

Field oriented control.

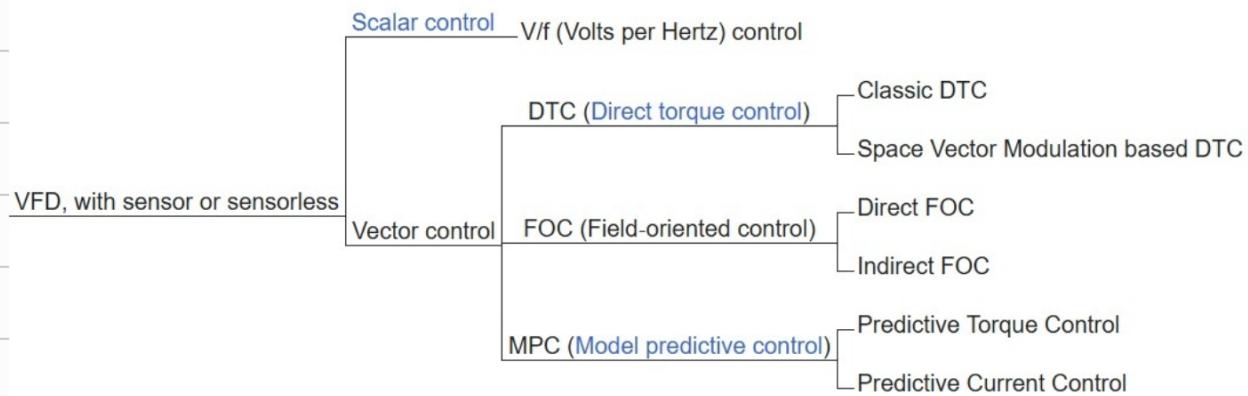
Benefits → Efficient torque control

High performance

Reduced torque ripple → Smoother motion

FOC (Vector control) → Control motors by managing the stator currents to create a rotating magnetic field. Aligns the stator and rotor magnetic fields orthogonally, maximizing torque production and enabling precise control of motor parameters (Clark and Park transforms)

* Proportional integral controllers are used to keep the measured current components at their reference values.



Hardware requirements

- micro controller STM or DSP → must be capable of real time mathematical computations
- Current and position sensors
- Motor driver.

STM32F103 (Blue Pill) – Budget-Friendly

1) Cortex-M3, 72 MHz

Basic FOC possible with SimpleFOC library

Limited RAM/Flash for advanced control

2) STM32F407 – High-Performance Choice

Cortex-M4, 168 MHz, FPU (Floating Point Unit)

Good for high-speed FOC and real-time control

More PWM and ADC channels for better motor control

3) STM32G4 Series – Designed for Motor Control

Cortex-M4, 170 MHz, FPU & DSP instructions

Built-in CORDIC (for fast FOC computations)

High-resolution PWM and ADCs for better torque control

Ideal for professional motion control applications

4) STM32H7 – Ultra-High Performance

Cortex-M7, 480 MHz, Dual ADCs

Best for high-end motor control applications

Overkill for simple stepper motor FOC

TI C2000 Series

Best for advanced motor control, widely used in EVs & robotics

- TMS320F28069/F280049/F280025 – DSP-based MCUs with fast FOC execution, built-in PWM & ADC optimizations.
- TMS320F28379D – High-end dual-core MCU with CLA (Control Law Accelerator) for real-time motor control.
- Best choice for professional motion control applications.

NXP kinetis & i.MX series

- Kinetis KV4x/KV5x – Cortex-M4/M7 with DSP, optimized for motor control.
- i.MX RT1050/1060 – High-performance MCUs (600 MHz) for complex motor applications.

Infineon XMC Series

- XMC4400/XMC4700 – Cortex-M4 with motor control peripherals like high-resolution PWM and fast ADCs.
- XMC1000 Series – Low-cost motor control MCUs.
- Best choice if using Infineon motor control ICs.

- * Best overall \rightarrow STM32H4, supports FOC with libraries.
- Not multicore but can do form of parallel processing
- \times Direct memory access without using CPU
- * CORDIC Accelerator \rightarrow fast FOC math processing
- \times F MAC \rightarrow DSP processing
- \times Interrupts & timer based multi tasking
- \times Multi threading.

Feedback sensor \rightarrow optical incremental encoder \rightarrow cheaper

Magnetic encoder (AS5042P, AMT102)

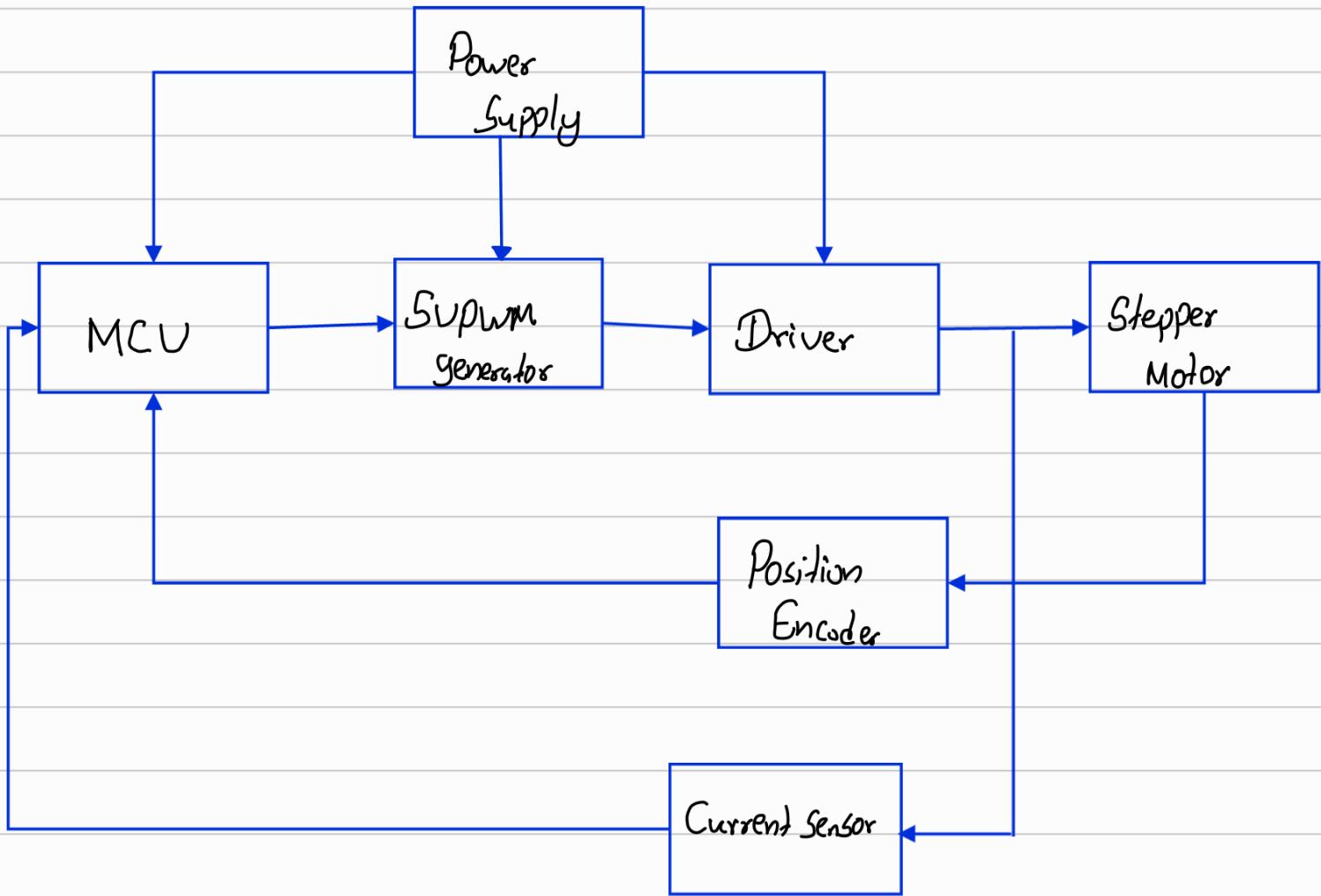
Absolute encoder (expensive but retains position after power off)

FOC

Why FOC

- \times generate precise amount of torque
- \times Controlling only current is not enough
 - \rightarrow apply currents orthogonal to the magnetic field.
- \gg Provide simple to use control values in a single vector
- \times representation of the current as a single vector that is defined by I_Q, I_D (Clarke and Park transformations)

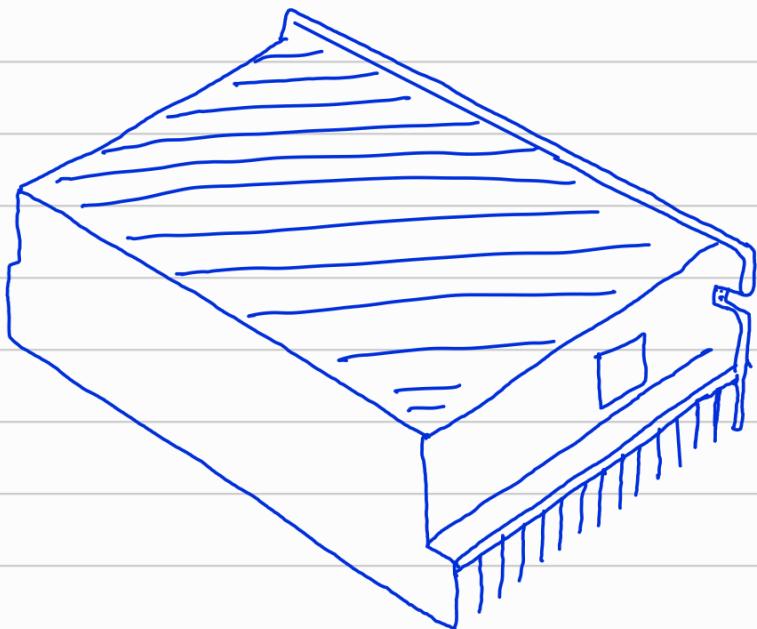
Block diagram



if motor operates at much higher speeds can use separate SVPWM generator (space vector PWM) between MCU and driver to reduce burden on MCU increasing safety, giving very fine torque and speed control and some highend drivers require very specific PWM.

Control type	Position	Current Sensors
Torque Control	X	✓
Speed Control	✓ (to get speed)	✓
Position Control	✓	✓ (for dynamic response)

Motor driver

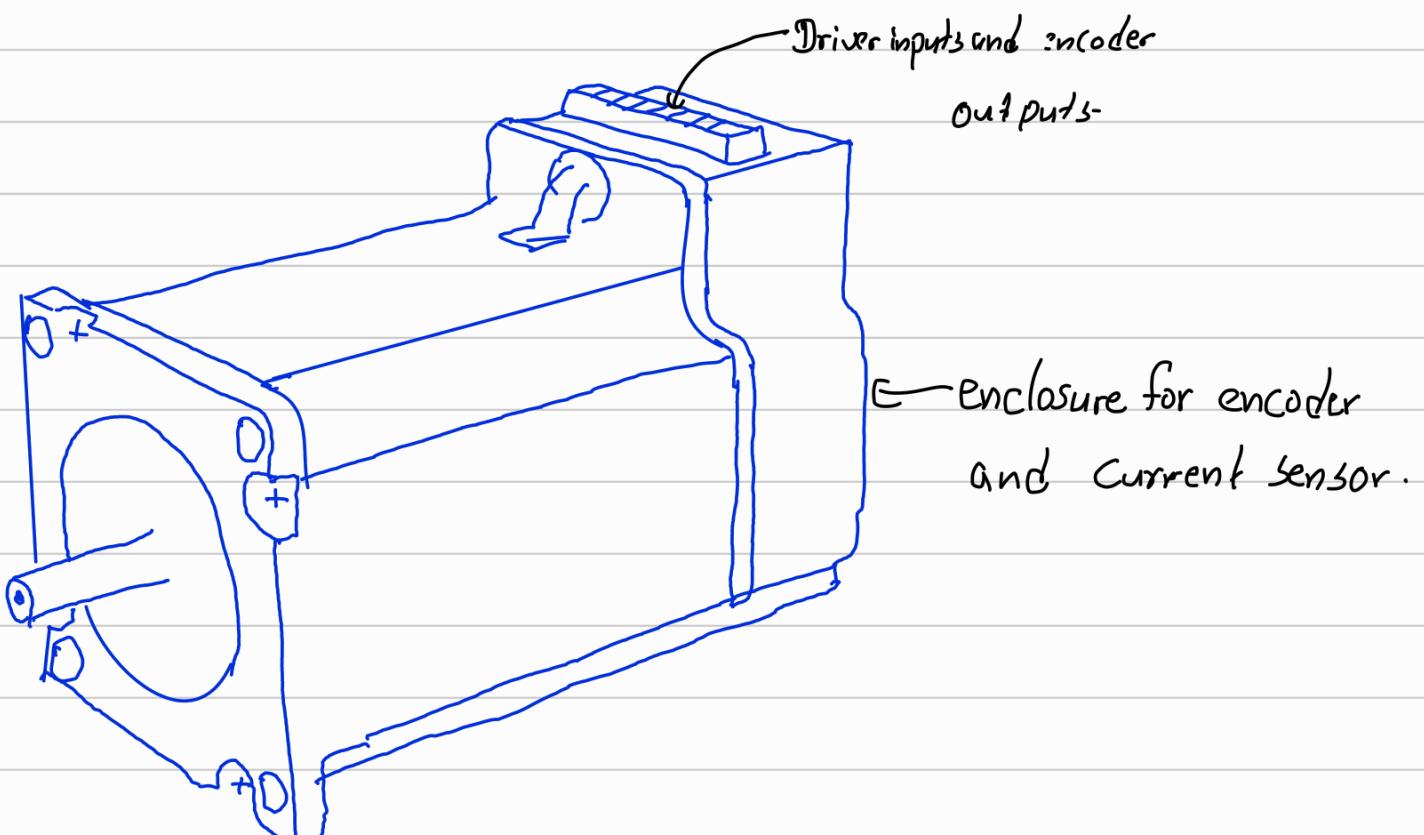


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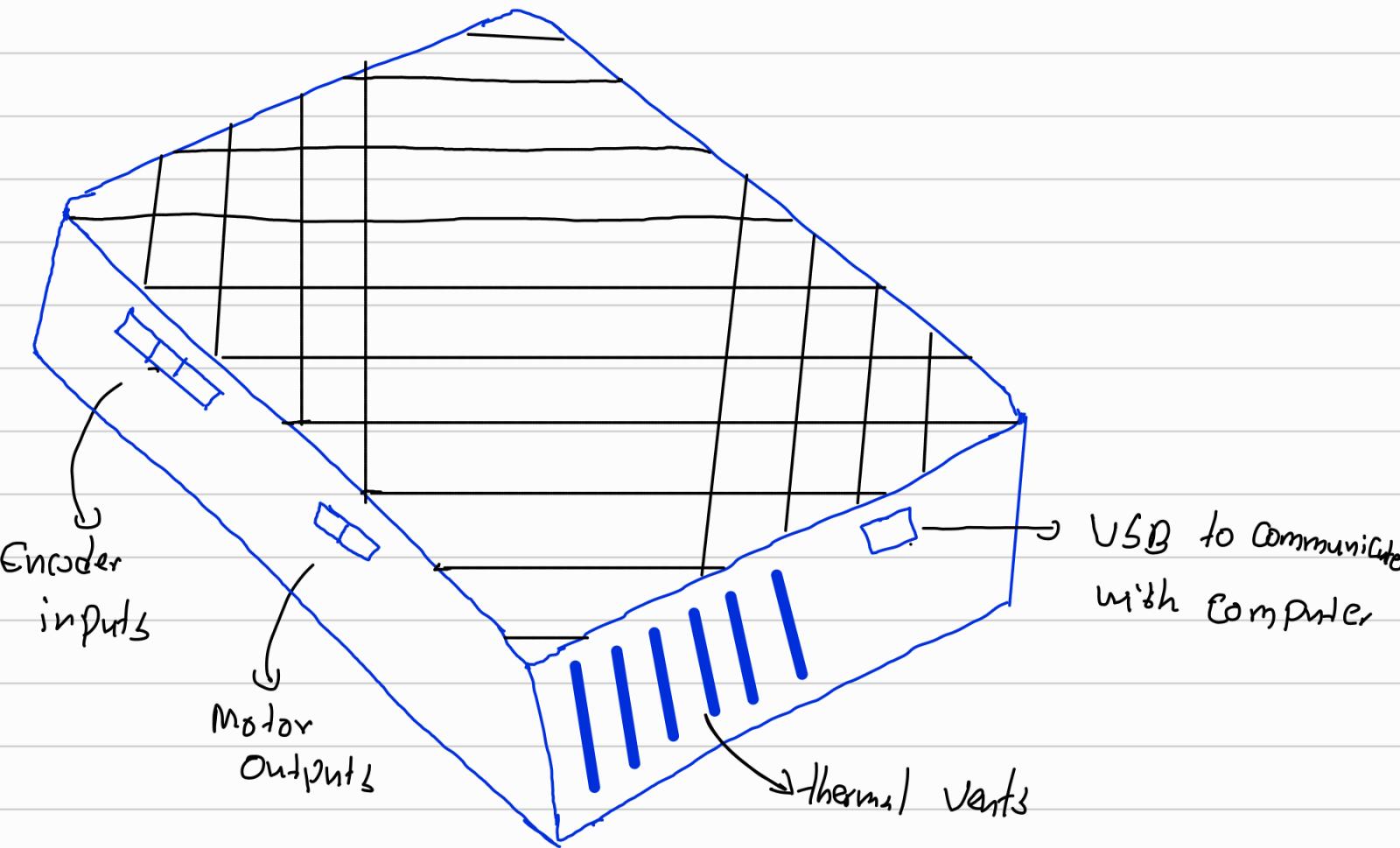
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Stepper motor with encoder



Driver with MCU



Back view

