



# DEMO TAMBAHAN SEMINAR PROPOSAL

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# Overview

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# Uji Coba dan Pengambilan Data

## Uji Coba 1

Sensor :

Piezoelektrik Arduino Module

Board :

ESP32

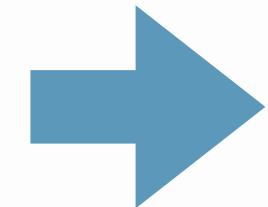


Permasalahan :

- Output sensor hanya sinyal analog
- Banyak sinyal bouncing
- Hasil hitung ToF tidak beraturan

Kesimpulan :

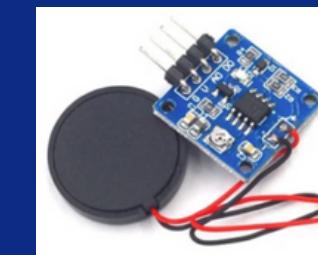
Menggunakan alternatif sensor dengan output digital.



## Uji Coba 2

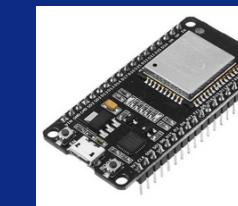
Sensor :

Piezoelektrik Switch TZT



Board :

ESP32



Permasalahan :

- Penggunaan output digital masih menimbulkan bouncing karena basic sensor ini adalah sensor vibrasi
- Hasil hitung ToF tidak konsisten

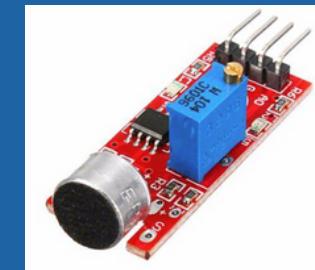
Kesimpulan :

Menggunakan alternatif sensor lain yang mampu mendeteksi suara

# Uji Coba dan Pengambilan Data

## Uji Coba 3

Sensor :  
Microphone Sensor KY-037



Board :  
ESP32

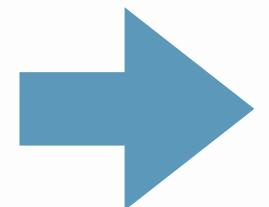


Permasalahan :

- Interval interupsi timeAlarmWrite ESP32 hanya mampu sampai 4 us.
- Hasil ToF untuk jarak dibawah 60 cm tidak stabil.

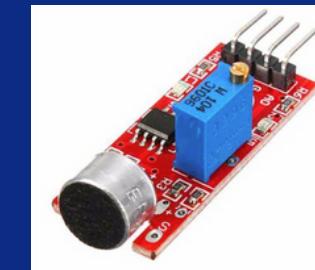
Kesimpulan :

Menggunakan alternatif board dengan clock speed lebih tinggi.



## Uji Coba 4

Sensor :  
Microphone Sensor KY-037



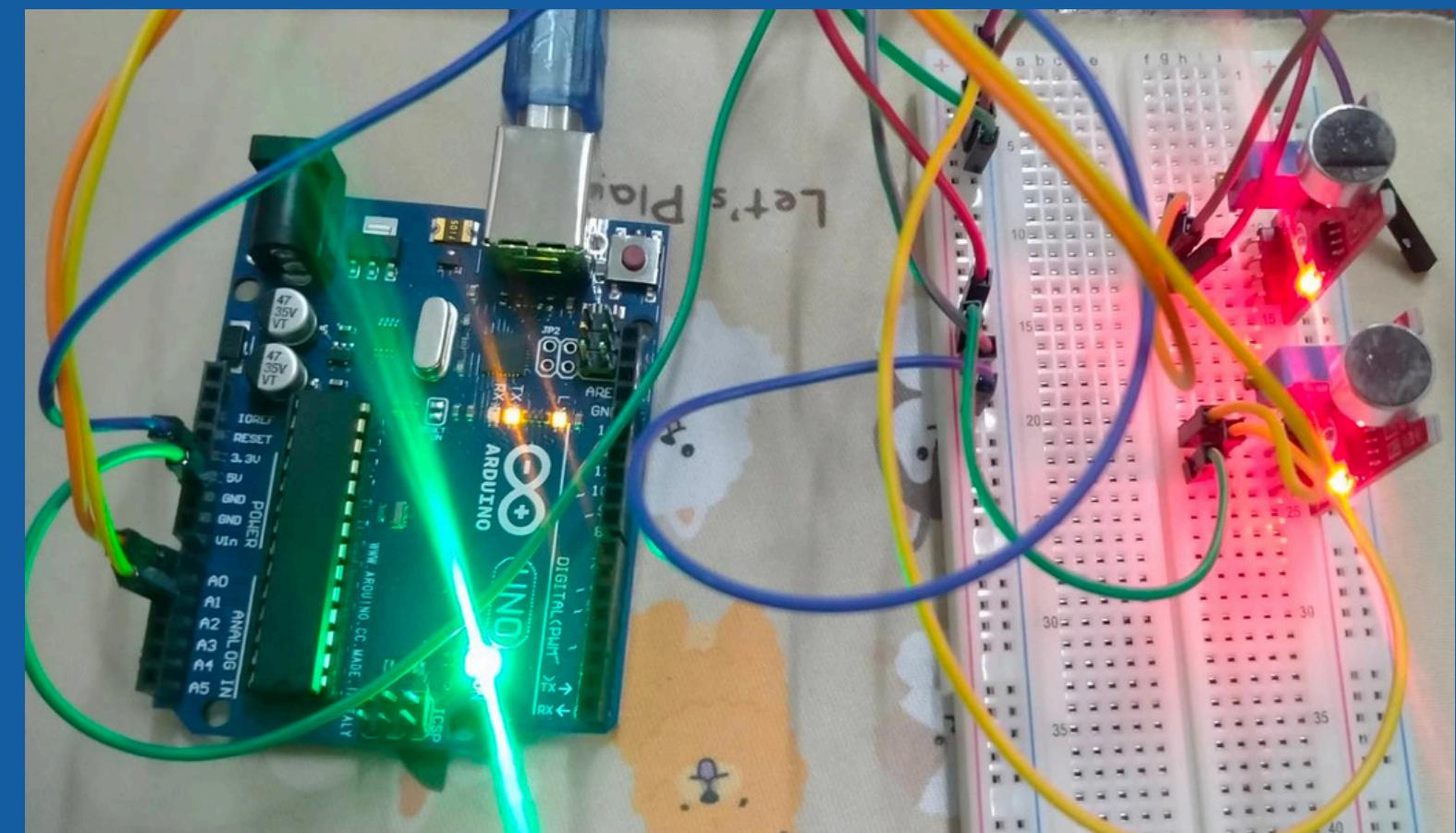
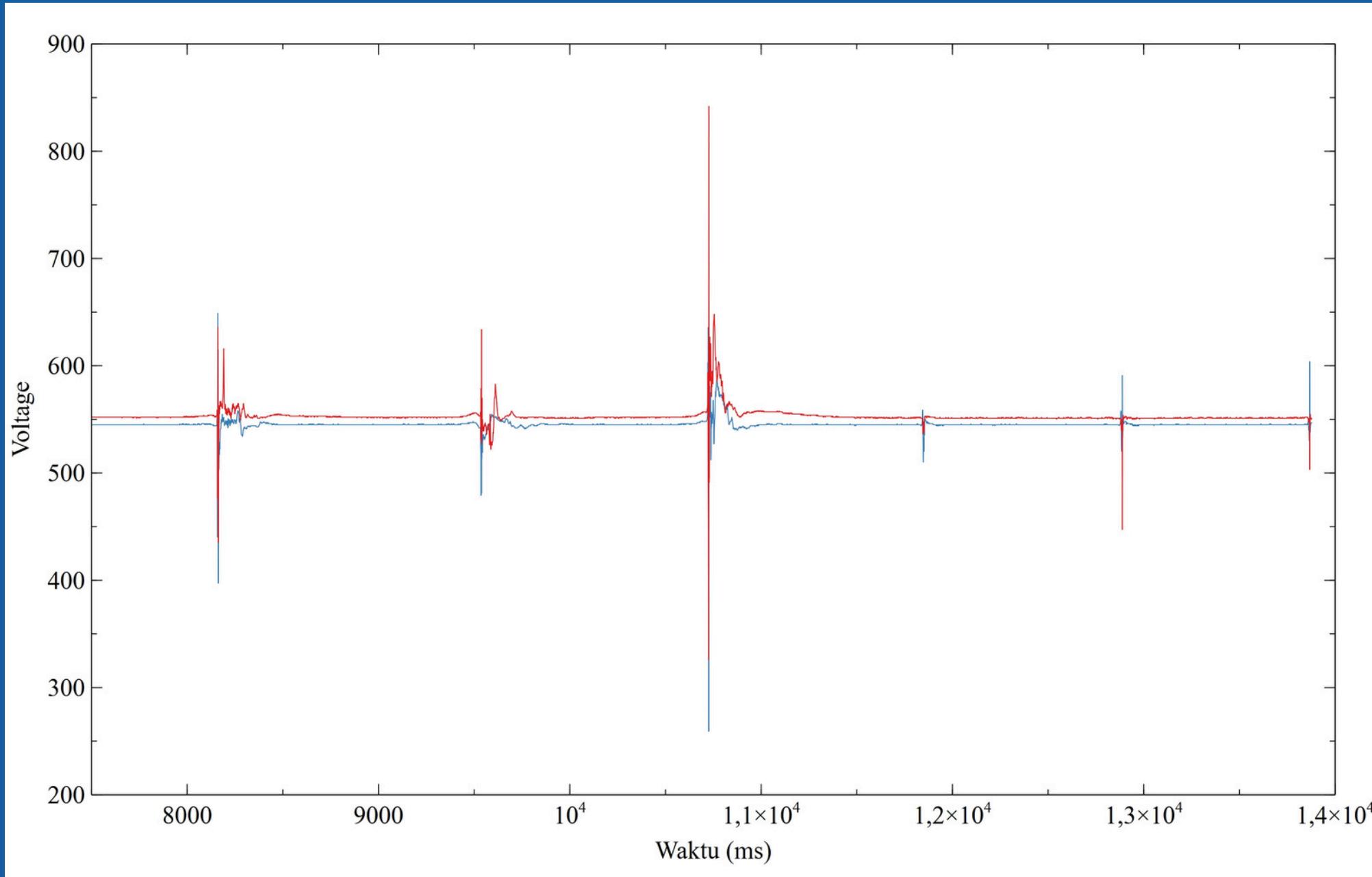
Board :  
Teensy 4.1



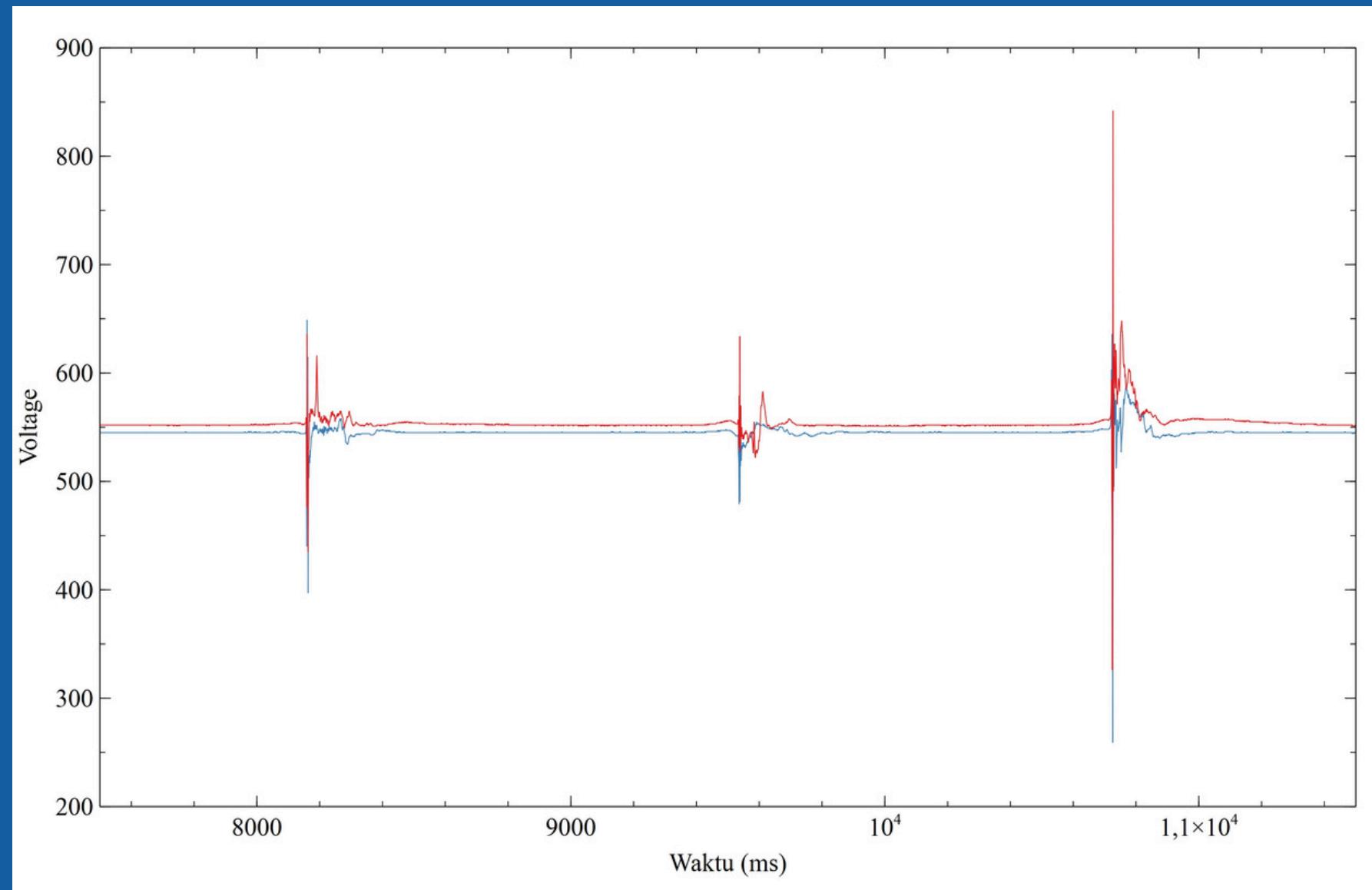
Kesimpulan :

- Mampu menghasilkan counter interrupt timer 1 us.
- Hasil hitung ToF sudah stabil.

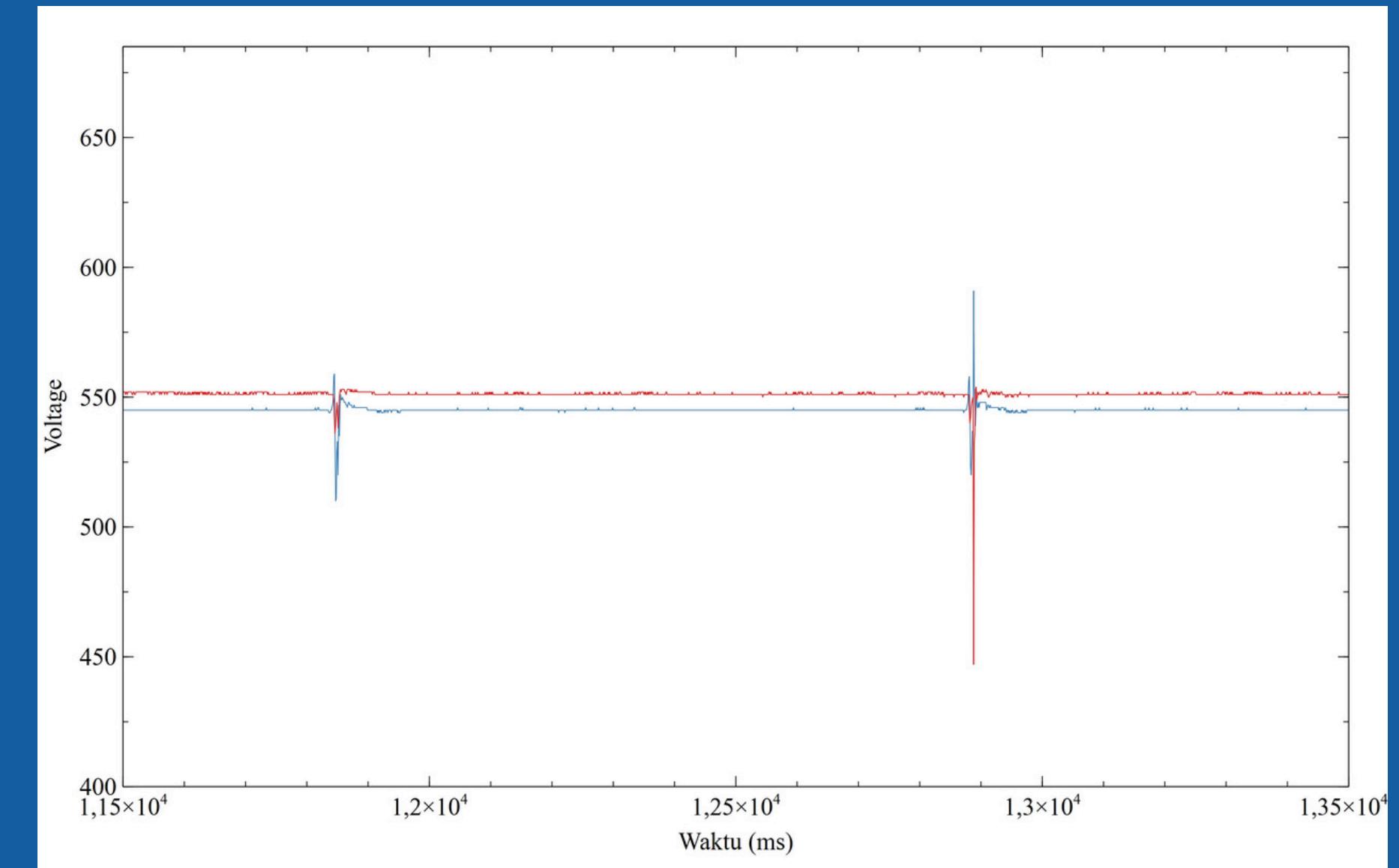
# Tampilan Sinyal Analog Sensor KY-037 dengan input suara tepukan tangan



# Tampilan Sinyal Analog Sensor KY-037



Tepukan Tangan



Jentikan Jari

# Uji Coba Piezo TZT dengan ESP32

Jarak (cm)	Waktu (us)	Kecepatan (m/s)
20	350	571,43
	331	604,23
	346	578,03
	413	484,26
	392	510,20
50	1105	452,49
	1119	446,83
	1118	447,23
	1162	430,29
	1249	400,32

# ESP32

Pengukuran awalnya dilakukan dengan menggunakan ESP32, dengan timer ber-interval 4 mikrosekon.

Pengujian dengan timer ber-interval 1 mikrosekon tidak bisa berjalan karena keterbatasan clock dari ESP32.

**240 MHz**

Frequency Clock

**2,8-3,6 V**

Operating Voltage

**38 pin**

GPIO Pin

**448 KB ROM**

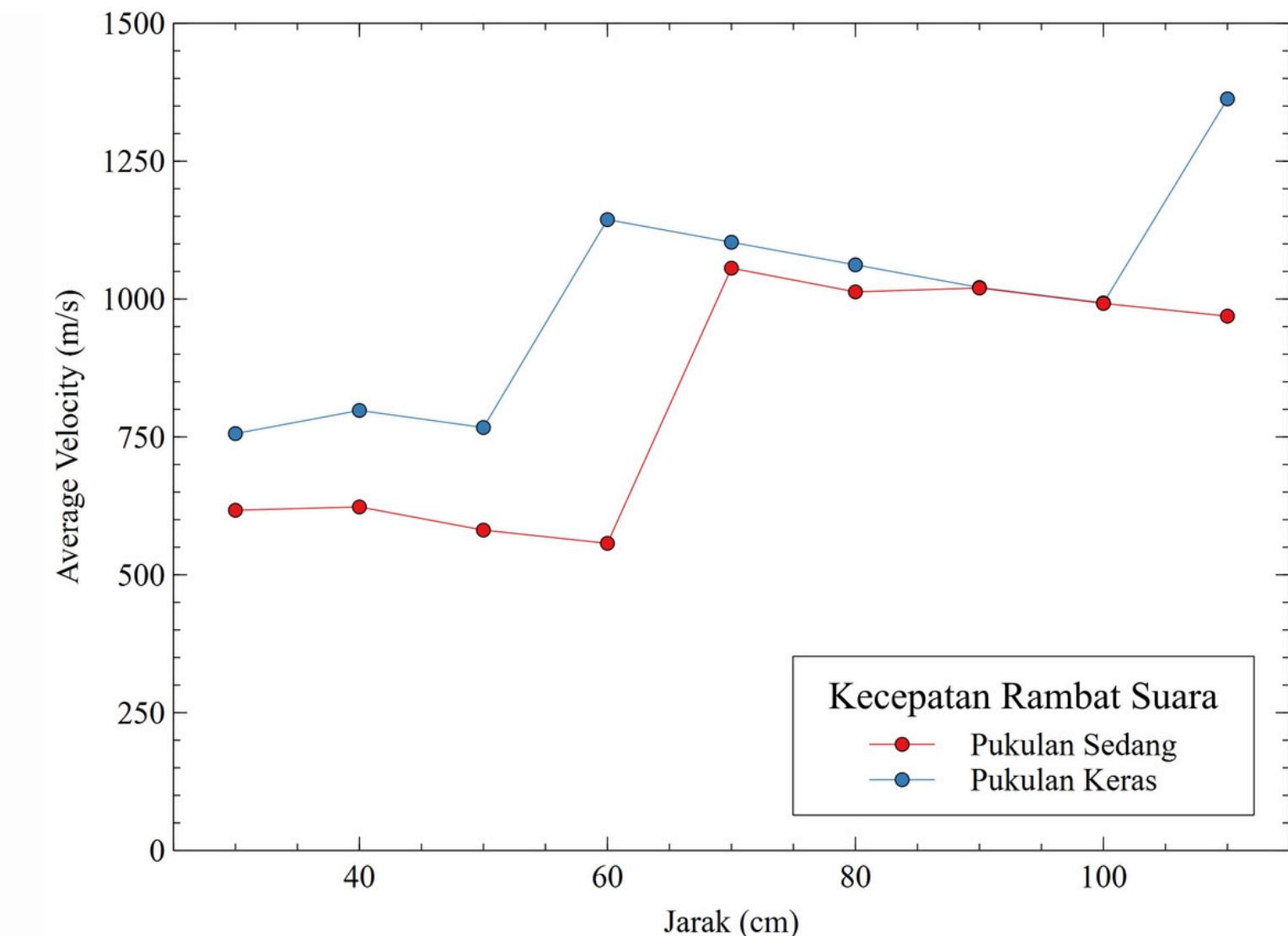
**520 KB SRAM**

**16 KB SRAM RTC**

Storage

```
void IRAM_ATTR onTimer() {
    // Increment the counter every time the timer interrupt occurs
    //microsecondsCounter++;
    microsecondsCounter=microsecondsCounter+4;
}

// Setup hardware timer
timer = timerBegin(0, 80, true); // Timer 0, prescaler 80, count up
timerAttachInterrupt(timer, &onTimer, true); // Attach onTimer function to timer
timerAlarmWrite(timer, 4, true); // Set alarm to trigger every 1 microsecond
timerAlarmEnable(timer); // Enable the timer alarm
```



# Data ESP32 (interval timer 4us)

JARAK (cm)	KEKUATAN KETUKAN				JARAK (cm)	KEKUATAN KETUKAN				JARAK (cm)	KEKUATAN KETUKAN					
	Sedang		Keras			Sedang		Keras			Sedang		Keras			
	t (us)	v (m/s)	t (us)	v (m/s)		t (us)	v (m/s)	t (us)	v (m/s)		t (us)	v (m/s)	t (us)	v (m/s)		
30	496	605	476	630	60	1088	551	524	1145	90	872	1032	880	1023		
	388	773	384	781		1080	556	520	1154		884	1018	876	1027		
	500	600	384	781		1096	547	516	1163		888	1014	872	1032		
	504	595	372	806		1004	598	524	1145		884	1018	872	1032		
	500	600	372	806		1104	543	524	1145		888	1014	880	1023		
	500	600	376	798		1112	540	528	1136		880	1023	884	1018		
	504	595	376	798		1148	523	532	1128		884	1018	884	1018		
	504	595	372	806		1024	586	508	1181		884	1018	888	1014		
	500	600	380	789		1016	591	528	1136		880	1023	884	1018		
	496	605	536	560		1124	534	544	1103		884	1018	892	1009		
Avg	489	617	403	756	Avg	1080	557	525	1144	Avg	883	1020	881	1021		
40	632	633	628	637	70	660	1061	636	1101	100	1004	996	1008	992		
	624	641	488	820		668	1048	632	1108		1004	996	1012	988		
	644	621	480	833		660	1061	640	1094		1012	988	1008	992		
	652	613	488	820		672	1042	632	1108		1008	992	1004	996		
	664	602	516	775		664	1054	632	1108		1008	992	1008	992		
	640	625	492	813		664	1054	636	1101		1004	996	1004	996		
	644	621	480	833		656	1067	640	1094		1008	992	1004	996		
	640	625	488	820		656	1067	636	1101		1012	988	1004	996		
	640	625	488	820		664	1054	632	1108		1008	992	1004	996		
	640	625	492	813		664	1054	632	1108		1008	992	1012	988		
Avg	642	623	504	798	Avg	663	1056	635	1103	Avg	1008	992	1007	993		
50	972	514	988	506	80	780	1026	756	1058	110	1136	968	1104	996		
	856	584	752	665		788	1015	756	1058		1144	962	448	2455		
	860	581	836	598		788	1015	760	1053		1136	968	1116	986		
	752	665	620	806		784	1020	752	1064		1132	972	464	2371		
	864	579	600	833		788	1015	748	1070		1136	968	752	1463		
	880	568	756	661		796	1005	752	1064		1128	975	1120	982		
	864	579	836	598		800	1000	752	1064		1128	975	764	1440		
	860	581	428	1168		796	1005	752	1064		1132	972	1120	982		
	876	571	428	1168		788	1015	752	1064		1132	972	1124	979		
	856	584	756	661		792	1010	756	1058		1144	962	1132	972		
Avg	864	581	700	767	Avg	790	1013	754	1062	Avg	1135	969	914	1363		

# Teensy 4.1

Frequency Clock up to 600 MHz.

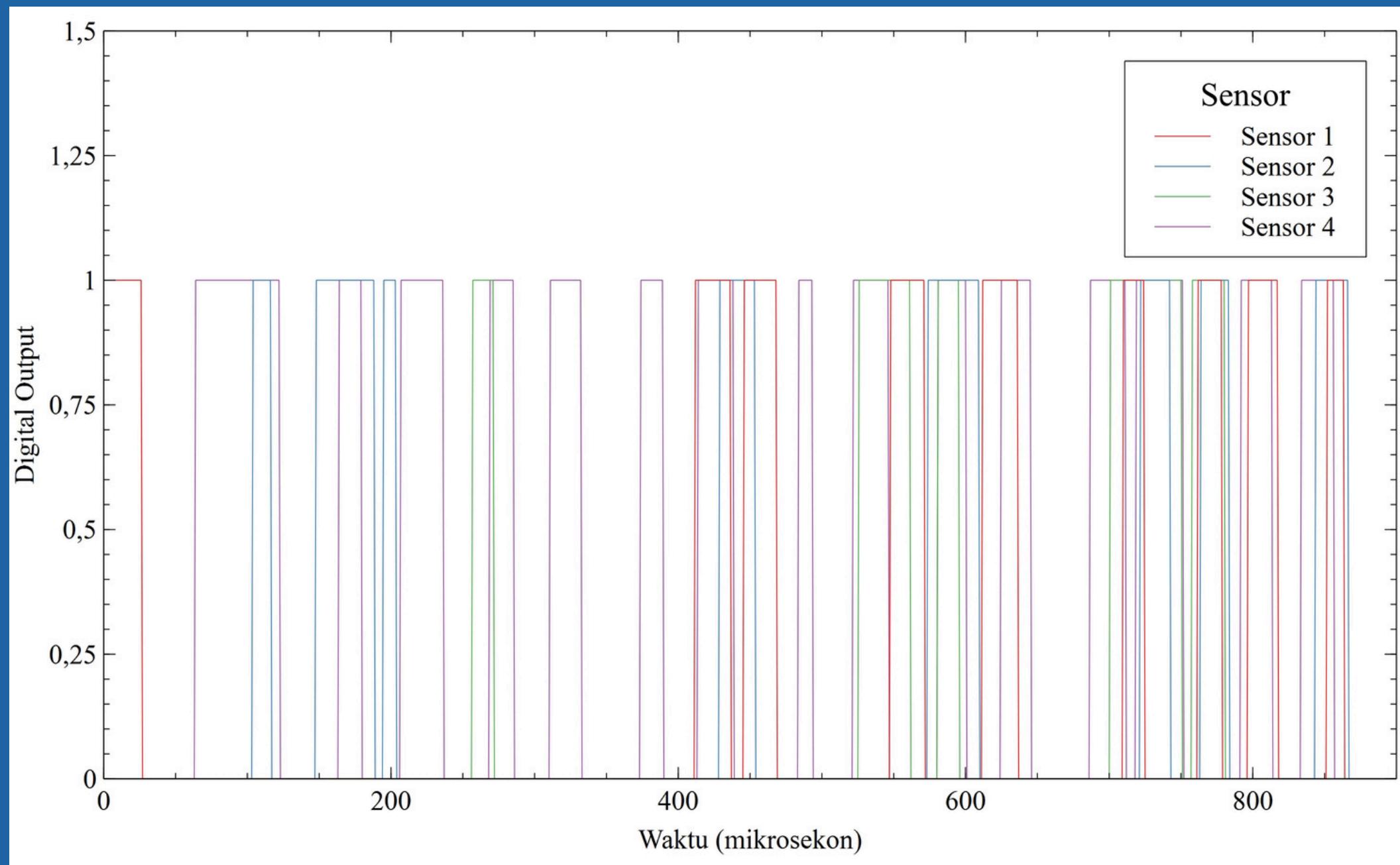
Seperti percobaan sebelumnya, sensor diletakkan di atas kayu. Sumber pukulan diberikan oleh palu besi besar.



Sensor dan Jarak (cm)	Ketukan Sedang					
	waktu tempuh (us)			kecepatan (m/s)		
	t2	t3	t4	v2	v3	v4
S2 = 20, S3 = 50, S4 = 120	194	560	1204	1031	893	997
	174	531	1181	1149	942	1016
	299	653	1300	669	766	923
	269	646	1281	743	774	937
	280	646	1289	714	774	931
	282	648	1294	709	772	927
	284	647	1293	704	773	928
	279	653	1295	717	766	927
	293	647	1298	683	773	924
	285	651	1295	702	768	927
Avg	264	628	1273	782	800	944

	Ketukan Keras					
	waktu tempuh (us)			kecepatan (m/s)		
	t2	t3	t4	v2	v3	v4
	276	647	1288	725	773	932
	278	651	1294	719	768	927
	274	647	1286	730	773	933
	273	644	1285	733	776	934
	279	646	1293	717	774	928
	272	644	1283	735	776	935
	277	641	1288	722	780	932
	270	644	1280	741	776	938
	270	644	1280	741	776	938
	275	641	1285	727	780	934
	274	645	1286	729	775	933

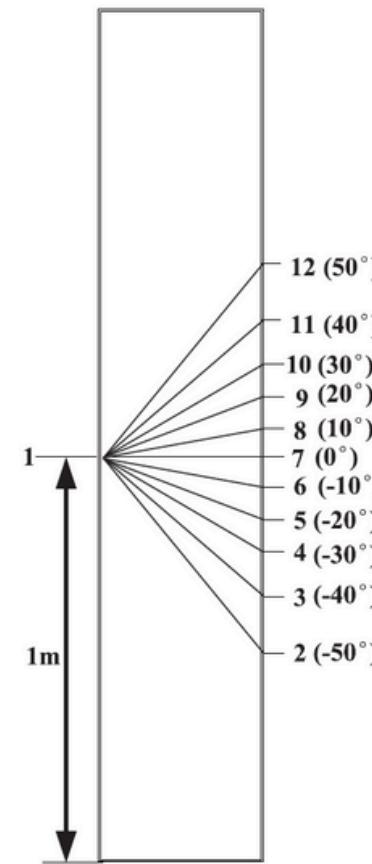
# Time Domain



# Longitudinal-Radial Plane of Trees for Defect Analysis



(a) The setup of field testing

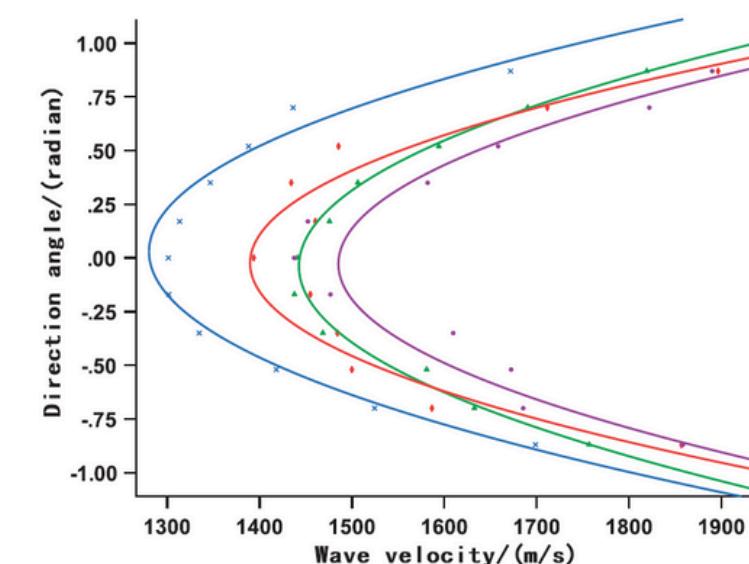


(b) The paths of stress wave measurements

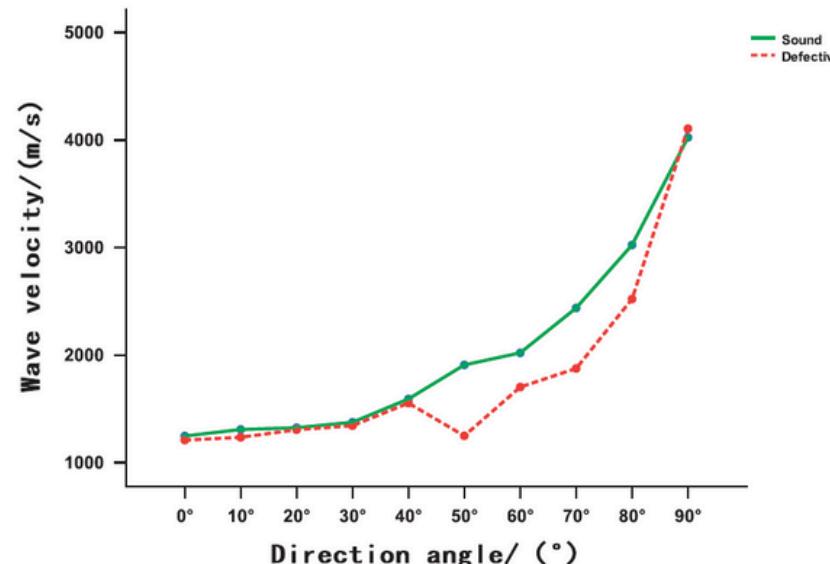
**Fig. 2.** Longitudinal stress wave testing setup of live trees.

**Table 1**  
Stress wave velocities measured in *LR* plane of healthy camphor trees (unit: m/s).

$\theta$	-50°	-40°	-30°	-20°	-10°	0	10°	20°	30°	40°	50°
$V_1(\theta)$	1698.7	1524.6	1418.1	1334.8	1301.8	1301.4	1313.6	1346.7	1388.2	1436.3	1671.2
$V_2(\theta)$	1756.8	1632.6	1580.9	1468.6	1437.8	1441	1475.7	1506.4	1594.1	1690.2	1819.2
$V_3(\theta)$	1856.7	1586.6	1500	1484.3	1455	1328.9	1460.4	1434.3	1485.5	1711.5	1896.3
$V_4(\theta)$	1858.1	1685.4	1672.3	1609.6	1476.8	1437.5	1452.3	1581.9	1658.3	1821.9	1889.9

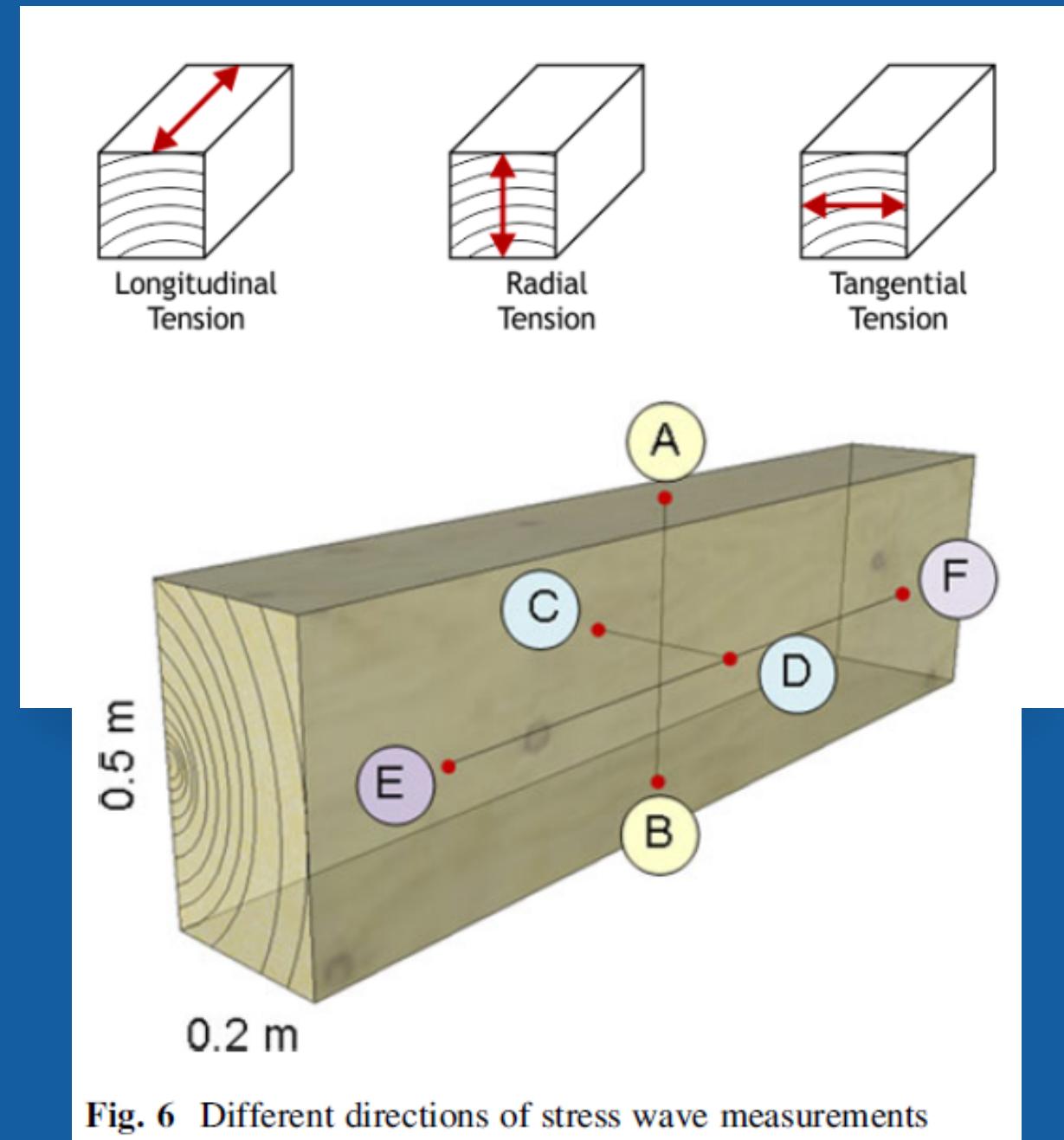


**Fig. 4.** Fitted curves of longitudinal stress wave velocities.



**Fig. 6.** Comparison of stress wave propagation velocities between sound and "defective" log.

# Stress Wave Velocity



Sumber: Li, G., Weng, X., Du, X., Wang, X., & Feng, H. (2016). Stress wave velocity patterns in the longitudinal–radial plane of trees for defect diagnosis. *Computers and Electronics in Agriculture*, 124, 23–28. <https://doi.org/10.1016/j.compag.2016.03.021>

**Table 1** Stress wave velocities of sound wood for different species, from [9, 12, 13]

Species	Stress wave velocity (m/s)	
	Longitudinal	Transverse
White ash	3,968–5,076	
Ash*		1,162–1,379
Beech*		1,670
Red beech*		1,206–1,412
Birch	4,695–5,747	1,140–1,479
Yellow birch	4,348–5,556	
Black cherry	4,831–5,435	1,451–1,613
Horse chestnut*		873–1,557
Sweet chestnut*		1,215–1,375
Fir*		910–1,166
Black fir*		1,480
Douglas-fir*		905–1,675
Japanese fir*		1,450
Silver fir*		1,360
Larch*		1,023–1,490
Lime*		940–1,183
Linden*		1,690
Black locust*		934–1,463
Maple*		1,006–1,690
Sugar maple	3,906–5,155	
Oak*		1,382–1,610
Live oak		627–1,631
White oak		1,258
Red oak	3,311–5,650	1,548–1,751
Pine*		1,066–1,146
Scotch pine*		1,470
Southern pine	5,000–5,882	
Plane*		950–1,033
Black poplar*		869–1,057
Pine poplar*		967–1,144
Silver poplar*		821–1,108
Yellow poplar	5,155–5,747	1,399–1,479
Spruce*		931–1,310
Sitka spruce	5,882	
Willow*		912–1,333

\* Measured on tree

Sumber: Dackermann, U., Crews, K., Kasal, B., Li, J., Riggio, M., Rinn, F., & Tannert, T. (2013). In situ assessment of structural timber using stress-wave measurements. *Materials and Structures*, 47(5), 787–803. <https://doi.org/10.1617/s11527-013-0095-4>

# Effects of Tangential Angles on Stress Waves Propagation Velocities in Log's Cross Section

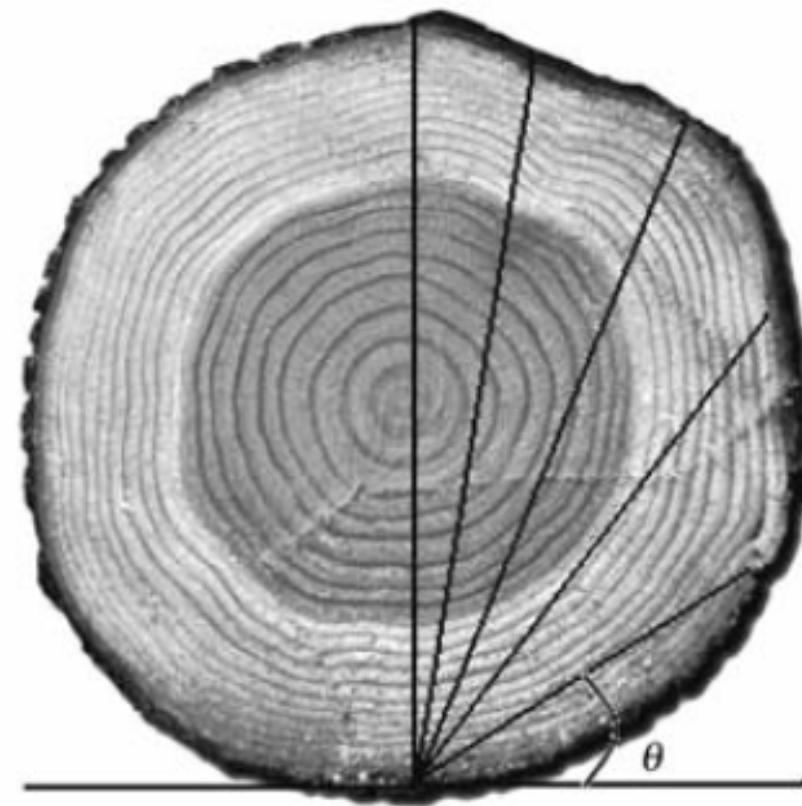
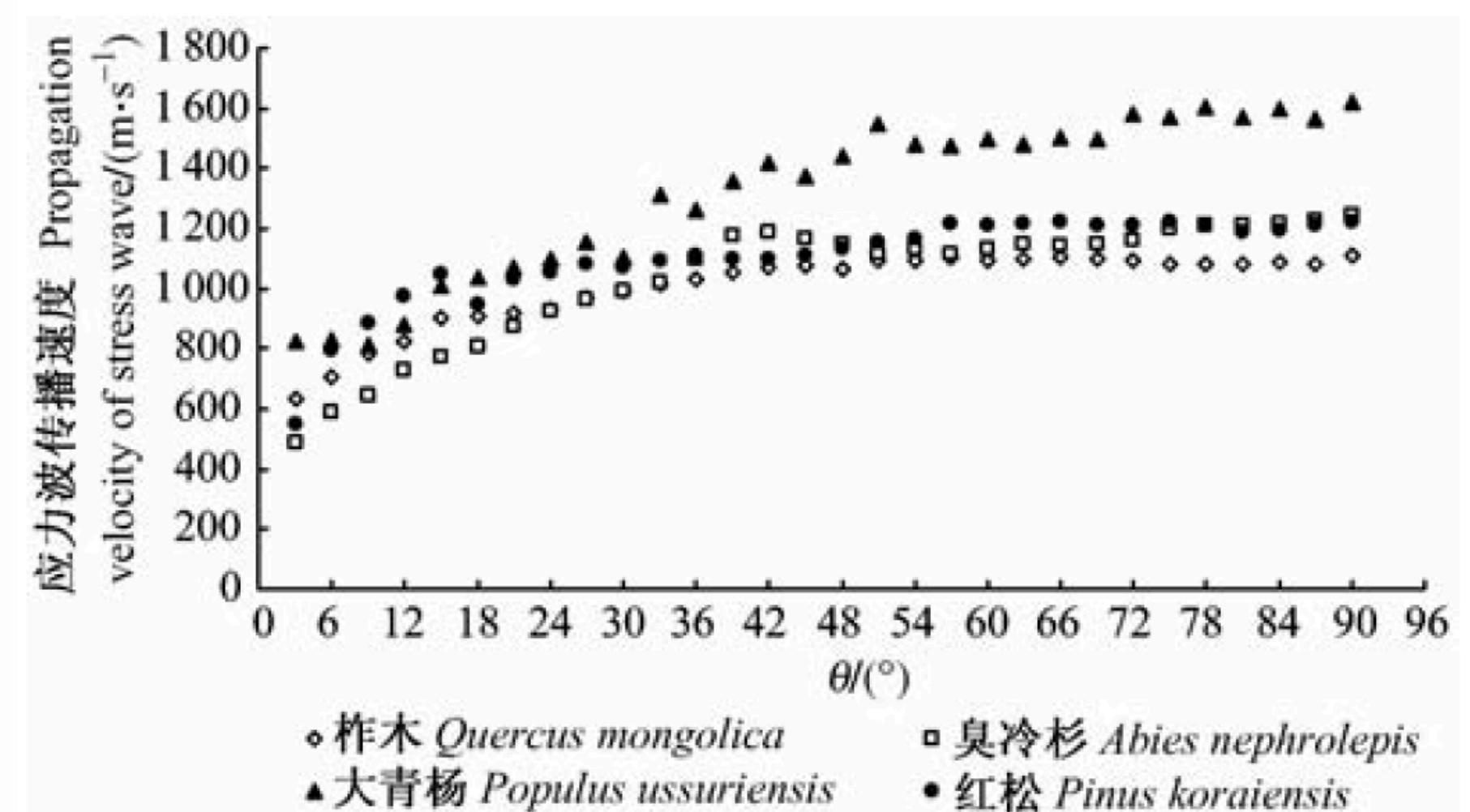


图 1 弦向角  $\theta$  示意

Fig. 1 Illustration diagram of tangential angle  $\theta$



Sumber: Effects of Tangential Angles on Stress Waves Propagation Velocities in Log's Cross Section

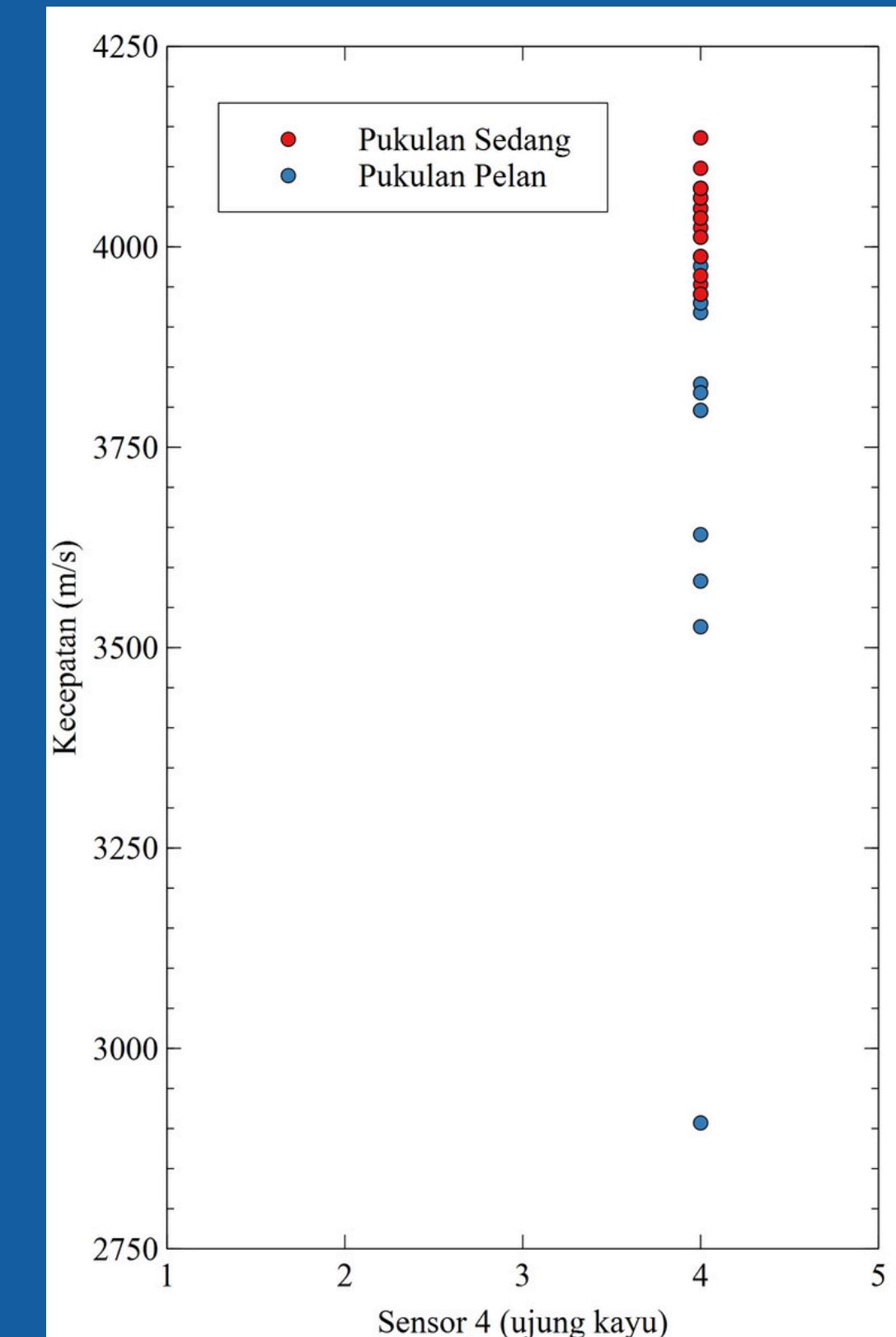
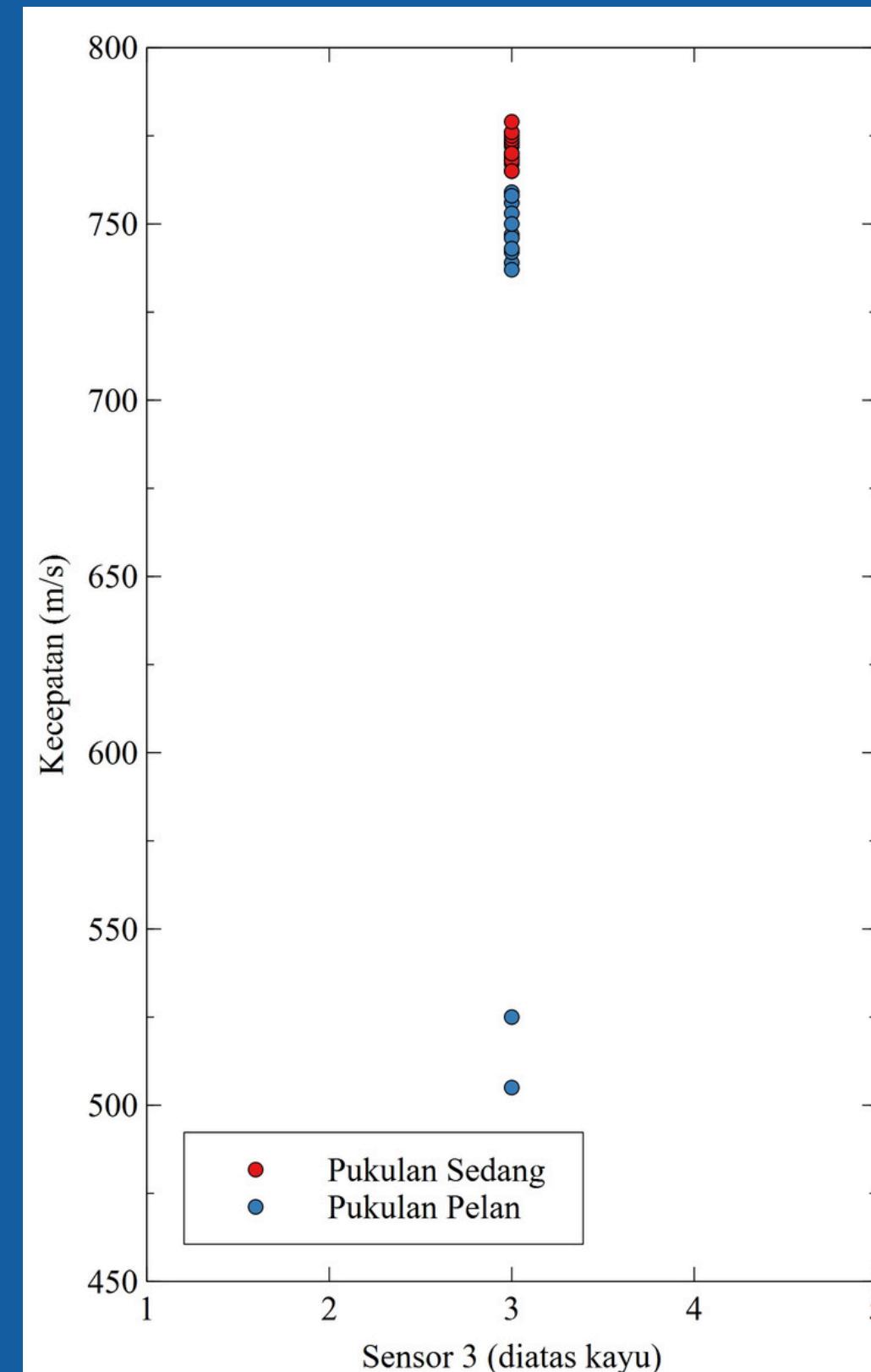
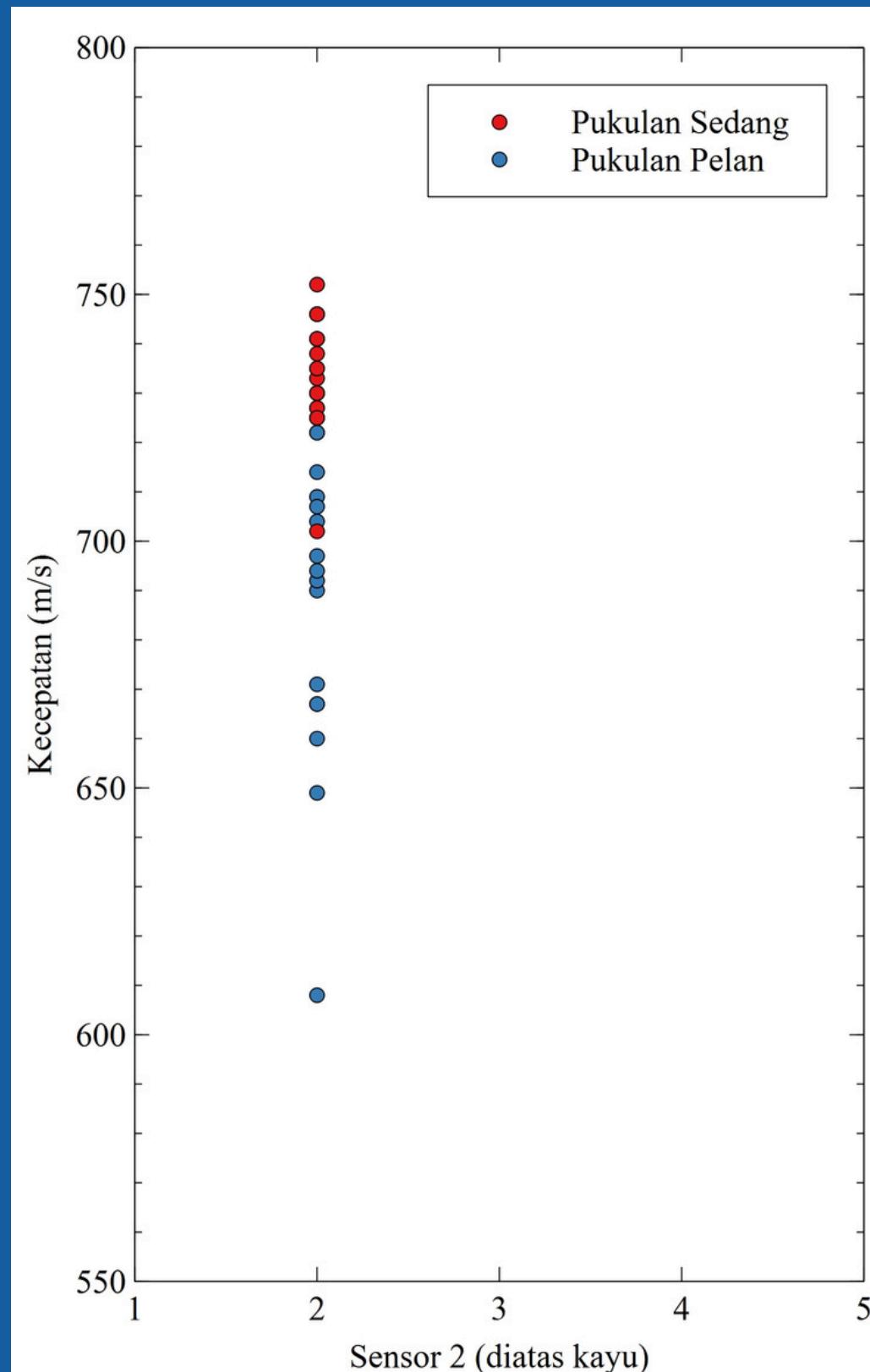
# Data Teensy 4.1

Sensor keempat diletakkan di ujung kayu, tidak diatasnya lagi.



Sensor dan Jarak (cm)	Ketukan Pelan						Ketukan Sedang					
	Waktu Tempuh (us)			Kecepatan (m/s)			Waktu Tempuh (us)			Kecepatan (m/s)		
	t2	t3	t4	v2	v3	v4	t2	t3	t4	v2	v3	v4
S2 = 20, S3 = 50, S4 = 134 (S4 di ujung kayu)	277	669	340	722	747	3941	274	651	336	730	768	3988
	284	654	329	704	765	4073	276	647	329	725	773	4073
	282	649	331	709	770	4048	273	654	336	733	765	3988
	276	649	329	725	770	4073	274	647	329	730	773	4073
	275	651	334	727	768	4012	272	649	332	735	770	4036
	280	652	336	714	767	3988	274	649	332	730	770	4036
	274	648	332	730	772	4036	272	649	333	735	770	4024
	276	650	337	725	769	3976	275	649	331	727	770	4048
	300	661	340	667	756	3941	276	647	329	725	773	4073
	277	659	341	722	759	3930	271	646	332	738	774	4036
	329	660	342	608	758	3918	270	646	330	741	774	4061
	298	677	368	671	739	3641	266	645	324	752	775	4136
	290	674	350	690	742	3829	268	645	327	746	775	4098
	289	670	351	692	746	3818	270	644	330	741	776	4061
	288	952	353	694	525	3796	285	654	329	702	765	4073
	308	664	341	649	753	3930	268	649	339	746	770	3953
	287	673	374	697	743	3583	270	644	334	741	776	4012
	300	678	380	667	737	3526	268	642	336	746	779	3988
	303	991	461	660	505	2907	268	642	338	746	779	3964
	283	667	353	707	750	3796	268	642	340	746	779	3941
Avg	289	692	351	694	732	3838	272	647	332	736	773	4033
Min	274	648	329	608	505	2907	266	642	324	702	765	3941
Max	329	991	461	730	772	4073	285	654	340	752	779	4136
Median	285,5	663	341	701	755	3930	271,5	647	332	737	773	4036
Deviation	13,9985	96,1695	29,6735	31,9215	75,1932	269,75	4,303	3,53144	4,19398	11,4243	4,20934	50,8223

# Sebaran Data Berdasarkan Pukulan



# Data Teensy 4.1

Pengukuran dengan jarak terdekat 10 cm.

Sensor dan Jarak (cm)	Ketukan Sedang					
	waktu tempuh (us)			kecepatan (m/s)		
	t2	t3	t4	v2	v3	v4
$S_2 = 10, S_3 = 70, S_4 = 134$	151	1195	479	662	586	2797
	144	1182	460	694	592	2913
	134	1190	415	746	588	3229
	127	668	370	787	1048	3622
	145	686	377	690	1020	3554
	136	684	382	735	1023	3508
	137	675	373	730	1037	3592
	139	1186	474	719	590	2827
	134	688	387	746	1017	3463
	132	667	367	758	1049	3651
Avg	138	882	408	727	855	3316



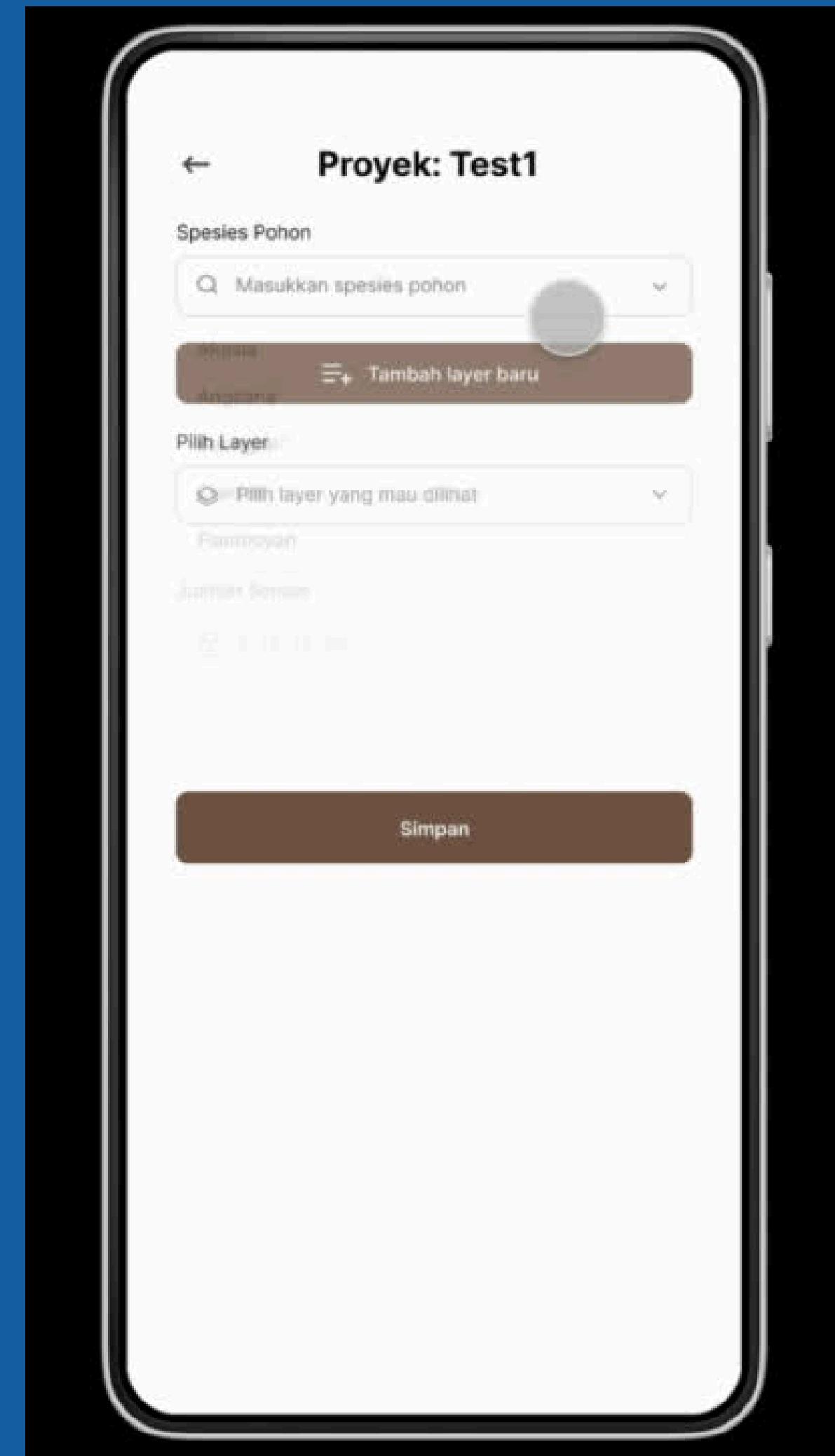
Pengukuran di ujung kayu yang petak.

Sensor dan Jarak (cm)	Ketukan Sedang					
	waktu tempuh (us)			kecepatan (m/s)		
	t2	t3	t4	v2	v3	v4
$S_2 = 30, S_3 = 60, S_4 = 77$	313	451	188	958	1330	4096
	325	456	191	923	1316	4031
	324	458	189	926	1310	4074
	317	451	188	946	1330	4096
	326	462	193	920	1299	3990
	340	871	186	882	689	4140
	319	457	202	940	1313	3812
	324	461	187	926	1302	4118
	339	873	177	885	687	4350
	320	860	189	938	698	4074
Avg	325	580	189	925	1127	4078

# THANK YOU!



# Prototype UI



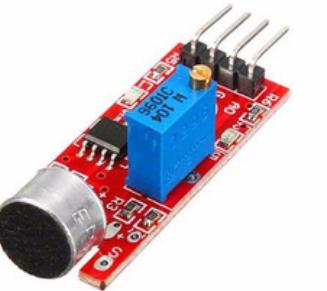
# Perbandingan Sensor

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nullam laoreet risus fringilla, egestas elit a, consequat augue. Phasellus sollicitudin felis mi, quis egestas ex ornare sed.



## Piezoelectric

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nullam laoreet risus fringilla, egestas elit a, consequat augue. Phasellus sollicitudin felis mi, quis egestas ex ornare sed quis adipiscing.



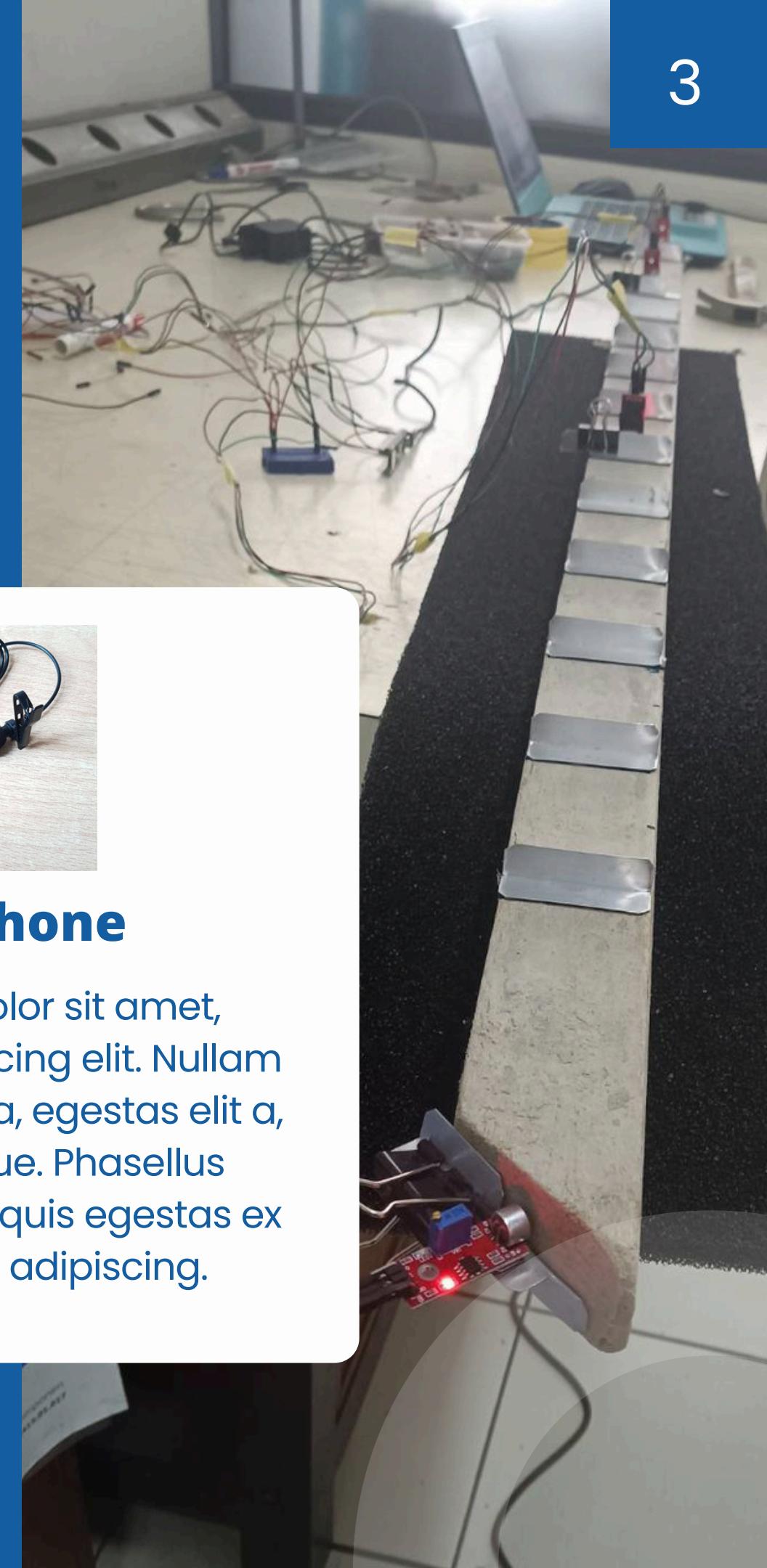
## KY-037

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nullam laoreet risus fringilla, egestas elit a, consequat augue. Phasellus sollicitudin felis mi, quis egestas ex ornare sed quis adipiscing.



## Microphone

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nullam laoreet risus fringilla, egestas elit a, consequat augue. Phasellus sollicitudin felis mi, quis egestas ex ornare sed quis adipiscing.



# Tampilan Sinyal Digital Sensor KY-037 (ketukan palu)

