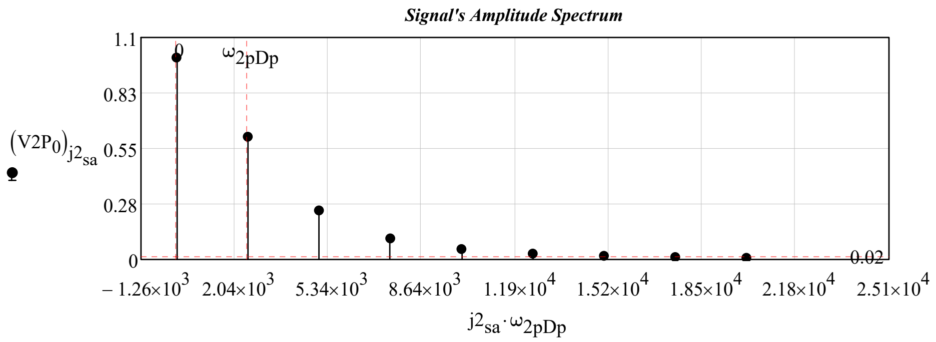
38 Poisson Derivative Profile Voltage Pulse Train

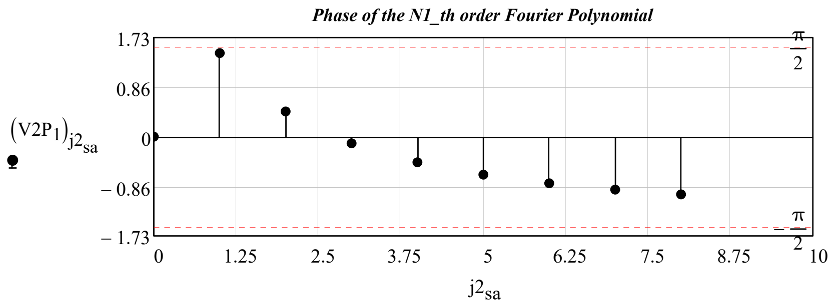


$$\omega_{2pDp} := \frac{2 \cdot \pi}{T_{ppsl}} \qquad V2pDp(t) := \frac{V_{2pDp}(t, \tau_{ptd\_}, T_{ppsl}, V_{pp}, N_{gd})}{V}$$

$$V2P := SPCT(V2pDp, rt_{gd}, N1\_, 0 \cdot s, T_{ppsl}) \qquad N1\_ = 50$$

$$j2_{sa} := 0 .. rows(V2P) - 1 \qquad \omega_{2pDp} = 2.513 \cdot \frac{krads}{s}$$





$$Bw_{sa} := V2P_3 \cdot Hz$$

$$Bw_{sa} = 4.8 \times 10^{-3} \cdot MHz$$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\qquad fpt_{so} = 9.6 \times 10^{-3} \cdot MHz$

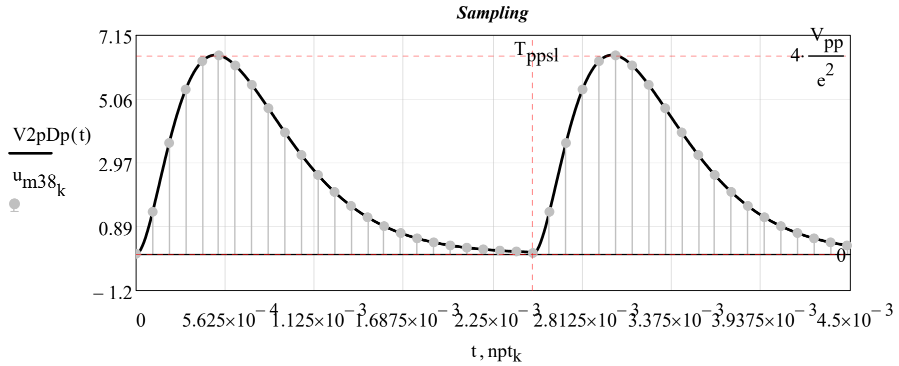
$$npt_k := \frac{k}{fpt_{so}}$$

Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{ppsl}} = 10.667$

$$(u_{m38})_k := V2pDp(npt_k)$$

$u_{m38}^T =$

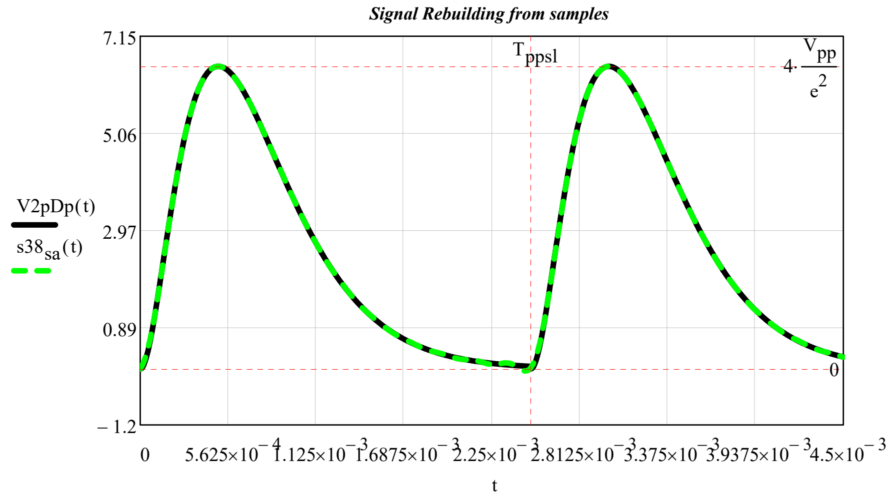
	0	1	2	3	4	5	6	7	8
0	0	1.373	3.622	5.372	6.296	6.485	6.156	5.524	...



$relerr = 10 \cdot \%$ $\qquad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\qquad \omega_{bwr} = 0.03 \cdot \frac{Mrads}{sec}$ $\qquad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

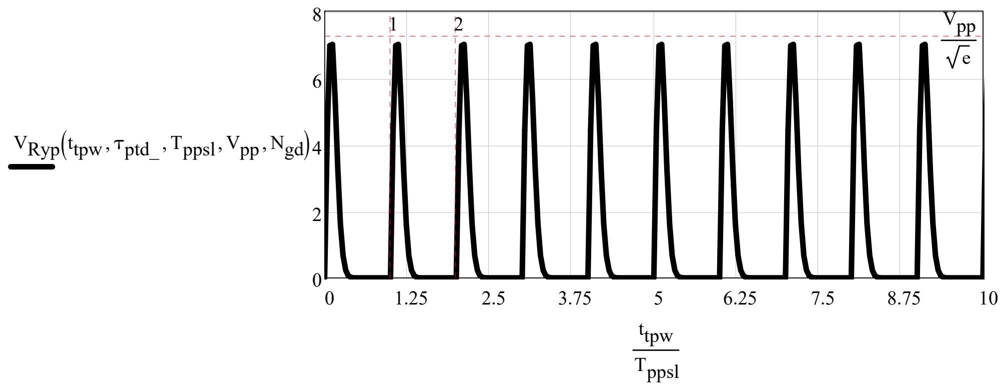
interpolation formula $\qquad s38_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m38_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi)\right)\right]$ $\qquad N0_{gd} - 1 = 255$ $\qquad relerr = 10 \cdot \%$



TEST Waveforms

Periodic Waveforms

39 Rayleigh Profile Voltage Pulse Train

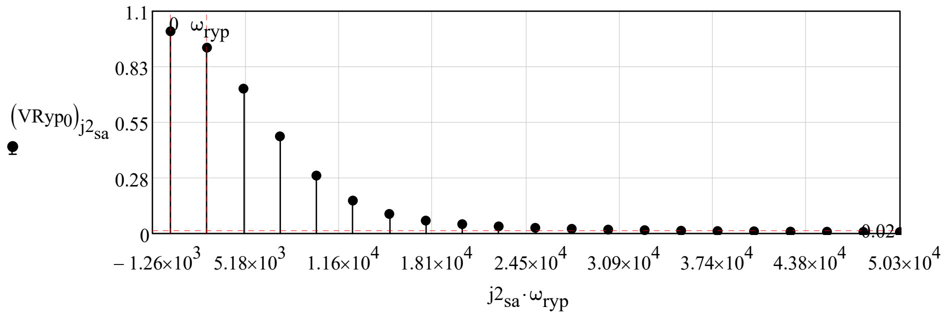


$\omega_{ryp} := \frac{2\cdot\pi}{T_{ppsl}}$ $\qquad V_{Ryp}(t) := \frac{V_{Ryp}(t, \tau_{ptd\_}, T_{ppsl}, V_{pp}, N_{gd})}{V}$

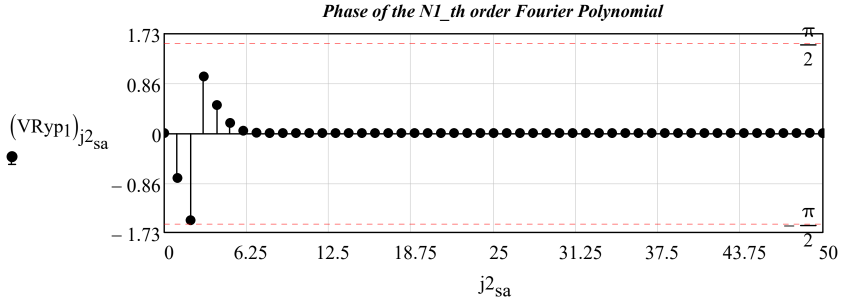
$VRyp := SPCT(V_{Ryp}, rt_{gd}, N1\_, 0\cdot s, T_{ppsl})$ $\qquad N1\_ = 50$

$j2_{sa} := 0 .. rows(VRyp_0) - 1$ $\qquad \omega_{ryp} = 2.513\cdot\frac{krads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := VRyp_3\cdot Hz$

$Bw_{sa} = 8\times 10^{-3}\cdot MHz$

sampling frequency: $\quad fpt_{so} := 2\cdot Bw_{sa}$ $\qquad fpt_{so} = 0.016\cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

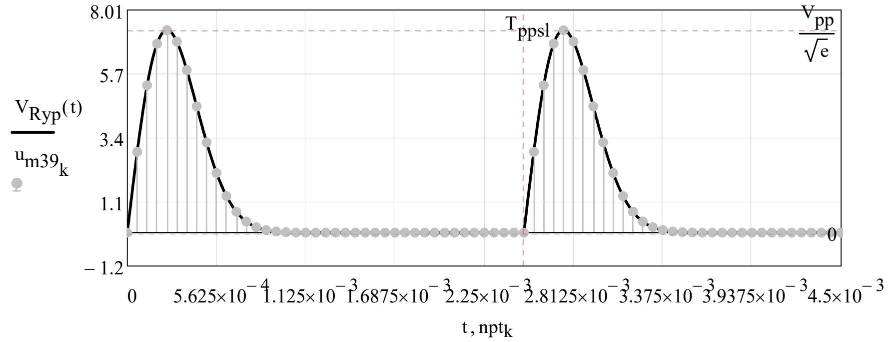
Frequency resolution: $\quad \frac{N0_{gd}}{fpt_{so}}\cdot\frac{1}{T_{ppsl}} = 6.4$

$(u_{m39})_k := V_{Ryp}(npt_k)$

$u_{m39}^T =$

	0	1	2	3	4
0	0	2.908	5.295	6.794	...

Sampling

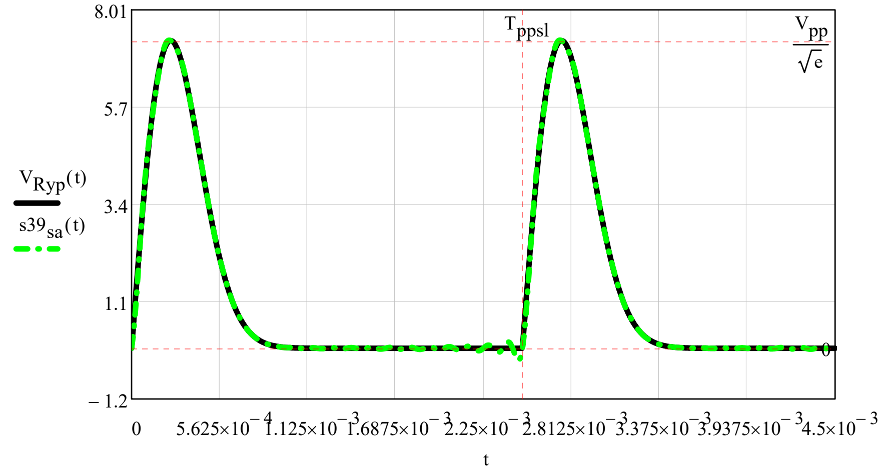


$relerr = 10\cdot\%$ $\qquad \omega_{bwr} := 2\cdot\pi\cdot Bw_{sa}$ $\qquad \omega_{bwr} = 0.05\cdot\frac{Mrads}{sec}$ $\qquad n\cdot\frac{\pi}{\omega_{bwr}} = n\cdot\frac{1}{2\cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\qquad s39_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1}\left(u_{m39_n}\cdot sinc(\omega_{bwr}\cdot t - n\cdot\pi)\right)\right]$ $\qquad N0_{gd} - 1 = 255$ $\qquad relerr = 10\cdot\%$

Signal Rebuilding from samples



Periodic Waveforms

40 Cap. Charge and Discharge Pulse Train

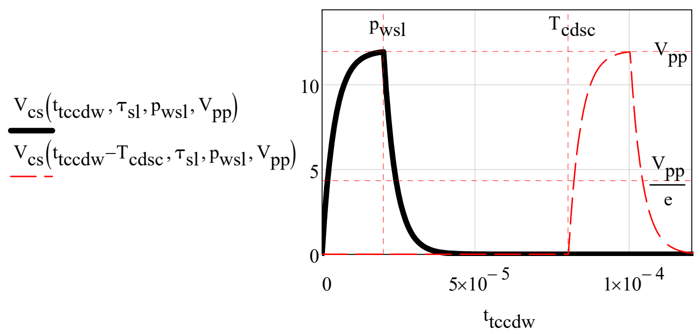
pulse width: $p_{wsl} := 20 \cdot \mu s$

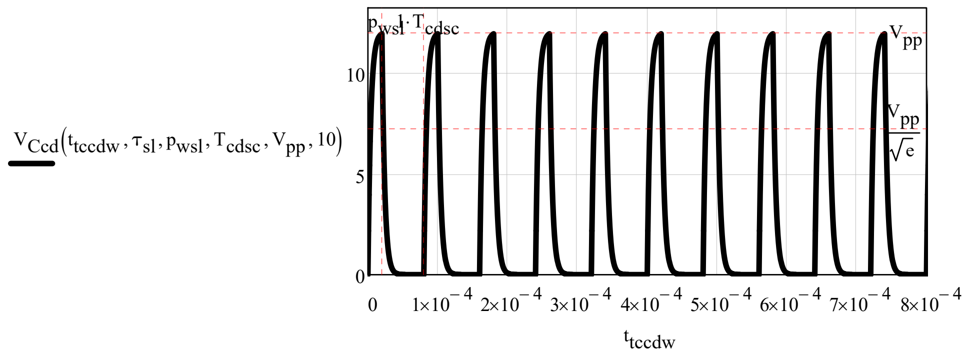
time constant $\tau_{sl} := \frac{p_{wsl}}{5}$

Period: $T_{cdsc} := 4 \cdot p_{wsl}$ $\omega_{cdsc} := \frac{2 \cdot \pi}{T_{cdsc}}$

$t_{tccdw} := 0 \cdot T_{cdsc}, 0 \cdot T_{cdsc} + \frac{100 \cdot T_{cdsc}}{10000} .. 100 \cdot T_{cdsc}$

Cap. Voltage Charge and Discharge



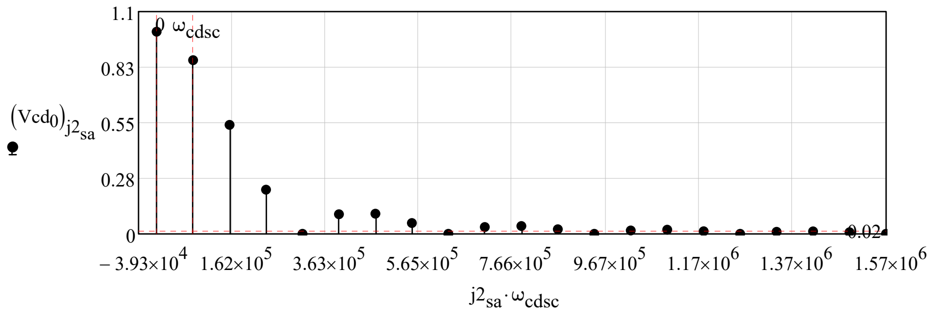


$VCcd(t) := \frac{V_{Ccd}(t, \tau_{sl}, p_{wsl}, T_{cdsc}, V_{pp}, 10)}{V}$

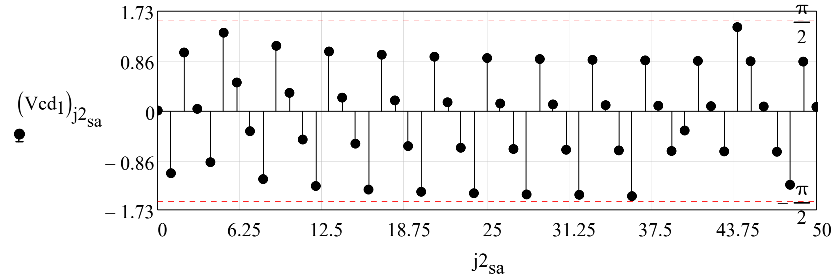
$Vcd := SPCT(VCcd, rt_{gd}, N1\_, 0 \cdot s, T_{cdsc})$ $N1\_ = 50$

$j2_{sa} := 0 .. rows(Vcd_0) - 1$ $\omega_{cdsc} = 78.54 \cdot \frac{krads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := Vcd_3 \cdot Hz$

$Bw_{sa} = 0.325 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $fpt_{so} = 0.65 \cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

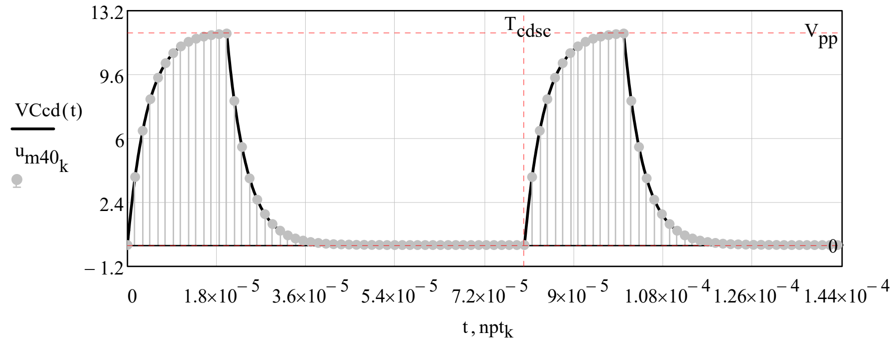
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{cdsc}} = 4.923$

$u_{m40_k} := VCcd(npt_k)$

$u_{m40}^{T} =$

	0	1	2	3	4
0	0	3.831	6.44	8.215	...

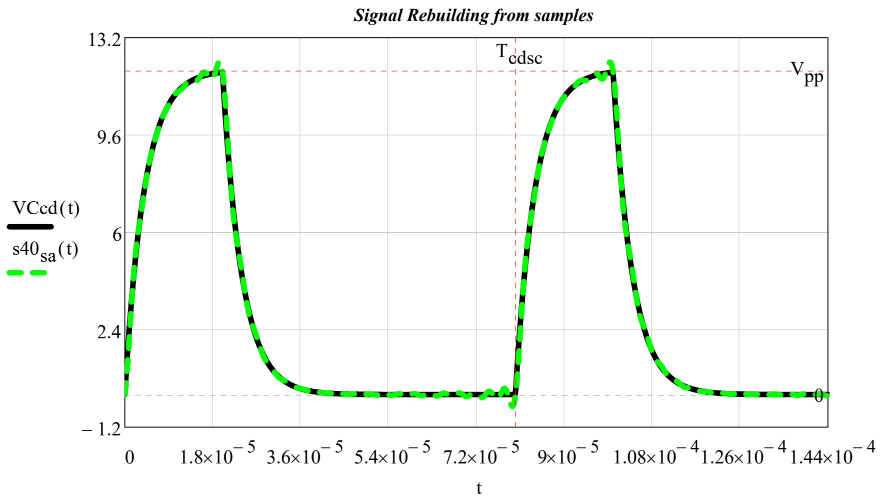
Sampling



relerr = 10·% $\omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\omega_{bwr} = 2.042 \cdot \frac{Mrads}{sec}$ $n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s40_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m40_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi)\right)\right]$ $N0_{gd} - 1 = 255$ relerr = 10·%

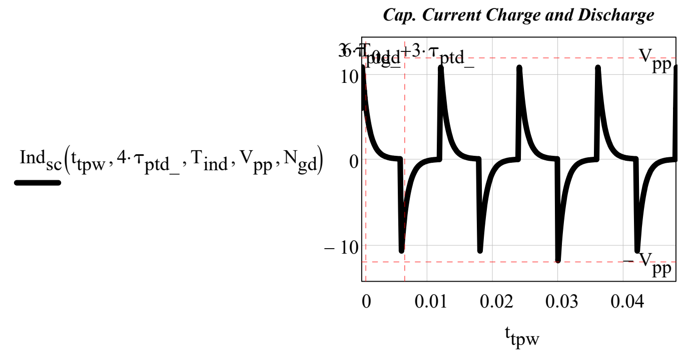


Periodic Waveforms

41 Induct Charge and Discharge Pulse Train

$T_{ind} := 6 \cdot T_{0gd}$

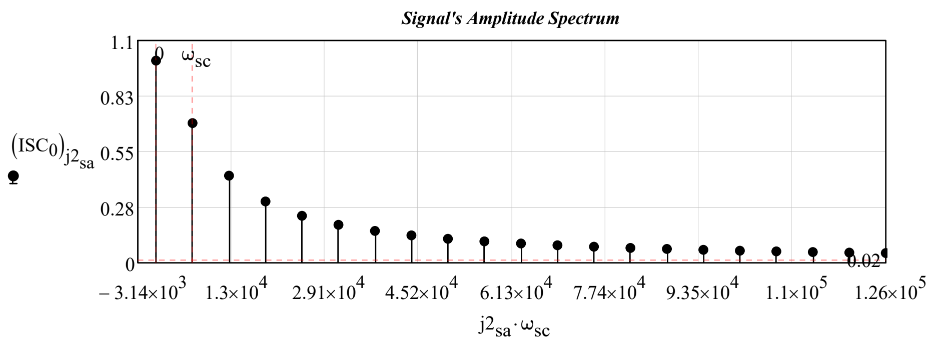
$$Ind_{sc}(t_{tw}, \tau_{ptd}, T_{ind}, V_{pp}) := \sum_{k=0}^{N_{gd}} \left[(-1)^k \cdot V_{dis}(t_{tw} - k \cdot T_{ind}, \tau_{ptd}, V_{pp}) \right]$$

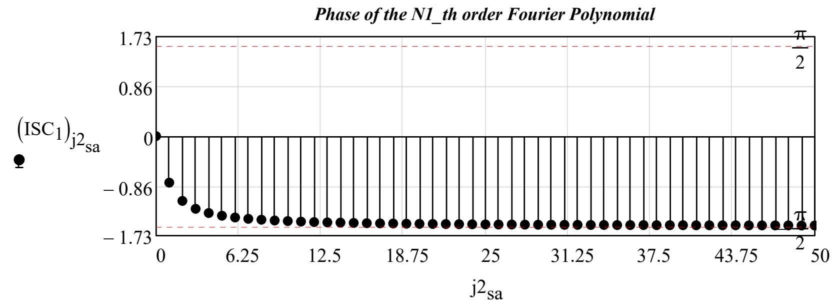


$$Indsc(t) := \frac{Ind_{sc}(t, 4 \cdot \tau_{ptd\_}, T_{ind}, V_{pp}, N_{gd})}{V}$$

$\omega_{sc} := \dfrac{2 \cdot \pi}{T_{0gd}}$ $\quad ISC := SPCT(Indsc, rt_{gd}, N1\_, 0 \cdot s, T_{ind})$ $\quad N1\_ = 50$

$j2_{sa} := 0 .. rows(ISC_0) - 1$ $\quad \omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \dfrac{Mrads}{s}$





$Bw_{sa} := ISC_3 \cdot Hz$

$Bw_{sa} = 8 \times 10^{-3} \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 0.016 \cdot MHz$

$npt_k := \dfrac{k}{fpt_{so}}$

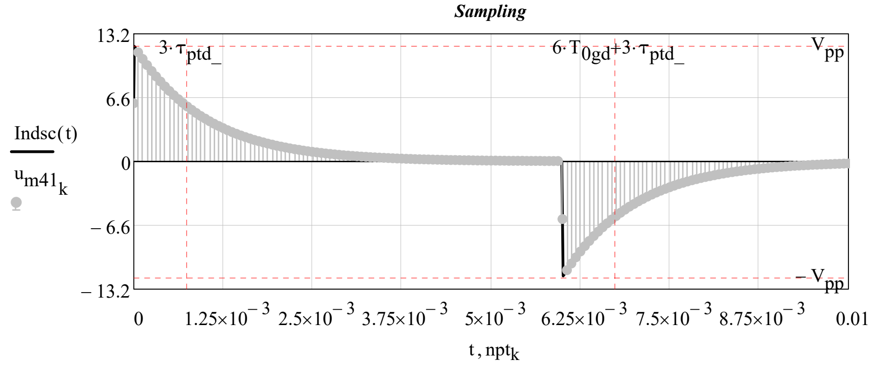
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{ind}} = 2.667$

$u_{m41_k} := Indsc(npt_k)$

$u_{m41}^T =$

	0	1	2	3	4	5	6
0	6	11.273	10.59	9.948	9.346	8.779	...

Sampling

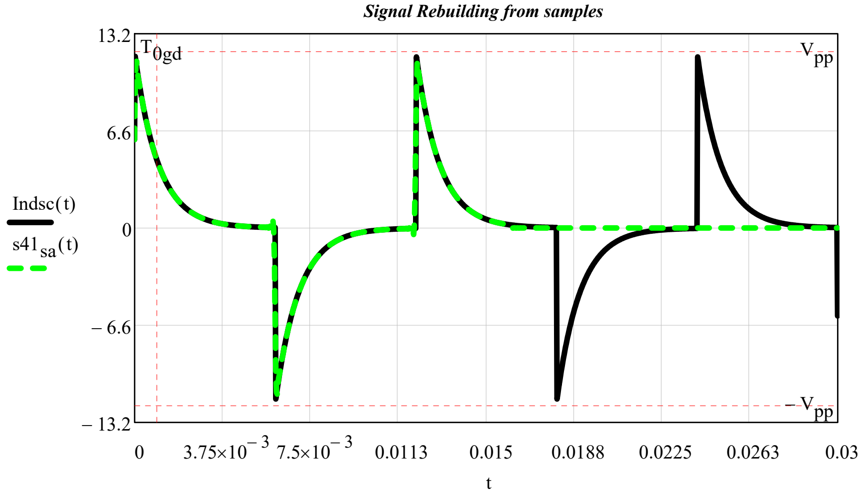


$relerr = 10 \cdot \%$ $\omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\omega_{bwr} = 0.05 \cdot \frac{Mrads}{sec}$ $n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $s41_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m41_n} \cdot sinc\left(\omega_{bwr} \cdot t - n \cdot \pi\right)\right)\right]$ $N0_{gd} - 1 = 255$ $relerr = 10 \cdot \%$

Signal Rebuilding from samples



Periodic Waveforms

42 Parbolic Cusps Pulse Train

Signal amplitude: $V_{pp} = 12 \cdot V$

Pulse width: $p_{wsl} = 20 \cdot \mu s$

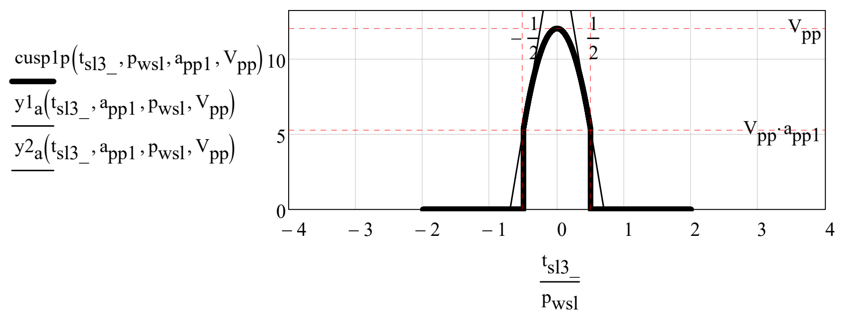
Duty cycle: $\delta_{cysl} := \gamma$

Period: $T_{pcsp} := \frac{p_{wsl}}{\delta_{cysl}}$ $\omega_{pcsp} := \frac{2 \cdot \pi}{T_{pcsp}}$

Max pulse amplitude and cusp ratio: $a_{pp1} := \frac{4}{9}$

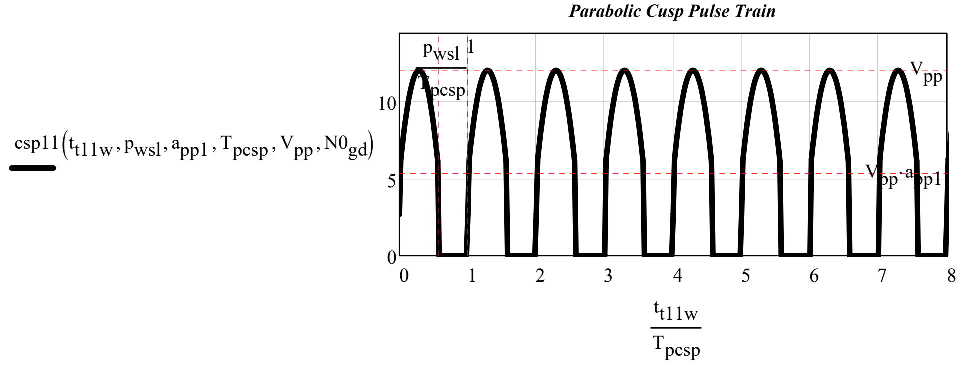
$$t_{sl3\_} := -2 \cdot p_{wsl}, -2 \cdot p_{wsl} + \frac{\left(2 \cdot p_{wsl} + 2 \cdot p_{wsl}\right)}{10000} .. 2 \cdot p_{wsl}$$

Parabolic Cusp Pulse



$$t_{t11w} := 0 \cdot T_{pcsp}, 0 \cdot T_{pcsp} + \frac{10 \cdot T_{pcsp} - 0 \cdot T_{pcsp}}{500} .. 10 \cdot T_{pcsp}$$

Parabolic Cusp Pulse Train

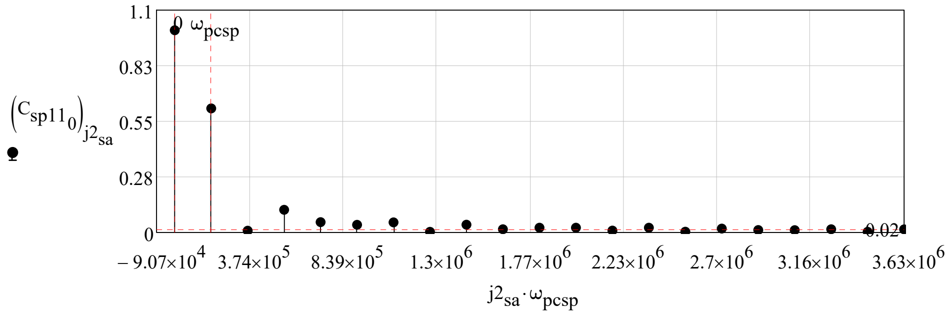


$$Csp11(t) := \frac{csp11\left(t, p_{wsl}, a_{pp1}, T_{pcsp}, V_{pp}, N0_{gd}\right)}{V}$$

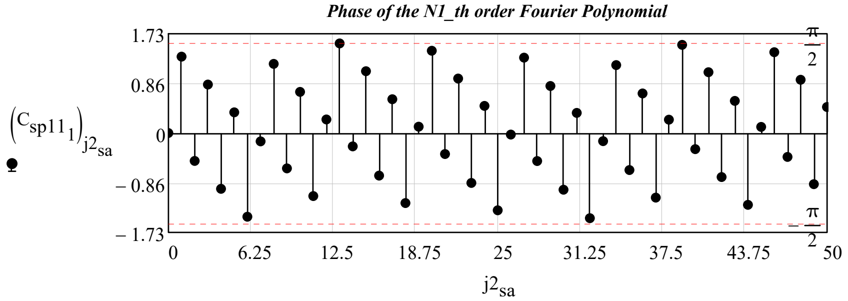
$C_{sp11} := SPCT\left(Csp11, rt_{gd}, N1\_, 0 \cdot s, T_{pcsp}\right)$ $N1\_ = 50$

$j2_{sa} := 0 .. rows\left(C_{sp11_0}\right) - 1$ $\omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := C_{sp11_3} \cdot Hz$

$Bw_{sa} = 1.385 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 2.771 \cdot MHz$

$npt_k := \dfrac{k}{fpt_{so}}$

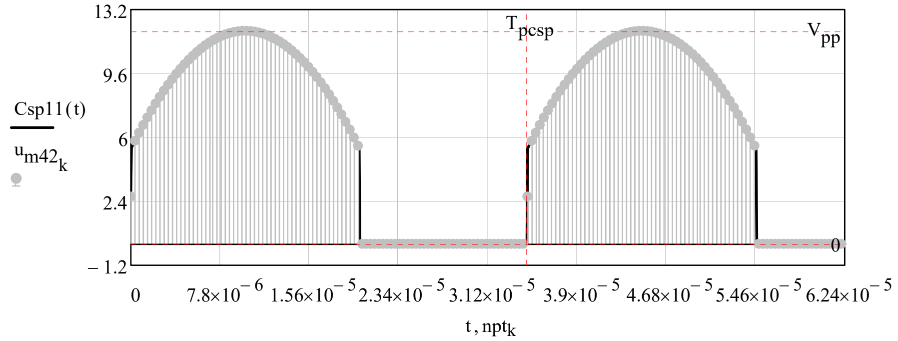
Frequency resolution: $\dfrac{N0_{gd}}{fpt_{so}} \cdot \dfrac{1}{T_{pcsp}} = 2.667$

$u_{m42_k} := Csp11\left(npt_k\right)$

$u_{m42}^{T} =$

	0	1	2	3	4	5	6	7
0	2.667	5.806	6.261	6.699	7.119	7.522	7.908	...

Sampling

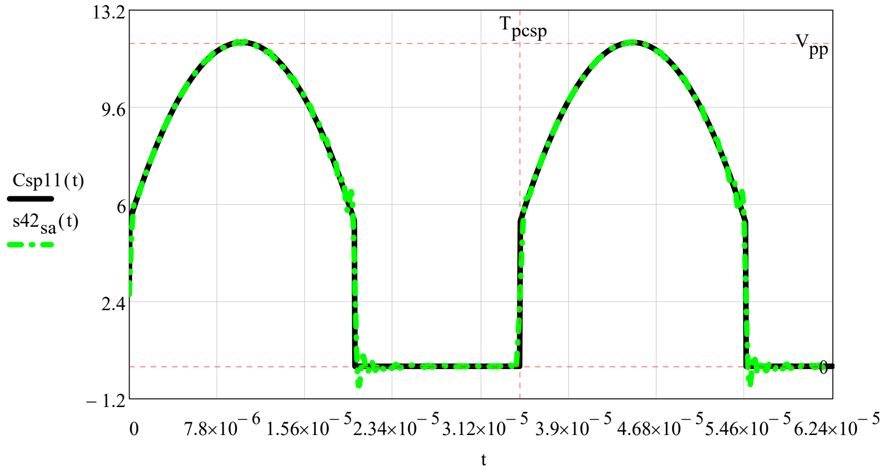


$relerr = 10 \cdot \%$ $\quad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\quad \omega_{bwr} = 8.704 \cdot \dfrac{Mrads}{sec}$ $\quad n \cdot \dfrac{\pi}{\omega_{bwr}} = n \cdot \dfrac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s42_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m42_n} \cdot sinc\left(\omega_{bwr} \cdot t - n \cdot \pi\right)\right)\right]$ $\quad N0_{gd} - 1 = 255$ $\quad relerr = 10 \cdot \%$

Signal Rebuilding from samples



Periodic Waveforms

43 Elliptic Cusps Pulse Train

Signal amplitude: $V_{pp} = 12 \cdot V$

Pulse width: $p_{wsl} = 20 \cdot \mu s$

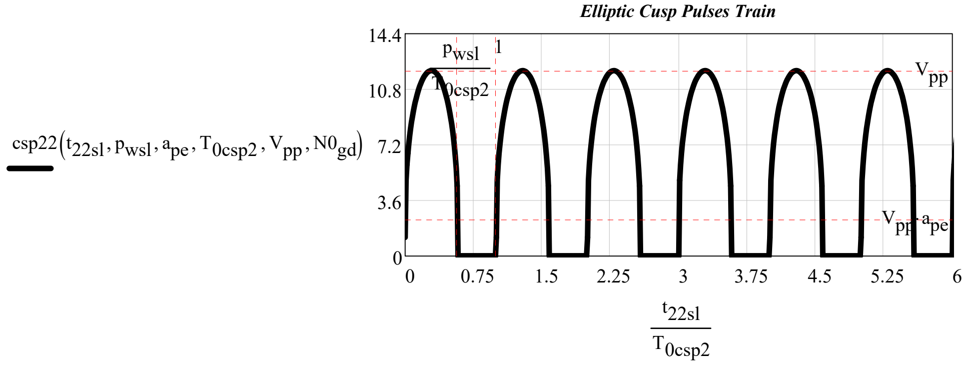
Duty cycle: $\delta_{cysl} := \gamma$

Period: $T_{0csp2} := \frac{p_{wsl}}{\delta_{cysl}}$

Max pulse amplitude and cusp ratio: $a_{pe} := \frac{2}{10}$

$$t_{22sl} := 0 \cdot T_{0csp2}, 0 \cdot T_{0csp2} + \frac{10 \cdot T_{0csp2} - 0 \cdot T_{0csp2}}{1000} .. 10 \cdot T_{0csp2}$$

Elliptic Cusp Pulses Train

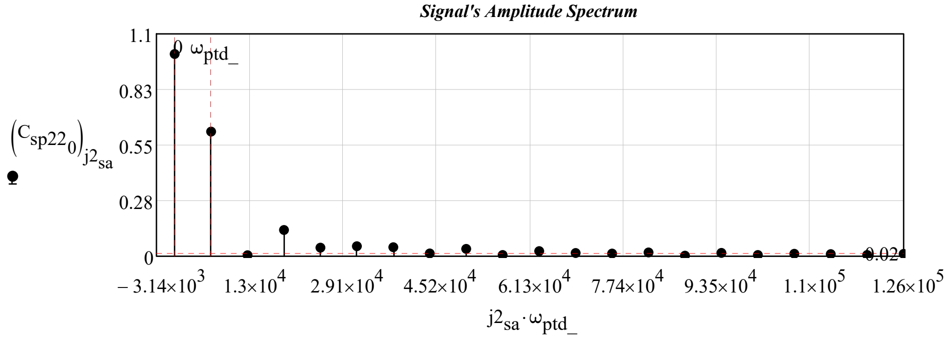


$$Csp22(t) := \frac{csp22(t, p_{wsl}, a_{pe}, T_{0csp2}, V_{pp}, N0_{gd})}{V}$$

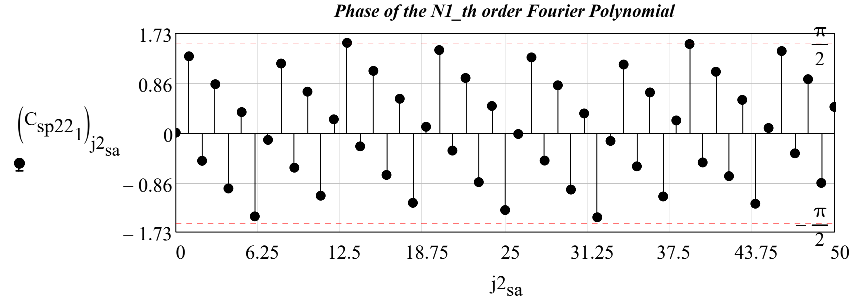
$C_{sp22} := SPCT(Csp22, rt_{gd}, N1\_, 0 \cdot s, T_{0csp2})$ $\quad N1\_ = 50$

$j2_{sa} := 0 .. rows(C_{sp22_0}) - 1$ $\quad \omega_{ptd\_} = 6.283 \times 10^{-3} \cdot \frac{Mrads}{s}$

Signal's Amplitude Spectrum



Phase of the N1_th order Fourier Polynomial



$Bw_{sa} := C_{sp22_3} \cdot Hz$

$Bw_{sa} = 1.385 \cdot MHz$

sampling frequency: $fpt_{so} := 2 \cdot Bw_{sa}$ $\quad fpt_{so} = 2.771 \cdot MHz$

$npt_k := \frac{k}{fpt_{so}}$

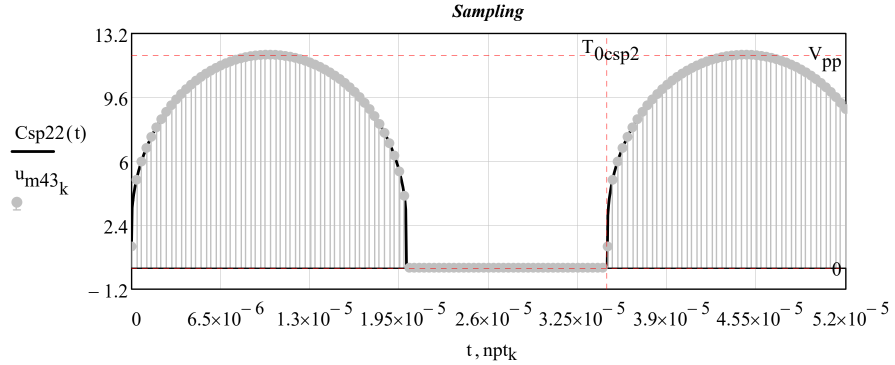
Frequency resolution: $\frac{N0_{gd}}{fpt_{so}} \cdot \frac{1}{T_{0csp2}} = 2.667$

$u_{m43_k} := Csp22(npt_k)$

$u_{m43}^T =$

	0	1	2	3	4	5	6	7
0	1.2	4.956	5.981	6.745	7.369	7.901	8.366	...

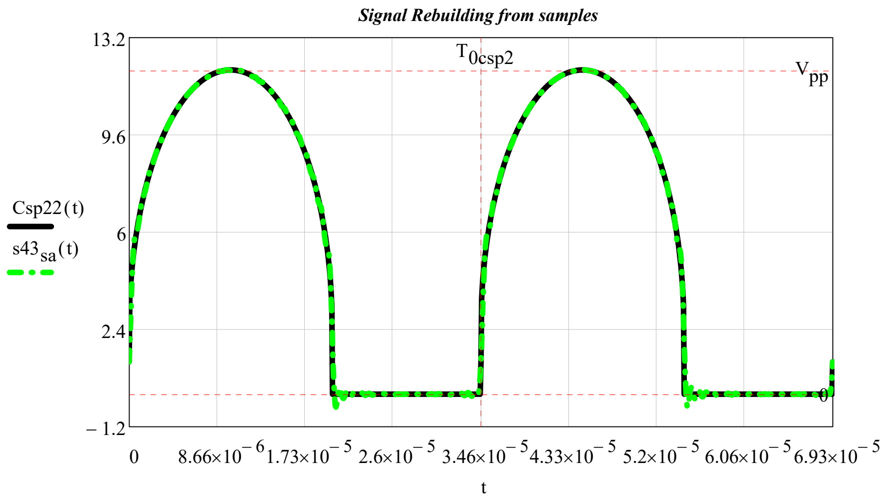
Sampling



$relerr = 10 \cdot \%$ $\quad \omega_{bwr} := 2 \cdot \pi \cdot Bw_{sa}$ $\quad \omega_{bwr} = 8.704 \cdot \frac{Mrads}{sec}$ $\quad n \cdot \frac{\pi}{\omega_{bwr}} = n \cdot \frac{1}{2 \cdot Bw_{sa}}$

Signal reconstruction according to the Shannon sampling theorem:

interpolation formula $\quad s43_{sa}(t) := \left[\sum_{n=0}^{N0_{gd}-1} \left(u_{m43_n} \cdot sinc(\omega_{bwr} \cdot t - n \cdot \pi) \right) \right]$ $\quad N0_{gd} - 1 = 255$ $\quad relerr = 10 \cdot \%$


Signal Rebuilding from samples
13.2
9.6
6
2.4
− 1.2
Csp22(t)
s43sa(t)
T0csp2
Vpp
0
0
8.66×10− 6
1.73×10− 5
2.6×10− 5
3.46×10− 5
4.33×10− 5
5.2×10− 5
6.06×10− 5
6.93×10− 5
t

Fine