

Bat Machine

Ultrasonic Sensor and Servo
Control With a FPGA

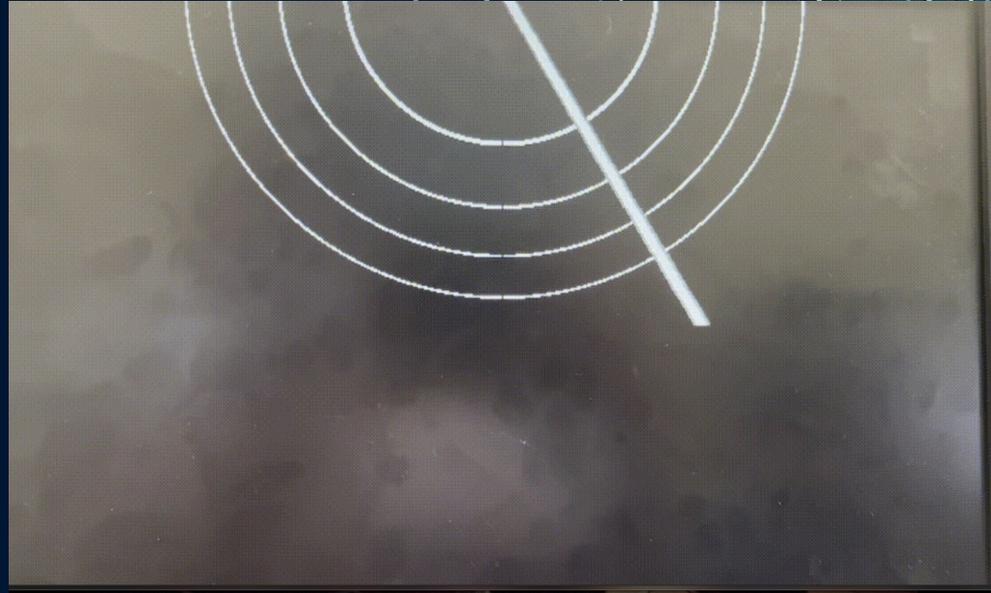
Lourdes Sanchez Medina

Nico Bykhovsky-Gonzalez

Project Delays

What Works

- Driver between ultrasonic sensor and peripheral
- Adjustable VGA radar according to echo signal (simulated)

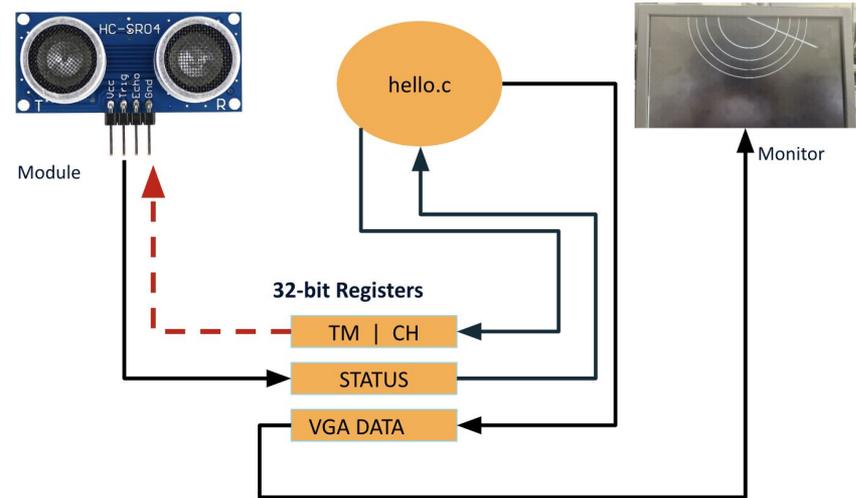


Project Delays

What Does Not Work

- Reading an echo signal from UltraSonic Sensor
- Controlling a servo motor with PWM

SYSTEM DIAGRAM



OVERVIEW

SOFTWARE

Calculate distance

HARDWARE

Status of Ultrasonic



OVERVIEW

SOFTWARE

Calculate distance

Radar Line Calculation

HARDWARE

Status of Ultrasonic

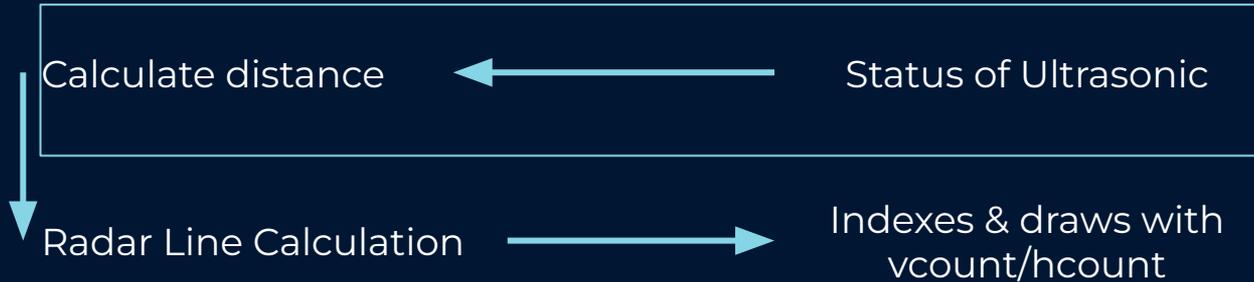
Indexes & draws with
vcount/hcount



OVERVIEW

SOFTWARE

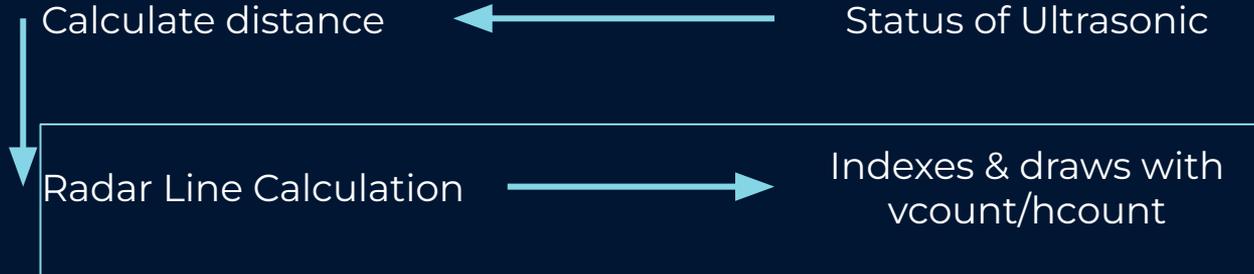
HARDWARE



OVERVIEW

SOFTWARE

HARDWARE



Platform Designer

System Contents Address Map Interconnect Requirements

System: soc_system Path: clk_0

Use	Connections	Name	Description	Export	Clock	Base	End
<input checked="" type="checkbox"/>		clk_0	Clock Source		exported		
		clk_in	Clock Input	clk			
		clk_in_reset	Reset Input	reset			
		clk	Clock Output	<i>Double-click to</i>	clk_0		
		clk_reset	Reset Output	<i>Double-click to</i>			
<input checked="" type="checkbox"/>		hps_0	Arria V/Cyclone V Hard Proce...				
		h2f_user1_clock	Clock Output	<i>Double-click to</i>	hps_0_h2...		
		h2f_mpu_events	Conduit	<i>Double-click to</i>			
		memory	Conduit	hps_ddr3			
		hps_jo	Conduit	hps			
		h2f_reset	Reset Output	<i>Double-click to</i>			
		h2f_axi_clock	Clock Input	<i>Double-click to</i>	clk_0		
		h2f_axi_master	AXI Master	<i>Double-click to</i>	[h2f_axi_...		
		f2h_axi_clock	Clock Input	<i>Double-click to</i>	clk_0		
		f2h_axi_slave	AXI Slave	<i>Double-click to</i>	[f2h_axi_...		
		h2f_lw_axi_clock	Clock Input	<i>Double-click to</i>	clk_0		
		h2f_lw_axi_master	AXI Master	<i>Double-click to</i>	[h2f_lw_a...		
<input checked="" type="checkbox"/>		vga_ball_0	VGA ball				
		reset	Reset Input	<i>Double-click to</i>	[clock]		
		avalon_slave_0	Avalon Memory Mapped Slave	<i>Double-click to</i>	[clock]	0x0000_0000	0x0000_07ff
		vga	Conduit	vga			
		clock	Clock Input	<i>Double-click to</i>	clk_0		
<input checked="" type="checkbox"/>		ultrasonic_sens...	ultrasonic_sensor				
		clock	Clock Input	<i>Double-click to</i>	clk_0		
		avalon_slave_0	Avalon Memory Mapped Slave	<i>Double-click to</i>	[clock]	0x0000_0000	0x0000_0003
		reset	Reset Input	<i>Double-click to</i>	[clock]		
		sensor	Conduit	sensor	[clock]		

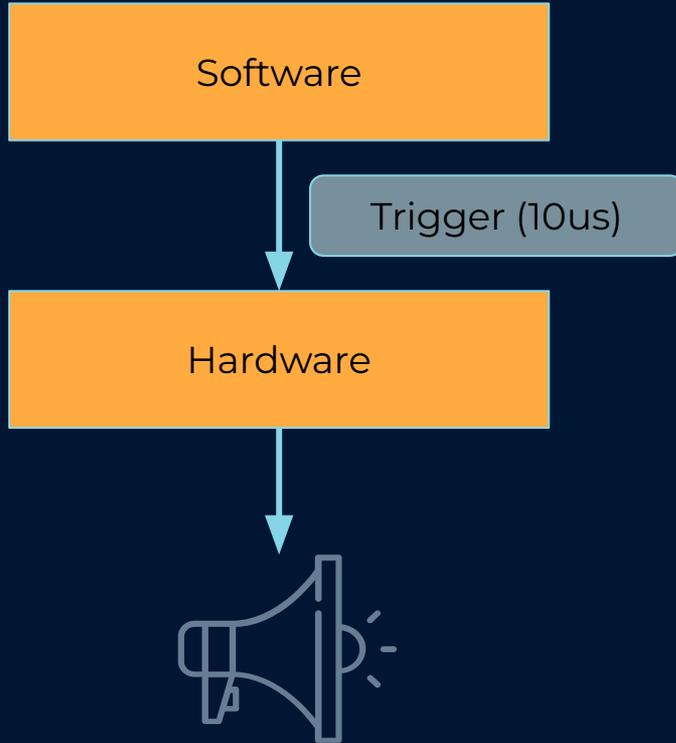
Platform Designer

System Contents Address Map Interconnect Requirements

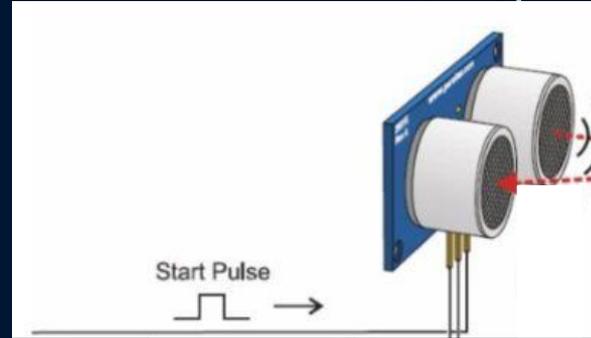
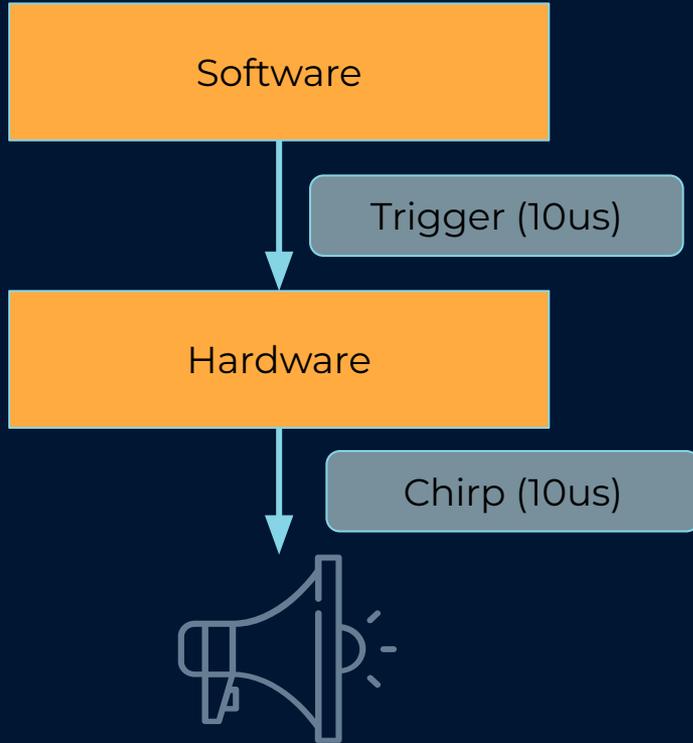
System: soc_system Path: clk_0

Use	Connections	Name	Description	Export	Clock	Base	End
<input checked="" type="checkbox"/>		<ul style="list-style-type: none"> clk_0 clk_in clk_in_reset clk clk_reset 	<ul style="list-style-type: none"> Clock Source Clock Input Reset Input Clock Output Reset Output 	<ul style="list-style-type: none"> clk reset <i>Double-click to</i> <i>Double-click to</i> 	<ul style="list-style-type: none"> <i>exported</i> clk_0 		
<input checked="" type="checkbox"/>		<ul style="list-style-type: none"> hps_0 h2f_user1_clock h2f_mpu_events memory hps_jo h2f_reset h2f_axi_clock h2f_axi_master f2h_axi_clock f2h_axi_slave h2f_lw_axi_clock h2f_lw_axi_master 	<ul style="list-style-type: none"> Arria V/Cyclone V Hard Proce... Clock Output Conduit Conduit Reset Output Clock Input AXI Master Clock Input AXI Slave Clock Input AXI Master 	<ul style="list-style-type: none"> <i>Double-click to</i> <i>Double-click to</i> hps_ddr3 hps <i>Double-click to</i> <i>Double-click to</i> <i>Double-click to</i> <i>Double-click to</i> <i>Double-click to</i> 	<ul style="list-style-type: none"> hps_0_h2... clk_0 [h2f_axi_... clk_0 [f2h_axi_... clk_0 [h2f_lw a... 		
<input checked="" type="checkbox"/>		<ul style="list-style-type: none"> vga_ball_0 reset avalon_slave_0 vga clock 	<ul style="list-style-type: none"> VGA ball Reset Input Avalon Memory Mapped Slave Conduit Clock Input 	<ul style="list-style-type: none"> <i>Double-click to</i> <i>Double-click to</i> vga <i>Double-click to</i> 	<ul style="list-style-type: none"> [clock] [clock] [clock] clk_0 	<ul style="list-style-type: none"> 0x0000_0000 	0x0000_07ff
<input checked="" type="checkbox"/>		<ul style="list-style-type: none"> ultrasonic_sens... clock avalon_slave_0 reset sensor 	<ul style="list-style-type: none"> ultrasonic_sensor Clock Input Avalon Memory Mapped Slave Reset Input Conduit 	<ul style="list-style-type: none"> <i>Double-click to</i> <i>Double-click to</i> <i>Double-click to</i> sensor 	<ul style="list-style-type: none"> clk_0 [clock] [clock] [clock] 	<ul style="list-style-type: none"> 0x0000_0000 	0x0000_0003

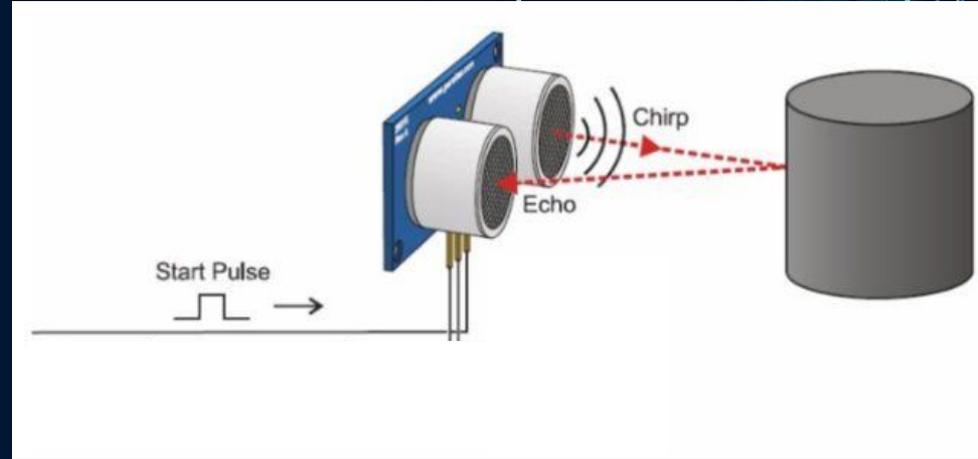
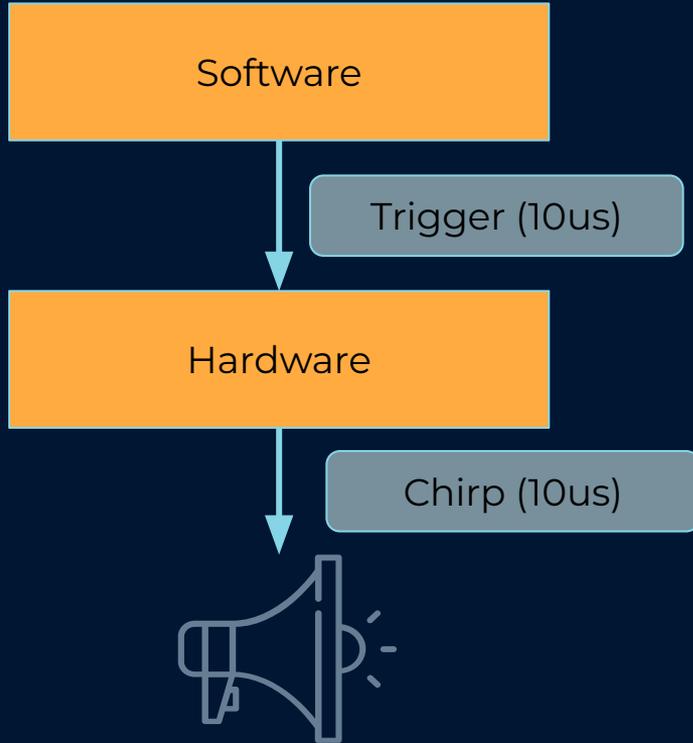
Ultrasonic Sensor Signals



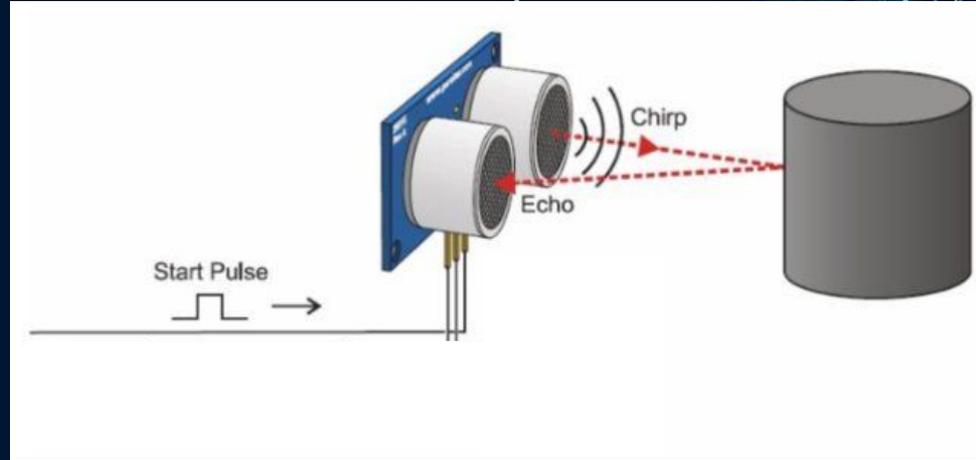
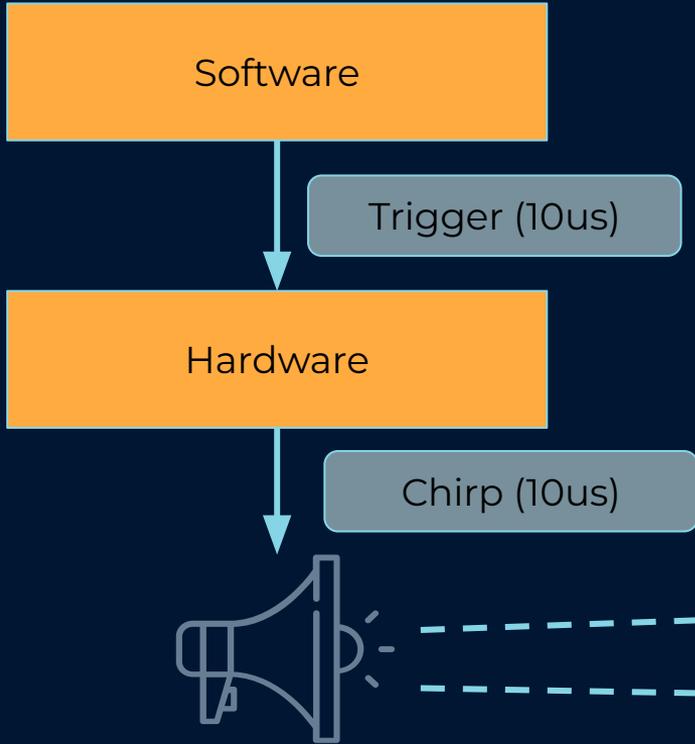
Ultrasonic Sensor Signals



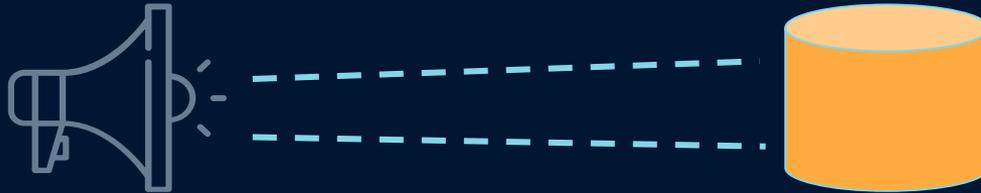
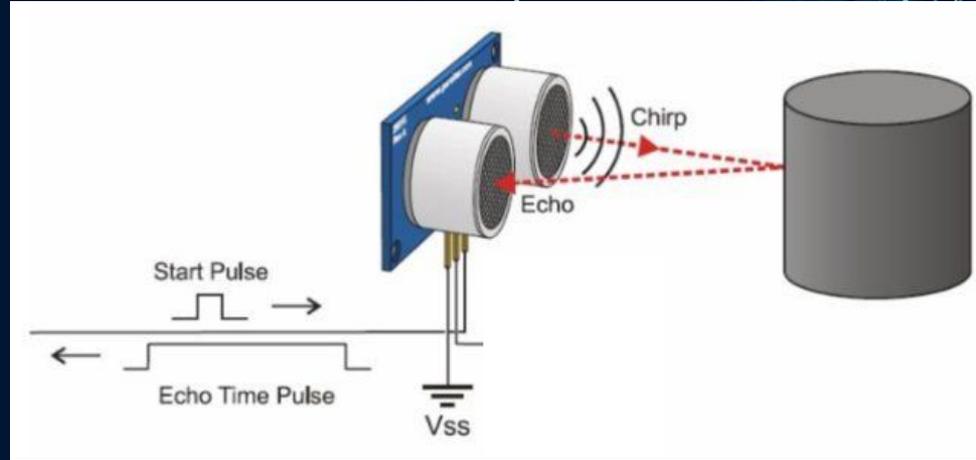
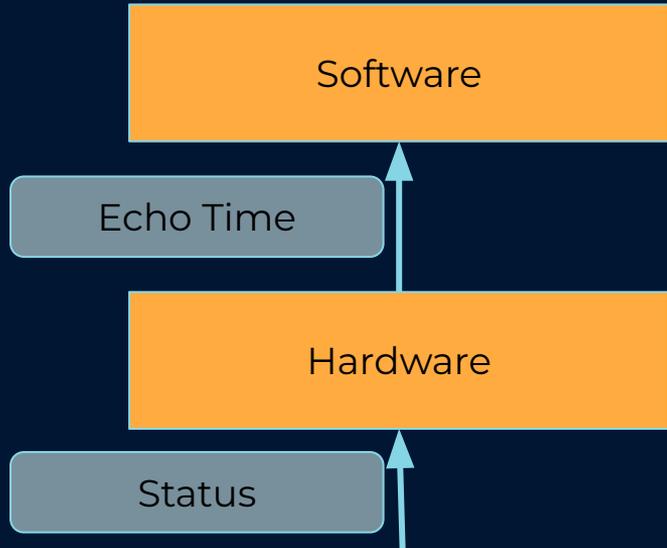
Ultrasonic Sensor Signals



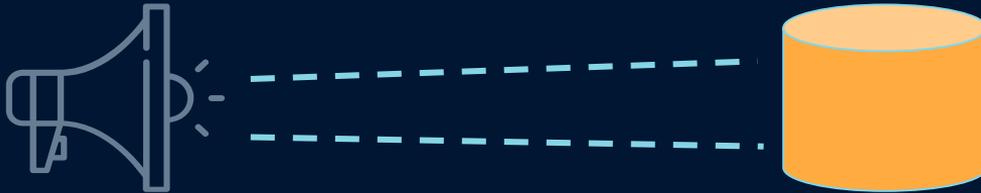
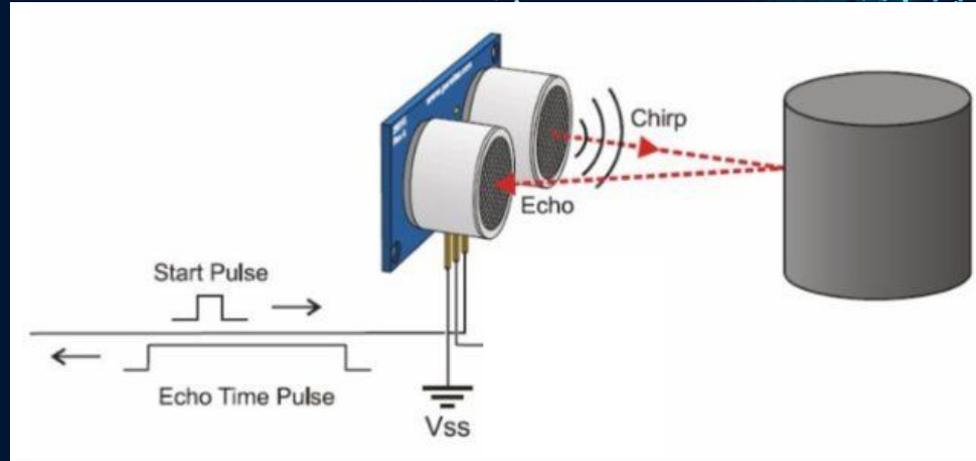
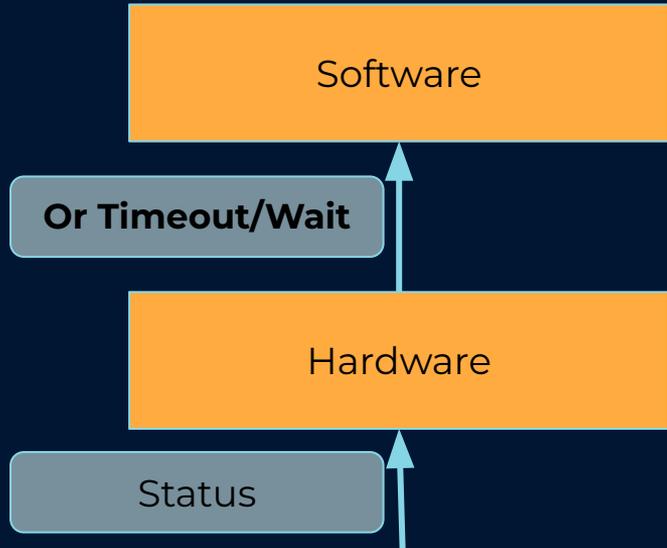
Ultrasonic Sensor Signals



Ultrasonic Sensor Signals



Ultrasonic Sensor Signals



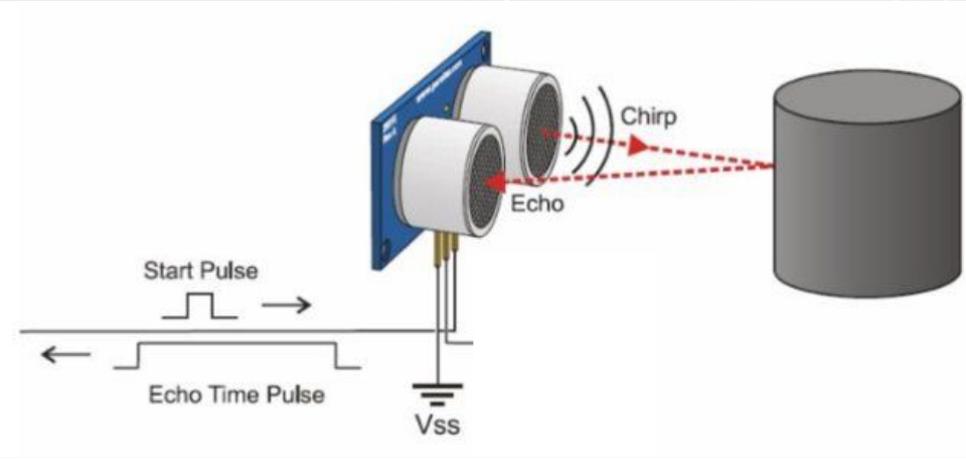
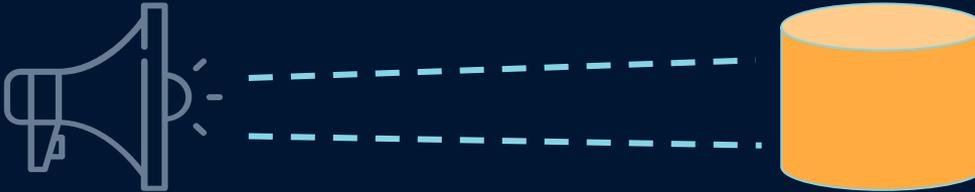
Ultrasonic Sensor Signals

$$\text{Distance} = (\text{SoS} \times \text{Time}) \div 2$$

Or Timeout/Wait

Hardware

Status



Defining the line

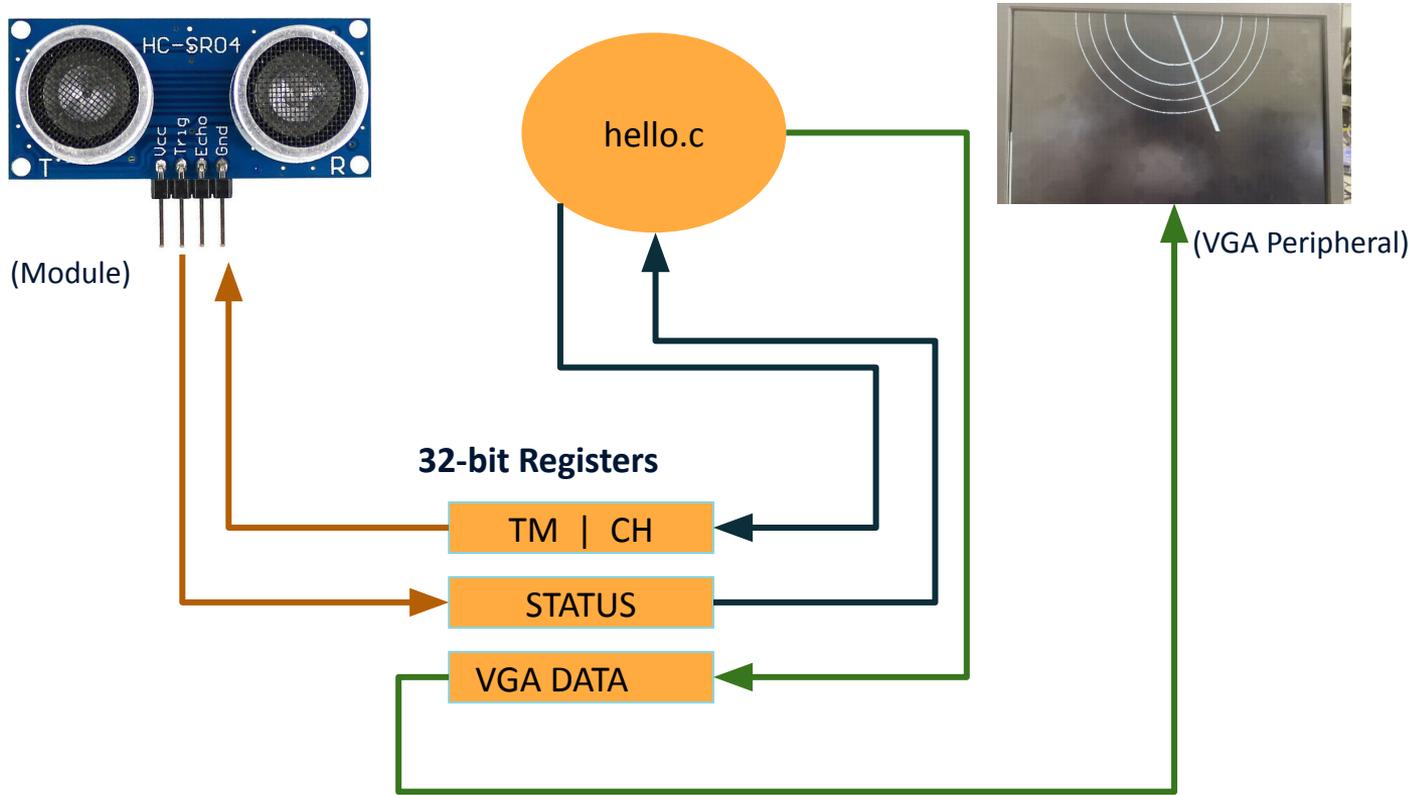
Given theta, define a line with horizontal ranges indexable by vcount.

Calculate horizontal distance:

$$X_{\text{high/low}} = \cos(\Theta) * (\text{skipped x distance}) +/- \Delta$$

```
int x0 = SCREEN_WIDTH/2 + (int)(cosf(theta * (float)M_PI / 180.0f) * vx) - (2 + AngleDistanceFrom90);  
int x1 = SCREEN_WIDTH/2 + (int)(cosf(theta * (float)M_PI / 180.0f) * vx) + (2 + AngleDistanceFrom90);
```

SYSTEM DIAGRAM



ULTRASONIC SENSOR + MODULE

GPIO 0	
1	2
3	4
5	6
7	8
9	10
11	12
13	14
15	16
17	18
19	20
21	22
23	24
25	26
27	28
29	30
31	32
33	34
35	36
37	38
39	40



If CHIRP:

- TRIGGER 10 microseconds
- Wait for ECHO; STATUS = 0.

TIMEOUT | CHIRP

If ECHO:

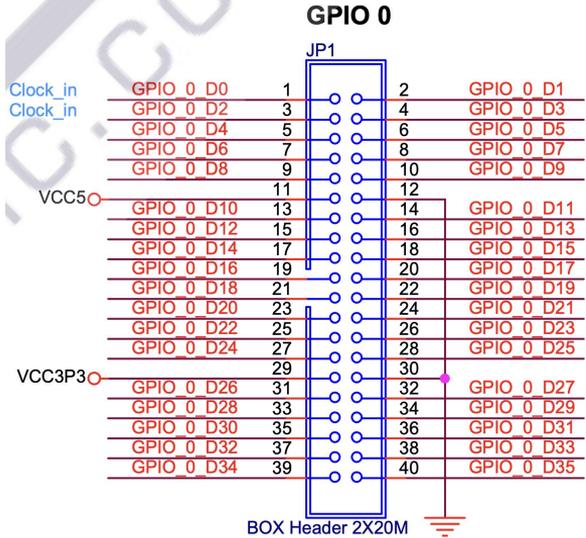
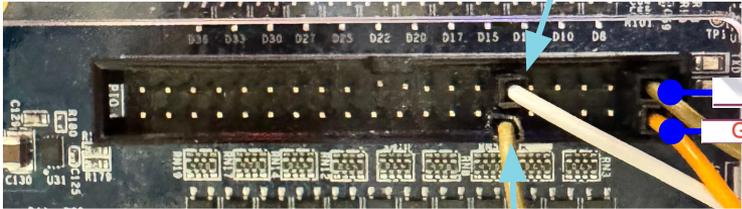
- Count echo; STATUS = 0.
- STATUS = Final Count.

STATUS

If echo takes too long:

- STATUS = Timeout.

ULTRASONIC SENSOR + MODULE



```
Writing config: timeout=0xffff, chirp=0, cfg=0xffff0000  
Echo status @ 132° = 0xe0688c92, chirp = 0  
Writing config: timeout=0xffff, chirp=0, cfg=0xffff0000  
Echo status @ 131° = 0xe0688c92. chirp = 0
```

```
Writing config: timeout=0xffff, chirp=0, cfg=0xffff0000  
Echo status @ 120° = 0xe0abcc74, chirp = 0  
Writing config: timeout=0xffff, chirp=0, cfg=0xffff0000  
Echo status @ 119° = 0xe0abcc74. chirp = 0
```