# Open Source Embedded Controller for SMA actuated Morphing Wing MAV

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Micro Air Vehicle (MAV) is a lightweight flying object of around 300mm size that can be flown by a ground pilot through radio commands or through an autopilot built on an embedded system. Appropriate morphing or shape changing of MAV wing during flight has the potential to give different aerodynamic benefits, similar to birds but the implementation of such a system poses weight, power, response time and size challenges. The all-up weight of MAV should be around 300g and the flight is powered by a on-board battery which has very less power to spare, given the difficulty to meet the target endurance of about 30 minutes. Active morphing was achieved by drooping the Leading Edge (LE) of MAV wing. Such a morphing form has the potential to give higher lift during takeoff, low speed loitering, negotiation of high-rise structures and landing. A MAV designed and developed at NAL, namely 'Black Kite' was used for this purpose.

This paper presents the Open source embedded controller namely Arduino adapted for the morphing of MAV using multiple Shape Memory Alloy based actuators. It describes a form of wing morphing obtained by drooping the leading edge of the wing, design and development of SMA based actuators, measurement and control of degree of morphing, integration of the whole system using the arduino autopilot board and the flight testing.

**FEW SLIDES OF THE INVITED LECTURE ARE GIVEN BELOW:**

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# Open Source Embedded Controller for SMA actuated Morphing Wing MAV

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## OUTLINE

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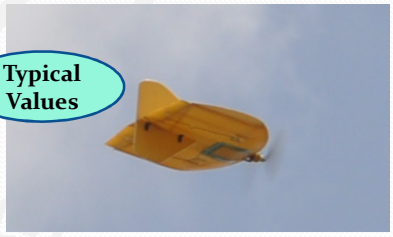
- Introduction to MAV
- Need for MAV wing morphing and L.E droop
- Selection of Shape Memory Alloy Actuator
- Radio Control of SMA through light-weight electronics
- Open source embedded controller for MAV
- In-flight measurement of LE droop angle
- Closed loop control of LE droop
- Wireless data acquisition of in-flight parameters
- Test results on ground, wind tunnel and flight
- Conclusions

# Introduction to MAV

MAV is a small unmanned air vehicle

- Size : 300mm
- All-up weight : 300g
- Range : 2 km
- Altitude : 200m
- Endurance : 30min

Typical Values

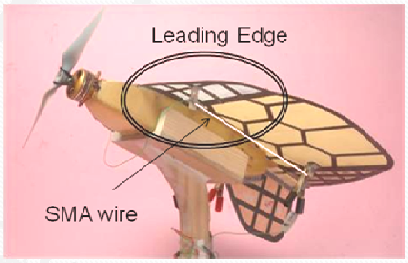


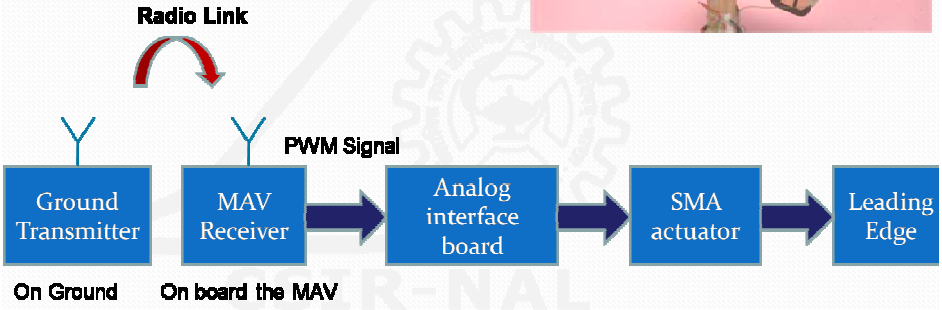
- Fixed, Rotary or flapping wing
- Generally battery operated
- Radio controlled or autonomous
- Application: Surveillance, reconnaissance



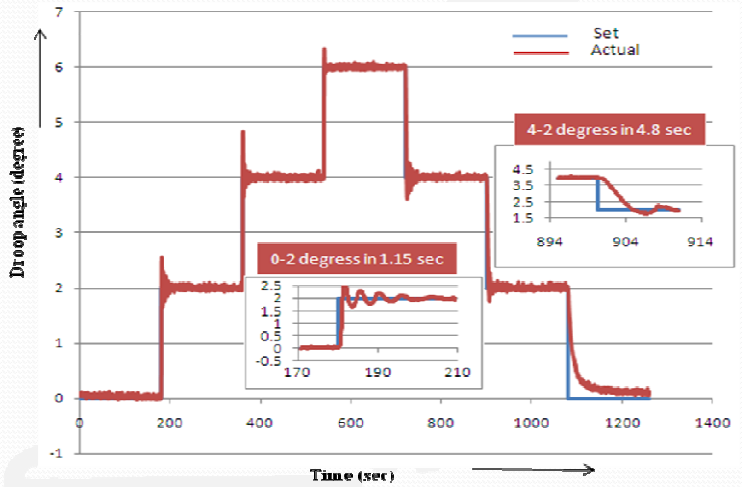
# SMA Actuator design-contd

**SMA actuator:**
- **Stress ~200MPa**
- **Strain ~ 3%**
- **Dia 0.3 mm**
- **Length: 500mm**



# Morphing controller - performance




Comparison of Set and Actual Droop Angle

Control Accuracy: ±0.2°
With Prop. ON



# Conclusions

- A practical RC controlled SMA actuator based LE morphing system for MAV application (300mm-class) was presented. Light-weight SMD based board, having compatibility with the MAV battery (8to 12V), receiver etc., was successfully developed
- Acceptable response time and proper operation under propeller running condition were obtained through pulse width control of SMA
- Good DA control accuracy of +/-0.2° was achieved even with the propeller-ON condition.
- The actuator and the control board along with the MAV were tested in the Wind tunnel successfully. Limited flight trials have shown successful remote controlled LE droop.