

Signal generation

- ▶ Write matlab code to generate different types of **discrete time signals**
- ▶ Learning objectives
 - ▶ Generate discrete time (1D) signals
 - ▶ Good coding practices

Signal generation

- ▶ Follow the example of the code `DATASCIENCE_COURSE/SIGNALS/crcbgenqcsig.m`
 - ▶ Do **git pull** `DATASCIENCE_COURSE` to get the latest update
 - ▶ Write your code in the same format as this function
 - ▶ Learn elements of good coding: Good documentation, Clean and understandable code
 - ▶ Script showing how to use the function: `DSP/testcrcbgenqcsig.m`
- ▶ Once your code is running well:
 - ▶ Use: **git pull → git add → git commit → git push**
 - ▶ **Remember the advice:** Pull before Push

QUADRATIC CHIRP SIGNAL

$$f(t) = A \sin(2\pi\Phi(t))$$

Instantaneous phase:

$$\Phi(t) = a_1 t + a_2 t^2 + a_3 t^3$$

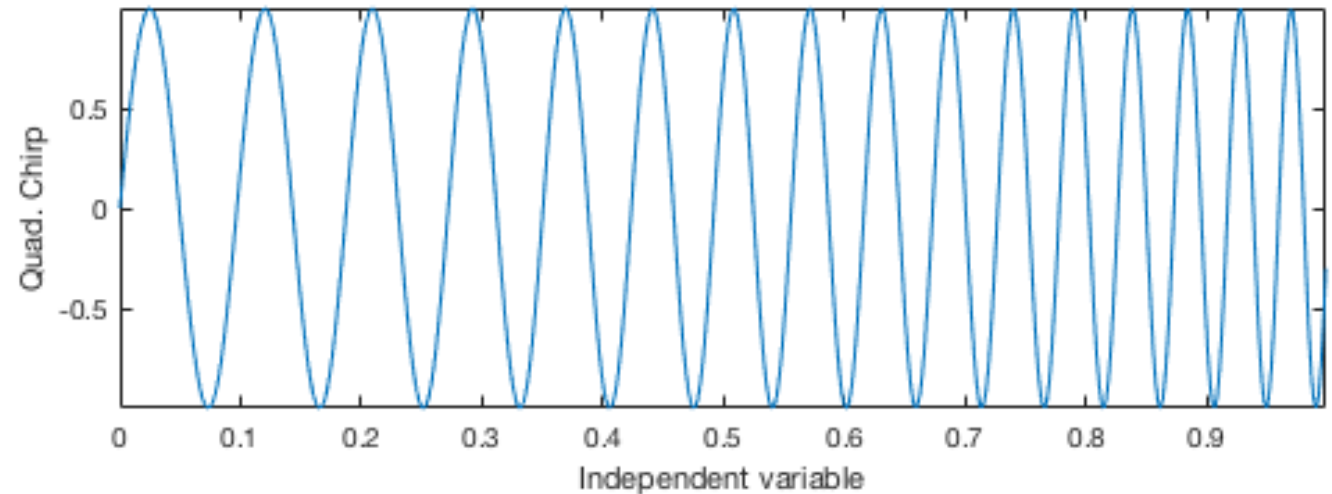
Parameters of the signal:

$$A, a_1, a_2, a_3$$

Instantaneous frequency:

$$\begin{aligned} f(t) &= \frac{d\Phi}{dt} \\ &= a_1 + 2a_2 t + 3a_3 t^2 \end{aligned}$$

$f(t)$ increases with t
 $1/f(t)$ (Instantaneous period) decreases with t



Example taken from textbook (“Swarm intelligence methods for Statistical Regression”, Chapter 1)

Format of a Matlab function definition

`function <output arguments> = <function name>(Input arguments)`

`function sigVec = crcbgenqcsig(dataX,snr,qcCoefs)`

- ▶ `dataX` : vector of time stamps $(t_0, t_1, \dots, t_{M-1})$ at which the samples of the signal $s(t)$ are to be computed.
- ▶ `qcCoefs`: vector of three coefficients $[a_1, a_2, a_3]$ that parametrize the phase of the signal $\Phi(t) = a_1 t + a_2 t^2 + a_3 t^3$
- ▶ `snr`: A special way to define the parameter A

$$\Phi(t) = a_1 t + a_2 t^2 + a_3 t^3$$

`phaseVec = qcCoefs(1)*dataX + qcCoefs(2)*dataX.^2 + qcCoefs(3)*dataX.^3;`

$$\sin(2\pi\Phi(t))$$

`sigVec = sin(2*pi*phaseVec);`

$$A \sin(2\pi\Phi(t))$$

`sigVec = snr*sigVec/norm(sigVec);`

Elements of good coding

```
function sigVec = crcbgenqcsig(dataX,snr,qcCoefs)
```

Function name should be descriptive but short: **CRCBook-Generate-Quadratic-Chirp-Signal**

```
% Generate a quadratic chirp signal
```

First comment is used by Matlab to generate Contents report

```
% S = CRCBGENQSIG(X,SNR,C)
```

Second line shows usage format (input and output arguments); Displayed with command "help crcbgenqcsig"

```
% Generates a quadratic chirp signal S. X is the vector of
```

```
% time stamps at which the samples of the signal are to be computed. SNR is
```

```
% the matched filtering signal-to-noise ratio of S and C is the vector of
```

```
% three coefficients [a1, a2, a3] that parametrize the phase of the signal:
```

```
% a1*t+a2*t^2+a3*t^3.
```

Describe what the code does and what is the meaning of each input and output argument

```
%Soumya D. Mohanty, May 2018
```

Author of the code (add additional lines for multiple authors), Date of creation

```
phaseVec = qcCoefs(1)*dataX + qcCoefs(2)*dataX.^2 + qcCoefs(3)*dataX.^3;
```

```
sigVec = sin(2*pi*phaseVec);
```

```
sigVec = snr*sigVec/norm(sigVec);
```

Variable names should be descriptive.
C++ convention: thisIsAVariableName .
Quadratic Chirp Coefficients

Tasks

- ▶ Write functions to generate the following signals
- ▶ Each function should be accompanied by its own test script ('test<function name>.m') following the example of testcrcbgenqcsig.m
 - ▶ Note: in your function, the overall amplitude A should be interpreted as SNR (see `crcbgenqcsig.m`)
- ▶ Make a plot of each signal
 - ▶ You have to choose a **sampling interval (or period)** Δ
$$t_n = n\Delta, \quad n = 0, 1, \dots, N - 1$$
 - ▶ **Sampling frequency** = $1/\Delta$

List of signals

- ▶ Sinusoidal signal

- ▶ $s(t) = A \sin(2\pi f_0 t + \phi_0)$

- ▶ Parameters: A, f_0, ϕ_0

- ▶ Linear chirp signal

- ▶ $s(t) = A \sin(2\pi(f_0 t + f_1 t^2) + \phi_0)$

- ▶ Parameters: A, f_0, f_1, ϕ_0

- ▶ Sine-Gaussian signal

- ▶ $s(t) = A \exp\left(-\frac{(t-t_0)^2}{2\sigma^2}\right) \sin(2\pi f_0 t + \phi_0)$

- ▶ Parameters: $A, t_0, \sigma, f_0, \phi_0$

List of signals

- ▶ Frequency modulated (FM) sinusoid
 - ▶ $s(t) = A \sin(2\pi f_0 t + b \cos(2\pi f_1 t))$
 - ▶ Parameters: A, b, f_0, f_1
- ▶ Amplitude modulated (AM) sinusoid
 - ▶ $s(t) = A \cos(2\pi f_1 t) \times \sin(\underbrace{f_0}_{2\pi} t + \phi_0)$
 - ▶ Parameters: A, f_0, f_1, ϕ_0
- ▶ AM-FM sinusoid
 - ▶ $s(t) = A \cos(2\pi f_1 t) \times \sin(2\pi f_0 t + b \cos(2\pi f_1 t))$
 - ▶ Parameters: A, b, f_0, f_1

List of signals

- ▶ Linear transient chirp

- ▶ $s(t) = \begin{cases} 0; & t \notin [t_a, t_a + L] \\ A \sin(2\pi(f_0(t - t_a) + f_1(t - t_a)^2) + \phi_0) \end{cases}$

- ▶ Parameters: $A, t_a, f_0, f_1, \phi_0, L$

- ▶ Exponentially damped sinusoid

- ▶ $s(t) = \begin{cases} 0; & t \notin [t_a, t_a + L] \\ A e^{-(t-t_a)/\tau} \sin(2\pi f_0 t + \phi_0) \end{cases}$

- ▶ Parameters: $A, t_a, f_0, \tau, \phi_0, L$

- ▶ Step FM

- ▶ $s(t) = \begin{cases} A \sin(2\pi f_0 t); & t \leq t_a \\ A \sin(2\pi f_1(t - t_a) + 2\pi f_0 t_a); & t > t_a \end{cases}$

- ▶ Parameters: A, t_a, f_0, f_1