STSPIN L6470 and L6472

ST motor drivers are moving the future

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Digital. Accurate. Versatile.

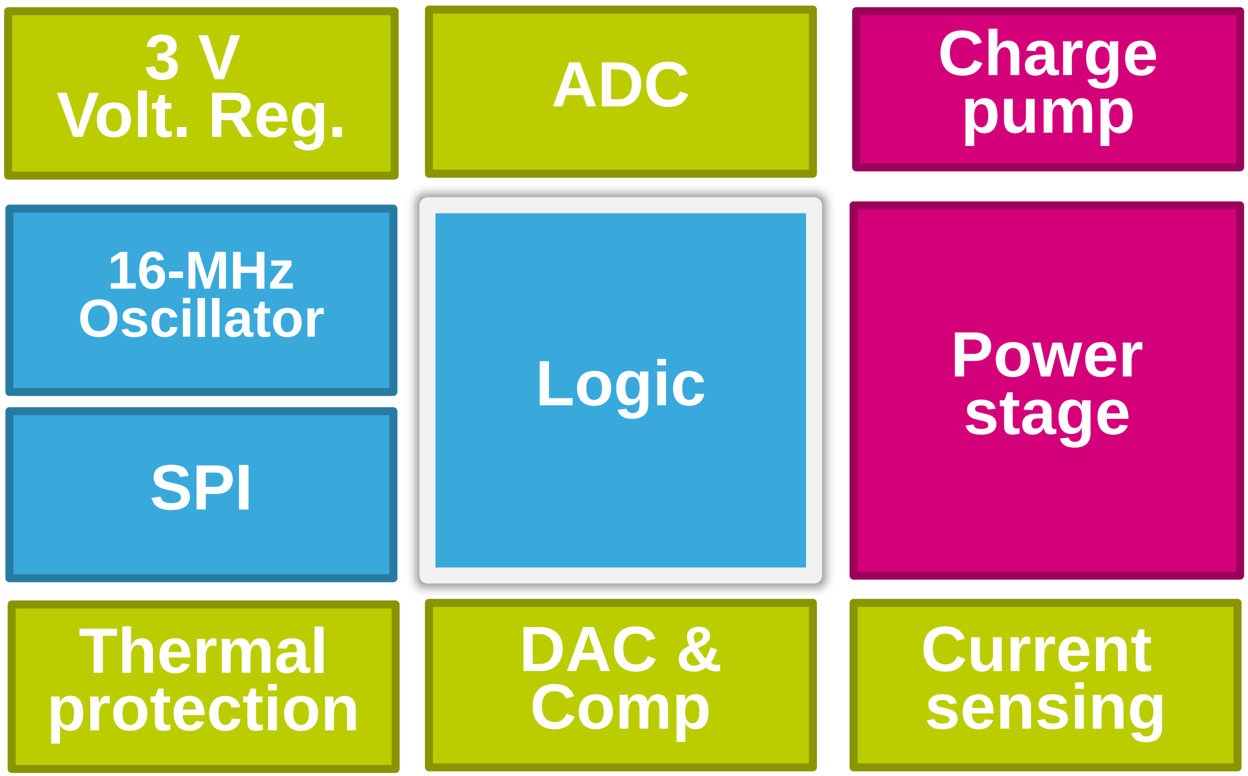
The L6470 and L6472 ICs integrate a complex logic core providing a set of **high-level features**

Logic

- **Current control algorithms**
- **Microstepping**
- **Programmable speed profile**
- **Comprehensive command set**
- **Protections**

Digital. Accurate. Versatile.

The devices also integrate **analog circuitry** and a **dual full-bridge power stage** making it a stand-alone solution for stepper motor driving applications.



L6470 and L6472 characteristics

- Supply voltage **from 8 to 45 V**
- Power stage
  - **3 A_{RMS}**
  - $R_{DS(ON)}$ = **0.28 Ω**
- **Integrated current sensing** (no external shunt)
- Up to **128 microsteps** (L6470)
- Current control
  - **L6470: Voltage mode driving**
  - **L6472: Advanced current control**
- **Sensorless stall detection** (L6470)
- **Digital Motion Engine**
  - Programmable speed profile
  - High-level commands
- 8-bit 5 MHz **SPI interface** (Daisy-chain compatible)
- Integrated 16 MHz oscillator
- Integrated 5-bit ADC
- Integrated 3 V voltage regulator
- **Overcurrent, overtemperature and undervoltage protections**
- **HTSSOP** and **POWERSO** packages

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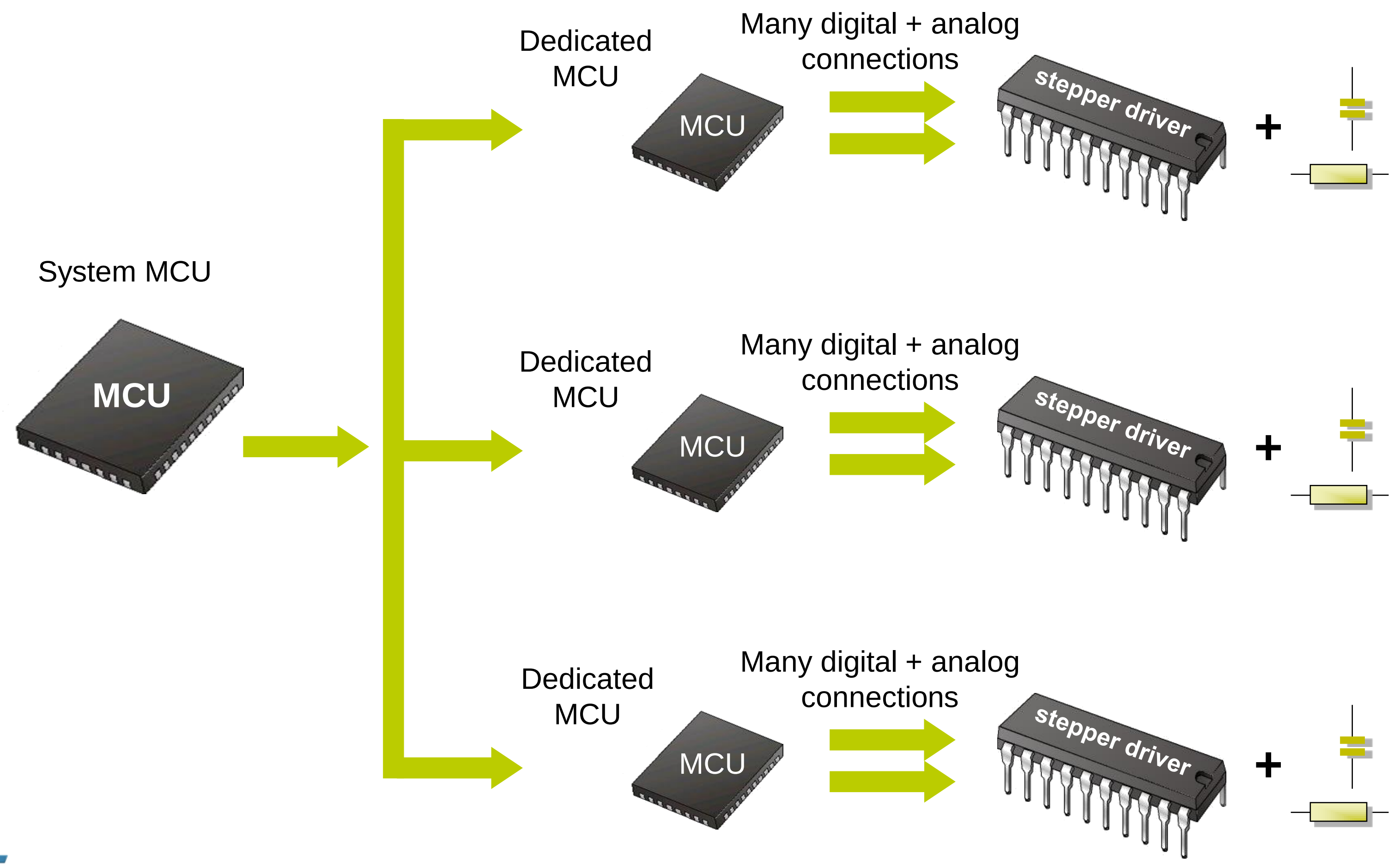
Intelligence integration

Before L6470 and L6472 …



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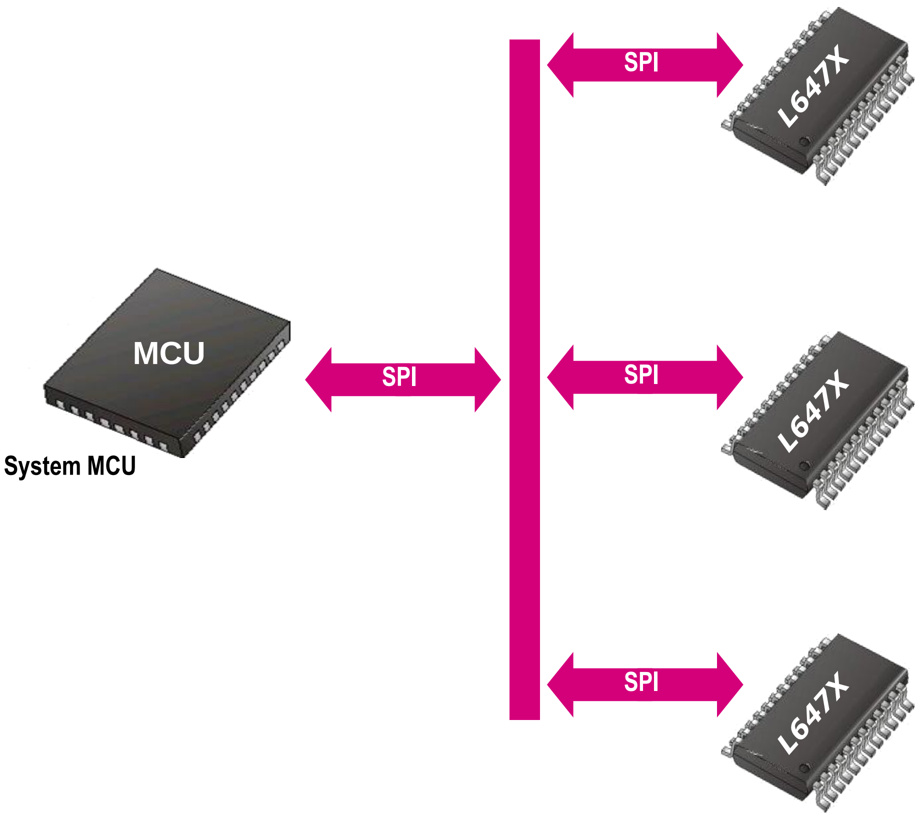
Intelligence integration

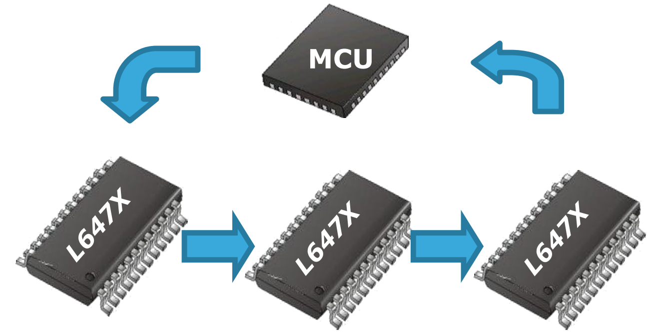
with **L6470 and L6472** ...

- System is greatly simplified
- No more dedicated MCU to perform speed profile and positioning calculations
- Less components
- Single MCU can drive more devices at the same time



A full-digital interface to MCU

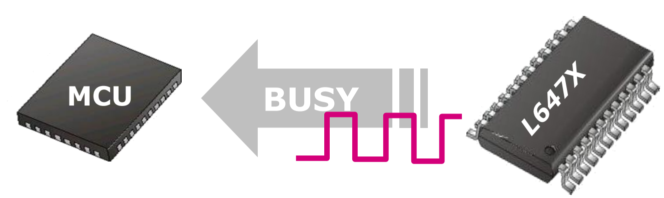
- The fast SPI interface with **daisy-chain** capability allows a single MCU to manage multiple devices



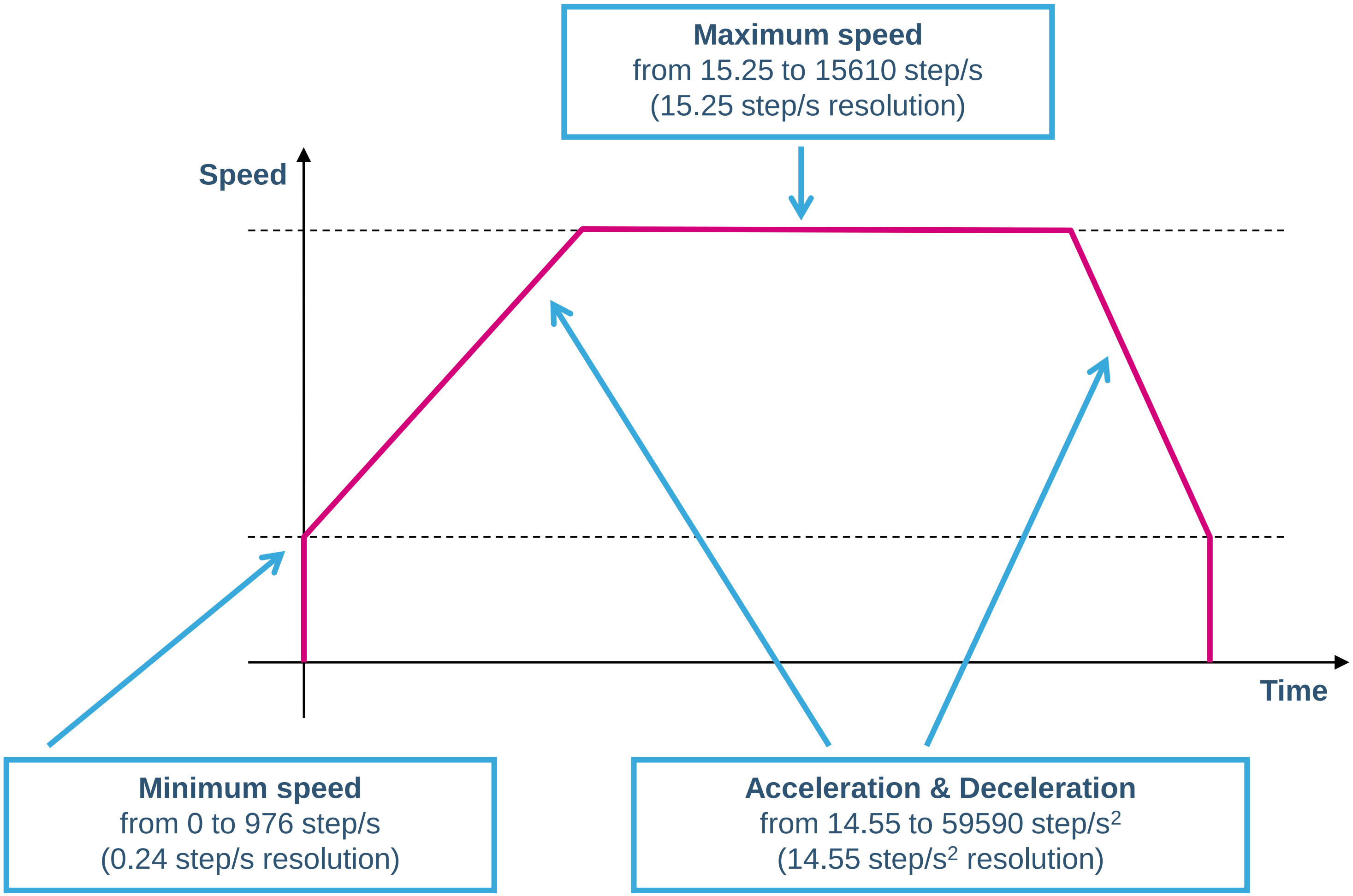
- Programmable alarm **FLAG** open-drain output for interrupt-based FW
  In daisy-chain configuration, **FLAG** pins of different devices can be OR-wired to save host controller GPIOs

- **BUSY** open-drain output allows the MCU to know when the last command has been performed
  In daisy-chain configuration, **BUSY** pins of different devices can be OR-wired to save host controller GPIOs

- BUSY can be used as **SYNC** signal giving a feedback of the step-clock to the MCU
  (programmable # of microsteps)



Fully programmable speed profile boundaries



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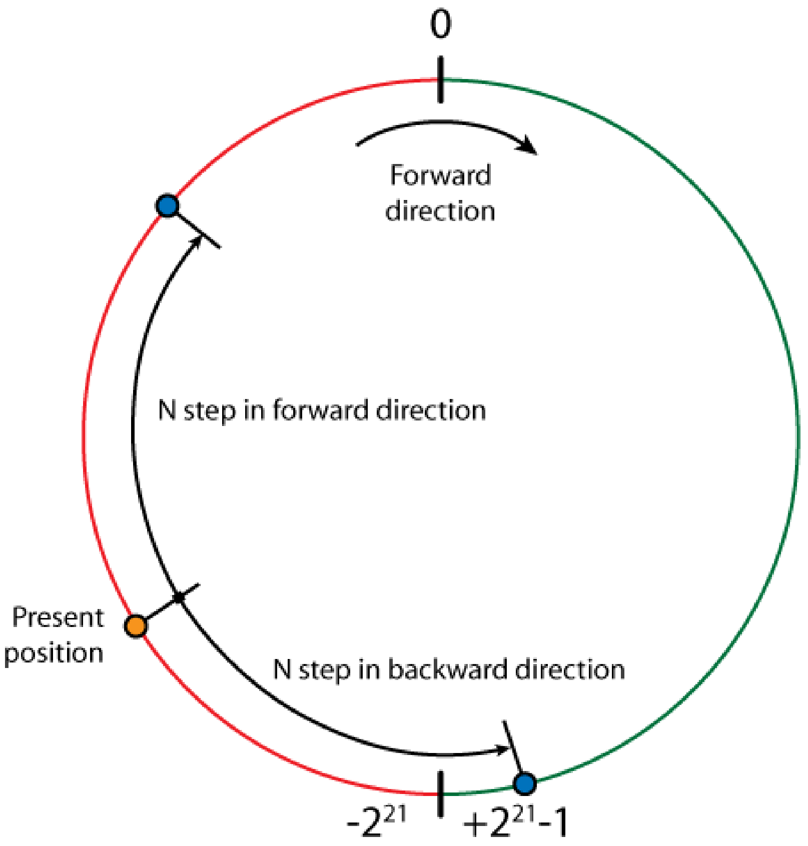
Positioning features: Movement command

Move(N, DIR) command perform a motion of N steps in the selected direction.

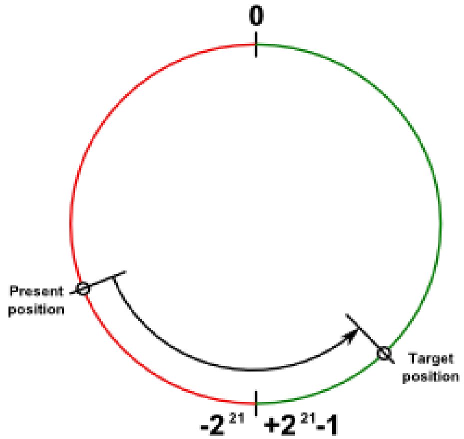
This command can be performed only when the motor is stopped.



Positioning features: Absolute positioning commands

GoTo(Target) command: reach the target position using shortest path.

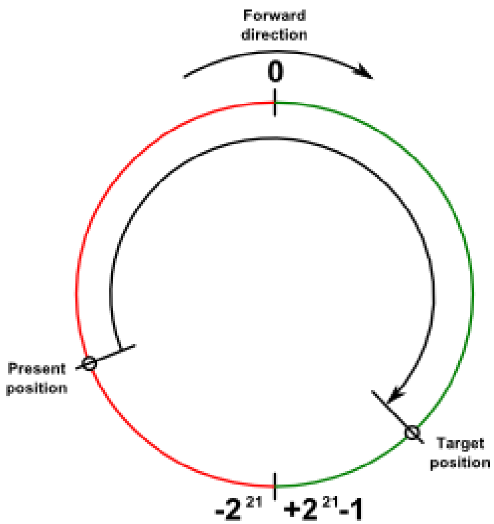
This command can be performed only when motor is stopped or is running at constant speed.



GoTo(Target pos)

GoTo_DIR(Target, DIR) command: reach the target position moving the motor in the selected direction.

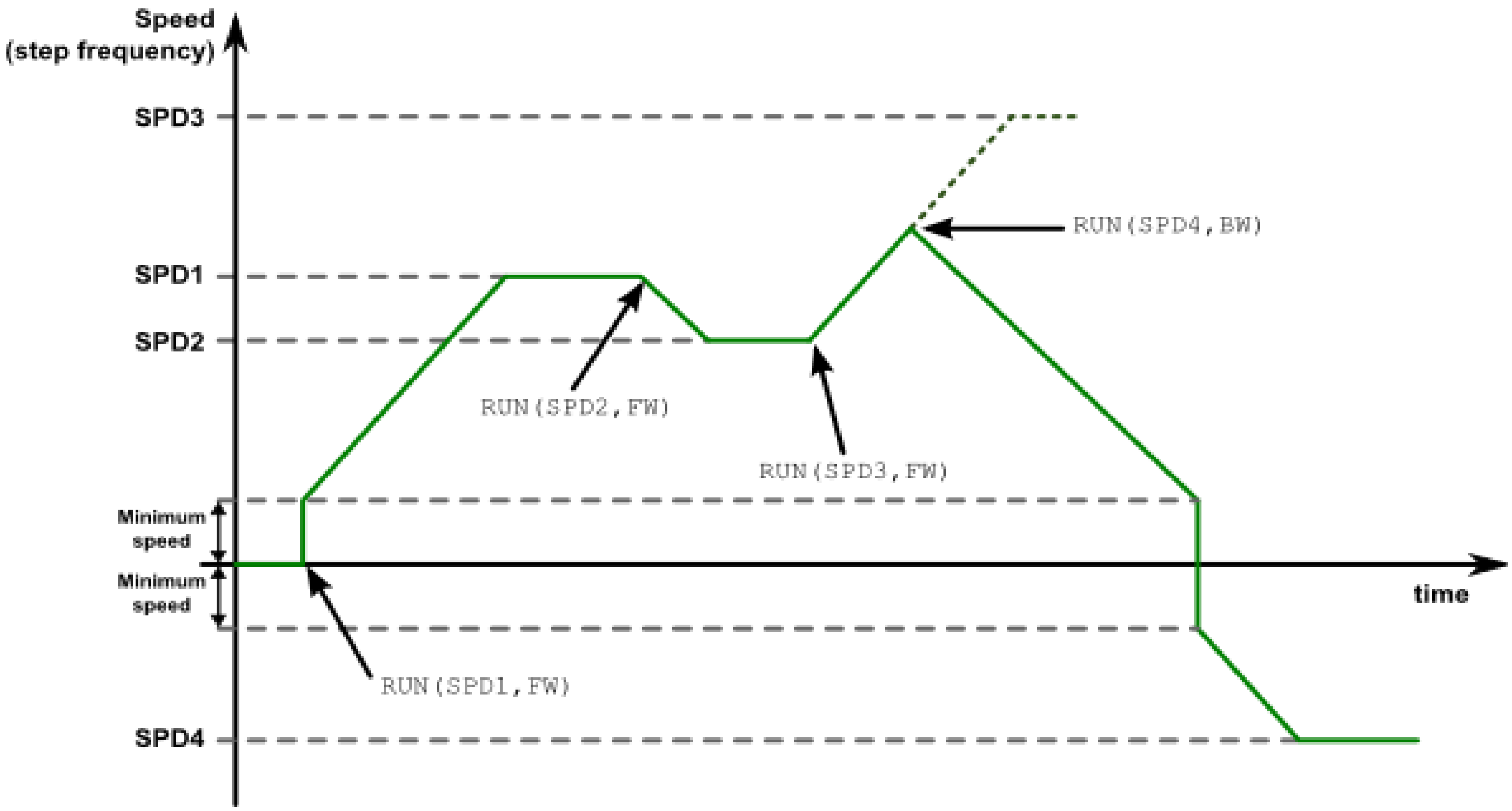
This command can be performed only when the motor is stopped or is running at constant speed.



GoTo_DIR(Target pos,FW)

Speed tracking features: Constant speed command

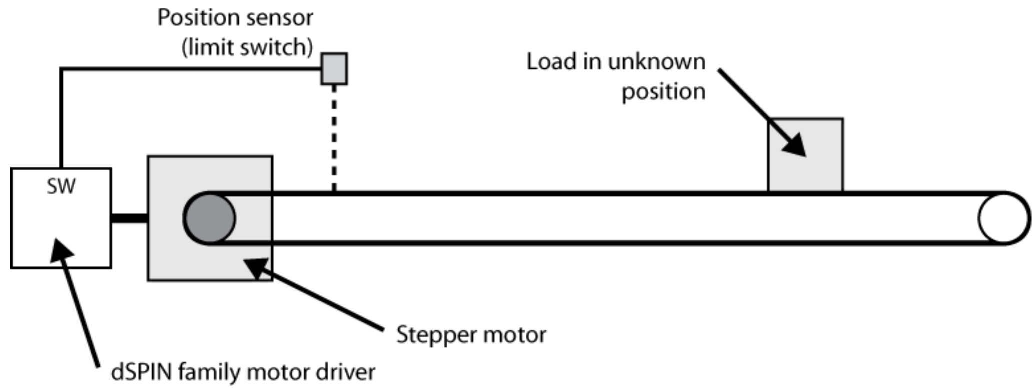
Run(SPD, DIR) command drives the motor to reach the target speed SPD in the selected direction. Target speed and direction can be changed anytime.



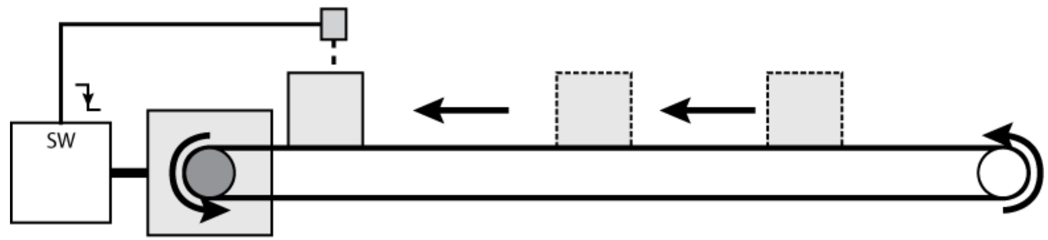
Limit switch management

At power-up, the load could be in an unknown position.

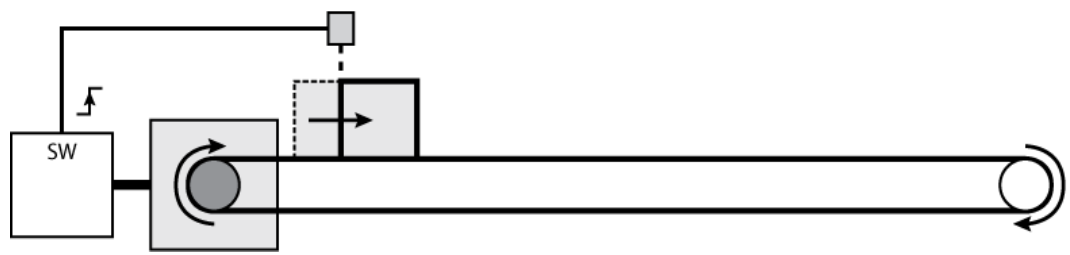
The absolute position counter should be initialized.



The **GoUntil** command moves the mechanical load to the limit switch position.



The **ReleaseSW** command moves the mechanical load on the limit switch triggering threshold.



Programmable overcurrent protection

Each MOSFET of the power stage is protected by an overcurrent protection system.

The overcurrent threshold can be programmed **from 375 mA to 6 A**.

When the current in one of the MOSFET exceeds the threshold, the whole power stage is **immediately turned OFF**.

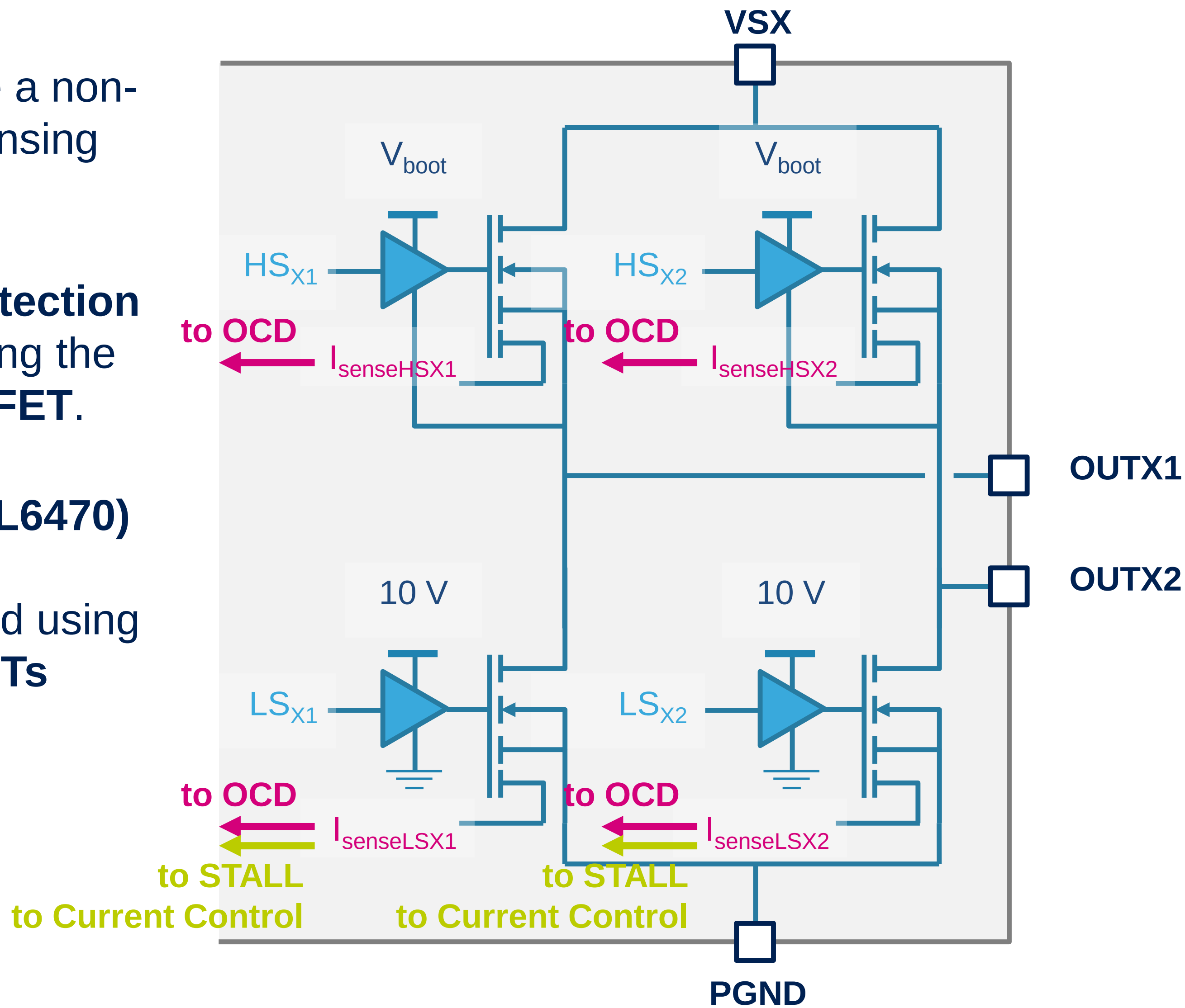
The power stage **cannot be enabled until a GetStatus command releases the failure condition**.

Current sensing

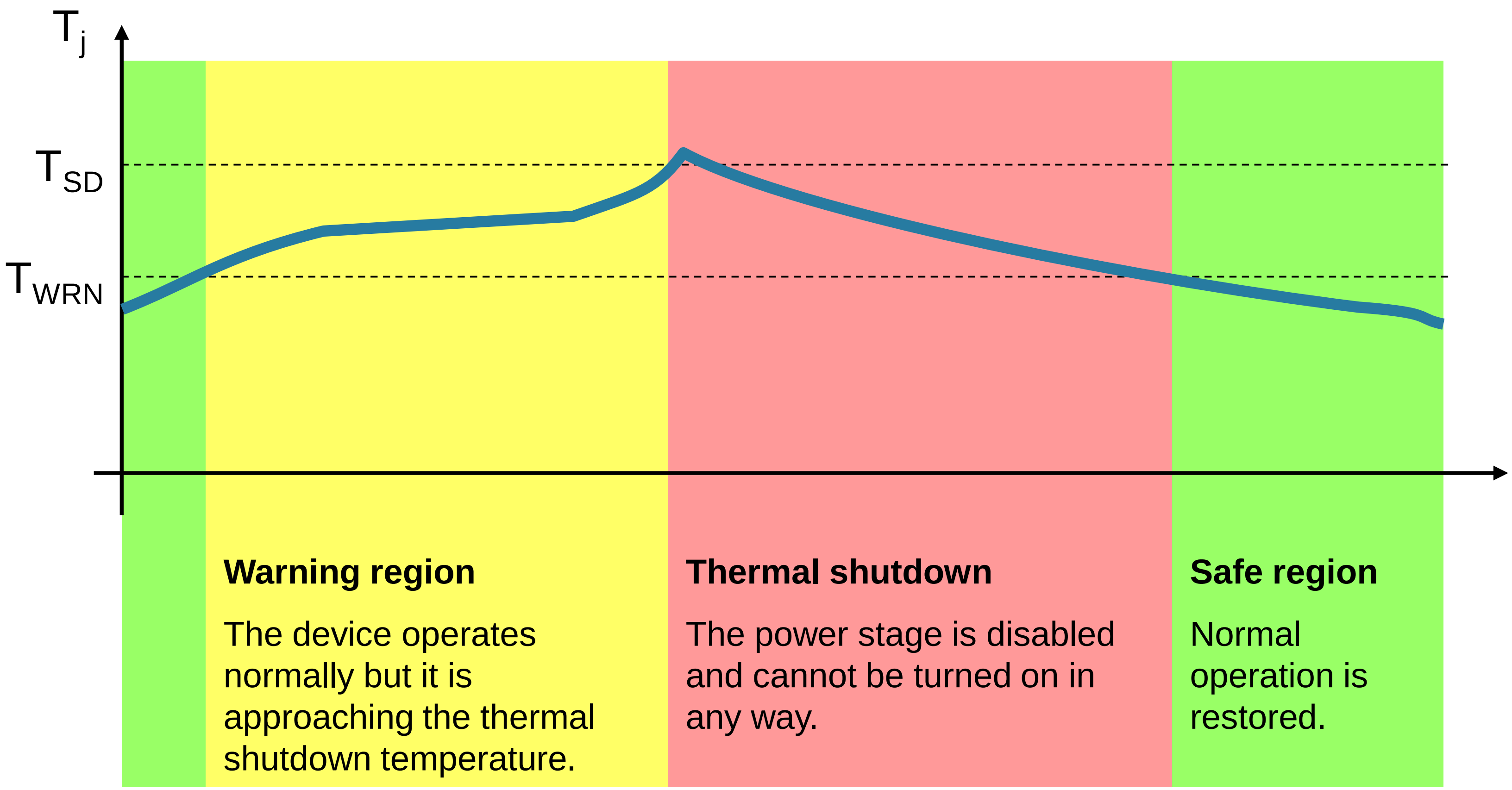
The devices integrate a non-dissipative current sensing on each MOSFET.

The **overcurrent protection** is performed measuring the current in **each MOSFET**.

The **stall detection (L6470)** and **current control (L6472)** are performed using the **low-side MOSFETs** current value.



Warning temperature and thermal shutdown



Diagnostic register

The devices integrate a diagnostic register collecting the information about the status of the system:

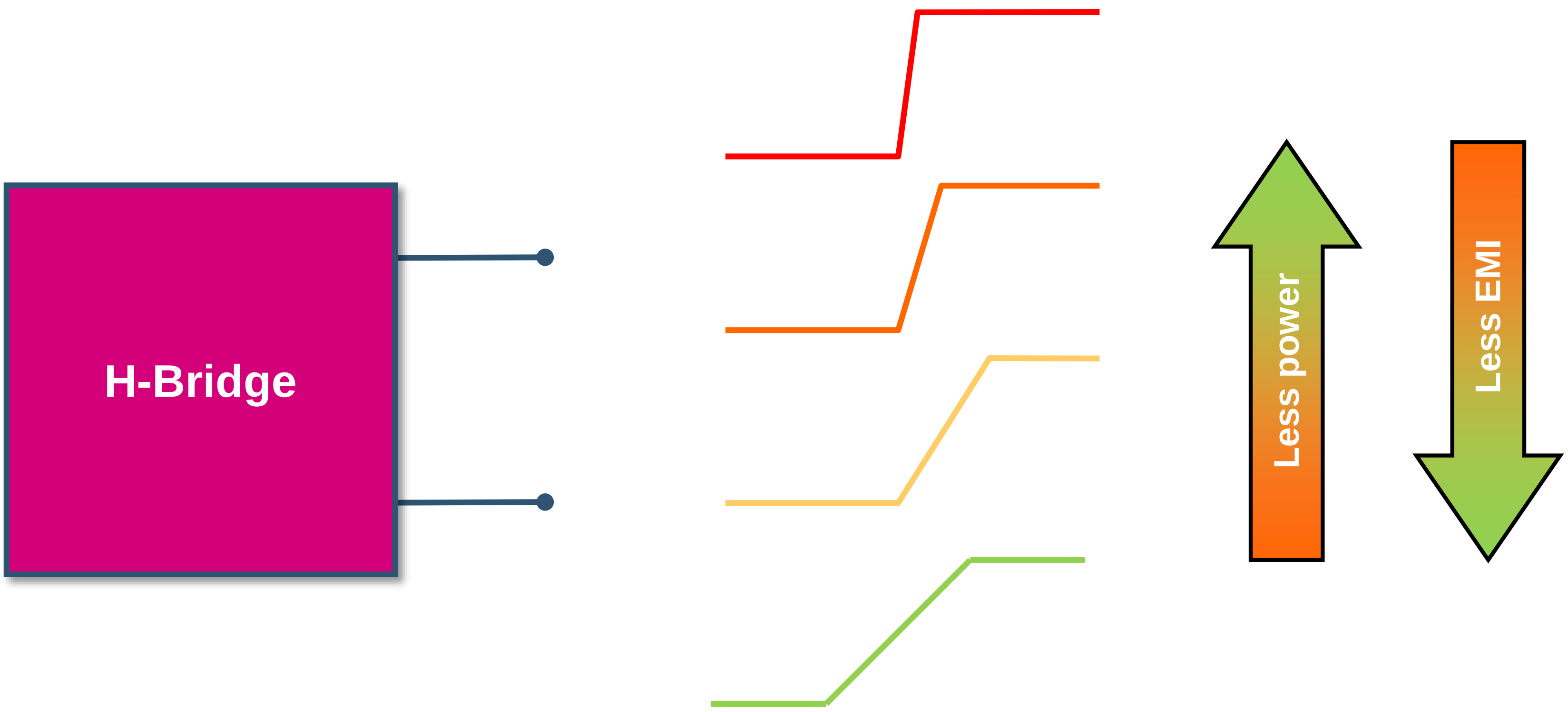
STATUS

Register

- Power stage enabled/disabled
- Command under execution (BUSY)
- Motor status (direction, acc., dec., etc.)
- Step-clock mode
- Overcurrent
- Thermal status
- Undervoltage (it also indicates the power-up status)
- Stall detection
- SW status
- SW input falling edge (limit switch turn-on)
- Incorrect or not performable command received

Programmable output slew-rate

Four output slew-rate values can be selected via SPI in order to fit the application EMI / Power dissipation tradeoff.



L6470
Voltage mode driving

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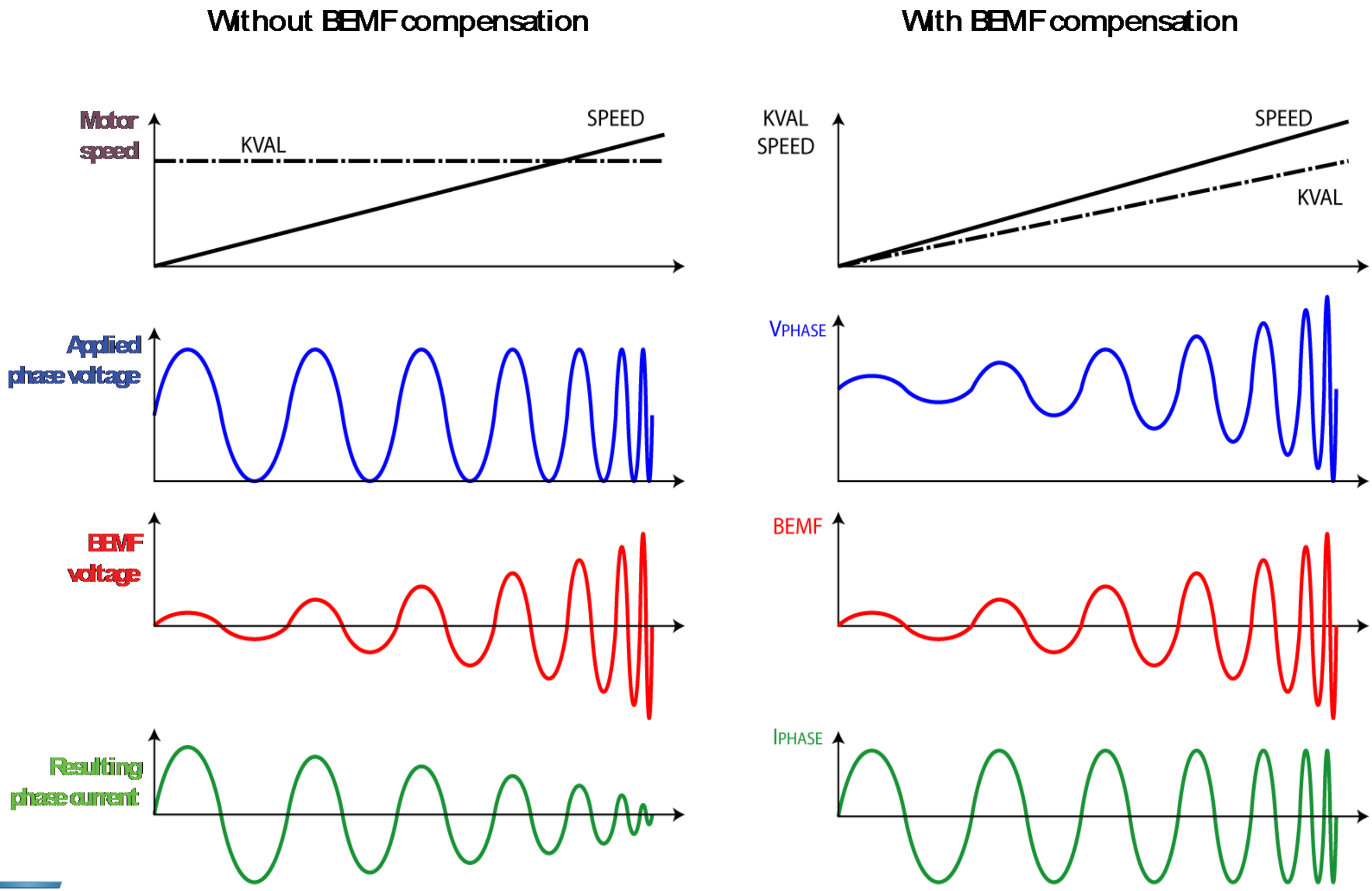
BEMF compensation

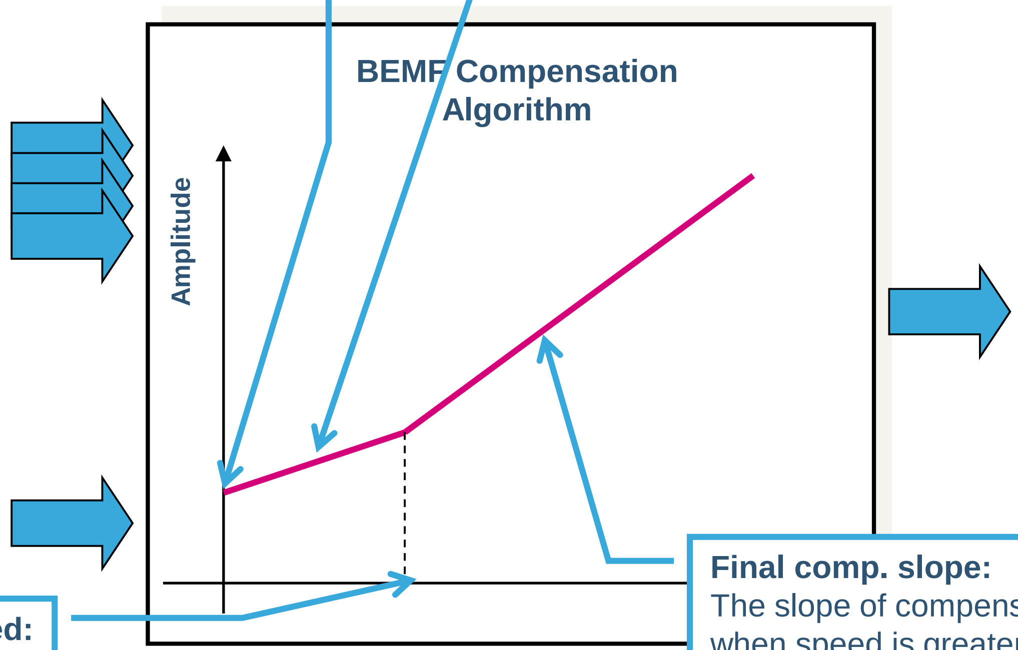


BEMF compensation

Starting amplitude:
The “zero speed” amplitude of the output sinewave

Starting comp. slope:
The slope of compensation curve when speed is lower than the *Intersect speed*

BEMF compensation parameters:
Starting amplitude
Starting comp. slope
Final comp. slope
Intersect speed



Sinewave amplitude

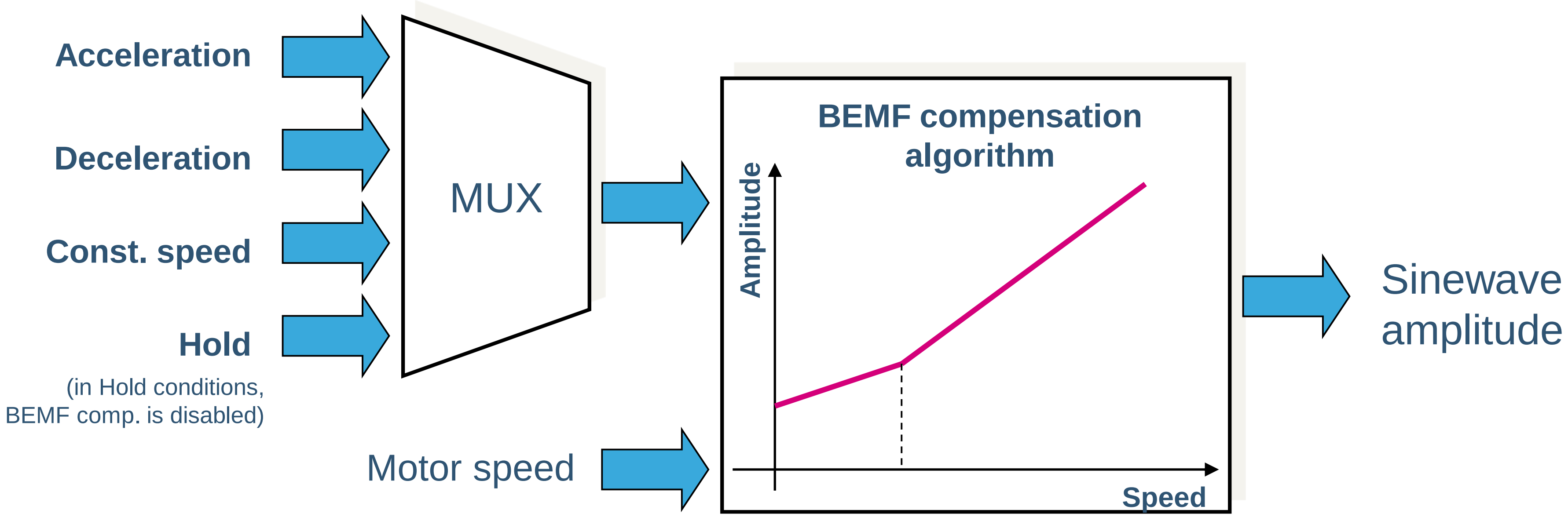
Motor speed

Intersect speed:
Speed at which the compensation curve slope switches from starting to final value

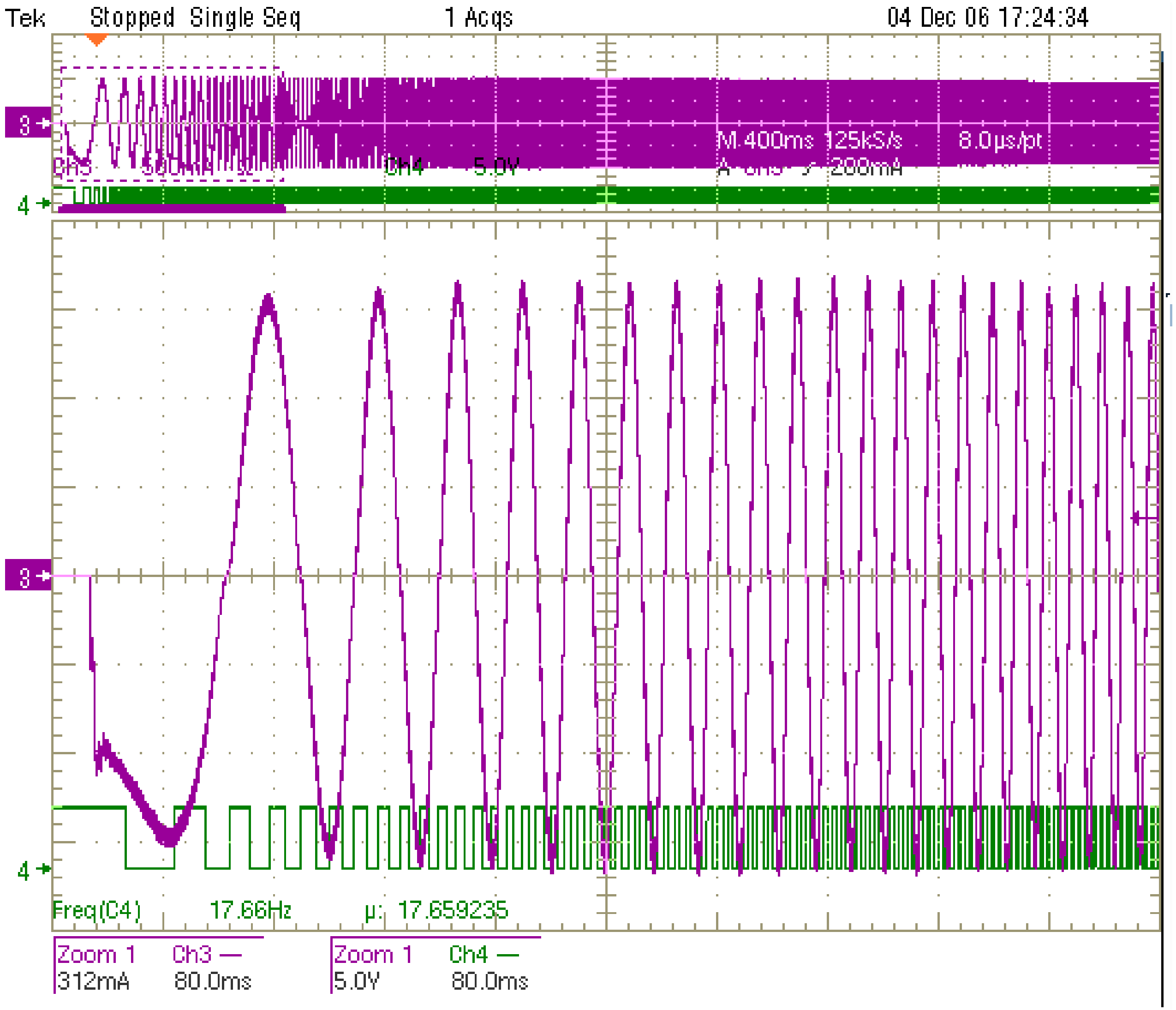
Final comp. slope:
The slope of compensation curve when speed is greater than the *Intersect speed*

BEMF compensation

According to motor conditions (acc/deceleration, constant speed, hold), a different torque, and then current, could be needed.

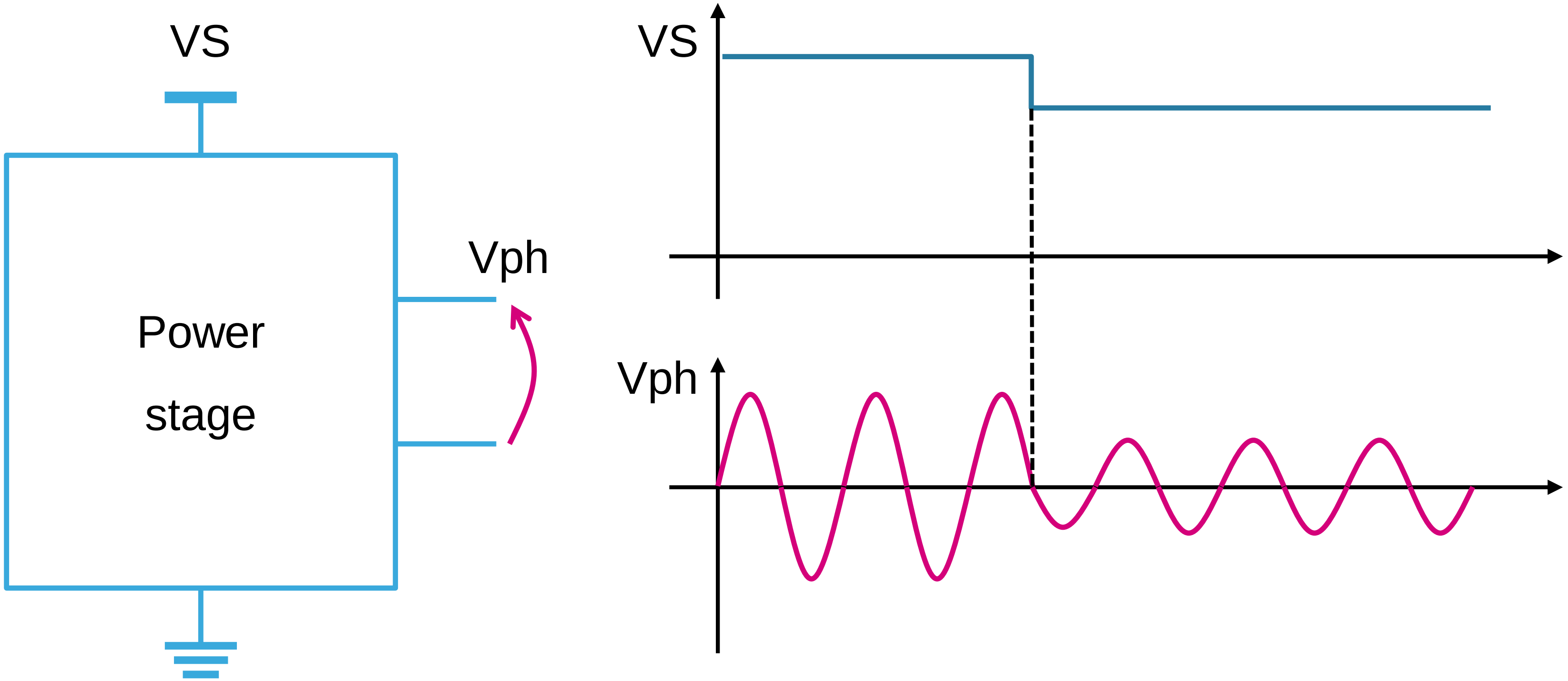


BEMF compensation

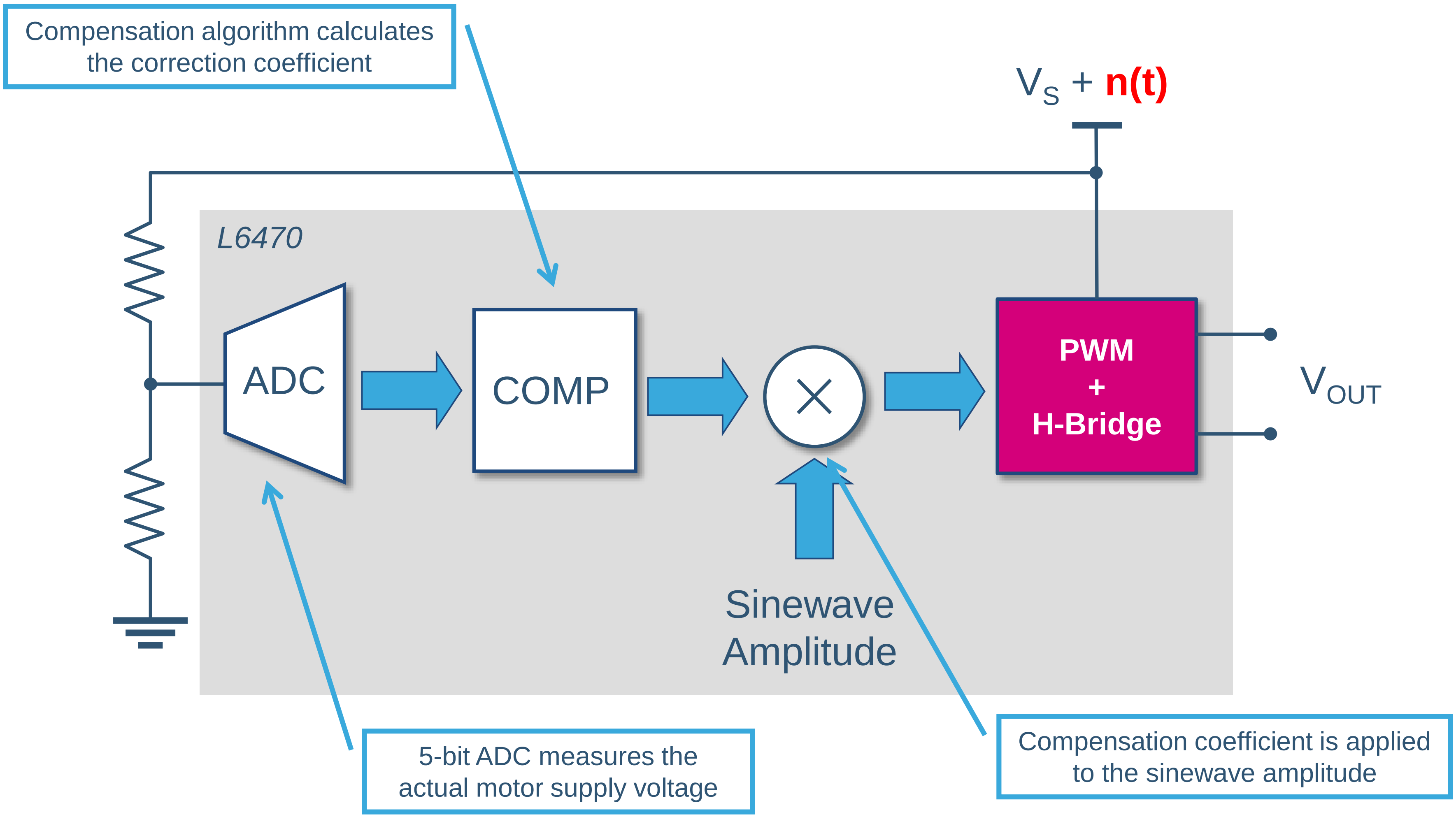


Supply voltage compensation

The voltage sinewaves are generated through a PWM modulation. As a consequence, the actual phase voltage depends on the supply voltage of the power stage.

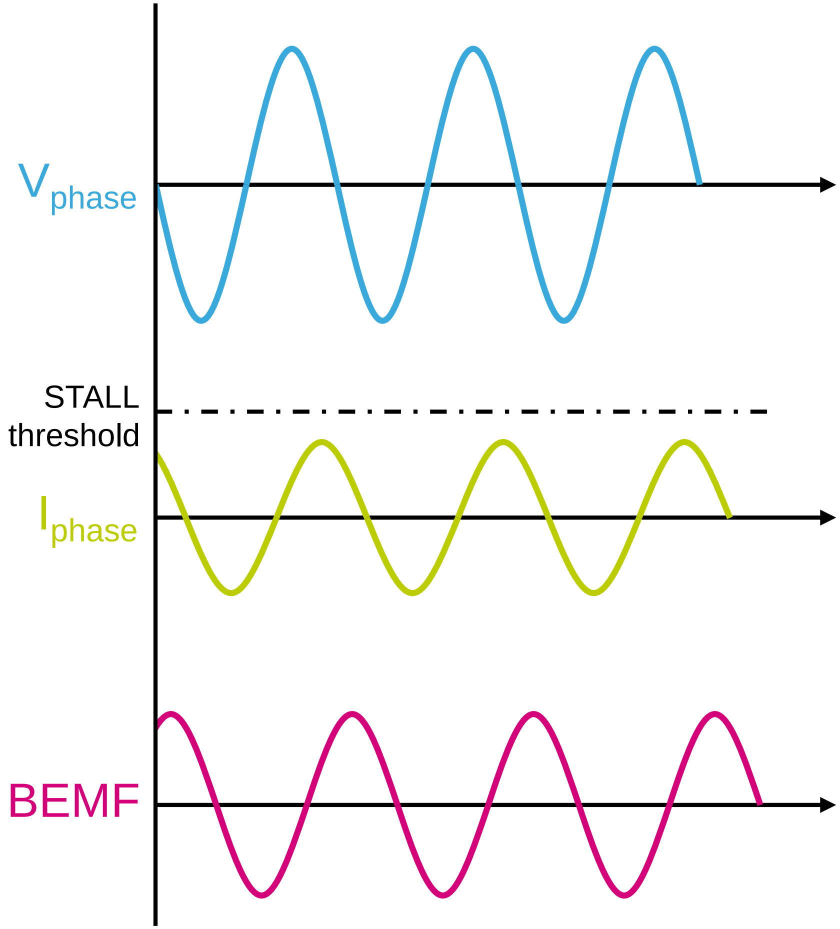


Supply voltage compensation

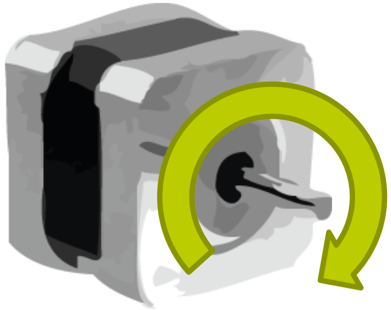


Sensorless stall detection

Using integrated current sensing and the adjustable STALL current threshold, a cheap and easy stall detection function can be implemented.



Normal operation



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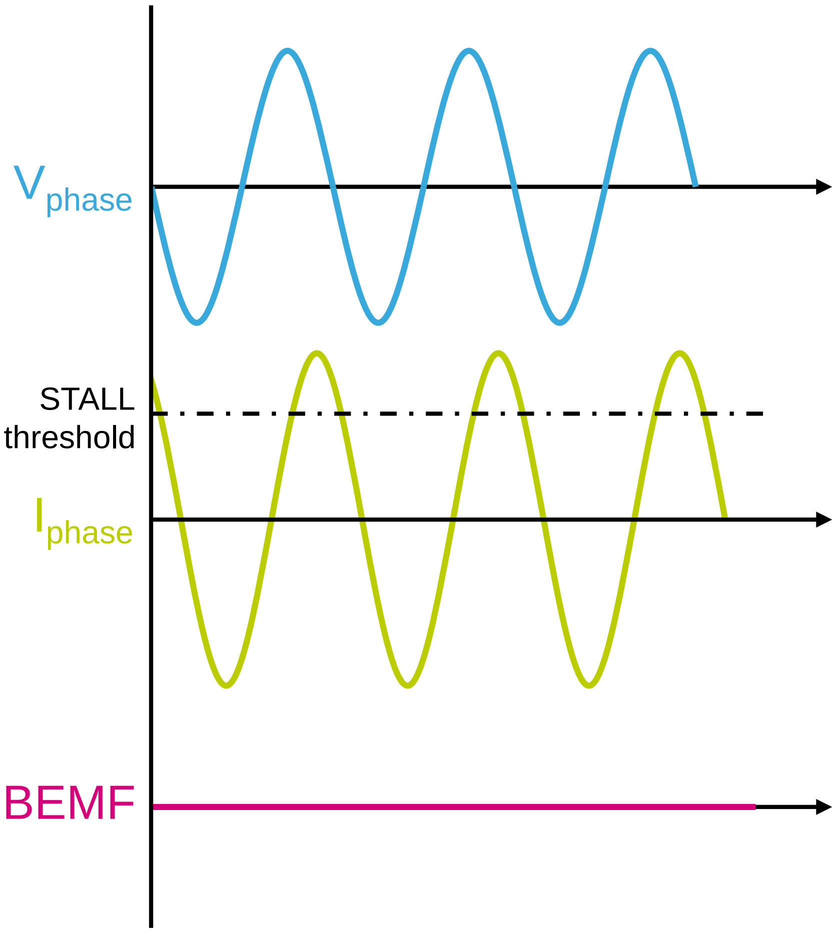
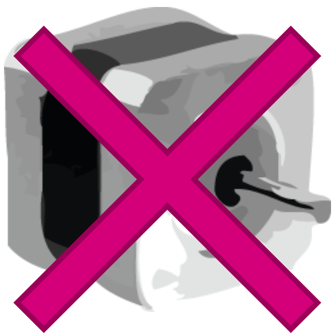


STALL!
BEMF is null and current is suddenly increased



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Sensorless stall detection limitations

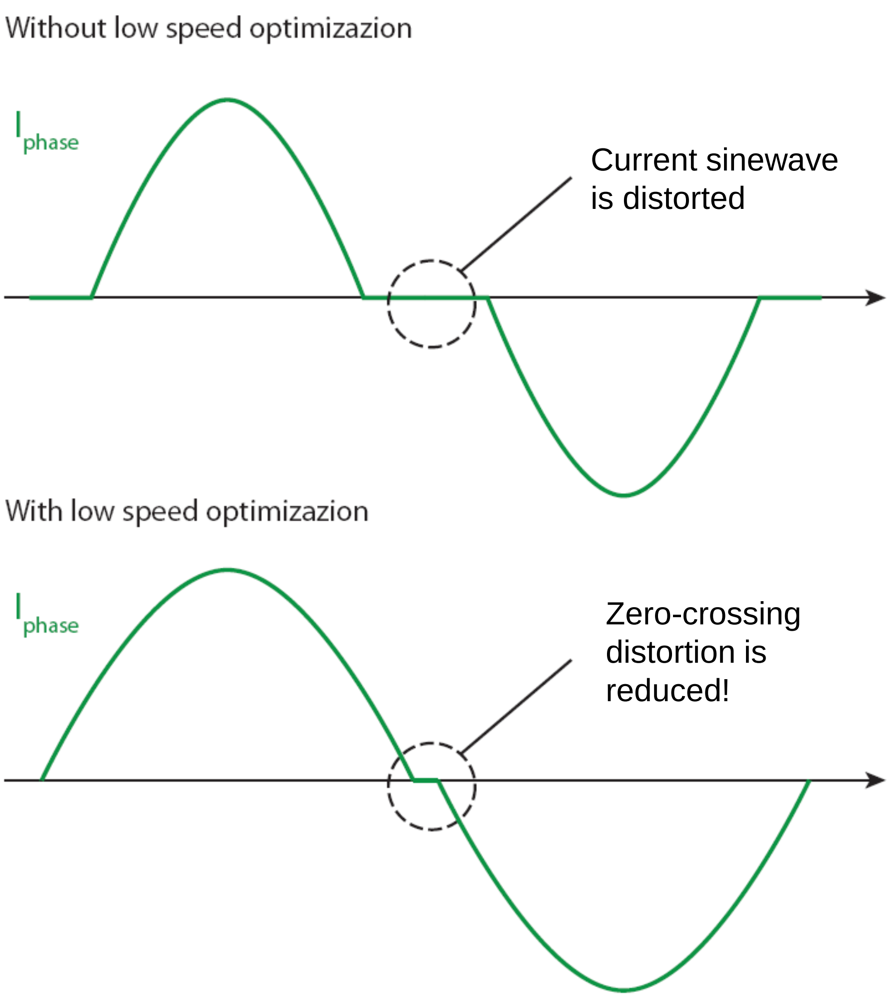
Stall detection performances can be reduced in the following conditions:

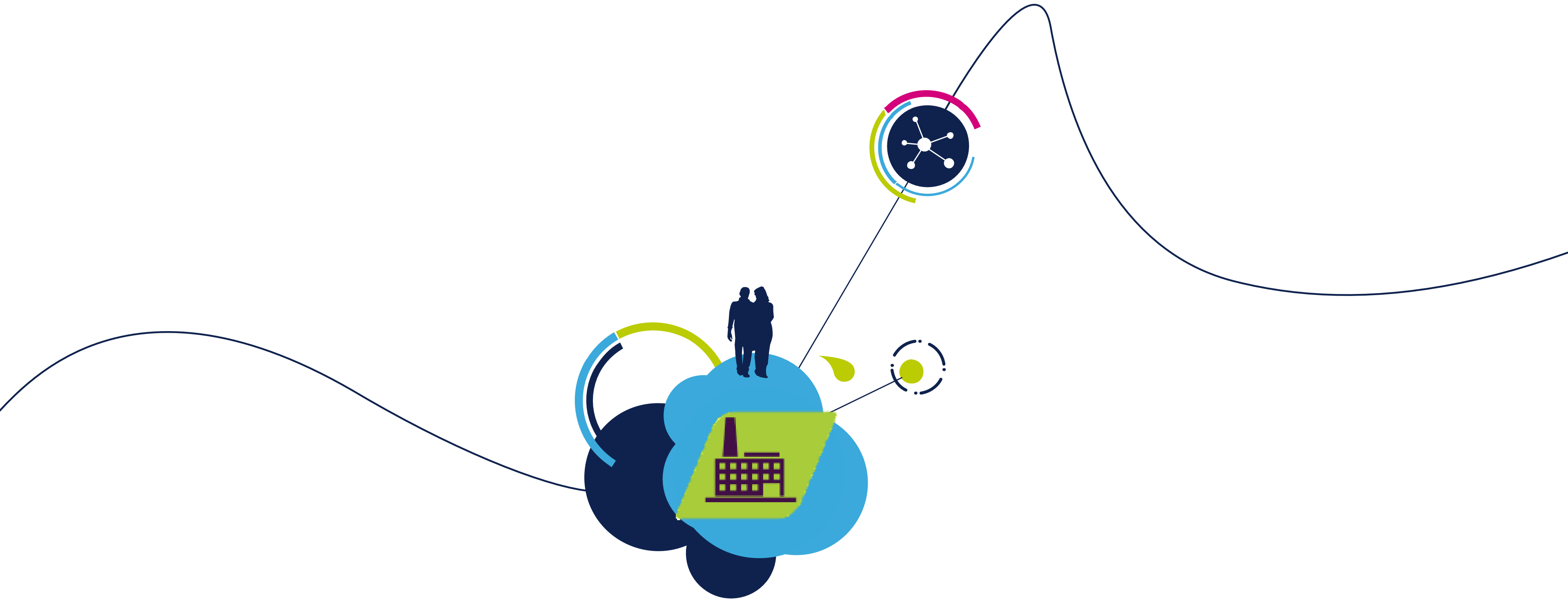
- Low speed
  (negligible BEMF value)
- High speed
  (current can be low due to the low-pass filtering effect of the inductor)

Slow speed optimization

- During low-speed movements, the sinewave current could suffer from zero-crossing distortion.
  As result, **the motor rotation is discontinuous.**

- New low-speed optimization algorithm heavily reduce the distortion.
  Smoothness of the driving is increased.





L6472
Advanced current control

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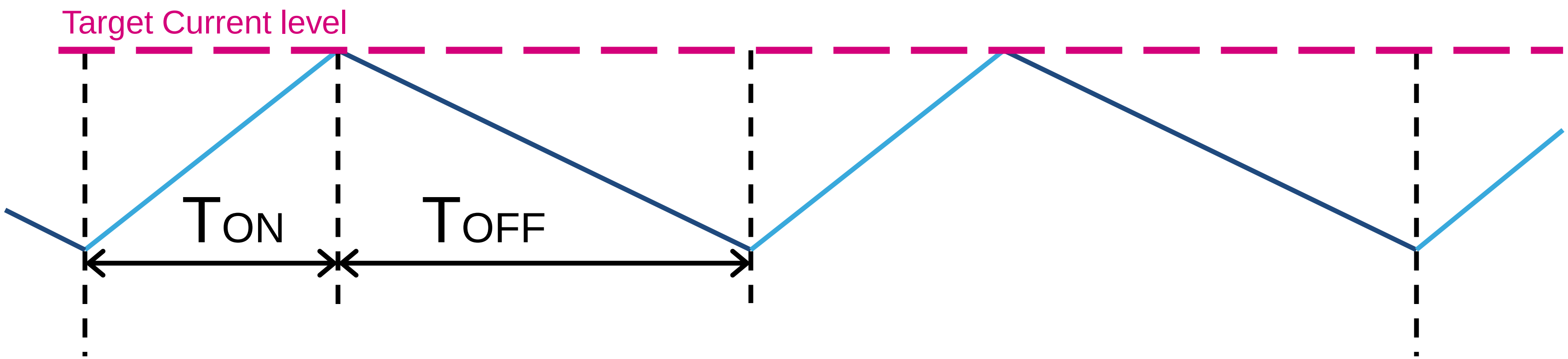
Advanced current control

- **Automatic selection of the decay mode**
  Stable current control in microstepping
- **Slow decay and fast decay balancing**
  Reduced current ripple
- **Predictive current control**
  Average current control

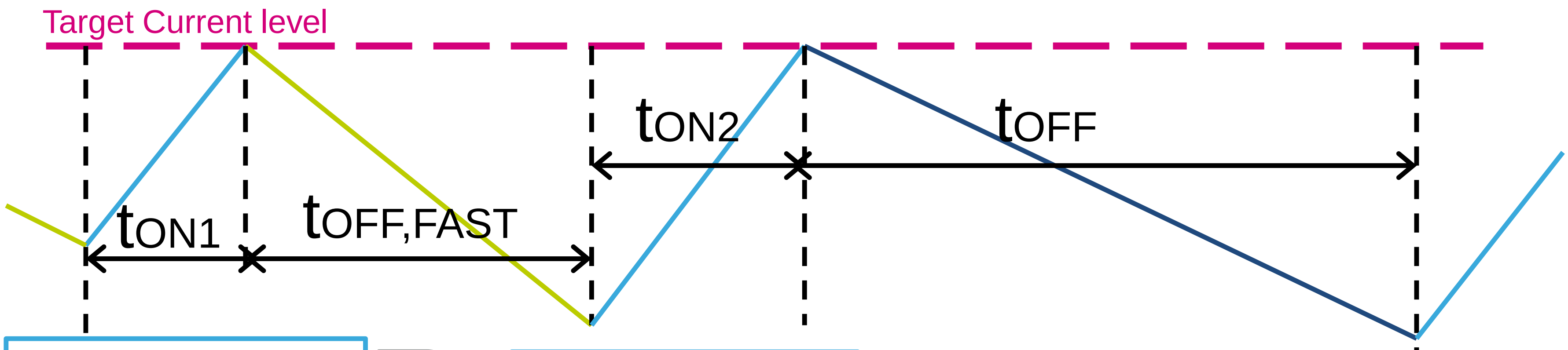
Challenges to perform the right decay



During the OFF state, both slow and fast decay must be used for a better control:

L6472 performs an
AUTO-ADJUSTED DECAY

Auto-adjusted decay



tON1 < TON_MIN

Fast decay for

tOFF,FAST = TOFF_FAST/8

in order to remove more energy than a slow decay

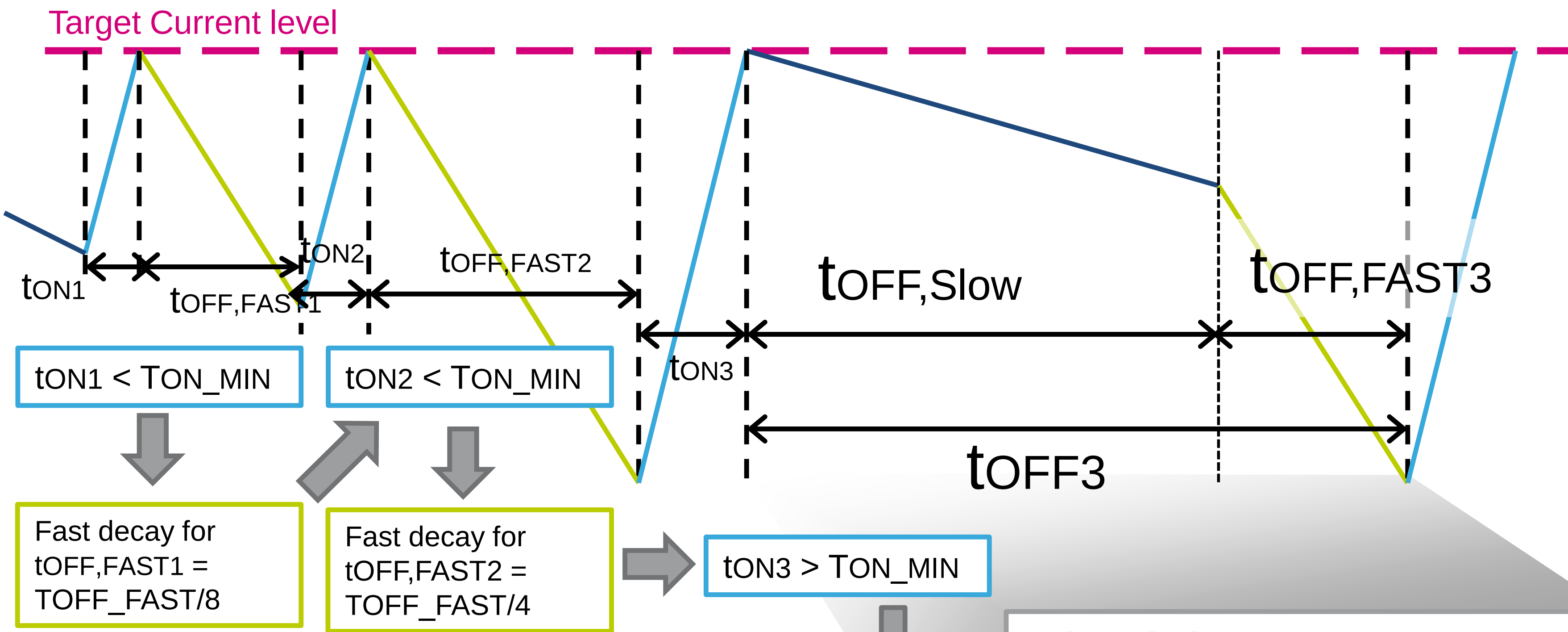
tON2 >TON_MIN

Slow decay for tOFF = TSW(*)

Parameter	Function
TON_MIN	Target minimum ON time
TOFF_FAST	Maximum fast decay duration
TSW	Fixed OFF time(*)

(*) No predictive control

Auto-adjusted decay



Mixed decay :

tOFF3 = TSW (*)

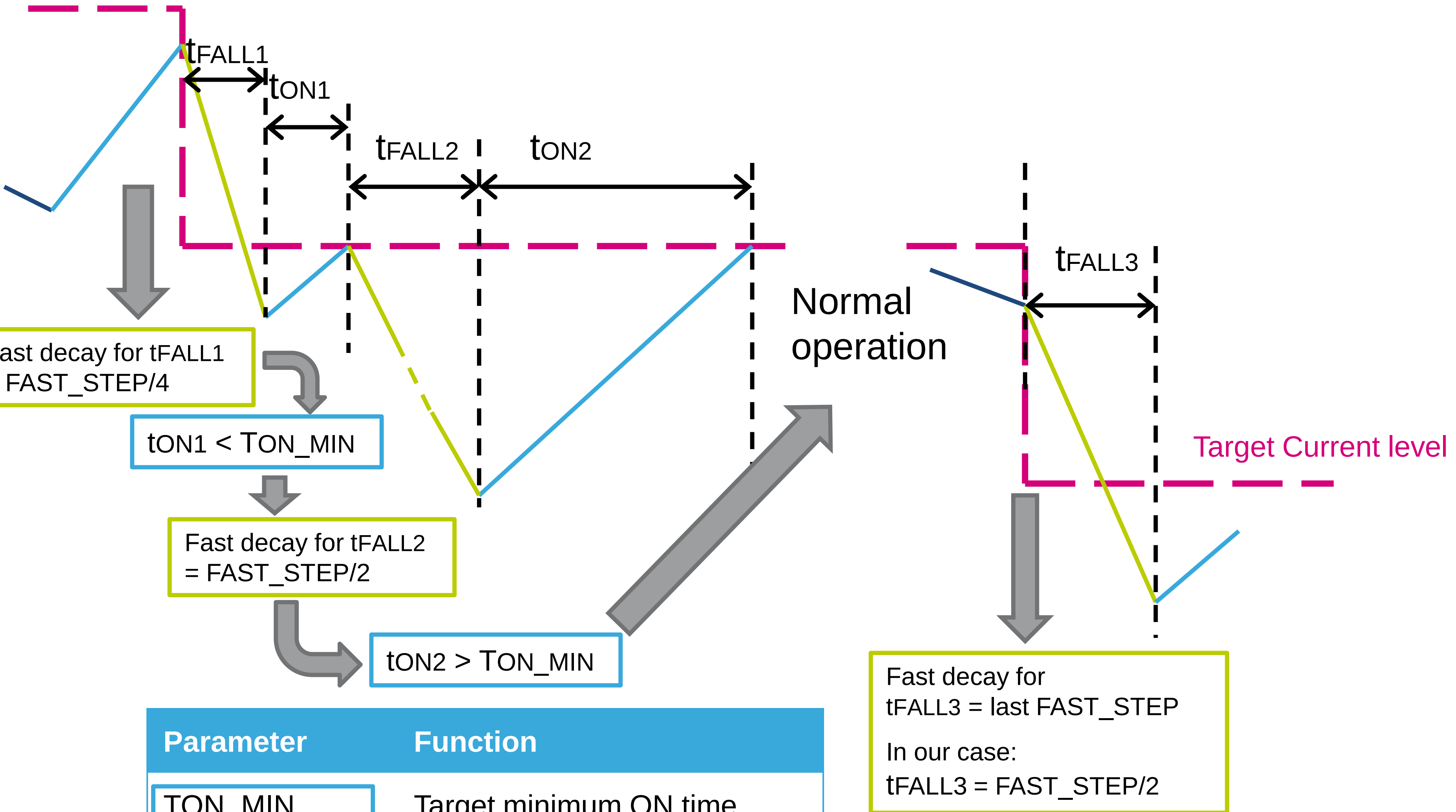
tOFF,FAST3 = tOFF,FAST2 = TOFF_FAST/4

tOFF,Slow = tOFF3 – tOFF,FAST3

Parameter	Function
TON_MIN	Target minimum ON time
TOFF_FAST	Maximum fast decay duration
TSW	Fixed OFF time(*)

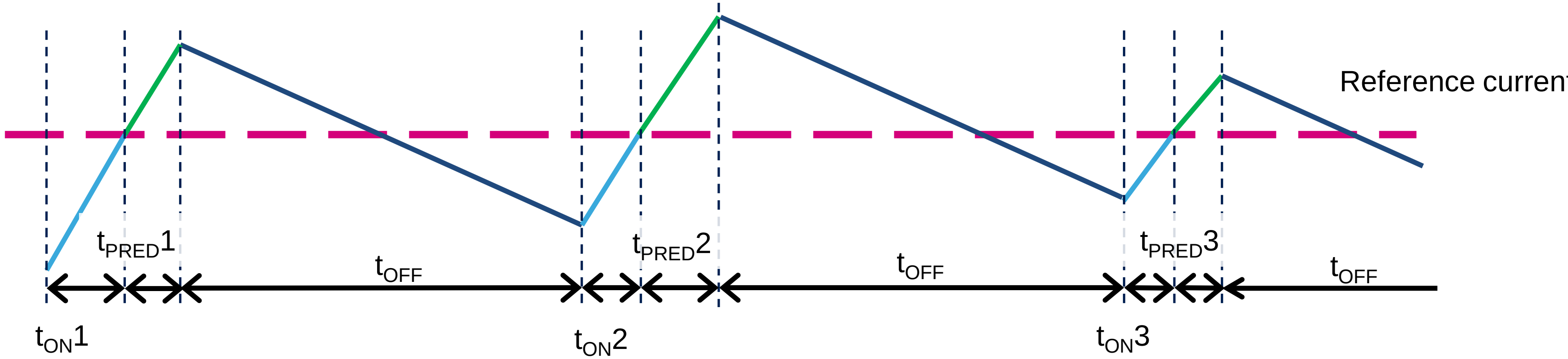
(*) No predictive control

Falling step control



Parameter	Function
TON_MIN	Target minimum ON time
FAST_STEP	Maximum fast decay duration during falling steps

Predictive current control: average current



t_{ON1} is measured

Extra on time of $t_{PRED}1$ is performed

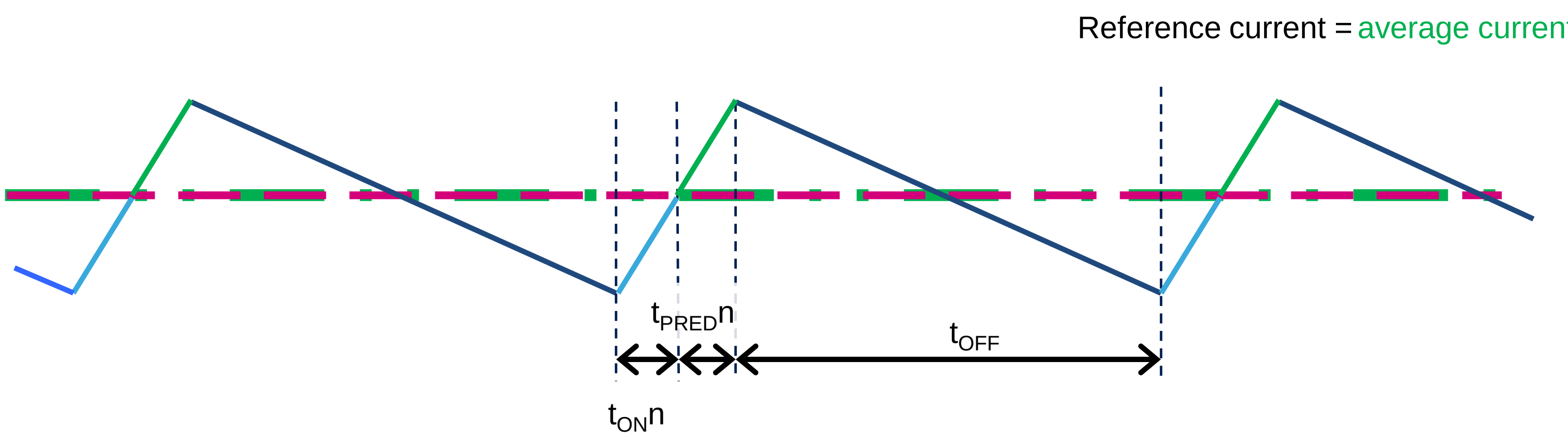
Current decay

The extra on time is calculated cycle-by-cycle using the following formula:

$$t_{PRED}n = (t_{ON}n\text{-}1 + t_{ON}n)/2$$

Note: The TON_MIN limit of the current control is checked on t_{ON} time only.
If t_{ON} < TON_MIN, no extra on time is performed and the decay adjustment sequence is performed.

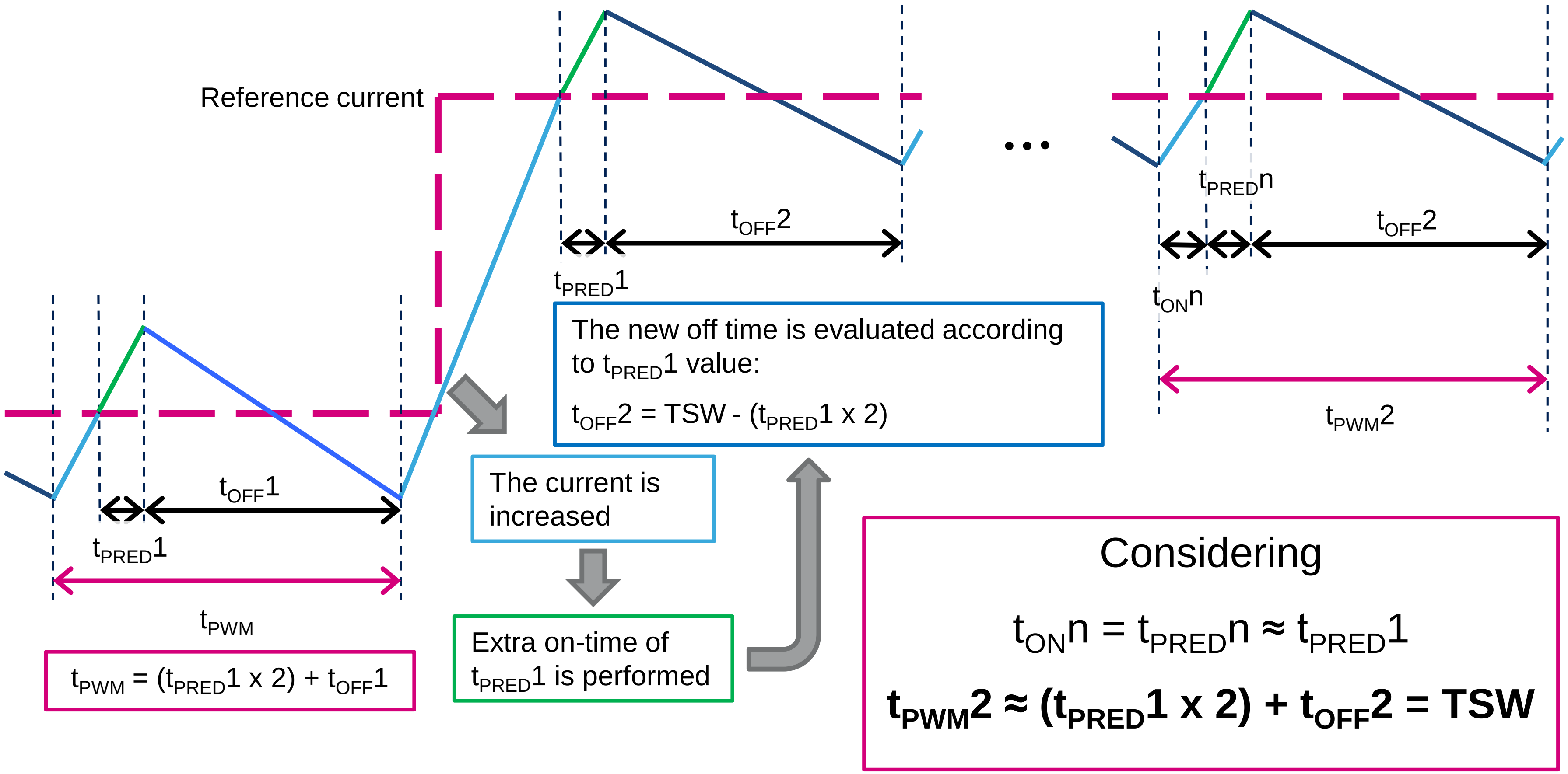
Predictive current control: average current



When the system reaches the stability → $t_{PRED}n = t_{ON}n$

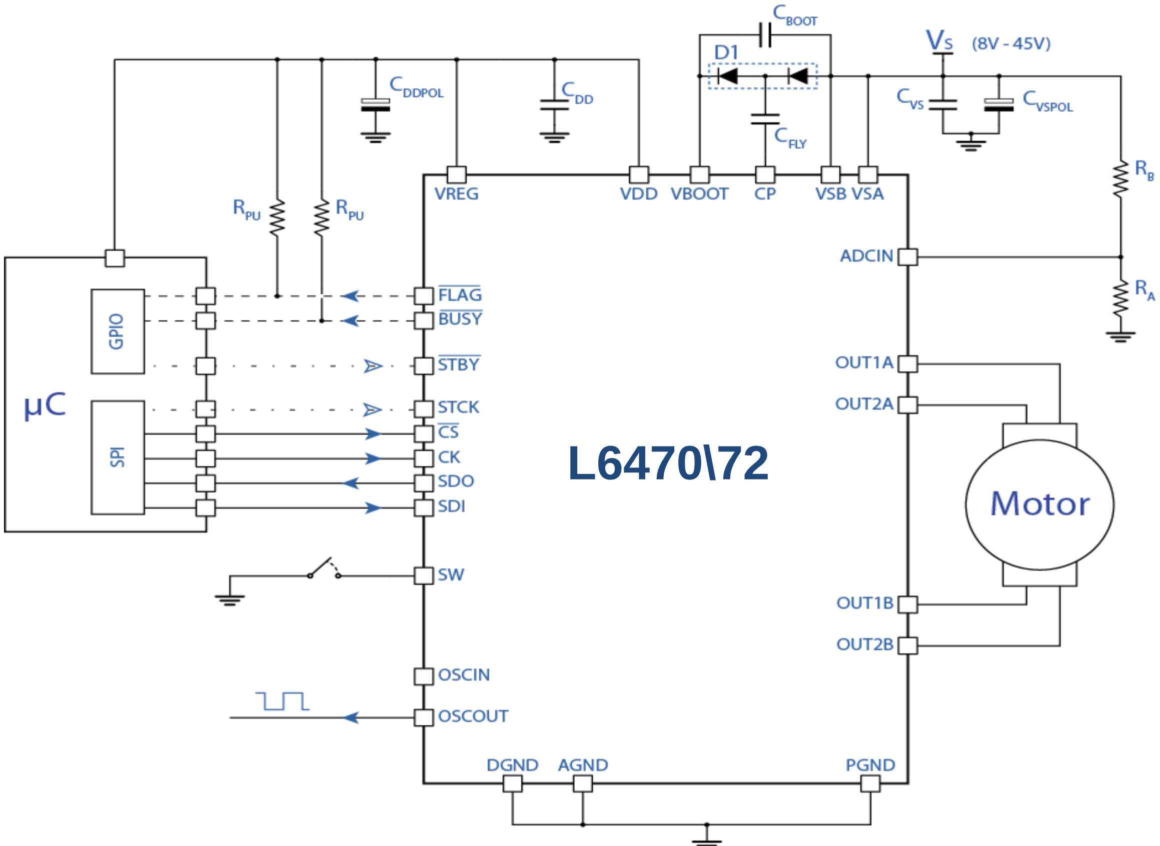
In this case the average current is equal to the reference: the system implements a control of the average value of the current.

Predictive current control: switching freq.



Typical application

- Minimal component count
- MCU needs only **1 SPI interface** and **2-4 optional GPIOs**



Competitive advantages

- High level of integration
- Integrated current sensing
- Advanced diagnostics
- Stand-alone solution
- Suitable for multi-motor applications

Further information and full design support can be found at www.st.com/stspin