



1 INTRODUCTION

The pump cascade function allows the control of up to 3 pumps in contemporary with the same VLB3 drive for a PID control for the maintaining of the value a physical variable (for example: maintaining of a pressure at a desired setpoint value).

The function provides the command of a main pump directly connected to the output of the drive and frequency modulated, and up to two assist pumps activated in case of necessity (if the main pump alone is not able to reach the setpoint) via two digital outputs in on-off mode (which means that, if activated, they run at the network frequency e.g. 50Hz).

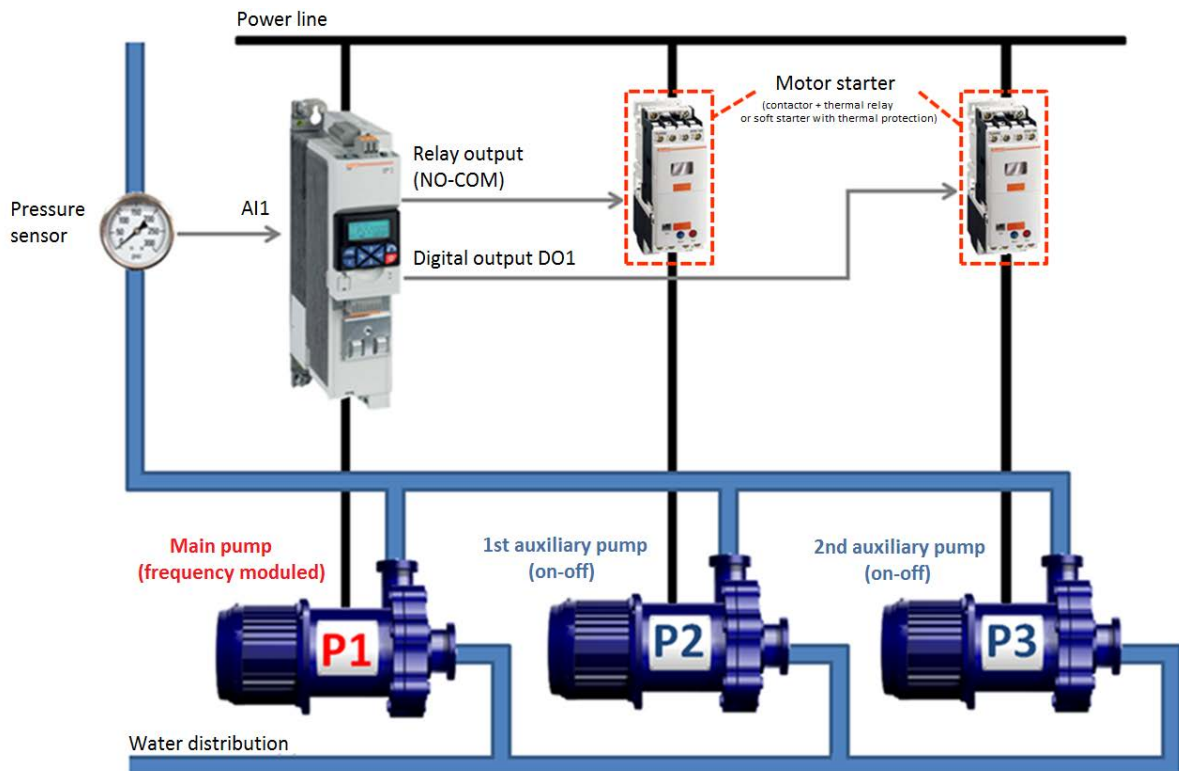
It is also possible to enable the auto-change function for an automatic alternation between the two assist pumps to balance their operating times.

The pump cascade function allows to manage multiple pumps without the necessity of an external PLC and extend the life of the pumping system reducing maintenance time and costs.

Note. This function is available from the firmware version 5.04.

2. GENERAL FUNCTION DESCRIPTION

In the picture below is shown a typical topology of the pump cascade application.



Legend

P1 = main pump (speed modulated)

P2 = assist pump 1 (on-off type)

P3 = assist pump 2 (on-off type)

AI1 = analog input 1 of VLB3

NO-COM = relay output of VLB3, e.g. for the command of assist pump 1 (P2)

DO1 = digital output of VLB3, e.g. for the command of assist pump 2 (P3)

Motor starter = contactor or soft starter for the command of the motor of the assist pump, complete with thermal protection.

The main pump P1 is always enabled and frequency (speed) modulated from the VLB3 according to the pressure of the plant, measured with a pressure sensor connected to an analog input of the drive.

The pump P2 is the first auxiliary pump (assist motor 1), which receives the command signal (on-off) from the relay output of the VLB3 (terminals NO-COM). This output is used to command a motor starter e.g. a contactor, which directly starts the pump P2 (which will run at the network frequency, e.g. 50Hz) when it receives the closing command from the drive.

The pump P3 is the second auxiliary pump (assist motor 2), which receives the command signal (on-off) from the digital output DO1 of the VLB3. This output is used to command a motor starter e.g. a contactor, which directly starts the pump P3 (which will run at the network frequency, e.g. 50Hz) when it receives the closing command from the drive.

AI1 is the first analog input of the VLB3 drive, to which has to be connected the output of a pressure sensor (typically type 0-10V or 4-20mA) for the measure of the pressure of the plant.

NO-COM is the relay output of the VLB3 drive, which commands the start/stop of the auxiliary pump P2 (assist motor 1).
DO1 is the digital output of the VLB3 drive, which commands the start/stop of the auxiliary pump P3 (assist motor 2).

Notes

- The presence of the second assist pump (P3) is optional, the system can work even with only one assist pump.
- The two outputs of the VLB3 drive are freely programmable: if desired, it is possible to program the relay output for the command of the pump P3 (assist pump 2) and the digital output for the command of the pump P2 (assist pump 1), or, in case of presence of just one auxiliary pump, it is possible to decide to command it through the relay output or the digital output.
- The assist pumps are typically switched via a direct-on-line starter, for example a contactor. If preferable, it is possible to use in alternative a soft starter in order to softly start and stop the pumps, to reduce the inrush currents and the mechanical stress thanks to acceleration and deceleration ramps.
- Provide a properly thermal protection for each pump: for the main pump P1 it is possible to use the integrated thermal protection of the VLB3 drive (see parameter P323.00), for the assist pumps install a dedicated thermal protection (e.g. thermal overload relay or motor protection circuit breaker).
- It is suggested the use a general purpose relay as interface between the digital outputs of the VLB3 and the contactors which command the auxiliary pumps.

3. THE WORKING PRINCIPLE

The working principle of the pump cascade function is described below.

- The user set via the keypad of the VLB3 (default setting) the setpoint of the pressure that wants to maintain in the plant.
- The VLB3 monitors the value of the pressure in the plant (feedback) through a pressure sensor connected to an analog input of the drive (default: analog input 1).
- If the pressure of the plant (feedback) is lower than the setpoint, the drive increases the speed of the main pump P1: the more the plant pressure is far from the setpoint, the more higher will be the speed of the pump P1; on the contrary, as the plant pressure increases and arrives close to the setpoint value, the drive reduces the speed of the pump P1, until the pressure reaches the setpoint value. This works as a standard PID control, where the pump P1 is frequency modulated according to the plant pressure.
- If after a certain time (programmable) the main pump P1 is running at the maximum speed (e.g. 50Hz) but the plant pressure does not reach the setpoint, the drive commands the activation of an assist pump (e.g. pump P2) by closing a digital output.
- The assist pump is typically commanded via a direct starter type on-off (for example: the relay output of the VLB3 supplies the coil of a contactor connected to the pump P2), so once activated it runs at the network frequency (e.g. 50Hz).
- Once the pump P2 has been activated, the drive VLB3 reduces the speed of the main pump P1 to take account of the contribution offered from the pump P2.
- At this point, the drive continues to module the speed of the main pump P1 according to the pressure demand. If the plant pressure reaches the setpoint, the drive reduces the speed of the pump P1 up to the minimum value and, after a delay time (programmable), it disconnects the assist pump P2 by opening the digital output used for its command.
- Otherwise, if even with the assist pump P2 switched on and the main pump P1 running at the maximum frequency the setpoint pressure is not reached, after a programmable delay time the drive commands the activation of the second assist pump P3 by closing the digital output DO1.
- Once the pump P3 has been activated, the drive VLB3 reduces the speed of the main pump P1 to take account of the contribution offered from the pump P3.
- Then, the drive continues to adjust the speed of the main pump P1 according to the pressure demand. When the plant pressure reaches the setpoint value, the drive reduces the speed of the pump P1 and, after a delay time (programmable), it disconnects one assist pump by opening the respective digital output used for its command. In the specific, it disconnects first the one which has worked for a longer time (default setting), in order to balance the operating time of the two assist pumps.
- For the disconnection of the second assist pump the same logic is followed: if the plant pressure is greater or equal to the setpoint value, the drive reduces the speed of the pump P1 and after a programmable delay time it switches off also the other assist pump.

Notes

- It is possible to enable one or two assist pumps according to the plant configuration with dedicated parameters (see parameter P400.56 and P400.57).
- To command the assist pumps, the digital outputs of the VLB3 drive must be programmed respectively with the functions *Pump Assistance motor 1* and *Pump Assistance motor 2* (see P420.01 and P420.02).
- As default, in order to balance the operating times of the two assist pumps, the assist pump which is switched on firstly is always the one with the lower operating time and the assist pump which is switched off firstly is always the one with the longer operating time. If preferable, it is possible to program the function in order to maintain always the same order of connection/disconnection of the two assist pumps (e.g. firstly P2 and secondly P3 independently from their operating times, see parameter P770.02).
- For the configuration of the PID control and the other functionalities of the drive (e.g. operating limits, acceleration or deceleration time, etc..) refer to the instruction manual I473.

4. OPERATING MODES

The pump cascade function provides two different operating modes (selectable with parameter P770.01):

- "Without ramping": after the switching on or off of an assist pump, the speed of the pump P1 is not influenced by the pump cascade function, it continues to be automatically adjusted by the drive according to the pressure demand.
- "With ramping": after the activation of an assist pump, the speed of the main pump P1 is forced to ramp down to a lower frequency value (*lower master frequency*, programmable), after which the drive returns to adjust its speed according to the pressure demand. On the contrary, when an assist pump is switched off, the drive forces the speed of the pump P1 to ramp up to a higher value (*upper master frequency*, programmable), after which the drive returns to adjust its speed according to the pressure demand.

For more details see the parameters table and the functional diagrams.

5. PARAMETERS TABLE

P770.01	0x405C:001	Pump Cascade: Activate Pump Cascade
0 ... [0] ... 2		<p>0: Disabled Pump cascade functionality is disabled.</p> <p>1: Without Ramping After reaching the <i>start frequency</i> (P770.03) or the <i>stop frequency</i> (P770.04), after the <i>start delay</i> P770.06 the drive switches on or off an assist pump, while the frequency of the main pump P1 is not influenced by the pump cascade function, it continues to be automatically adjusted by the drive according to the pressure demand.</p> <p>2: With Ramping After reaching the <i>start frequency</i> (P770.03) or the <i>stop frequency</i> (P770.04), after the <i>start delay</i> P770.06 the drive switches on or off an assist pump and decreases or increases with a ramp the frequency of the main pump P1 to the value <i>lower master frequency</i> (P770.07) or <i>upper master frequency</i> (P770.08). For more details see the functional diagrams.</p>
P770.02	0x405C:002	Pump Cascade: Start/stop order
0 ... [1] ... 1		<p>0: Assist Pump Number The assist pump number defines the starting order: the drive will always start firstly the assist pump 1 and then the assist pump 2.</p> <p>1: Operating Time The assist pump with the lower operating time starts first. The assist pump with the longer operating time stop first.</p>
P770.03	0x405C:003	Pump Cascade: Start frequency
0.0 ... [40.0] ... 599.0 Hz		After reaching the <i>start frequency</i> and expiration of the delay time P770.06 an assist pump is started. Note. The start behavior depends on the setting in P770.01 and P770.02.
P770.04	0x405C:004	Pump Cascade: Stop frequency
0.0 ... [10.0] ... 599.0 Hz		After reaching the <i>stop frequency</i> and expiration of the delay time P770.06 an assist pump is stopped. Note. The stop behavior depends on the setting in P770.01 and P770.02.
P770.05	0x405C:005	Pump Cascade: Settling time
0.0 ... [5.0] ... 3600.0 s		This parameter is used to set a delay time to prevent switching on and off a further assist pump after an assist pump was switched on or off.
P770.06	0x405C:006	Pump Cascade: Start delay
0.0 ... [2.0] ... 3600.0 s		This parameter defines a delay time after the reaching of the <i>start frequency</i> (P770.03) or <i>stop frequency</i> (P770.04) before switch on or off an assist pump.
P770.07	0x405C:007	Pump Cascade: Lower master frequency
0.0 ... [20.0] ... 599.0 Hz		This parameter represents the frequency setpoint to which the main pump P1 is ramped down when the <i>start frequency</i> (P770.03) is reached after the start delay P770.06. The ramp times for this functionality can be adjusted with the parameters P606.01 and P606.02.

		Note. This parameter is only active if pump cascade mode P770.01 is set to 2 (With Ramping).
P770.08	0x405C:008	Pump Cascade: Upper master frequency
0.0 ... [30.0] ... 599.0 Hz		This parameter represents the frequency setpoint to which the main pump P1 is ramped up when the <i>stop frequency</i> (P770.04) is reached after the start delay P770.06. The ramp times for this functionality can be adjusted with the parameters P606.01 and P606.02. Note. This parameter is only active if pump cascade mode P770.01 is set to 2 (With Ramping).
P770.09	0x405C:009	Pump Cascade: Auto change time
0 ... [0] ... 1000 h		This time can be set to keep the lifetime of every assist pump equal. If a running assist pump exceeds the <i>Auto Change Time</i> P770.09, the drive checks if another assist pump is available and stopped. If this is the case the drive will switch between the two assist pumps. If <i>Auto Change Time</i> P770.09 is set to 0 the function is disabled.
P770.10	0x405C:010	Pump Cascade: Auto change time delay
-10.0 ... [0.0] ... +10.0 s		In case of activation of the auto change function (P770.09 different from 0), this parameter defines the exchanging mode between the two assist pumps when an auto change event is performed. P770.10 = 0.0s: The stop of an assist pump and the start of the other assist pump takes place in the same instant. P770.10 > 0.0s: Delay time between the stop of an assist pump and the start of the other assist pump. P770.10 < 0.0s: First the second assist pump is started. After passing the <i>auto change time delay</i> P770.10 the first assist pump stops.
P770.11	0x405C:011	Pump Cascade: Timer reset
0 ... [0] ... 1		If enabled (P770.11=1), the operating time of the assist pumps (P770.13 and P770.14) is set to 0.
P770.12	0x405C:012	Pump Cascade: Status word
Read only		Pump cascade status word. Bit 0: assist pump 1 in use The assist pump 1 is enabled in P400.56. Bit 1: assist pump 2 in use The assist pump 2 is enabled in P400.57. Bit 2: reserved Bit 3: assist pump 1 is running The assist pump 1 is switched on. Bit 4: assist pump 2 is running The assist pump 2 is switched on. Bit 5: reserved Bit 6: upper limit reached <i>Start frequency</i> P770.03 is reached. Bit 7: lower limit reached <i>Stop frequency</i> P770.04 is reached. Bit 8: cannot follow The main pump has reached the maximum frequency P211.00 and no free assist pump is available.
P770.13	0x405C:013	Pump Cascade: Operating time assist pump 1
Read only [d:h:m:s]		Display the operating time of assist pump 1. The operating time is reset if P770.11=1 or the trigger of the function P400.58 is TRUE.
P770.14	0x405C:014	Pump Cascade: Operating time assist pump 2
Read only [d:h:m:s]		Display the operating time of assist pump 2. The operating time is reset if P770.11=1 or the trigger of the function P400.58 is TRUE.
P400.56	0x2631:056	Pump Cascade: Enable assist motor 1

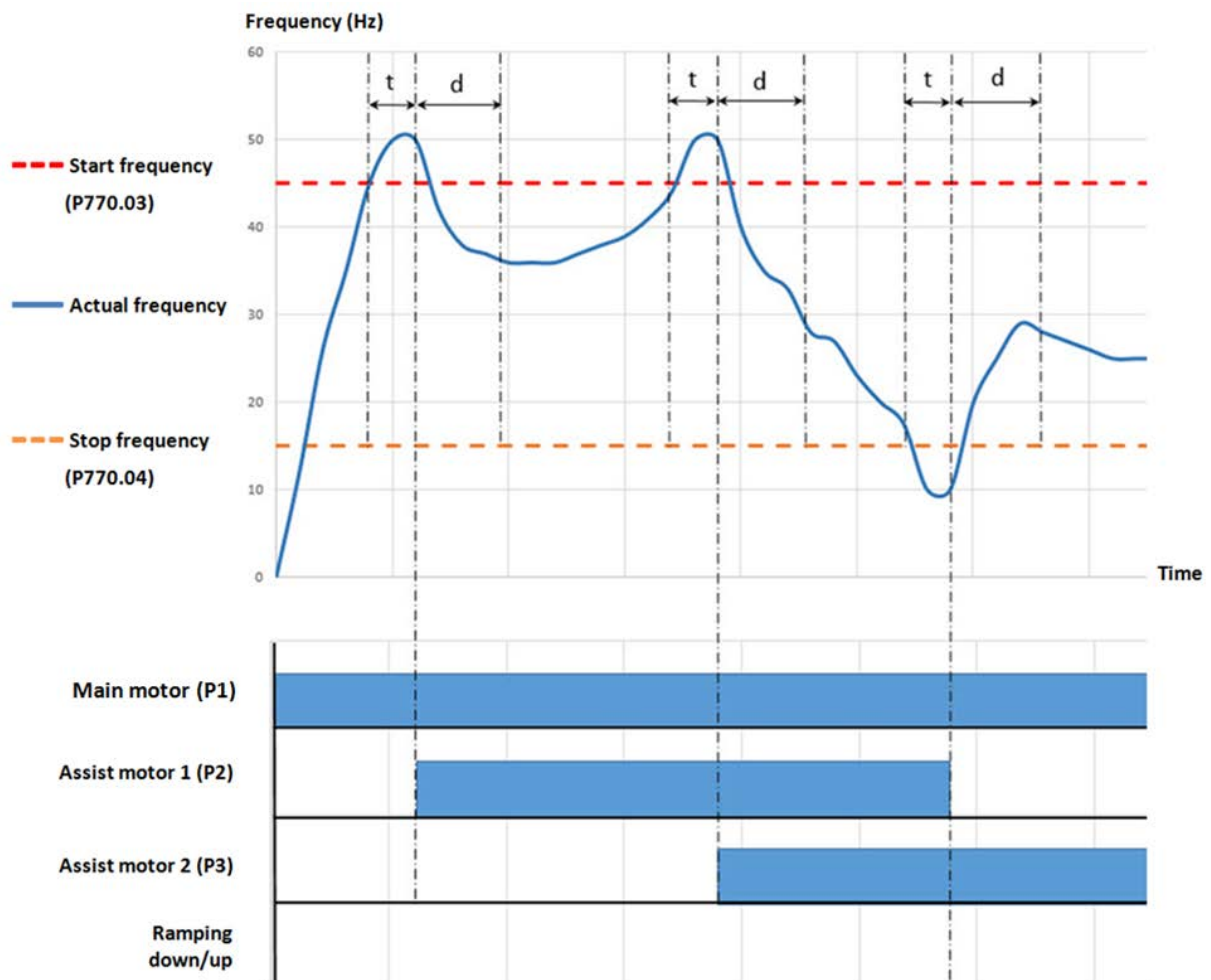
(Reference: see P400.01)		Trigger for the enable of the assist pump 1. The assist pump can be enabled with the function list and activated and deactivated over a dedicated source.
P400.57	0x2631:057	Pump Cascade: Enable assist motor 2
(Reference: see P400.01)		Trigger for the enable of the assist pump 2. The assist pump can be enabled with the function list and activated and deactivated over a dedicated source.
P400.58	0x2631:058	Pump Cascade: Reset timer
(Reference: see P400.01)		Trigger for the reset of the assist pumps operating times.
P420.01	0x2634:001	Relay output function
(Reference: see P420.01)		To configure the relay output of the VLB3 for the command of an assist pump set this parameter to <i>Pump Assistance motor 1</i> [160] or <i>Pump Assistance motor 2</i> [161].
P420.02	0x2634:002	Digital output 1 function
(Reference: see P420.01)		To configure the DO1 digital output of the VLB3 for the command of an assist pump set this parameter to <i>Pump Assistance motor 2</i> [161] or <i>Pump Assistance motor 1</i> [160].

6. FUNCTIONAL DIAGRAMS

The following diagrams are created with an arbitrarily output frequency of the drive. It should give a view how the different parameters work in the application for the two operating modes (without ramping and with ramping).

6.1 Without ramping

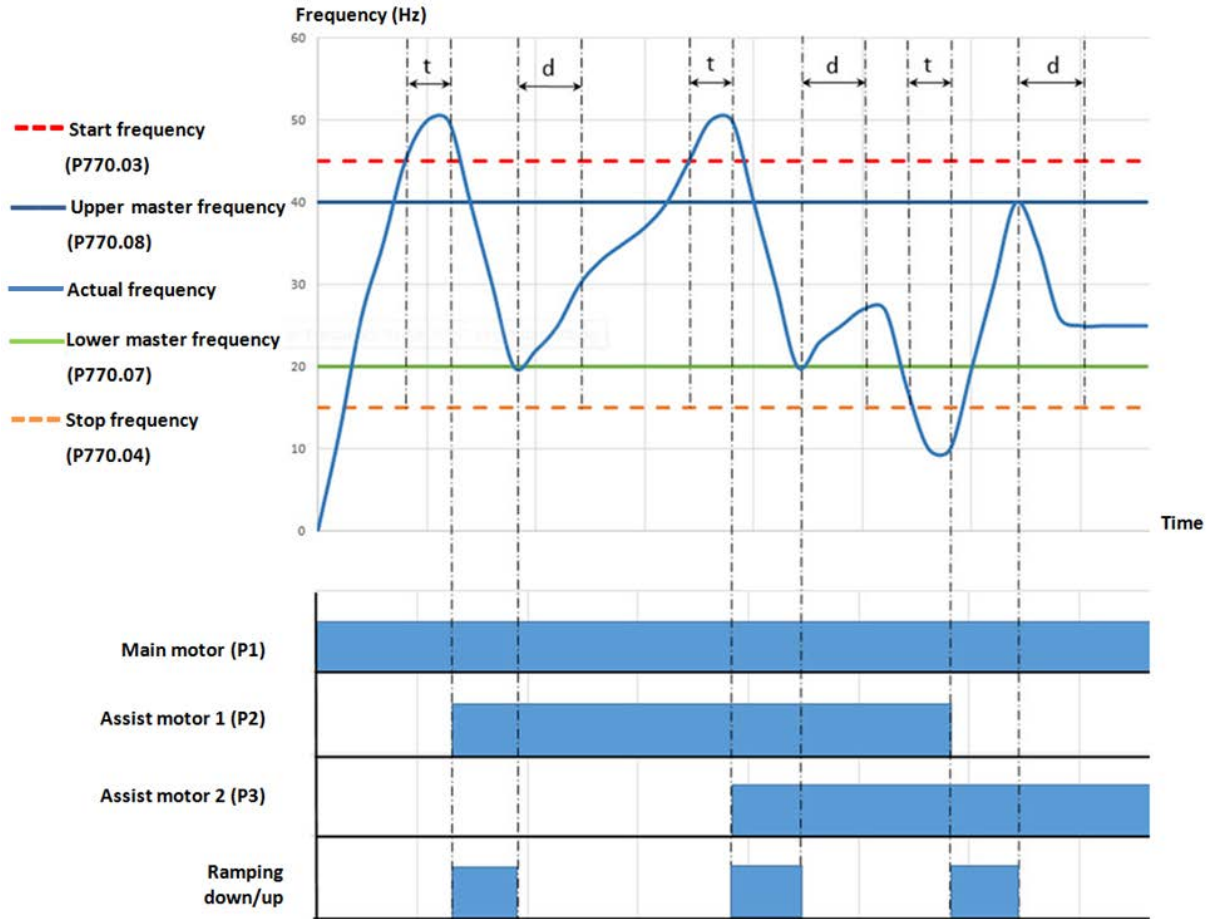
Set P770.01 = 1



d = settling time P770.05
t = start delay P770.06

6.2 With ramping

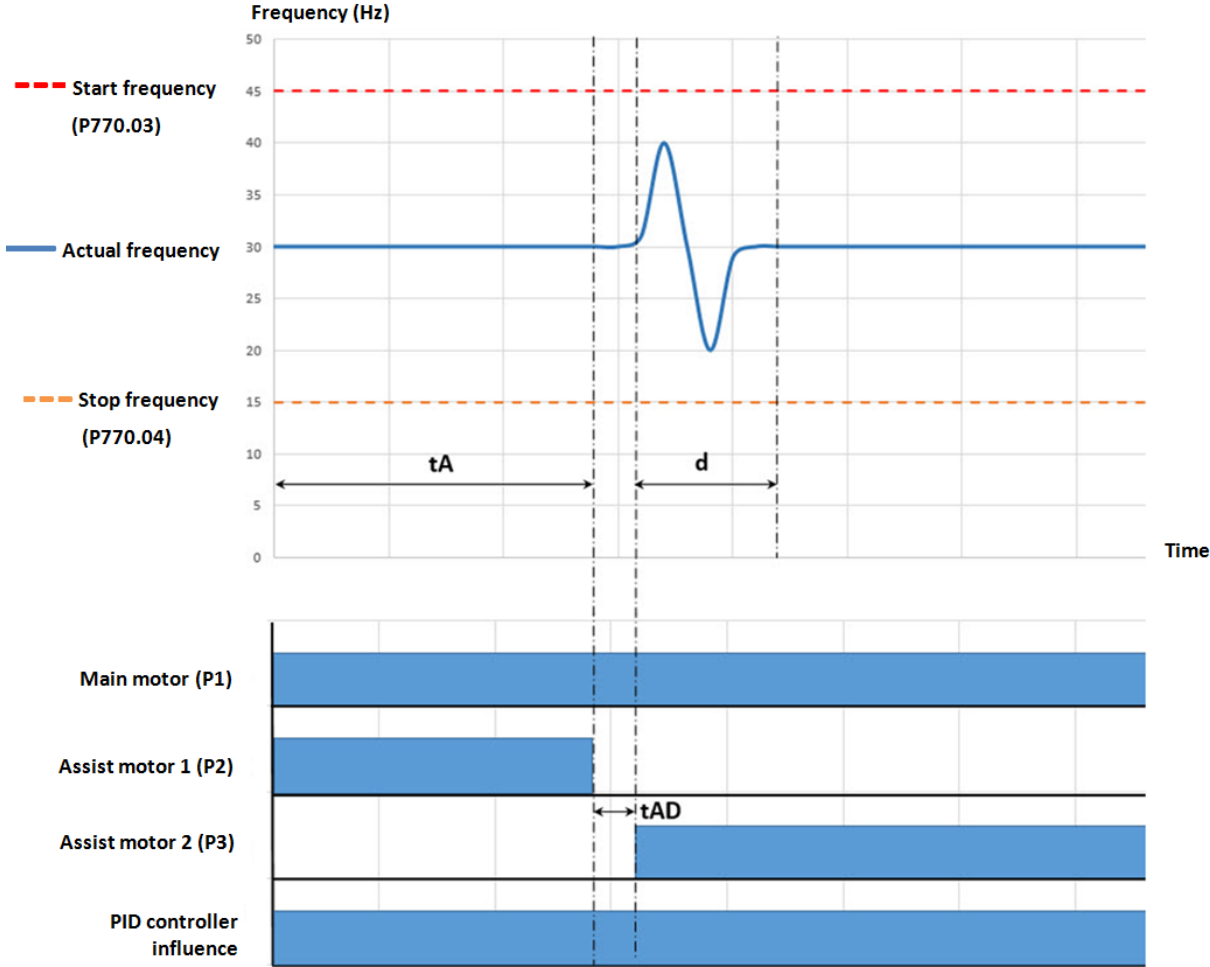
Set P770.01 = 2



d = settling time P770.05

t = start delay P770.06

6.3 Auto change function



d = settling time P770.05
 tA = auto change time P770.09
 tAD = auto change time delay P770.10