EXPERIMENTAL INVESTIGATION OF SWITCHING FREQUENCY OF MAGNETIC SESNOR USING STATISTICAL APPROACH

R.Rakesh[1], I.Karthic Subramiyan[2], Dr.R.Arumugam[3] and M.Rajathi[4]

[1]Department of ECE
[2]Department of Aerospace Engineering
[3]Department of Mathematics
[4]Department of Software Engineering
Periyar Maniammai Institute of Scicence and Technology (PMIST),
Thanjavur – 613 403, Tamilnadu, India.
[1]Email: rak2win@gmail.com, [2]Email: karthiksubu85@gmail.com
[3]Email: arumugamr2@gmail.com, [4]Email: sixfaceraji2010@gmail.com

Abstract

World is getting evolved around technology, automation technology is one such technology which moves the world to smarter and comfort zone.Robotics and automation technology find its position in real time application with IoT etc. Industrial sensors further categorized as retro reflective sensor, capacitibve sensor, photoelectric sensor, ultrasonic sensor and magnetic sensor(Proximity sensor). The switching frequency of the sensor is the key factor to determine the performance of the system.In this paper a detailed study on one such key factor named switching frequency is taken for experimental study with magnetic sensors. In this paper, a genuine attempt is made statistically for captureing the switching frequency using PLC based on SPSS tool.

Keywords: Switching frequency, PLC, Proximity e-Sensor

1. Introduction

This proximity sensor is an non contact sensor which emits an electromagnetic field or a beam of electromagnetic radiation and it observes the changes in the field.The target is the object which is been observed by the magnetic sensor.This sensor is highly reliable because of beeing the non contact and one such application of its is used as touch sensor in short range application. In any industry the calucaltion of vibration between the shafts in industrial machinaries can be easily caluculated with such magnetic sensor.It can easily sense the presence of metalic target rather than non metallic target. A Statistical approach on experimental study for determining switching frequency of inductive sensor using PLC discussed by R.Arumugam et. al., (2019) [1]. R.Rakesh, Dr. R.Arumugam and M.Rajathi (2020), focused on A Statistical Study on Segregation and Reuse of Domestic Waste in Apartments at Metro Cities Using Automation Technology (PLC) [2]. A Statistical approach Experimental study for determining switching frequency of retro reflector sensor using PLC based on statistical approach discussed by R.Rakesh, Dr. R.Arumugam, M.Rajathi and U.SaravanaKumar [3]. The direction of rotation of the field can be reversed by interchanging the connection to the supply of any two leads of a three phase induction motor [4]. The circuit consists of an input LC-filter, a bridge rectifier, and only controlled power switch. The switch operates in a soft communication mode and serves as a high frequency generator. Avoltage-fed resonant LCL inverter with phase control was presented in [5]. A statistical study was made for the prediction of Corona Virus COVID-19 in India by Dr. R.Arumugam and M.Rajathi [6]. Also, some applications based on the mobile learning through the statistical approach given byM.Rajathi and R.Arumugam [7]. R.Arumugam et. al., focused on the Impact of Diabetic based on the Statistical Study [8].

Jung, J et. al., presented a control method of reducing the size of the dc-link capacitors of a converter-inverter system [9]. The main idea is to utilize the inverter operation status in the current control of the converter. This control strategy is effective in regulating the dc-voltage level. Even the dc-link capacitor is arbitrarily small and the load varies abruptly. Harus, L.G.et. al., [10], a method was proposed to accurately predict the minimum required temperature recovery, considering repeatability and accuracy of leak detector by investigating the relation between temperature recovery time and applied pressures using PLC system. Since 2013, García I. and Zubia J. et al. from University of the Basque Country had been continuously published the results of optical method application in tip clearance measurement [11–15].

2. Methodology

In this paper an inovative method of capturing this switching frequency of magnetic sensor using PLC at three different levels like low,medium and high.Fianly a comparision is made using ANOVA test and descriptive statics used to measure quality of variation of the particular test.The SPSS is used to check several level statistical data.This test was conducted at Centre for excellence in training and research in Automation Technology of PMIST, deemed to be university in Tamilnadu,India.

2.1 Programmable Logic Controller (PLC)

Control System Engineering has occupied a vital role in automation technology. Gone are the days were manual control method was used .The technology has evolved so much by the intervention of electrical controls like relay switch and further so on with electronic control systems like PLC (Programmable Logic controllers).The relays controls with logic operations on and off mode .The invention of low cost computer known as PLC has a great advantage over the relay logics. Hence it was used for its cost effectiveness. The debugging aid makes programming easier and reduce downtime reliable components reduce the MTBF.

2.2 Working prinicple:

The active elecment of the proximity sensor (magnetic sensor) would be the coil which generates the electromagnetic field as the current pases through the coil. Any ferrite core produces magnetic field while alternating current passes through it.When the metallic object approaches near the sensor ,this magnetic field gets disturbed and hence the sensor sense the object and the reverse happens when an non metallic object approaches the target. The change in the magnetic field due to the steel plate also produce a change in the coil so that impedence change.

Ladder Diagram for Determining The Switching Frequency of Magnetic sensor

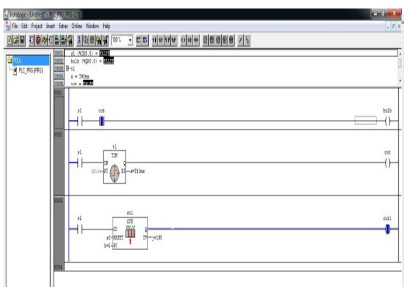

Figure 1 Ladder diagram-level 1

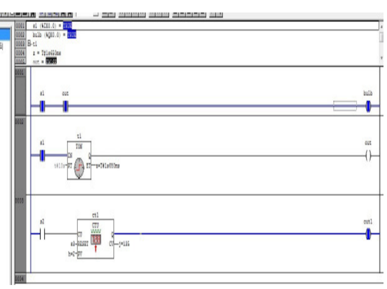

Figure 2 Ladder diagram-level 2

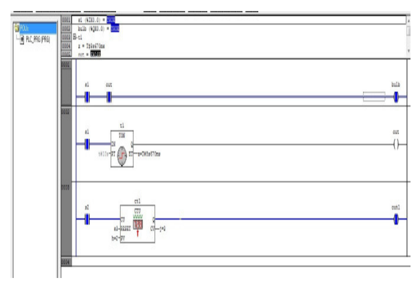

Figure 3 Ladder diagram-level 3

2.2 Target

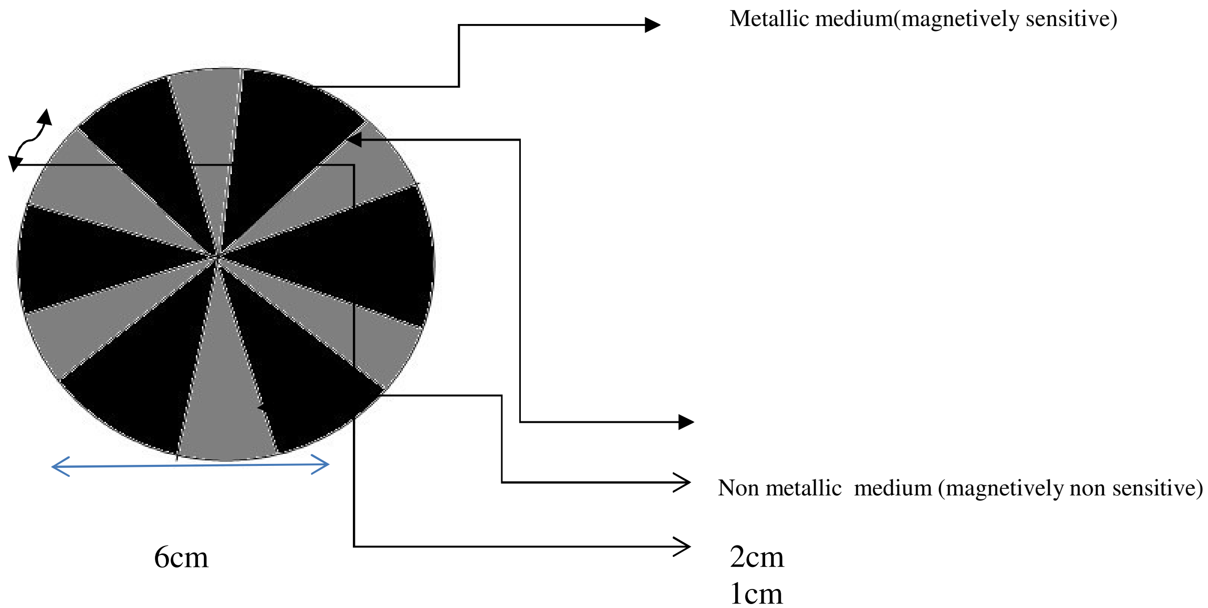

Figure 4 Showing the Target arrangement (metal and non metal slots arranged cascade manner on circle)

Distance between disc and sensor; - 1mm

Disc diameter; - 6cm

Number of metal pcs in disc; - 6pcs

Figure 5: Indra logic kit foor PLC

Figure 6: measure the speed of the motor in RPM

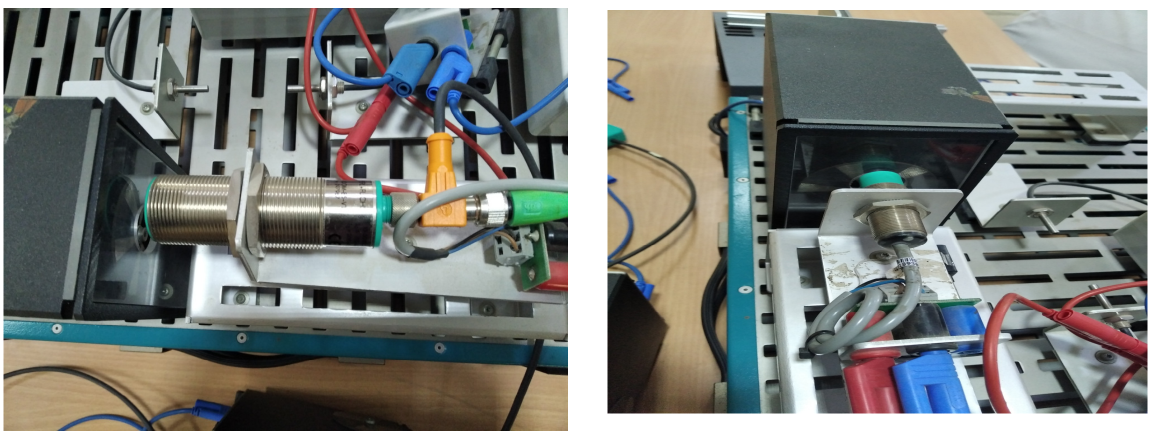

Figure 7: Magnetic sensor (Proximity sensor) aligned in front of the rotary target coupled with motor.

3. Analysis

Table -1 Reading of Switching Frequency Overall (1 to 5 Trials)

S.No	Trial	Set	Rpm	Switch Frequency Trial1	Trail 2	Trial 3	Trial 4	Trial 5
1	Low	1	3100	220	235	310	180	210
		2	3200	240	220	218	175	190
		3	3400	250	215	185	182	202
		4	3500	224	225	185	172	206
		5	3700	230	215	190	182	211
2	Medium	1	19,100	270	280	260	263	256

		2	19,200	233	270	282	267	254
		3	15,300	240	271	260	250	255
		4	16,100	242	280	240	265	261
		5	18,700	230	262	246	250	272
3	High	1	40,100	112	90	70	70	53
		2	40,200	102	84	54	56	44
		3	40,300	92	82	53	54	41
		4	40,400	96	81	52	44	58
		5	40,100	90	97	56	45	54

Table -2 One way ANOVA

				Sum of Squares	df
SWITCH FREQUE MCY	Between Groups	(Combined)		66805.600	13
		Linear Term	Weighted	52027.937	52027.937
			Deviation	14777.663	1231.472
	Within Groups			242.000	1
	Total			67047.600	14
SET	Between Groups	(Combined)		22.000	13
		Linear Term	Weighted	.001	1
			Deviation	21.999	12
	Within Groups			8.000	1
	Total			30.000	14
TRAIL	Between Groups	(Combined)		92933.900	13
		Linear Term	Weighted	57367.980	1
			Deviation	35565.920	12
	Within Groups			24.500	1
	Total			92958.400	14
TRIAL	Between Groups	(Combined)		125319.600	13
		Linear Term	Weighted	77986.127	1
			Deviation	47333.473	12
	Within Groups			98.000	1
	Total			125417.600	14
TRIAL4	Between Groups	(Combined)		107338.833	13
		Linear Term	Weighted	51865.330	1
			Deviation	55473.503	12
	Within Groups			312.500	1
	Total			107651.333	14
TRIAL5	Between Groups	(Combined)		118549.233	13
		Linear Term	Weighted	73698.136	1
			Deviation	44851.097	12
	Within Groups			.500	1
	Total			118549.733	14

				Mean Square	F
SWITCH FREQUEMCY	Between Groups	(Combined)		5138.892	21.235
		Linear Term	Weighted	52027.937	214.991
			Deviation	1231.472	5.089
	Within Groups			242.000	
	Total				
SET	Between Groups	(Combined)		1.692	.212
		Linear Term	Weighted	.001	.000
			Deviation	1.833	.229
	Within Groups			8.000	
	Total				
TRAIL	Between Groups	(Combined)		7148.762	291.786
		Linear Term	Weighted	57367.980	2341.550
			Deviation	2963.827	120.973
	Within Groups			24.500	
	Total				
TRIAL	Between Groups	(Combined)		9639.969	98.367
		Linear Term	Weighted	77986.127	795.777
			Deviation	3944.456	40.250
	Within Groups			98.000	
	Total				
TRIAL4	Between Groups	(Combined)		8256.833	26.422
		Linear Term	Weighted	51865.330	165.969
			Deviation	4622.792	14.793
	Within Groups			312.500	
	Total				
TRIAL5	Between Groups	(Combined)		9119.172	18238.344
		Linear Term	Weighted	73698.136	147396.273
			Deviation	3737.591	7475.183
	Within Groups			.500	
	Total				

				Sig.
SWITCH FREQUENCY	Between Groups	(Combined)		.168
		Linear Term	Weighted	.043
			Deviation	.335
	Within Groups			
	Total			
SET	Between Groups	(Combined)		.951
		Linear Term	Weighted	.992
			Deviation	.941
	Within Groups			

	Total			
TRAIL	Between Groups	(Combined)		.046
		Linear Term	Weighted	.013
			Deviation	.071
	Within Groups			
	Total			
TRIAL	Between Groups	(Combined)		.079
		Linear Term	Weighted	.023
			Deviation	.123
	Within Groups			
	Total			
TRIAL4	Between Groups	(Combined)		.151
		Linear Term	Weighted	.049
			Deviation	.201
	Within Groups			
	Total			
TRIAL5	Between Groups	(Combined)		.006
		Linear Term	Weighted	.002
			Deviation	.009
	Within Groups			
	Total			

Table -3 Descriptive statistics

Descriptive Statistics

	Mean	Std. Deviation	N
Rpm	20426.67	15728.430	15
Switch Frequency	191.40	69.203	15
Trial4	163.67	87.689	15
Set	3.00	1.464	15

Table -4 Correlation

Correlations

		RPM	SWITCH FREQUENCY	TRIAL4	SET
Pearson Correlation	RPM	1.000	-.881	-.694	-.007
	SWITCH FREQUENCY	-.881	1.000	.933	-.082
	TRIAL4	-.694	.933	1.000	-.050
	SET	-.007	-.082	-.050	1.000
Sig. (1-tailed)	RPM	.	.000	.002	.490
	SWITCH FREQUENCY	.000	.	.000	.385

	TRIAL4	.002	.000	.	.430
	SET	.490	.385	.430	.
N	RPM	15	15	15	15
	SWITCH FREQUENCY	15	15	15	15
	TRIAL4	15	15	15	15
	SET	15	15	15	15

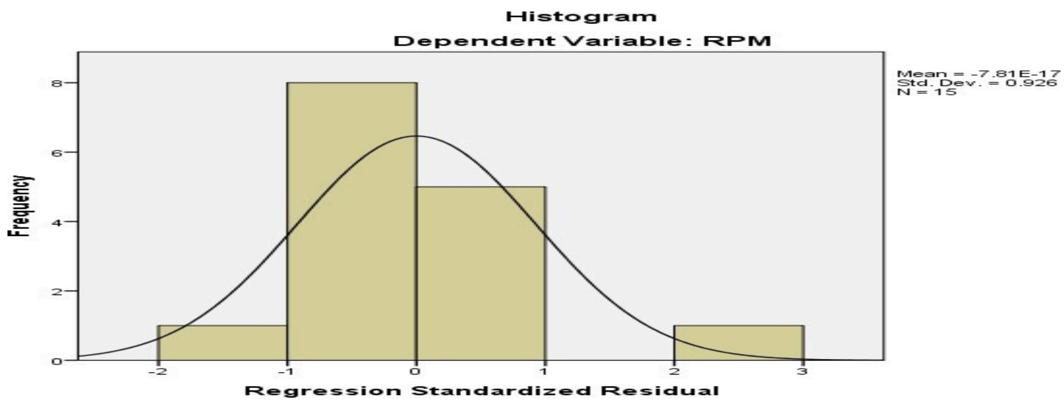

Figure 8: Regression standardized residual

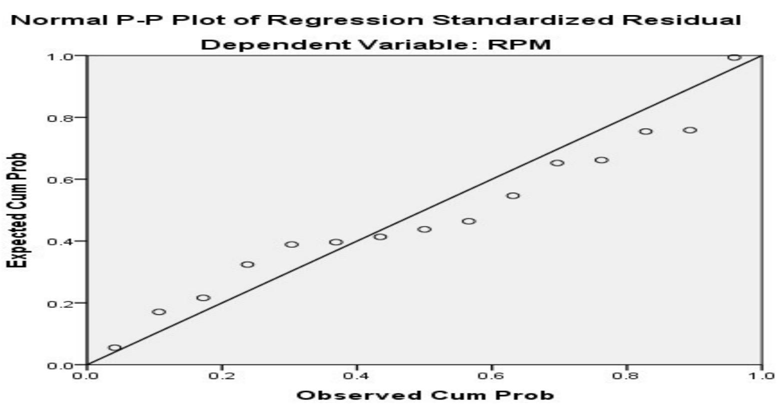

Figure 9: Normal P-P plot of Regression standardized residual

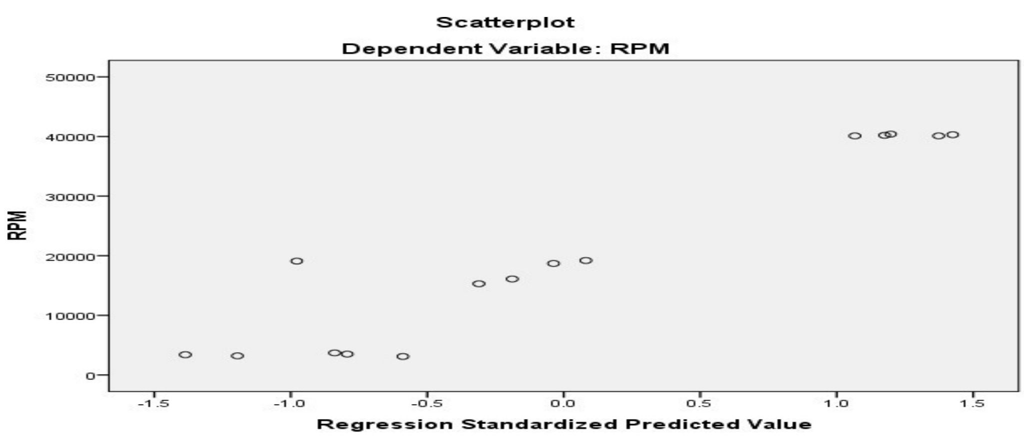

Figure 10: Scatter plot of Regression

Table -5 Chi-square test

			Trail	Trial	Trial4
Chi-Square			1.467[d]	1.467[d]	1.467[d]
df			12	12	12
Asymp. Sig.			1.000	1.000	1.000
Monte Carlo Sig.	Sig.		1.000[b]	1.000[b]	1.000[b]
	99% Confidence Interval	Lower Bound	1.000	1.000	1.000
		Upper Bound	1.000	1.000	1.000

Test Statistics

			TRIAL5
Chi-Square			.000[e]
df			14
Asymp. Sig.			1.000
Monte Carlo Sig.	Sig.		1.000[b]
	99% Confidence Interval	Lower Bound	1.000
		Upper Bound	1.000

4. Discussion of the Study

Table 1 represents the different levels of reading of Switching Frequency and Overall from1 to 5 Trials. Table 2 represents the one way ANOVA table SET, trial 2, trial 3, trail 4 and trial 5. From the ANOVA Table the p value of the SET and Switching Frequencies are significant. The significant trials are respectively, 0.168, 0.043, 0.335, 0.951, and 0.992 and 0.941. Similarly for the trial 2, trial 3, trial 4 and trial 5 between and within groups are statistically significant at 5% level at different degrees of freedom. Third table represents the descriptive statistics like mean and standard deviations of all trials with N = 15 and table four shows that the Pearson’s correlation among all the trials, the results are positive as well as negative. Figure 8, 9 and 10 illustrates that the regression standardized residual, Normal P-P plot of Regression standardized residual and scatter plot of regression. Finally the last table is also representing for all the trials are getting significant at 5% level with same lower and upper bound.

5. Summary and Conclusion

In this paper a genuine attend is made to calibrate the switching frequency of Magnetic sensor (proximity sensor) using a motor driven by PLC. In this paper, the switching frequency at the various levels viz., low, medium and high using PLC and using descriptive statistics and chi-square test we focus that the output reading calibrated are significant.. The proposed mathematical model of the system successfully represents the real behavior of **SWICHING FREQUENCY OF MAGNETIC SENSOR using PLC** system and frequency control based on the SPSS.

References

[1] Dr.R.Arumugam, R.Rakesh, M.Rajathi, A Statistical approach on experimental study for determining switching frequency of inductive sensor using PLC, International Journal of Research and Analytical Reviews (IJRAR), Vol.6, Issue 2, June 2019, 469-473.

[2] R.Rakesh, Dr. R.Arumugam and M.Rajathi, "A Statistical Study on Segregation and Reuse of Domestic Waste in Apartments at Metro Cities Using Automation Technology (PLC)", AEGAEUM JOURNAL, ISSN 0776-3808 / Impact Factor 6.1, Vol.8, Issue 4, April 2020, Page No 1214-1221.

[3] R.Rakesh, Dr. R.Arumugam, M.Rajathi and U.SaravanaKumar **"**A Statistical approach On experimental study for determining switching frequency of retro reflector sensor Using PLC**",** International Journal of Advance Research, Ideas and Innovations in Technology, ISSN 2454-132X / Impact Factor 6.078, Vol.6, Issue 3, May-June 2020, Page No 640-647.

[4] S.R.Venupriya, K.P.Thanusre, P.Saranya, "A Novel Method Of Induction Motor Speed Control Using PLC", International Journal for Research in Applied Science & Engineering Technology (IJRASET) , 3(2), 2015.

[5] Shenkman A. "Axelrod B. Berkovich Y. Improved modification of the single-switch AC-AC converter for induction heating applications". IEE, Proc-Electr Power Appl 2004, 151(1), 1-4.

[6] Dr. R.Arumugam, and M.Rajathi, " A Markov Model for Prediction of Corona Virus COVID-19 in India- A Statistical Study", Journal of Xidian University, ISSN 1001-2400/ Impact Factor 5.4, Vol.14, Issue 4, April 2020, Page No 1422-1426.

[7] M.Rajathi and R.Arumugam, "Applications of Mobile Learning In The Higher Educational Institutions Through Statistical Approach" International Journal of Recent

Technology and Engineering, Paper Id: A3296058119, ISSN 2277-3878(online) / Impact Factor 5.11, Vo.8, Issue 1, May 2019, Page No 1431-1439

[8] Dr. R.Arumugam, V.Nandhini, M.Rajathi, "The Impact of Diabetic based on BMI, BP and Sugar –A Statistical Study", Compliance Engineering Journal, ISSN 0898-3577 / Impact Factor 6.2, Vol.12, Issue 1, Jan 2021, Page No 207-221

[9] Jung, J., Lim, S., Nam, K. "A feedback linearizing control scheme for a PWM converter-inverter having a very small DC-Link capacitor". IEEE, Trans and Applications 1999, 35 (5).

[10] Harus, L.G., Cai, M., Kawahima, K., Kagawa, T. "Determination of temperature recovery time in differential-pressure-based air leak detector ", Measurement Science and Technology 17(2006) 411-418.

[11] García, I.; Beloki, J.; Zubia, J. An Optical Fiber Bundle Sensor for Tip Clearance and Tip Timing Measurements in a Turbine Rig. Sensors 2013, 13, 7385–7398. [CrossRef] [PubMed]

[12] García, I.; Zubia, J.; Berganza, J. Different Configurations of a Reflective Intensity-Modulated Optical Sensor to Avoid Modal Noise in Tip-Clearance Measurements. J. Lightw. Tech. 2015, 12, 2663–2669. [CrossRef]

[13] García, I.; Przysowa, R.; Amorebieta, J.; Joseba, Z. Tip-Clearance Measurement in the First Stage of the Compressor of an Aircraft Engine. Sensors 2016, 16, 1897. [CrossRef] [PubMed]

[14] Gil-García, J.M.; Solís, A.; Aranguren, G. An Architecture for On-Line Measurement of the Tip Clearance and Time of Arrival of a Bladed Disk of an Aircraft Engine. Sensors 2017, 17, 2162. [CrossRef] [PubMed]

[15] Durana, G.; Amorebieta, J.; Fernandez, R. Design, Fabrication and Testing of a High-Sensitive Fibre Sensor for Tip Clearance Measurements. Sensors 2018, 18, 2610. [CrossRef] [PubMed]