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3 DOF Revolute Articulated Manipulator

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A STUDY OF ENERGY UTILISATION IN A VARIABLE LINK LENGTH 3 DOF  
REVOLUTE ARTICULATED MANIPULATOR

WAN SULAIMAN BIN WAN MOHAMAD

Thesis submitted in fulfilment of the requirements  
for the award of the degree of  
Master of Engineering in Mechanical

Faculty of Mechanical Engineering  
UNIVERSITI MALAYSIA PAHANG

JULAI 2011

## **SUPERVISOR'S DECLARATION**

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Engineering in Mechanical.

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## LIST OF SYMBOLS

$\omega$ or $\dot{\theta}$	Angular velocity
$d$	Distance
$\theta$	Angular position/displacement
$\alpha$ or $\ddot{\theta}$	Angular acceleration
$\Theta, \Phi$	Angles
$t$	Time
$t_b$	Blending time
$E$	Energy
$E_{actual}$	Actual energy
$e_e, e_t, e_m$	Electrical, thermal and mechanical efficiency respectively
$\tau$	Torque
$V$	Velocity vector
$R$	Displacement vector
$K$	Kinetic energy
$P$	Potential energy
$M, m$	Mass
$h$	Height
$I$	Mass Moment of Inertia/ Product inertia
$L$	Lagrangian Function
$g$	Gravitational acceleration
$L$	Link length
$X, Y, Z$	Axes



**LIST OF ABBREVIATIONS**

LSPB	Linear segment parabolic blending
PC	Personal computer
AC	Alternating current
DOF	Degree of freedom
2D	Two-dimensional
3D	Three-dimensional
PE	Potential Energy
KE	Kinetic Energy
TE	Total Energy

## ABSTRACT

Determination of manipulator link lengths is one of the important criteria in robotic design. Previous researches on link lengths optimization did not take much into account on the energy consumed by a manipulator's actuators. The purpose of this study is to find the minimum energy utilization for a 3 DOF revolute articulated manipulator to perform certain point-to-point task by varying the link lengths. The lengths of the second and third link of the developed manipulator can be varied accordingly. The investigation of energy for different link length combinations was carried out theoretically and experimentally. In the simulation, the work-energy method was constituted in order to determine the average mechanical energy of the manipulator. In the experiments, the actual energy of the system was calculated by multiplying the reading torque with the angular displacement of each link. Both energy for different link length combinations from the simulation and experiment were compared with the energy consumed by the fixed manipulator link length. These comparison yielded percentage savings. Then, the percentage savings from the simulation were compared with the percentage savings obtained from the experiments. The simulation shows that, different trajectory of motions results in different link length combinations that could give optimum average energy utilization. Results of the simulations and experiments show that, improved of mechanical energy utilization could be achieved by having variable link length of manipulator rather than having fixed length of manipulator's arms. The result of optimized link length from the experiment shows that the saving of energy utilization could be achieved up to **16.73 %** corresponding to the **19.66 %** saving obtained from the simulation. All in all, the use of the variable link length manipulator is utterly important as far as energy saving is concerned.

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