Automation

Rotary Inverted Pendulum

Walking Robot

Maze Game

Humanoid robot

Rotary Inverted Pendulum
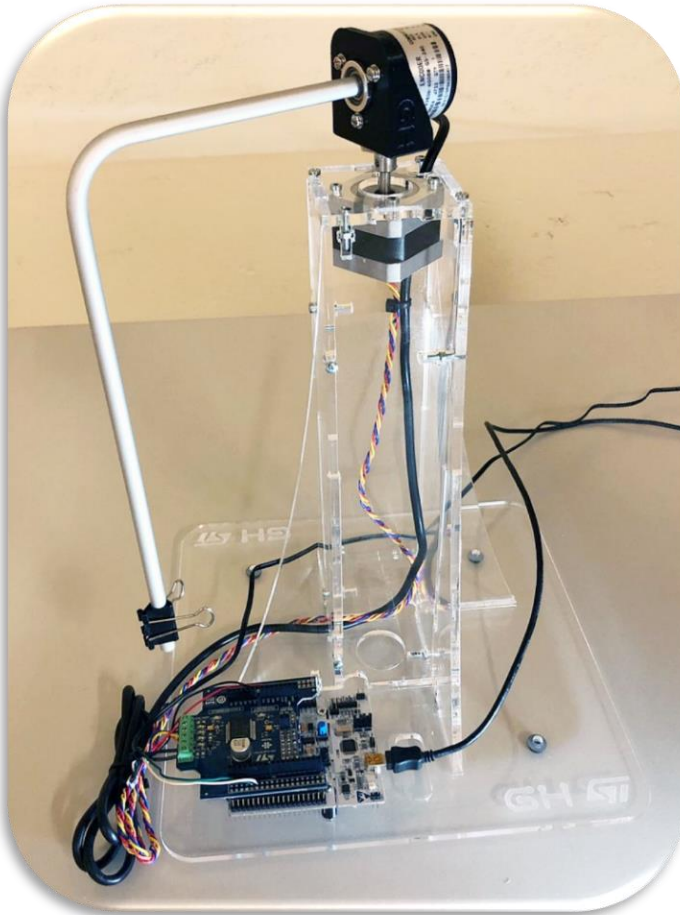
A Kit to Experiment with Stepper Motor Control and Control Systems

Based on STM32 ODE

Part of a Large Educational Ecosystem

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Furuta Rotary Inverted Pendulum Kit

- **Components**
  - Nucleo F401RE
  - IHM01A1 Motor Controller with L6474PD
  - Stepper Motor
  - Optical Encoder

- **Structure**
  - Interlocking easy to assemble structure
  - Rigid structure
  - Customizable motor mount

- **System Power**
  - 12V Power Supply
  - 5V USB Power or Computer Interface via USB

Ecosystem

- Stepper Motor systems appear in broad class of consumer, vehicle, industrial and medical robotics systems

- Brushless Motor with integrated encoder rapidly expanding in each application area

- Multiple Sensor and Structural Choices

Highly Flexible Architecture

- Learn the basic of stepper motor control

- Experiment with different control system strategies in a *real time solved unstable* system (PID, root locus, State Space, LQR etc…)

- Interface with MATLAB to build custom electro-mechanical models and asses system performances in real time

Ideal Educational Tool

- Motor Control Curriculum – based on an unstable system
  - Instructor objectives
    - Introduce Frequency Response Design
    - Introduce Root-Locus Design
    - Enable course projects
    - Provide all students with access to platforms in Year 1

- System Development
  - Developed Frequency Response Design application
  - Developed Root-Locus Design application

- Full open source curriculum material under development @ UCLA

Educational Platform Roadmap

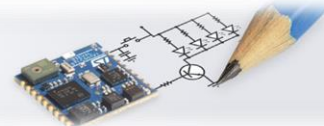## Part of a large educational ecosystem

Embedded Systems

The SensorTile Curriculum
ACCESS NOW!

- **Introduction to Embedded Systems with the SensorTile**
- **Capstone level course on IoT**

- **Low level FW programming with Drone01**

STM32 Cube.AI

- **Embedded AI**
  - Electrical Eng.
  - Computer Science
  - IoT
  - …

Embedded Systems and IoT

Motor Control and Robotics

Firmware programming with Drones

- Electrical Eng.
- Control & Automation
- Robotics
- Aerospace
- …

Power Electronics

- **Introduction to motor control and control systems**

Future development under development:

- More on motor control
- Power conversion

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Walking Robot

STSPIN32F0

3 phase motor controller with embedded STM32 MCU

New FW algorithms

From position control to servo drive
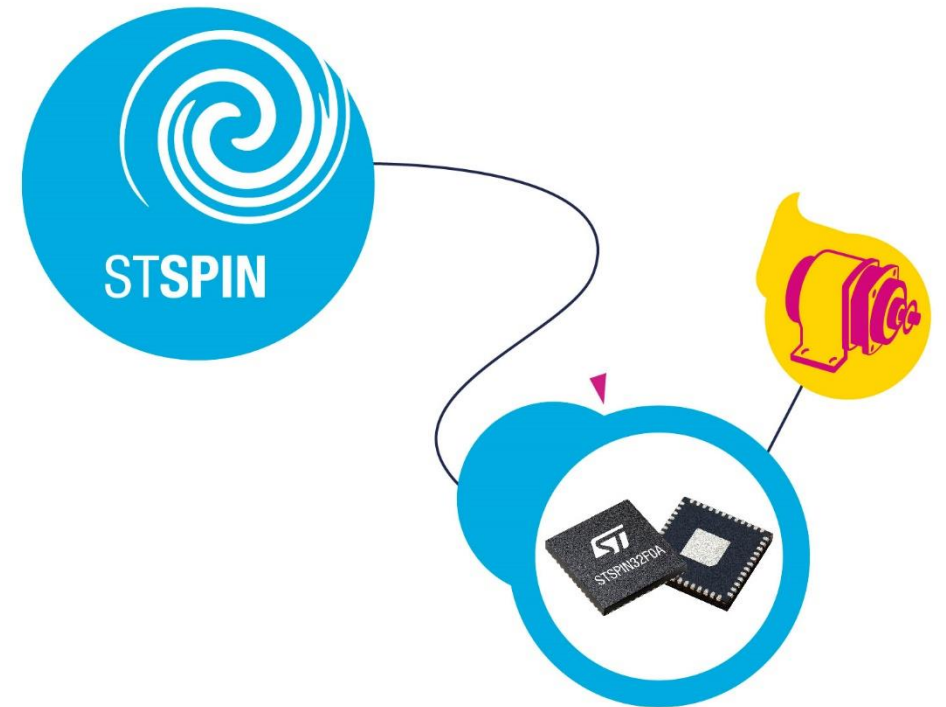
EVALKIT-ROBOT-1

Maxon motor

Walking robot demo

First PMSM robotic demo with ST products

STSPIN32F0

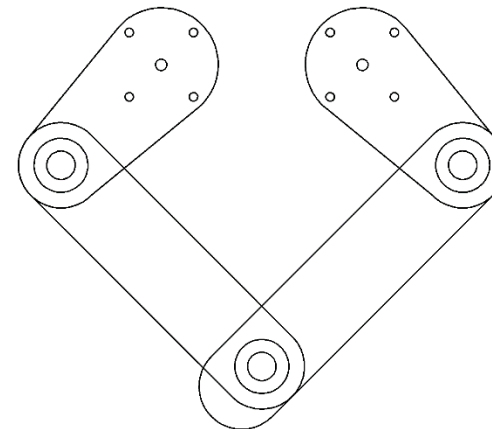Cost effective solution for motor driving with integrated gate drivers in the STM32 ecosystem

- 32-bit ARM® Cortex ® - M0

- Three-phase gate drivers

- VDC bus 8 to 45V

- 3.3V DC/DC buck converter regulator

New Firmware Algorithms

- Position control with encoder

- Servo drive capability

- Master/slave MODBUS communication

- Inverse kinematic FW for a 5 bars leg

MODBUS

EVALKIT-ROBOT-1

- **Key Features**
  - 36 V 6 Apk power stage
  - STSPIN32F0A advanced 3-phase motor controller embedding Cortex-M0 MCU
  - STL7DN6LF3 60 V, 35 mΩ Dual N-channel MOSFETs
  - Hall sensors + Encoder interface
  - Extremely compact footprint (40 mm x 40 mm)
  - Maxon EC-i 40 100 W 3-phase brushless DC motor
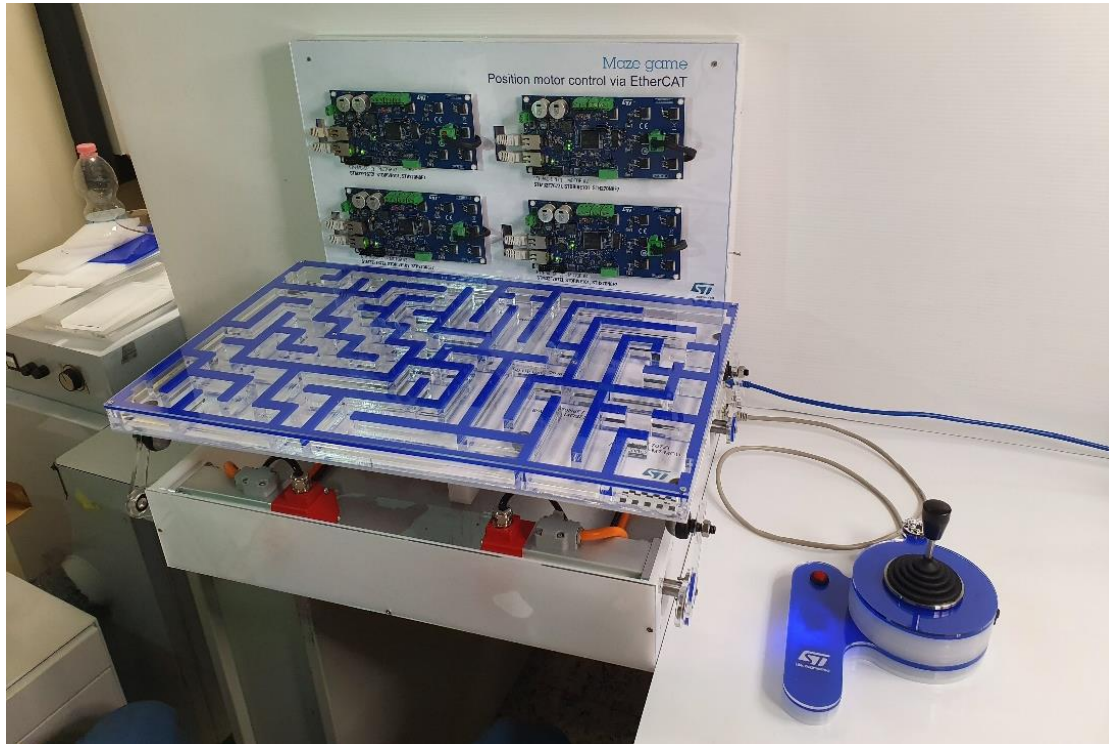 - Maxon ENX 16 EASY 1024-pulse incremental encoder

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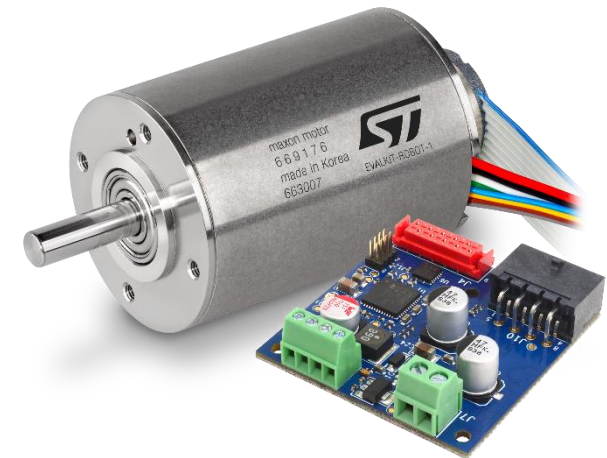
Walking Robot Demo

First PMSM robotic demo with ST products

- 1 x NUCLEO-F303RE board as Modbus Master

- 8 x STSPIN32F0A-SERVO boards

- 8 x Maxon motors with gearbox

- X-NUCLEO-IDB05A1 + STEVAL-BCN002V1B as remote control

- Developed in collaboration with UniCt

UNIVERSITÀ degli STUDI di CATANIA

Maze Game

Demo Overview

Real Time communication through EtherCAT

Embedded Algorithm for Position Control
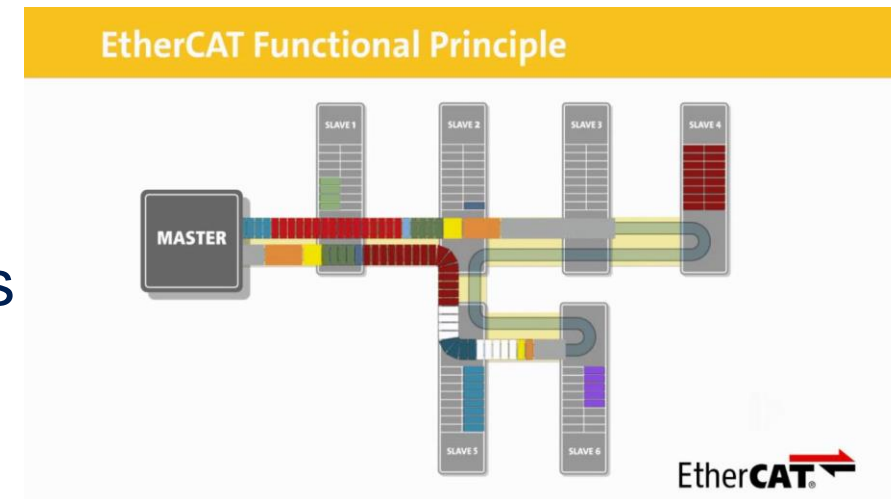
EtherCAT solution based on STM32

Demo Overview

- Wired connectivity, based on Hilscher network controller NETX90

- Wireless connectivity for user interface based on X-NUCLEO-IDB05A1 and BCN002V1B BlueCoin

- Kinematic inversion and position control embedded in a ST servo drive solution

Realtime Communication Through Ethercat

EtherCAT Functional Principle

- Ethercat based communication

- Master send position command to each of 4 slaves

- Fine axis synchronization and jitter control

EtherCAT Solution Based on STM32

- Bus interface using NETX90 network controller

- Processing unit for communication and driving based on STM32F767ZI

- Incremental Encoder and RS485 interface for ENDAT and BSSi encoder

- Actuation based on STDRIVE101 and STH270N8F7-2 STripFET™ F7 Power MOSFET
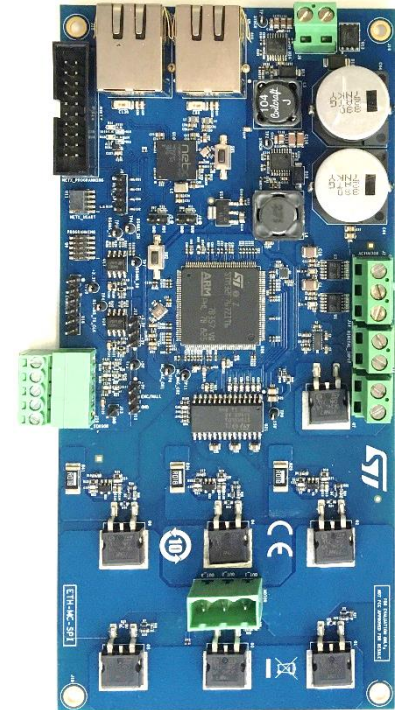
Embedded Algorithm for Position Control

Manage motor position with high precision

- Embedded position control algorithm for STM32F7 platform, control of jerk and adaptive

- Inverse kinematic firmware (from XY to motor angle)

- Motor drive Actuation (Field Oriented Control)

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STM32 F1 + **STSPIN**
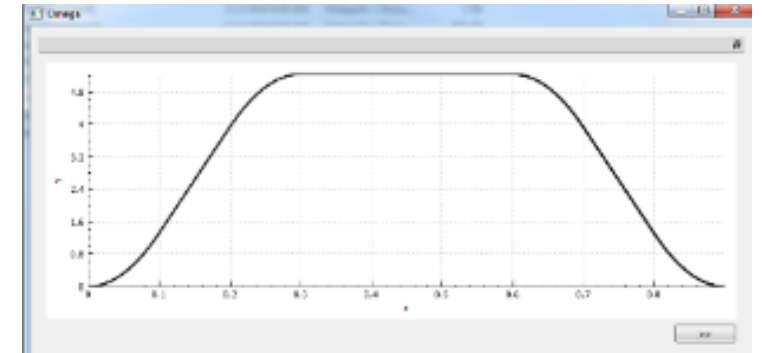
ROBOTIS
We Provide Creativity

A Transformable Robot controlled by a smartphone app

- **A robot transformer** shifting **from humanoid to car** controlled by smartphone app

- **Example of complex cinematic motion algorithms using ST devices**.

- **STM32F1 + STSPIN2 series**

- Robotis owns deep know-how in robotics and develop 2 kind of products:

  - OS robotics platforms for edu/home, based on

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