

# Modeling and Simulation of SCORA-ER14 Robot in ADAMS Platform

Ashok Kumar Jha, Partha Pratim Roy, Ajoy Kumar Dutta, Jyotirmoy Saha

**Abstract**— SCORA-ER14 robot is a four degree of freedom robot which is basically used in assembly operations in industry. This is a SCARA (Selective Compliance Assembly Robot Arm) based robot. The first two joints of this are revolute joints which enable it to move freely in a two dimensional horizontal plane. The third joint is the prismatic joint which enables it to move in vertical direction. Thus it has a three dimensional workspace and hence it can perform any manipulation with convenience. The analysis of its performance in different kinematic and dynamic conditions is very essential to figure out the kind of tasks it can perform and also to estimate its efficiency while doing those tasks. To analyze these effects we have chosen a virtual platform where we can build the robot using computer aided design tools and later simulate its performance on different motion paradigms. For this purpose ADAMS is an obvious choice as we can perform both modeling and simulation on this. So, first the entire model of the robot is created with minute details. Then the material is chosen properly and the mass matrices are formed. After that the joints are given different motion to see the torques produced. By observing these simulation results we can clearly estimate the performance of this robot and can design the work environment for the robot quite efficiently.

**Index Terms**—SCORA-ER14 Robot, Modeling, Simulation, ADAMS.

## I. INTRODUCTION

The entire discussion in this paper is presented in the following manner. First the modeling section is introduced. The topology of the connectivity of different parts in the modeling is given by a table. Then the view of the actual robot which is going to be modeled is shown. The different parts of the modeling and their wireframe model are shown next, which completes the modeling section. Next is the introduction of simulation and some brief about the ADAMS software. Then the simulation strategy and the motion paradigm is introduced before going straight into the display of results.

**Manuscript received July 20, 2014.**

**Mr. Ashok Kumar Jha**, Associate Professor in Manufacturing Engineering Dept., NIT Jamshedpur, Jamshedpur, India, 8987571650,

**Mr. Partha Pratim Roy**, Ex ME student, Production Engineering Dept., Jadavpur University, Kolkata.

**Dr. Ajoy Kumar Dutta**, Associate Professor in Production Engineering Dept., Jadavpur University, Kolkata, India

**Dr. Jyotirmoy Saha**, Professor in Production Engineering Dept., Jadavpur University, Kolkata, India

There are cases of motion on which the entire simulation is done. For each case the torque produced at joints and the end-effector velocity is shown at different axes. Finally we the outcomes of the simulation results are discussed in the conclusion section.

## II. MODELING OF THE ROBOT

### A. Introduction

ADAMS is acronym for Automatic Dynamic Analysis of Mechanical System. The software ADAMS is used to generate automatically the dynamic model of a Closed loop mechanism. ADAMS is automatically taken into account in the dynamic model under Simulink and the model is parameterized to facilitate the modification of the model. Also, the ADAMS model can improve the model accuracy by taking advantage of the automatic calculation of the inertia properties of all the parts of the mechanism. This tool allowed us to easily modify several designs and investigate their effect on the dynamic behavior of the system. In this project, ADAMS components: ADAMS/View (A/View) has been used for building, simulating and animating models of SCORA-ER14 robot. The isometric view of the SCORA-ER14 robot has been shown in Fig.1. All the parts of the robot is also labeled in this figure.

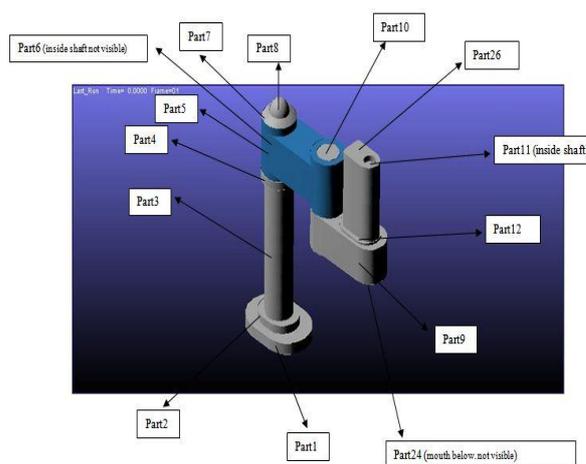


Fig.1. Different parts of Scora-ER14 Robot.

The wireframe model of the isometric view is also shown in Fig.2, while the positions of the revolute joints are shown in Fig.3. The top view of the robot gives us some more insight about the model, which has been shown in Fig.4.

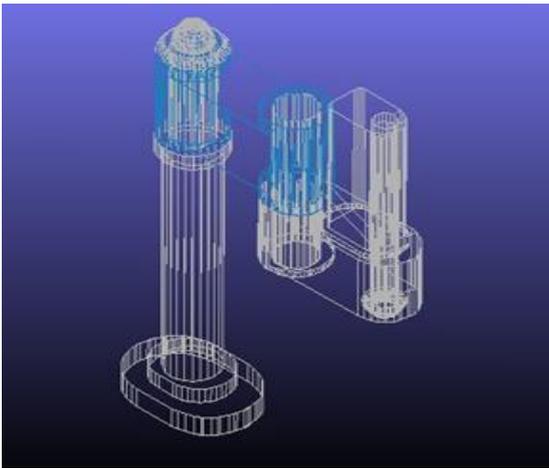


Fig.2. Wireframe model with Isometric view.

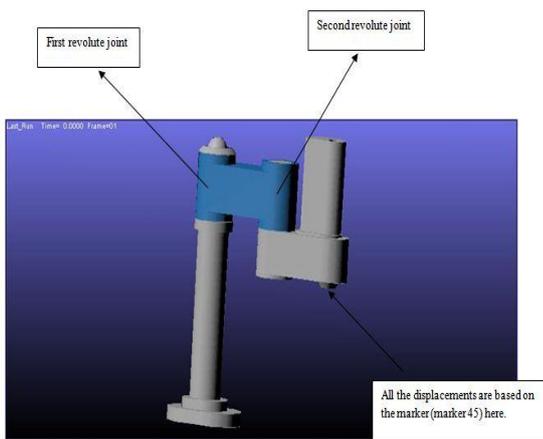


Fig.3. Position of the revolute joints on the robot.

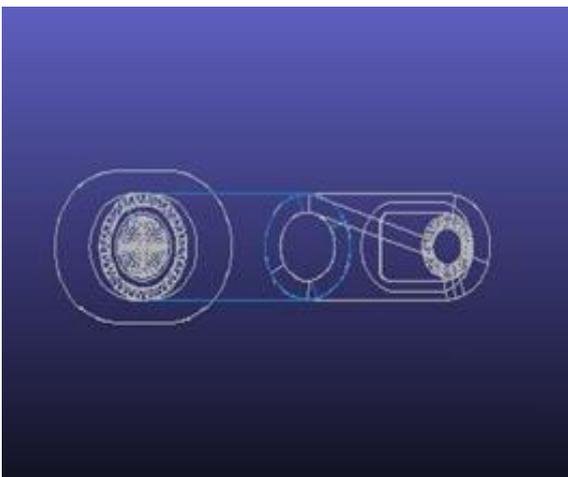


Fig.4. Wireframe model of the top view of the robot

**B. Topology of the model**

Topology is very important in connection with the modeling of any robot. This is basically of two types. One is topology by parts and the other one is the topology by connection. Topology by parts simply tells about the parts associated with a particular part and the topology by connection tells us how these parts are connected among each other. In Table.I the topology by connection is briefly shown

for better understanding of the model.

Table.I: Topology by Connection

Name of Joint	Connects
JOINT_1 (Fixed Joint)	➤ part12 (Part) ➤ ground (Part)
JOINT_2(Fixed Joint)	➤ part13 (Part) ➤ part12 (Part)
JOINT_3 (Fixed Joint)	➤ part13 (Part) ➤ part12 (Part)
JOINT_3 (Fixed Joint)	➤ part4 (Part) ➤ part13 (Part)
JOINT_4 (Fixed Joint)	➤ part6 (Part) ➤ part4 (Part)
JOINT_5 (Revolute Joint)	➤ part5 (Part) ➤ part4 (Part)
JOINT_6 (Fixed Joint)	➤ part3 (Part) ➤ part5 (Part)
JOINT_7 (Revolute Joint)	➤ part7 (Part) ➤ part3 (Part)
JOINT_8 (Fixed Joint)	➤ part8 (Part) ➤ part7 (Part)
JOINT_9 (Fixed Joint)	➤ part9 (Part) ➤ part8 (Part)
JOINT_10 (Fixed Joint)	➤ part10 (Part) ➤ part7 (Part)
JOINT_11 (Translational Joint)	➤ part11 (Part) ➤ part9 (Part)
Motion	Constraints
MOTION_1 (Rotational Motion)	JOINT_5 (Revolute Joint)
MOTION_2 (Rotational Motion)	JOINT_7 (Revolute Joint)
MOTION_3 (Translational Motion)	JOINT_11 (Translational Joint)

The original view of the SCORA-ER14 robot installed in lab is shown in Fig.5.



Fig.5. Photographic View of SCORA-ER14 Robot

### III. SIMULATION OF THE ROBOT

#### A. Introduction

Modeling is the process of producing a model, which is a representation of the construction and working of some system of interest. A model is similar to but simpler than the system it represents. One purpose of a model is to enable the analyst to predict the effect of changes to the system. On the one hand, a model should be a close approximation to the real system and incorporate most of its salient features. On the other hand, it should not be so complex that it is impossible to understand and experiment with it. A good model is a judicious tradeoff between realism and simplicity[1].

A simulation of a system is the operation of a model of the system. The operation of the model can be studied, and hence, properties concerning the behavior of the actual system or its subsystem can be inferred. In its broadest sense, simulation is a tool to evaluate the performance of a system, existing or proposed, under different configurations of interest and over long periods of real time. Simulation is used before an existing system is altered or a new system built, to reduce the chances of failure to meet specifications, to eliminate unforeseen bottlenecks, to prevent under or over-utilization of resources, and to optimize system performance[2].

#### B. Simulation of the Model

After the robot model has been verified correctly, the model becomes ready for simulation. The steps for simulation are now described briefly.

##### 1) The Simulation Panel

The simulation panel can be accessed by clicking on the simulation tool in the main toolbox. The simulation panel is shown in Fig.6.



Fig.6. Simulation Panel

The simulation panel is where one can access all commands that are needed to simulate the SCORA-ER14 Robot model. The first sets of buttons on the simulation panel are the

Rewind, Stop and Play. The first choice in the simulation operation is to decide what type of simulation is to be performed (Default, Dynamic, Kinematic or Static, where Default is the usual choice, as shown above). In this SCORA-ER14 Robot model, Kinematic type of simulation has been chosen [3].

##### 2) Settling time and End time

The next choice on the simulation panel is to choose either an End Time or Duration for simulation. Choosing an end time will start the simulation from rest while a duration sets the amount of time that the simulation runs, not necessarily starting it from rest. This is done by selecting End Time or Duration from the option field on the simulation panel. In the present SCORAER14 Robot model simulation, the end time has been selected as 5 seconds [4].

##### 3) Settling the time steps

Time steps are used in ADAMS/View to determine how the simulation is run. One can choose a Step Size, which is the amount of time that passes between each image or Steps, which is the number of steps that occur in the whole simulation. Both options are pretty similar. This is done by selecting Steps or Step Size from the option field on the simulation panel. In the present simulation, the steps have been selected as 50 [5].

#### C. Simulation Results

Simulations are done on the Scora ER14 Robot's model developed in ADAMS software. In the simulations the torque produced at Joint1 and Joint2 is plotted against time for three different cases. Also the end effector's position, velocity and acceleration in the horizontal X and Z direction is plotted against time.

The three different cases are:

- Joint1 is in motion only.
- Joint2 is in motion only.
- Joint1 and Joint2 both are in motion.

All the simulations are done by considering the joint velocity as 1 degree/s and run for 50s.

The following figures are showing the simulation results for different cases.

##### 1) Case I:

The magnitude of the torque is shown in Fig.7 while the velocity of the end effector along X and Z axes are shown in Fig.8 and Fig.9 respectively.

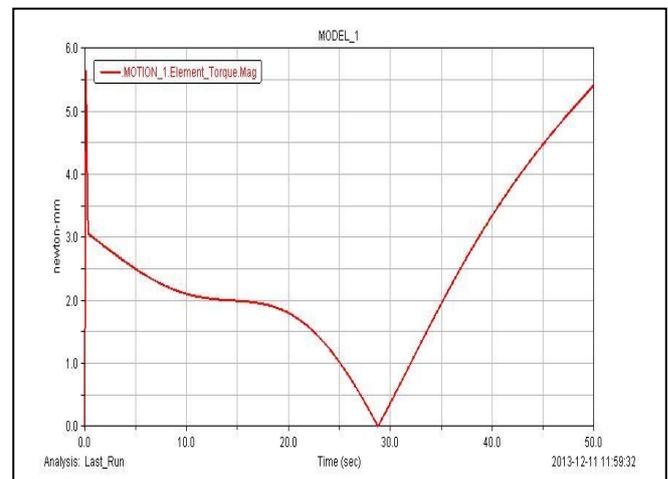


Fig.7. Magnitude of the torque at joint1 for case.1

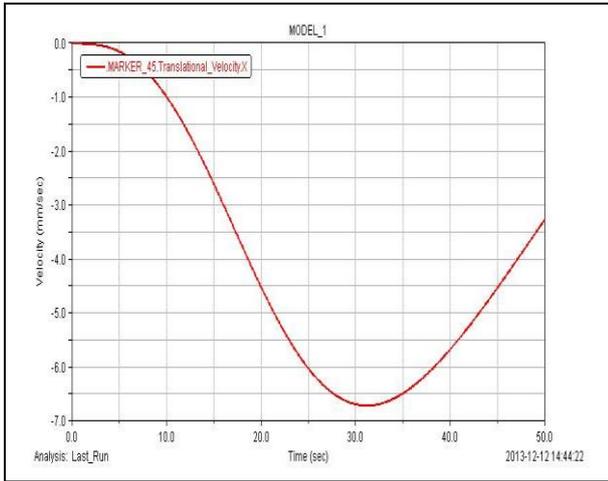


Fig.8: Velocity of the end effector along X axis for case. I

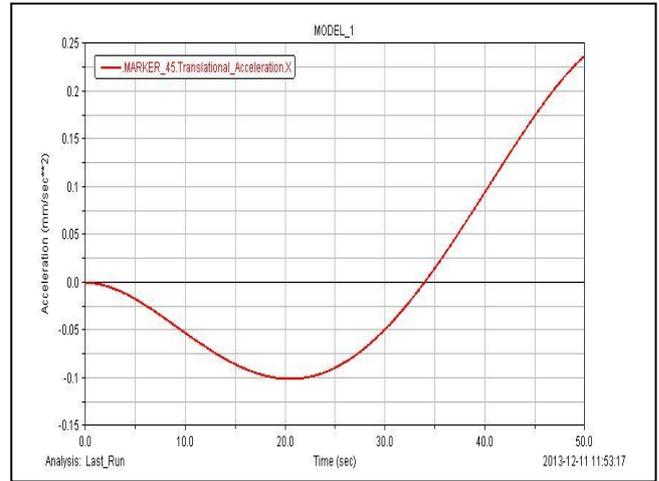


Fig.11: Acceleration of the end effector along X axis for Case.II.

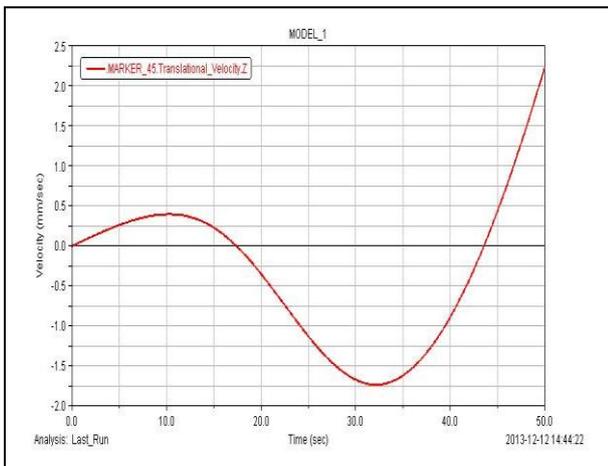


Fig.9: Velocity of the end effector along Z axis for Case.I

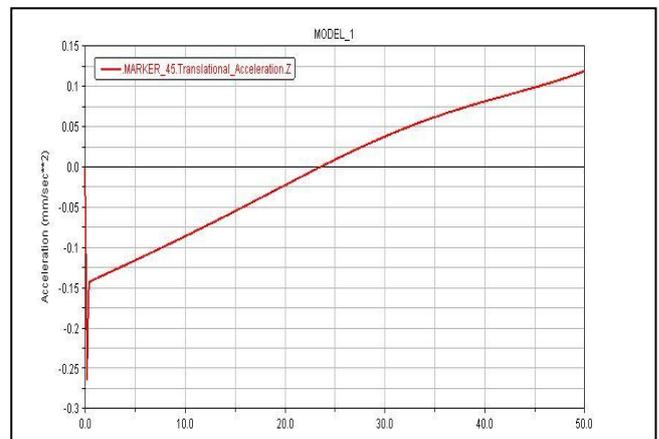


Fig.12: Acceleration of the end effector along Z axis for Case.II.

2) Case II.

The magnitude of the torque at joint 2 is shown in Fig.10 and the acceleration produced in X and Z direction for the end-effector is shown in Fig. 11 and Fig.12 respectively.

3) Case III.

The magnitude of the torque produced at joint1 and joint2 are shown in Fig.13 and Fig.14 respectively. And the displacement of the end-effector in X and Z direction are shown in Fig.15 and Fig.16 respectively.

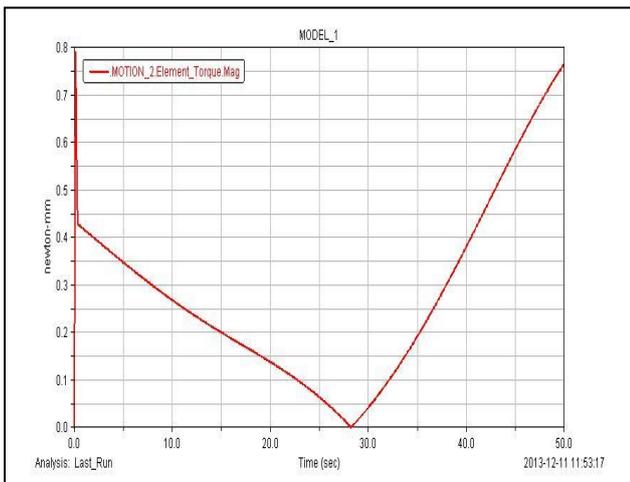


Fig.10: Magnitude of the torque at joint2 for Case.II

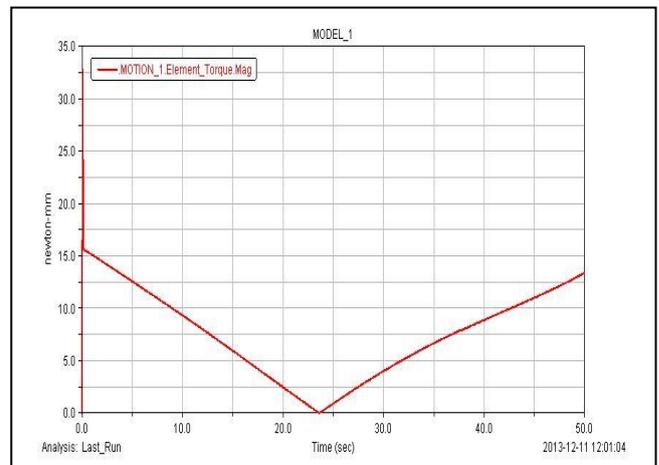


Fig.13: Magnitude of the torque at joint1 for Case.III.

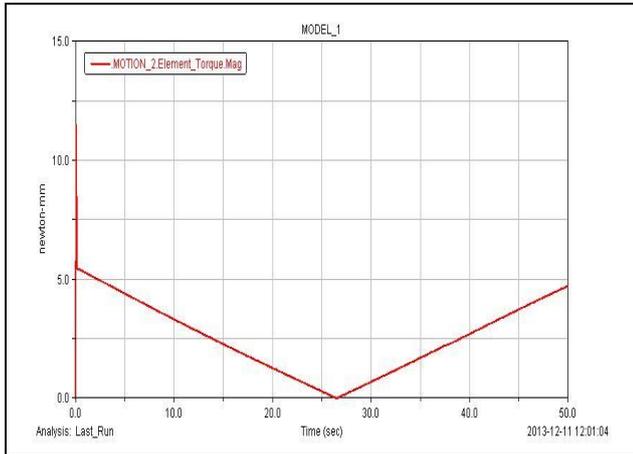


Fig.14: Magnitude of the torque at joint2 for Case.III

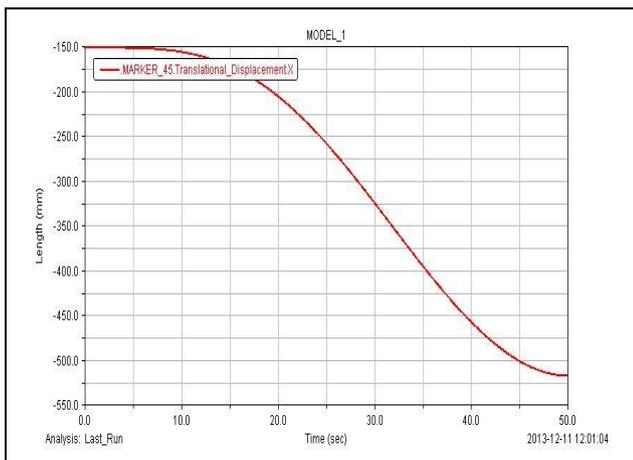


Fig.15: Displacement of the end effector along X axis for Case.III.

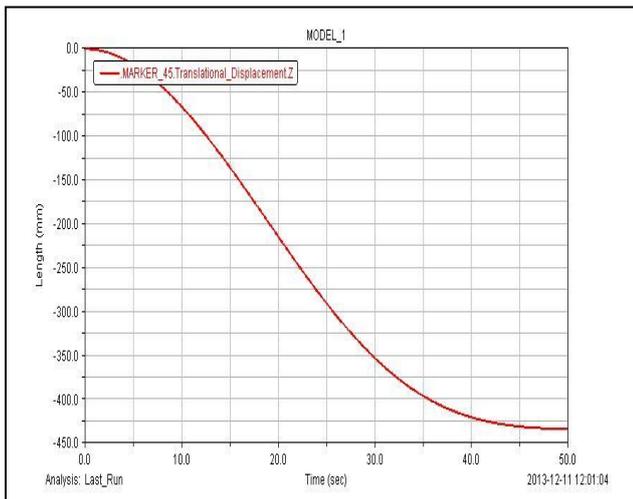


Fig.16: Displacement of the end effector along Z axis for Case.III.

#### IV. CONCLUSION

The dynamic properties of the manipulator is essentially dependant on the choice of material to manufacture the manipulator as it is related to the mass inertia tensor of different parts assembled to form the robot manipulator. Also the velocity and acceleration plays a vital role in the development of the torque profile of different joints. At higher velocities the centrifugal/coriolis component becomes effective. Otherwise its effect is negligible. We notice here higher values of torques for higher acceleration values and the torque requirement for an under actuated joint is zero. Also the configuration of the manipulator link is a key factor for obtaining the torques as it affects the kinetic and potential energy of the manipulator and the inertia tensor is also dependant on it.

#### REFERENCES

- [1] *Kinematic Modeling And Graphical Simulation Of A Scara Type Robot For Robot Performance Study*, Partha Pratim Roy, M.E. Thesis, Jadavpur University, 2011
- [2] *Examples and application of ADAMS software in the mechanics of machines teaching*, Xuyang Cao; Cleghorn, W.L., Computer Science and Education (ICCSE), 2010 5th International Conference on , vol., no., pp.1637,1641, 24-27 Aug. 2010
- [3] *Dynamics analysis of mine trunk based on virtual simulation software ADAMS*, Aiyong Yao; Xiaoyan Xiong; Ruiyuan Cao, Consumer Electronics, Communications and Networks (CECNet), 2011 International Conference on , vol., no., pp.1186,1189, 16-18 April 2011.
- [4] *A Method for obtaining direct and inverse pose solutions to Delta parallel robot based on ADAMS*, Jingjun Zhang; Lihong Shi; Ruizhen Gao, Chaoyang Lian, Mechatronics and Automation, 2009. ICMA 2009. International Conference on , vol., no., pp.1332,1336, 9-12 Aug. 2009.
- [5] *Dynamic simulation of radial active magnetic bearing system for high speed rotor using ADAMS and MATLAB co-simulation*, Ki-Chang Lee; Do-Kwan Hong; Yeon-Ho Jeong; Chi-Yen Kim; Min-Cheol Lee, Automation Science and Engineering (CASE), 2012 IEEE International Conference on , vol., no., pp.880,885, 20-24 Aug. 2012.