International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.14, pp 163-173, 2017

Predicting and Enhancing the Reliability of Computer Operated Robot by Considering Software, Hardware and Interfacing Modules

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Abstract : In the present scenario, the real challenge between the corporate companies is to ensure high quality and high reliable products to the customers. The quality performance of a firm is often assessed by the reliability of the firm's equipment and machinery. The reliability prediction and enhancement will help firm's productivity and efficiency while reducing cost and increasing their competitiveness. A new modular design approach has been developed for predicting the reliability for any real time mechatronics system in order to reduce design complexity. This modular design approach consists of various modules for predicting the reliability and mainly incorporates the cause and effect diagram and fault tree analysis techniques for software and hardware and interfacing modules. This paper mainly focuses on reliability prediction and improvement for computer based pneumatic operated robot by logical modules developed using Lab VIEW software.
Key words : Design Reliability, Fault tree Analysis, Hardware Reliability, LabVIEW Software, Robot Quality, Software Reliability.

1.0 Introduction

Improving the product on a continuous basis is the essential need for the manufacturing industry today. The quality enhancement is achieved through many ways. One of such method is through automation of machine elements to accomplish desired process parameters and constant product quality. The quick intensification of computer based systems in automation prefers the slow replacement of the current equivalent systems with software based digital systems. Mechatronics design approach is a recent but rapidly developing multidisciplinary approach is the key design of automated systems which integrate the hardware elements, interfacing modules and software codes with in to mechanical equipment's. Also the mechatronics design approach will improve the obtainable capabilities of the mechanical machinery and also incorporating the new features[2]. Automation is the key for producing quality goods at a faster rate with various type of intelligence embedded into the system makes the system reliable and user friendly. Mechatronics system design cannot be carried consecutively but it has to be done concomitantly.

In order to design an automated system it is necessary to treat the whole sub system in an integrated way during the design process. The modular approach reduced the complexity in control synchronization for the successful automation of the task. A system cannot be reliable if it does not have high quality. Likewise a system cannot be of high quality if it is not reliable. The goal of quality and reliability systems is the same to achieve customer satisfaction. The Cause and effect diagram and fault Tree Analysis (FTA) are mainly used to design a highly reliable and dependable system in the design stage. When assessing the reliability of automation systems there are some extraordinary features to consider. First of all, the reliability of automation system is a stuff of the practice environment as well as that of the system itself. Although there may be errors in the software which can cause a loss of security purpose only when certain inputs arising with very low possibility are introduced into the system. In other words, the reliability of a system depends on the operational profile, which as the probability distribution of input structures varies from one environment to another. This confines the use of standard operational experience in the determination of reliability parameters. The quantitative reliability assessments should always be based on certain indication which is most frequently the operational experience statistics. Usually in the case of safety critical automation system this evidence is either very limited or not applicable due to the differences between the operational profiles of the data sources and the actual system[1]. Another of evidence is acquired from the dynamic testing system if high reliability with high sureness level is required, the number of tests is very large, and it may be basically unbearable to test a system comprehensively enough. Thus the use of extra proof from other sources is unavoidable for proper reliability assessment. There are many quantitative analysis methods for system reliability. But the Fault tree analysis techniques suitable techniques to provide the systematic description of the combinations of possible occurrences in n automation system and also which can result in an undesirable outcome. This method can combine hard ware, software, interfacing module and human failures.

1.1 Need of Fault Tree Analysis Technique

In a multifaceted system two or more components can fail at the same time it is very difficult to assess the reliability of such systems. The use of fault tree method assumes the individuality of elementary probabilities of failures and boolean variables. Fault trees are very influential particularly when they are solved using binary decision diagrams. Unfortunately, when numerous failures are expected to affect a component, the model needs a demonstration as numerous states variables. Then the Fault Tree approach is close to its limit. The measurable fault tree analysis is made in a empirical manner from the top event that corresponds to the unwanted event.The Similar uncomplicated event may appear several times on the bottom of the tree.Moreover the frequent events in the fault tree induce dependence between minimal cuts that can induce an approximation error of the system reliability if it is not calculated with BDD.The fault tree obviously shows all the dissimilar connections that are necessary to result in the top event. In creating the fault tree, a thorough understanding is obtained of the logic and basic causes foremost to the top event. And also fault tree is a palpable record of the methodical analysis of the reason and basic reasons important to the top event.FTA is a deductive analysis approach for determining an undesired event into its causes of the problem. And also it is a backward looking analysis, looking backward at the causes of a given event. Specific stepwise logic and symbols are used in the process to illustrate the event relationships of the system. To quantify the failure probability and to optimize tests and the probability of the accident scenario is thereby determined by FTA. The practice and competence of these methods be contingent on the type and the construction of the system as well as the involvement of the reliability engineer.

2.0 Computer Controlled Loading and Unloading Robotic Arm

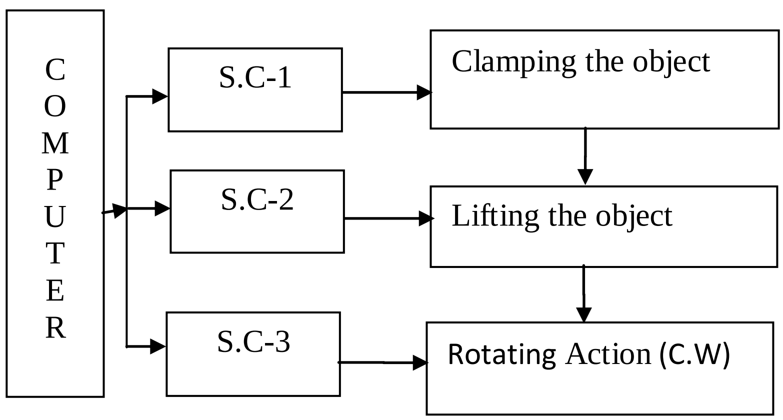
Robotics is the science of designing robots suitable for real life applications in automated manufacturing and other non-manufacturing environments. As per International Standards Organization (ISO), it can also be defined as, an industrial robot is an automatic, and servo controlled, easily programmable, multipurpose manipulator, with numerous areas for the handling of work pieces, tools or special devices. Variably programmed processes make the implementation of a variety of tasks possible. Here we are designing a robotic arm that is entirely well-designed by pneumatic principles and thus decreasing the difficulty in designing, manufacturing and machining. This helps in reducing the overall cost of the robot right from designing to manufacturing since costly electronic circuits are not used. When compared to electronic robot these pneumatic robots with concurrent and progressive pneumatic circuits are accomplished of performing the same task automatically with support of even an unskilled labour which in turn decreases the running cost of the machine. These types of pneumatic robots can be used in places where repetitive action is required such as the assembly line and also in places where remote operation is required[1]. The success and advancement of these types of robot depends mainly upon the difficulty of the pneumatic circuit. Effective design increases the efficiency and reliability of these robots. The well designed robots are particularly wanted for certain work task to reduce the labour and also increase the productivity. Pneumatic system tends to have long operating lives and need very little protection and easily planned using distinctive cylinders with the accessories. The direction of airflow is controlled by the solenoid operated direction control valves (DCVs). These DCVs are operated through the 12V Relays, which can be controlled by DAQ cards (Data Acquisition Cards) with hardware interfacing circuits. There are three pneumatic cylinders are used in this loading and unloading pick and place robotic arm[1]. The cylinder 1 is used for getting base rotation, cylinder 2 is used for lifting the robotic arm to the required level of height and cylinder 3 is used for clamping and declamping the objects. The FRL unit circuit is used to filter the compressed air and regulate the pressure level in to the operating condition.

2.1 Design of Reliable Pick and Place Robot Manipulator

In the robot design the purpose of a joint is to permit relative motion between two links or arms of a robot. It offers precise relative motion between two links .Generally one joint provides the robot with one degree of freedom. There are numerous joints such as the linear joints, orthogonal joints, rotational joint, twisting joints and revolving joints. The cost of hinged joints is very a smaller amount and can also fulfil our requirement. The reliability of the hinged joins are mainly relies on the strength and weight to be lifted. The robot manipulator is usually mounted on a track or deferred from a pathway that is capable of reaching desired distances and locations. It is used to transfer materials, tools and objects from source point to the destination point. In the robot manipulator the body assembly is used to attain the position of the object in the work envelope. The robot design can help to reduce the weight of the body and also the volume of materials used. The design of wrist assembly connected with end effector is mainly used for the positioning of the object in the work volume. To reduce the complexity of the wrist assembly the end effector can be attached to the arm directly using hinged joints. The gripper is used for lifting and placing the objects which is controlled by pneumatic cylinder[5]. The Robot to reach different locations and perform the tasks it has to rotate around its own axis. The base rotation is controlled by rack and pinion mechanism which is fully controlled by pneumatic cylinder.

2.1.1 Forward Sequence

The forward sequence in the pick and place robot are achieved by energizing the solenoid coils 1, 2, 3 to activate the pneumatic cylinders 1, 2, 3 sequentially. The cylinder-1 is used to hold the objects in the conveyor line; the cylinder -2 is used to lift the robotic arm in to some prescribed height to avoid the collision of other peripherals connected in the machining Centre. Then the cylinder -3 is activated to rotate the base to the specified location to place the components. This forward sequences are illustrated in the fig.1.0. The sequence of the operation is evenly time delay by 5seconds. The computer with data acquisition interfacing modules are used to control the solenoid coils by supplying the D.C voltage to activate the pneumatic cylinders.



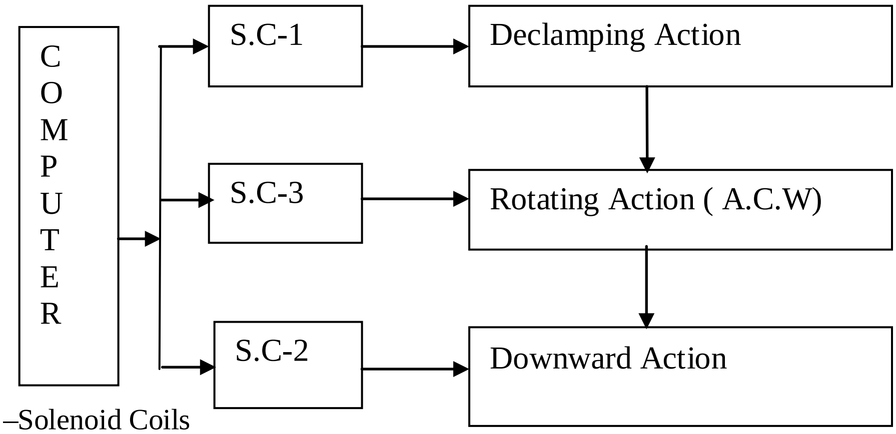
S.C –Solenoid Coils

C.W-Clock Wise

Fig. 1.0. Forward Sequence of the Robot

2.1.2 Reverse Sequence

To get the reverse sequences in the pick and place robot the solenoid coils 2, 1, 3 are deenergized sequentially with the even time delay of 5Seconds by the computer. When the solenoid coil-2 is deenergized the arm will get downward action. Then the solenoid coil-1 is deenergized the object is declamped from the gripper of the robot. And then the solenoid coil-3 is deenergized the robot rotate and go to the initial position. This reverse sequences are illustrated in the fig.2.0. Then the cycle of this total operation is repeated by connecting the feedback loop to the first frame structure in the LabVIEW software with computer. After the solenoid coil-3 is deenergized the signal is connected to the first structure to execute the cycle of operation of the pick and place robot repeatedly.



S.C –Solenoid Coils

A.C.W-Anti Clock Wise

Fig. 2.0. Reverse Sequences of Pick and Place Robot

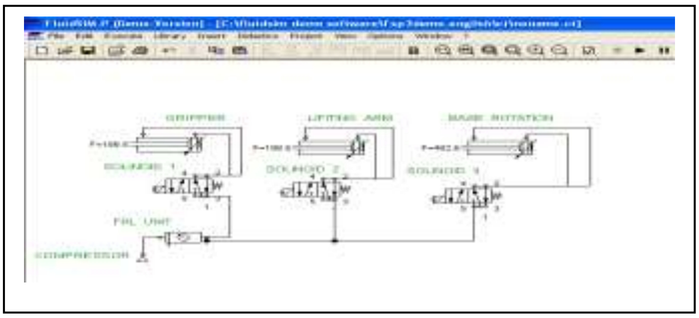


Fig. 3.0. Simulation of Pneumatic Circuits for Loading and Unloading Robotic Arm.

The sequential pneumatic circuits are to be designed to control the robot. The each pneumatic cylinder is actuated at proper sequence and are also kept active for the desired period of time. To design safe and precise pneumatic circuits it is very essential to develop the circuit through the FLUIDSIM (PNEUMOSIM) software. FLUIDSIM is a software package that can be used for simulation, creation and study of pneumatics and hydraulics. PNUEMOSIM is used for deigning and testing of pneumatic circuits. All the functions of this tool can be nicely combined and are easily accessible. This tool can contain cutway animations and drawings of cylinders, valves and flow control devices. Drag and drop features are supported to draw simple pneumatic circuits. The virtual compressors with FRL units are connected to the Directional Control Valves for activating the double acting actuator by line connections provided in the software. To verify the circuit connection all the solenoid valves are energized sequentially by pressing the execution button in the software. The pneumatic circuit connection has designed for actuating the pick and place robot with proper sequences is illustrated in figure 3.0.

In the Pneumatic circuit the compressor gives the compressed air, and it is connected with the Filter Regulator and Lubricator (FRL) unit to the Directional Control valve for actuating the double acting cylinders.

The pick and place robot consists three pneumatic cylinders which are sequentially energized with proper time delay when the control signal receives from the computer. The specifications of all the pneumatic sub components are tabulated in table 1.0.

Table 1.0 Specification of Pneumatic Sub Components

S.No	Component name	Specifications
1	Compressor	Required pressure from air compressor range = (6-10) bar
2	Solenoid operated direction control valve	Voltage=24V
3	Double acting cylinder	Cylinder size = (piston dia * stroke length) Clamping cylinder= (20*75)Lifting cylinder= (20*125) Rotating cylinder= (32*125) (All dimensions are in mm)
4	Electrical relay	Relay: Voltage 5v
5.	AC to DC converter	Ac voltage: 230V Dc voltage: 24 V
6.	Pneumatic hose tube	Pneumatic hose tube dia: 4 mm

4.0 Interfacing of Robot with Computer

Data Acquisition is the process of obtaining signals from actual domain occurrences, digitizing the signals, Investigating, Offering and exchangeable the data in to required format. DAQ hardware acts as the interface between the computer and the external world which mainly function as a device that digitizes incoming analog signals so that the computer can interpret them. The analog and digital input and output devices are connected with the DAQ system to acquire the real time signal and also provide the even time delay to control the robot actuation. Driver software is mostly used for easily communicating with the hardware analog and digital devices[4]. Human machine interface (HMI) is mainly achieved by data acquisition system with proper hardware and software accessories. In order to create DAQ application the programming development tool, such as LabVIEW software is essential. The flow diagram is illustrated in fig.4.0.

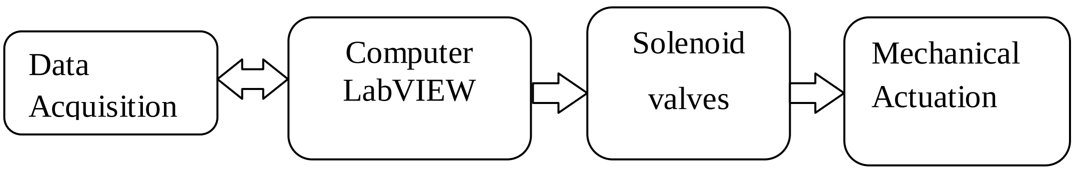


Fig. 4.0 interfacing of robotic arm with computer

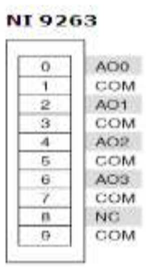


Fig. 5.0. Pin Configuration.

Data acquisition (DAQ) is the process of measuring an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound with a computer. A DAQ system consists of sensors, DAQ measurement hardware, and a computer with programmable software. Compared to traditional measurement systems, PC-based DAQ systems exploit the processing power, productivity, display, and connectivity capabilities of industry-standard computers providing a more powerful, flexible, and cost-effective measurement solution. CompactDAQ is a portable, rugged DAQ platform that integrates connectivity and signal conditioning into modular I/O for directly interfacing to any sensor or signal. In the above hardware setup, DAQ card (NI 9263) is used to interface the computer and hard wares. DAQ software is needed in order to work with a PC. DAQ card (NI9263) receives the digital input and gives the analog output to the relay. A relay is an electrically operated switch. In DAQ cards input signal received from Lab-VIEW software and give output to the 5V relay through three channels[3]. (Channel 0-2), then relay gives current to the solenoid operated directional control valve (24v). A solenoid DCV is an electromechanically operated valve; which is controlled by an electric current through a solenoid. Solenoids contain an electromagnet with a movable plunger and used to translate electrical energy into linear mechanical motions. This solenoid operated DCVS activate the three pneumatic cylinders as per the sequence of Lab-VIEW program[3]. In the pneumatic operated robot there are three solenoid coils are used to get the sequence of operation of the robot. The pin configuration of the analog output DAQ card shown in fig. 5.0.

4.1 Pin Configuration of Analog Output DAQ Card (NI 9263)

In the pin configuration diagram the solenoid coil-1 is connected to the channel 0. Solenoid coil-2 is connected to the channel1. Solenoid coil -3 is connected to the channel -2.After connecting this solenoid coil to the DAQ cards, the measurement and automation explorer software is used to conduct the self-test for the hardware devices. If the self-test is pass then the hardware device is ready to perform the operations. The solenoid coils are sequentially energized with time delay of 5 seconds for performing the operation of the robot. The logical software codes are developed in the LabVIEW software are illustrated in fig.6.0.

Fig. 6.0. Lab-VIEW Software Codes

5.0 LabVIEW Software Program Implementation

In the LabVIEW codes consist sequence structure which contains one or more sub diagrams, or frames, that execute in sequential order. Within each frame of a sequence structure, as in the rest of the block diagram, data reliance determines the execution order of nodes. The flat sequential executes frames from left to right and when all data values wired to a frame are available. The data leaves each frame as the frame finishes executing. This means the input of one frame can depend on the output of another frame. The output can emit from any frame. As with Case structures, data at input tunnels is available to all frames.

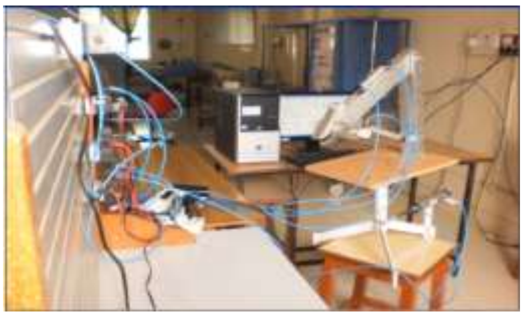


Fig. 7.0. Computer Based Pneumatic Operated Robot Arm (Prototype)

In the LabVIEW software block diagram panel, the flat sequential structure is extended to three frame by selecting the add frame option. The data acquisition inputs are connected to the frames of flat sequential structure for generating the analog signal when the respective solenoid coils are energized. Then the Boolean

ON /OFF switch is wired on the logical codes to control the complex system. Then the output of the case structure is connected to the DAQ assistant 1 icon and also it is connected to the frame-2and fame -3 of the flat sequential structure. The output of the frame -2 is taken as feedback and it is connected to the first frame of the flat sequential structure. This feedback value is connected to the constant value terminal of comparative equal icon for repeated execution of this program. To get the proper sequence of the pneumatic operated robot solenoid coils 1, 2 and 3 are energized sequentially with time delay of 5 seconds. The Lab-VIEW software interfaced with pick and place robots are shown in the fig.7.0.

6.0 Reliability Prediction Methodology

During system design, the top-level reliability requirements are usually allocated to subsystems by design engineers and reliability engineers working together. Reliability design begins with the development of a model. Reliability uses Fault tress models to provide a graphical means of evaluating the relationships between different parts of the automation system. These models incorporate predictions based on parts count failure rates taken from historical data. While the predictions are often not accurate in an absolute sense, they are valuable to assess relative differences in design alternatives. After a system is produced, reliability engineering monitors, assesses, and corrects deficiencies. Monitoring includes electronic and visual surveillance of critical parameters identified during the fault tree analysis design stage. The data should be constantly analyzed using statistical techniques, such as Weibull analysis and linear regression, to ensure the system reliability meets requirements. Reliability data and estimates are also key inputs for system logistics. Data collection is highly dependent on the nature of the system and the size of the organization. Most large organizations have quality control groups that collect failure data on equipment, and machinery and therefore better data. Consumer product failures are often tracked by the number of returns. For systems in storage or standby, it is necessary to establish a test program to inspect and test random samples. Any changes to the system, such as field upgrades or recall repairs, require additional reliability tasks to ensure the reliability of the modification. Since it is not possible to anticipate all the failure modes of a given system, especially ones with a human element, failures will occur. The reliability program also includes a systematic root cause analysis that identifies the relationships involved in the failure. Corrective actions may be implemented. When possible, system failures and corrective actions are reported to the reliability engineering organization. One of the most common methods to apply a Reliability Operational Assessment is Failure Reporting, Analysis and Corrective Action Systems. The following steps are followed to find out the reliability of the computer based pick and place robot.

Step - 1. Identify the sub components of the complex system
Step- 2. Draw the cause and effect diagram
Step- 3 . Develop the fault tree using fault tree analyzer
Step- 4. Collect the sources of failure data for individual components
Step- 5. Find the merged failure probability for all modules (Weibull Analysis and Linear Regression)
Step- 6. Find the reliability of the whole system

7.0 Weibull Reliability Analysis Method

In Weibull Reliability analysis the specialist tries to make forecasts about the life of all products in the population by fitting a statistical distribution to life data from an illustrative sample of units. The parameterized distribution for the data set can then be used to assess important reliability characteristics of the product or probability of failure at a specific time, the mean life and the failure rate. Life data analysis requires the practitioner to

- Gather life data for the subcomponents/ system
- Select a lifetime distribution that will fit the data and model the life of the product.
- Estimate the parameters that will fit the distribution to the data.
- Generate plots and results that estimate the life characteristics of the components , such as the reliability or mean life.

7.1 Life data

The term "life data" refers to capacities of components life. The component life can be stately in hours, miles, cycles or any other metric that relates to the period of successful procedure of a particular component. Since time is a common measure of life, life data points are often called "times-to-failure" and component life will be defined in terms of time throughout the rest of this guide. There are various types of life data and because each type offers various evidence about the life of the product, the analysis method will contrast depending on the data type. With "complete data," the exact time-to-failure for the unit is known (e.g., the unit failed at 100 hours of operation). With "suspended" data, the unit functioned effectively for a known period of time and then sustained to activate for a supplementary unknown period of time (e.g., the unit was still operating at 100 hours of operation). With "interval" data, the exact time-to-failure is unknown but it falls within a known time range. For example, the unit failed between 100 hours and 150 hours (interval censored) or between 0 hours and 100 hours (left censored).

7.2 Lifetime Distributions

Statistical distributions have been formulated to mathematically model or represent certain behavior of the system. The probability density function (pdf) is a mathematical function that defines the distribution. The pdf can be represented mathematically or on a plot where the x-axis represents time, as shown in fig.8.0.

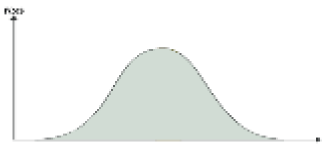


Fig. 8.0 probability distribution function

The equation below gives the *pdf* for the 3-parameter Weibull distribution model which can be applied in a variety of forms (including 1-parameter, 2-parameter, 3-parameter or mixed Weibull).The analyst chooses the life distribution that is most suitable to model each specific data set based on past knowledge and goodness-of-fit tests.

$$f(t) = \frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1} e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}} \quad (1)$$

In order to fit a statistical model to a life data set, the predictor estimates the parameters of the life distribution that will make the function most closely fit the data. The parameters control the scale, shape and location of the *pdf* function. For example, in the 3-parameter weibull reliability model the scale parameter η, defines where the bulk of the distribution lies. The shape parameter, β, defines the shape of the distribution and the location parameter, γ, defines the location of the distribution in time and life distribution function are calculated and tabulated in table 2.0.

Table 2.0 Calculated Life distributional data

S.NO	Scale Parameter (η)	Shape parameter (β)	Location parameter (γ)	Time period (t) (yrs.)	Life distribution function f(t)
1.	1	1	0	1	0.367879
2	1	1	0	2	0.135335
3	1	1	0	3	0.0497871
4	1	1	0	4	0.0183156
5	1	1	0	5	0.00673795
6	1	1	0	6	0.00247875
7	1	1	0	7	0.000911882
8	1	1	0	8	0.000335463
9	1	1	0	9	0.00012341
10	1	1	0	10	4.5399×10^{-5}

8.0 Lab VIEW Codes for Life Distribution Function

The LabVIEW software can also be used for generating the logical codes for life distribution function in the weibull reliability analysis. The input values such as scale parameter, shape parameter, location parameter and also time period are given in the front panel the life distributional values will be indicated in the front panel array. The life distributed data values are sown in the waveform graph for the input parameter values of for η=1, β-1, γ=0, t=1 to 10 yrs. are illustrated in fig.9.0.

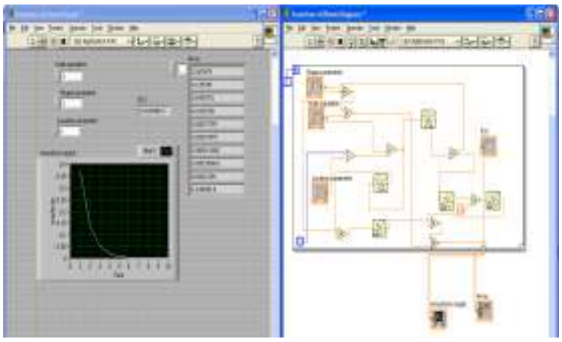


Fig.9.0 Lab VIEW Codes for life distribution function

9.0 Fault Tree Analysis

9.1 Creating Fault tree

Fault tree analysis (FTA) is a top down approach which is used to detect the failure of the subsystem of computer operated robot. The reliability of complex system is analyzed with boolean logic to merge a series of lower-level events. This analysis method is mainly used to predict the reliability of integrated systems to classify the best ways to condense threat and also to determine event rates of a safety level. FTA is used in assessing the software and hardware reliability for debugging purposes and is closely related to cause-removal technique. The failure probability of each sub components is identified and interprets in the Fault tree analysis technique to find out the overall failure probability of the system. The most serious outcome such as explosion, toxic release, accidents is selected as the top event. This technique is constructed by releasing the sequences of events which individually or in combination, could lead to the top event. The tree is constructed by deducing in turn the pre-conditions for the top event and then successfully for the next levels of events, until the basic causes are identified.

9.1.1 Quantification of FTA Probability scale

The fault tree for the pick and place robot are created in a sequence manner and illustrated in the fig. 10.0. the scale for calculating the failure probability are shown as follows.

1 in 10 – Frequent, 1 in 100- Probable, 1 in 1000 - Occasional, 1 in 10000 Remote, 1 in 100000- Improbable, 1 in 1 million – Extremely remote.

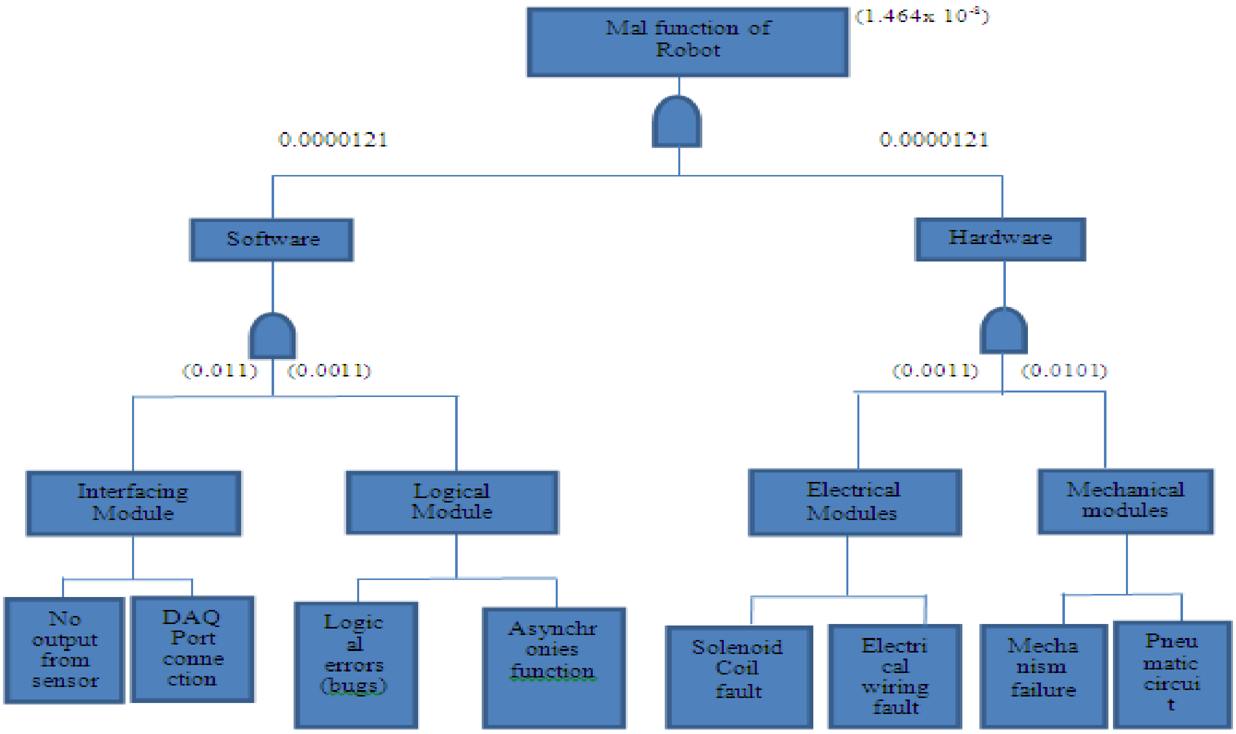


Fig.10.0. Fault tree for pick and place robot

10.0 Failure Data Collection

The failure probability for all the sub modules of pick and place robot are collected from handbooks and tabulated in the table 3.0.

Table 3.0 Failure data for software, interfacing and hardware components

S. No	Component Type	Components Name	Notation	Failure probability(λ)	λ Average	λ merged
1	Software Module	I/O DAQ Assistant Software module	SC1	0.045	0.045 0.09	
2		Flat and case structure software module	SC2	0.045		
3.	Pneumatic Module	Compressor	PC1	0.40	0.275 0.55	
4.		Directional control valves	PC2	0.15		
5.		Double acting cylinder	PC3			
6.	Mechanical Module	Rack and pinion	MC1	0.05	0.05 0.05	
7.		Ball Joint	MC2			
8.		Aluminium structure	MC3			**0.2267**
9.	Electrical Module	Solenoid coil	EC1	0.30	0.35 0.70	
10.		Relay	EC2	0.40		
11.		AC to DC conveter (230 To 24v)	EC3			
12.	Interfacing Module	Data Acquisition Card (NI 9263)	IC1	0.35	0.35 0.35	
13	Computer module	Central Processing Unit	CC1			
14		Peripheral devices	CC2			
15		Memory devices	CC3			

11.0 Reliability Model

The overall reliability of the computer controlled pick and place robot are calculated by the following merged reliability modelling approach.

$\lambda_{merged} = \left(\prod_{i=1}^{n} \lambda_i\right)^{1/n}$
n- number of records having failures or second source failure rate
λ_i - failure rate from each individual source.
%- percentage of total hours associated with records
F(S) = F (SWn, INn, HWn) where n= (1, 2…k)
SW_n= F (SM_1, SM_2,…..SM_K)
IN_n = F (IN_1,IN_2,……..IN_k)
HWn= F(PU_n,EE_n,ME_n)
HW = Hardware Components
SW = Software Components
IN = Interfacing Modules
ME= Mechanical Components
EE =Electrical and Electronics Components
PU= Pneumatic Components
R(s) = 1- F(s)

12.0 Conclusion

The automatic pick place robot operation is necessary for all the production industries to produce the high quality components as per the customer requirements. The pneumatic actuators are very cheap than all type of actuators, So that the automated technology can be implemented with the lowest cost. The computer based pick and place robots are also implemented with all other connecting modules of computers, so one computer can be used to perform all type of integration in the machining centre. The online monitoring system can also be implemented with these modules to get high reliable and safety Automation system.

References

1. Gregory S. Fischer, IulianIordachita, Csaba Csom, Junichi Tokuday, Philip W. Mewes. Pneumatically Operated Mri-Compatible Needle Placement Robot. IEEE International Conference on Robotics and Automation. PASADENA, CA, USA. 2008,May, 19-23.
2. Torben O. Andersen, Henrik C. Pedersen and Michael R. Hansen. Mechatronic system design based on an optimization approach. Mechatronics Day 2007 - International Workshop, Aalborg University Institute of Energy Technology Institute of Energy Technology, DK-9210 Aalborg East, Denmark., 4-7,2007.
3. Hans-PetterHalvorsen, Data Acquisition in Lab VIEW, Telemark University College, Department of Electrical Engineering, Information Technology and Cybernetics, 2011.
4. Terry Stratoudakis, Pe, Building Applications With LabVIEW, Ale System Integration Melville, New York, March 5, 2009.
5. Naresh Raghavan, Pneumatic Control for Robotics and Industrial Automation, 2007.

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