



Automatic calibration and testing for industrial analog modules

Nilesh D. Bhandare¹ (Student), Dr. Shiajirao M. Sangale² (Guide)

^{1,2} Electronics Engineering Department,
K.B.P. College of Engineering,
Satara, Maharashtra, INDIA.

Abstract: Automation is the basic requirement of industrial development. Programmable Logic Controller plays major role in the development of industrial process in automation. It can be abbreviated as PLC. A PLC has many I/O pins that can be used for controlling applications. There are expansion modules of PLC for controlling processes. To develop a test jig for analog as expansion of PLC is the main objective of the paper is the series of PLC and its analog can be developed. The input signals to analog module are thermocouple and RTD as per industrial standard. The modbus serial communication protocol is used for the communication between PLC, test jig, analog expansion module. Test jig is controlled from PC with software utility via serial communication port. This test jig can be used for calibrating input and output pins of modules. The advanced technique, for the development of test jig will make the testing procedure easier, which will enhance performance.

Keywords: Automation, Expansion module, PLC, Test jig.

I. Introduction

In the recent years, industry has grown exponentially and growth in industrialization has increased the production. The increase in production requires calibration and testing of equipment to enhance accuracy and production rate. The human interaction in the process of testing manufactured component or device results the errors in the testing and calibration process. The automatic testing is the thrust for industry for accurate testing and calibration. The modular tests are generally preferred these days due to its capital investment and system size without sacrificing the performance. But it doesn't serve the purpose. Therefore it is required to designed develop automatic testing system which enhances the efficiency, accuracy and the product quality to meet the customer requirements. The Automatic Test Equipment (ATE) may remove the human intervention up to maximum extent and provides The test efficient as well as fast testing equipment. Most of the test equipments are under the control of computers because computers run at very high speed, which each programs taking typical less than two microseconds. Even though it may take many of these steps to control conversion of operations can often be completed in few milliseconds.

II. Related work

As industry needs to offer the efficient and exact devices get manufactured. The testing and calibration are efficient to avoid malfunctions of the components. The recent trend is to make the calibration and testing of devices automatically by self test or calibrate it by less human intervention. Evaluation of test results in manual systems, which compares the the results to reestablished limits or uses his judgment control of the test sequence is also done by the operator usually following a written test and sequence. The switching of connections the test equipment and the unit under Test (UUT) by a manually operated pre-wired switch box. Present, most of the testing of electronic components, sub-assemblies, modules and systems are still done manually. Switching, control, evaluation and recording are usually done by operator [1].

As the complexity among the testing increases due to atomization and the manual methods of testing tended to time consummating when the quantities of devices or the number of tests performed made it difficult to made schedules [1]. Manual system which consists of analog module, PLC, calibrator of YOKOGAWA. PC with test utility which provides calibration and testing modes.

Hambali, Nasal, S.; Hazmi, M et al proposed the automatic detection of temperature calibration for uncertainty calculation and confidence limit determination system. The test was conducted using RTD sensor and repeated three times. The data acquisition (DAQ) card is used to interface the temperature instrument and the computer. In order to determine the uncertainty and confidence limits of the temperature measurement, graphical user interface (GUI) system has been developed in Visual Basic (VB) programming language. The developed measurement

system shows that the uncertainty of RTD can be calculated by interfacing the instrument to the computer through DAQ card [2].

Dai Wen; Lin Qing; Lu Qiang, et al proposed the “Calibration System for Thermocouple Application Based on Technology of Virtual Instrument and Neural Network” In automatic calibration system for thermocouple, means to realize transfer between thermocouple and temperature are methods of tables and establish mathematical model of thermocouple character Est. and gradient descent algorithm with momentum factor is used to adjust the parameters of RBF neural network [3]

Carlob Muscas et al proposed “An automatic Test Equipment for the Calibration of Voltage Transducers” They proposed the operation and the design of automatic test equipment (ATE) for calibration of voltage transducers in wide range of frequency [4].

DMM-32X-AT includes Diamond Systems' patented auto-auto calibration technology. This automatic calibration system which provides the changes in temperature without requiring any involvement by user or application program. An on-board microcontroller monitors the board's temperature and uses on board calibration circuitry to calibrate board automatically [5].

III. Manual system

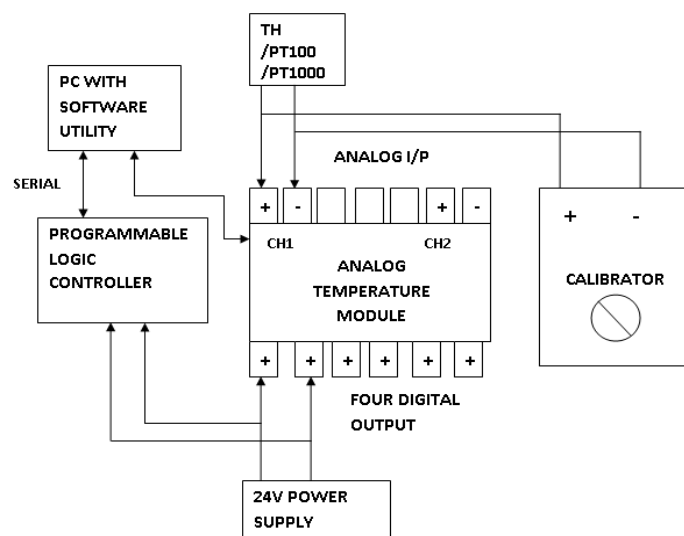


Figure 1. Manual calibration system.

In this manual system there are total four blocks

- Programmable Logic Controller(PLC)
 - Analog Temperature Module
 - Calibrator
 - PC with software Utility.
- 1) First Block is PLC in which application gets downloaded. In this system we are going to use temperature module supported PLC. PLC which has certain application which will be helpful for temperature module.
 - 2) Second block which is consisting of temperature modules which are connected to the PLC. Temperature module has two analog inputs and four digital outputs.
 - 3) In this system we are using manual calibrator. This calibrator is directly connected to the input of the temperature module for Calibration. In calibrator there is Source mode is selected for calibration of Input of Temperature module.
 - 4) PC with software utility in this system which consist of Graphical User Interface (GUI) which is based on the Vb, .net.
- In this system using manual calibrator. This calibrator is directly connected to the input of the temperature module for Calibration. In calibrator there is Source mode is selected for calibration of Input of Temperature module. The calibrator has following Specifications:-
- 1) Source and measure operations can be performed at the same time (Select from the following source signal and measurement signal options: voltage, current, resistance, thermocouple (TC), resistance temperature detector (RTD), Frequency, pulse).

- AC voltages, including supply voltage, can be measured.
- Includes a wide array of additional functions.
- Easy operation.
- Compact size and Lightweight
- Values set in steps of 4-20 mA
- 24V DC Power Supply to Transmitter
- Divided output (n/m) function
- Output settings are divided, eliminating the need for bothersome Calculations for percentage output.
- Memory function

IV. Proposed work

Implement Arm micro-controller based system for automatic calibration and testing of industrial analog modules to increase quality and performance of the device manufacturing which meets the following objectives:-

- 1) To increase quality in analog device manufacturing, analog module contains inputs such as RTD, Thermocouple, Voltage, Current etc
- 2) The development and implementation of calibration and testing system for increasing the performance and Throughput.
- 3) To study how to sourcing different types of analog signals by using RS232 based calibrator.
- 4) To develop and implement hardware and firmware required using ARM micro-controller based system
- 5) Implementation of Software utility for easy operator interface.
- 6) Generation of testing and calibration report.

A. Block diagramme of proposed work:

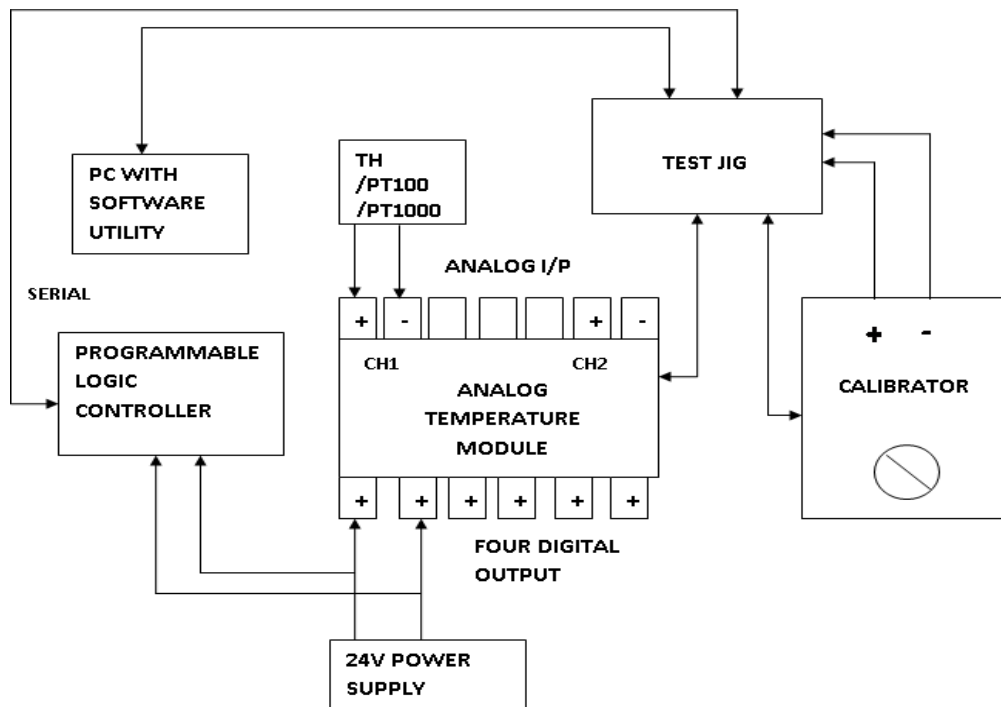


Figure 2. Automatic calibration System

- 1) Fig.2 shows connection setup for TEST JIG which requires 24V supply PLC, Analog temperature module. The main purpose of ARM micro-controller based system is auto calibration and auto testing of 2 channels of 2 different types of inputs RTD and Thermocouple and 4 Digital output.
- 2) TEST JIG communicates with calibrator, temperature module, PLC on serial port. It also communicates with PC through serial port.
- 3) In Calibration mode, TEST JIG communicates with software utility, temperature module and calibrator using different serial ports. In testing mode, TEST JIG communicates with software utility, calibrator and PLC using different serial ports.
- 4) Software utility sends a command to TEST JIG to calibrate input then ARM micro-controller based system sends a command to calibrator, calibrator set its output as per command after getting inputs from calibrator, TEST JIG sends command to Temperature Expansion module to calibrate input.

- 5) In testing mode, software utility sends command to TEST JIG to test inputs and outputs of temperature module.
- 6) In this system TEST JIG is ARM micro-controller Board which consist of relays for controlling auto calibration and which consists of four serial ports for communication of PLC, Calibrator, PC, Temperature module.

V. Results and Discussion

Manual System Results

Microsoft Excel - nlCIO2AI2AO_AnaIO_COUNT

File Edit View Insert Format Tools Data Window Help																		
Arial 10 B I U																		
B C D E F G H I J K L M N O																		
Serial No : 1																		
Date :																		
ANALOG INPUT ERROR COUNT=																		
ANALOG OUTPUT CURRENT COUNT= 0.045																		
ANALOG OUTPUT VOLTAGE COUNT= 0.06																		
Input Range		Expected Count	Measured Count							Acceptable Error		Result						
			CH1				CH2											
A			Input	Count	Diff	Output	V/I	Input	Count	Diff	Output	V/I	Input	Count	Diff	Output	Volt / Current	
						V/mA	Diff				t	Diff						
0 to 20mA		0	0	0	0	0	0	0	0	0	0	0	±8	±0.045	PASS			
		5	1024	1024	5	1024	5	1024	5	1024	5	1024	±8	±0.045	FAIL			
		10	2048	2048	10	2048	10	2048	10	2048	10	2048	±8	±0.045	FAIL			
		15	3072	3072	15	3072	15	3072	15	3072	15	3072	±8	±0.045	FAIL			
		20	4095	4095	20	4095	20	4095	20	4095	20	4095	±8	±0.045	FAIL			
4 to 20mA		4	0	0	4	0	0	4	0	0	4	0	±8	±0.045	FAIL			
		8	1024	1024	8	1024	8	1024	8	1024	8	1024	±8	±0.045	FAIL			
		12	2048	2048	12	2048	12	2048	12	2048	12	2048	±8	±0.045	FAIL			
		16	3072	3072	16	3072	16	3072	16	3072	16	3072	±8	±0.045	FAIL			
		20	4095	4095	20	4095	20	4095	20	4095	20	4095	±8	±0.045	FAIL			
0V to 10V		0	0	0	0	0	0	0	0	0	0	0	±8	±0.060	PASS			
		2.5	1024	1024	2.5	1024	2.5	1024	2.5	1024	2.5	1024	±8	±0.060	FAIL			
		5	2048	2048	5	2048	5	2048	5	2048	5	2048	±8	±0.060	FAIL			
		7.5	3072	3072	7.5	3072	7.5	3072	7.5	3072	7.5	3072	±8	±0.060	FAIL			
		10	4095	4095	10	4095	10	4095	10	4095	10	4095	±8	±0.060	FAIL			
-10V to +10V		-10	0	0	0	0	0	0	0	0	0	0	±10		PASS			
		-5	1024	1024	5	1024	5	1024	5	1024	5	1024	±8		FAIL			
		0	2048	2048	0	2048	0	2048	0	2048	0	2048	±8		FAIL			
		5	3072	3072	5	3072	5	3072	5	3072	5	3072	±8		FAIL			
		10	4095	4095	10	4095	10	4095	10	4095	10	4095	±8		FAIL			

Sheet1/

1) In this manual calibration system we enter calibration count manually then it shows pass/fail if it is within the range. If calibration is done properly the count sheet displays green mark and if calibration is not done properly then red mark is displayed in count sheet.

But in manual system has certain disadvantages:-

- This method is very much time consuming
- Operator skills must be required
- In this method there are various human errors.
- Due to human errors decrease in quality

VI. Conclusion

Automatic detection procedure for temperature measurement calibration for RTD by using manual as well as automatic system has been presented in this paper. Test jig is useful for auto calibration and testing. The PC-based adaptive software improves the calibration accuracy and provides user friendliness. This automation will improve quality and efficiency. Test jig is controlled from PC with software utility via serial communication port. This test jig can be used for calibrating input and output pins of modules. Further the implementation of automatic calibration system using Test Jig and arm micro-controller is the future scope of study. The implementation work will be performed at 'Renu electronics Pvt Ltd.' Pune. The advanced technique, for the development of test jig will make the testing procedure easier, which will enhance performance.

VII. References

- [1] Robert A Grim "Automated Testing", HEWLETT-PACKARD JOURNAL, Vol.20, No.12, August 1969.
- [2] Hambali, N.; Saat, S.; Ramli, M.S.; Hazmi, M., "Automatic detection computer-based (ADCob) system for temperature measurement calibration of RTD," Electrical, Control and Computer Engineering (INECCE), 2011 International Conference on, vol., no., pp.166, 171, 21-22 June 2011.
- [3] Dai Wen; Lin Qing; Lu Qiang, "Calibration System for Thermocouple Application Based on Technology of Virtual Instrument and Neural Network," Electronic Measurement and Instruments, 2007. ICEMI '07. 8th International Conference on, vol., no., pp.1-268,1-273, Aug. 16 2007-July 18 2007
- [4] Carlo Muscas, Member, IEEE, Lorenzo Peretto, Member, IEEE, Renato Sasdelli, Member, IEEE, and Andrea Briani" An Automatic Test Equipment for the Calibration of Voltage Transducers"IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, VOL. 50, NO. 6, DECEMBER 2001
- [5] Diamond System corporation,"Diamond-MM-32X-AT Analog I/O module", [Online] Available: <http://www.diamondsystems.com/products/dmm32x>[Accessed:12 August, 2013].
- [6] RAE Systems, Inc,"Automatic test and Calibration", [Online] Available: <http://www.raesystems.com/products/autorae2>[Accessed:12 August, 2013].
- [7] Thales group, "Test and calibration services"[Online]

- Available:http://www.thalesgroup.com/Contries/Australlia/Documents/Calibration_Test_Services_Brouchure_doc/[Accessed:12 August,2013].
- [8] Honeywell International Ltd,"BW Technologies Micro Dock II Test/Calibration Docking System", [Online] Available:<http://www.instrumart.comproducts/28637/bw-technologies-microdock-ii-testcalibration-docking-system>[Accessed:12 August, 2013].

VIII. Acknowledgments

The authors are thankful to the Department of Electronics, Shivaji University, KBP College of Engineering, Satara India for providing research facilities and their faculty for being the constant source of inspiration. The authors would like to thank Dr. Sangle & Prof. Aldar of Institute of KBP Satara, for their valuable support during the preparation of this paper. And the last but not least special thanks to Mr. Santosh shinde and Mr. Sharad Patil from 'Renu electronics Pvt Ltd.'Pune.for permitting to do the implementation work.