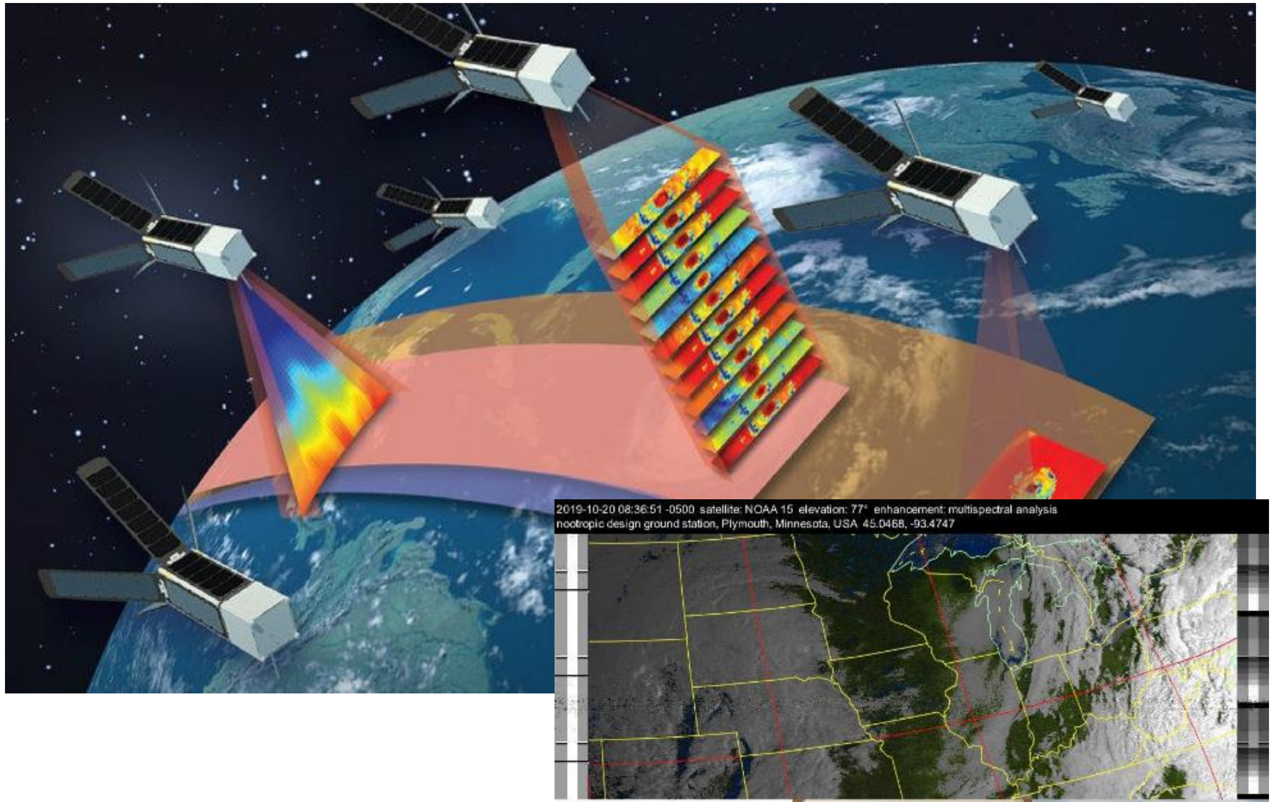
SATÉLITES DE TELECOMUNICAÇÕES

Desenvolvimento de Software Defined Radio (SDR) para estações terrestres de comunicação

MathWorks®

Instalar Matlab



Datas: 20 e 27 de Outubro, 03 de Novembro

1ª aula

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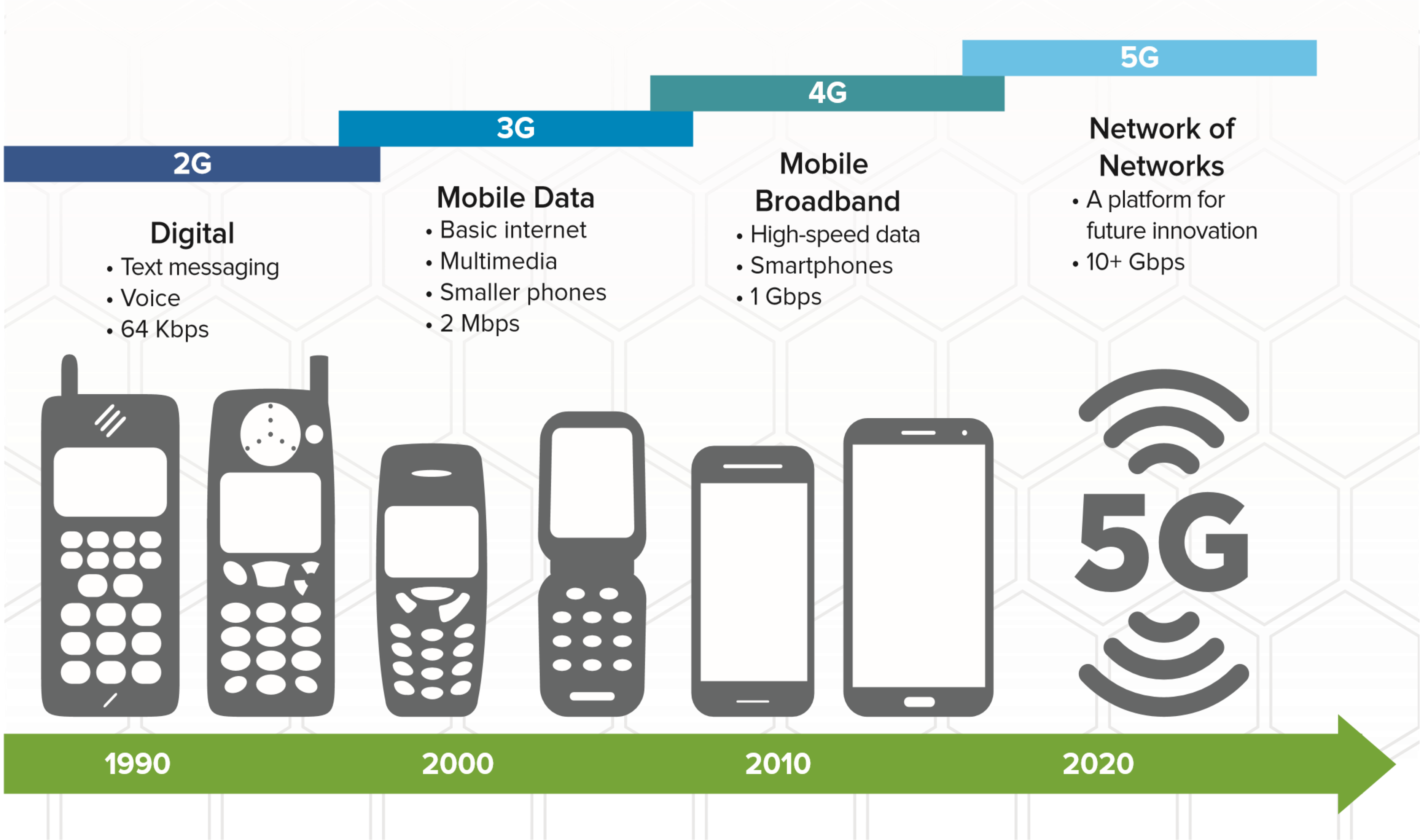
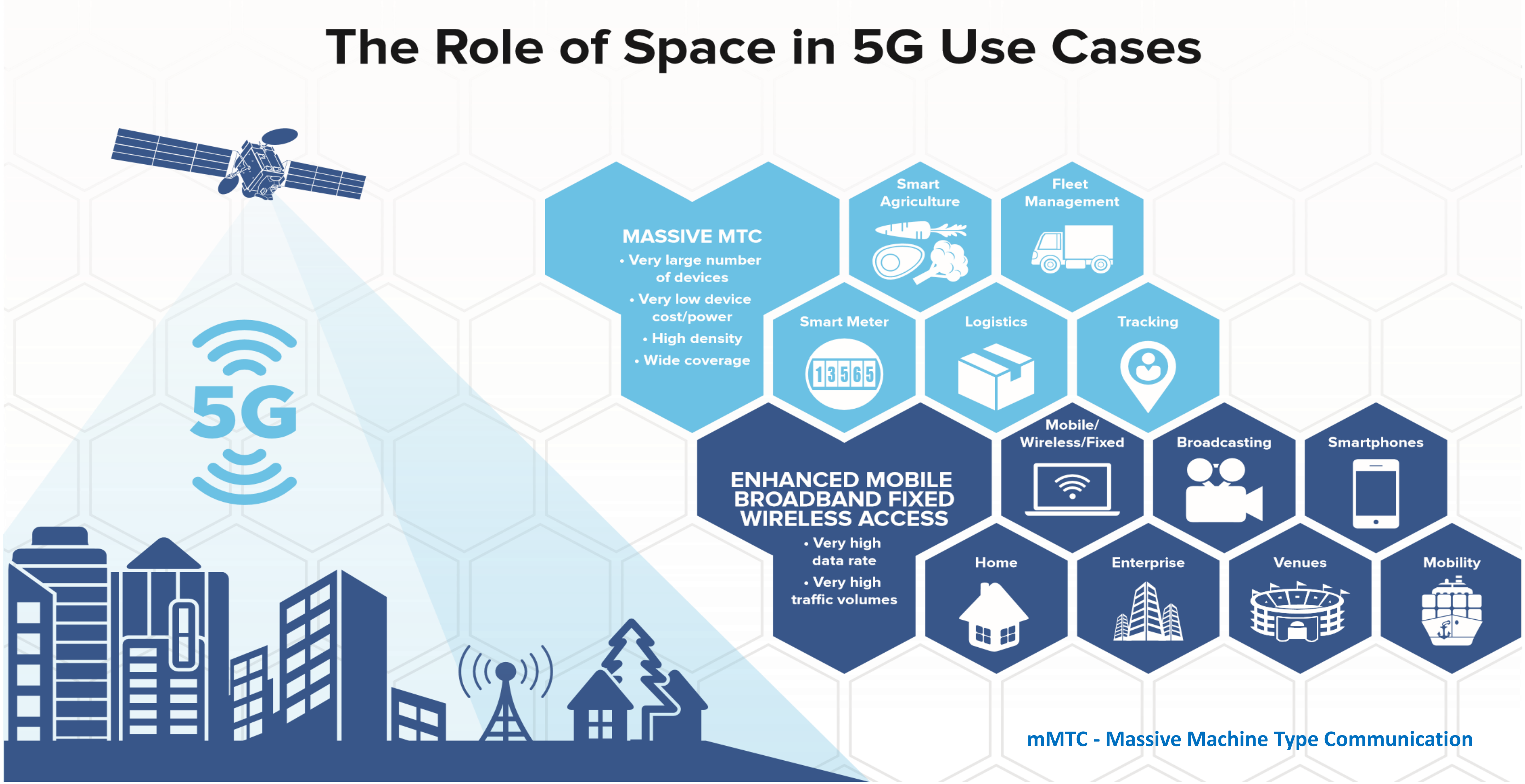
LEA ENGENHARIA AEROESPACIAL LICENCIATURA

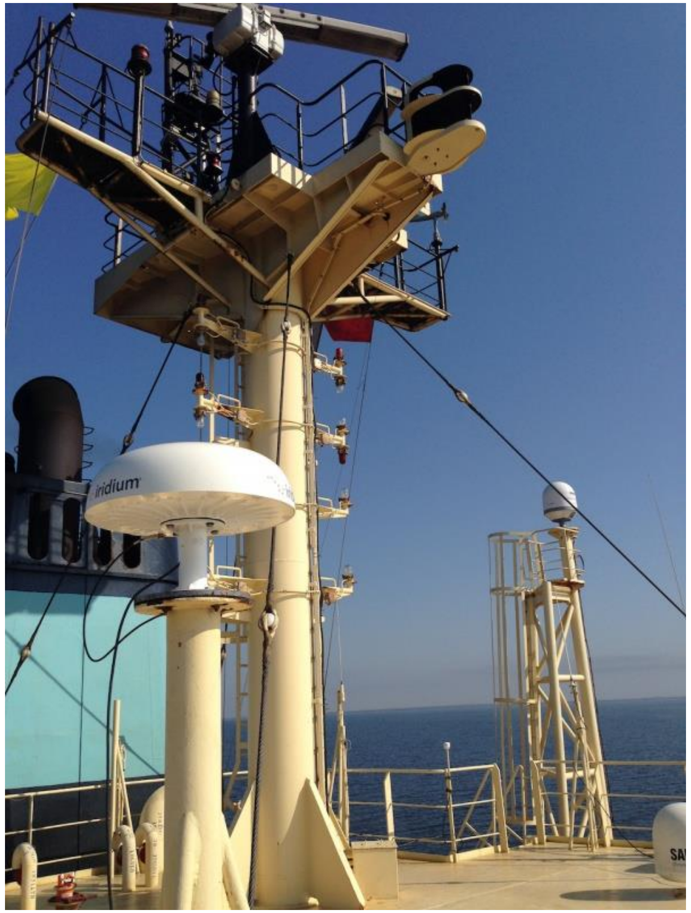


Ref: The Role of Space-based Communications in the 5G Era, Intelesat whitepaper

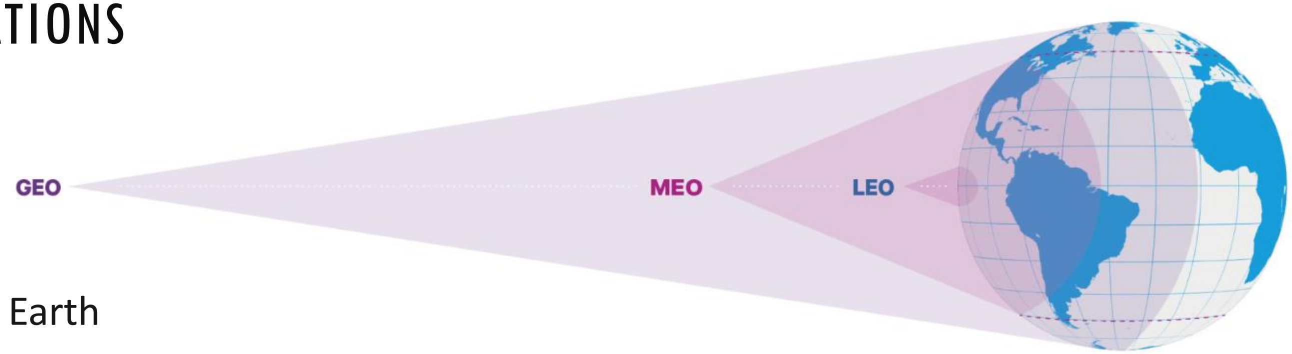


mMTC - Massive Machine Type Communication

INTRODUCTION TO THE SATELLITE TELECOMMUNICATIONS



Communications satellite



GEO – Geosynchronous Orbit (Altitude 35,786km)

Match the rotation of the Earth → stationary to the Earth

Hundreds of GEO satellites are in orbit today

Delivering services such as weather data, broadcast TV, and some low-speed data communication (high latency)

NGSO – Non-Geostationary Orbit

MEO – Medium Earth Orbit (Altitude 2000 to 35,786km)

It has been used for GPS and other navigation applications.

High Throughput Satellites (HTS), based on MEO constellations have been deployed to deliver low-latency, high-bandwidth data connectivity to service providers, government agencies, and commercial enterprises.

MEO satellites bring fibre-like performance to remote areas where laying fibre is not viable, such as cruise, commercial maritime, aero, offshore platforms, network backhaul in difficult terrain, and humanitarian relief operations.

LEO – Low Earth Orbit (Altitude 180 to 2000km)

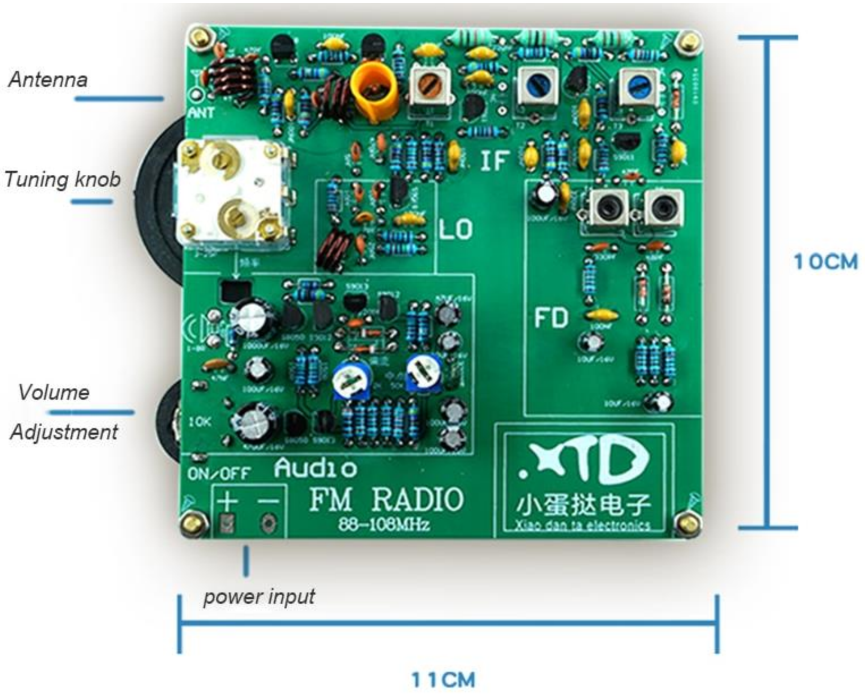
LEO is densely populated with thousands of satellites in operation today, primarily addressing science, imaging, and low-bandwidth telecommunications needs. The next generation of HTS LEO satellites intends to serve communication markets such as mass-consumer and enterprise broadband internet.

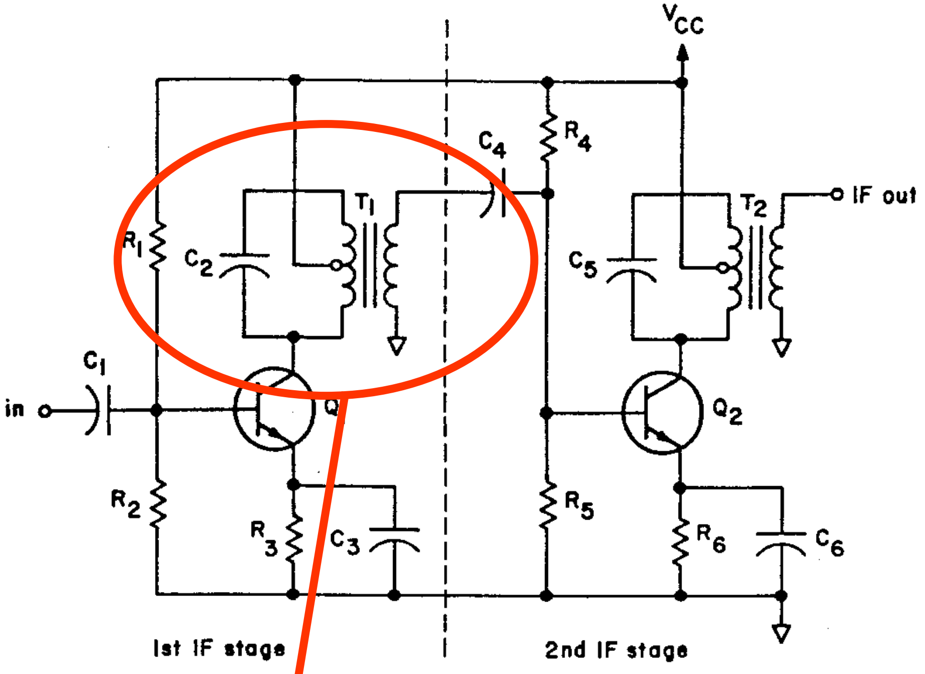
Ref: Stewart Sanders, GEO, MEO, AND LEO, “How orbital altitude impacts network performance in satellite data services” , SES whitpaper

SOFTWARE-DEFINED RADIO IN SATELLITE COMMUNICATIONS

Introduction to Software-Defined Radio

Hardware (defined) Receivers





They are designed for a specific application and can hardly be adapted for other functionalities

They are tuned in the factory and remain unchanged

Software Defined Radio – Original Concept

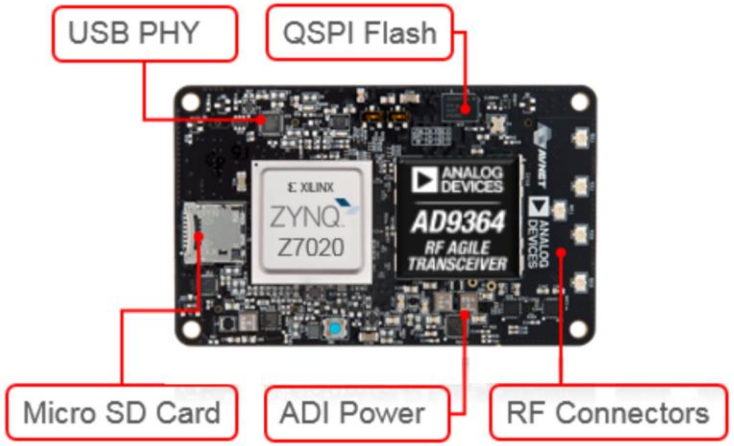
What's the Software Defined Radios (SDRs) ?

- A radio in which <u>some</u> or <u>all</u> of the physical layer functions are software defined.
- This is contrasted with older radios where all of their functionality is determined by hardware.
- SDR serves as an enabling technology for intelligent radios

SDR, Why Use It?

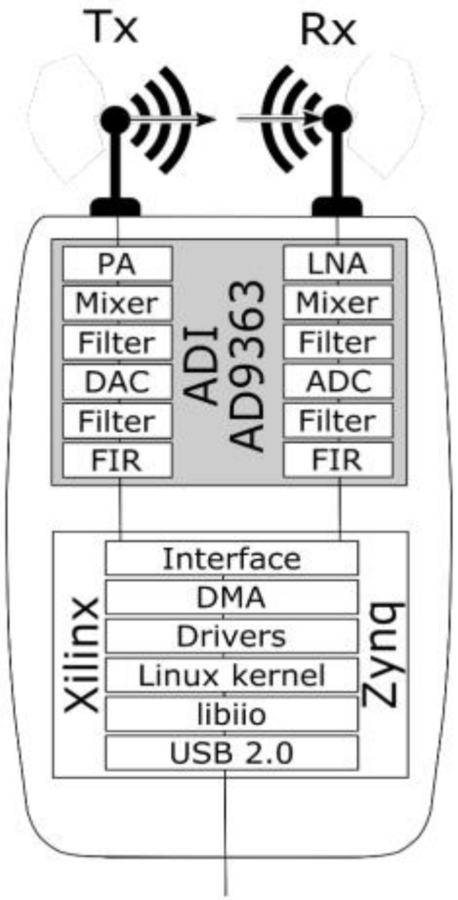
- Flexibility
- RAT (radio access technology) agnostic
- Can be updated on the fly
- Interoperability
- Easier to upgrade by a non-technician or remotely
- Minimal infrastructure requirements for use in the field
- Brings Analog and Digital World Together

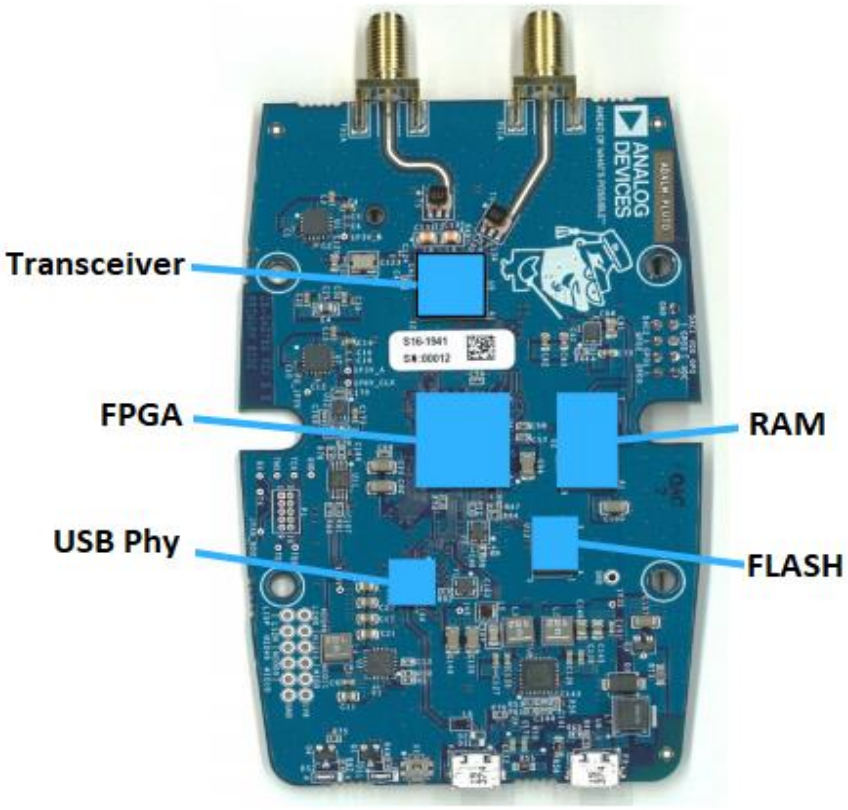
Commercial and Educational SDRS



Educational SDR –Adalm Pluto

Adalm-Pluto



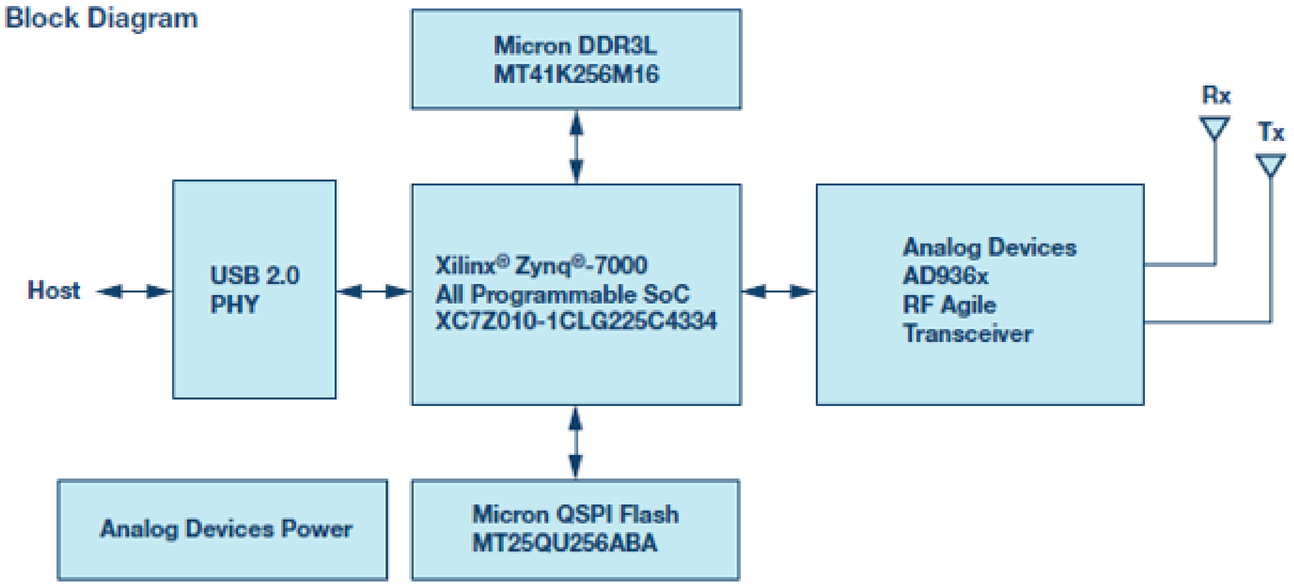


Educational SDR –Adalm Pluto

Adalm-Pluto

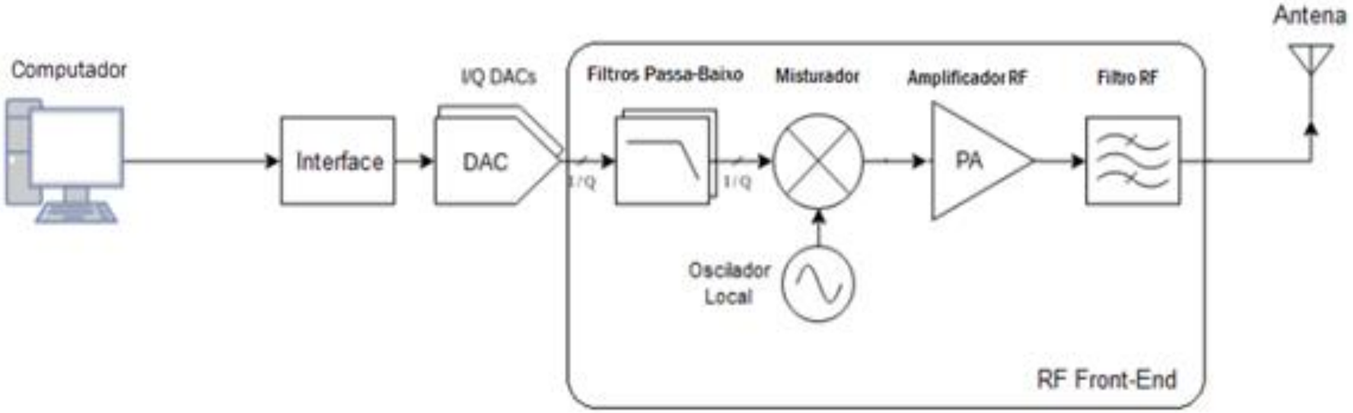
Specifications	Typical
Power	
DC Input (USB)	4.5 V to 5.5 V
Conversion Performance and Clocks	
ADC and DAC Sample Rate	65.2 kSPS to 61.44 MSPS
ADC and DAC Resolution	12 bits
Frequency Accuracy	±25 ppm
RF Performance	
Tuning Range	325 MHz to 3800 MHz
Tx Power Output	7 dBm
Rx Noise Figure	<3.5 dB
Rx and Tx Modulation Accuracy (EVM)	–34 dB (2%)
RF Shielding	None
Digital	
USB	2.0 On-the-Go
Core	Single ARM Cortex®-A9 @ 667 MHz
FPGA Logic Cells	28k
DSP Slices	80
DDR3L	4 Gb (512 MB)
QSPI Flash	256 Mb (32 MB)

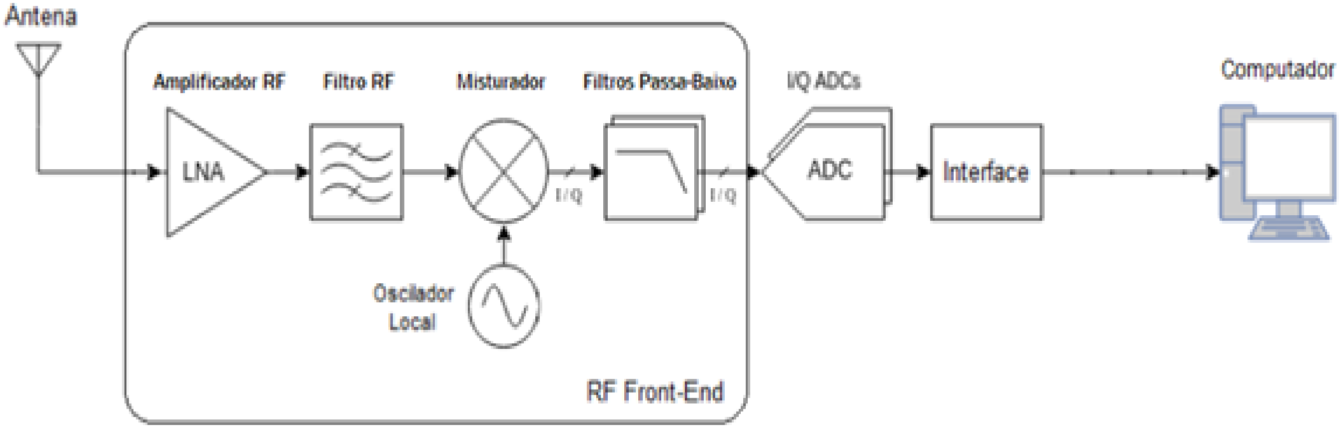
Simplified Block Diagram



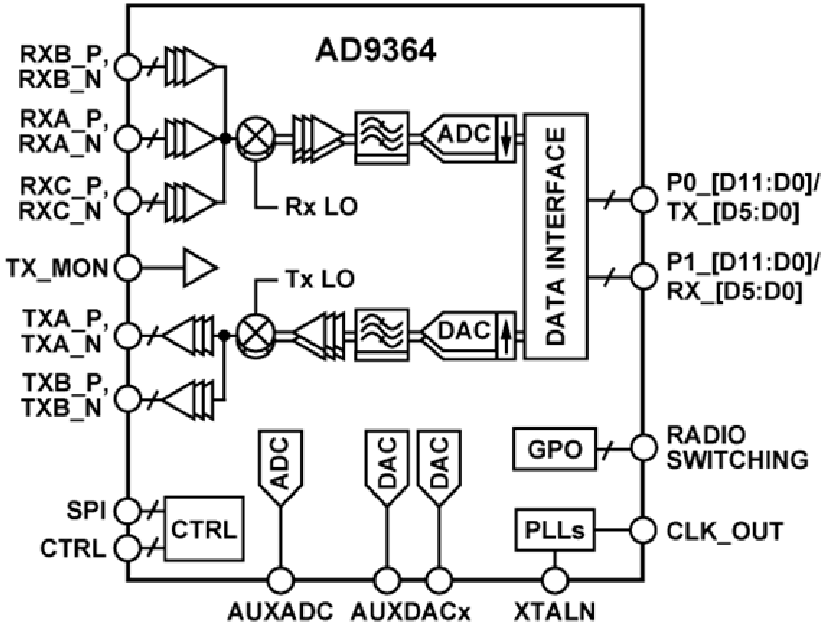
RF Transceiver	LO Tuning Range	Bandwidth
AD9363 (factory default)	325 - 3800 MHz	20 MHz
AD9364	70 - 6000 MHz	56 MHz

SDR –Software-defined radio





SDR –Software-defined radio



- RF 1 × 1 transceiver with integrated 12-bit DACs and ADCs
- Band: 70 MHz to 6.0 GHz
- Supports TDD and FDD operation
- Tunable channel bandwidth: <200 kHz to 56 MHz
- Dual receivers: 6 differential or 12 single-ended inputs
- Superior receiver sensitivity with a noise figure < 2.5 dB
- RX gain control
- Real-time monitor and control signals for manual gain
- Independent automatic gain control

The receiver consists of 2 high dynamic range ADCs digitize the received I and Q signals and pass them through configurable decimation filters and 128-tap FIR filters to produce a 12-bit output signal at the appropriate sample rate.

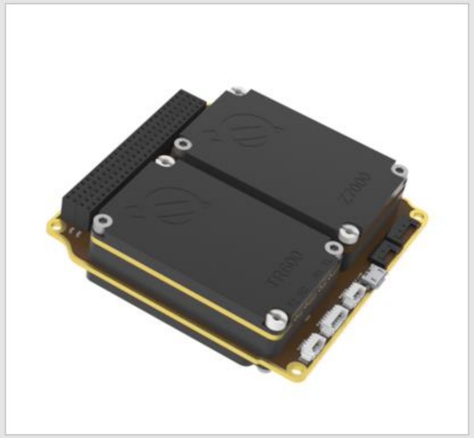
Price: $130.00

Space qualified SDRS

GOMSPACE

SOLUTIONS PLATFORMS **PRODUCTS** CONSTELLATION MANAGEMENT CAREERS INVESTOR RELATIONS CONTACT

> Products > Mission Payloads > Software Defined Radio



ADD TO QUOTE REQUEST

Space qualified Software Defined Radio (SDR) Platform for Sensing and Communication Applications using powerful and advanced FPGA Technology

The SDR platform is utilized for a high-speed S-band ground link and for inter-satellite links utilizing S- or K band in a highly miniaturized radio system for long distance communication.

On GOMX-3 the SDR platform is used for signal sensing with an L-band antenna for spectrum characterization. Significant calculation capacity for advanced signal processing and detection techniques is available in a very compact design.

The FPGA module can be available for other advanced processing requirements such as image processing etc. utilizing the high capacity of the system. Software is available for in-orbit programming or applying scripting tools limiting size of program uploads.

To help our customers get started with developing applications on our SDR platform we offer a standard training program. To learn more about this download our flyer in the menu to the left or contact our sales department.

Highlighted features:

- Flight proven Software Defined Radio platform software for payload application development
- Standard GomSpace Motherboard – daughter board concept, up to 4 modules
- FPGA module and Transceiver modules

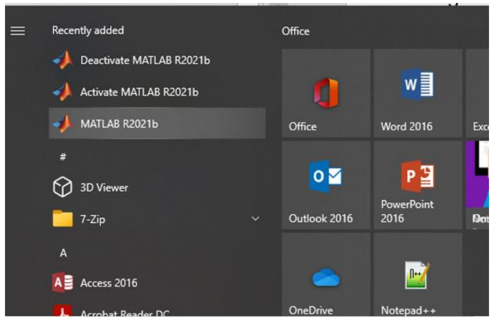
EXERCISE 1

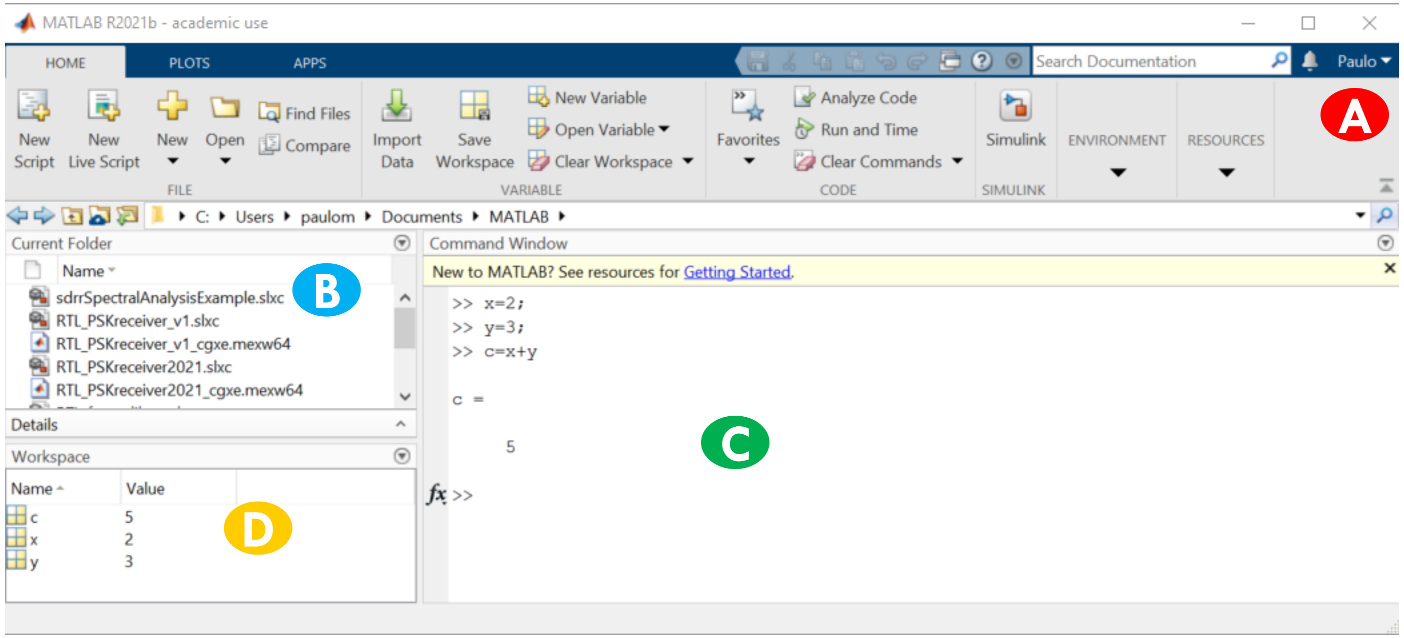
GETTING STARTED WITH MATLAB AND SIMULINK

EXERCISE 1) GETTING STARTED WITH MATLAB AND SIMULINK

1) Open Matlab
2) Explore the MATLAB interface
3) Execute Code Via the Command Window

Example:





A The ***Menu Ribbon***, shown here with the main 'Home' tab open. This allows you to work with files and variables, open Simulink, setup the environment, and access help and support.

B The ***Current Folder*** pane shows the files within the present folder. This facility acts like Windows Explorer — you can open files, as well as move, rename and delete them.

C The ***Command Window*** is the place for directly entering commands, including single statements or short sets of statements, running scripts and calling functions.

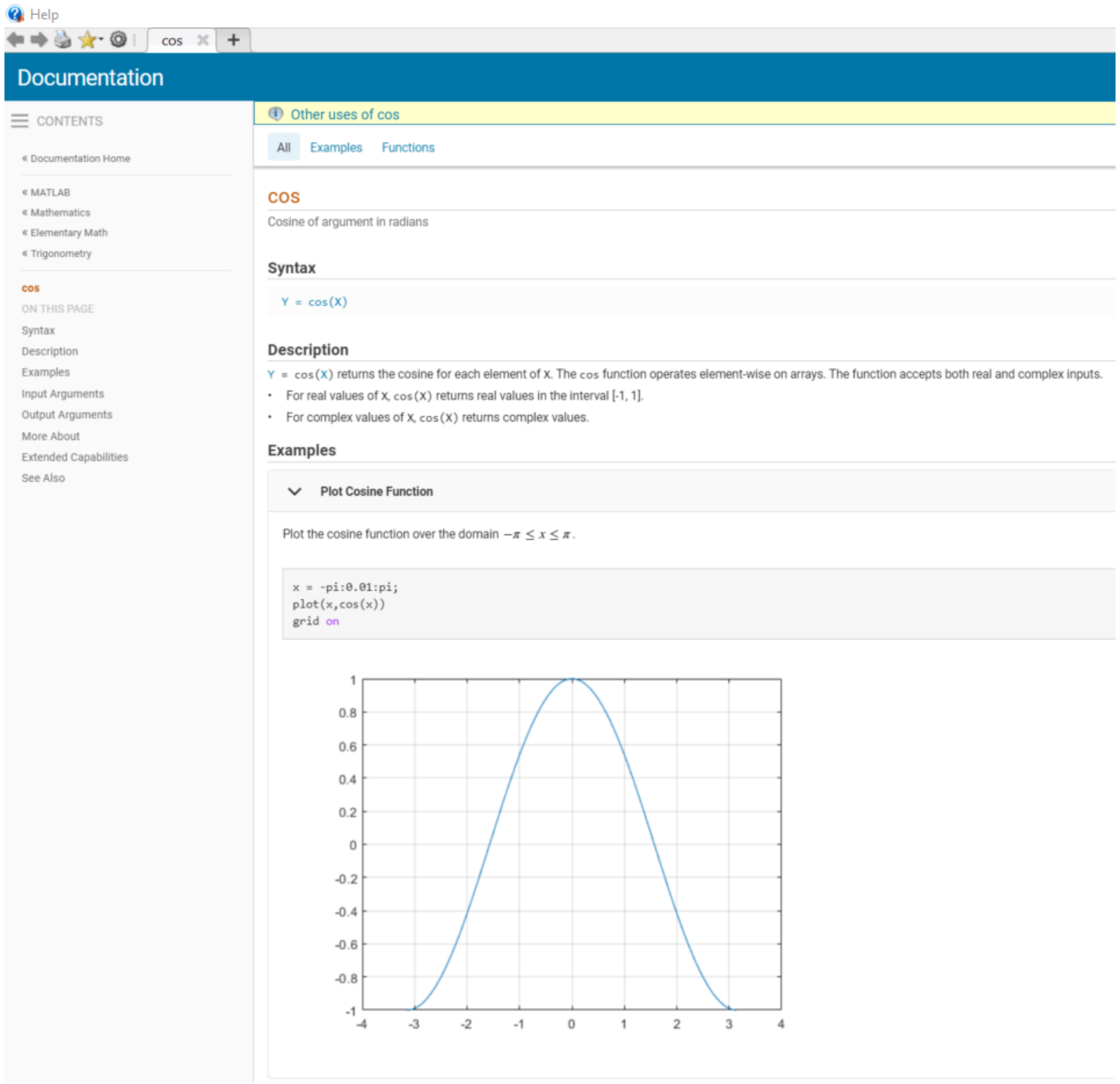
D The ***Workspace*** shows all of the variables currently held in memory, of various types (scalars, arrays, matrices, strings, structures, etc.). These can be inspected / edited here.

EXERCISE 1) HELP

Command Window

New to MATLAB? See resources for Getting Started.

```
>> cos(pi)

ans =

    -1

>> help cos
 cos    Cosine of argument in radians.
    cos(X) is the cosine of the elements of X.

    See also acos, cosd, cospi.

    Documentation for cos
    Other functions named cos

>> doc cos
```



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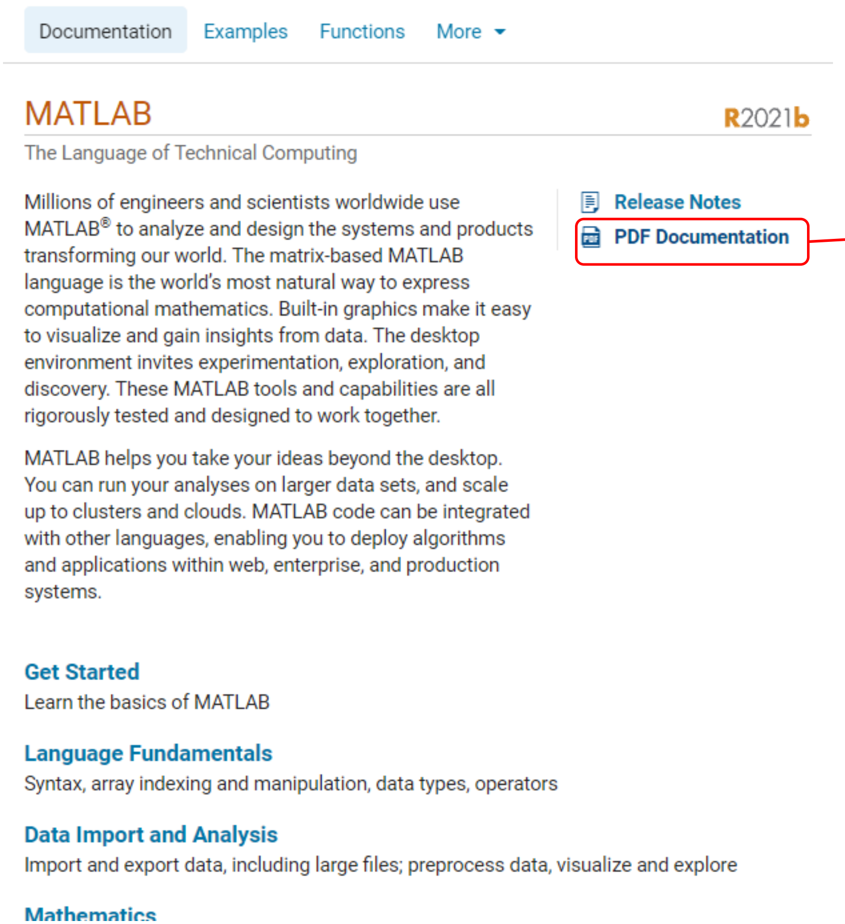

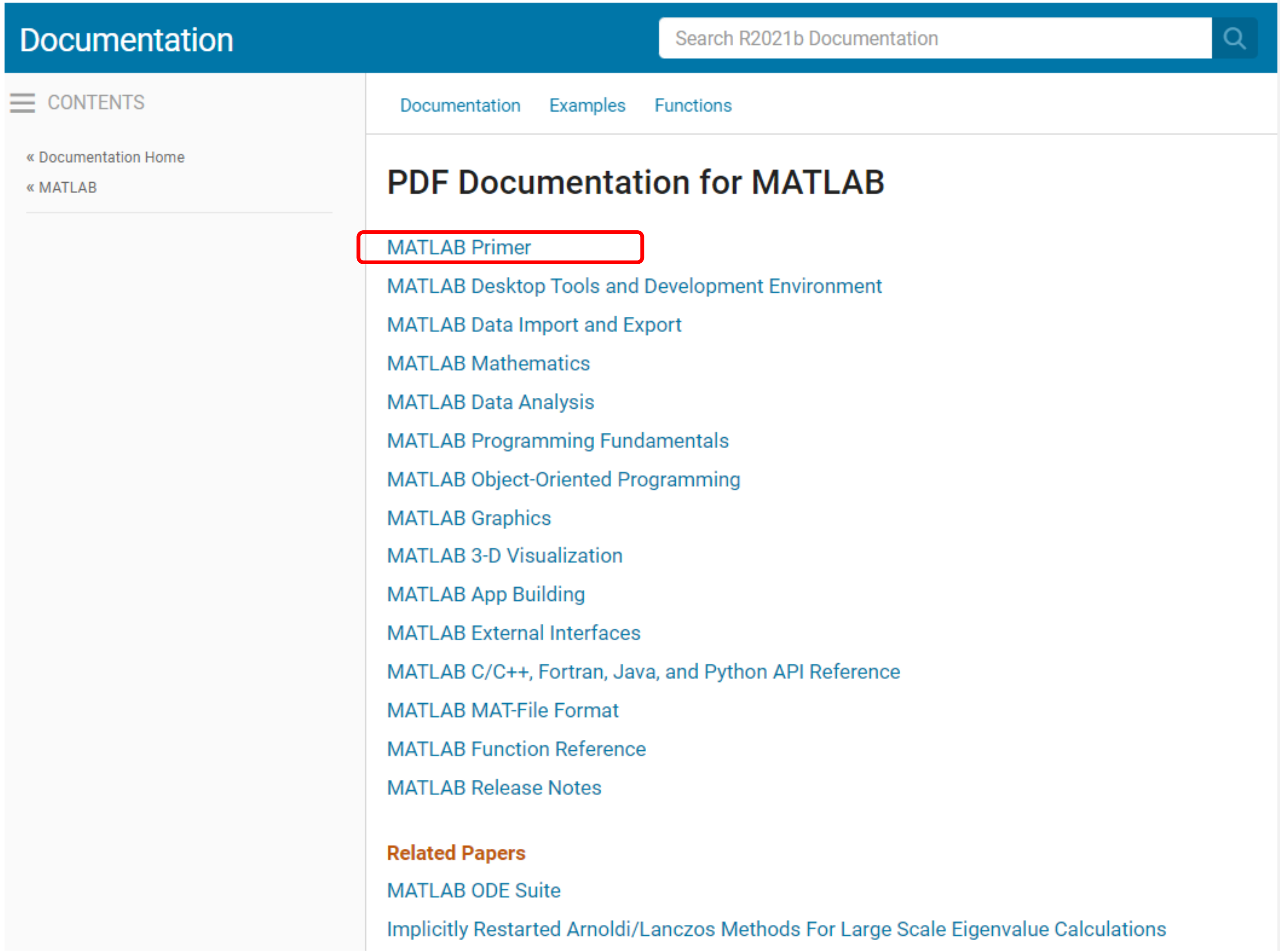

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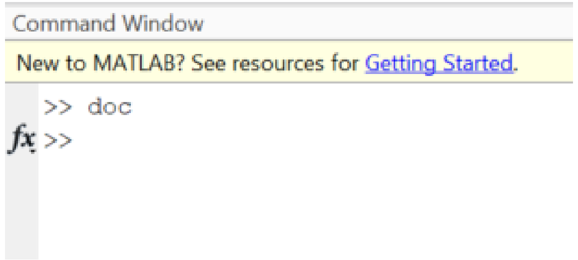

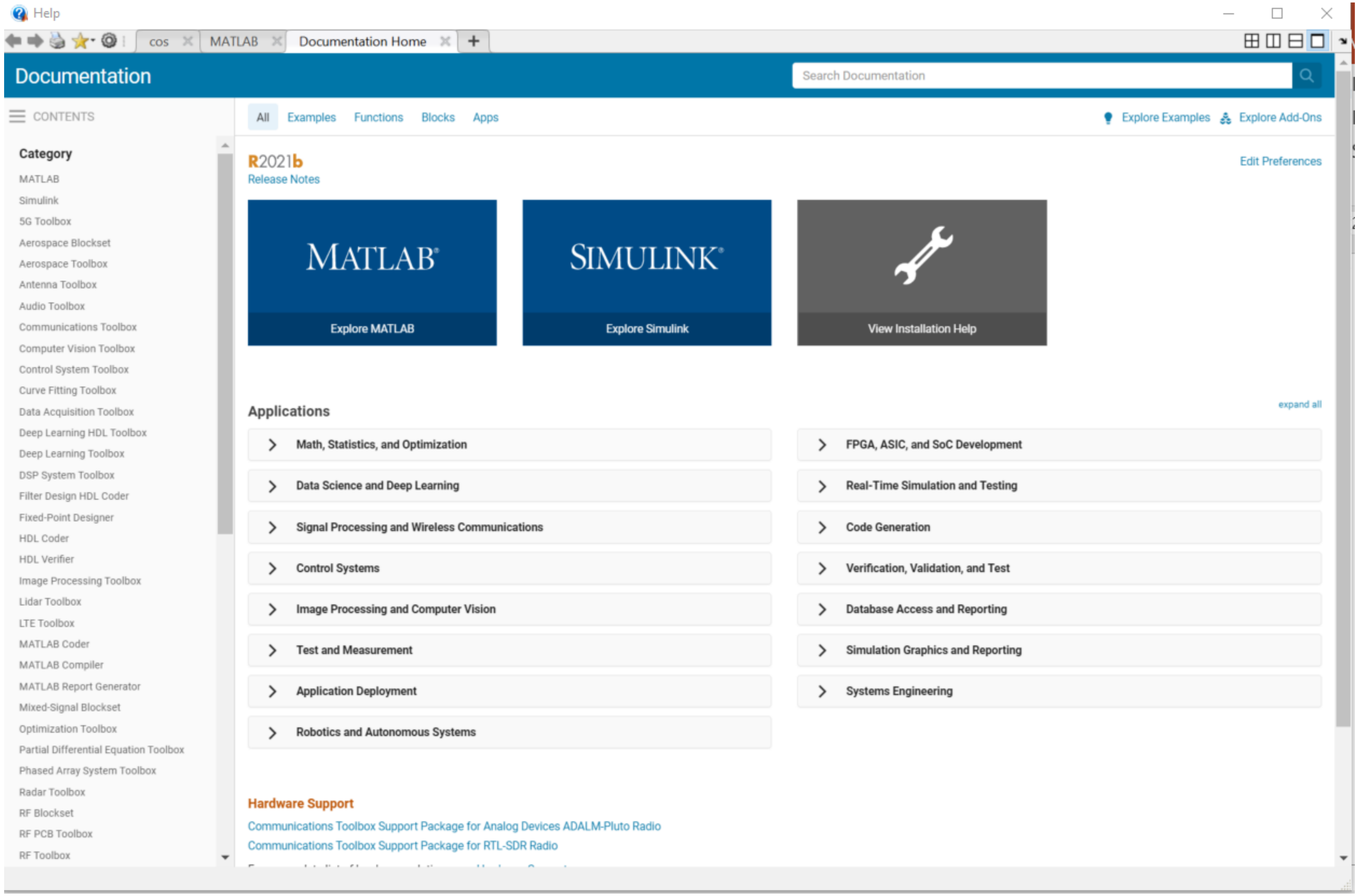

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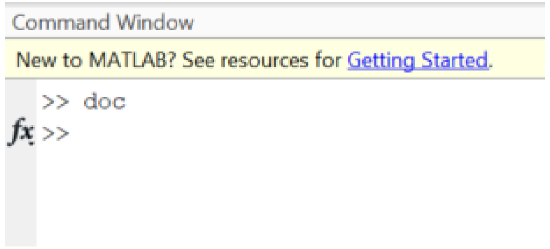
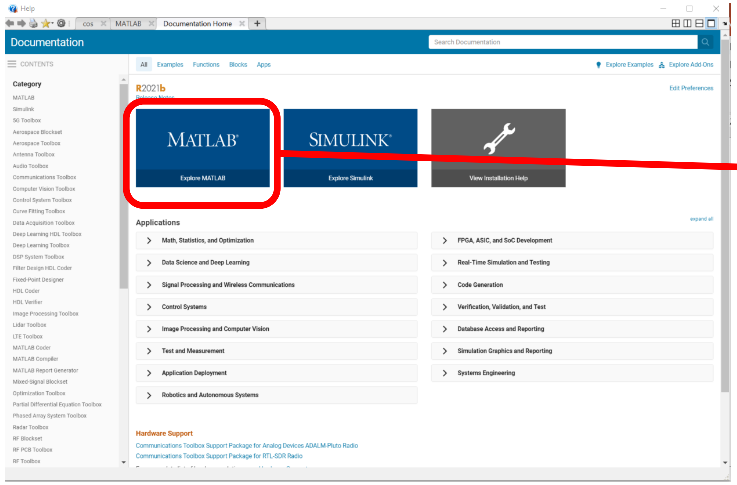
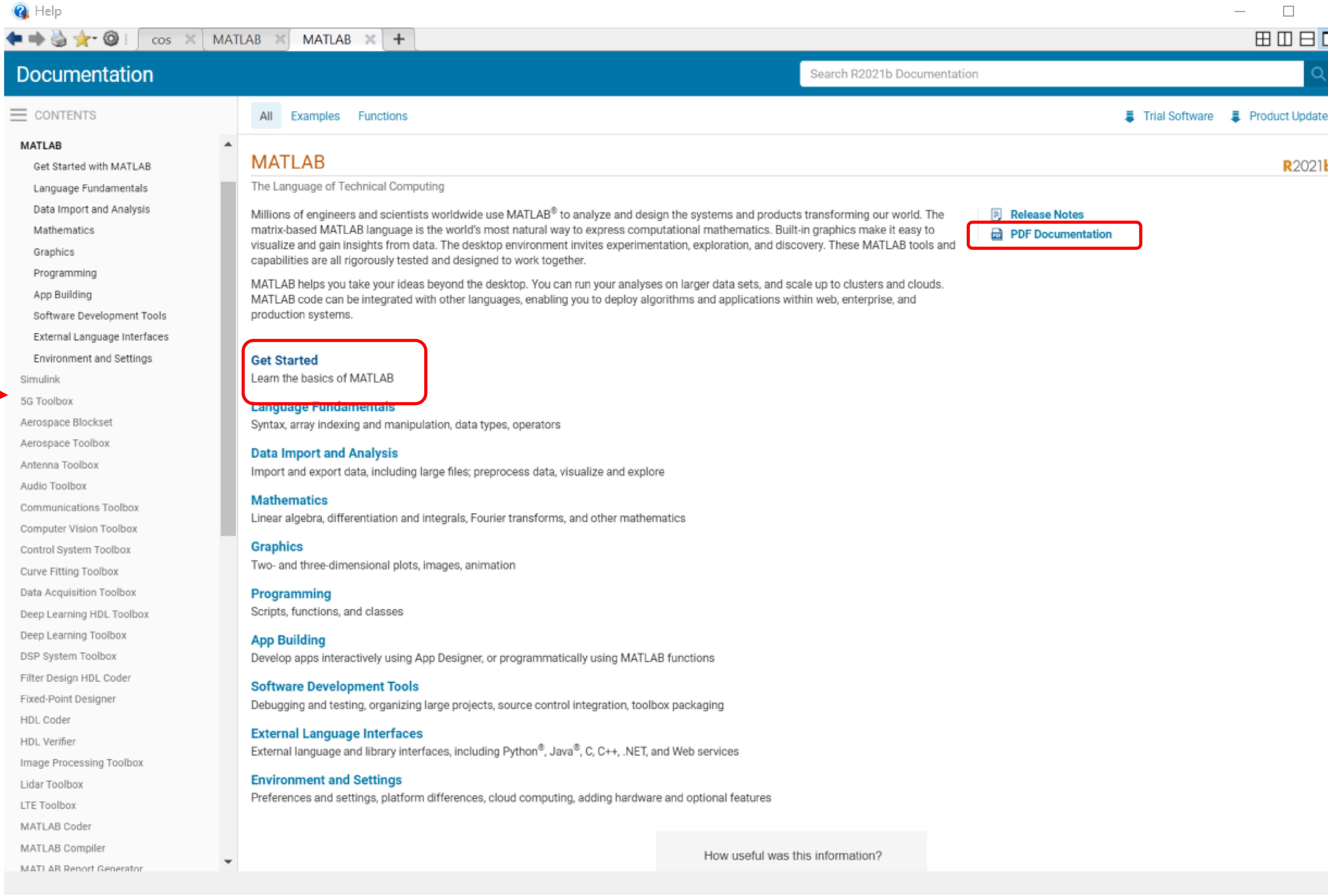
EXERCISE 1) GETTING STARTED WITH MATLAB AND SIMULINK







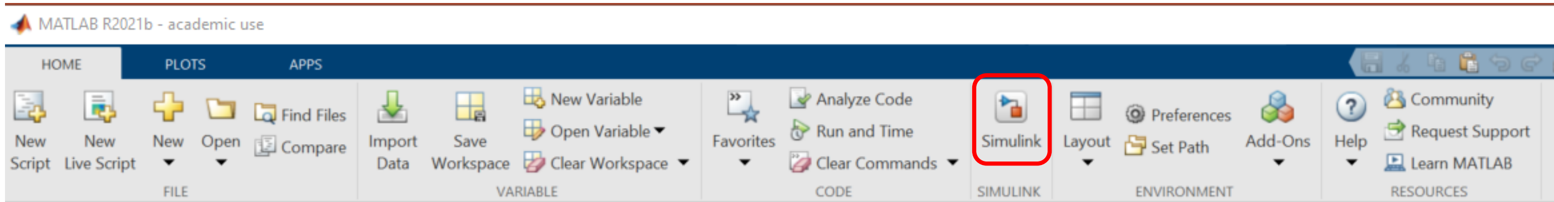
Introducing Simulink

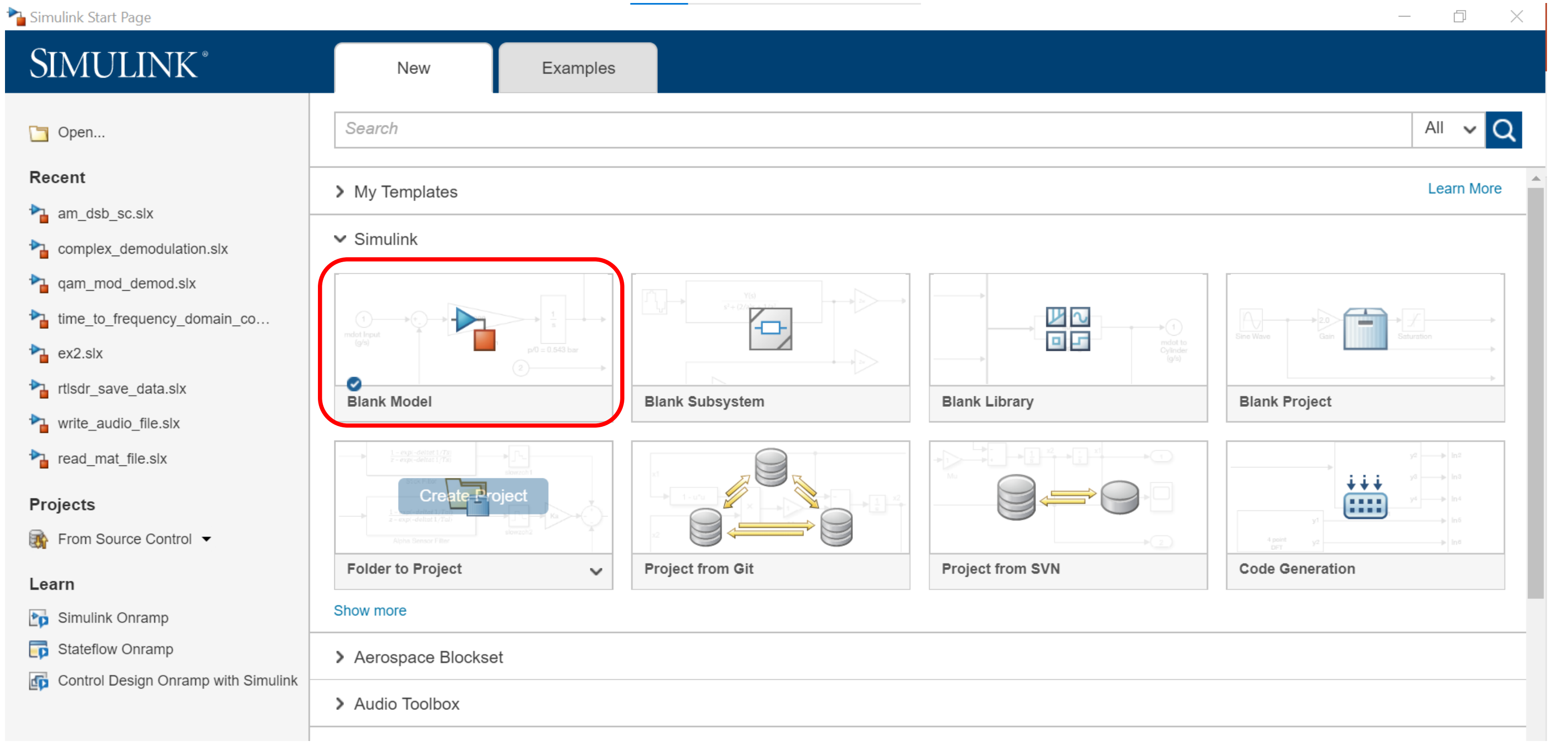
Simulink is a block diagram environment for multidomain simulation and Model-Based Design
It can be created block diagrams, where blocks represent parts of a system.
A block can represent a physical component, a small system, or a function.
Simulink provides block libraries that are collections of blocks grouped by functionality

How to start?

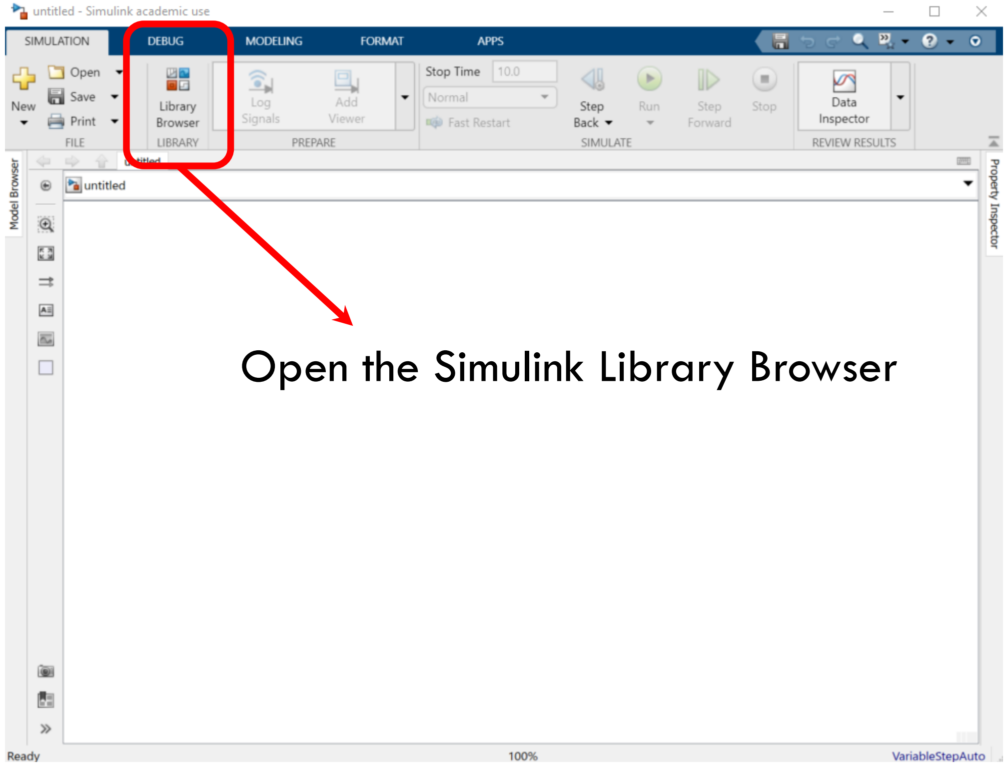
a) To start Simulink, from the MATLAB Home tab click in Simulink

b) At the new window, click on “Blank Model”

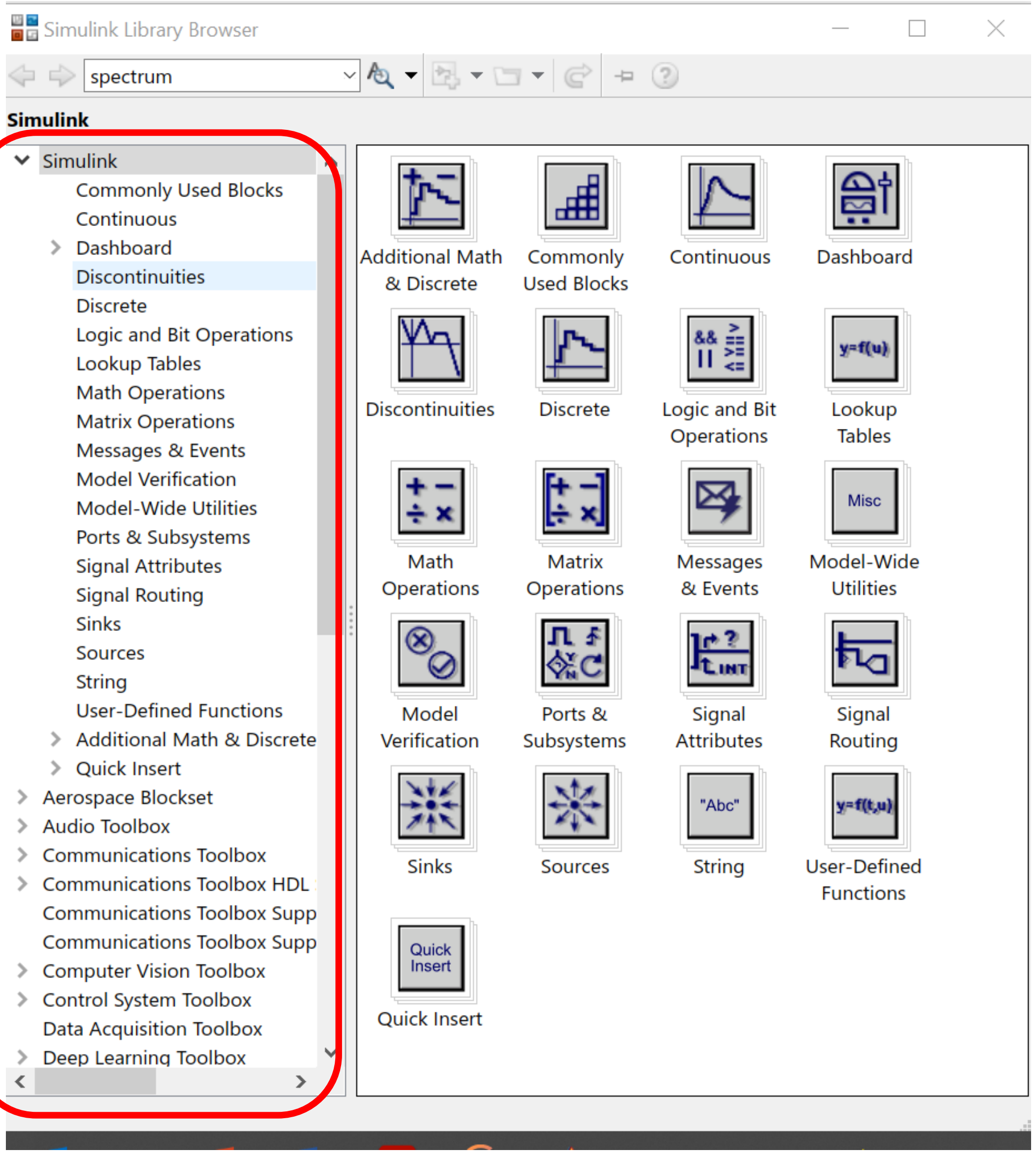




Introducing Simulink



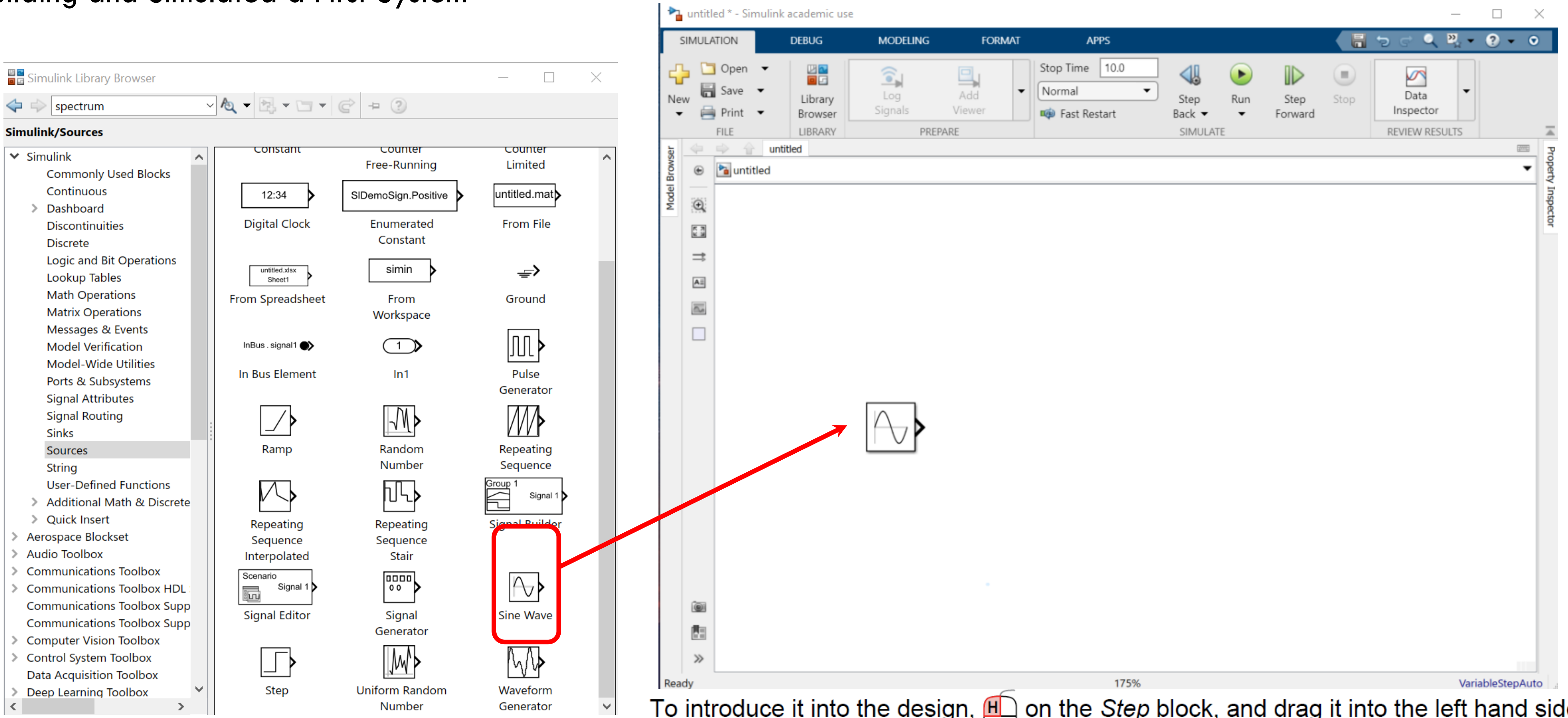
Open the Simulink Library Browser



List of available libraries

Introducing Simulink

Building and Simulated a First System



To introduce it into the design, H on the *Step* block, and drag it into the left hand side of the 'first_system' Simulink model, then release the mouse.

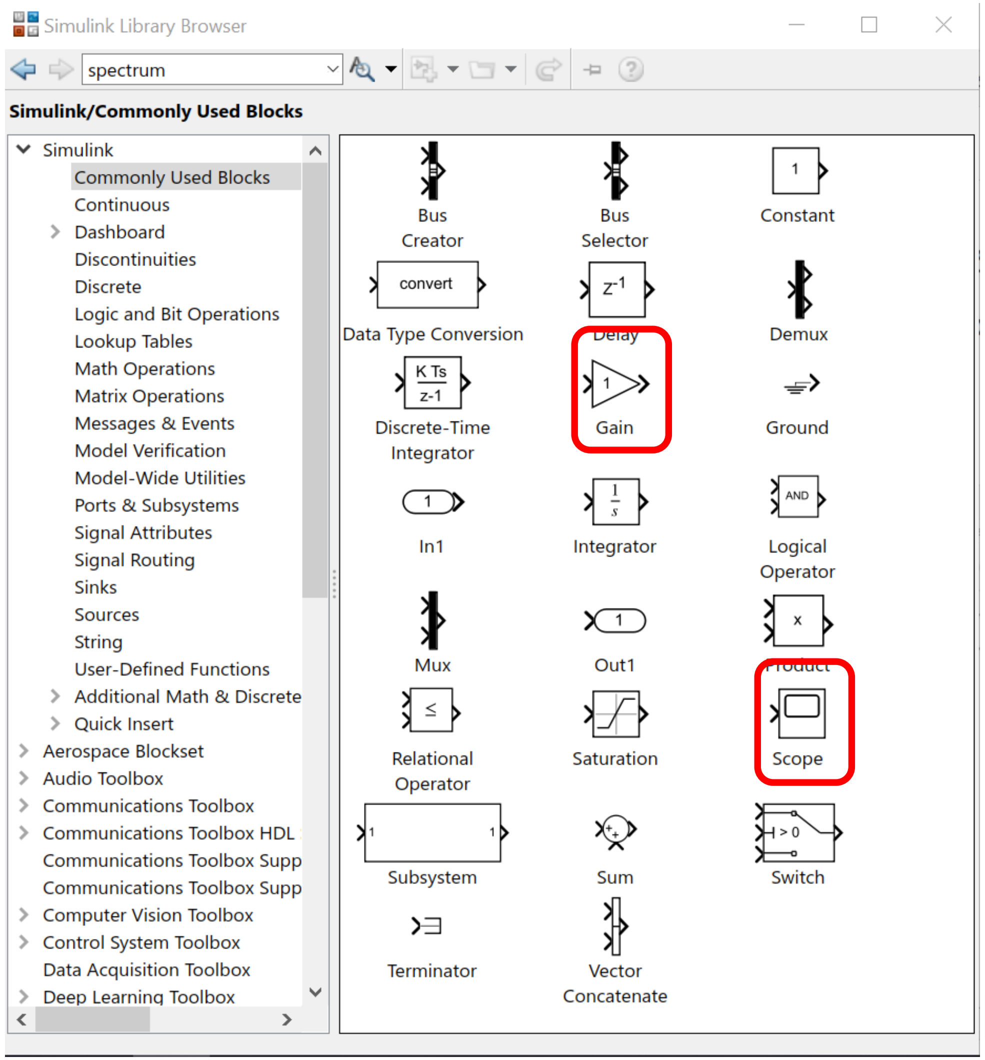
Introducing Simulink

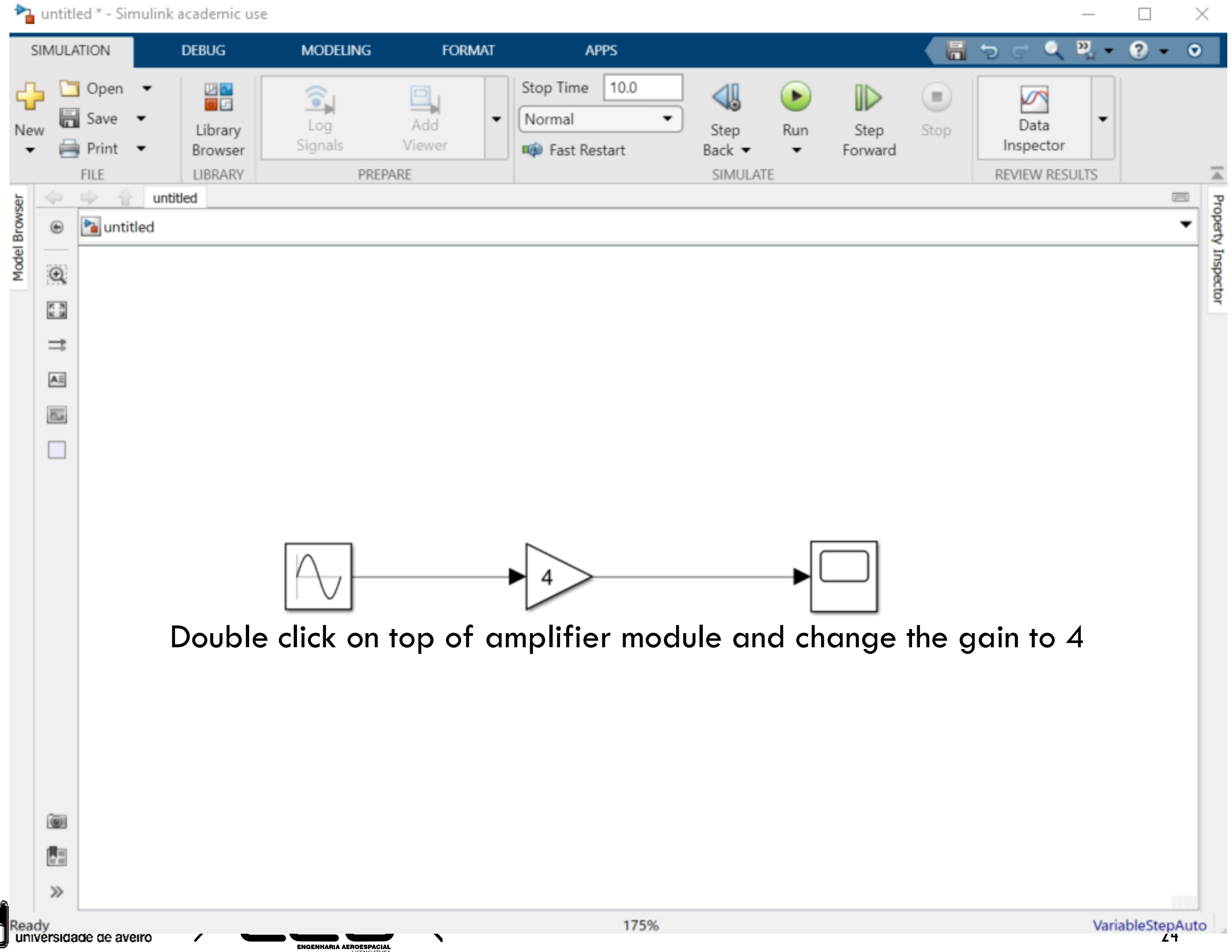
Building and Simulated a First System

Insert Gain and Scope and connect the blocks together with wires.

Firstly, hover the mouse over the output port of the source, until you see a cross-hair appear.

Then H and drag the mouse across to the input port of the Amplifier





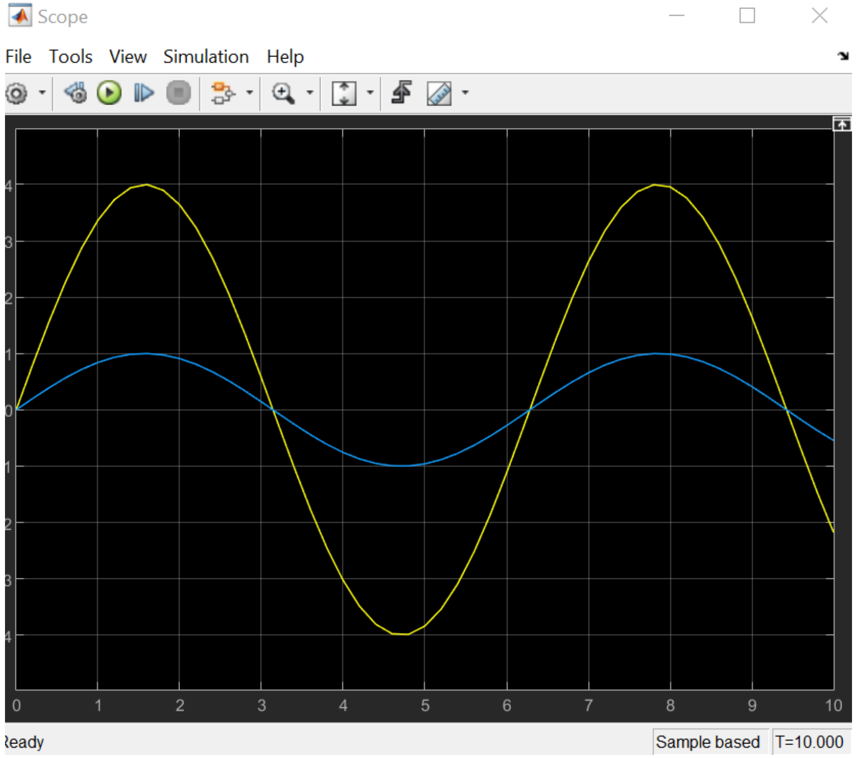
Double click on top of amplifier module and change the gain to 4

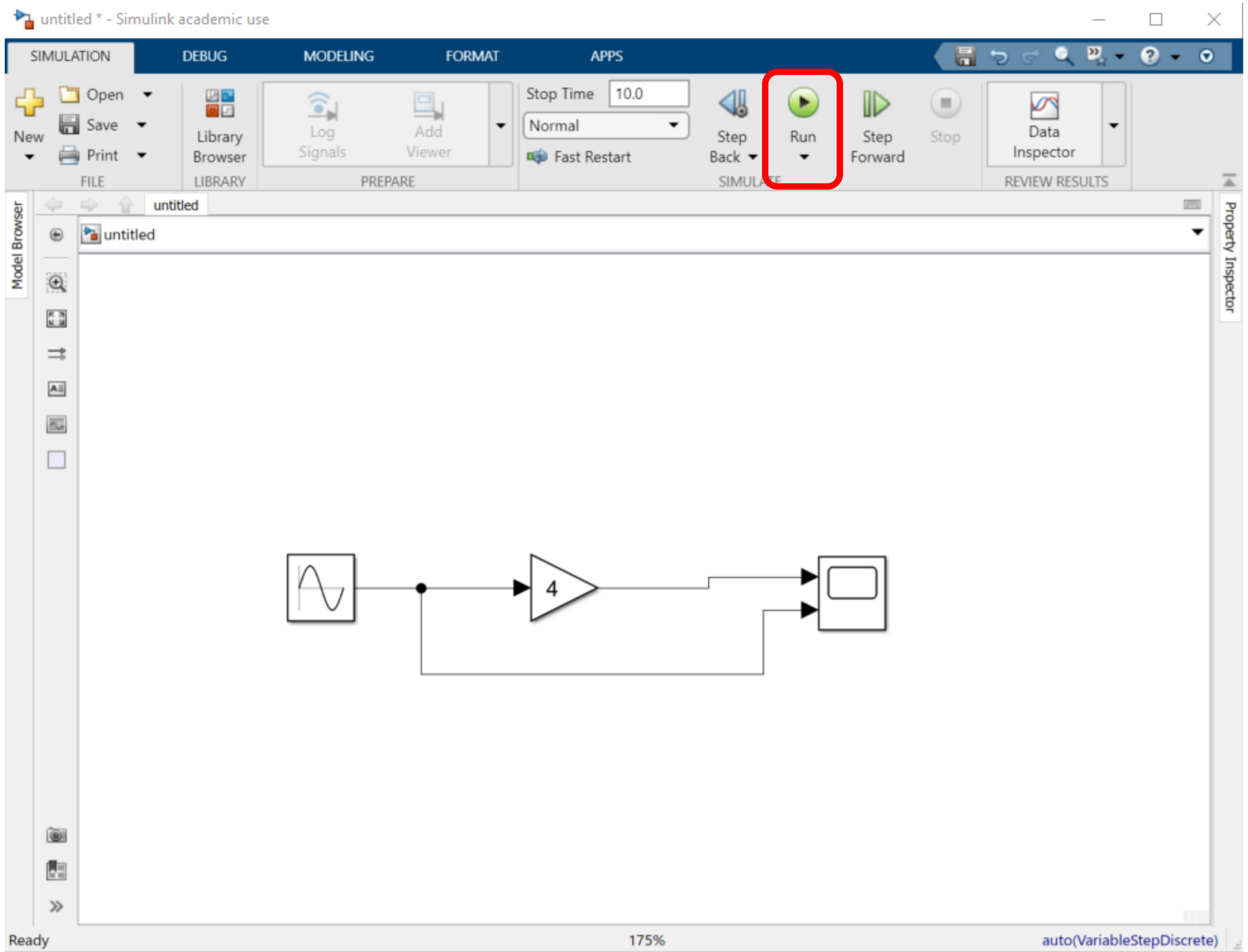
Introducing Simulink

Building and Simulated a First System

Try to include a new wire from source to scope ☺

Click on Run and click on Scope



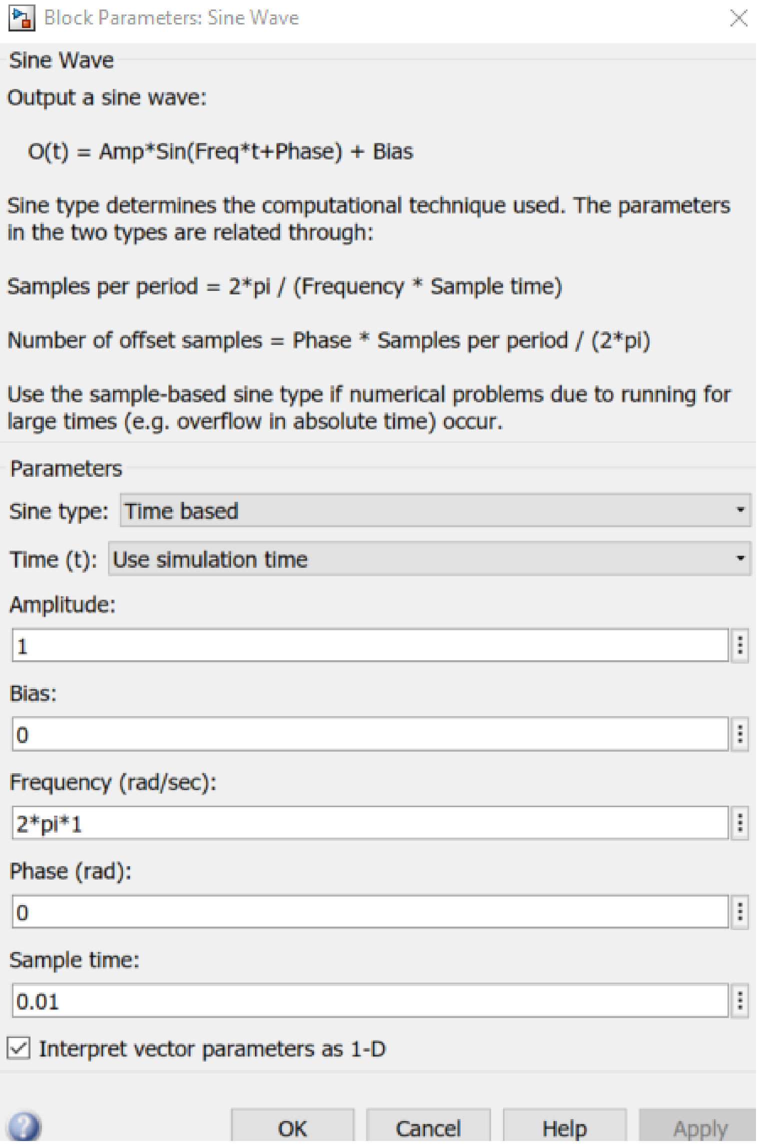


- Is this what you were expecting?
- Determine the mathematical expression of the signal before and after the amplifier
- Try to change the gain and see what happen

Introducing Simulink

Building and Simulated a First System

- Open the Block Parameters of Sine Wave by double clicking
- Change de Frequency (rad/s) to 2*pi and Sample time to 0.01
- Analyze the waveforms at the scope and determine the new mathematical expressions



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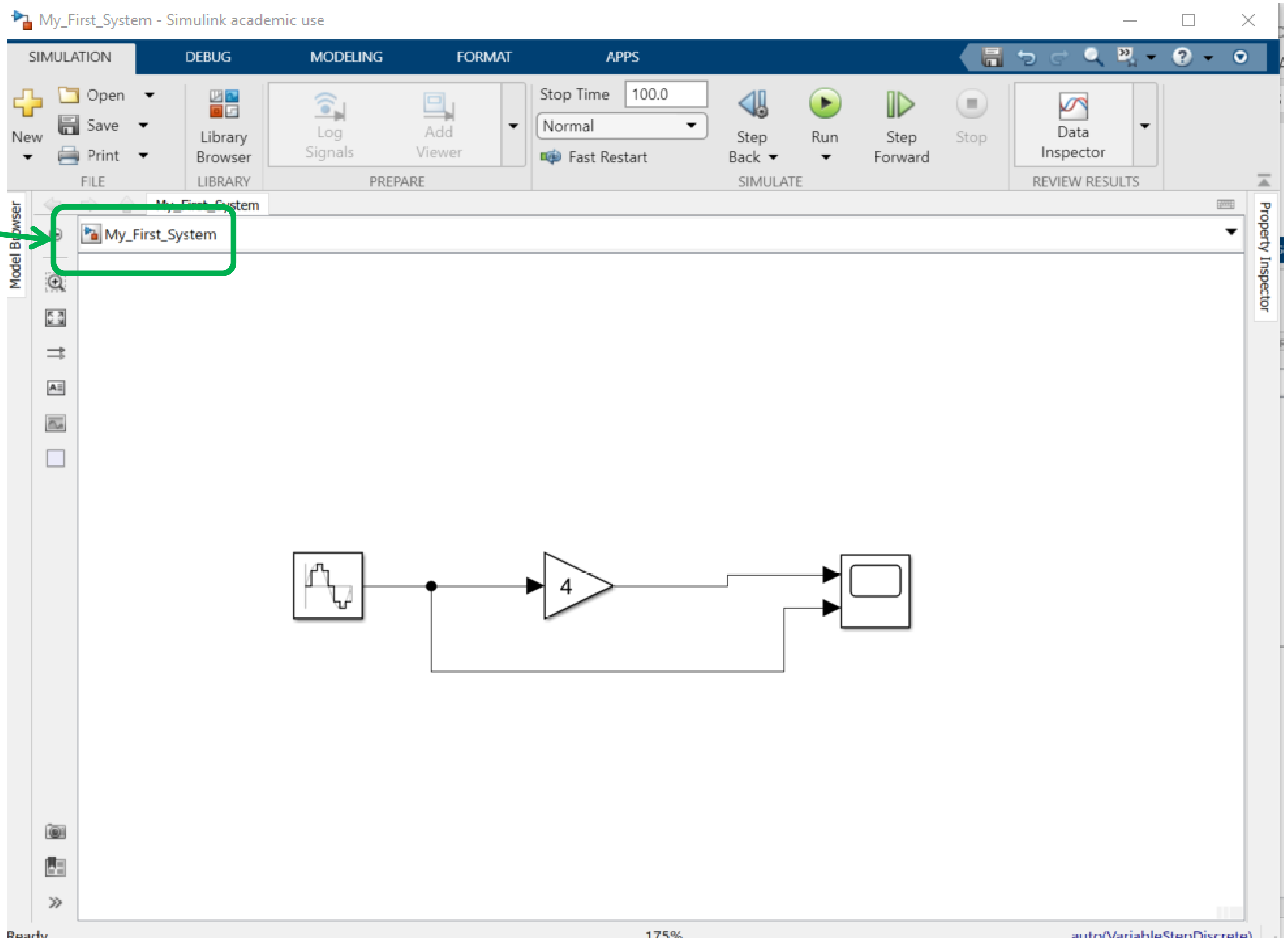
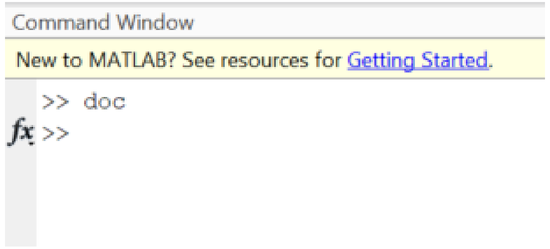
Introducing Simulink

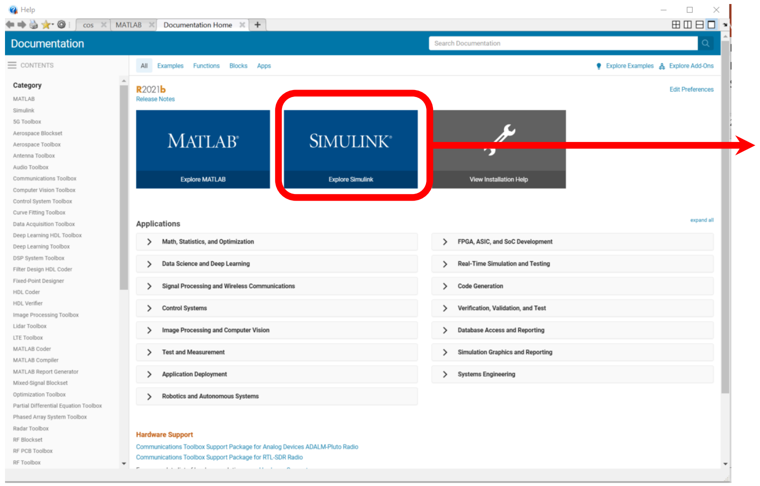
Building and Simulated a First System

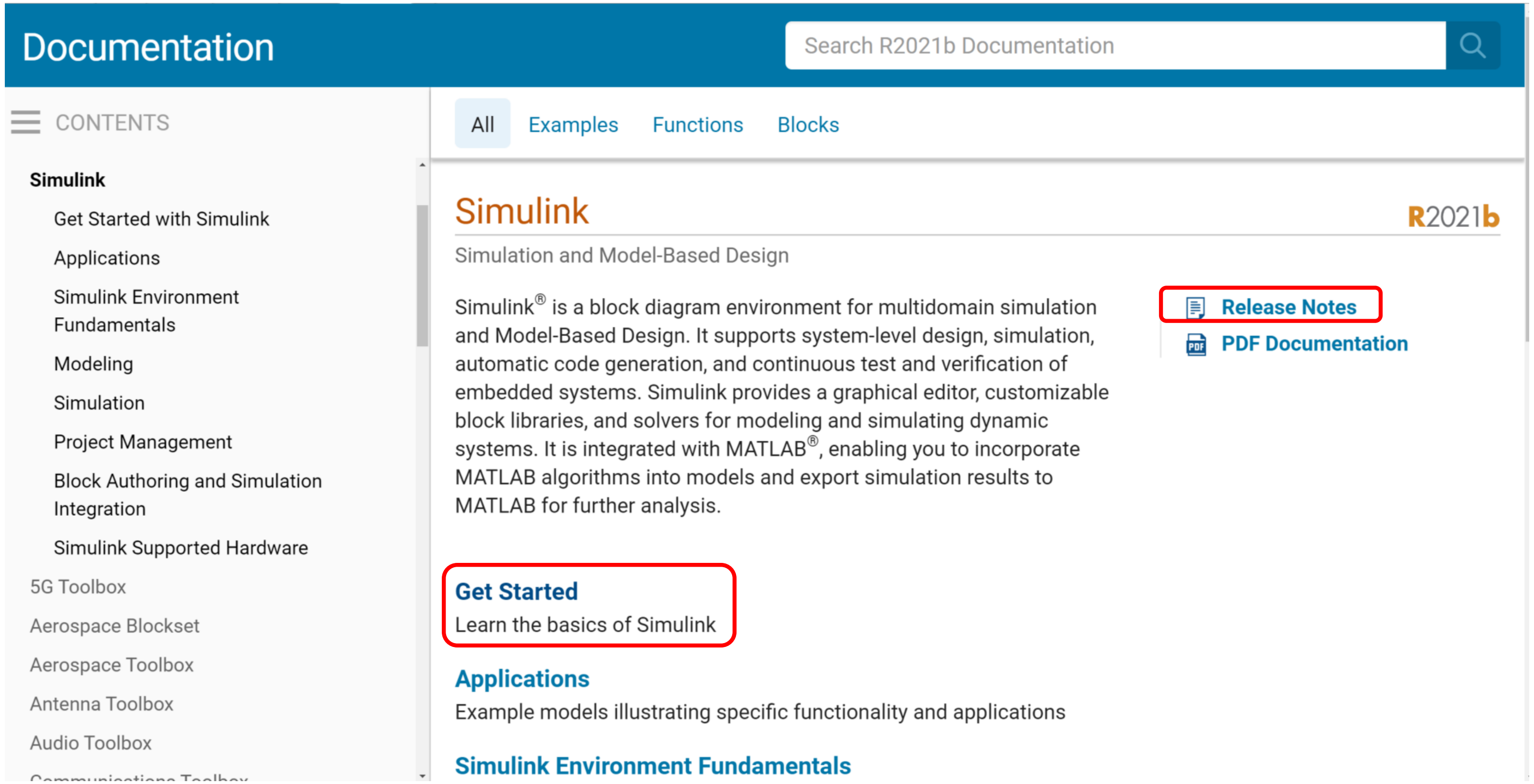
Save in your directory with the name:
 “My_First_System”



EXERCISE 1) GETTING STARTED WITH MATLAB AND SIMULINK







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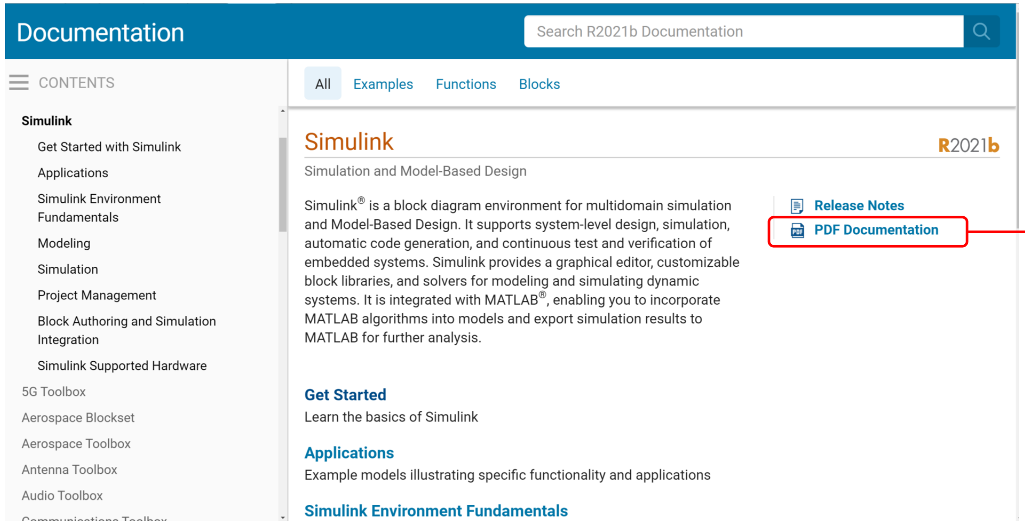

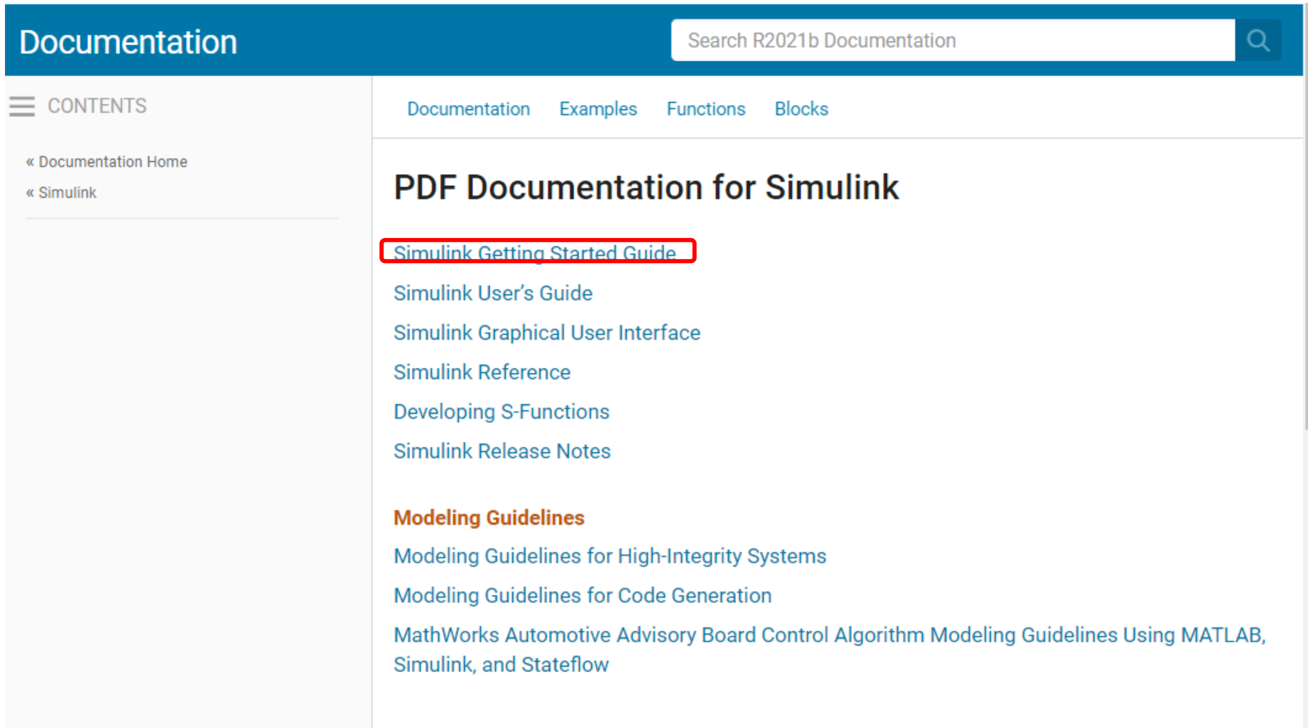

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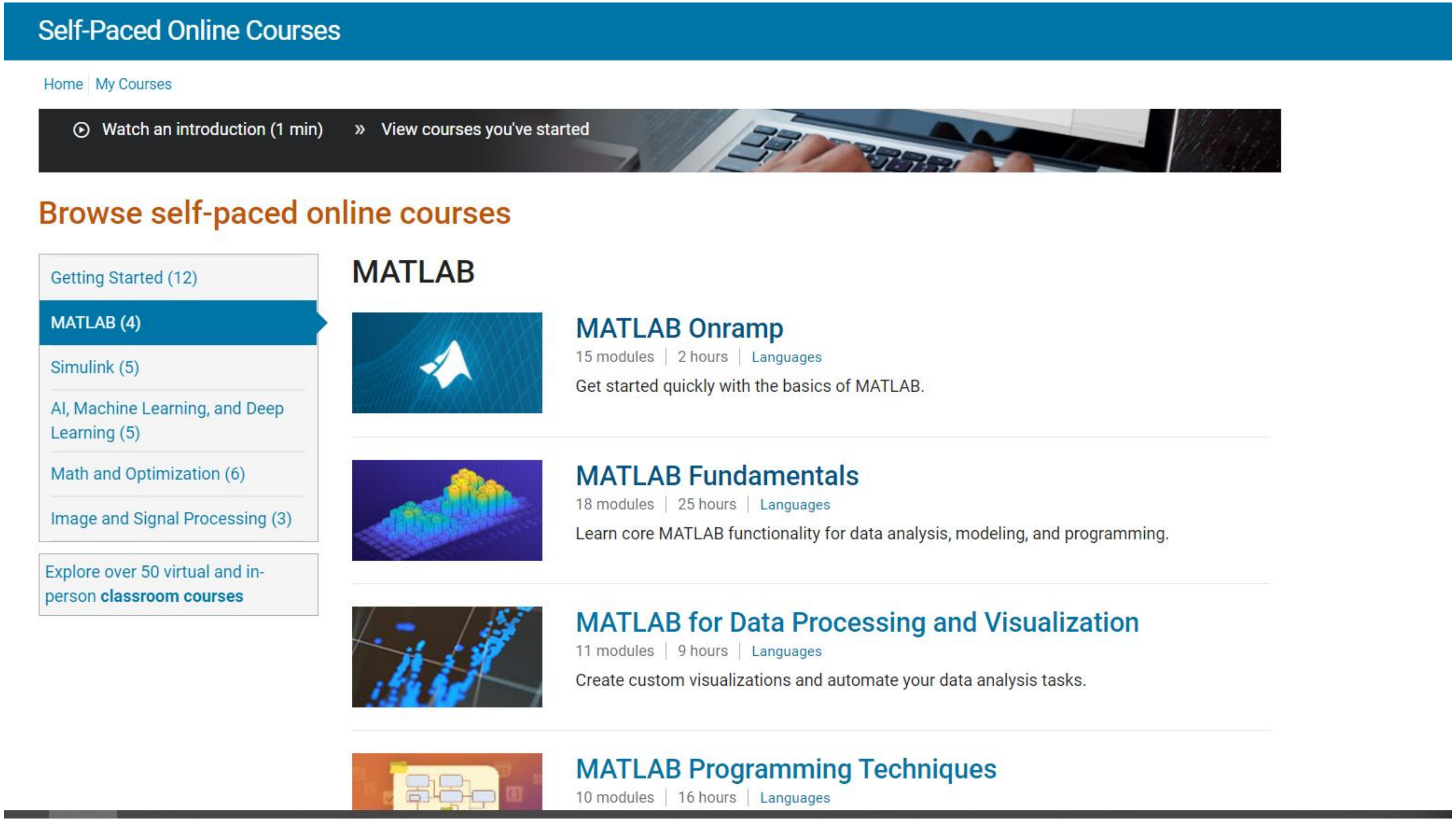
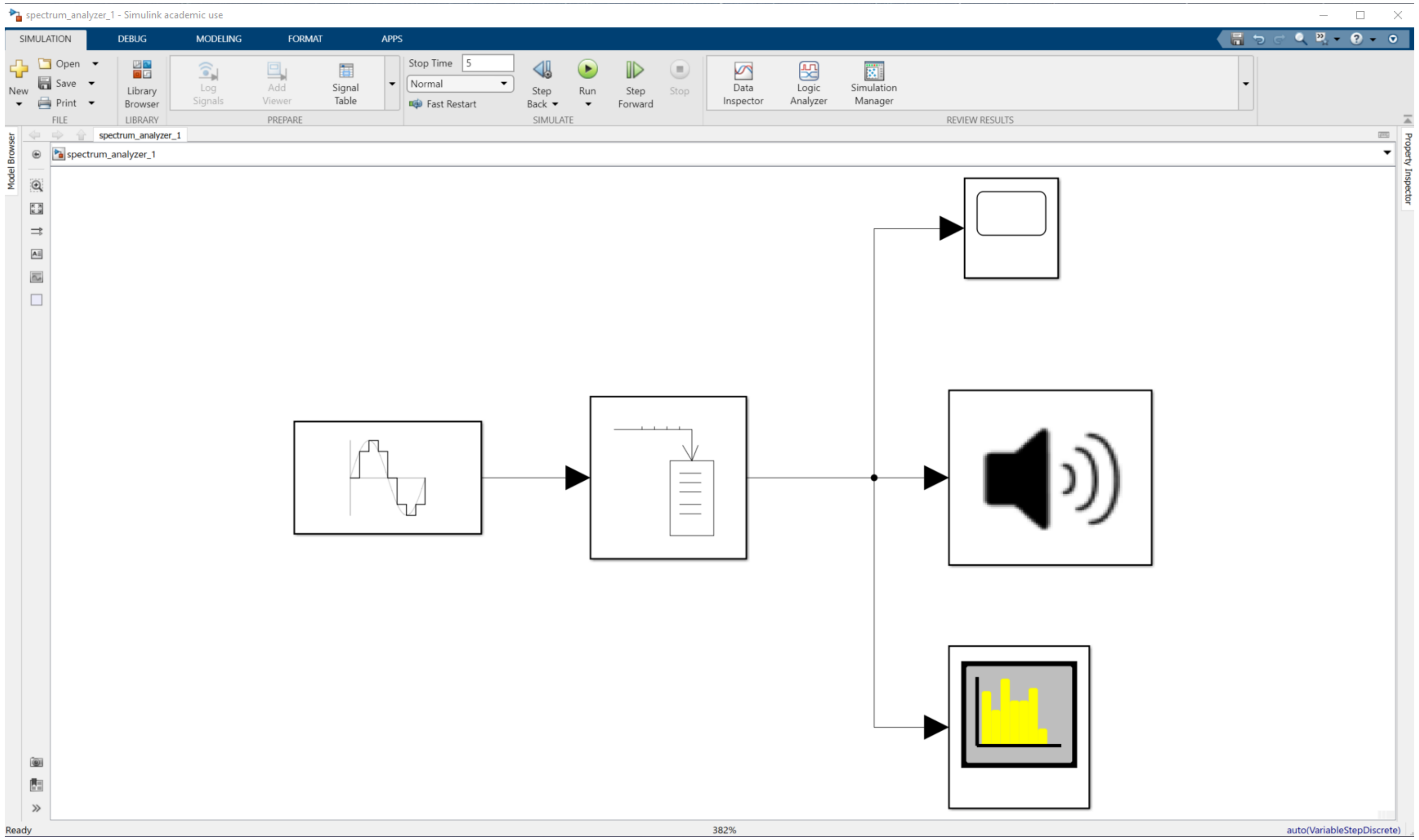


Frequency Domain Plots

- Open the model

Spectrum_analyser_1.slx

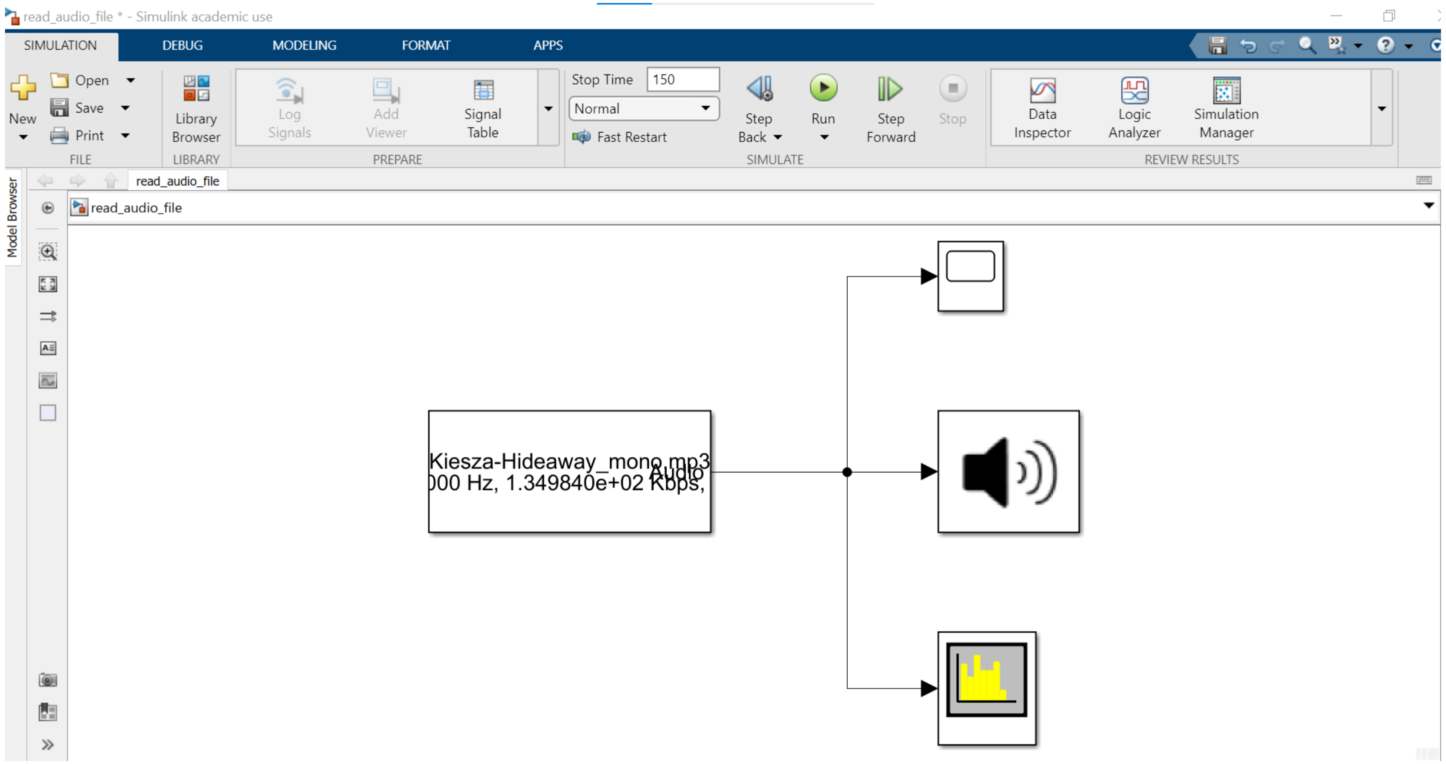
- Analyze the time domain waveform and the spectrum and listen the sound
- Double the frequency and analyze again
- Repeat until you cannot ear the sound
- Take the conclusions



Frequency Domain Plots

- Open the model:

  read_audio_file.slx



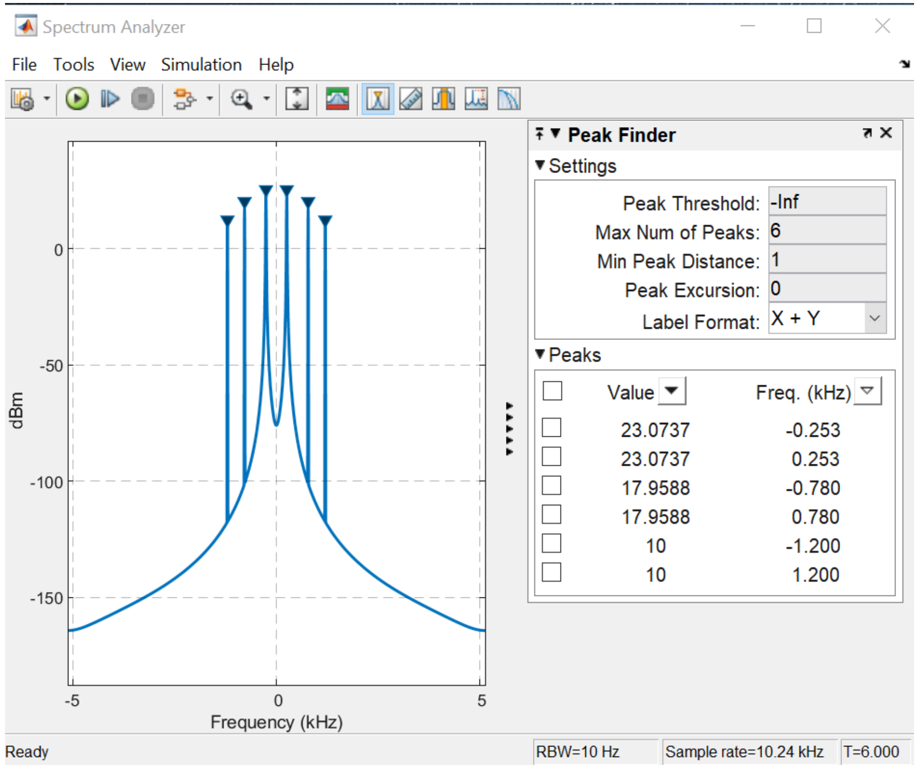
- Analyze the time domain waveform and the spectrum and listen the sound.

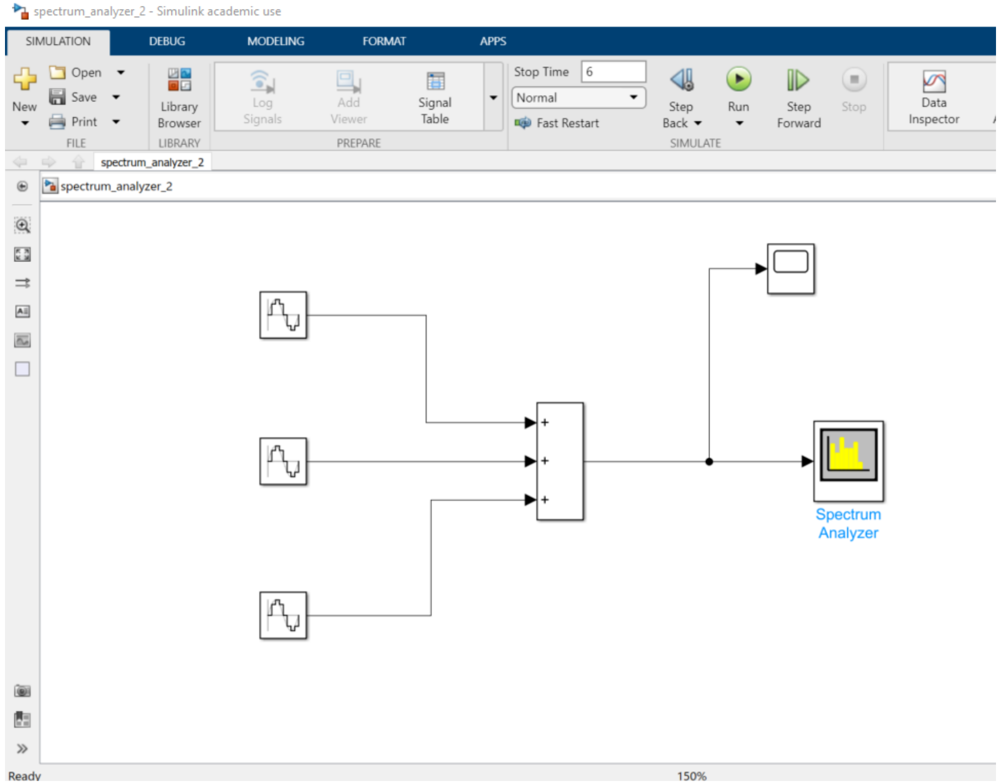
- Comment the waveforms

Frequency Domain Plots

- Open the model: Spectrum_analyser_2.slx

- Analyze the signal in time and frequency domain
- In frequency domain, determine the frequency and power of each spectrum line.
- Compare with the theoretical values





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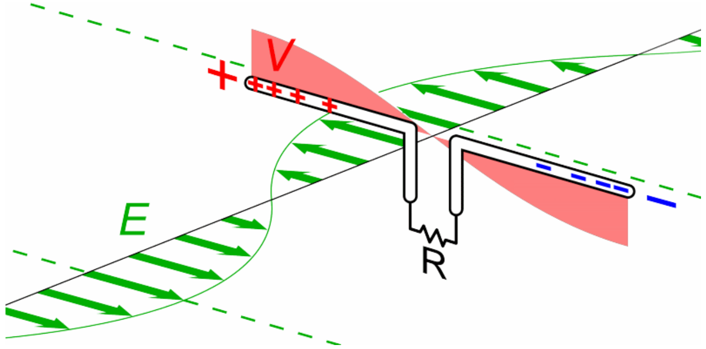
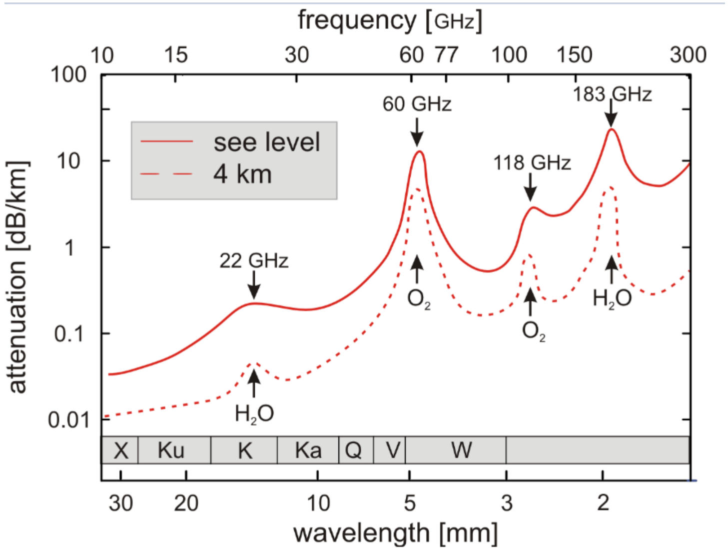
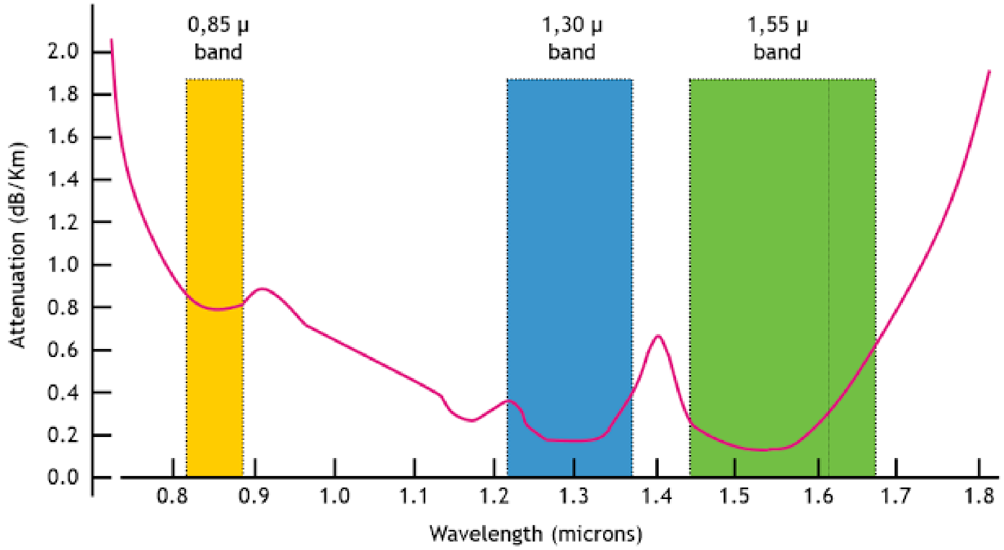
Modulation



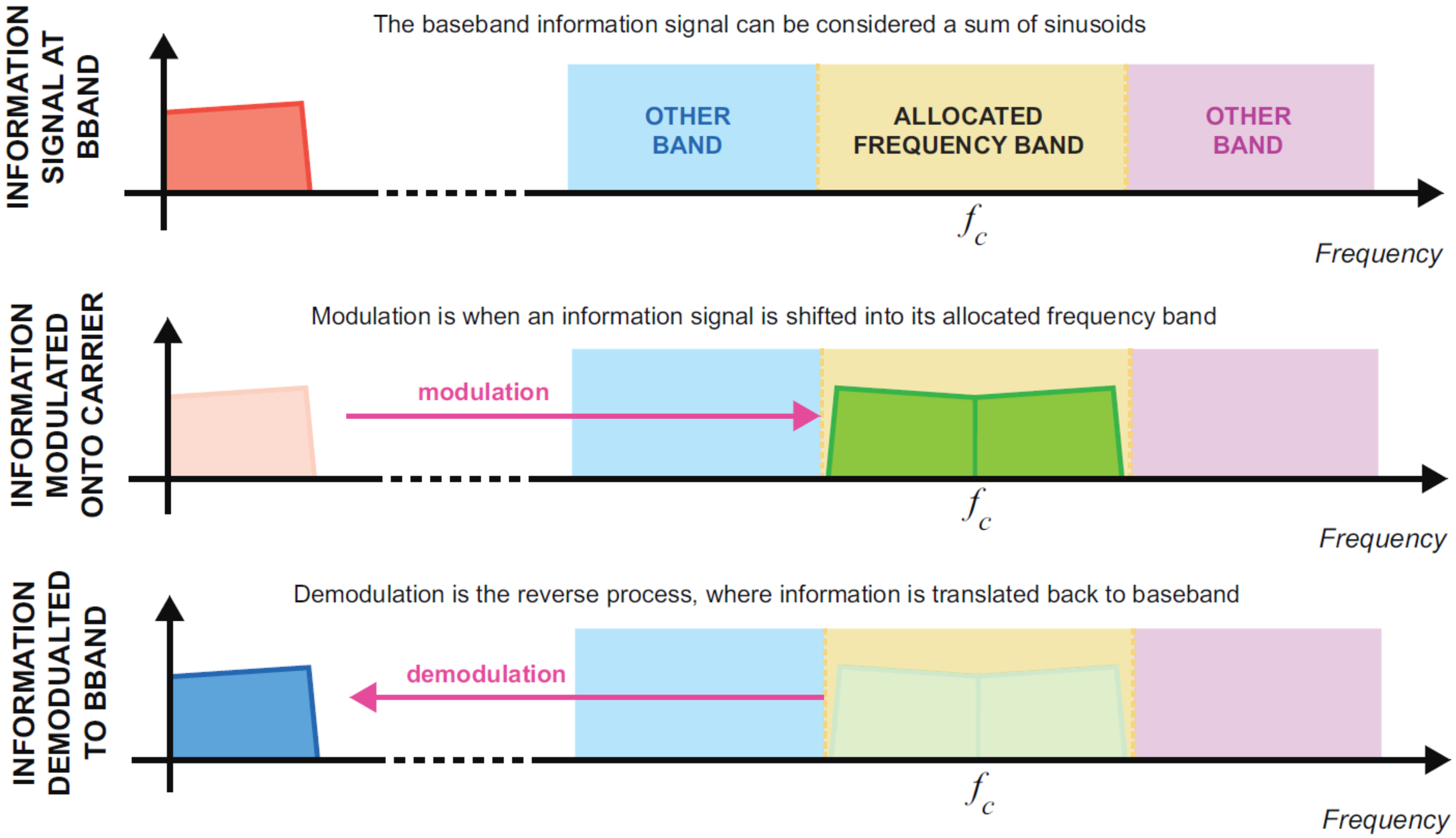
F (Hz)	$\lambda = \frac{c}{f}$
1KHz	300 km!
1MHz	300m
300MHz	1m
3GHz	10cm
30GHz	1cm

https://www.electronicsforu.com/resources/learn-electronics/transmission-basics-designing-dipole-antenna



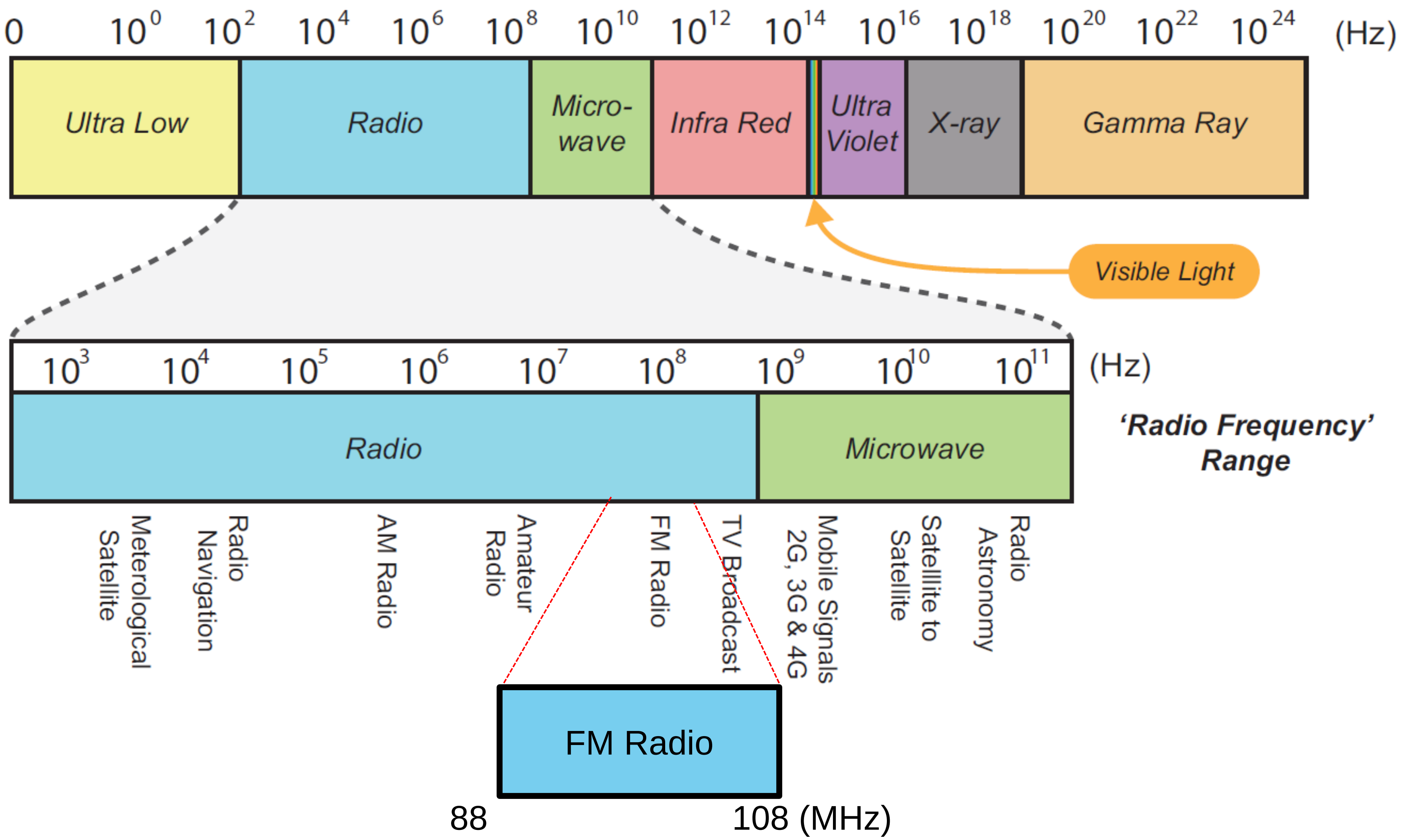


Modulation

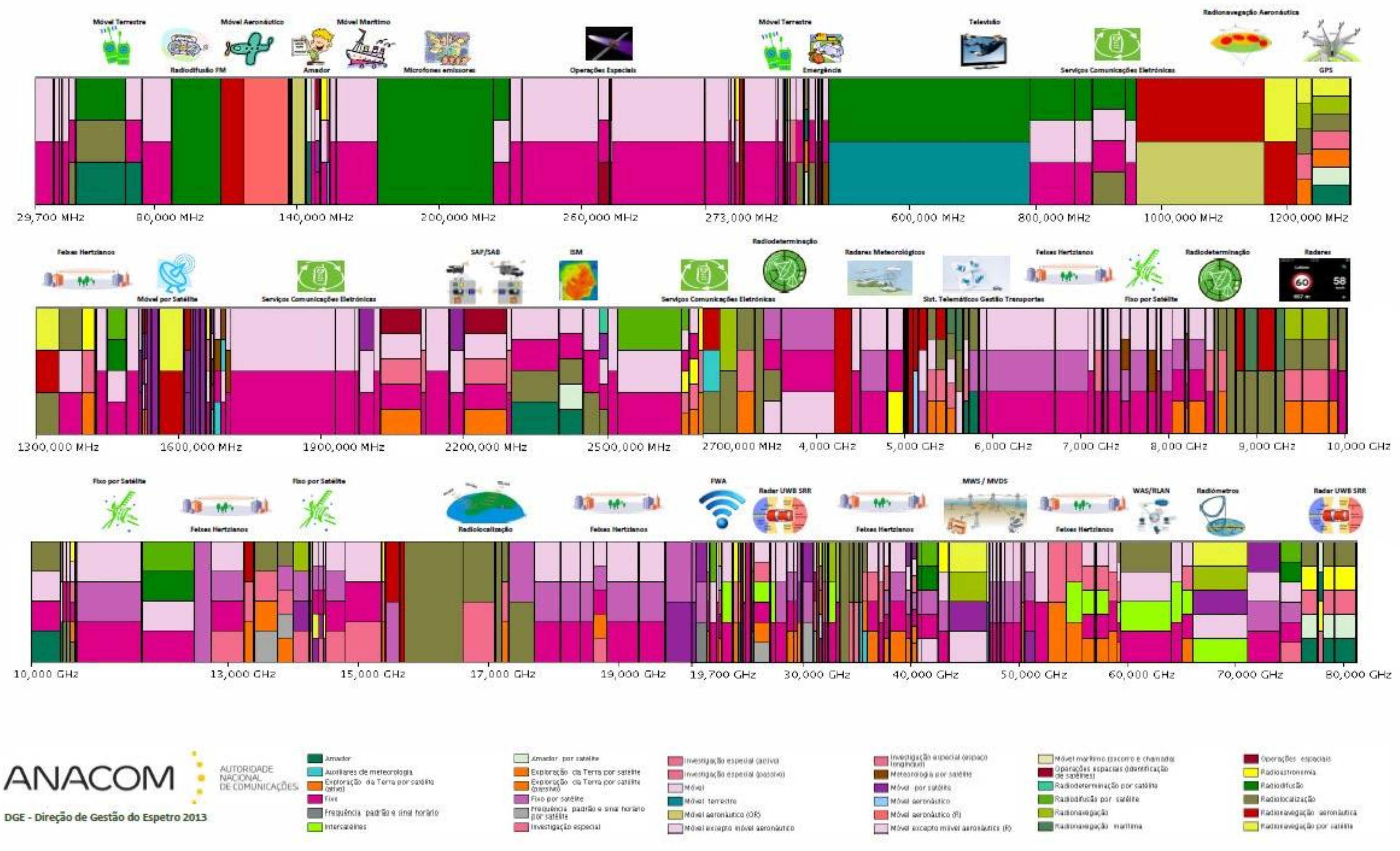


INFORMATION SIGNAL AT BBAND
The baseband information signal can be considered a sum of sinusoids
OTHER BAND
ALLOCATED FREQUENCY BAND
OTHER BAND
f_c
Frequency
INFORMATION MODULATED ONTO CARRIER
Modulation is when an information signal is shifted into its allocated frequency band
modulation
f_c
Frequency
INFORMATION DEMODUALTED TO BBAND
Demodulation is the reverse process, where information is translated back to baseband
demodulation
f_c
Frequency

Electromagnetic Spectrum

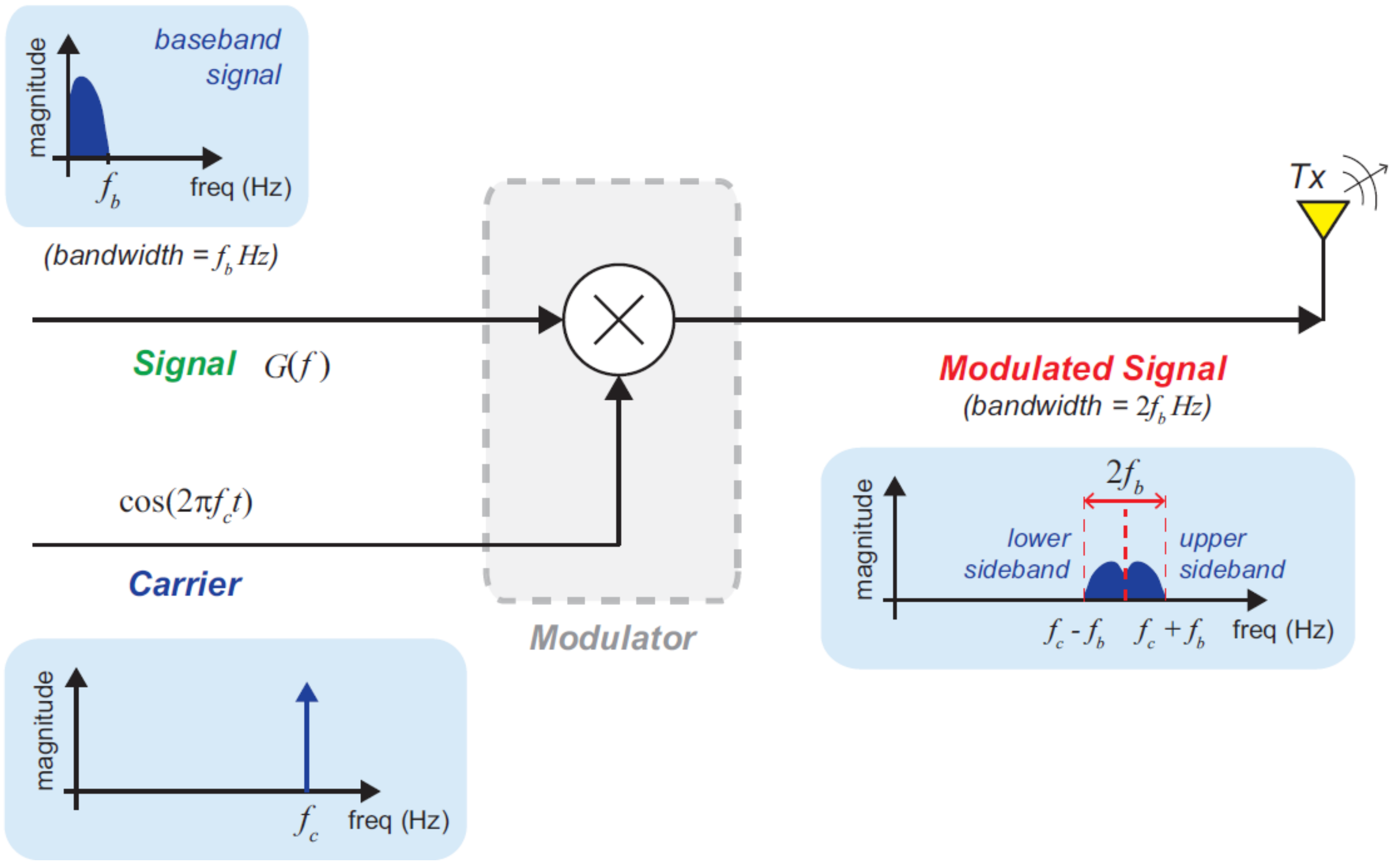


Electromagnetic Spectrum



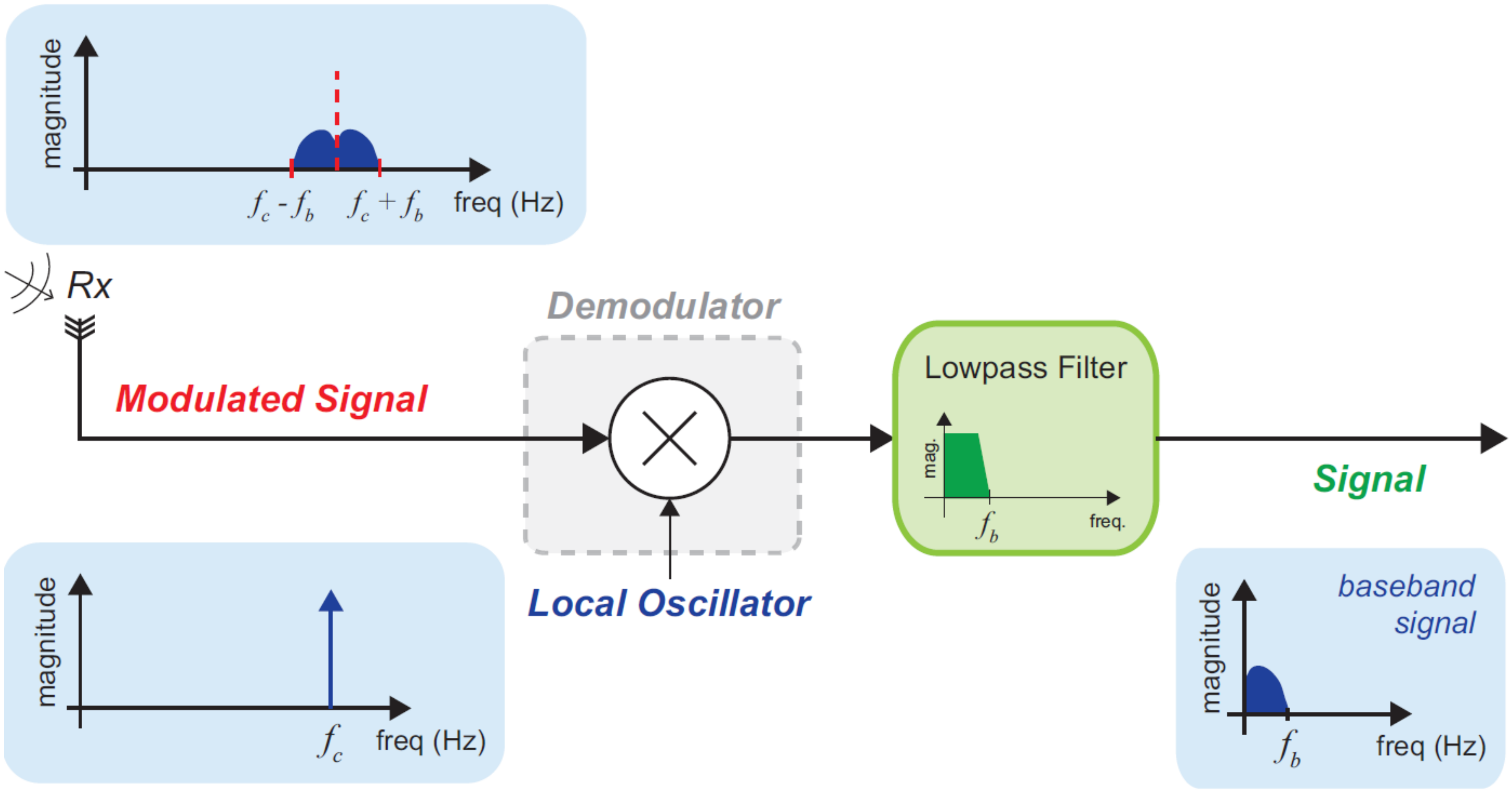
Amplitude Modulation

Modulating a baseband signal to produce an upper and lower sideband



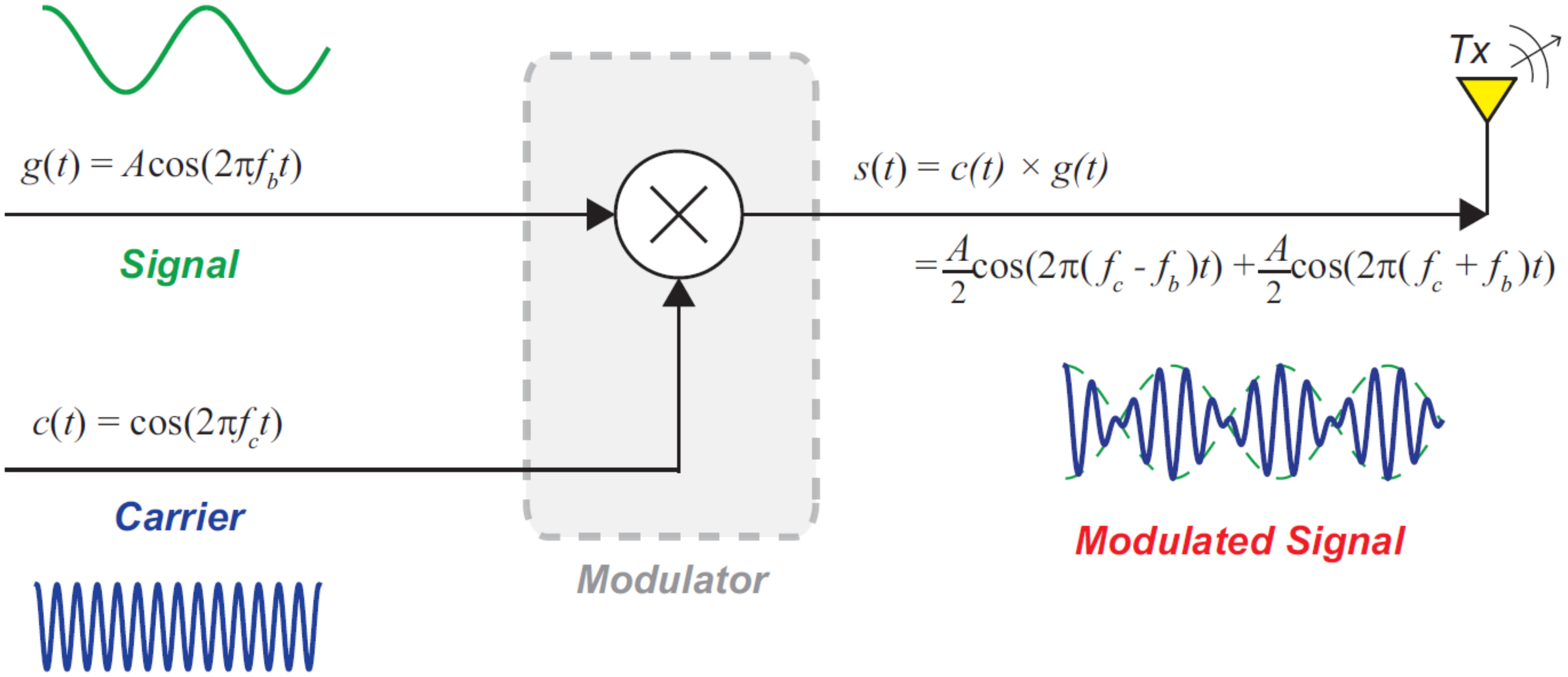
Amplitude Demodulation

Amplitude demodulation of AM transmitted signal



Amplitude Modulation

Example: Modulating a baseband signal based on a simple line spectra (cosine wave baseband)

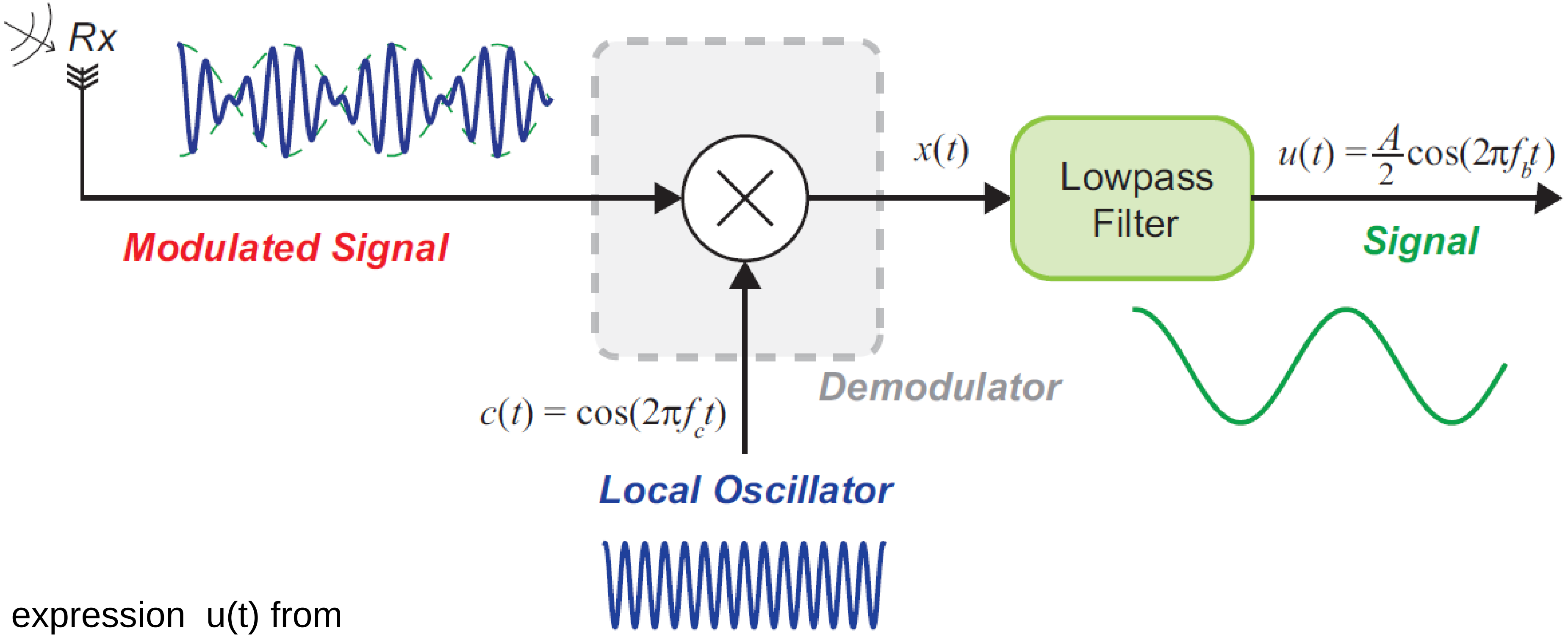


Exercise
Get the mathematic expression s(t) from g(t) and c(t)

Amplitude Demodulation

Amplitude demodulation of AM transmitted signal where a baseband signal is a simple line spectra (cosine wave baseband)

$$s(t) = \frac{A}{2}\cos(2\pi(f_c - f_b)t) + \frac{A}{2}\cos(2\pi(f_c + f_b)t)$$



Exercise

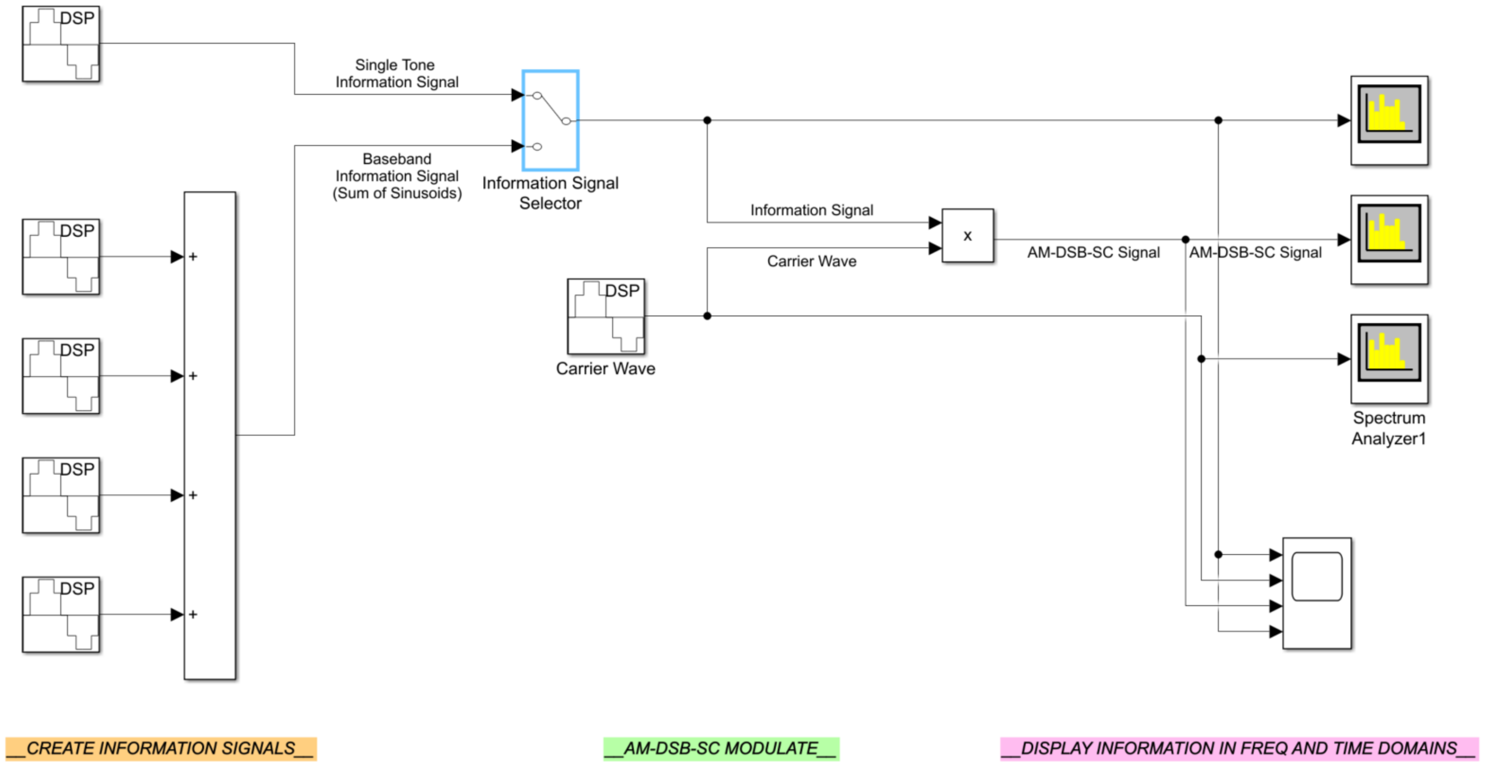
Get the mathematic expression u(t) from s(t) and x(t)

Frequency Domain Plots

- Open the model: am_dsb_sc.slx

- With the switch set to “Single Tone analyze the signals at the Time Scopes and Spectrum Analyzers. Comment the results

- Set the Information Signal selector switch to “Baseband Information Signal and re-run the simulation. Compare the results



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