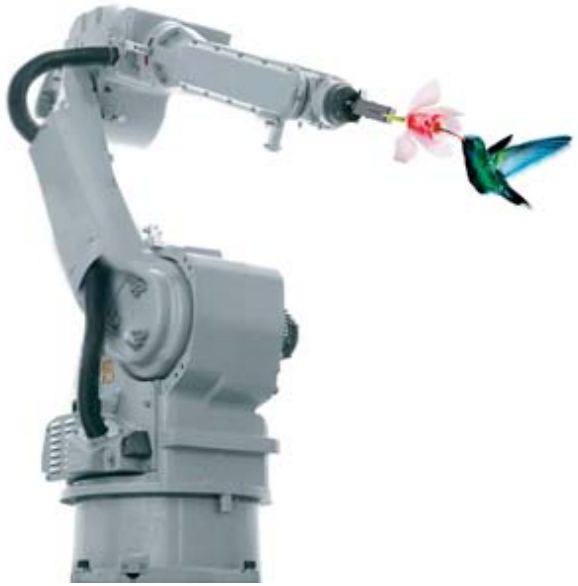
1000 Series Technical Training

Yaskawa Drives Department



Motor Control Settings

Rev.: 05 (01.03.2011)

Overview and Contents

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How to use this Presentation ?

This presentation shows all property and parameters that can be found in any of the J1000, V1000, A1000 drives. To distinguish whether the property or parameter is available in all of the drives or only in A1000 for example, please note the „ticks“ in the grey bar:

In the example above the function or the parameter would be available in V1000 and A1000 but NOT in J1000.

Default settings (i.e. the standard setting from the factory) are underlined.

Availability in different control modes:

Technical Training – Motor Control

C6: Carrier Frequency

C6-01: Drive Duty Selection

Note: For Information which parameter is available in which drive and mode, see the following slides.

- **2 Current Ratings:**
  - **C6-01 = 0: Heavy Duty (HD) – standard current rating, 150% overload / 60 s**
    C6-01 = 1: Normal Duty (ND) – increased current rating, 120% overload / 60 s
- **Motor related parameter will be reset to default values when changing C6-01:**
  - **Motor data settings**
    E2-01 (Motor Rated Current) **E2-02 (Motor Rated Slip),**
    E2-03 (Motor No-load Current) **E2-05 (Motor Line-to-Line Resistance),**
    E2-06 (Motor Leakage Inductance) **E2-11 (Motor Rated Power)**
  - **Carrier Frequency Selection**
    C6-02 (Carrier Frequency Selection) **C6-03 (Carrier Frequency Upper Limit)**
    C6-04 (Carrier Freq. Lower Limit) **C6-05 (Carrier Freq. Proportional Gain)**
  - **Motor Inertia settings**
    C5-17 (Motor Inertia)
    L3-24 (Motor Acceleration Time for Inertia Calculations)
    n5-02 (Motor Acceleration Time)
  - **Stall prevention**
    L3-02 (Stall Prevention Level during Acceleration),
    L3-03 (Stall Prevention Limit during Acceleration),
    L3-06 (Stall Prevention Level during RUN)

C6: Carrier Frequency

C6-02: Carrier Frequency Selection

C6-02	All modes except AOLV/PM	Only AOLV/PM (A1-02 = 6)	Drive
1 [1) 2) 3)]	2.0 kHz	2.0 kHz	J V A
2 [1) 2) 3)]	5.0 kHz	4.0 kHz	J V A
3 [1) 2)]	8.0 kHz	6.0 kHz	J V A
4 [1) 2)]	10.0 kHz	8.0 kHz	J V A
5 [1)]	12.5 kHz	10.0 kHz	J V A
6 [1)]	15.0 kHz	12.0 kHz	J V A
7	Swing PWM 1	—	J V A
8	Swing PWM 2	—	J V A
9	Swing PWM 3	—	J V A
A	Swing PWM 4	—	J V A
F	User defined (see below)	—	J V A

Note 1: Selectable for 2A0004 to 2A0138 (≤ 30 kW HD), 4A0002 to 4A0103 (≤ 45 kW HD)
Note 2: Selectable for whole range 200V class + 4A0002 to 4A0362 (≤ 132 kW HD)
Note 3: Selectable for whole range 200V class + 4A0002 to 4A0675 (≤ 315 kW HD)

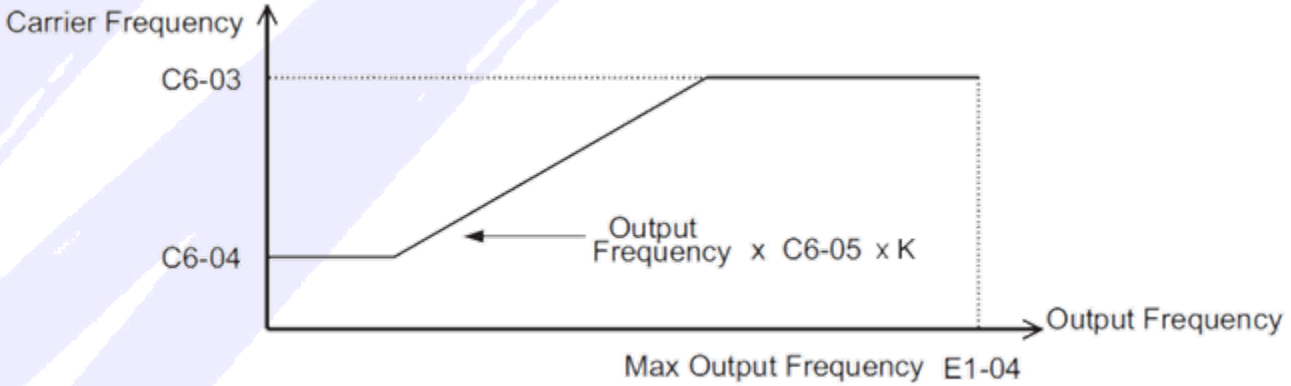
C6: Carrier Frequency

C6-03: Carrier Frequency Upper Limit
C6-04: Carrier Frequency Lower Limit

C6-05: Carrier Frequency Proportional Gain

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Setting a variable Carrier Frequency in V/f control



- Carrier Frequency will change linearly between C6-04 (Lower Limit) and C6-03 (Upper Limit) with C6-05 (Proportional Gain)
- J1000 and V1000: Factor K is added (depends on C6-03 setting)
  - ➔ Optimal compromise between best setting for motor (high carrier) and best setting for drive (low carrier)!
  - ➔ Use high carrier only in the speed range where it makes most sense!

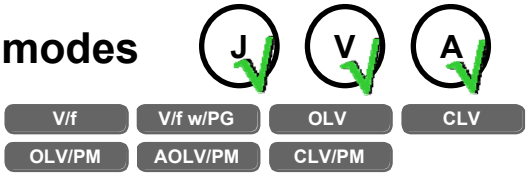
Note 1: Setting range for minimum and maximum carrier frequencies is the same as described above for C6-02.

Note 2: Carrier Frequency will be constant (value C6-03) when gain is below 7

C6: Carrier Frequency

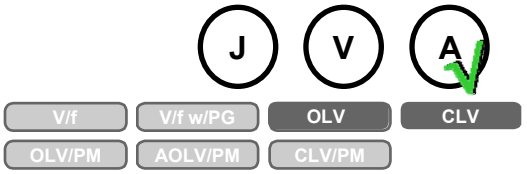
C6-03: Carrier Frequency Upper Limit
C6-09: Carrier Frequency during Rotational Auto-Tuning

Setting a fixed user defined Carrier Frequency for Vector control modes



- Set C6-02 = F (User defined)
- Set Carrier Frequency in C6-03

Setting Carrier Frequency During Rotational Auto-Tuning



Normally no change needed.
For setting Carrier Frequency manuall, set ...

- C6-09 = 1 (Carrier Frequency set in C6-03 is used during tuning)
- C6-03 (Carrier Frequency Upper Limit) to a higher value

➔ Adapt tuning process to your needs. With higher carrier frequency, tuning will work even for motors with low inductance (e. g. high speed motors).

C6: Carrier Frequency

C6-01 to C6-09: Parameters for Carrier Frequency selection

Higher carrier frequency will result in...

- lower audible noise
- lower motor losses due to better voltage sine wave form
- higher inverter losses due to more frequent IGBT switching

Parameter	Name	Range	Control Mode
C6-02	Carrier Freq. Selection	0 to F (See above)	V/f, V/f w/PG, OLV, CLV, OLV/PM, AOLV/PM, CLV/PM
C6-03	Carrier Freq. Upper Limit	0 to 15 kHz 1)	V/f, V/f w/PG, OLV, CLV, OLV/PM, AOLV/PM, CLV/PM
C6-04	Carrier Freq. Lower Limit	0 to 15 kHz 1)	V/f, V/f w/PG, OLV, CLV, OLV/PM, AOLV/PM, CLV/PM
C6-05	Carrier Freq. Prop. Gain	0 to 99	V/f, V/f w/PG, OLV, CLV, OLV/PM, AOLV/PM, CLV/PM
C6-09	Carrier Frequency during Rotational Auto-Tuning	0: 5 kHz 1: Use C6-03	V/f, V/f w/PG, OLV, CLV, OLV/PM, AOLV/PM, CLV/PM

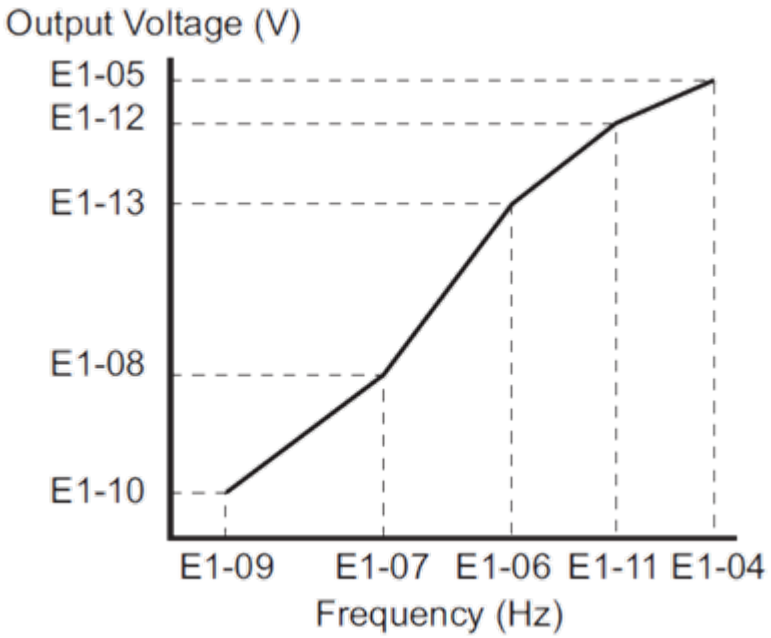
Note: Setting range depends on C6-02 depends on drive size.
Refer to C6-02 description. Range for up to 4A0103 (≤ 45 kW HD) is given.
Available range is described above for C6-02.

E1: V/f Pattern for Motor 1
E3: V/f Pattern for Motor 2

E1-04 to E1-13: V/f pattern settings for Motor 1
E3-04 to E3-13: V/f pattern settings for Motor 2

Parameter		Name
Motor 1 (J V A)	Motor 2 (J V A)	
E1-04	E3-04	Maximum Output Frequency (FMAX)
E1-05	E3-05	Maximum Voltage (VMAX)
E1-06	E3-06	Base Frequency (FBASE)
E1-07	E3-07	Middle Output Frequency (FMID)
E1-08	E3-08	Middle Output Freq. Voltage (VMID)
E1-09	E3-09	Minimum Output Frequency (FMIN)
E1-10	E3-10	Minimum Outp. Freq. Voltage (VMIN)
E1-11	E3-11	Middle Output Frequency 2 (FMID2)
E1-12	E3-12	Middle Outp. Freq. Voltage 2 (VMID2)
E1-13	E3-13	Base Voltage (VBASE)

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM



Condition for setting:

E1-09 ≤ E1-07 < E1-06 ≤ E1-11 ≤ E1-04

E1: V/f Pattern for Motor 1
E3: V/f Pattern for Motor 2

E1-04 to E1-13: V/f pattern settings for Motor 1
E3-04 to E3-13: V/f pattern settings for Motor 2

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

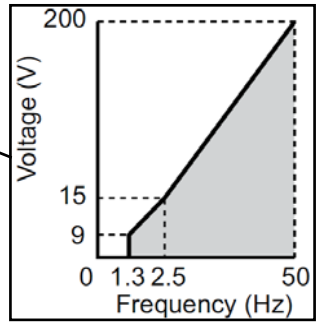
- Default values for V/f pattern parameters depend on ...
  - Control mode (A1-02)
  - Drive size
  - Drive Duty Selection (C6-01, HD/ND mode)
  - Motor Code Selection (E5-01, only for PM motor control)
  - V/f Pattern Selection (E1-03)
- Voltage default values for 400 V class are doubled in relation to 200 V class. Technical manual gives values for 200 V class drive.
- All V/f pattern parameters can be adjusted manually. Set E1-03 = F for using "Custom V/f".

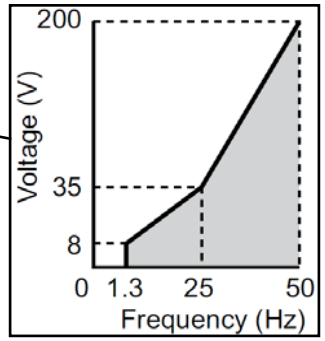
E1: V/f Pattern for Motor 1
E3: V/f Pattern for Motor 2

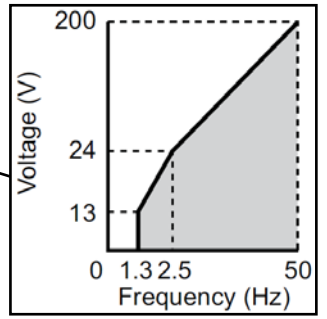
E1-03: V/f Pattern Selection

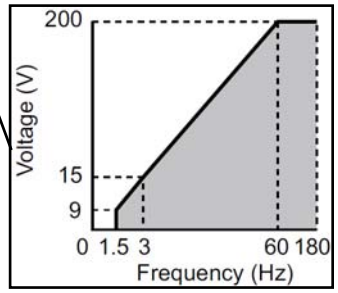
V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- **Constant torque characteristics (4 options)**
  - 0: 50 Hz (equal to E1-03 = F)
  - 1: 60 Hz
  - 2: 60 Hz with FBASE (E1-06) = 50 Hz,
  - 3: 72 Hz with FBASE (E1-06) = 60 Hz
- **Derated torque characteristics (4 options)**
  - 4 / 5: 50 Hz / 60 Hz with lower VMID (E1-08)
  - 6 / 7: 50 Hz / 60 Hz with higher VMID (E1-08)
- **High starting torque characteristics (4 options)**
  - 8 / 9: 50 Hz / 60 Hz with lower VMID (E1-08)
  - A / B: 50 Hz / 60 Hz with higher VMID (E1-08)
- **Characteristics for const. output range (3 options)**
  - Constant output between
    - C: 60 and 90
    - D: 60 and 120
    - E: 60 and 180 Hz









E1: V/f Pattern for Motor 1
E3: V/f Pattern for Motor 2

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E1-04 to E1-13: V/f pattern settings for Vector control modes
E3-04 to E3-13: Motor 2 V/f pattern settings for Vector control modes

Parameter		Name	OLV	CLV	PM Control (Motor 1 only)
Motor 1	Motor 2				
E1-03	–	V/f Pattern selection	F (Custom V/f)	F (Custom V/f)	F (Custom V/f)
E1-04	E3-04	Maximum Output Freq. (FMAX)	50.0 Hz	50.0 Hz	1)
E1-05	E3-05	Maximum Voltage (VMAX)	400.0 V 2)	400.0 V 2)	1)
E1-06	E3-06	Base Frequency (FBASE)	50.0 Hz	50.0 Hz	1)
E1-07	E3-07	Middle Output Frequency (FMID)	3.0 Hz	0.0 Hz	(Not available)
E1-08	E3-08	Middle Output Freq. Volt. (VMID)	28.8 V 2)	0.0 V	(Not available)
E1-09	E3-09	Minimum Output Freq. (FMIN)	0.5 Hz	0.0 Hz	1)
E1-10	E3-10	Min. Output Freq. Volt. (VMID)	6.0 V 2)	0.0 V	(Not available)
E1-11	E3-11	Middle Output Freq. 2 (FMID2)	0.0 Hz	0.0 Hz	(Not available)
E1-12	E3-12	Mid. Outp. Freq. Volt. 2 (VMID2)	0.0 V	0.0 V	(Not available)
E1-13	E3-13	Base Voltage (VBASE)	0.0 V	0.0 V	(Not available)

Note 1: Default value depends on Motor Code Selection (E5-01)
Note 2: Values for 400 V class drive are given. Divide values by 2 for 200 V class drive.
Note 3: Values depend on drive size

E2: Motor 1 Parameters
E4: Motor 2 Parameters

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E2-01 to E2-06: Motor data for Motor 1
E4-01 to E4-06: Motor data for Motor 2

Mot. 1	Mot. 2	Name / Detailed Description	Drive	Mode
E2-01	E4-01	Motor Rated Current 1)	J V A	V/f V/f w/PG OLV CLV
E2-02	E4-02	Motor Rated Slip, set in Hz. $E2\text{-}02 = FBASE - \frac{n_{RATED\_RPM}}{60} \cdot \frac{E2-04}{2}$	J V A J V A	V/f V/f w/PG OLV CLV V/f V/f w/PG OLV CLV
E2-03	E4-03	Motor No-Load Current 1)	J V A	V/f V/f w/PG OLV CLV
E2-04	E4-04	Number of Motor Poles		
E2-05	E4-05	Motor Line-to-Line Resistance: Set in Ω. Convert when entering manually: E-type/B-type insulation: 0.92 * test report value at 75°C F-type insulation: 0.87 * test report value at 115°C	J V A	V/f V/f w/PG OLV CLV
E2-06	E4-06	Motor Leakage Inductance 1) Voltage drop due to leakage inductance in % of motor rated voltage. Set for motors with low inductance (e. g. high speed motors)	J V A	V/f V/f w/PG OLV CLV

Note 1: Set in 0.01 A for up to 4A0023/2A0040 (ND mode) and 4A0031/2A0056 (HD mode) and 0.1 A for drive sizes above.

E2: Motor 1 Parameters
E4: Motor 2 Parameters

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E2-07 to E2-11: Motor data for Motor 1
E4-07 to E4-11: Motor data for Motor 2

Mot. 1	Mot. 2	Name / Detailed Description	Drive	Mode
E2-07	E4-07	Motor Iron-Core Saturation Coefficient 1 Sets the iron core saturation of the motor at 50% of the magnetic flux.	J V A	V/f V/f w/PG OLV CLV
E2-08	E4-08	Motor Iron-Core Saturation Coefficient 2 Sets the iron core saturation of the motor at 75% of the magnetic flux.	J V A	V/f V/f w/PG OLV CLV
E2-09	E4-09	Motor Mechanical Loss Sets the mechanical motor losses in % of motor rated power. Set when using a motor with high torque losses (e. g. due to bearing friction).	J V A	V/f V/f w/PG OLV CLV
E2-10	E4-10	Motor Iron Loss for Torque Compensation In V/f control enter the motor iron loss in W.	J V A	V/f V/f w/PG OLV CLV
E2-11	E4-11	Motor Rated Power Set the power from the motor name plate in kW	J V A	V/f V/f w/PG OLV CLV

E2: Motor 1 Parameters
E4: Motor 2 Parameters

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E2-01 to E2-11: Motor data for Motor 1
E4-01 to E4-11: Motor data for Motor 2

Motor 1	Motor 2	Name	Range	Default Value
E2-01	E4-01	Motor Rated Current	2)	1)
E2-02	E4-02	Motor Rated Slip	0.00 to 20.00 Hz	1)
E2-03	E4-03	Motor No-Load Current	0.00 to E2-01 – 0.01 or 0.1 A	1)
E2-04	E4-04	Number of Motor Poles	2 to 48	4
E2-05	E4-05	Motor Line-to-Line Resistance	0.000 to 65.000 Ω	1)
E2-06	E4-06	Motor Leakage Inductance	0.0 to 40.0%	1)
E2-07	E4-07	Mot. Iron-Core Saturation Coeff. 1	0.00 to 0.50	0.50
E2-08	E4-08	Mot. Iron-Core Saturation Coeff. 2	E2-07 to 0.75	0.75
E2-09	E4-09	Motor Mechanical Loss	0.0 to 10.0%	0.0%
E2-10	E4-10	Mot. Iron Loss for Torque Comp.	0 to 65535 W	1)
E2-11	E4-11	Motor Rated Power	0.00 to 650.00 kW	1)

Note 1: Default value depends on drive size and C6-01 (Drive Duty Selection)
Note 2: Setting range depends on drive size and C6-01 (10% to 200% of drive rated current)

Motor 2 Selection

Digital Input Selection
H1-xx = 16

J V A

V/f | V/f w/PG | OLV | CLV
OLV/PM | AOLV/PM | CLV/PM

- Switching between 2 motors is possible by setting a digital input to H1-xx = 16
- Independent Motor 2 settings for
  - Motor 2 Control Mode Selection (E3-01)
  - Motor Parameters (E4-01 to E4-11)
  - Acceleration / Deceleration Time (C1-05 to C1-08)
  - Slip Compensation (C3-21 to C3-25, only A1000)
  - Torque Compensation (C4-07, only A1000)
  - V/f Pattern (E3-04 to E3-13)
  - Automatic Speed Regulator (ASR, C5 group, only A1000)
    Available for: V/f | V/f w/PG | OLV | CLV / OLV/PM | AOLV/PM | CLV/PM
  - Settings for PG Speed Feedback (F1 group, only A1000)
    Available for: V/f | V/f w/PG | OLV | CLV / OLV/PM | AOLV/PM | CLV/PM
- Motor selection during RUN is not possible

Note: Description of the mentioned functions see below

E5: PM Motor Settings

E5-01 to E5-24: Motor data for permanent magnet motors

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Param.	Name	Default	Range
E5-01	Motor Code Selection When using a Yaskawa PM motor set motor code according to table in the manual. Motor parameter are set automatically. Set FFFF when using a 3rd party PM motor	1)	0000 to FFFF
E5-02	Motor Rated Power	2)	0.10 to 650.00 kW
E5-03	Motor Rated Current Set in 0.01 A for up to 4A0023/2A0040 (ND mode) and 4A0031/2A0056 (HD mode) and 0.1 A for drive sizes above	2)	1)
E5-04	Number of Motor Poles	2)	2 to 48
E5-05	Motor Stator Resistance Set the motor resistance for one phase	2)	0.000 to 65.000 Ω

Note 1: Default depends on drive size, control mode (A1-02) and duty selection (C6-01)

Note 2: Default depends on motor code selection (E5-01)

E5: PM Motor Settings

E5-01 to E5-24: Motor data for permanent magnet motors

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Param.	Name	Default	Range
E5-06	Motor d-Axis Inductance	1)	0.00 to 300.00 mH
E5-07	Motor q-Axis Inductance	1)	0.00 to 600.00 mH
E5-09	Motor Induction Voltage Const. 1 2) Sets induced phase peak voltage Unit: mV/(rad/s)	1)	0.0 to 2000.0 mV/(rad/s)
E5-24	Motor Induction Voltage Const. 2 2) Sets induced phase to phase rms voltage Unit: mV/(rpm)	1)	0.0 to 2000.0 mV/(r/min)
E5-11	Encoder Z-pulse Offset OLV/PM AOLV/PM CLV/PM Offset between encoder Z pulse and rotor magnetic axis. CLV for PM motors only	0.0°	-180 to 180°

Note 1: Default depends on motor code selection (E5-01)

Note 2: Set either E5-09 or E5-24. Setting both > 0 will trigger an oPE08 alarm

E5: PM Motor Settings

E5-01: Motor Code Selection

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

B.7 Parameters that Change with the Motor Code Selection

◆ YASKAWA SSR1 Series IPM Motor (For Derated Torque)

Table B.12 200 V, 1750 r/min Type YASKAWA SSR1 Series IPM Motor

No.	Name	Unit	Default Settings							
E5-01	Motor Code Selection	–	1202	1203	1205	1206	1208	120A	120B	120D
	Voltage Class	V	200	200	200	200	200	200	200	200
	Rated Power	kW	0.4	0.75	1.5	2.2	3.7	5.5	7.5	11
	Rated Speed	r/min	1750	1750	1750	1750	1750	1750	1750	1750
E5-02	Motor Rated Power	kW	0.4	0.75	1.5	2.2	3.7	5.5	7.5	11.0
E5-03	Motor Rated Current	A	1.77	3.13	5.73	8.44	13.96	20.63	28.13	41.4
E5-04	Number of Motor Poles	–	6	6	6	6	6	6	6	6
E5-05	Motor Stator Resistance (r1)	Ω	8.233	2.284	1.470	0.827	0.455	0.246	0.198	0.094
E5-06	Motor d-Axis Inductance (Ld)	mH	54.84	23.02	17.22	8.61	7.20	4.86	4.15	3.40
E5-07	Motor q-Axis Inductance (Lq)	mH	64.10	29.89	20.41	13.50	10.02	7.43	5.91	3.91
E5-09	Motor Induction Voltage Constant 1 (Ke)	mVs/rad	223.7	220.3	240.8	238.0	238.7	239.6	258.2	239.3
E5-24	Motor Induction Voltage Constant 2 (Ke)	mV/(r/min)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E1-04	Maximum Output Frequency	Hz	87.5	87.5	87.5	87.5	87.5	87.5	87.5	87.5
E1-05	Maximum Voltage	V	190.0	190.0	190.0	190.0	190.0	190.0	190.0	190.0
E1-06	Base Frequency	Hz	87.5	87.5	87.5	87.5	87.5	87.5	87.5	87.5
E1-09	Minimum Output Frequency	Hz	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
C5-17	Motor Inertia	kgm²	0.0011	0.0017	0.0023	0.0043	0.0083	0.014	0.017	0.027
L3-24	Motor Acceleration Time for Inertia Calculations	s	0.092	0.076	0.052	0.066	0.075	0.083	0.077	0.084
n5-02	Motor Acceleration Time	s	0.092	0.076	0.052	0.066	0.075	0.083	0.077	0.084
n8-49	d-Axis Current for High Efficiency Control (OLV/PM)	%	-7.6	-11.5	-9.1	-19.0	-18.7	-23.4	-18.5	-10.9

Motor Code tables in technical manual – Appendix B.7

➔ **Only enter code of your motor, everything else is done automatically!**

T1: Induction Motor Auto-Tuning
T2: PM Motor Auto-Tuning

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T1-01 to T1-11: Setup parameters for induction motor tuning
T2-01 to T2-17: Setup parameters for PM motor tuning

V/f | V/f w/PG | OLV | CLV
OLV/PM | AOLV/PM | CLV/PM

- Auto-Tuning simplifies commissioning of the drive
  - ➔ Just enter motor name plate data and press RUN key!
- Multiple tuning modes are available for …
  - tuning Induction Motors in Vector control
    - Tuning is always needed because drive calculates internal motor model
  - tuning PM Motors in Vector control
    - Tuning even more essential than for induction motors
    - PM motors will step out when using wrong motor data
      - ➔ Tune PM motors in the same way as induction motors. No need for complicated manual tuning of third party motors.
  - reaching highest performance in Closed Loop Vector control (CLV)
    - Automatic Speed Regulator (ASR) can be set up automatically.
    - Inertia of the whole machine can be measured by the drive
      - ➔ Just enter motor inertia. Often no further adjustments needed for functions like Powerloss Ride-throu !

T1: Induction Motor Auto-Tuning
T2: PM Motor Auto-Tuning

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T1-01: Auto-Tuning Mode Selection
T2-01: PM Motor Auto-Tuning Mode

T1-01	Auto-Tuning Mode Selection	Drive	Control Mode
0	Rotational Auto-Tuning	J V A	V/f V/f w/PG OLV CLV
1	Stationary Auto-Tuning 1	J V A	V/f V/f w/PG OLV CLV
2	Stationary Auto-Tuning for Line-to-Line Resistance	J V A	V/f V/f w/PG OLV CLV
3	Rotational Auto-Tuning for V/f Control	J V A	V/f V/f w/PG OLV CLV
4	Stationary Auto-Tuning 2	J V A	V/f V/f w/PG OLV CLV

T2-01	PM Motor Auto-Tuning Mode Selection	In Drive	Control Mode
0	PM Motor Parameter Settings	J V A	OLV/PM AOLV/PM CLV/PM
1	PM Stationary Auto-Tuning	J V A	OLV/PM AOLV/PM CLV/PM
2	PM Stationary Auto-Tuning for Stator Resistance	J V A	OLV/PM AOLV/PM CLV/PM
3	Z Pulse Offset Tuning	J V A	OLV/PM AOLV/PM CLV/PM

T1: Induction Motor Auto-Tuning

T1-01 = 0: Rotational Auto-Tuning
Auto-Tuning for Vector control

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Use ...

- when load can be decoupled or is below 30% of rated motor torque
- when Induction Motors are used in Vector control modes
  - ➔ Gives the most accurate results and is highly recommended if possible

Motor data	Tuning data	Name	Tuning
E2-11	T1-02	Motor Rated Power	Input
E1-13 = E1-05	T1-03	Motor Rated Voltage	Input
E2-01	T1-04	Motor Rated Current	Input
E1-06 = E1-04	T1-05	Motor Base Frequency	Input
E2-04	T1-06	Number of Motor Poles	Input
—	T1-07	Motor Base Speed (in r/min)	Input
F1-01	T1-08	PG Number of Pulses per Revolution (Only CLV)	Input

T1: Induction Motor Auto-Tuning

T1-01 = 0: Rotational Auto-Tuning
Auto-Tuning for Vector control

V/f | V/f w/PG | OLV | CLV
OLV/PM | AOLV/PM | CLV/PM

- Use ...
  - when load can be decoupled or is below 30% of rated motor torque
  - when Induction Motors are used in Vector control modes

➔ Gives the most accurate results and is highly recommended if possible

Motor data	Tuning data	Name	Tuning
E2-03	T1-09	Motor No-load Current	Output
E2-02	T1-10	Motor Rated Slip	Output
E2-05	—	Motor Line-to-Line Resistance	Output
E2-06	—	Motor Leakage Inductance	Output
E2-07	—	Motor Iron Core Saturation Coefficient 1	Output
E2-08	—	Motor Iron Core Saturation Coefficient 2	Output

T1: Induction Motor Auto-Tuning

T1-01 = 1: Stationary Auto-Tuning 1
Auto-Tuning for Vector control

V/f | V/f w/PG | OLV | CLV
OLV/PM | AOLV/PM | CLV/PM

- Use when ...
  - it is not possible for the motor to rotate freely
  - it is not possible to run the motor with less then 30% of rated torque
  - induction motors are used in Vector control modes
  - a detailed motor report is not available

Motor data	Tuning data	Name	Tuning
E2-11	T1-02	Motor Rated Power	Input
E1-13 = E1-05	T1-03	Motor Rated Voltage	Input
E2-01	T1-04	Motor Rated Current	Input
E1-06 = E1-04	T1-05	Motor Base Frequency	Input
E2-04	T1-06	Number of Motor Poles	Input
—	T1-07	Motor Base Speed (in r/min)	Input
F1-01	T1-08	PG Number of Pulses per Revolution (Only CLV)	Input

T1: Induction Motor Auto-Tuning

T1-01 = 1: Stationary Auto-Tuning 1
Auto-Tuning for Vector control

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- Use when ...
  - it is not possible for the motor to rotate freely
  - it is not possible to run the motor with less then 30% of rated torque
  - induction motors are used in Vector control modes
  - a detailed motor report is not available

Motor data	Tuning data	Name	Tuning
E2-03	T1-09	Motor No-load Current	Input
E2-02	T1-10	Motor Rated Slip	Output
E2-05	—	Motor Line-to-Line Resistance	Output
E2-06	—	Motor Leakage Inductance	Output
E2-07	—	Motor Iron Core Saturation Coefficient 1	Output
E2-08	—	Motor Iron Core Saturation Coefficient 2	Output

T1: Induction Motor Auto-Tuning

T1-01 = 4: Stationary Auto-Tuning 2
Auto-Tuning for Vector control

V/f | V/f w/PG | OLV | CLV
OLV/PM | AOLV/PM | CLV/PM

- Use when...
  - it is not possible for the motor to rotate freely
  - it is not possible to run the motor with less then 30% of rated torque
  - Induction Motors are used in Vector control modes
  - a detailed motor report is available

Motor data	Tuning data	Name	Tuning
E2-11	T1-02	Motor Rated Power	Input
E1-13 = E1-05	T1-03	Motor Rated Voltage	Input
E2-01	T1-04	Motor Rated Current	Input
E1-06 = E1-04	T1-05	Motor Base Frequency	Input
E2-04	T1-06	Number of Motor Poles	Input
—	T1-07	Motor Base Speed	Input

T1: Induction Motor Auto-Tuning

T1-01 = 4: Stationary Auto-Tuning 2
Auto-Tuning for Vector control

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- Use when...
  - it is not possible for the motor to rotate freely
  - it is not possible to run the motor with less then 30% of rated torque
  - Induction Motors are used in Vector control modes
  - a detailed motor report is available

Motor data	Tuning data	Name	Tuning
E2-03	T1-09	Motor No-load Current	Input
E2-02	T1-10	Motor Rated Slip	Input
E2-05	—	Motor Line-to-Line Resistance	Output
E2-06	—	Motor Leakage Inductance	Output
E2-07	—	Motor Iron Core Saturation Coefficient 1	Output
E2-08	—	Motor Iron Core Saturation Coefficient 2	Output

T1: Induction Motor Auto-Tuning

T1-01 = 2: Stationary Auto-Tuning for Line-to-line Resistance Auto-Tuning for V/f control and for Vector control

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- Use ...
  - when motor cable length has been changed significantly after tuning
  - in V/f control when motor cable is longer then 50 m
  - when drive and motor capacity differs
- Additional tuning.
- Not needed after Auto-Tuning when cable has not been changed.

Motor data	Tuning data	Name	Tuning
E2-11	T1-02	Motor Rated Power	Input
E2-01	T1-04	Motor Rated Current	Input
E2-05	—	Motor Line-to-Line Resistance	Output

T1: Induction Motor Auto-Tuning

T1-01 = 3: Rotational Auto-Tuning for V/f control
Auto-Tuning for V/f control

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- Use in V/f control ...
  - when Speed Estimation type Speed Search is used
  - when Energy Saving Function is used
  - when drive and motor capacity differs
  - in order to improve accuracy of Torque Compensation and Slip Compensation

Motor data	Tuning data	Name	Tuning
E2-11	T1-02	Motor Rated Power	Input
E1-13 = E1-05	T1-03	Motor Rated Voltage	Input
E2-01	T1-04	Motor Rated Current	Input
E1-06 = E1-04	T1-05	Motor Base Frequency	Input
E2-04	T1-06	Number of Motor Poles	Input
—	T1-07	Motor Base Speed	Input

T1: Induction Motor Auto-Tuning

T1-01 = 3: Rotational Auto-Tuning for V/f control
Auto-Tuning for V/f control

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- Use in V/f control ...
  - when Speed Estimation type Speed Search is used
  - when Energy Saving Function is used
  - when drive and motor capacity differs
  - In order to improve accuracy of Torque Compensation and Slip Compensation

Motor data	Tuning data	Name	Tuning
E2-03	T1-09	Motor No-load Current	Output
E2-02	T1-10	Motor Rated Slip	Output
E2-10	T1-11	Motor Iron Loss	Input
b8-04	—	Energy Saving Coefficient Value	Output
E2-05	—	Motor Line-to-Line Resistance	Output
E2-06	—	Motor Leakage Inductance	Output

T2: Permanent Magnet Motor (PM Motor) Auto-Tuning

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T2-01 = 0: PM Motor Parameter Settings
Tuning for PM Motor control

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- Use when detailed motor test report is available
- All needed parameters are requested one after another for entering manual

Motor data	Tuning data	Name	OLV/PM AOLV/PM CLV/PM	Tuning
E5-02	T2-04	PM Motor Rated Power	OLV/PM AOLV/PM CLV/PM	Input
E1-13 = E1-05	T2-05	PM Motor Rated Voltage	OLV/PM AOLV/PM CLV/PM	Input
E5-03	T2-06	PM Motor Rated Current	OLV/PM AOLV/PM CLV/PM	Input
E1-06 = E1-04	T2-07	PM Motor Base Frequency	OLV/PM AOLV/PM CLV/PM	Input
E5-04	T2-08	Number of PM Motor Poles	OLV/PM AOLV/PM CLV/PM	Input
E1-06 = E1-04	T2-09	PM Motor Rated Speed	OLV/PM AOLV/PM CLV/PM	Input
E5-05	T2-10	PM Motor Stator Resistance	OLV/PM AOLV/PM CLV/PM	Input
E5-06	T2-11	PM Motor d-Axis Inductance		Input

T2: Permanent Magnet Motor (PM Motor) Auto-Tuning

YASKAWA

T2-01 = 0: PM Motor Parameter Settings
Tuning for PM Motor control

J V A

- Use when detailed motor test report is available
- All needed parameters are requested one after another for entering manual

<table>
<tr><th>Motor data</th><th>Tuning data</th><th>Name</th><th>Mode</th><th>Tuning</th></tr>
<tr><td>E5-06</td><td>T2-11</td><td>PM Motor d-Axis Inductance</td><td>OLV/PM AOLV/PM CLV/PM</td><td>Input</td></tr>
<tr><td>E5-07</td><td>T2-12</td><td>PM Motor q-Axis Inductance</td><td>OLV/PM AOLV/PM CLV/PM</td><td>Input</td></tr>
<tr><td rowspan="2">E5-09 or E5-24</td><td>T2-13</td><td>Induced Voltage Constant Unit Selection
PM Motor Induced Voltage Constant
<table><tr><td><u>T2-13 = 0</u></td><td>mV/(rpm)</td><td>E5-24 = T2-14</td><td>E5-09 = 0</td></tr><tr><td>T2-13 = 1</td><td>mV/(rad/s)</td><td>E5-09 = T2-14</td><td>E5-24 = 0</td></tr></table></td><td>OLV/PM AOLV/PM CLV/PM</td><td>Input</td></tr>
<tr><td>T2-14</td><td>OLV/PM AOLV/PM CLV/PM</td><td>Input</td></tr>
<tr><td>F1-01</td><td>T2-16</td><td>PG Number of Pulses per Revolution</td><td>OLV/PM AOLV/PM CLV/PM</td><td>Input</td></tr>
<tr><td>E5-11</td><td>T2-17</td><td>Encoder Z-Pulse Offset</td><td>OLV/PM AOLV/PM CLV/PM</td><td>Input</td></tr>
</table>

T2: Permanent Magnet Motor (PM Motor) Auto-Tuning

YASKAWA

T2-01 = 1: PM Stationary Auto-Tuning
Auto-Tuning for PM Motor control

J V A

- Use ...
  - when unknown motor is used and a detailed motor test report is <u>not</u> available

Motor data	Tuning data	Name	Mode	Tuning
—	T2-03	PM Motor Type Select SPM or IPM motor Required for Stationary Tuning	OLV/PM AOLV/PM CLV/PM	Input
E5-02	T2-04	PM Motor Rated Power	OLV/PM AOLV/PM CLV/PM	Input
E1-13 = E1-05	T2-05	PM Motor Rated Voltage	OLV/PM AOLV/PM CLV/PM	Input
E5-03	T2-06	PM Motor Rated Current	OLV/PM AOLV/PM CLV/PM	Input
E1-06 = E1-04	T2-07	PM Motor Base Frequency	OLV/PM AOLV/PM CLV/PM	Input
E5-04	T2-08	Number of PM Motor Poles	OLV/PM AOLV/PM CLV/PM	Input
E1-06 = E1-04	T2-09	PM Motor Rated Speed	OLV/PM AOLV/PM CLV/PM	Input
E5-05	T2-10	PM Motor Stator Resistance (1 Phase)	OLV/PM AOLV/PM CLV/PM	Output

T2: Permanent Magnet Motor (PM Motor) Auto-Tuning

YASKAWA

T2-01 = 1: PM Stationary Auto-Tuning
Auto-Tuning for PM Motor control

J V A

- Use ...
  - when unknown motor is used and a detailed motor test report is not available

Motor data	Tuning data	Name	Mode	Tuning
E5-06	T2-11	PM Motor d-Axis Inductance	OLV/PM AOLV/PM CLV/PM	Output
E5-07	T2-12	PM Motor q-Axis Inductance	OLV/PM AOLV/PM CLV/PM	Output
E5-09 or E5-24	T2-13	Induced Voltage Constant Unit Selection Stationary Auto-Tuning will set in mV/(rpm)	OLV/PM AOLV/PM CLV/PM	Output
	T2-14	PM Motor Induced Voltage Constant Stationary Auto-Tuning will set value in E5-24. Value is not measured but taken from a comparable Yaskawa PM motor.	OLV/PM AOLV/PM CLV/PM	
—	T2-15	Pull-In Current Level for PM Motor Tuning	OLV/PM AOLV/PM CLV/PM	Input
F1-01	T2-16	PG Number of Pulses per Revolution	OLV/PM AOLV/PM CLV/PM	Input
E5-11	T2-17	Encoder Z-Pulse Offset	OLV/PM AOLV/PM CLV/PM	Input

T2: Permanent Magnet Motor (PM Motor) Auto-Tuning

T2-01 = 1: PM Stationary Auto-Tuning
Auto-Tuning for PM Motor control

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Manual measuring of "PM Induced Voltage Constant"

- The drive sets the values of a matching Yaskawa PM Motor
  → Value from Stationary Tuning is not in every case the best setup
- Performance can be improved by measuring the value manually:
  1. Set b1-03 = 1 (Stopping Method Selection "Coast to Stop")
  2. Run the motor with a defined speed (n_{RPM})
  3. Record the output voltage between 2 motor phases using a scope
  4. Measure the peak-to-peak voltage of the first sine wave after the drive has been stopped
  5. Set E5-09 to 0 and calculate the value for E5-24 using the formula:

$$E5\text{-}24 = \frac{1000 \cdot V_{PEAK\_TO\_PEAK}}{2 \cdot \sqrt{2} \cdot n_{RPM}}$$

$V_{PEAK\_TO\_PEAK}$ → Measured peak-to-peak voltage in V

n_{RPM} → Rated motor speed in r/min

T2: Permanent Magnet Motor (PM Motor) Auto-Tuning

T2-01 = 2: PM Stationary Auto-Tuning for Stator Resistance Auto-Tuning for PM Motor control

- Use ...
  - when motor data are set manually or by motor code and motor cable is longer than 50 m
  - when motor cable has been changed significantly

Motor data	Tuning data	Name	Mode	Tuning
E5-03	T2-06	PM Motor Rated Current	OLV/PM AOLV/PM CLV/PM	Input
E5-05	T2-10	PM Motor Stator Resistance	OLV/PM AOLV/PM CLV/PM	Output

T2: Permanent Magnet Motor (PM Motor) Auto-Tuning

T2-01 = 3: Z Pulse Offset Tuning
Auto-Tuning for PM Motor control

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- Use ...
  - when motor data are set manually or by motor code
  - when encoder has been replaced
- Sets the diviation between rotor magnetic axis and encoder Z pulse as angle
- No need to use, when motor data were set by PM Stationary Auto-Tuning (T2-01 = 1)

Motor Data	Tuning Data	Name	Tuning
E5-11	—	Encoder Z-Pulse Offset	Output

T3: ASR and Inertia Tuning

T3-01 ~ 04: Auto-Tuning Input Data

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Input data and parameters for Inertia and ASR Tuning

Motor Data	Tuning Data	Name	Inertia Tuning (T1-01/T2-01 = 8)	ASR Tuning (T1-01/T2-01 = 9)
—	T3-01	Test Signal Frequency	Input	Input
—	T3-02	Test Signal Amplitude	Input	Input
C3-17	T3-03	Motor Inertia	Input	Input
—	T3-04	System Response Frequency	Input	Input
C5-18	—	Motor Inertia Ratio	Output	Output
L3-24	—	Motor Acceleration Time	Output	Output
L3-25	—	Load Inertia Ratio	Output	Output
n5-03	—	Feed Forward Control Ratio Gain	Output	Output
C5-01	—	ASR Proportional Gain	—	Output

T3: ASR and Inertia Tuning

T1-01: Auto-Tuning Mode Selection
T2-01: PM Motor Auto-Tuning Mode Selection

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Additional Tuning for CLV and CLV for PM motors

- "Inertia Tuning" (T1-01/T2-01 = 8) is recommended for the functions:
  - Feed Forward control
    (Enables quicker response to speed reference steps)
  - Kinetic Energy Buffering Ride-Thru
    (Energy buffering for controlled ramp down at input power loss)
  - Intelligent Stall Prevention during Deceleration
    (Adapts deceleration time automatically if DC bus voltage gets too high)

    ➔ Complicated manual setting for these functions not needed.
    Just use Inertia Tuning and everything is running.

- "ASR Gain Tuning" (T1-01/T2-01 = 9):
  - Same as "Inertia Tuning"
  - Additional tuning of speed controller (ASR = "Automatic Speed Controller")

    ➔ No need for time consuming manual speed controller setup

b2: DC Injection Braking at Stop / Short Circuit Braking

YASKAWA

b2-01: DC Braking Start Frequency
b2-02: DC Braking Current
b2-04: DC Braking Time at Stop

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Executed after "Ramp to Stop" deceleration

- **Complete stop by DC Injection Braking**
  - ➔ **Defined stop of the rotor down to zero even in V/f and Open Loop Vector control. No coasting, when frequency cannot become lower.**
- **When the Output Frequency falls below the higher one of either b2-01 (DC Injection Braking Start Frequency) or E1-09 (Minimum Output Frequency), a DC current is injected into the motor (J1000: E1-09 is braking start frequency).**

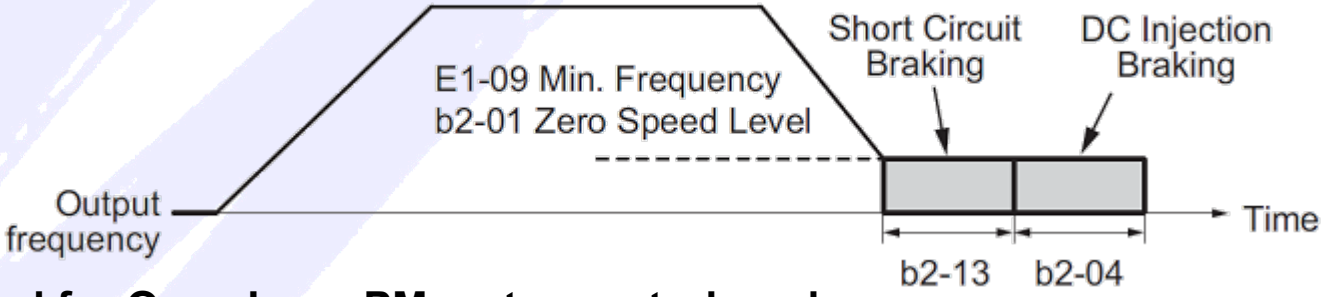
Parameter	Name (Available in drive ...)	Range	Default
b2-01	DC Inj. Braking / Zero Speed Start Freq (V, A)	0.0 to 10.0 Hz	0.5 Hz
b2-02	DC Injection Braking Current (J, V, A) (in % of drive rated current)	0% to 100%	50%
b2-04	DC Inj. Brak. / Zero Speed Time at Stop (J, V, A)	0.00 to 10.00 s	0.50 s

b2: DC Injection Braking and Short Circuit Braking

b2-01: Braking Start Frequency
b2-02/18: Braking Current
b2-04/13: Braking Time at Stop

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Executed after "Ramp to Stop" deceleration



- Additional for Open Loop PM motor control modes
  - Short Circuit Braking: Braking torque by shorten the motor windings
  - Combine with DC Injection Braking for getting more braking torque
    ➔ Make use of special features of PM motors

Parameter	Name (Available in drive ...)	Range	Default
b2-13	Short Circuit Brake Time at Stop (V, A)	0.00 to 25.50 s	0.50 s
b2-18	Short Circuit Braking Current (A) (in % of motor rated current E2-01)	0.0% to 200%	100.0%

b2: DC Injection Braking and Short Circuit Braking

b2-01: DC Braking Start Frequency
b2-02: DC Braking Current
b2-04: Braking Time at Stop

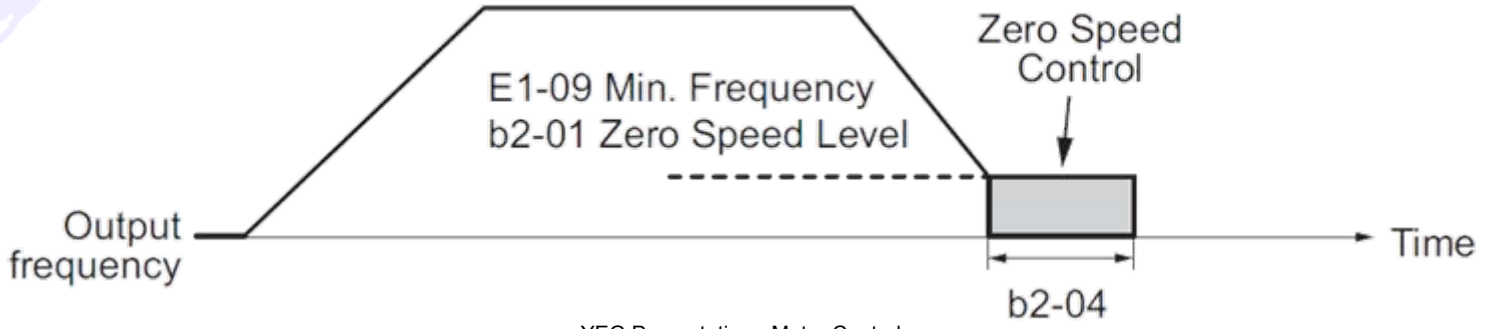
J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Executed after "Ramp to Stop" deceleration

- **Zero Speed Control in CLV for induction motors and PM motors**
  Output frequency falls below b2-01 (DC Injection Braking Start Frequency):
  - **Speed regulator will continue.**
  - **Output speed = 0 rpm is regulated for the time b2-04 (set in seconds).**

➔ **Whole Vector control and speed control functionality even when motor is stopped.**
➔ **Excellent torque performance even at zero speed.**

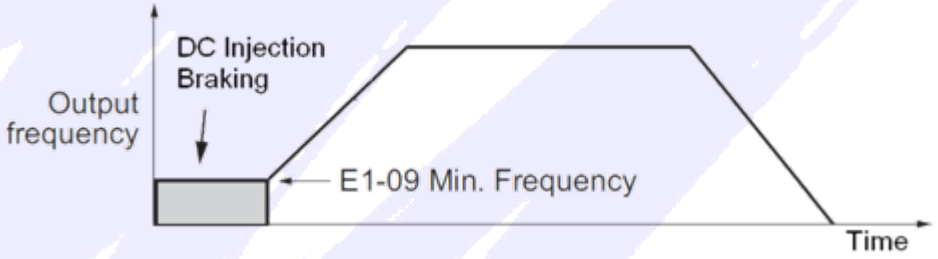


b2: DC Injection Braking and Short Circuit Braking

b2-02: DC Injection Braking Current
b2-03: DC Injection Braking Time at Start

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

DC Injection / Short Circuit Braking at Start



Stops a coasting motor before starting

- ➔ **Example: Ventilation fan – Avoid high starting current due to coasting!**
- ➔ **Example: Lift in Open Loop – Build up torque with DC braking before start!**

Parameter	Name	Range	Default
b2-02	DC Injection Braking / Zero Speed Current (in % of drive rated current)	0% to 100%	50%
b2-03	DC Injection Braking Time at Start	0.00 to 10.00 s	0.00 s
b2-12	Short Circuit Braking Time at Start	0.00 to 25.50 s	0.00 s
b2-18	Short Circuit Braking Current (in % of motor rated current E2-01)	0.0 to 200.0%	100.0%

b2: DC Injection Braking and Short Circuit Braking

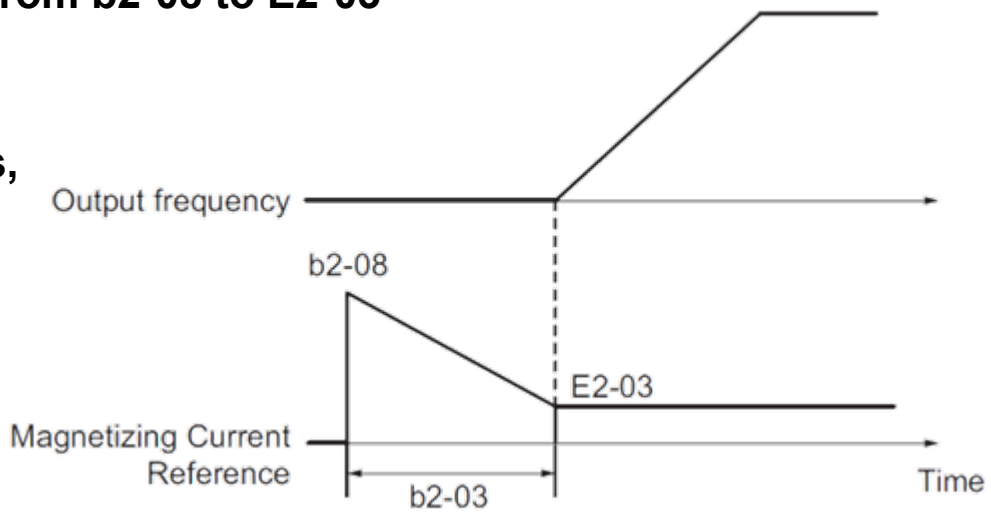
b2-03: DC Injection Braking Time at Start
b2-08: Magnetic Flux Compensation Value

V/f | V/f w/PG | **OLV** | CLV | OLV/PM | AOLV/PM | CLV/PM

Magnetic Flux Compensation

- DC injection level changes linearly from b2-08 to E2-03 (motor no-load current)

  ➔ Improved starting of machines, requiring high starting torque (boost for magnetic flux)



Parameter	Name	Range	Default
b2-03	DC Injection Braking Time at Start	0.00 to 10.00 s	0.00 s
b2-08	Magnetic Flux Compensation Value (in % of no-load current E2-03)	0 to 1000%	0%

b8: Energy Saving
Energy Saving function for Induction Motors

b8-01 to b8-06: Setup parameters for Energy Saving function

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Basic Principle

- Drive output will be adapted automatically, especially when operating with light load.
  - ➔ Speed-Torque characteristic is adjusted, so that the motor operates always at rated slip (most efficient operation point).

Note:

- Function will lead to softer speed-torque characteristic
- Function can cause problems in high dynamic applications
  - Stalling
  - Insufficient torque
- Most essential:
  Accurate motor tuning.
  Apply Auto-Tuning, even for V/f control!

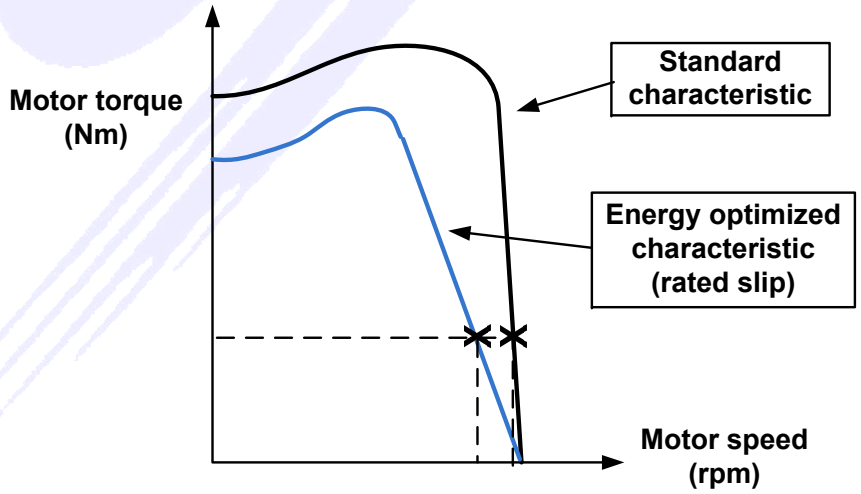
b8: Energy Saving
Energy Saving function for Induction Motors

b8-01 to b8-06: Setup parameters for Energy Saving function

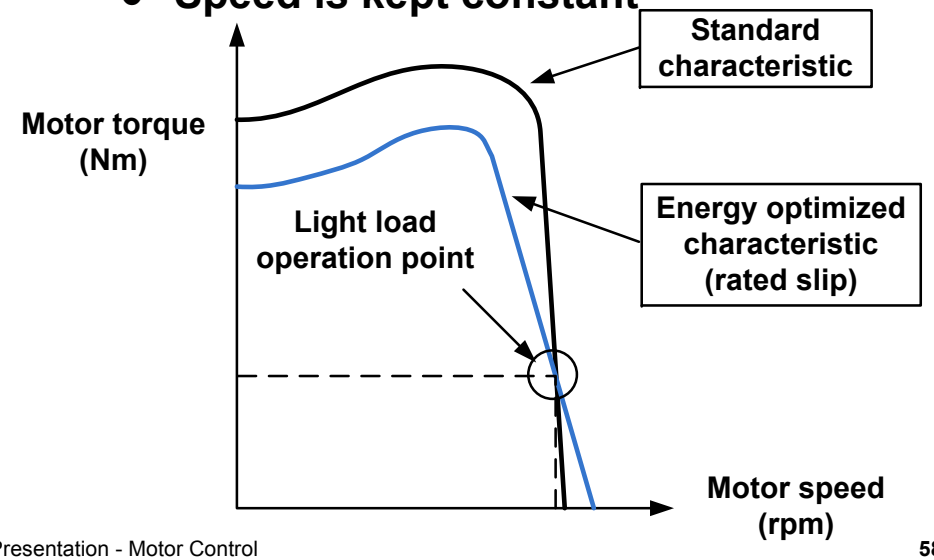
J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- V/f V/f w/PG
  - Voltage is decreased, if load situation makes it possible
  - Less energy consumption
  - Speed might decrease slightly



- OLV CLV
  - Magnetizing current Id (and by that voltage) is decreased and frequency is controlled if load situation makes it possible
  - Less energy consumption
  - Speed is kept constant



b8: Energy Saving for Induction Motors

b8-01 to b8-06: Setup parameters for Energy Saving function

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Setup for V/f control

Voltage is controlled directly!

Parameter	Name / Description	Range	Default
b8-01	Energy Saving Control Selection	0: Disabled 1: Enabled	0
b8-04	Energy Saving Coefficient Value ▪ Run with light load ▪ Adjust while monitoring U1-08 (Output Power) ▪ Lower values = lower energy consumption ▪ Too low values can cause stalling	0.00 to 655.00	Depends on drive size, motor size (E5-11) and HD/ND mode selection (C6-01).
b8-05	Power detection filter time ▪ Shorter time = better response ▪ Too short time can cause instability	0 to 2000 ms	20 ms
b8-06	Search Operation Voltage Limit ▪ Set, when using Energy Saving in conjunction with Speed Search ▪ Output voltage will always be kept above b8-06 during Speed Search	0 to 100% (Set in % of motor rated voltage)	0%

b8: Energy Saving for Induction Motors

b8-01 to b8-06: Setup parameters for Energy Saving function

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Setup for Vector control

Voltage is controlled indirectly via magnetizing (Id) !

Parameter	Name / Description	Range	Default
b8-01	Energy Saving Control Selection	0: Disabled 1: Enabled	0
b8-02	Energy Saving Gain ▪ Increase until power monitor U1-08 reaches minimum value ▪ Too high values can cause stalling or hunting	0.0 to 10.0	Note 1
b8-03	Energy Saving Control Filter Time Constant ▪ Shorter time = quicker response ▪ Too short time can cause instability	0.00 to 10.00 s	Note 1 Note 2

Note 1: Depends on Control Mode Selection (A1-02)

Note 2: Depends on Drive Duty Selection (C6-01)

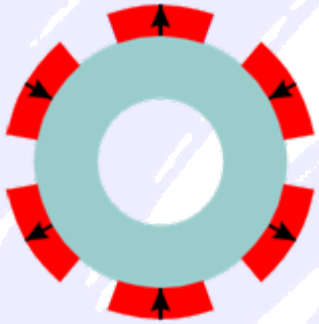
b8: Energy Saving for PM Synchronous Motors

b8-01: Energy Saving Control Selection

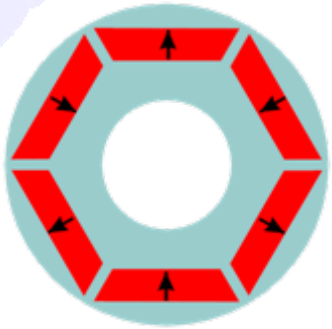
J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Completely different principle: PM motors have no slip !



SPM motor
No magnetic saliency



IPM motor
Magnetic saliency

Available with IPM motors !

Set only b8-01 = 1 (default setting for PM motor control)

Principle of reluctance torque:

- **Rotor turns to position with smallest magnetic resistance (lowest L)**
- **Torque component, additional to normal torque production**
  - ➔ **Improved efficiency**
- **Take care to provide accurate motor data**
  - ➔ **No additional tuning needed – A1000 optimizes automatically**
  - ➔ **Stationary Auto-Tuning for PM motors**

C3: Slip Compensation

C3-01: Slip Compensation Gain
C3-21: Motor 2 Slip Compensation Gain

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Before adjusting the slip compensation parameters make sure, that motor rated current (E2-01), motor rated slip (E2-02) and motor no-load current (E2-03) are set properly!

- Slip Compensation function keeps motor speed constant in all load conditions and compensates slip when load is changed
- Frequency Reference is constant and motor speed is incorrect ?
  - If speed is too low increase C3-01 (Slip Compensation Gain)
  - If speed is too high decrease C3-01

Parameter		Name	Range	Default
Motor 1 (J V A)	Motor 2 (J V A)			
C3-01	C3-21	Slip Compensation Gain	0.0 to 2.5	V/f : 0.0 (disabled) OLV CLV : 1.0

C3: Slip Compensation

C3-02: Slip Compensation Delay Time
C3-22: Motor 2 Slip Compensation Delay Time

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Before adjusting the slip compensation parameters make sure, that motor rated current (E2-01), motor rated slip (E2-02) and motor no-load current (E2-03) are set properly!

- **Slip is compensated too slowly or motor speed is not stable ?**
  - **If compensation is too slow decrease C3-02 (Slip Compensation Delay Time)**
  - **If speed is not stable increase C3-02**

Parameter		Name	Range	Default
Motor 1 (J V A)	Motor 2 (J V A)			
C3-02	C3-22	Slip Compensation Delay Time	0 to 10000	(Depends on control mode)

C3: Slip Compensation

C3-03: Slip Compensation Limit
C3-23: Motor 2 Slip Compensation Limit

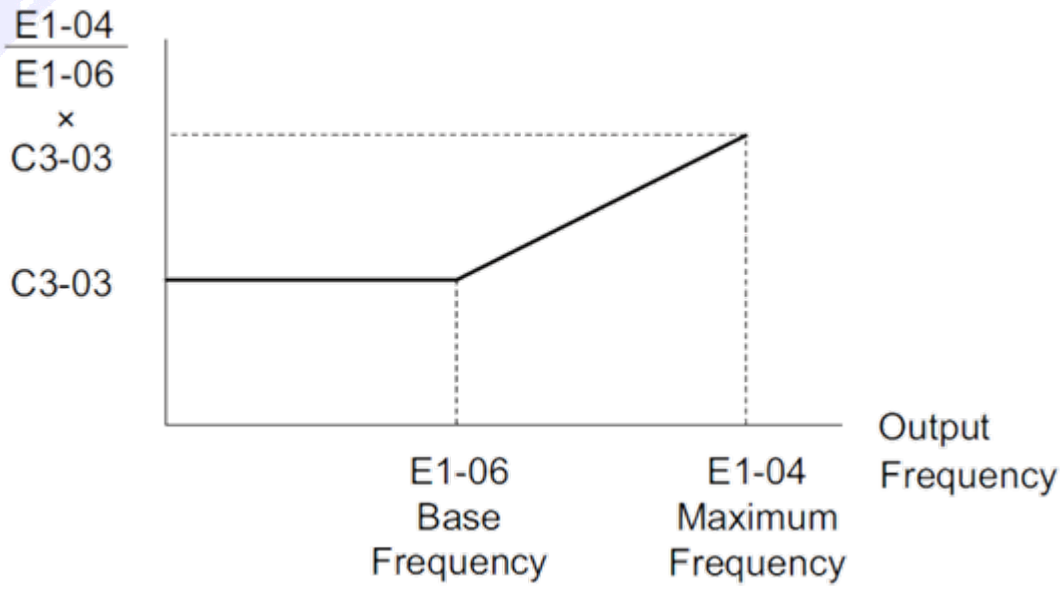
J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Additional Tuning for V1000 and A1000:

C3-03 (Slip Compensation Limit)

- **Sets the upper limit for the Slip Compensation function**
- **Constant power range: Limit is increased linearly because of higher compensation requirement**
- **Setting not needed for control modes with speed feedback**



Motor 1 (J V A)	Motor 2 (J V A)	Name / Description	Range	Default
C3-03	C3-23	Slip Compensation Limit (in % of motor rated slip E2-02)	0 to 250%	200%

C3: Slip Compensation

C3-04: Slip Compensation Selection during Regeneration
C3-24: Motor 2 Slip Compensation Selection during Regeneration

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Setup for regenerative operation

Motor 1	Motor 2	Name	Range	Drive
C3-04	C3-24 (Only A1000)	Slip Compensation Selection during Regeneration	0: Disabled	J V A
			1: Enabled above 6 Hz	J V A
			2: Enabled whenever Slip Compensation is possible	J V A

Note:

- Possible frequency range for Slip Compensation will be calculated automatically by using the motor rated slip (E2-02)
- Absolut minimum value is 2 Hz even if C3-04 = 2

C3: Slip Compensation

C3-05: Output Voltage Limit Operation Selection

V/f | V/f w/PG | OLV | CLV
OLV/PM | AOLV/PM | CLV/PM

Operation when output voltage is saturated

- Drives internal output voltage reference exceeds the input voltage (E1-01)
  → Voltage becomes saturated
    → Drive can not respond to speed or load changes as fast as normal
      → Speed becomes unstable
      → Slip Compensation function stops operation
- Occurs when
  - operating in constant power range
  - high torque at high speed is needed
- With C3-05 = 1 (Output Voltage Limit Operation is enabled)
  - Internal Flux Reference is decreased (lower Id, flux producing current)
  - Output Voltage keeps below 90% of Maximum Output Voltage (E1-05)
  - Slip Compensation continues operation

Note: Output current can increase for up to 10% in constant power range. Consider this when using this function.

C3: Slip Compensation

C3-05: Output Voltage Limit Operation Selection

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Operation when output voltage is saturated

C3-05 = 1
(flux decreased during voltage saturation)

- Output voltage keeps below 90% of E1-01 (Max. Output Voltage)
- Slip Compensation can continue working because adaption of output voltage is still possible
- Speed accuracy good as ever
- Output Current can be up to 10% higher due to the flux reduction

C3-05 = 0
(disabled, normal operation)

- Complete voltage is output (Limit is 100% of E1-01)
- Slip Compensation is disabled
- Normal motor control process determines internal flux reference
- Torque performance might be better, especially during load changes

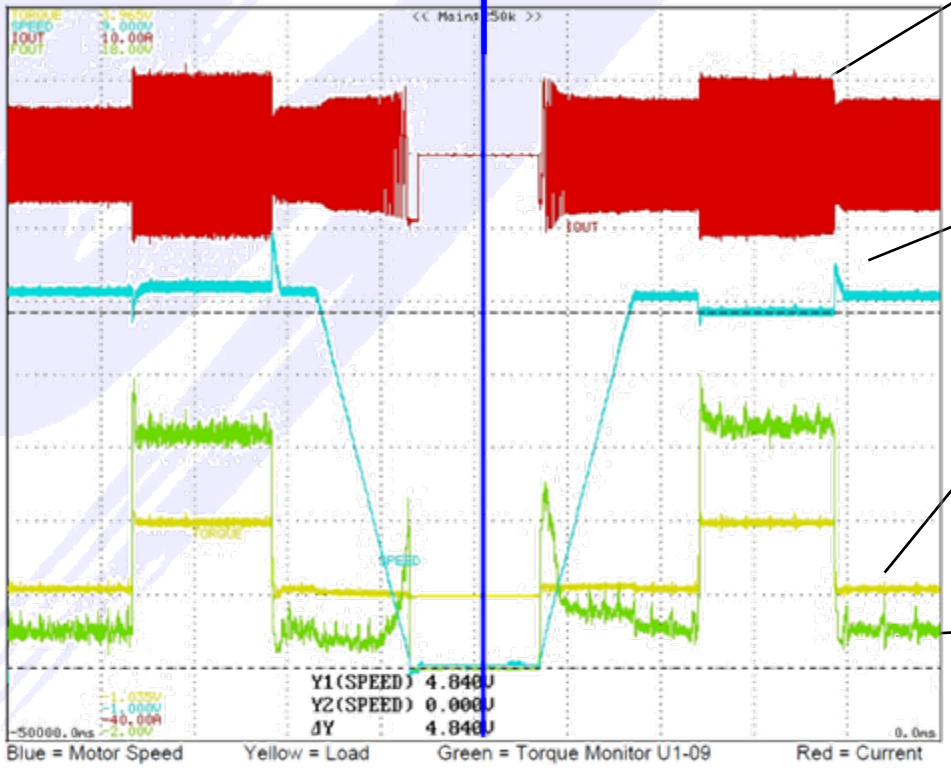
Parameter	Name	Range	Default
C3-05	Output Voltage Limit Operation Selection	0: Disabled 1: Enabled	0

C3: Slip Compensation

C3-05: Output Voltage Limit Operation Selection

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

C3-05 = 1 (enabled) C3-05 = 0 (disabled)



Red: Output Current

Blue: Motor speed

Yellow: Motor torque

Green: Monitor U1-09
Internal Torque Reference

C4: Torque Compensation

C4-01 to C4-07: Setup parameters for Torque Compensation function

V/f | V/f w/PG | OLV | CLV
OLV/PM | AOLV/PM | CLV/PM

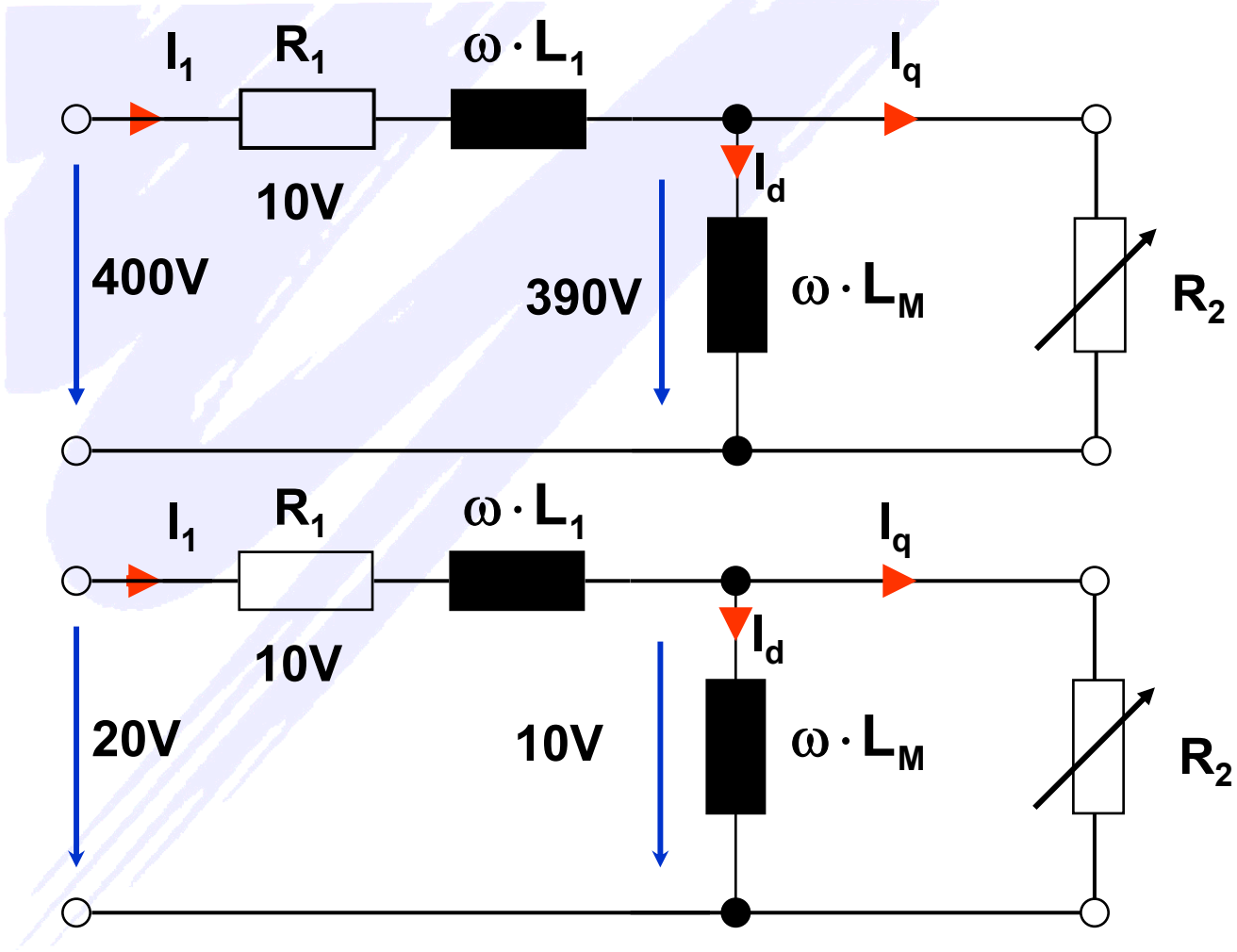
- Torque Compensation improves torque performance in Open Loop control
- Better performance especially at start or when load is applied
- Voltage loss due to R1 is higher at lower speed.
  - V/f V/f w/PG : Voltage loss is compensated by higher voltage
  - OLV/PM OLV : Voltage loss is compensated by higer torque producing current Iq (Internal Torque Reference is increased)
- E2-05 (Motor Line-to-Line Resistance) must be set
- For PM motors: E5-05 (Motor Stator Resistance) must be set

Execute Auto-Tuning even for V/f control or make sure that accurate motor data is set manually before adjusting Torque Compensation parameters!

C4: Torque Compensation

C4-01 to C4-07: Setup parameters for Torque Compensation function
Automatic Voltage Drop Compensation

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM



High Speed:

- High $\omega \cdot L_M$
- Proper voltage at main inductance L_M
- Relatively small voltage drop over R_1

Low Speed:

- Low $\omega \cdot L_M$
- Too low voltage at main inductance L_M
- Relatively high voltage drop over R_1

The figures assume constant load conditions

C4: Torque Compensation

C4-01: Torque Compensation Gain
C4-07: Motor 2 Torque Compensation Gain
C4-02: Torque Compensation Delay Time

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Tuning for V/f control and OLV/PM control

Drive calculates voltage loss due to R1 and compensates by adapting output voltage

- **C4-01 (Torque Compensation Gain)**
  Sets the amount of voltage compensation

  J V A

  - Longer motor cables
  - Insufficient torque at start or when load is applied → Increase value in steps of 0.05
  - Oscillation occurs → Decrease value in steps of 0.05
  - OLV/PM : In most cases adjustment is not needed

- **C4-02 (Torque Compensation Delay Time)**

  J V A

  - Normally no need to adjust
  - Slow response to load changes → Decrease value in small steps
  - Motor oscillates: → Increase value in small steps

C4: Torque Compensation

C4-01: Torque Compensation Gain
C4-02/03: Torque Compensation Delay Time 1 / Delay Time 2

J V A

V/f | V/f w/PG | **OLV** | CLV
OLV/PM | AOLV/PM | CLV/PM

Tuning for Open Loop Vector control for Induction Motors

Voltage losses are compensated by increasing the Internal Torque Reference and by that the torque producing current (Iq)

- **C4-01 (Torque Compensation Gain)**
  - **Increase when using long motor cable**
  - **Decrease when oscillation occurs**
- **C4-02 (Torque Compensation Delay Time)**
  - **Decrease when response is slow**
  - **Increase in case of oscillation, especially for high inertia loads**
  - **When increasing, increase n2-02 (AFR Time Constant) proportionall**
- **C4-06 (Torque Compensation Delay Time 2)**
  - **Regenerative operation or Speed Search (parameter group b3) used:**
    → Increase, when overvoltage (ov) faults occur.
  - **When increasing, increase n2-03 (AFR Time Constant 2) proportionally**
  - **AFR means Automatic Frequency Regulator further information see below**

Normally no need to adjust.
Modify only if really needed.

C4: Torque Compensation

C4-03/04: Torque Compensation at Forward Start / at Reverse Start
C4-05: Torque Compensation Time Constant

V/f | V/f w/PG | **OLV** | CLV
OLV/PM | AOLV/PM | CLV/PM

Tuning for Open Loop Vector Control for Induction Motors

- C4-03 (Torque Compensation at Forward Start)
  C4-04 (Torque Compensation at Reverse Start)
  - Sets the amount of torque at forward and at reverse start, respectively
  - Increase, when load pulls the motor in opposite direction of RUN command
  - Setting 0.00% will disable this function
- C4-05 (Torque Compensation at Start Time Constant)
  - Time constant for C4-03 (Torque Compensation at Forward Start) and C4-04 (Torque Compensation at Reverse Start)
  - Faster response neeeded: Increase value
  - Motor oscillates: Decrease value
- OLV and high inertia loads: Motor might trip with OV at low speed (e. g. 3 Hz)
  - Increase delay time C4-02 and AFR time constant n2-02
  - Lower AFR gain n2-01

C4: Torque Compensation

C4-01 to C4-07: Setup parameters for Torque Compensation function

Parameter	Name / Description	Range	Default	Available in
C4-01	Torque Compensation Gain	0.00 to 2.50	1.00	J V A — V/f, V/f w/PG, OLV, OLV/PM
C4-02	Torque Compensation Delay Time 1	0 to 60000 ms	200 ms	J V A — V/f, V/f w/PG, OLV, OLV/PM
C4-03	Torque Compensation at Forward Start	0.0 to 200.0 %	0.0%	J V A — V/f, V/f w/PG, OLV, OLV/PM
C4-04	Torque Compensation at Reverse Start	-200.0 to 0.0 %	0.0%	J V A — V/f, V/f w/PG, OLV, OLV/PM
C4-05	Torque Compensation Time Constant	0 to 200 ms	10 ms	J V A — V/f, V/f w/PG, OLV, OLV/PM
C4-06	Torque Compensation Delay Time 2	0 to 10000 ms	150 ms	J V A — V/f, V/f w/PG, OLV, OLV/PM
C4-07	Motor 2 Torque Compensation Gain	0.00 to 2.50	1.00	J V A — V/f, V/f w/PG, OLV, OLV/PM

C5: Automatic Speed Regulator (ASR)

C5-01 to C5-38: Setup parameters for Automatic Speed Regulator (ASR)

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

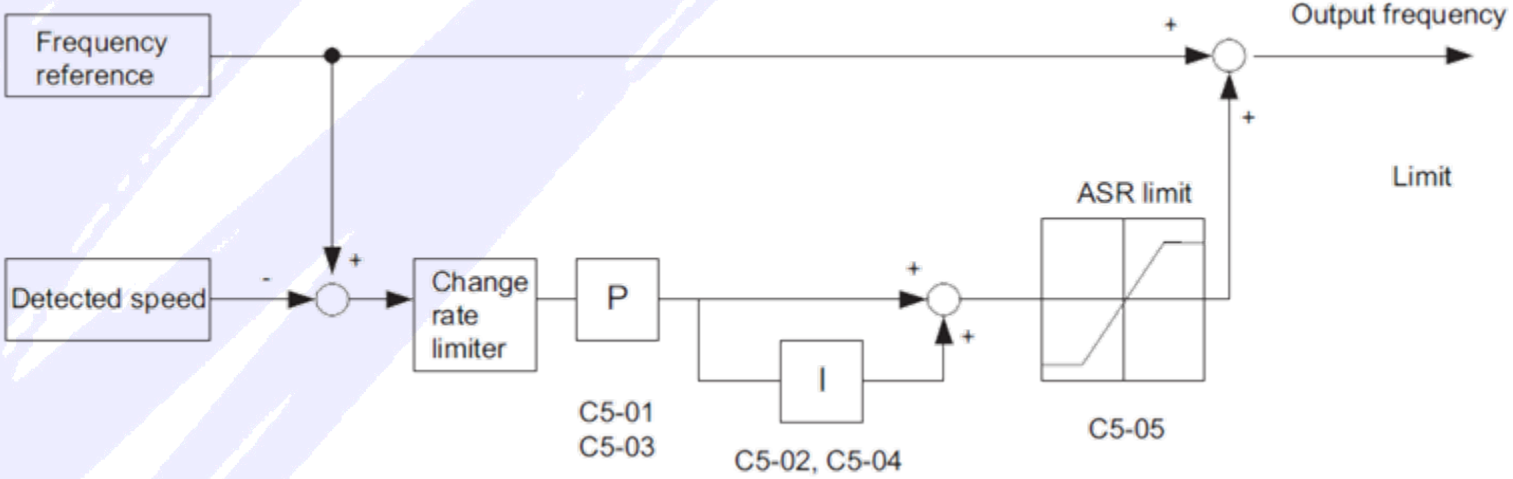
- Automatic Speed Regulator (ASR) regulates the motor speed by using a speed feedback signal from the motor
- V/f control with PG feedback:
  - Output Frequency is controlled directly
  - Encoder (PG = Pulse Generator) can be connected directly to the motor shaft or via a gear to the load (gear ratio can be set)
    - ➔ Simplest way to get high speed accuracy. Use for applications which does not need high dynamic torque!
    - ➔ Can be used, when connecting multiple motors to one drive. Connect encoder signal from one motor, other motors will follow!
- Vector control modes (CLV, AOLV/PM and CLV/PM):
  - Output Frequency is controlled via Internal Torque Reference
  - Encoder must be connected to motor shaft because internal motor model requires direct feedback. Gears will cause distortion in feedback.
    - ➔ Highest performance in speed and torque accuracy. Gain full control about what your motor is doing!

C5: Automatic Speed Regulator (ASR)

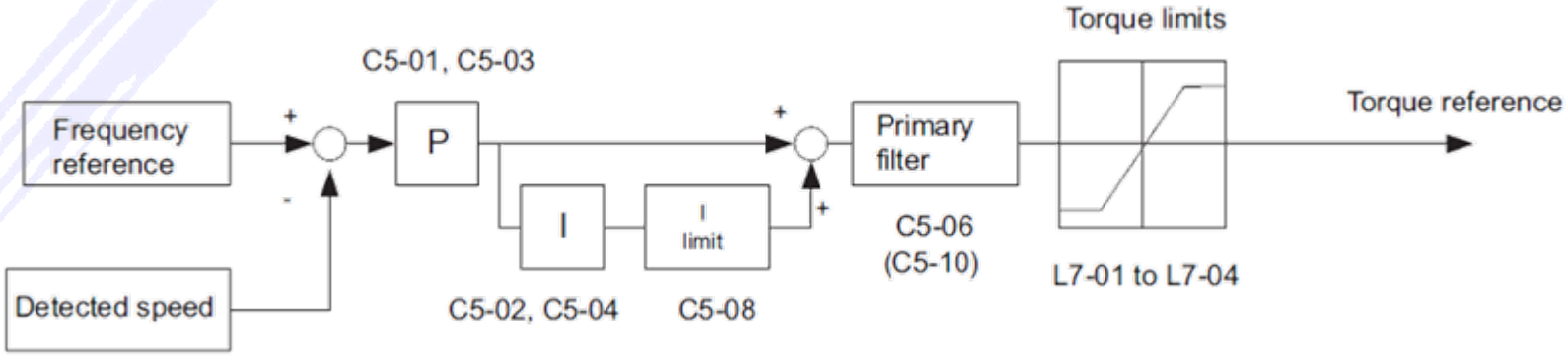
C5-01 to C5-38: Setup parameters for Automatic Speed Regulator (ASR)

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

ASR for V/f with PG: Correction value is a frequency



ASR for CLV, CLV/PM and AOLV/PM: ASR output is Internal Torque Reference



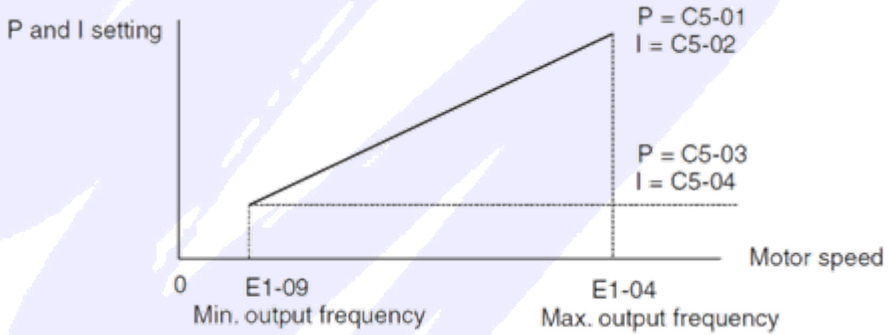
C5: Automatic Speed Regulator (ASR)

C5-01/03: ASR Proportional Gain 1 / ASR Proportional Gain 2
C5-02/04: ASR Integral Time 1 / ASR Integral Time 2

J V A

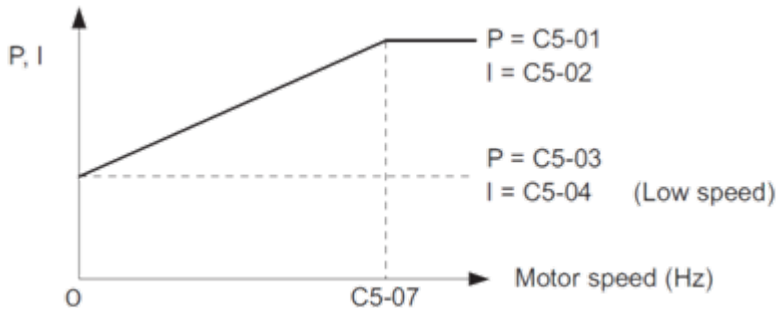
V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

V/f control with PG feedback



- Gain 2 (C5-03) and I. Time 2 (C5-04) are valid at Min. Output Freq. (E1-09)
- Gain 1 (C5-01) and I. Time 1 (C5-02) are valid at Max. Output Freq. (E1-04)
- Linear calculation depending on speed
- Default: C5-01 > C5-03
  C5-02 > C5-04

Vector control (IM and PM motors)



- Gain 2 (C5-03) and I. Time 2 (C5-04) are valid at Zero Speed operation
- Gain 1 (C5-01) and I. Time 1 (C5-02) are valid above C5-07 (ASR Gain Switching Frequency)
- Linear calculation depending on speed
- Default: C5-07 = 0
  → Only C5-01 and C5-02 are valid

C5: Automatic Speed Regulator (ASR)

C5-01/03: ASR Proportional Gain 1 / ASR Proportional Gain 2
C5-02/04: ASR Integral Time 1 / ASR Integral Time 2

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Adjustment procedure for V/f control with PG feedback

Second gain / integral time settings are always needed!

1. **Run the motor at minimum speed (E1-09)**
   - **First increase C5-03 (ASR P. Gain 2) as much as possible without oscillation**
   - **Then decrease C5-04 (ASR I. Time 2) as much as possible without oscillation**
2. **Run the motor at maximum speed (E1-04)**
   - **First increase C5-01 (ASR P. Gain 1) as much as possible without oscillation**
   - **Then decrease C5-02 (ASR I. Time 1) as much as possible without oscillation**
3. **Check speed precision and speed response during acceleration/deceleration. Insufficient precision and response?**
   - **Set C5-12 (Integral Operation during Accel/Decel) = 1**
   - **Integral control will be enabled outside constant speed operation**

C5: Automatic Speed Regulator (ASR)

C5-01/03: ASR Proportional Gain 1 / ASR Proportional Gain 2
C5-02/04: ASR Integral Time 1 / ASR Integral Time 2

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Adjustment procedure for Vector control modes

Second Gain / Integral time setting are not always needed! When C5-07 = 0, set only C5-01 and C5-02!

1. Start the drive with zero speed operation (f_{REF} = 0 Hz)
   - First increase C5-01 (ASR P. Gain 1) as much as possible without oscillation
   - Then decrease C5-02 (ASR I. Time 1) as much as possible without oscillation
2. Run at normal operating speed.
   - Check for under/overshoot of motor speed when changing reference
   - Check for oscillation
   - Oscillation or under/overshoot occur? Decrease gain + increase int. time.
3. No more oscillation or under/overshoot but poor speed response/accuracy?
   - Set C5-03 = C5-01 and C5-04 = C5-02
   - Set ASR Gain Switching Frequency (C5-07), e. g. to 60% of rated speed
   - Run with a speed higher than C5-07
   - Adjust C5-03 and C5-04 like described for "1." and check performance!

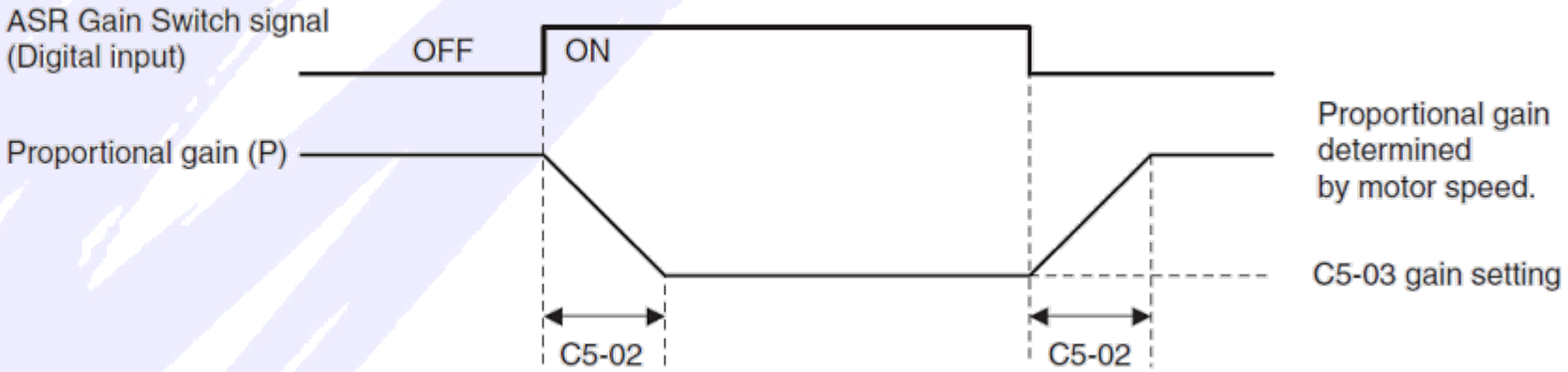
C5: Automatic Speed Regulator (ASR)

C5-01/03: ASR Proportional Gain 1 / ASR Proportional Gain 2
C5-02/04: ASR Integral Time 1 / ASR Integral Time 2

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Gain switching via Digital Input (Vector control modes only)



- When Digital Input is set to H1-xx = 77H (ASR Gain Switch) ...
  - Input is closed: C5-03 (ASR Proportional Gain 2) is used
  - Input is opened: C5-01 (ASR Proportional Gain 1) is used
  - Gain is changed linearly with the time C5-02 (ASR Integral Time 1)
  - H1-xx = 77H has higher priority than C5-07 (ASR Gain Switching Frequency)

C5: Automatic Speed Regulator (ASR)

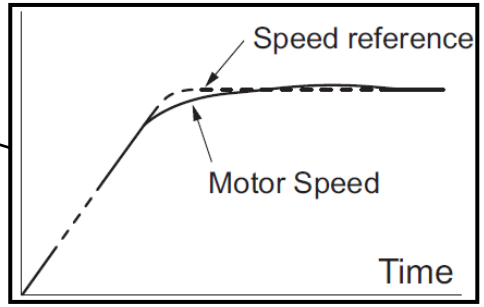
C5-01/03: ASR Proportional Gain 1 / ASR Proportional Gain 2
C5-02/04: ASR Integral Time 1 / ASR Integral Time 2

J V A

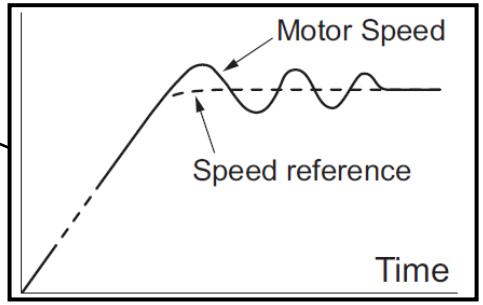
V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Setup Problems and Corrective Actions

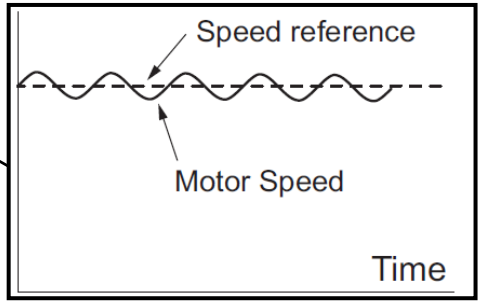
- **Slow response to speed changes / Long lasting deviation**
  - Increase gain (C5-01/03)
  - Decrease integral time (C5-02/04)



- **Over/Undershoot at end of Accel./Decel.**
  - Decrease gain (C5-01/03)
  - Increase integral time (C5-02/04)



- **Vibration and Oscillation at constant speed**
  - Decrease gain (C5-01/03)
  - Increase integral time (C5-02/04)
  - Increase delay time (C5-06)



C5: Automatic Speed Regulator (ASR)

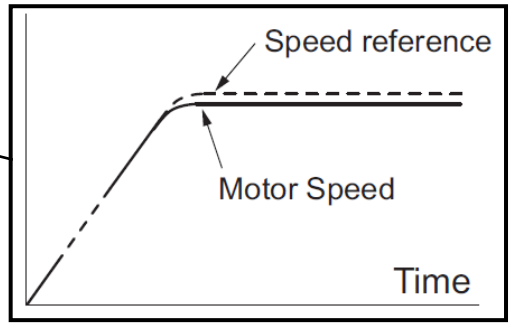
C5-01/03: ASR Proportional Gain 1 / ASR Proportional Gain 2
C5-02/04: ASR Integral Time 1 / ASR Integral Time 2

J V A

V/f | **V/f w/PG** | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Setup Problems and Corrective Actions

V/f w/PG only: Slip not fully compensated



- Check the setting of the encoder resolution
  - A1000:
    Set number of pulses in
    F1-01 (PG 1 Pulses Per Revolution)
  - V1000 or A1000 without Speed Control Card
    (Simple PG Feedback):
    Set pulse frequency at max. speed to H6-02 (Pulse Input Scaling)
    Set H6-04 = 0% (Pulse Input Bias)
    Set H6-03 = 100% (Pulse Input Gain)
- Check gear ratio in F1-12 (PG 1 Gear Teeth 1) and F1-13 (PG 1 Gear Teeth 2)
- Check if ASR is working at its output limit (C5-05):
  - Check monitor U6-04 (ASR Output)
  - When it operates at the limit, increase C5-05

C5-01/03: ASR Proportional Gain 1 / ASR Proportional Gain 2
C5-02/04: ASR Integral Time 1 / ASR Integral Time 2

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Setup Problems and Corrective Actions

- When it is not possible to get satisfactory performance by tuning C5 parameters: Encoder might be faulty!

  The Encoder feedback can be checked like this:

  - Set to V/f control (A1-02 = 0)
  - Run the motor and check monitor U1-05 (Motor speed)
    - Check if motor speed value is like expected (consider slip and slip compensation)
    - Output U1-05 to an analogue output (e. g. H4-01 = 105) and measure the value with a scope. Check for hunting, short-time feedback losses or similar.
  - In case of unexpected results, check encoder, encoder wiring and encoder settings

Note: U1-05 monitor will be available even in control modes without feedback as long as a speed feedback option board is connected.

C5: Automatic Speed Regulator (ASR)

C5-01 to C5-08: Parameter Overview – Automatic Speed Regulator

Parameter	Name / Description	Range	Default	Available in
C5-01 C5-03	ASR Proportional Gain 1 / ASR Proportional Gain 2	0.00 to 300.00	0.20 (V/f w/PG)	J V A V/f w/PG AOLV/PM CLV CLV/PM
C5-02 C5-04	ASR Integral Time 1 / ASR Integral Time 2	0.000 to 10.000 s	0.2000s (V/f w/PG)	J V A V/f w/PG AOLV/PM CLV CLV/PM
C5-05	ASR Limit	0.0 to 20.0	5.0%	J V A V/f w/PG AOLV/PM CLV CLV/PM
C5-06	ASR Primary Delay Time Constant	0.000 to 0.500 s	0.004 s	J V A V/f w/PG AOLV/PM CLV CLV/PM
C5-07	ASR Gain Switching Frequency	0.0 to 400.0 Hz	0.0 Hz	J V A V/f w/PG AOLV/PM CLV CLV/PM
C5-08	ASR Integral Limit	0.0 to 400.0 %	% of Motor Rated Torque	J V A V/f w/PG AOLV/PM CLV CLV/PM

C5: Automatic Speed Regulator (ASR)

C5-12 to C5-38: Parameter Overview – Automatic Speed Regulator

Parameter	Name / Description	Range	Default	Available in
C5-12	Integral Operation during Accel/Decel	0: Disabled 1: Enabled	0	J V A V/f w/PG AOLV/PM CLV CLV/PM
C5-17	Motor Inertia (Refer to description of "Feed Forward Control")	0.0001 to 600.0001 kgm²	1)	J V A V/f w/PG AOLV/PM CLV CLV/PM
C5-18	Load Inertia Ratio (Refer to description of "Feed Forward Control")	0.0 to 6000.0	1.0	J V A V/f w/PG AOLV/PM CLV CLV/PM
C5-21 to C5-38	Same as C5-01 to C5-18 for Motor 2	See Motor 1 settings		J V A

Note 1: Factory default setting depends on drive size and HD / ND selection (Drive Duty Selection, C6-01)

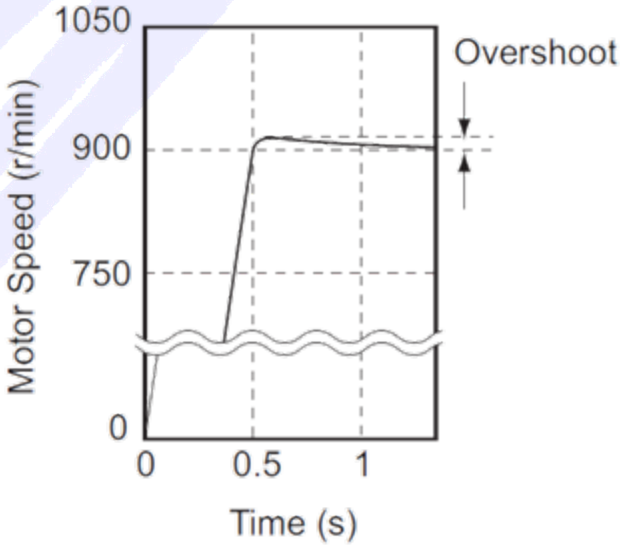
n5: Feed Forward Control

n5-01: Feed Forward Control Selection
n5-02: Motor Acceleration Time

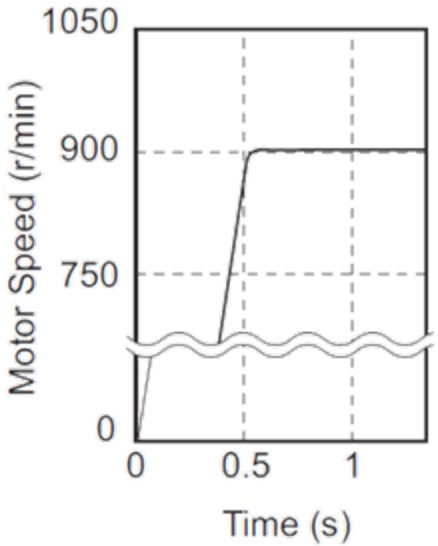
J V A

V/f | V/f w/PG | OLV | CLV
OLV/PM | AOLV/PM | CLV/PM

- Use Feed Forward Control, when oscillation or overshoot/undershoot at end of acceleration occurs in CLV.
- Usefull especially for applications needing high ASR gain
  - ➔ Much better response to Frequency Reference changes.
    Set ASR gain freely and don't worry about negative effects!



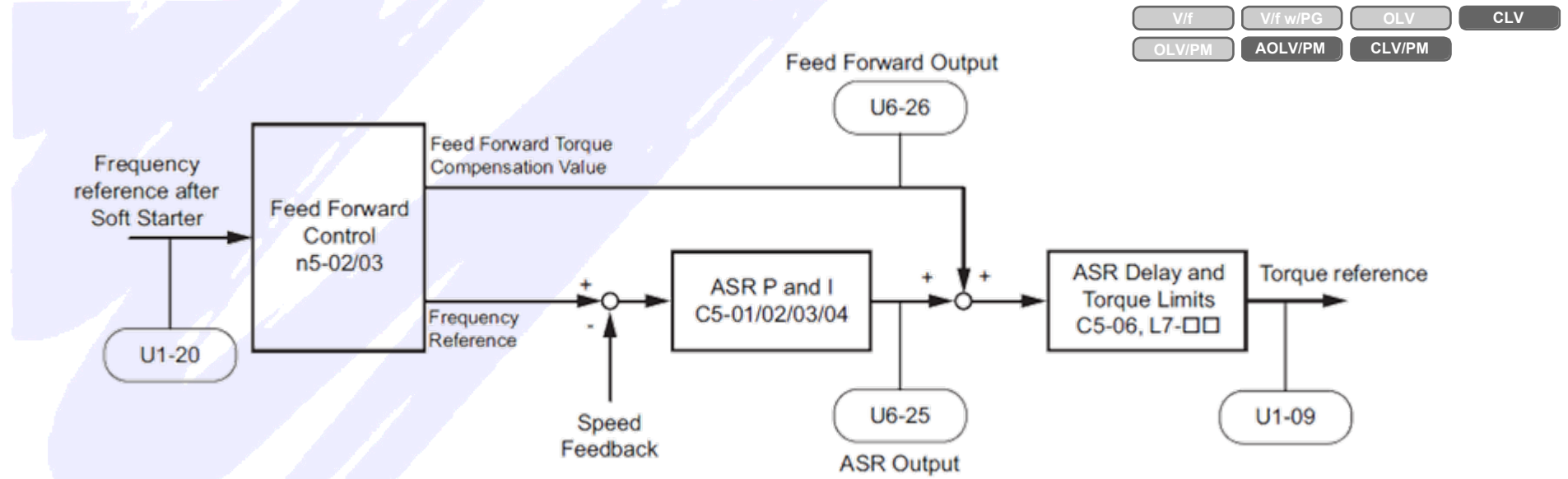
Conventional Speed Control



Feed Forward Control

n5: Feed Forward Control

n5-01 to n5-03: Setup parameters for Feed Forward Control



- **Normal ASR operation: ASR outputs Torque Reference**
- **ASR + Feed Forward Control: Additional component added to Torque Reference**
  - **This component bypasses PI controller**
  - **Effect is similar to derivative control component (PID controller): Controller output depends linearly on derivation of speed deviation**
    - ➔ **Very high controller output directly after reference step. Controller reacts faster and overshoot is avoided**

n5: Feed Forward Control

n5-01 to n5-03: Setup parameters for Feed Forward Control

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Parameter	Name	Range	Default
n5-01	Feed Forward Control Selection	0: Disabled 1: Enabled	0
n5-02	Motor Acceleration Time Time for accel. from 0 to E1-06 at rated torque. Set like described on next slide.	0.001 to 10.000 s	1)
n5-03	Feed Forward Control Gain Inertia ratio between load and motor. Set like described below.	0.00 to 100.00	1.00
C5-17	Motor Inertia Set data from motor manufacturer	0.0001 to 600.00 kgm²	1)
C5-18	Load Inertia Ratio Set by Inertia or ASR Gain Auto-Tuning	0.0 to 6000.0	1.0

Note 1: Factory default setting depends on drive size and Drive Duty Selection (C6-01)

n5: Feed Forward Control

n5-02: Motor Acceleration Time

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Setting n5-02 (Motor Acceleration Time)

- Value can be set by Auto-Tuning. Recommended if possible.
- Value can be calculated. Needed values are ...
  - motor inertia (J_{Motor})
  - rated motor speed in r/min (n_{RATED_RPM})
  - rated motor torque in Nm (T_{RATED_Nm})

$$n5-02 = \frac{\pi \cdot J_{Motor} \cdot n_{rated}}{30 \cdot T_{rated}}$$

- Value can be measured
  - Due to very short times in many cases not applicable. Follow these steps:

1. Decouple motor and load.
2. Make sure, that motor data and ASR parameters are already set properly.
3. Set the acceleration time to zero (C1-01 = 0)
4. Set the forward torque limit in parameter L7-01 to 100%
5. Set the Frequency Reference equal to the rated motor speed
6. While monitoring the motor speed in U1-05, start the motor in the forward direction and measure the time it takes to reach the rated speed.
7. Reset C1 and L7 parameters and set n5-02 to the measured value.

n5: Feed Forward Control

n5-03: Feed Forward Control Gain

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Setting n5-03 (Feed Forward Control Gain)

- Value can be set by Auto-Tuning. Recommended if possible.
- Value can be measured. Follow these steps:
  1. Set parameter n2-02 (Motor Acceleration Time) correctly.
  2. Couple motor and load.
  3. Set the acceleration time to zero (C1-01 = 0)
  4. Set all torque limits (L7 group) to a value that will easily be reached during the test (T_{LIM_TEST}).
  5. Set Frequency Reference to a value in the upper speed range (f_{REF_TEST}).
  6. While monitoring the motor speed in U1-05, start the motor in the forward direction and measure the time it takes to reach the rated speed (t_{ACCEL}).
  7. Reset C1 and L7 parameters and set n5-03 to the result of the formular:

$$n5-03 = \frac{t_{ACCEL} \cdot T_{LIM\_TEST} \cdot f_{rated}}{n5-02 \cdot f_{REF\_TEST} \cdot 100} - 1$$

t_{ACCEL}: Measured acceleration time
T_{LIM_TEST}: L7 setting
f_{RATED}: Motor rated frequency in Hz
f_{REF}: Freq. Reference during Test

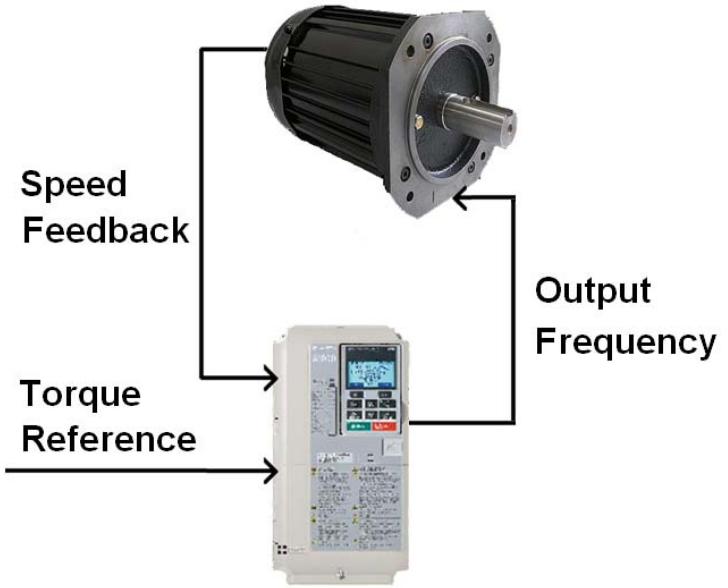
d5: Torque Control

d5-01: Torque Control Selection

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

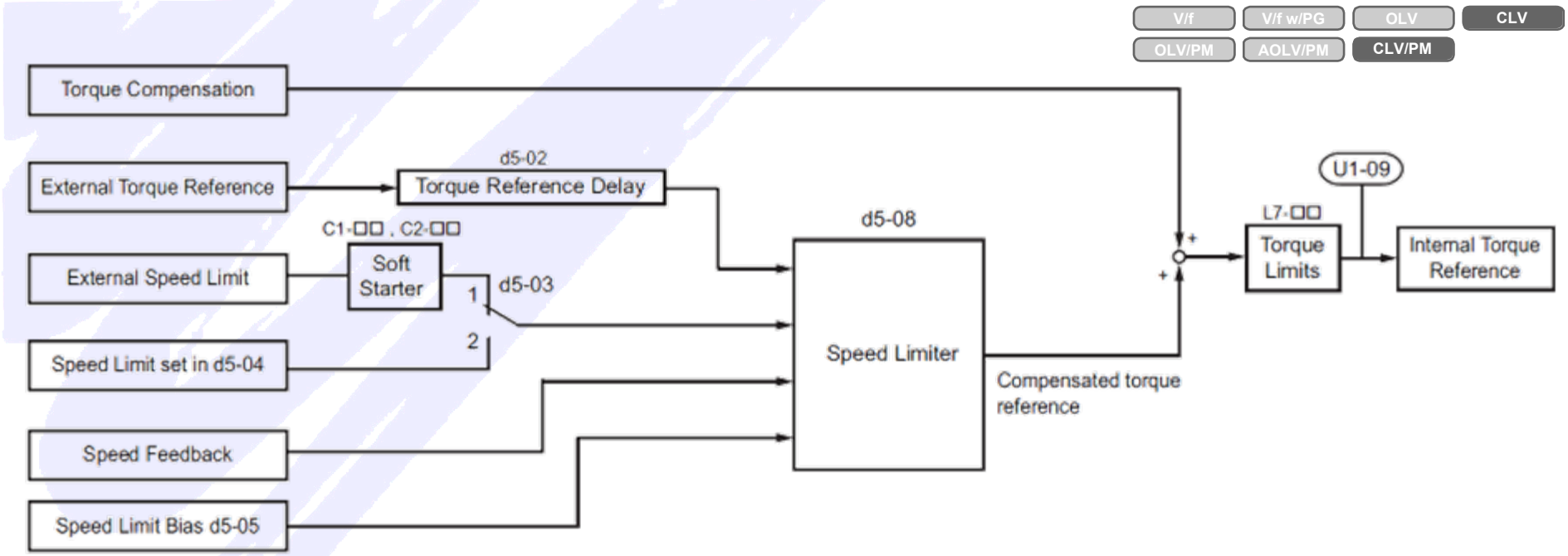
- Torque is controlled instead of speed
- Drive accelerates or decelerates if load is not in balance with Torque Reference
  - ➔ Example: Winder application. Yarn, wire etc. will be destroyed when torque is not correct!
- Speed limit reached and still not enough torque:
  - Drive changes to Speed Control
  - Speed Controller ASR is active
  - Motor speed is kept at the speed limit …
    - — until either torque limit is decreased
    - — or speed limit is increased



Parameter	Name	Range	Default
d5-01	Torque Control Selection	0: Speed Control 1: Torque Control	0

d5: Torque Control

d5-01 to d5-08: Setup parameters for Torque Control



Internal Torque Reference is determined by ...

- **External Torque Reference, Torque Compensation (optional added value), Speed Limit, Torque Limits (L7-xx parameter, Refer to Presentation "Drive Protection")**

Parameter	Name	Range	Default
d5-02	Torque Reference Delay Time	0 to 1000 ms	0 ms

d5: Torque Control

H3-Group, H5-Group, F2-Group, F6-Group Input Setup for Torque Reference

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Polarity of Internal Torque Reference

Run command direction	External Torque Reference Polarity	Internal Torque Reference Polarity
Forward	+ (positive)	Forward direction
	- (negative)	Reverse direction
Reverse	+ (positive)	Reverse direction
	- (negative)	Forward direction

- Negative values for External Torque Reference can be input ..
  - by using negative voltage input signals
  - by using positive voltage input signals with negative bias settings
  - by using a digital input set to H1-xx = 78 (External Torque Reference Polarity Inversion)
- Directly by Memobus, only positive External Torque Reference values can be input

d5: Torque Control

H3-Group, H5-Group, F2-Group, F6-Group
Input Setup for Torque Reference

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Source for External Torque Reference

Input Source	Settings
Analogue Inputs (A1, A2, A3)	▪ Set H3-02, H3-06 or H3-10 = 13 (Torque Reference/Torque Limit)
Analogue Option Card (V1, V2, V3)	▪ Set F2-01 = 0 (A1, A2, A3 are replaced by V1, V2, V3) ▪ Set H3-02, H3-06 or H3-10 = 13 (Torque Reference/Torque Limit)
Memobus (Register 0004h)	▪ Set Register 000Fh, Bit 2 = 1 ▪ Send Torque Reference to Register 0004h
Communication Option Card (e. g. Mechatrolink, Devicenet, ...)	▪ Set F6-06 = 1 (Torque Reference/Torque Limit from option card enabled) ▪ Refer to the option card manual for details

d5: Torque Control

H3-Group, H5-Group, F2-Group, F6-Group
Input Setup for Torque Reference

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Source for Torque Compensation

- Analogue Inputs (A1, A2, A3)
  - Set H3-02, H3-06 or H3-10 = 14 (Torque Reference / Torque Limit)
- Analogue Option Card
  - Set F2-01 = 0 (A1, A2 and A3 are replaced by the option card inputs)
  - Set H3-02, H3-06 or H3-10 = 14 (Torque Compensation)
- MEMOBUS Register 0005h
  - Set Register 000Fh, Bit 3 = 1
  - Send Torque Compensation Signal to Register 0005h
- Communication Option Card
  - Refer to the option card manual for details

d5: Torque Control

d5-03 to d5-05: Setup for Speed Limit and Speed Limit Bias
d5-08: Unidirectional Speed Limit Bias

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Setup for Speed Limit and Speed Limit Bias

- Source for Speed Limit is either the source selected in b1-01 or parameter d5-04
- Speed Limit Bias can be added to the Speed Limit

Parameter	Name	Range	Default
d5-03	Speed Limit Selection	1: Limit set by the frequency reference (b1-01) 2: Limit set by d5-04	1
d5-04	Speed Limit Set in % of max. outp. freq. (E1-04)	-120% to +120%	0%
d5-05	Speed Limit Bias Set in % of max. outp. freq. (E1-04)	0 to 120%	10%
d5-08	Unidirectional Speed Limit Bias	0: Disabled 1: Enabled	1

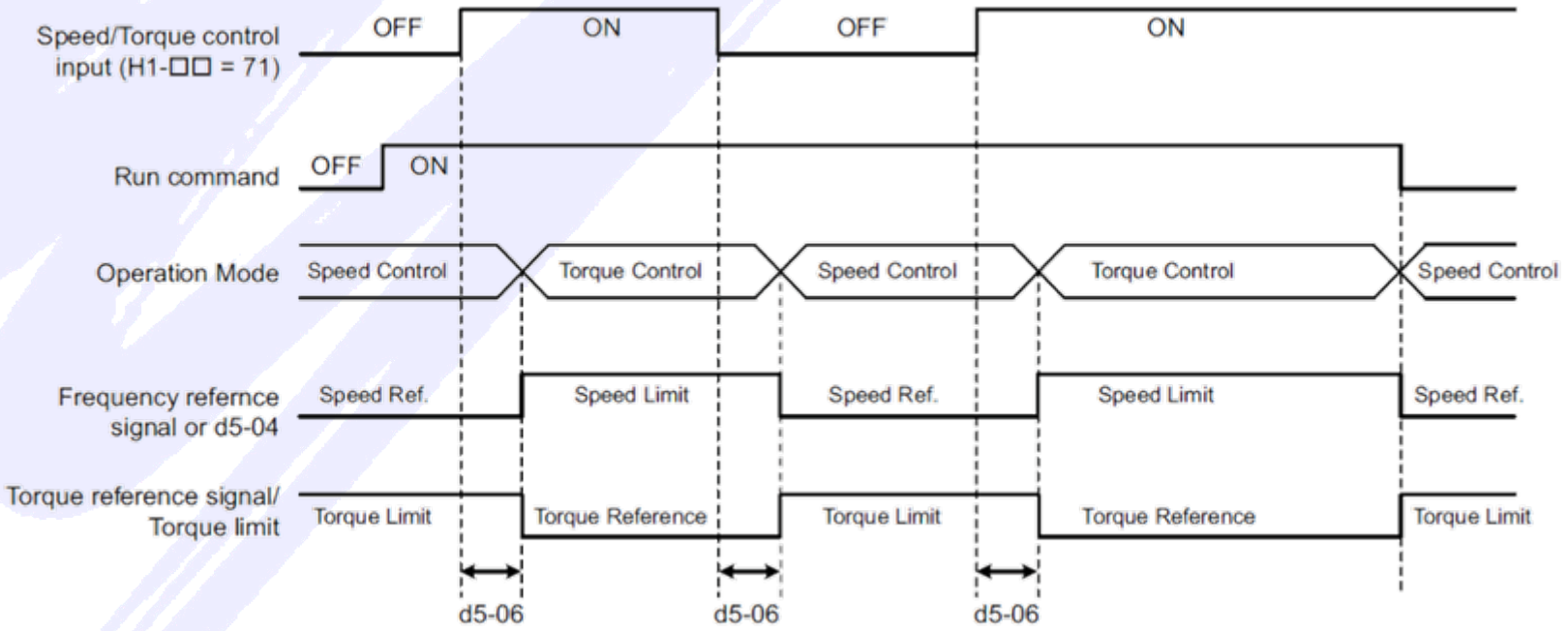
d5: Torque Control

d5-06: Switching between Torque and Speed Control

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Switching with digital input (H1-xx = 71



Parameter	Name	Range	Default
d5-06	Speed/Torque Control Switchover Time Reference values keep constant during this time	0 to 1000 ms	0 ms

Note: d5-01 (Torque Control Selection) must be set to 0 (Speed Control)

d6: Field Weakening / Field Forcing

d6-01: Field Weakening Level
d6-02: Field Weakening Frequency Limit

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Field Weakening function

- Lowers the output voltage for reaching lower energy consumption
- Lower voltage means lower intensity of the magnetic field
  → Lower torque production → Use for known and unchanging light load condition
- Can be triggered by digital input (H1-xx = 63)
  ➔ Activate during run when load is low, e. g. in non-working times!
- Various different load conditions or more torque required?
  - Use Energy Saving Control instead (automatic adaption of voltage)
  - Can not be activated by digital input during RUN

Parameter	Name	Range	Default
d6-01	Field Weakening Level Set the level to that output voltage is reduced in % of maximum output voltage (E1-05)	0 to 100%	80%
d6-02	Field Weakening Frequency Limit Set the minimum output frequency for that Field Weakening can be activated in Hz.	0 to 400.0 Hz	0.0 Hz

d6: Field Weakening / Field Forcing

d6-03: Field Forcing Selection
d6-06: Field Forcing Limit

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Field Forcing function

- Motor time constant can have negative influence when Id is changed:
  Field Forcing improves responsiveness to changes to the flux producing current (Id) reference
- Applies a boost to the flux producing current (Id) reference

Note: Consider that using this function will cause a higher motor current!

Parameter	Name	Range	Default
d6-03	Field Forcing Selection	0: Disabled 1: Enabled	0
d6-06	Field Forcing Limit Sets the maximum value to that the flux producing current (Id) reference can be increased. Set in % of No-Load Current (E2-03).	100% to 400%	400%

n1: Hunting Prevention

n1-01 to n1-05: Setup parameters for Hunting Prevention function

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- Hunting Prevention supresses hunting in V/f control by slowing the response of Torque Compensation function
- Hunting might occur ...
  - when driving low inertia and light load
  - when using high carrier frequency
  - at output frequencies < 30 Hz
- Hunting prevention is enabled by default n1-01 = 1
  - n1-02 (Hunting Prevention Gain Setting) J V A
    - Hunting occurs with light load:
      Increase by steps of 0.1 until hunting ceases
    - Motor stalls: Decrease by steps of 0.1 until stalling ceases
  - n1-03 (Hunting prevention Time Constant) J V A
    - Adjustment normally not needed, might be helpful for large inertia loads
    - Hunting occurs: Increase n1-03.
      → Response will be slower, but maybe oscillation at lower speed
    - Oscillation at lower speed: Decrease n1-03

n1: Hunting Prevention

n1-01 to n1-05: Setup parameters for Hunting Prevention function

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- For reverse operation
  n1-05 (Hunting Prevention Gain while in Reverse)
  - Same as n1-02 (Hunting Prevention Gain Setting) but for Reverse operation
    ➔ Allows optimal tuning for applications with different load requirements depending on rotation direction

- For applications with load ripple: Hunting Prevention might cause hunting
  - The drive detects the load ripple and tries to compensate them. Hunting might get worse due to that.
  - Increase n1-02/n1-05 or disable Hunting Prevention by setting n1-01 = 0

  ➔ Sample Application: Screw Compressor.
  Torque ripple occurs always when expelling compressed air

n1: Hunting Prevention

n1-01 to n1-05: Setup parameters for Hunting Prevention function

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Param.	Name	Range	Default	Drive
n1-01	Hunting Prevention Selection	0: Disabled 1: Enabled	1	J V A
n1-02	Hunting Prevention Gain Setting	0.00 to 2.50	1.00	J V A
n1-03	Hunting Prevention Time Constant	0 to 500 ms	Depends on drive size	J V A
n1-05	Hunting Prevention Gain while in Reverse When set to 0.00, n1-02 is used for Reverse operation	0.00 to 2.50	0.00	J V A

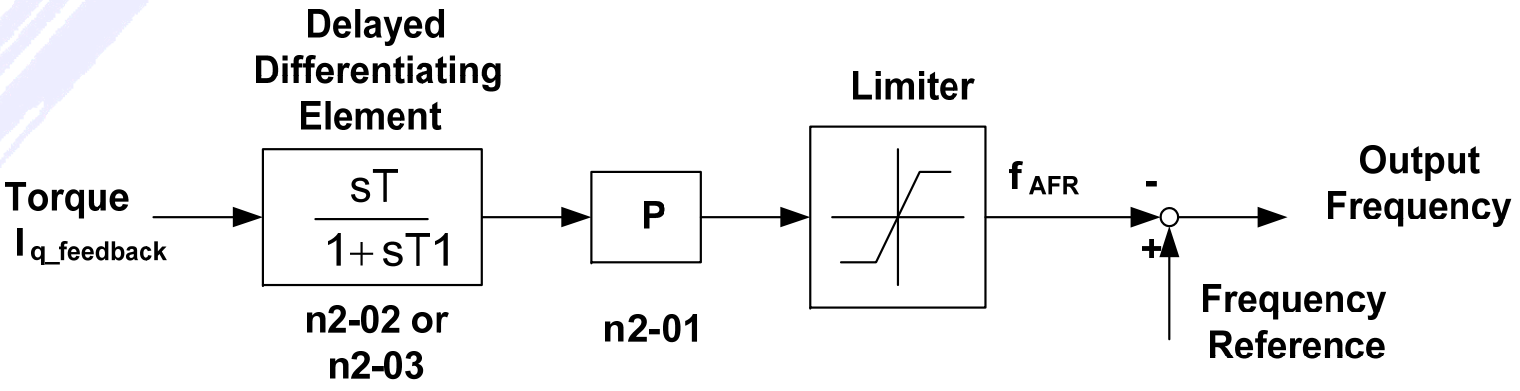
n2: Speed Feedback Detection Control Tuning

n2-01 to n2-03: Setup parameters for Automatic Frequency Regulator (AFR)

V/f | V/f w/PG | **OLV** | CLV | OLV/PM | AOLV/PM | CLV/PM

Improved speed response for Open Loop Vector control

- Speed fluctuation due to sudden load changes is compensated
- Drive calculates the amount of speed fluctuation (f_{AFR}) by using the differential of the torque producing current
- Speed fluctuation due to sudden load changes is
- Normally no adjustment needed. Fine tuning is possible with
  - Gain P (n2-01)
  - Delay time T1 (n2-02 or n2-03)



n2: Speed Feedback Detection Control Tuning

n2-01 to n2-03:
Setup parameters for Automatic Frequency Regulator (AFR)

J V A

V/f | V/f w/PG | **OLV** | CLV | OLV/PM | AOLV/PM | CLV/PM

- n2-01 (Speed Feedback Detection Control Gain) can be adjusted when …
  - hunting occurs while driving low load:
    Increase in small steps of 0.05 until hunting ceases
  - the response is low:
    Decrease in small steps of 0.05 until stalling ceases
  - check the effect of the changes while adjusting
- Which delay time is used, depends on the sudden situation of the machine:
  - Normal operation:
    Use n2-02 (SpeedSpeed Feedback Detection Control Time Constant 1)
  - Regenerative operation or during Speed Search:
    Use n2-03 (Speed Feedback Detection Control Time Constant 2)

Parameter	Name	Range	Default
n2-01	Speed Feedback Detection Control Gain	0.00 to 10.00	1.00
n2-02	Speed Feedback Detection Control Time Constant 1	0 to 2000 ms	50 ms
n2-03	Speed Feedback Detection Control Time Constant 2	0 to 2000 ms	750 ms

n2: Speed Feedback Detection Control Tuning

n2-01 to n2-03: Setup parameters for Automatic Frequency Regulator (AFR)

V/f | V/f w/PG | **OLV** | CLV | OLV/PM | AOLV/PM | CLV/PM

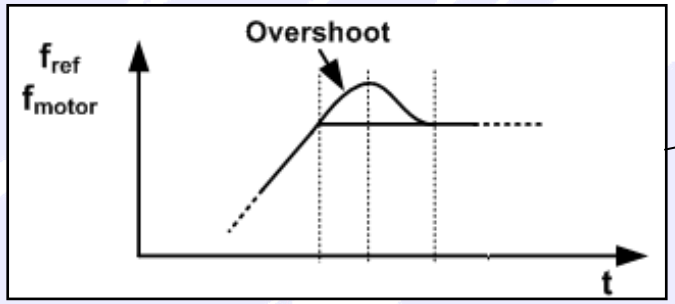
- n2-02 (Time Constant 1) can be adjusted ...
  - when hunting occurs during normal operation: Increase value
  - when response is slow: decrease value
- n2-03 (Time Constant 2) can be adjusted …
  - when OV (DC Bus Overvoltage) fault occurs at the end of acceleration or when the load changes (happens especially with high inertia load): Increase value
- When increasing n2-02 increase C4-02 (Torque Compensation Delay Time 1) as well
- When increasing n2-03 increase C4-06 (Torque Compensation Delay Time 2) as well

Parameter	Name	Range	Default
n2-01	Speed Feedback Detection Control Gain	0.00 to 10.00	1.00
n2-02	Speed Feedback Detection Control Time Constant 1	0 to 2000 ms	50 ms
n2-03	Speed Feedback Detection Control Time Constant 2	0 to 2000 ms	750 ms

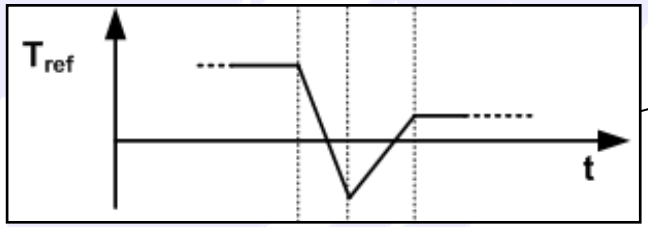
n2: Speed Feedback Detection Control Tuning

n2-02: Speed Feedback Detection Control Time Constant 1
n2-03: Speed Feedback Detection Control Time Constant 2

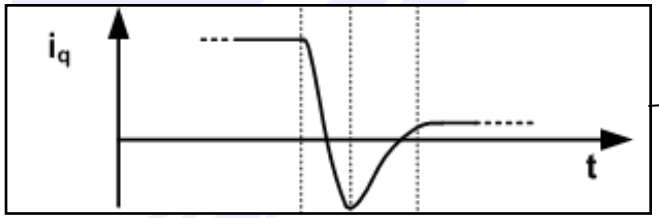
V/f | V/f w/PG | **OLV** | CLV | OLV/PM | AOLV/PM | CLV/PM



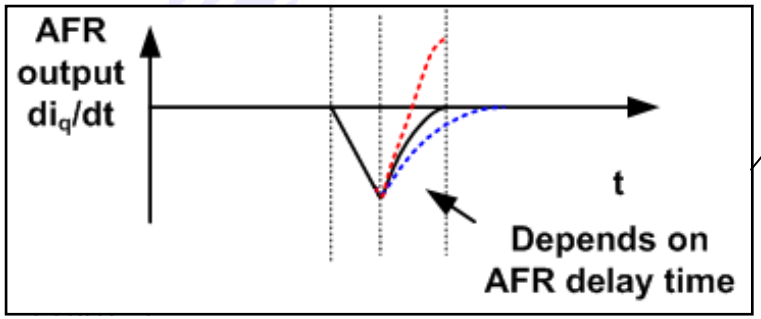
- Motor can not follow the load exactly.
- Especially with high inertia load over-shooting e. g. at acceleration end may occur



- Due to the overshoot the torque reference becomes negative for a short time.
- The motor may enter the regenerative mode



- The torque producing current reference becomes negative also



- Red curve: AFR delay time is too short
  → Output frequency is lowered too fast
  → Motor can not follow → Hunting occurs
  → OV (DC Bus Overvoltage) fault may occur

n2: Speed Feedback Detection Control Tuning

n2-01 to n2-03: Setup parameters for Automatic Frequency Regulator (AFR)

V/f | V/f w/PG | **OLV** | CLV | OLV/PM | AOLV/PM | CLV/PM

- For OLV and High Inertia Load do like described for C4 (Torque Compensation):
  - Increase n2-02 at the same time as C4-02
  - Decrease n2-01

Parameter	Name	Range	Default
n2-01	Speed Feedback Detection Control Gain	0.00 to 10.00	1.00
n2-02	Speed Feedback Detection Control Time Constant 1	0 to 2000 ms	50 ms
n2-03	Speed Feedback Detection Control Time Constant 2	0 to 2000 ms	750 ms

Condition: n2-02 ≤ n2-03 (oPE08 error will be triggered when n2-02 > n2-03)

n6: Online Tuning

n6-01: Online Tuning Selection
n6-05: Online Tuning Gain

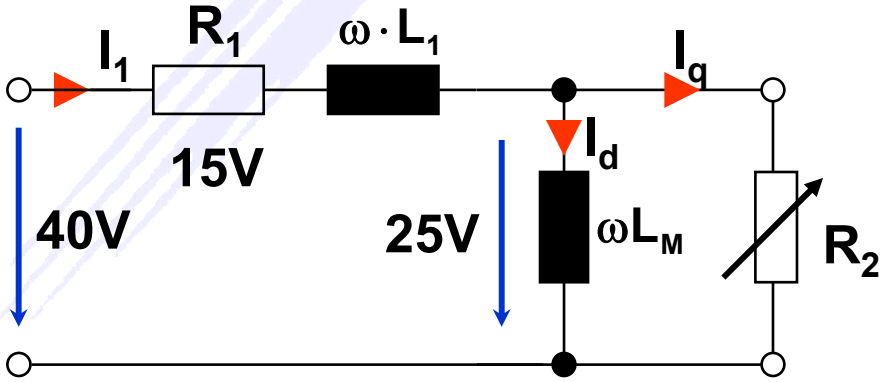
J V A

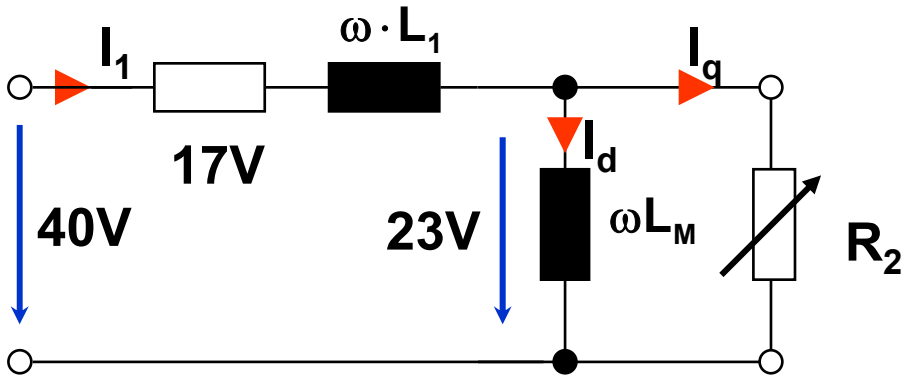
V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

- Automatic adaption of output voltage, when influence of stator resistance changes
- Voltage drop due to stator resistance can change, when temperature rises
  - Stator inductance (L_1) value keeps constant
  - Main inductance (L_M) value keeps constant
  - Stator resistance (R_1) value rises
    → Lower magnetizing voltage → torque loss and speed inaccuracy
- Stator Resistance R1 can increase for 40%

Example: Rated load at low speed

If motor resistance R1 rises for e. g. 20%, the magnetizing voltage reduces for 2 V





n6: Online Tuning

n6-01: Online Tuning Selection
n6-05: Online Tuning Gain

V/f | V/f w/PG | **OLV** | CLV | OLV/PM | AOLV/PM | CLV/PM

- **Activate by using n6-01 (Online Tuning Selection)**
  - **n6-01 = 0: Disabled** (J) (V) (A)
  - **n6-01 = 1: Line-to-Line Resistance Tuning** (J) (V) (A)
    - **Online Tuning is active for output frequencys up to 6 Hz**
    - **The value of Motor Line-to-Line Resistance (E2-05) is adapted for optimal load and overload performance**
  - **n6-01 = 2 (Only A1000): Voltage Correction** (J) (V) (A)
    - **Online Tuning is active for whole output frequency range**
    - **Not resistance value but output voltage is adapted**
    - **Only available, when Energy Saving function is disabled (b8-01 = 0) For description of Energy Saving function see above**

n6: Online Tuning

n6-01: Online Tuning Selection
n6-05: Online Tuning Gain

V/f | V/f w/PG | **OLV** | CLV | OLV/PM | AOLV/PM | CLV/PM

- **Fine tune by using n6-05 (Online Tuning Gain)** J V A
  - **Normally no adjustment needed**
  - **If oL2 (Drive Overlaod) occurs: Increase in steps of 0.10**
  - **For motors with a relatively large rotor time constant Decrease value**

Parameter	Name	Range	Default
n6-01 J V A	Online Tuning Selection	0: Disabled 1: Line-to-Line Resistance Tuning 2: Voltage Correction (Only A1000)	V1000: 1 A1000: 2
n6-05 J V A	Online Tuning Gain	0.10 to 5.00	1.00

PM Motor Control

Types of PM Motors and Control Modes

n8: PM Motor Control Tuning

n8-01 to n8-65:
Setup parameters for PM motor control

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Overview: Which control mode suits my PM motor best?

Mode / Drive	OLV/PM (V, A)	AOLV/PM (V, A)	CLV/PM (V, A)
Applicable motors	SPM (Surface PM) IPM (Interior PM)	SPM (Surface PM) IPM (Interior PM)	SPM (Surface PM) IPM (Interior PM)
Basic principle	Pull-In Current Id / Torque producing current Iq controlled seperately	Speed Observer serves as "virtual encoder" when using IPM motors and detects rotor angle	Encoder provides feedback about rotor speed and position
Performance	100% torque at 5% speed possible Min. speed:max. speed = 1:20	200% torque at 0% speed possible Min. speed:max. speed = 1:100	200% torque at 0% speed Min speed:max. speed = 1:1500
→	Simple, reliable Vector control performance. Drive all major types of PM motors, e. g. ECOiPM!	Nearly Closed Loop performance without any additional equipment! Even positioning is possible!	Highest performance for all PM motors! Efficient like PM motors, user friendly like IM motors!

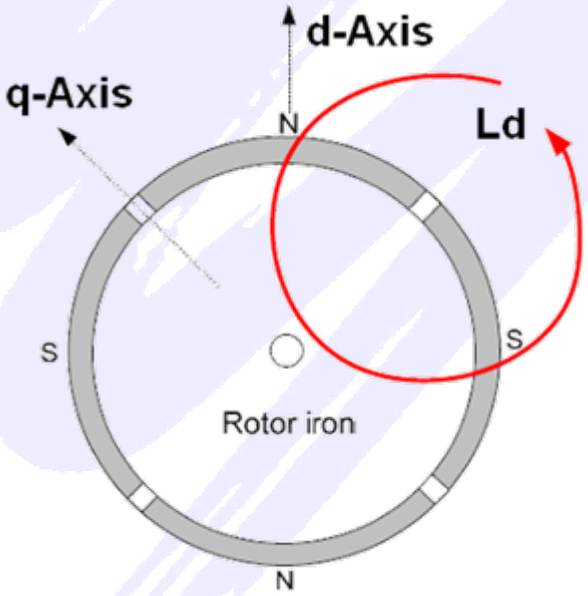
n8: PM Motor Control Tuning

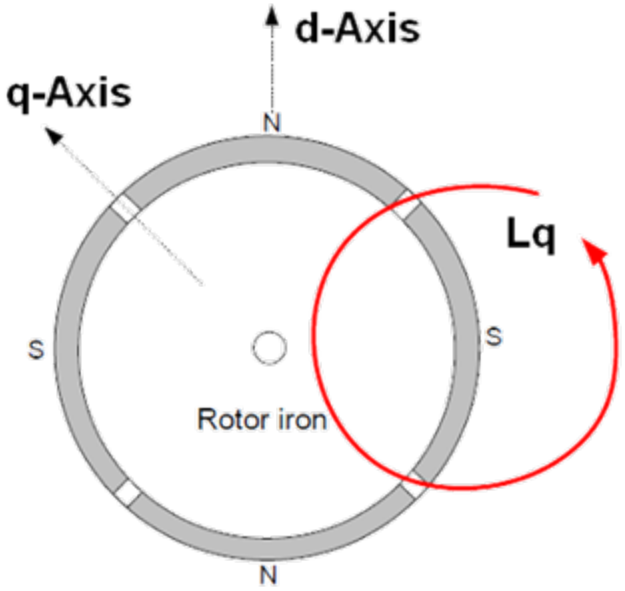
n8-01 to n8-65:
Setup parameters for PM motor control

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

SPM motors:

➔ **Example: Yaskawa ECOiPM with IE3 efficiency!**





Direction of d-axis:

- **Inductance is Ld**
- **Same direction as magnetic north pole**
- **Ld = Lq (No magnetic saliency)**

Direction of q-axis:

- **Inductance is Lq**
- **Direction to the gap between the poles**
- **SPM motor: Ld = Lq**

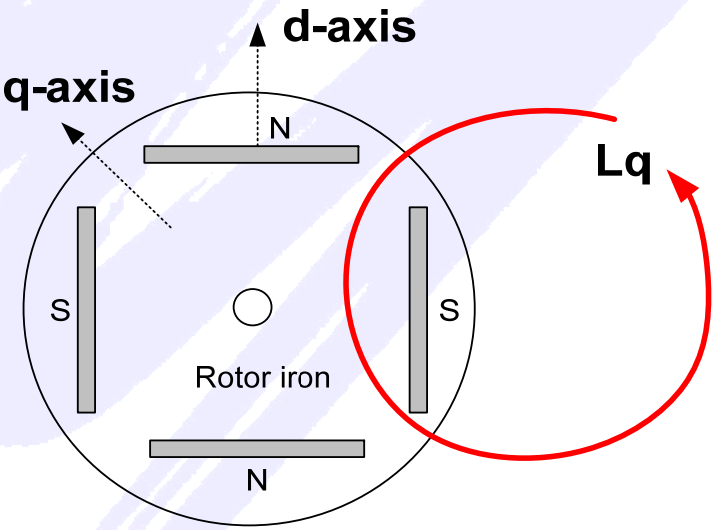
n8: PM Motor Control Tuning

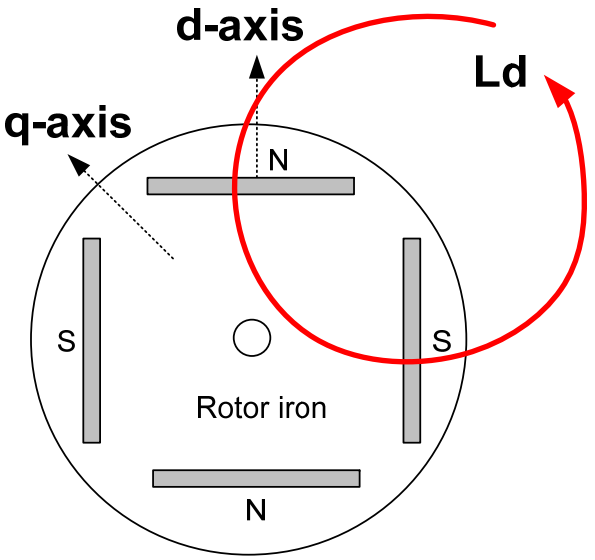
n8-01 to n8-65:
Setup parameters for PM motor control

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

IPM motors:

➔ **Example: Yaskawa SSR1 Series IPM Motor**





Direction of q-axis:

- High inductance path Lq
- Direction to the gap between the poles
- IPM motor: Ld < Lq

Direction of d-axis:

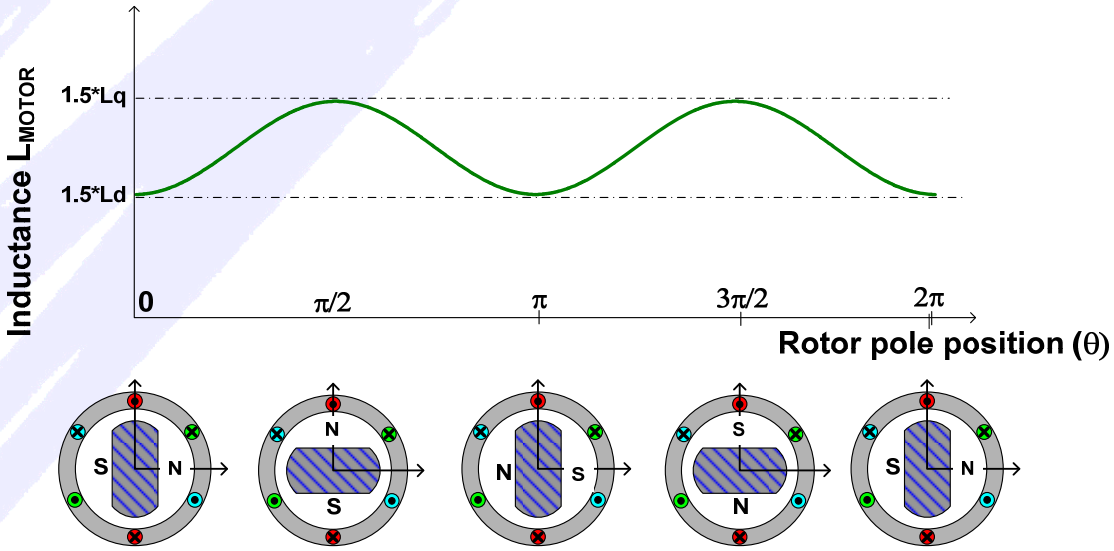
- Low inductance path Ld
- Same direction as magnetic north pole
- IPM motor: Ld < Lq

n8: PM Motor Control Tuning

n8-01 to n8-35 and n8-57:
Setup parameters for Advanced Open Loop Vector Control for PM motors

V/f | V/f w/PG | OLV | CLV | OLV/PM | **AOLV/PM** | CLV/PM

PM motor control in AOLV/PM



Most essential in AOLV/PM: Magnetic Saliency

- Stator inductance L_{MOTOR} varies depending on the angular rotor position
- Maximum and Minimum values are known by Ld (E5-06) and Lq (E5-07)

- Drive calculates angle by using this information

PM Motor Control

Tuning for Open Loop Vector Control for PM Motors (V1000 Mode)

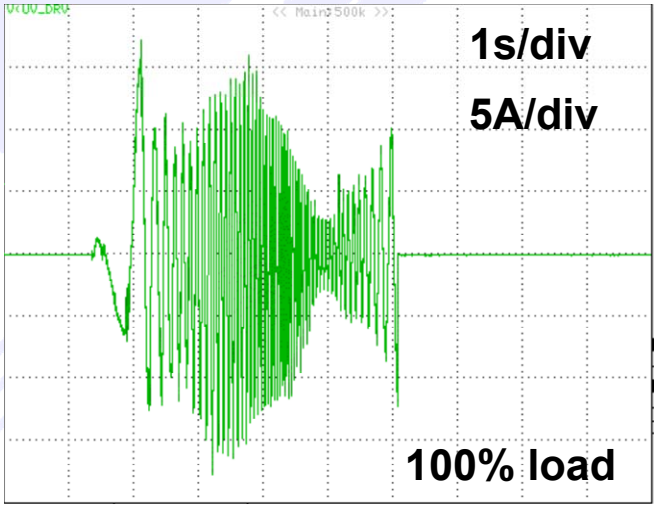
n8: PM Motor Control Tuning

n8-51: Acceleration/Deceleration Pull-In Current

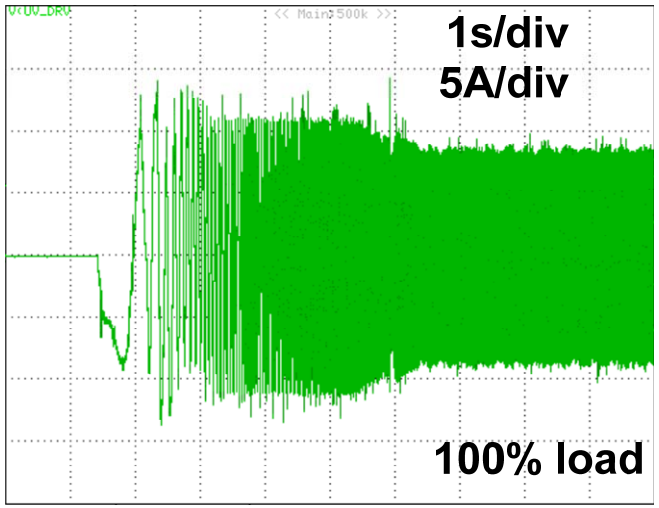
V/f | V/f w/PG | OLV | CLV | **OLV/PM** | AOLV/PM | CLV/PM

OLV/PM : Setup for Pull-In Current (Id)

- **n8-51 (Acceleration/Deceleration Pull-In Current)**
  - **Reference for Pull-In current during acceleration and deceleration**
  - **A large amount of starting torque is required: Increase value**
  - **Drive outputs excessive current during acceleration: Decrease value**



n8-51 = 30 (big oscillation and stalling)



n8-51 = 80 (starts good)

n8: PM Motor Control Tuning
Setup for OLV/PM control mode

n8-48: Pull-In Current
n8-49: d-Axis Current for High Efficiency Control

J V A

V/f | V/f w/PG | OLV | CLV
OLV/PM | AOLV/PM | CLV/PM

Don't change n8 parameters before motor data (E1 and E5 group) is set accurately!

OLV/PM : Setup for Pull-In Current

- n8-48 (Pull-In Current)
  - Pull-In Current reference during no-load operation or at constant speed
  - Hunting occurs or speed is unstable at light load and constant speed: Increase value
  - Current is too high at light load or at constant speed: Decrease value slightly
- n8-49 (d-Axis Current for High Efficiency Control)
  - Not relevant for SPM motors. Set n8-49 = 0.
  - IPM motor with high load at constant speed (> 90% rated speed):
    - ➔ Use reluctance torque component!
      - Increase absolute value of n8-49
      - Negative Id is injected to the motor
      - Energy consumption can be reduced by using reluctance torque
  - Unstability occurs when driving heavy loads: Increase n8-49

n8-47: Pull-In Current Compensation Time Constant
n8-54: Voltage Error Compensation Time Constant

V/f | V/f w/PG | OLV | CLV | **OLV/PM** | AOLV/PM | CLV/PM

OLV/PM : Setup for Pull-In Current (Id)

- n8-47 (Pull-In Current Compensation Time Constant)
  - Should be reduced to about 0.5 s in most cases
  - Time constant for making reference for Id and and actual output value agree
  - Motor oscillates:
    Decrease value
  - Agreeing output value reference of Id takes too long:
    Increase value

- n8-54 (Voltage Error Compensation Time Constant)
  - Time constant for Voltage Error Compensation
  - Voltage Error Compensation compensates the voltage Vd, which controls the flux producing current Id.
  - When oscillation occurs at start or at sudden load changes at low speed:
    - Increase value in steps of 0.1 s
    - If increasing does not help, set n8-51 (Accel./Decel. Pull-In Current) = 0

n8: PM Motor Control Tuning

n8-55: Load Inertia

V/f | V/f w/PG | OLV | CLV | **OLV/PM** | AOLV/PM | CLV/PM

OLV/PM : Load inertia setting

- **n8-55 (Load Inertia)**
  Effect is similar to AFR (Automatic Frequency Regulator) in OLV:
  Improved speed stability at sudden load changes

  - **Ratio between motor inertia and load inertia**
  - **Select the range which matches the application:**
    - **0: less than 1:10**
    - **1: between 1:10 to 1:30**
    - **2: between 1:30 to 1:50**
    - **3: higher than 1:50**

  - **When motor/load ratio is not known, n8-55 can be set like follows:**
    - **Poor speed control response or STo (Motor Step Out) occurs at start: Load might be higher than set value, increase n8-55**
    - **Oscillation of hunting occurs : Load might be lower than set value, decrease n8-55**

n8: PM Motor Control Tuning

n8-45: Speed Feedback Detection Control Gain
n8-65: Speed Feedback Detection Control Gain during OV Suppression

V/f | V/f w/PG | OLV | CLV
OLV/PM | AOLV/PM | CLV/PM

OLV/PM : Speed Feedback Detection Control

- n8-45 (Speed Feedback Detection Control Gain)
  - Normally no need to adjust
  - Motor oscillation or hunting occurs:
    Increase value carefully while checking response
  - Decreasing slowers the drive response when load changes
- n8-65 (Speed Feedback Detection Control Gain during OV Suppression)
  - Used instead of n8-45 when Overvoltage Suppression function is active (parameters L3-11 and L3-17, see presentation "Drive Protection")
  - Normally no need to adjust
  - Motor oscillation or hunting occurs:
    Increase value carefully while checking response
  - Decreasing slowers the drive response when load changes and OV Suppression is active

n8: PM Motor Control Tuning

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n8-45 to n8-55 and n8-65:
Setup parameters for Open Loop Vector control for PM motors

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

PM motor control in OLV/PM

Param.	Name / Description	Range	Default
n8-48	Pull-In Current	20 to 200% 1)	30%
n8-49	d-Axis Current for High Efficiency Control	-200.0 to 0.0% 1)	2)
n8-51	Acceleration/Deceleration Pull-In Current	0 to 200% 1)	50%
n8-47	Pull-In Current Compensation Time Const.	0.0 to 100.0 s	5.0 s
n8-54	Voltage Error Compensation Time Const.	0.00 to 10.00 s	10.00 s
n8-55	Load Inertia	0: Less than 1:10 1: Between 1:10 and 1:30 2: Between 1:30 and 1:50 3: Higher than 1:50	0
n8-45	Speed Feedback Detection Control Gain	0.00 to 10.00	0.80
n8-65	Speed Feedback Detection Control Gain during OV Suppression	0.00 to 10.00	1.65

Note 1: Set in % of Motor Rated Current (E2-01)
Note 2: Default value depends on Motor Code Selection (E5-01)

PM Motor Control

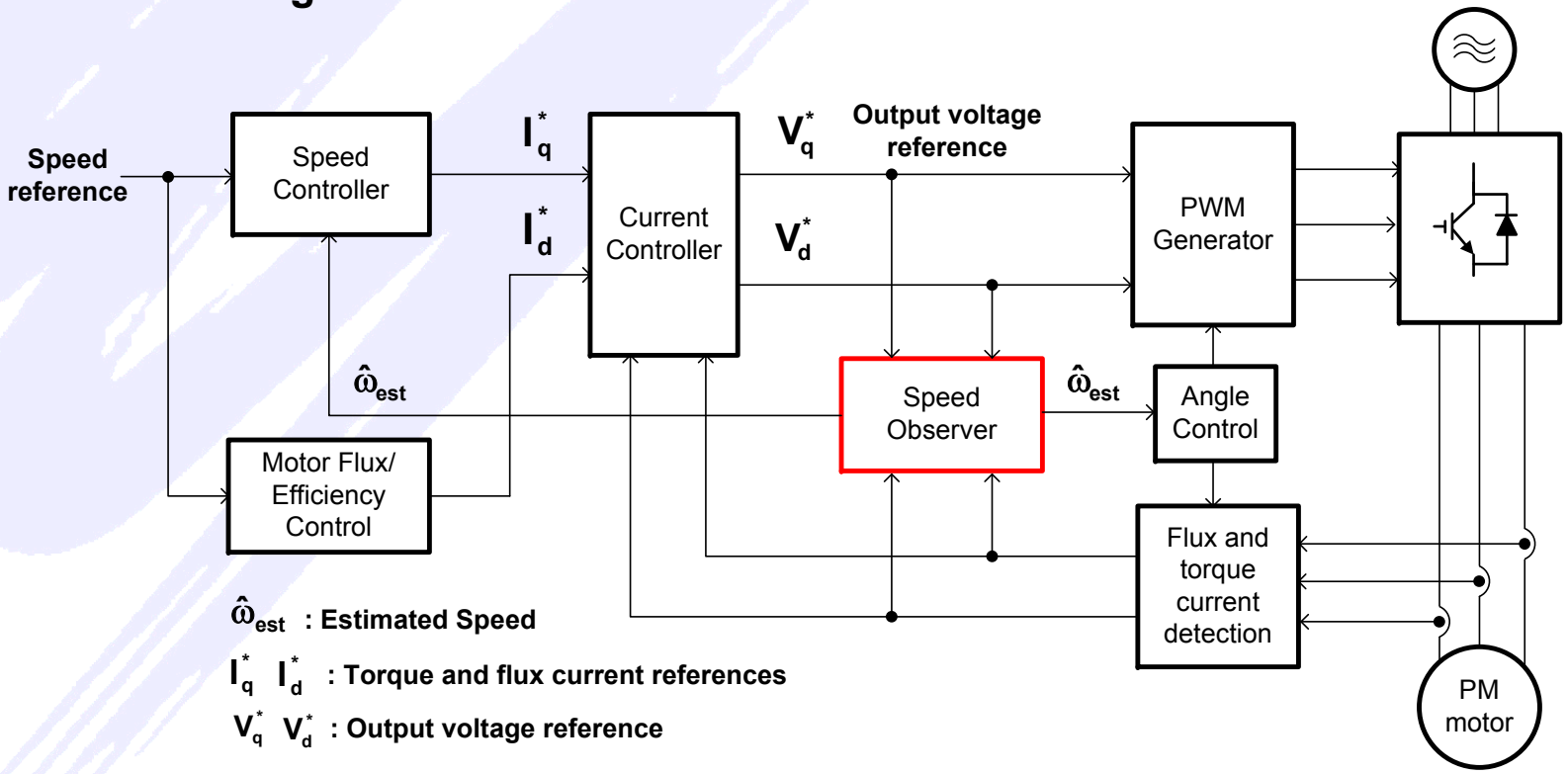
Tuning for Advanced Open Loop Vector Control for PM Motors (A1000 Mode)

n8: PM Motor Control Tuning
Setup for AOLV/PM control mode

n8-01 to n8-35 and n8-57:
Setup parameters for Advanced Open Loop Vector Control for PM motors

V/f | V/f w/PG | OLV | CLV | OLV/PM | **AOLV/PM** | CLV/PM

Control block diagram for AOLV/PM



- Core of control algorithm is Speed Observer
- Calculates motor speed from magnetizing current and torque current feedback
- ASR parameters must be set (C5 group)

n8: PM Motor Control Tuning
Setup for AOLV/PM control mode

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n8-01 to n8-35 and n8-57:
Setup parameters for Advanced Open Loop Vector Control for PM motors

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | **AOLV/PM** | CLV/PM

Don't change n8 group parameters before motor parameter are set!

- n8-35 must be set to select the control principle for starting after power up
  - 0: Pull-In
  - 1: High Frequency Injection
  - 2: Pulse Injection
- When using IPM motors:
  - Set n8-35 = 1 or 2 for to enable rotor position calculation.
  - For zero speed operation:
    - Set Minimum Output Frequency to zero (E1-09 = 0)
    - Enable High Frequency Injection even during run (n8-57 = 1, see below)
- When using SPM motors
  - Set n8-35 = 0: Pull-In
    Rotor uses Pull-In Current for starting like in OLV/PM.
  - Rotor will be pulled in place at startup by injecting DC voltage.

n8: PM Motor Control Tuning

n8-01 to n8-35 and n8-57: Setup parameters for Advanced Open Loop Vector Control for PM motors

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

When using IPM motors set the following parameters:

- n8-01 (Initial Rotor Position Estimation Current)
  - Set the amount of current, which flows during position calculation at start
  - Set in % of motor rated current (E5-01)
  - Increase if accuracy of rotor position calculation is insufficient
  - If motor name plate lists an "Si" value, enter it here
- n8-57 (High Frequency Injection)
  - 0: Disabled (High Frequency Injection only used at start)
  - 1: Enabled (High Frequency Injection enabled at start and during Run)
  - Must be set to 1 when using zero speed control
  - Will cause audible noise up to a certain speed, when enabled

When using SPM and IPM motors set ...

- n8-02 (Polar Attraction Current)
  - Sets the current, which pulls the rotor into position after position calculation
  - Increase for higher starting torque
  - Set in % of motor rated current (E5-01)

n8: PM Motor Control Tuning

n8-01 to n8-35 and n8-57: Setup parameters for Advanced Open Loop Vector Control for PM motors

J V A

V/f | V/f w/PG | OLV | CLV | OLV/PM | **AOLV/PM** | CLV/PM

PM motor control in AOLV/PM

Parameter	Name / Description	Range	Default
n8-01	Initial Rotor Position Estimation Current	0 to 100% 1)	50%
n8-02	Pole Attraction Current	0 to 150% 1)	80%
n8-35	Initial Rotor Position Detection Selection	0: Pull-In 1: High Frequency Injection 2: Pulse Injection	1
n8-57	High Frequency Injection	0: Disabled 1: Enabled	0

Note 1: Set in % of Motor Rated Current (E5-01)

PM Motor Control

Tuning for Closed Loop Vector Control for PM Motors (A1000 Mode)

n8: PM Motor Control Tuning

n8-35: Initial Rotor Position Detection Selection

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

Closed Loop Vector control for PM motors (SPM and IPM):

- Before tuning n8 parameters set
  - E5 parameters (Motor data)
  - F1 parameters (PG speed feedback)
  - C5 parameters (ASR settings)
- Set n8-35 (Initial Rotor Position Detection Selection) like for Open Loop modes
  - After powering up: Magnetic pole search is performed
  - After that: Rotor position is calculated from the encoder signal.
    Rotor position is saved until the drive is switched off.
  - Select like in AOLV/PM:
    - 0: Pull-In
      Select when driving SPM motors
    - 1: High Frequency Injection
      Select for best accuracy when using IPM motors
    - 2: Pulse Injection
      Select when High Frequency Injection makes too much noise

Note: Only PG encoder can be used, currently no support for Resolver/EnDAT/Hiperface

PM Motor Control

All PM motors and all PM control modes

n8: PM Motor Control Tuning

n8-62: Output Voltage Limit

V/f | V/f w/PG | OLV | CLV | OLV/PM | AOLV/PM | CLV/PM

All PM motors control modes (SPM and IPM):

- **Motor can not be controlled properly when Back EMF exceeds input voltage. Field weakening operation: Output voltage might be near to drive input voltage**

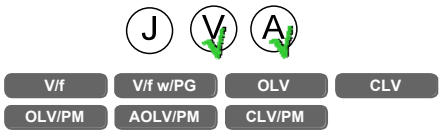
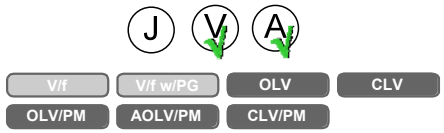
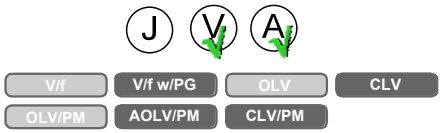
- **n8-62 (Output Voltage Limit)**
  - **Voltage saturated → Speed Regulator can't act freely → Poor speed accuracy**
  - **Voltage is near the input voltage (E1-01) and speed is not at set value: Decrease n8-62**
  - **Never set n8-62 > E1-01**

Parameter	Name	Range	Default	Drive	Mode
n8-62	Output Voltage Limit	0.0 to 460.0 V 1)	400.0 V 1)	J V A	OLV/PM, AOLV/PM, CLV/PM

Note 1: Max. value and default setting for 400 V class. For 200 V class divide by 2.

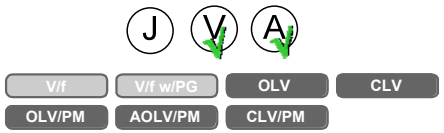
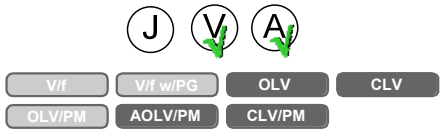
U6: Operation Status Monitors

U6-01 to U6-26: Monitors, related to the status of motor control

Monitor	Name / Description	Output Level	Unit	Available in
U6-01	Motor Secondary Current (Iq) Value of torque producing current Iq	100% = Motor secondary rated current (rated Iq)	0.1%	
U6-02	Motor Excitation Current (Id) Value of flux producing current Id	100% = Motor secondary rated current	0.1%	
U6-03	ASR Input (devation freq. of ASR)	100% = Max. Output Freq. E1-04	0.01%	
U6-04	ASR Output (output value of ASR)	100% = Motor secondary rated current		

U6: Operation Status Monitors

U6-01 to U6-26: Monitors, related to the status of motor control

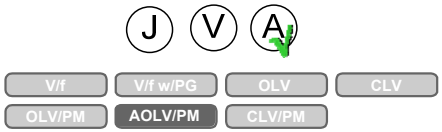
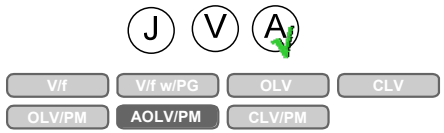
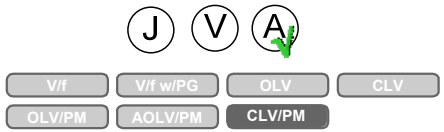
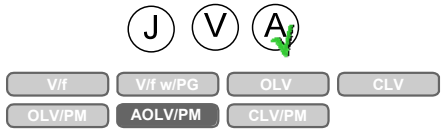
Monitor	Name / Description	Output Level	Unit	Available in
U6-05	Output Voltage Reference (Vq) Torque producing current Iq is controlled via the voltage Vq	100%: 400 V [1) 2)]	0.1 V	
U6-06	Output Voltage Reference (Vd) Flux producing current Id is controlled via the voltage Vd			
U6-07 (q-Axis) U6-08 (d-Axis)	q-Axis ACR Output d-Axis ACR Output Output Values of Automatic Current Regulator (ACR). ACR controls Iq and Id, respectively. ACR outputs reference values for Vq and Vd.	100%: 400 V [1)]	0.1%	

Note 1: 400 V for 400 V class drive, 200 V for 200 V class drive

Note 2: Root-mean-square value

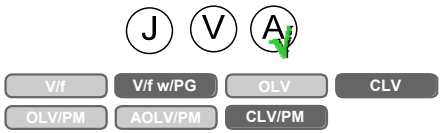
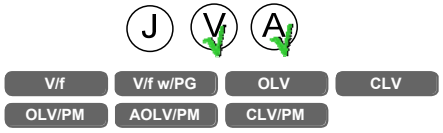
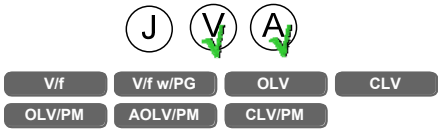
U6: Operation Status Monitors

U6-01 to U6-26: Monitors, related to the status of motor control

Monitor	Name / Description	Output Level	Unit	Available in
U6-09	Advance Phase Compensation (Δθ) AOLV/PM: Degree of forward phase correction after calculating the deviation of Δθcmp	100%: 180° 0%: -180°	0.1°	
U6-10	Control Axis Deviation (Δθ) Deviation between rotor fixed (Id and Iq) and stator fixed (Iα and Iβ) coordinate system which is currently used	100%:180° 0%: -180°	0.1°	
U6-13	Flux Position Detection (Sensor) CLV/PM: Rotor position in electrical degree from encoder	100%: 180° 0%: -180°	0.1°	
U6-14	Flux Position Detection (Observer) AOLV/PM: Rotor position in electrical degree from observer (position calculation function)	100%: 180° 0%: -180°	0.1°	

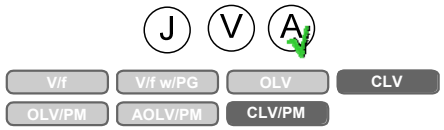
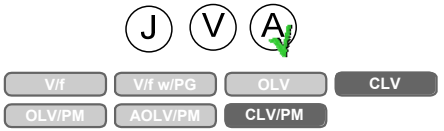
U6: Operation Status Monitors

U6-01 to U6-26: Monitors, related to the status of motor control

Monitor	Name / Description	Output Level	Unit	Available in
U6-18	Speed Detection PG1 Counter Number of pulses for first PG encoder option (Motor 1)	100%: 65536 ppr (pulses per rev.)	1 pulse	
U6-19	Speed Detection PG2 Counter Number of pulses for second PG encoder option (Motor 2)			
U6-20	Frequency Reference Bias (Up/Down 2) Bias value used to adjust Frequency Reference (Up/Down 2 function)	100% = Max. Output Freq. E1-04	0.1%	
U6-21	Offset Frequency Offset value, added the main Frequency Reference (analog input, set to "Frequency Bias")	100% = Max. Output Freq. E1-04	0.1%	

U6: Operation Status Monitors

U6-01 to U6-26: Monitors, related to the status of motor control

Monitor	Name / Description	Output Level	Unit	Available in
U6-22	Zero Servo Pulse Movement Number of PG pulses the rotor has moved from its last position (pulse number multiplied by 4 due to 2 track encoder)	100%: 4 x Pulses per revolution (F1-01 x 4)	1 pulse	
U6-25	Feedback Control Output Output value of Automatic Speed Regulator ASR.	100%: Motor secondary rated current (rated Iq)	0.01%	
U6-26	Feed Forward Control Output Output value of Feed Forward Control function. Displays the value which is added to the torque reference from the ASR.	100%: Motor secondary rated current (rated Iq)	0.01%