# 3. REFERENCES AND FEEDBACKS

The drive references are the following:

- Main speed/torque reference
- Speed/torque limit reference
- PID reference
- PID feedback

## 3.1. Main Speed/Torque Reference

If a speed control (e.g. **C011 = Speed** for Motor 1) is used, the main reference is a speed reference, while if a torque control is used (e.g. **C011=Torque** or **C011=Speed** for Motor 1, but the digital input is closed for the Slave programmed with C170), the main reference of the drive is a torque reference.
The main reference can be one of the following:

- Analog/digital inputs programmed as sources (see parameters **C143-C146** in the CONTROL METHOD MENU)
- PID output if **C294 PID Action = 1: [Reference]**
- Digital inputs programmed as Multispeed (see MULTISPEED MENU) only when the main reference is a speed reference.

## 3.2. Speed/Torque Limit Reference

If a speed control is used (e.g. **C011 = Speed** for Motor 1) and a VTC or FOC algorithm is used, you can program a source as an external torque limit (see parameter **C147** in the CONTROL METHOD MENU).
If a torque control is used and an external speed limit has been set up (e.g. **C011 = Torque with Speed Limit** for Motor 1) and a FOC algorithm is used, you can program one source as an external speed limit (see parameter **C147** in the CONTROL METHOD MENU).

## 3.3. PID Reference

If the internal PID regulator is enabled **(C291 different from Disabled)**, its reference is given by default by the sum of the three sources programmed as references (see parameters **C285-C287** in the PID CONFIGURATION MENU).
Different types of PID reference control (Two PIDs and 2-zone mode) are available based on the setting in parameter **C291a** (PID Control Mode).

## 3.4. PID Feedback Reference

The PID feedback by default is the sum of the three sources programmed as feedback (see parameters **C288-C290** in the PID CONFIGURATION MENU).
Different types of PID feedback control (Two PIDs and 2-zone mode) are available based on the setting in parameter **C291a** (PID Control Mode).

## 7.2. "VTC" Control Algorithm

**1) Wiring:** Follow the instructions stated in the "Caution Statements" and "Installation" sections in the **Sinus Penta's Installation Instructions Manual**.

**2) Power on:** Power on the drive and do not close the link to the **START** input to prevent the motor from running.

**3) Parameter modification:** Access parameter **P000** (Key parameter) and set its code (default value: 00001). Select the Engineering access level setting P001= Eng. Use the **ESC**, ▲,▼ and **SAVE/ENTER** keys to access the programming parameters. Also refer to the Menu Tree.

**4) Supply voltage:** Set the real supply voltage for the drive. You can set either mains voltage range or the DC supply stabilized by a Regenerative Penta drive. To set the type of power supply for the drive, access the MOTOR CONFIGURATION MENU and set configuration parameter **C008** to the value corresponding to the installation concerned.

**5) Motor parameters:** Set **C010** (Control Algorithm) as VTC Vector Torque Control. Set the motor ratings as follows:

- **C015** (fmot1) rated frequency
- **C016** (rpmnom1) rated rpm
- **C017** (Pmot1) rated power
- **C018** (Imot1) rated current
- **C019** (Vmot1) rated voltage
- **C029** (Speedmax1) max. speed desired.

Also set **C022** (resistance of one stator phase for a star connection or one third of one phase resistance for a delta connection) and **C023** (stator leakage inductance of one phase for a star connection or one third of the leakage of one phase for a delta connection). The value for **C022** corresponds to half the resistance value measured with an ohm-meter between two phases of the motor. If values to be set for **C022** and **C023** are not known, motor autotune is required (see step 6), otherwise, go to step 7. Press SAVE/ENTER each time a new parameter is set.

**6) Autotune:** First remove the **ENABLE** command, then access the AUTOTUNE MENU and set **I073** [1: Motor Tune] and **I074** = [0: All Ctrl no rotation]. Use the **ESC** key to accept changes. Close the **ENABLE** command and wait until tune is complete (Warning "**W32** Open Enable" is displayed). The drive has computed and saved the values for **C022** (stator resistance) and **C023** (leakage inductance).

If alarm "**A097** Motor Wires KO" trips, check the motor wiring. If alarm "**A065** Autotune KO" trips, this means that the **ENABLE** command has opened before autotune was complete. In this case, reset the drive sending a command from terminal MDI3, or press the **RESET** key in the display/keypad and perform the autotune procedure again.

**NOTE** With the Autotuning function, calculate the value of the leakage inductance (**C023**). From the resulting value, manually subtract the value in mH of the output inductance installed between the drive and the motor.

**7) Overload:** Set parameter **C048** in the LIMITS MENU based on the maximum torque that can be generated expressed as a percentage of the motor rated torque.

**8) Startup:** Activate the **ENABLE** input (terminal 15) and the **START** input (terminal 14) and send a speed reference. The RUN LED and REF LED will come on and the motor will start. Make sure that the motor is rotating in the correct direction. If not, set parameter **C014** (Phase Rotation) to [1:Yes], or open the ENABLE and START inputs, remove voltage from the drive and, after waiting at least 5 minutes, reverse two of the motor phases.

**9) Speed regulator adjustment:** If overshoot occurs when the speed setpoint is attained or if a system instability is detected (uneven motor operation), adjust the parameters relating to the speed loop (SPEED LOOP AND CURRENT BALANCING MENU). Set the two parameters relating to integral time (**P125, P126**) as [Disabled] and set low values for the parameters relating to proportional gain (**P127, P128**). Set equal values for **P127** and **P128** and increase them until overshoot takes place when the setpoint is attained. Decrease **P127** and **P128** by approx. 30%, then decrease the high values set for integral time in **P125** and **P126** (keep both values equal) until an acceptable setpoint response is obtained. Check to see if the motor runs smoothly at constant speed.

**10) Possible failures:** If no failure occurred, go to step 11. Otherwise, check the drive connections paying particular attention to supply voltages, DC link and input reference. Also check if alarm messages are displayed. In the MEASURES MENU, check the speed reference (**M000**), the reference speed processed by the ramps (**M002**), the supply voltage of the control section (**M030**), the DC-link voltage (**M029**), the condition of the control terminals (**M033**). Check to see if these readouts match with the measured values.

**11) Additional parameter modifications:** When parameter **P003** = Standby Only (condition required for changing C parameters), you can change **Cxxx** parameters in the CONFIGURATION menu only when the drive is DISABLED or STOPPED, whereas if **P003** = Standby + Fluxing, you can change Cxxx parameters when the motor is stopped but the drive is enabled.

Before changing any parameters, remember that the correct code for parameter **P000** must be previously set up.

You can write down any custom parameters in the table provided on the last pages of this Programming Manual.

**12) Reset:** If an alarm trips, find the cause responsible for the alarm and reset the drive. Enable input MDI3 (terminal 16) for some time, or press the **RESET** key on the display/keypad.

# 13. INPUTS FOR REFERENCES MENU

## 13.1. Processing Speed/Torque References

The "**main reference**" is the value, at constant rpm, for the controlled physical variable (speed or torque) (**M000**, **M007**) "required" for the drive.
This reference is acquired by the drive only if the **START** command is active and the drive is **RUNNING**, otherwise it is ignored.
The **main reference** is the reference at constant rpm: when the drive is **RUNNING**, it will increment the speed or torque **set–point** which will reach the main reference with a timed ramp (see the RAMPS MENU).
The drive operating mode is factory-set to **MASTER** with a **speed** reference. In **SLAVE** mode, a **torque** reference is used; this operating mode may be configured for **VTC** control (Vector Torque Control) and **FOC** control (Field Oriented Control) only.
The **control algorithm** and the **MASTER/SLAVE mode** can be set for each of the 3 programmable motors, depending on which motor is active at that moment (motor 1, motor 2 or motor 3).
To enable the **SLAVE** mode, set the following parameters to **1** or **2**:
**C011** (motor 1)
**C054** (motor 2)
**C097** (motor 3)
The SLAVE mode may also be selected through a digital input (see the DIGITAL INPUTS MENU).
When the main reference is acquired by the drive (**RUNNING** on), it becomes the reference for the time ramps generating the current speed/torque set–point for the connected motor.
The set up of the main reference is based on a number of parameters included in several menus:

**Table 20: Parameters used for the Inputs for References Menu**

| Parameters | Menu | Contents |
|---|---|---|
| **P050 ÷ P074** | **References** | Scaling parameters for references sent from analog inputs REF, AIN1, AIN2.<br>Scaling parameters for references sent from encoder and frequency input.<br>Parameters for changes made using the UP and DOWN keys.<br>Parameter for JOG reference setting.<br>Parameter for drive disabling in case of reference at min. value. |
| **P390 ÷ P399** | **References from option board** | Scaling parameters for references sent from analog inputs XAIN4, XAIN5. |
| **P080 ÷ P098** | **Multispeed** | Parameters setting preset multispeed values to be selected through digital inputs. |
| **P105 ÷ P108** | **Prohibit Speed** | Parameters setting prohibit speed values. |
| **P115 ÷ P121** | **Reference Variation Percent** | Parameters setting slowing down values percent to be selected through digital inputs. |
| **C143 ÷ C146** | **Control Method** | Parameters setting the reference source. |
| **C011, C028, C029** | **Configuration of Motor 1** | Parameter setting the Master (speed) mode or the Slave (torque) mode. Parameters setting the min. speed or the max. speed. |
| **C054, C071, C072** | **Configuration of Motor 2** | |
| **C097, C114, C115** | **Configuration of Motor 3** | |
| **C047, C048** | **Limit for Motor 1** | Parameters setting the min. torque and the max. torque. |
| **C090, C091** | **Limit for Motor 2** | |
| **C133, C134** | **Limit for Motor 3** | |

The following pages contain block diagrams illustrating speed reference processing (Figure 7) and torque reference processing (Figure 8). Menus and parameters used are also stated.

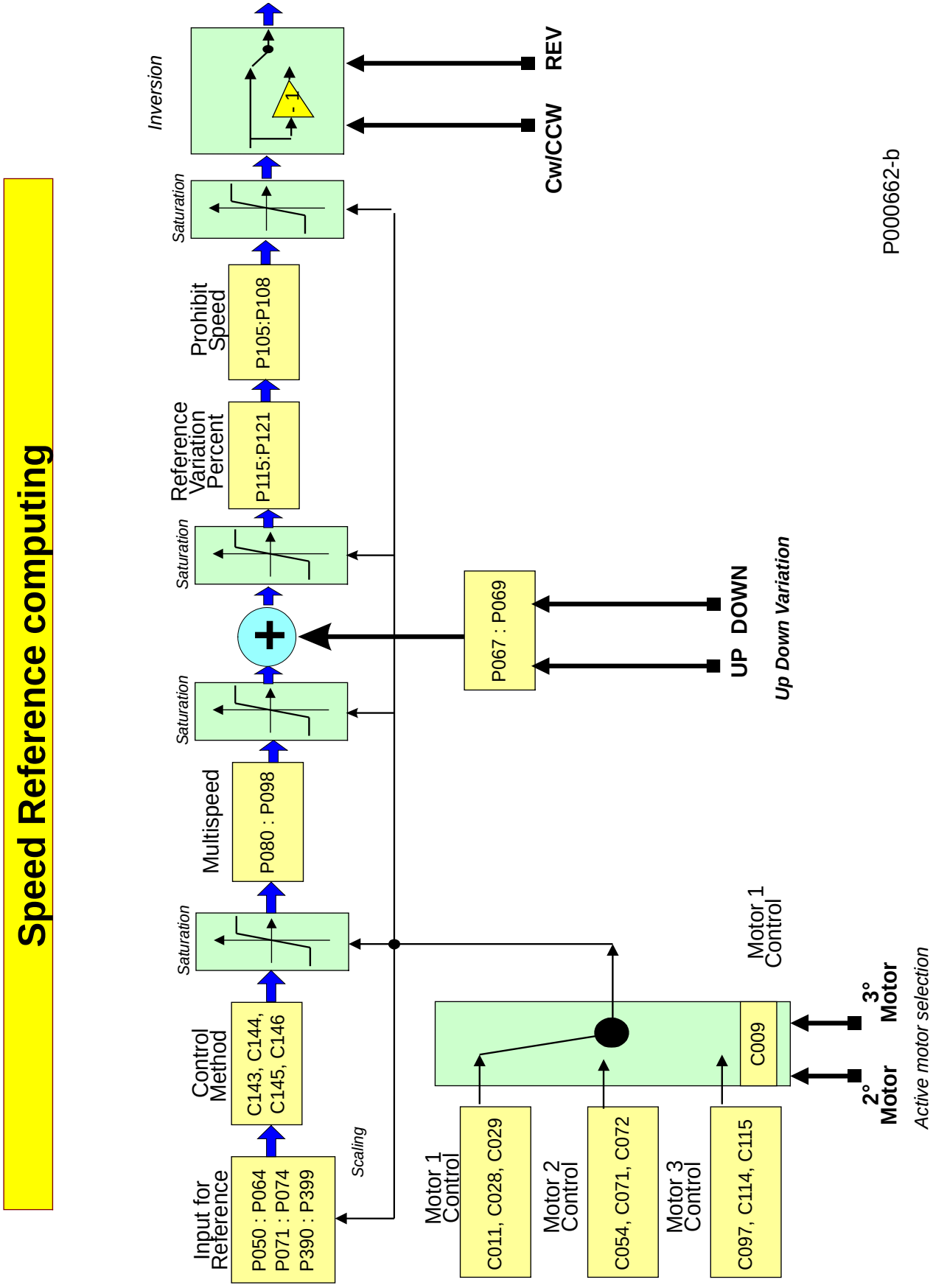


**Figure 7: Speed Reference computing**

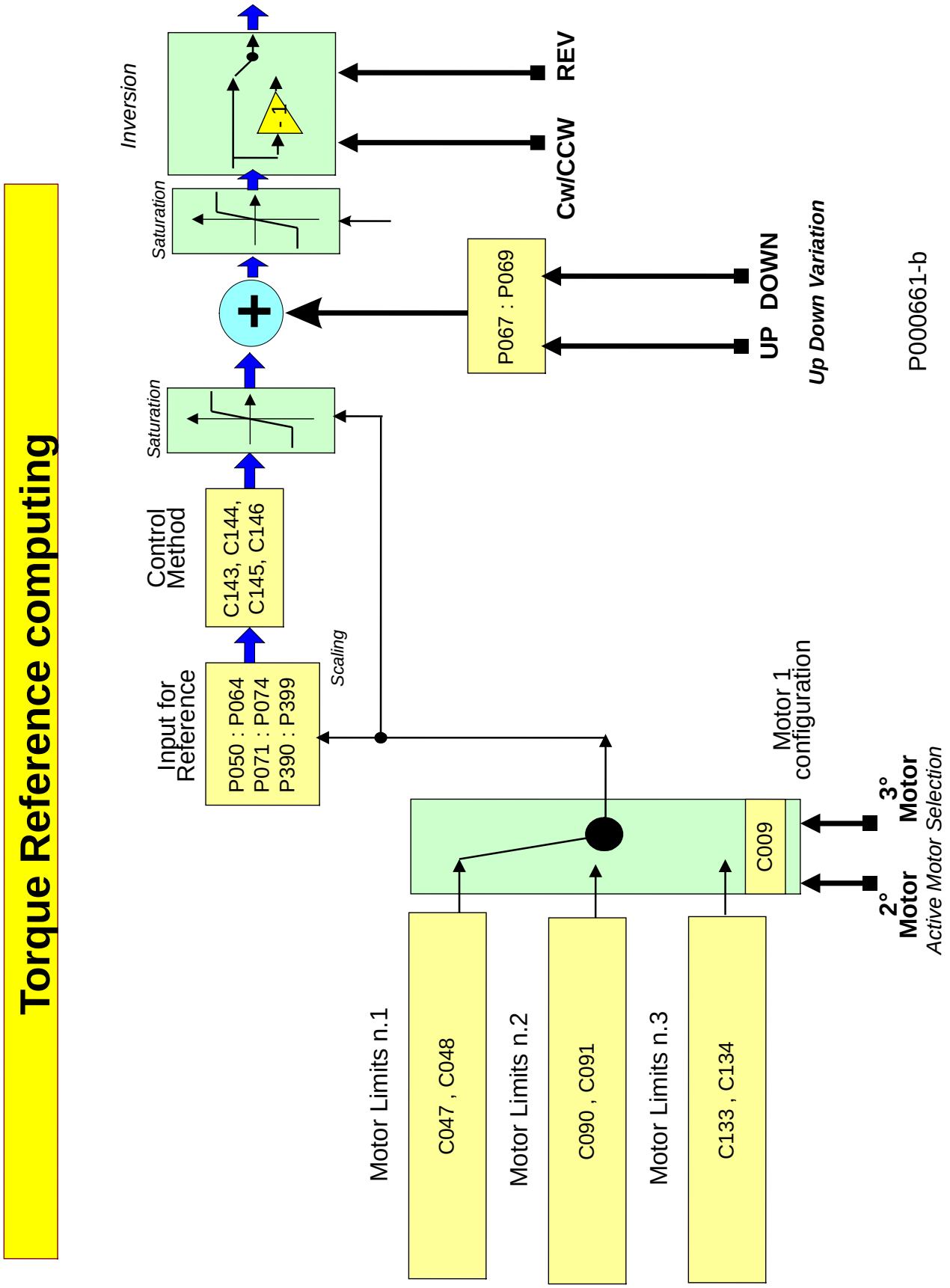


**Figure 8: Torque Reference computing**

### 32.1.8. Torque Control (VTC and FOC Only)

VTC and FOC controls allow controlling the drive with a torque reference instead of a speed reference. To do so, set [1: Torque or 2: Torque with Speed Limit [FOC only] in the relevant parameter (**C011** for motor 1, **C054** for motor 2, **C097** for motor 3).
In this way, the main reference corresponds to the motor torque demand and may range from **C047** to **C048** (**Limits Menu**) for motor 1 (minimum and maximum torque expressed as a percentage of the motor rated torque). For motors 2 and 3, the parameters relating to min. and max. torque (**C090**, **C091** and **C133**, **C134**) are included in the Limits Menu 2 and Limits Menu 3.
Using a 0020 drive connected to a 15kW motor, **C048** is factory-set to 120% of the motor rated torque. If the max. reference is applied (**C143** = REF), the torque reference will be 120%.
If a 7.5kW motor is connected, **C048** may exceed 200%; torque values exceeding 200% may be obtained based on the value set in **C048**.
The motor rated torque results from the following formula:
$C=P/\omega$
where P is the rated power expressed in W and $\omega$ is the rated speed of rotation expressed in radiants/sec.
Example: the rated torque of a 15kW motor at 1420rpm is equal to:

$$C = \frac{15000}{1420 \cdot 2\pi/60} = 100.9 \text{ Nm}$$

The starting torque is:
**rated torque * 120% = 121.1 Nm**

## 32.2. List of Parameters C008 to C128

**Table 71: List of parameters C008 to C128**

| Parameter | FUNCTION | User Level | MODBUS Address | DEFAULT VALUES |
|---|---|---|---|---|
| C008 | Rated mains voltage | BASIC | 1008 | 2:[380÷480V] |
| C009 | N. of configured motors | ENGINEERING | 1009 | 1 |

| Parameter | | FUNCTION | User Level | MODBUS Address | DEFAULT VALUES |
|---|---|---|---|---|---|
| C010 | M1 | Type of control algorithm | BASIC | 1010 | 0: IFD |
| C053 | M2 | | | 1053 | |
| C096 | M3 | | | 1096 | |
| C011 | M1 | Type of reference | ADVANCED | 1011 | 0: Speed (MASTER mode) |
| C054 | M2 | | | 1054 | |
| C097 | M3 | | | 1097 | |
| C012 | M1 | Speed feedback from encoder | BASIC | 1012 | 0: No |
| C055 | M2 | | | 1055 | |
| C098 | M3 | | | 1098 | |
| C013 | M1 | Type of V/f curve | BASIC | 1013 | See Table 75 and Table 79 |
| C056 | M2 | | | 1056 | |
| C099 | M3 | | | 1099 | |
| C014 | M1 | Phase rotation | ENGINEERING | 1014 | 0: No |
| C057 | M2 | | | 1057 | |
| C100 | M3 | | | 1100 | |
| C015 | M1 | Rated motor frequency | BASIC | 1015 | 50.0 Hz |
| C058 | M2 | | | 1058 | |
| C101 | M3 | | | 1101 | |
| C016 | M1 | Rated motor rpm | BASIC | 1016 | 1420 rpm |
| C059 | M2 | | | 1059 | |
| C102 | M3 | | | 1102 | |
| C017 | M1 | Rated motor power | BASIC | 1017 | See Table 76 and Table 80 |
| C060 | M2 | | | 1060 | |
| C103 | M3 | | | 1103 | |
| C018 | M1 | Rated motor current | BASIC | 1018 | See Table 76 and Table 80 |
| C061 | M2 | | | 1061 | |
| C104 | M3 | | | 1104 | |
| C019 | M1 | Rated motor voltage | BASIC | 1019 | Depending on the drive voltage class |
| C062 | M2 | | | 1062 | |
| C105 | M3 | | | 1105 | |
| C020 | M1 | Motor no-load power | ADVANCED | 1020 | 0.0% |
| C063 | M2 | | | 1063 | |
| C106 | M3 | | | 1106 | |
| C021 | M1 | Motor no-load current | ADVANCED | 1021 | 0% |
| C064 | M2 | | | 1064 | |
| C107 | M3 | | | 1107 | |
| C022 | M1 | Motor stator resistance | ENGINEERING | 1022 | See Table 76 and Table 80 |
| C065 | M2 | | | 1065 | |
| C108 | M3 | | | 1108 | |
| C023 | M1 | Leakage inductance | ENGINEERING | 1023 | See Table 76 and Table 80 |
| C066 | M2 | | | 1066 | |
| C109 | M3 | | | 1109 | |
| C024 | M1 | Mutual inductance | ADVANCED | 1024 | 250.00mH |
| C067 | M2 | | | 1067 | |
| C110 | M3 | | | 1110 | |

| | | | | | |
|---|---|---|---|---|---|
| **C025** | **M1** | Rotor time constant | ADVANCED | 1025 | 0 ms |
| **C068** | **M2** | | | 1068 | |
| **C111** | **M3** | | | 1111 | |
| **C026** | **M1** | Time constant of bus voltage low-pass filter | ENGINEERING | 1026 | 0 ms |
| **C069** | **M2** | | | 1069 | |
| **C112** | **M3** | | | 1112 | |
| **C028** | **M1** | Min. motor speed | BASIC | 1028 | 0 rpm |
| **C071** | **M2** | | | 1071 | |
| **C114** | **M3** | | | 1114 | |
| **C029** | **M1** | Max. motor speed | BASIC | 1029 | 1500 rpm |
| **C072** | **M2** | | | 1072 | |
| **C115** | **M3** | | | 1115 | |
| **C030** | **M1** | Flux weakening speed | ENGINEERING | 1030 | 90% |
| **C073** | **M2** | | | 1073 | |
| **C116** | **M3** | | | 1116 | |
| **C031** | **M1** | Max. speed alarm | ADVANCED | 1031 | 0: Disabled |
| **C074** | **M2** | | | 1074 | |
| **C117** | **M3** | | | 1117 | |
| **C032** | **M1** | Reduction in quadratic torque curve | ADVANCED | 1032 | 30% |
| **C075** | **M2** | | | 1075 | |
| **C118** | **M3** | | | 1118 | |
| **C033** | **M1** | Frequency of maximum reduction in quadratic torque curve | ADVANCED | 1033 | 20% |
| **C076** | **M2** | | | 1076 | |
| **C119** | **M3** | | | 1119 | |
| **C034** | **M1** | Voltage Preboost for IFD | BASIC | 1034 | See Table 75 and Table 79 |
| **C077** | **M2** | | | 1077 | |
| **C120** | **M3** | | | 1120 | |
| **C034a** | **M1** | VTC Torque boost for positive reference | ENGINEERING | 1204 | 0% |
| **C077a** | **M2** | | | 1206 | |
| **C120a** | **M3** | | | 1208 | |
| **C034b** | **M1** | VTC Torque boost for negative reference | ENGINEERING | 1205 | 0% |
| **C077b** | **M2** | | | 1207 | |
| **C120b** | **M3** | | | 1209 | |
| **C035** | **M1** | Voltage Boost0 at programmable frequency | ADVANCED | 1035 | See Table 75 and Table 79 |
| **C078** | **M2** | | | 1078 | |
| **C121** | **M3** | | | 1121 | |
| **C035a** | **M1** | Boost0 aplication frequency | ADVANCED | 1027 | 5% |
| **C078a** | **M2** | | | 1070 | |
| **C121a** | **M3** | | | 1113 | |
| **C036** | **M1** | Voltage Boost1 at programmable frequency | ADVANCED | 1036 | See Table 75 and Table 79 |
| **C079** | **M2** | | | 1079 | |
| **C122** | **M3** | | | 1122 | |
| **C037** | **M1** | Boost1 application frequency | ADVANCED | 1037 | See Table 75 and Table 79 |
| **C080** | **M2** | | | 1080 | |
| **C123** | **M3** | | | 1123 | |
| **C038** | **M1** | Autoboost | ADVANCED | 1038 | See Table 75 and Table 79 |
| **C081** | **M2** | | | 1081 | |
| **C124** | **M3** | | | 1124 | |
| **C039** | **M1** | Slip compensation | ADVANCED | 1039 | 0: Disabled |
| **C082** | **M2** | | | 1082 | |
| **C125** | **M3** | | | 1125 | |
| **C040** | **M1** | Voltage drop at rated current | ADVANCED | 1040 | 0: Disabled |
| **C083** | **M2** | | | 1083 | |
| **C126** | **M3** | | | 1126 | |

| | | | | | |
|---|---|---|---|---|---|
| **C041** | **M1** | Fluxing ramp time | ENGINEERING | 1041 | See Table 74 and Table 78 |
| **C084** | **M2** | | | 1084 | |
| **C127** | **M3** | | | 1127 | |
| **C042** | **M1** | Vout saturation percentage | ENGINEERING | 1042 | 100% |
| **C085** | **M2** | | | 1085 | |
| **C128** | **M3** | | | 1128 | |

**C008 Rated Mains Voltage**

| | | | |
|---|---|---|---|
| **C008** | **Range** | 0 ÷ 8 | 0: [ 200 ÷ 240 ] V<br>1: 2T Regen.<br>2: [ 380 ÷ 480 ] V<br>3: [ 481 ÷ 500 ] V<br>4: 4T Regen.<br>5: [ 500 ÷ 600 ] V<br>6: 5T Regen.<br>7: [ 600 ÷ 690 ] V<br>8: 6T Regen. |
| | **Default** | 2 | 2: [ 380 ÷ 480 ] V |
| | **Level** | BASIC | |
| | **Address** | 1008 | |
| | **Function** | This parameter defines the rated voltage of the mains powering the drive, thus allowing obtaining voltage ranges to be used for the drive operation. The value set in this parameter depends on the **Drive voltage class.**<br>To supply the drive via a non-stabilized DC source, the corresponding AC voltage range must be used (see Table 72). DO NOT USE xT Regen settings in this case. | |

**Table 72: Equivalence between AC mains range and DC range**

| AC Mains | DC range |
|---|---|
| 200÷240 Vac | 280÷338 Vdc |
| 380÷480 Vac | 530÷678 Vdc |
| 481÷500 Vac | 680÷705 Vdc |
| 500÷600 Vac | 705÷810 Vdc |
| 600÷690 Vac | 810÷970 Vdc |

**NOTE**

**Select xT Regen** (where x relates to the voltage class of the drive) **if the drive is DC-supplied through a regenerative Sinus Penta or a different drive used to stabilize the DC bus to a higher level than the stabilization level obtained when rectifying the 3-phase mains.**

**C009 N. of Configured Motors**

| | | | |
|---|---|---|---|
| **C009** | **Range** | 1÷3 | 1÷3 |
| | **Default** | 1 | 1 |
| | **Level** | ENGINEERING | |
| | **Address** | 1009 | |
| | **Function** | This parameter determines the number of motors to be configured. The active motor is selected through digital inputs programmed with **C173** and **C174** (see the DIGITAL INPUTS MENU).<br>The programming parameters of the Motor Control 2 Menu can be accessed only if **C009** = 2 or 3; the programming parameters of the Motor Control 3 Menu can be accessed only if **C009** =3. | |