

The Elements of Smyle (Transceiver Design)

Overview: Students arrange transceiver elements to form a transceiver topology that converts one signal to another. Students are given a list of transceiver elements and frequencies, but they need to construct the proper order of the elements and associate the frequencies with the correct transceiver element. Signals are depicted as either time-domain or frequency-domain signals. Transceiver elements include linear filters, samplers, static nonlinearities, mixers, and adders. Students also draw the signal after each transceiver element.

Setting: In-class or Take-home activity.

Curricular elements: Making/Tinkering & Gamification

Prerequisites: Understand how sampling, mixing, modulation and filters impact a signal.

Topics/concepts covered: Mixing, sampling, filtering. Time and frequency domain representations.

Learning outcomes:

- identify elements of common transceiver topologies
- organize transceiver elements into a workable order
- identify the significance of each transceiver element

Expected time to complete: at least 20-30 minutes

Required hardware/materials: Gameboard, signal cards, element cards, frequency tokens, 10-sided die, erasable marker. Students receive instructions and submission sheet. Instructor has answer guide.

Required instructor interaction: Instructor available to answer questions, check answers.

Common mistakes/pitfalls: Students may rely on other nearby students for answers, impeding the development of their own understanding.

Method of assessment: Compare submission sheet to answer guide.

Contributors: A. G. Klein, J. Rosenblum, H. Smith

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Description

Each small group is given a kit containing:

- Elements of Smyle gameboard
- Signal cards
- Element cards
- Role cards
- Frequency shards
- Erasable marker
- 10-sided die

The group is also given an instruction sheet which describes how to play the game, and what the recipes (scenarios) are for the transceiver topologies. The group is also given a submission sheet, which they use to record their solutions to the recipes. Provide the groups with a scratch sheet and pencil; some students may benefit from having somewhere else to draw as they work through the recipe.

For each recipe, students are given the input and output signals, and the elements to use in creating a transceiver topology, along with frequency values available. The student playing the role of “System Design Engineer” then arranges the elements into a correct order and places the frequency tokens onto the appropriate signal blocks.

Signal types given include: sinusoid, sampled sinusoid, added signal, square wave, and DC signal. They are shown in both time-domain as well as frequency-domain signal plots.

The transceiver elements included in this activity are: sampler, low-pass filter, high-pass filter, downsampler, quantizer, squaring function, mixer + oscillator, and adder + oscillator. Frequency values are between 1kHz and 40 kHz are also specified for each recipe.

The scenarios have increasing complexity as earlier scenarios demonstrate how to create particular signal types using the transceiver elements.

The Elements of Smyle activity allows students to physically manipulate representations of transceiver elements. This tactile creative process appeals to hands-on learning styles and makes this a type of making/tinkering exercise.

The gameboard, cards, die, and assigned roles make this activity a classic game style. Elements of gamification in this activity include clearly defined goals, collaboration as students work together to arrive at an answer, and different levels of difficulty. Competition can be added as an additional element of gamification by rewarding the group that completes the most recipes correctly for bonus points in the course.

Assembly

All print materials are single-sided. Print the gameboard on 100# coverstock, or heavy weight bond. The gameboard does not need to be cut, but it must be laminated. Print the signal cards, role cards, element blocks, and frequency tokens on 80# cardstock or heavier. Laminating the cards is recommended, but not necessary. Laminating the signal shards is optional, but due to their size is not recommended.

Assembling the board and cards will require:

- 38 pairs of adhesive velcro dots or strips measuring 3/4" in diameter (14 hooks, 38 loops)
- Or 52 magnetic dots/cuts of magnetic tape measuring 3/4"
- Scissors or precision blade (Using a paper cutter will produce inaccurate crops)

Once the gameboard and cards are laminated and cut, place the 14 adhesive velcro* hooks where indicated on the gameboard and on element blocks LPF (λ), HPF (η), Sampler (σ), Mixer + Oscillator (μ), and Adder + Oscillator (ρ). Center and place the 38 velcro loops on the blank/reverse side of each signal card, element block, and frequency shard.

*If using magnetic dots or magnetic tape, be aware of directionality and polarity of the magnets.

Elements of Smyle Instructions

The absent-minded Dr. Sam Smyle needs to create a bunch of radio signals, but Dr. Smyle mixed up the transceiver elements and frequencies for each recipe. Help Dr. Smyle sort out the order of the transceiver elements, and which frequencies are associated with each element. Between each element placed on the board, sketch the signal at that point. Sketch the signal in time-domain, in frequency-domain, or both.

The Elements of Smyle is a game for 3–5 players. The **System Design Engineer** arranges all of the elements in a correct order and places the frequency tokens, **The Oscilloscope** draws the signal created at each checkpoint between elements, and the other players are **Quality Assurance (QA) Engineers**, making sure that the work of The System Design Engineer and The Oscilloscope looks good. After each level, players switch roles, so that each person has an opportunity to do each role.














































Each team begins by completing recipes A, B and C. Afterwards, roll a 10-sided die to choose the next recipes you will complete. (If you repeat a roll, just roll again.)

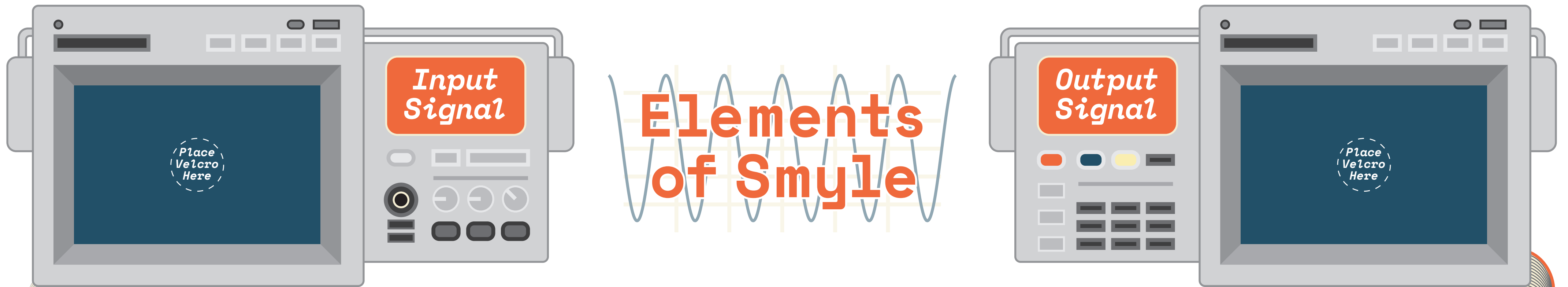
Recipe	Starting Signal	Final Signal	Elements	Frequencies (kHz)
A	IV	II	μ	Choose One
B	III	XIV	$\mu \gamma$	Choose One
C	XIII	VIII	$\lambda \lambda \mu \mu$	1, 5, 10, 20
1	I	XII	$\eta \mu \gamma$	3, 4
2	VIII	XIII	$\eta \lambda \mu \mu \gamma$	1, 9, 10, 11
3	IV	IX	$\delta \eta \mu \sigma$	4, 4, 40
4	VIII	III	$\lambda \beta$	Choose One
5	IV	IX	$\eta \lambda \gamma \sigma$	4, 6, 20
6	VIII	VII	$\rho \delta \varepsilon \sigma$	9, 40
7	VIII	XV	$\eta \lambda \gamma$	2, 6
8	XI	X	$\lambda \mu \mu$	6, 9, 11
9	XI	VI	$\rho \lambda \mu \mu$	1, 4, 4, 10
10	VIII	V	$\delta \lambda \gamma \sigma$	2, 40

Elements of Smyle Submission Sheet

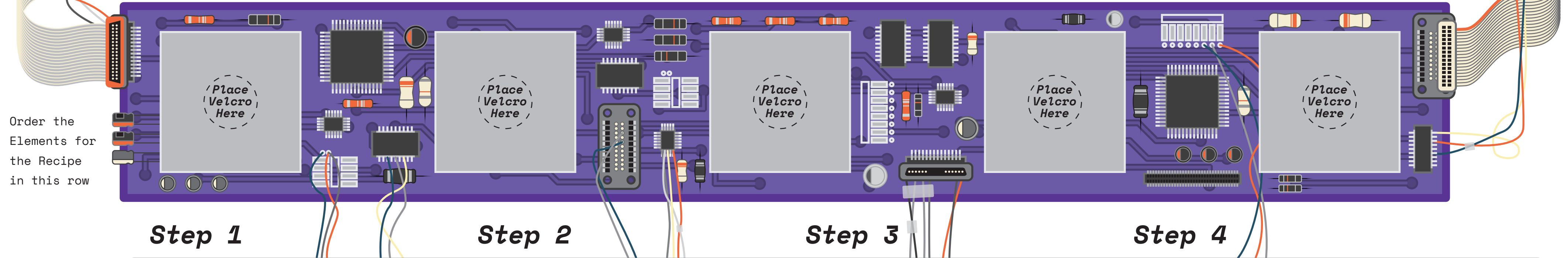
Names:

Begin by completing recipes A, B and C. Afterwards, roll a 10-sided die to choose the next recipes you will complete. (If you repeat a roll, just roll again.)

Recipe	Element 1	Element 2	Element 3	Element 4	Element 5
A	kHz 	kHz 	kHz 	kHz 	kHz 
B	kHz 	kHz 	kHz 	kHz 	kHz 
C	kHz 	kHz 	kHz 	kHz 	kHz 
#:	kHz 	kHz 	kHz 	kHz 	kHz 
#:	kHz 	kHz 	kHz 	kHz 	kHz 
#:	kHz 	kHz 	kHz 	kHz 	kHz 
#:	kHz 	kHz 	kHz 	kHz 	kHz 
#:	kHz 	kHz 	kHz 	kHz 	kHz 
#:	kHz 	kHz 	kHz 	kHz 	kHz 



Smyle Signal Processing Machine



Order the Elements for the Recipe in this row

Draw the signal at each step as it goes through the machine.

Choose between drawing in the **time** or **frequency** domains.

Time

Freq

	t	t	t	t
	f	f	f	f

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λ **Ideal LPF**
Cutoff: Stick Velcro Here

η **Ideal HPF**
Cutoff: Stick Velcro Here

σ **Sampler**
Sample Rate: Stick Velcro Here

ϵ **Downsampler**
 $M = 5$

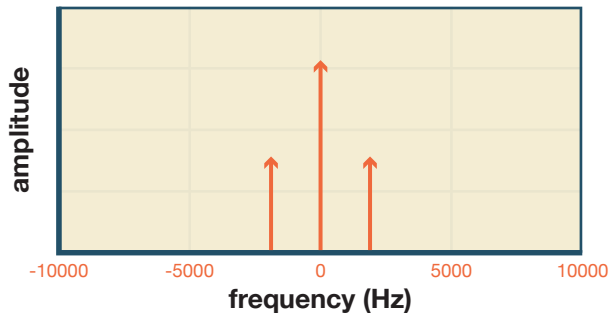
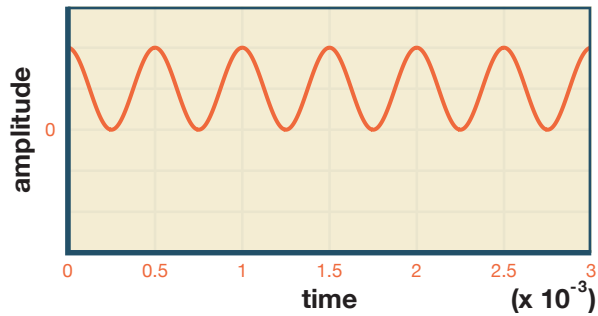
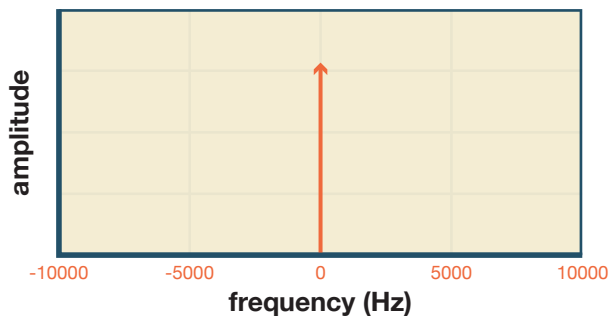
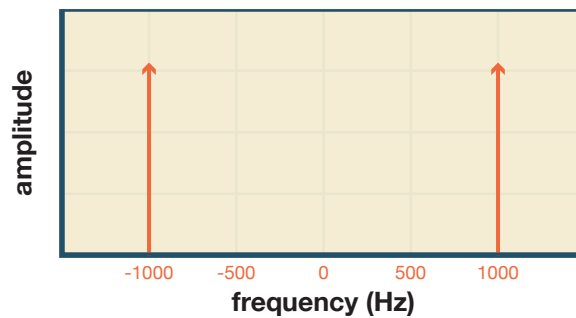
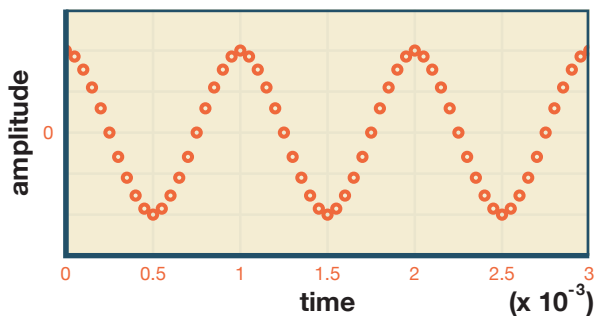
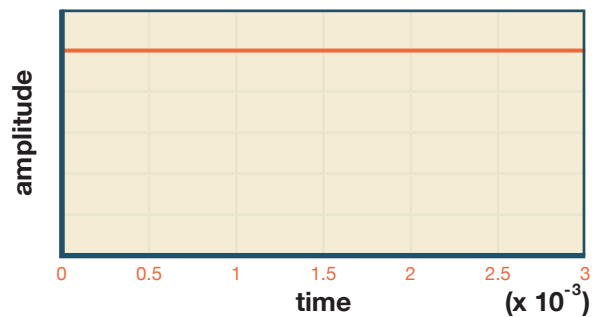
δ **Downsampler**
 $M = 2$

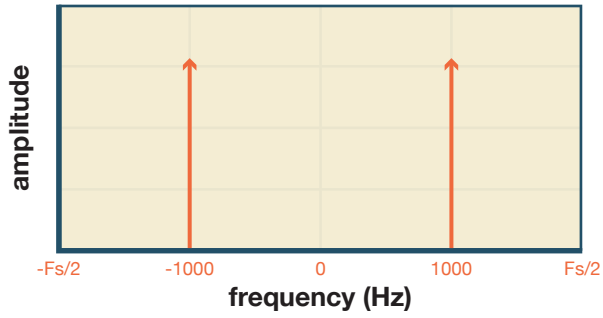
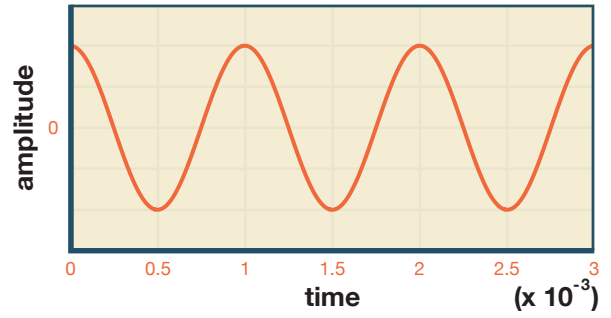
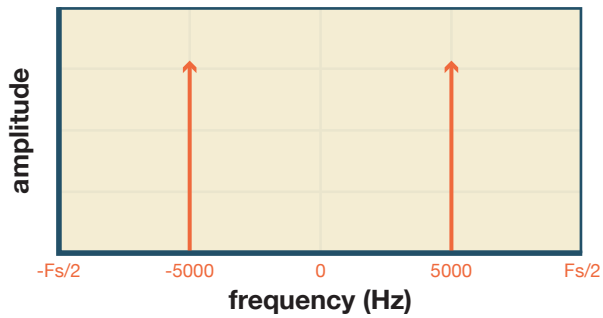
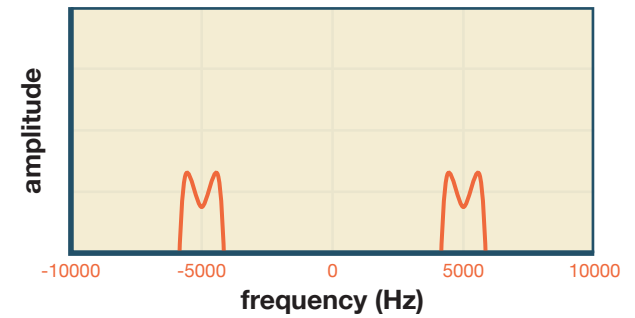
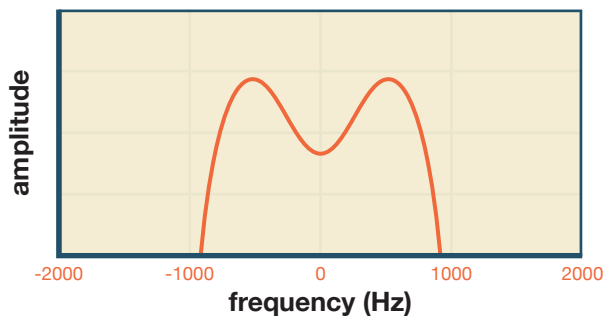
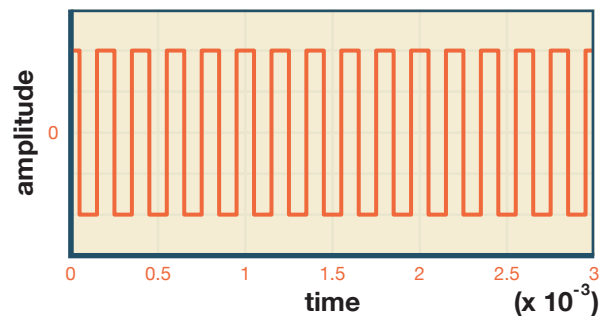
γ **One-Bit Quantizer**
if $u > 0, y = 1$
if $u < 0, y = -1$

μ **Mixer + Oscillator**
Frequency: Stick Velcro Here

ρ **Adder + Oscillator**
Frequency: Stick Velcro Here

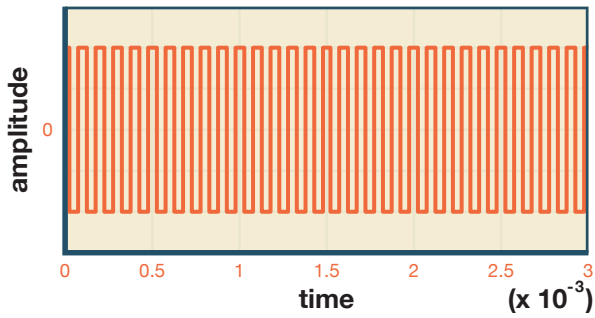
β **Squaring Function**

I**DC + 2 kHz Sinusoid****II****DC + 2 kHz Sinusoid****III****DC Signal****IV****1 kHz Sinusoid****V****1 kHz Sinusoid sampled at 20 kHz****VI****DC Signal**

VII**1 kHz Sinusoid sampled at 4 kHz****VIII****1 kHz Sinusoid****IX****5 kHz Sinusoid sampled at 20 kHz****X****5 kHz Centered M-Blob****XI****DC-Centered M-Blob****XII****5 kHz Square Wave**

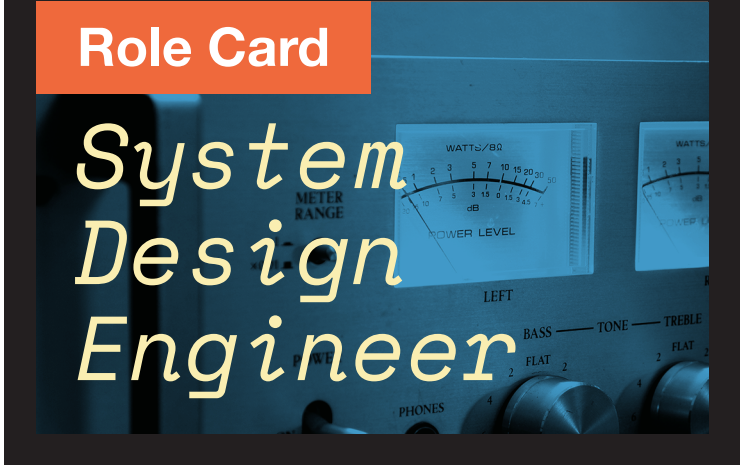
XIII

10 kHz Square Wave



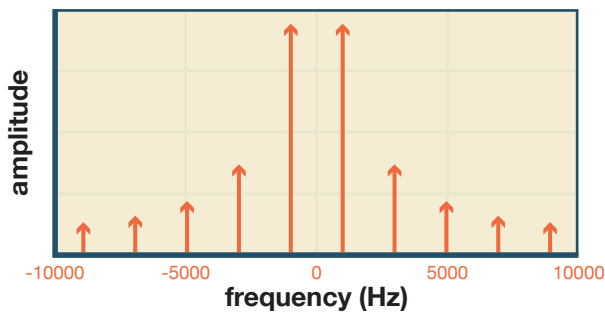
Role Card

*System
Design
Engineer*



XIV

1 kHz Square Wave



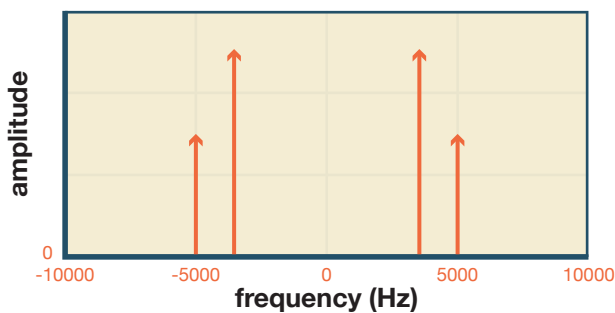
Role Card

*QA
Engineer*



XV

3 kHz + 5 kHz Sinusoid



Role Card

Oscilloscope



1
KHZ

2
KHZ

3
KHZ

4
KHZ

5
KHZ

40
KHZ

6
KHZ

9
KHZ

10
KHZ

11
KHZ

20
KHZ

4
KHZ

