Adjustment of the NCT servo amplifier

1. Table of contents

2. General description of motors

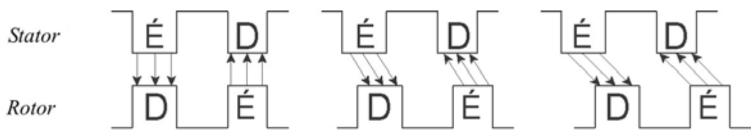
An electric machine which transform electric power into mechanic power is a motor.

2.1. The function of synchronous servomotors

The transformation of electric power into energy of motion is most possible by using three-phased current. The currents of the three phases are running according to 3 sine functions shifted in a 120 degree from each other. If we switch this 3-phased current in a 3 phased winding shifted symmetrically in place by its outline, then that creates a turning magnetic field. We are able to establish more than one north-south pair of poles along the outline. Thus, going around the outline we meet more north-south pair of poles, for example the electric's 120 degree shift phase in the case of 2 pairs of poles we results in a geometric turning of 60 degree. So if we switch a given frequency 3-phased voltage onto a winding like this, the speed per second of the turning magnetic filed is going to be $n=f_1/p$, in which case "p" is the number of pair of poles, "f" is the switched voltage's frequency. In case of synchronous servomotors this winding is created on the stator, the permanent magnets on the rotor provide the magnetic field. The power resulting from the interaction of the magnetic field and the current running in the winding will force the rotor together with the rotation field to turn.

If the number of flux lines connected to the coil changes induced voltage is created. The magnetic field which is turning with synchronous speed is accomplished by the excitation of the rotor and armature current. This resultant field crosses the conductors of the stator and induces voltage in them. In motoric operation the excitation of the rotor creates a magnetic field which establishes nearly the same induced voltage as the external voltage switched on the armature. This is the internal induced voltage of the motor what maximal value is: $U_{max}=\omega*N*\Phi_{max}=2\pi f_1*N*\Phi_{max}$, where N is the number of the stator coil, Φ_{max} is the flux maximum created by the stator. The effective value of the induced voltage is important for us: $U_i=U_{max}/\sqrt{2}$. If the shaft of the motor is not loaded then as much current is running in the stator winding which can cover the losses needed for the turning of the permanent magnetic rotor.

If the turning of the rotor is breaked by a torque switched on the shaft, in other words we acquire torque from the motor, the magnetic axis of the rotor will move away from the magnetic axis of the stator. If in imagination we separate the magnetic field created by the rotor from the armature magnetic field, then we illustrate the two fields as two magnets.

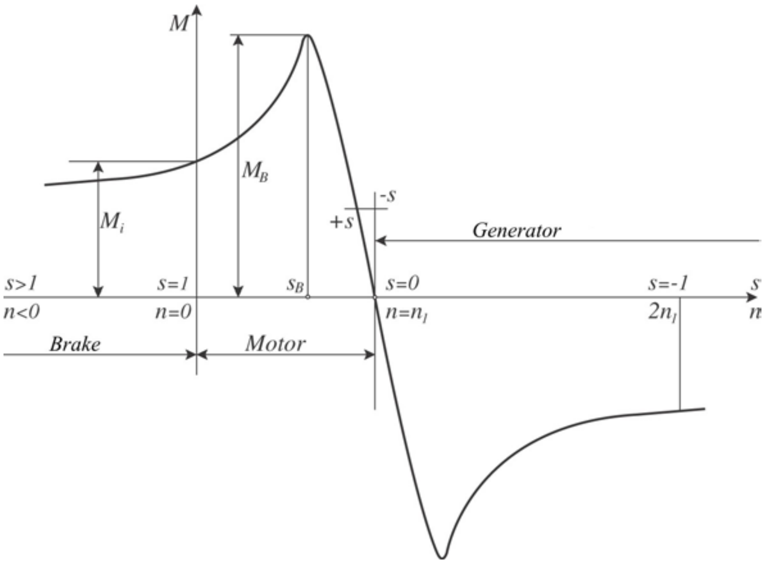


2.1.figure. Angular variation

The difference between the magnetic axes is called angular variation. Its value can be maximum 90 degree in theory. By the growth of the angular variation the rotor's magnetic field does not help the creation of the resultant field as it did in no-load condition even though the armature would need the same flux for the establishment of the induced voltage which is balanced with the terminal voltage. If this balance is disintegrated then the difference between terminal voltage and the induced voltage will result in a current in the armature circle, that the strengthened armature's magnetic field will produce the induced voltage suitable for the new balance.

2.2. Function of asynchronous motors

Asynchronous machine is a machine for which operation turning magnetic field is needed. The speed of the rotor differs from the speed of the magnetic field, and between the stator and the rotor the electro induction makes a connection (induction machines). Generally we feed the asynchronous machines from the side of the stator with electric power, and similarly to the transforms we call that primary side. The rotor is a short circuited coiled (squirrel cage) rotor. Switch the 3-phased asynchronous machine's stator winding into a 3-phased symmetric f_1 frequential grid. In this case in the stator's winding which is shifted in place, current is running which is shifted in time, and that created a turning magnetic field. The speed of this per second is: $n_0=60*f_1/p$ where "p" is the number of the machine's pair of poles. The flux lines of the turning magnetic field cross the rotor's and stator's conductors. Thus in each winding induced voltage is created. The value of the stator's induced voltage per phases is : $U_{i1}=4.44*\Phi*f_1*N_1*\xi_1$, where Φ is the maximum value of the turning flux which is sine distributed along the outline, N_1 is the number of the stator's winding per phase, ξ_1 is the stator's coiled factor. When the rotor is out of action because of the identity pairs of poles winding and the flux line's speed of crossing the rotor's induced voltage frequency is the same. The stator' induced voltage because of the voltage drop caused by magnetizing current is smaller than terminal voltage. If the rotor of the synchronous machine is out of action and if 3-phased voltage is switched on the stator's winding, than the induced voltage in the rotor creates current in the short circuited coil. The stator's turning magnetic field and the rotor's current's interaction creates torque, which tries to shifts the rotor. The arising brake makes the rotor turning, which speed (n) is smaller than the turning magnetic field (n_0). The induced voltage's frequency in the rotor's conductors, in this case: $f_2=(n_0-n)*p/60$. The n_0-n speed different relative value is called slip: $s=(n_0-n)/n_0$. The value of the slip describes the asynchronous machine's operations very well: we talk about motoric operation if the value of the slip is bigger than 0, but smaller than 1; in case of generator operation the slip is smaller than 0; in brake operation the slip is bigger than 1. In motoric operation the torque of the asynchronous machine depends on the square of the terminal voltage, on the primary and secondary resistance and on the stray reactance, and also depends on the slip.



2.2.figure. Torque-slip characteristic of asynchronous motor

The line that falls in between the n_B and n_0 is stable, while the line between the n_B and n=0 is instable. Where n_B means the breakdown torque's speed. The breakdown torque is the motor' maximal torque.

3. Function of NCT synchronous servo amplifier

The machine tools' carriages are moved by synchronous servomotors. Permanent magnetic rotors are used exclusively for synchronous servomotors. These permanent magnets ensure us the flux pole, which is a conducted magnetic field inside of the motor. Depending on the induction field's shape distributed in place which is created by the permanent magnetic rotor we differentiate square and sine field motors. NCT synchronous servo amplifiers drive sine-fielded synchronous servomotors. Synchronous servo amplifiers provide fluctuationless torque and speed feeding for servomotors. With synchronous servo amplifiers we can provide fluctiationless torque and speed resulting feed for the servomotors. In case of fitted feeds like this the shape of the stator's phase current should be chosen according to the shape of the field and its phase position should be synchronize to the angle of rotor.

3.1. Frequential operation of sinusoidal fielded synchronous machine

In case of a synchronous machine fed by a frequency converter a turning magnetic field is created. This turning magnetic field is followed by the rotor and as a consequence the shaft of the motor begins to turn. In fixed state the rotor turns together with the turning magnetic field. In synchronous motors the angular speed of the field and the angular speed of the rotor is the same ($\omega=\omega_1$). The angular speed of the turning field is $\omega_1=2\pi f_1/p$, where "p" is the number of pair of poles, f_1 is the frequency of the stator's phase current. The speed of the synchronous motor can be changed continuously with the help of f_1 frequency. In case of a sine field machine the maximum of the induction field points out the "d" axis of the rotor. The "q" axis is perpendicular to the "d" axis.

3.1.1. Current generator feed

In the practice of permanent magnetic sinusoidal fielded synchronous motoric servo drives current vector controlled feed is used. When I_1 is the value of the armature current, and ϑ_p torque angular can change provided that the pole flux Ψ_{p1} is constant, as the torque is the function of the I_1 current and the ϑ_p torque angular. In this case I_1 vector's angular and value is determined by the torque and the angular speed. The servo drives optimal operation and the field reduction operation is similar to that. Ψ_{p1} pole flux is insured by the permanent magnets. The current can be changed rapidly because of the L_d and L_q inductivities, we can gain good dynamics by the drive if it owns the appropriate reserved voltage.

3.2. Sine fielded synchronous servo drive

In permanent magnetic sine fielded synchronous motors, from the rotor's position we can reach the best servo qualities by current vector control.

3.2.1. Normal operation

In normal operation the ϑ_p torque angular is 90°+k*180°, $\cos\vartheta_p=0$ and $I_{d1}=0$. The drive can provide the nominal values as long as the inverter has an adequate reserved voltage.

3.2.2. Field reduction operation

The inverter is unable to give out voltage bigger than the given amplitude. This means that the further increase of the angular speed is only possible in field reduction operation because of the constancy of the U_1 voltage. The characteristic of the field reduction is that $I_{d1}<0$ in other words in opposite direction with Ψ_{p1} pole flux. It has an effect as if Ψ_{p1} created with the magnetic field would decrease.

4. The basics of the NCT asynchronous servo amplifiers' action

In asynchronous motoric servo drives 3-phased, squirrel caged rotor asynchronous servomotors are used. The construction of the coiled stator is the same as the construction of a 3-phased synchronous machine, the squirrel caged rotor is usually made of aluminium. Asynchronous servomotors different many characteristics from the general asynchronous motors. In order to the decrease of the inertia torque the relation of the rotor's l/D is big. Their nominal frequency is usually different from the 50Hz, their nominal voltage is smaller than 3*400V grid voltage, so the machine is less saturated. The advantages of these motors is the vest brushless simple quality. NCT servo amplifiers are able to operate appropriately the general asynchronous motors as well. In case of asynchronous motors we get the fluctuationless torque in constant state by sinusoidal symmetric feed.

4.1. Frequency converted operation of asynchronous machines

4.1.1. Current generator feed

In this cases the amplitude of the stator's I_1 is permanent because of current control. Ψ_1 stator flux and Ψ_{r1} rotor flux is changing depending on the frequency of U_1 terminal voltage and the load. We have to pay attention to the fact that next to ω_r=0 the motor can even be filled by small I_1 current.

4.1.2. Field reduction operation

In this case of any kind of feed, U_1 terminal voltage cannot be increased above a given frequency, because the inverter that feeds the motor is unable to produce any more voltage and the ironless of the stator would reach an unaffordable value. When this happens the inverter gives out an U_{1max} voltage only above a determined circular frequency, thus U_1/ω_1 relation decreases which results in field reduction. The increase of f_1 frequency goes together with the decrease of the flux. The maximal torque decreases proportionately with the decrease of flux on the square.

5. Basic settings of servo amplifiers

The controls have to comply with three basic requirements:

- The operation of the control should be stable;
- The error of the control in constant state has to be as small as possible;
- The control has to meet the specified qualitative requirements.

In case of a control of a given structure, the loop-gain and/or the time constants should be modified if we want to improve the characteristics. There is no way to change the time constants that characterize the controlled segment, the sensor and the actuating unit. The changes in characteristics of quality can be doubtful by the modification of loop-gain. For example, if we want to decrease the errors of constant state, i.e. the loop-gain is increased than the control time will become shorter, as the control circular frequency has grown and at same time the phase margin has lessen which leads to the instability of the system. If the control is not stable or doesn't comply with the quality requirements then the operation can be improved in two ways:

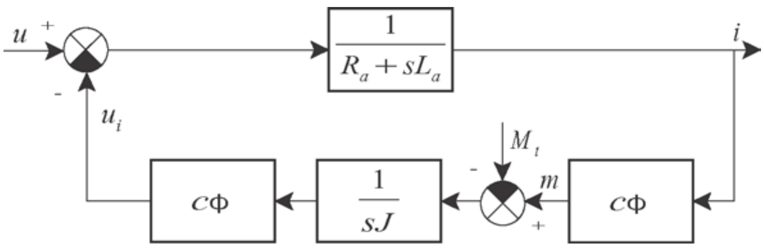
- The structure or the element of the control has to be changed. The system has to be built by terms of which dynamic characteristics will be able to carry out the specifications of the control. It's not possible to have this solution generally.
- The other possibility is that we switch an accessory elements with dynamic characteristics in the control loop, which would modify the system's characteristics in order to the circumstances.

This later process, which is the adjustment of the elements improving the transmission characteristics of the control, is called compensation. The changing of certain characteristics of the control loop will change the other characteristics as well. In most cases serial compensation is used which means that we install the signal forming term in the forward path of the control loop in a serial way. The compensation is regarded as serial as well if we form an inner loop from the terms independently changing in parameter in the forward path.

5.1. The setting of the current controller

The controlled segment is the synchronous servomotor in the control. The type number of the signal transfer function concerning the current of the servomotor is –1, in other words it's derivative. We would like to modify it into type 0, because the quality of the control depending on the size of the energy accumulators in the loop is decided by the quality of signal changing in case of differential character. Thus the use of these types of systems is not accepted for machine tools' operations. In the current controller we use a serial PI compensative element.

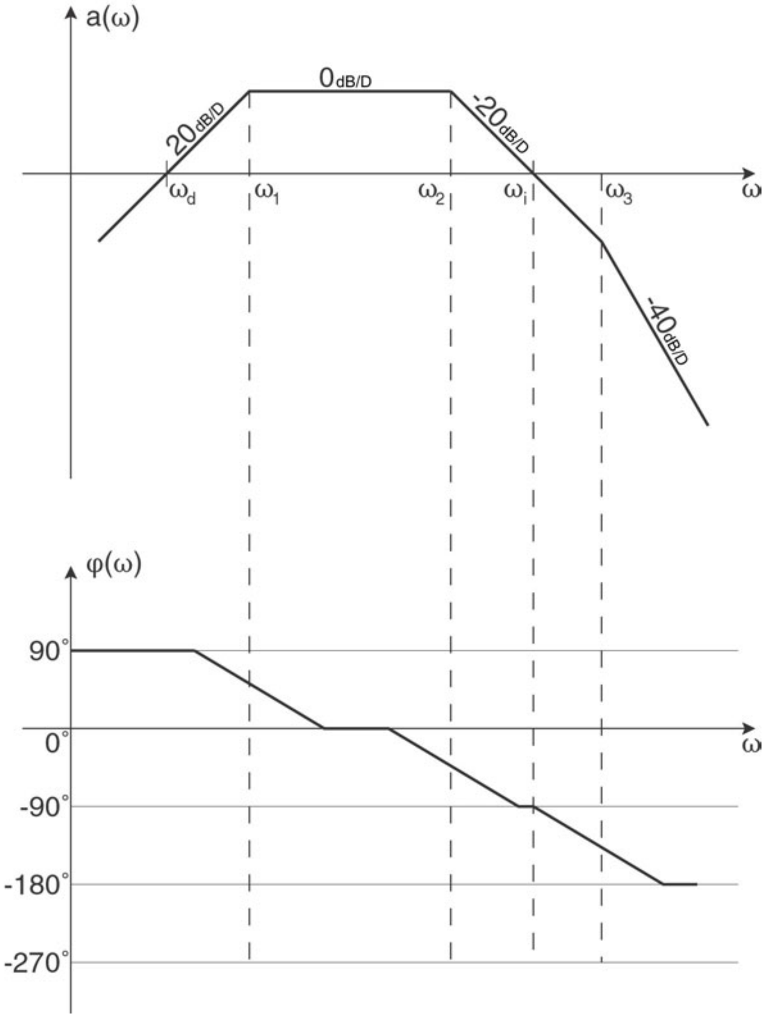
5.1.1. PI controller



5.1 figure. Block diagram of electric motor in case of terminal voltage entrance and in case of current exit.

On the basis of 5.1 figure we can state the terminal voltage-current transfer function of the servomotor.

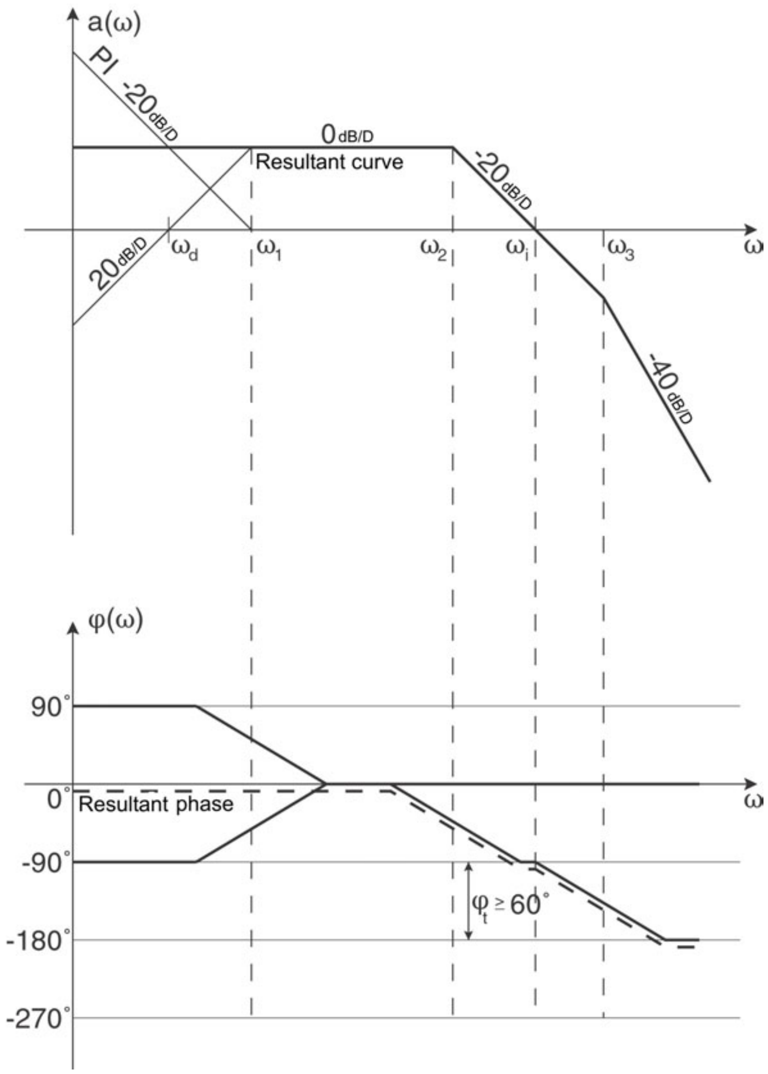
$$Y_{i,Uk}(s) = \frac{\Theta}{(c \cdot \Phi)^2} \cdot \frac{s}{1 + s \cdot T_m + s^2 \cdot T_m \cdot T_v}$$



5.2 figure Current transfer function of servomotors (Bode-diagram).

We can see that we have to change the transfer function 0 type to make the transfer stable in permanent state.

The most simple way to do that is using an ideal PI compensative element.



5.3 figure. Installation of PI compensative element into the transfer function (bode).

The installation of the integral element is said to be good if we can put the integral time constant onto the T_1 angular point. Then the derivative segment of the servomotor can be changed become into a proportional segment as a whole. If we choose a smaller integral time, i.e. ω_i circular frequency is bigger than the angular point frequency ω_1 . Then the integrator segment reaches as far as the motor's clearly proportional segment. Thus a –20dB/D rate of rise segment is created which causes a shift in the phase function. So in these cases for the appropriate stability, to have the needed phase we have to decrease the gain at the speed of the control loop's expense. If we choose a longer integral time, the ω_i circular frequency will be smaller than ω_1 angular point frequency and a break occurs in the transfer function all the time. A derivative type segment stays in the circle which makes the function of the control-loop quicker, but increases the uncertainty concerning the sudden control signals, and makes the stability smaller in permanent state. The system remains instable.

5.1.2. Examination of stability

We can examine the answer function for the unit offset of the drive system by drives and conductors with the help of oscilloscope. In ideal cases the answer function for unit offset control signals of the drive system would be suitable for the aperiodic limit case. For the fastening of the system we can allow an overshoot to a certain extent.

5.4.figure. Good case.

In figure 5.4. we can see an answer function to a good unit step signal. From the diagram we can determine the answer function is overshot but afterwards it gets the constant state without swinging. This is the most optimal state which meets the quality requirements the best.

5.5.figure. Slow case.

In figure 5.5. we can recognize that the system is adjusted into aperiodic case but reaches the permanent state slowly.

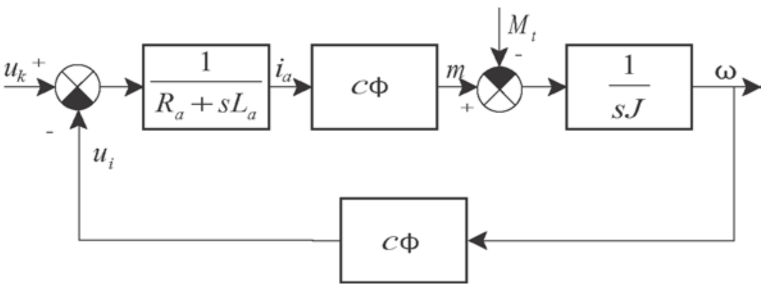
5.6.figure. Swinging case.

In figure 5.6. we can recognize that the adjustment is instable because the system in permanent state starts a periodic swing.

5.2. The adjustment of the speed controller

The Bode-diagram of a servomotor’s terminal voltage-angular speed transfer function is 0 type, in other words it is proportional type. In the interest of the angular speed, i.e. of the stability we install in a compensative element. This element can be PI or PID. PID compensation can be used because there is not any derivative element in transfer function of the motor, but it can only be used in digital control signal course. PID compensation can be use because in the resultant transfer function of the motor there is no differential element but in case of digital basic signal input it should not be used.

5.2.1. PI controller

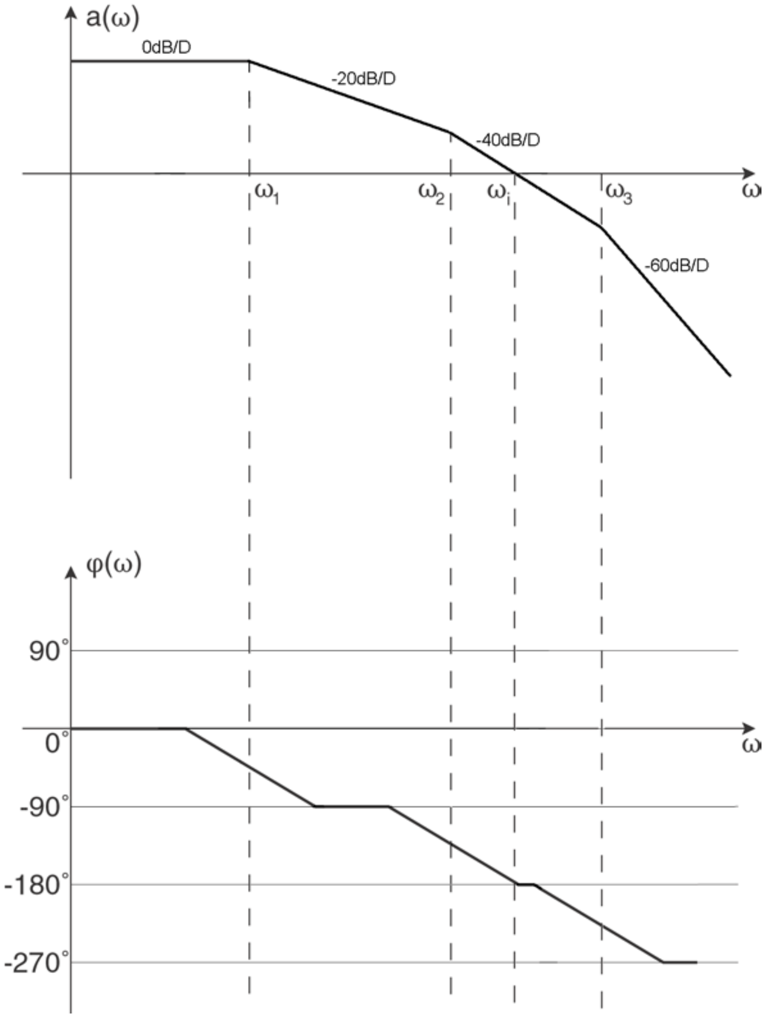


5.7. figure. Block diagram of a servomotor in case of terminal voltage entry and angular speed exit.

On the basis of the block diagram we can put down the transfer function of terminal voltage-angular speed.

$$Y_{\omega,Uk}(s) = \frac{1}{c \cdot \Phi} \cdot \frac{1}{1 + s \cdot T_m + s^2 \cdot T_m \cdot T_v}$$

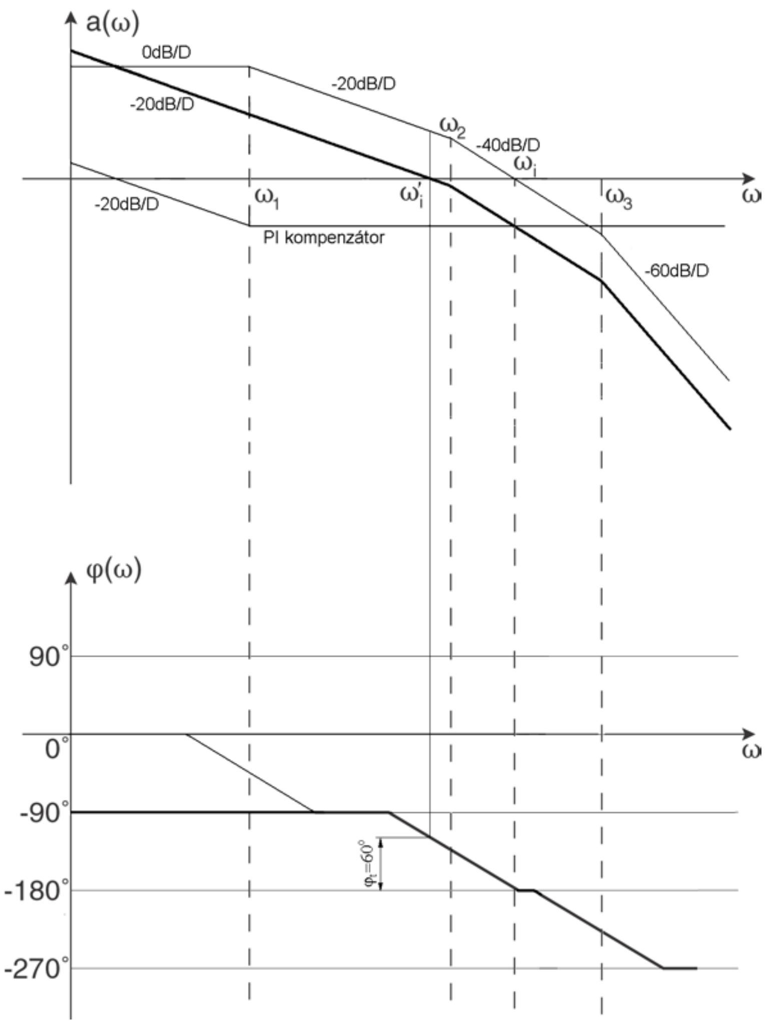
The Bode-diagram can be drawn on the basis of the transfer function, too.



5.8. figure. Speed transfer function of a servomotor (Bode-diagram)

A PI compensative element is installed in the control-loop, but it means that the transfer function is made 1 type.

We have to be careful not to change the reserved phase smaller than it is permitted for the sake of stability.



5.9.figure. Installation of PI compensative element

The integral time constant of the compensative element is also should be put on ω_1 angular point circular frequency. This gain should be adjusted in a way that on the basis of the phase function the reserved phase would be chosen for the smallest value which is allowed. In the point where the value of the reserved phase crosses the phase function the gain of the amplitude function should be 0dB. Then in permanent state the system won't oscillate.

5.2.2. PID controller

Now we install a PID compensative element. The speed up the controlling process of the system with the derivate element, i.e. the rate of rise of the response function for the unit offset function is bigger so it reaches permanent state quicker. The D element is only be used in case of digital control signal entry, as in case of analogue entry the noise would be strengthened. In permanent state the response function would show a rather instable state. As for the integral time constant it is the same procedure as in case of the PI compensation. The time constant of the derivative element is set on 1-1.5 decade higher circular frequency than circular frequency of integral.

5.2.3. Stability analysis

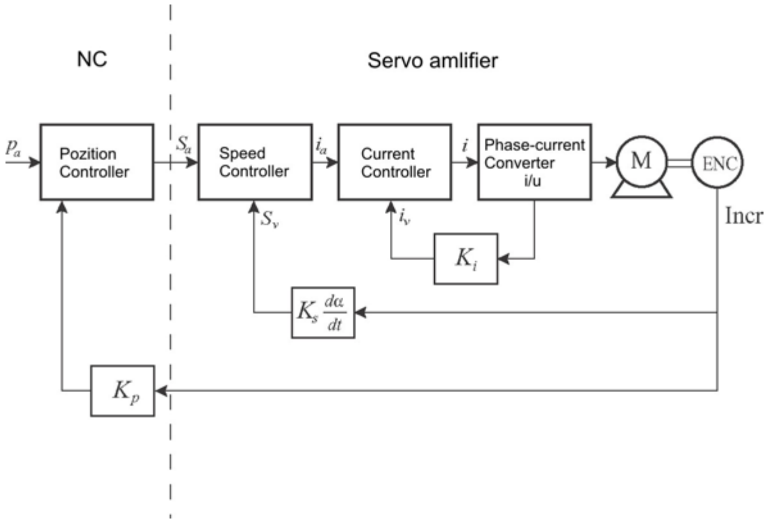
In a stability analysis the procedure is the same as in a current controller analysis, i.e. the stability is examined by oscilloscope. The signal of speed can be checked by the oscilloscope of drive and the conductor.

5.11.figure.

5.12.figure.

5.13.figure.

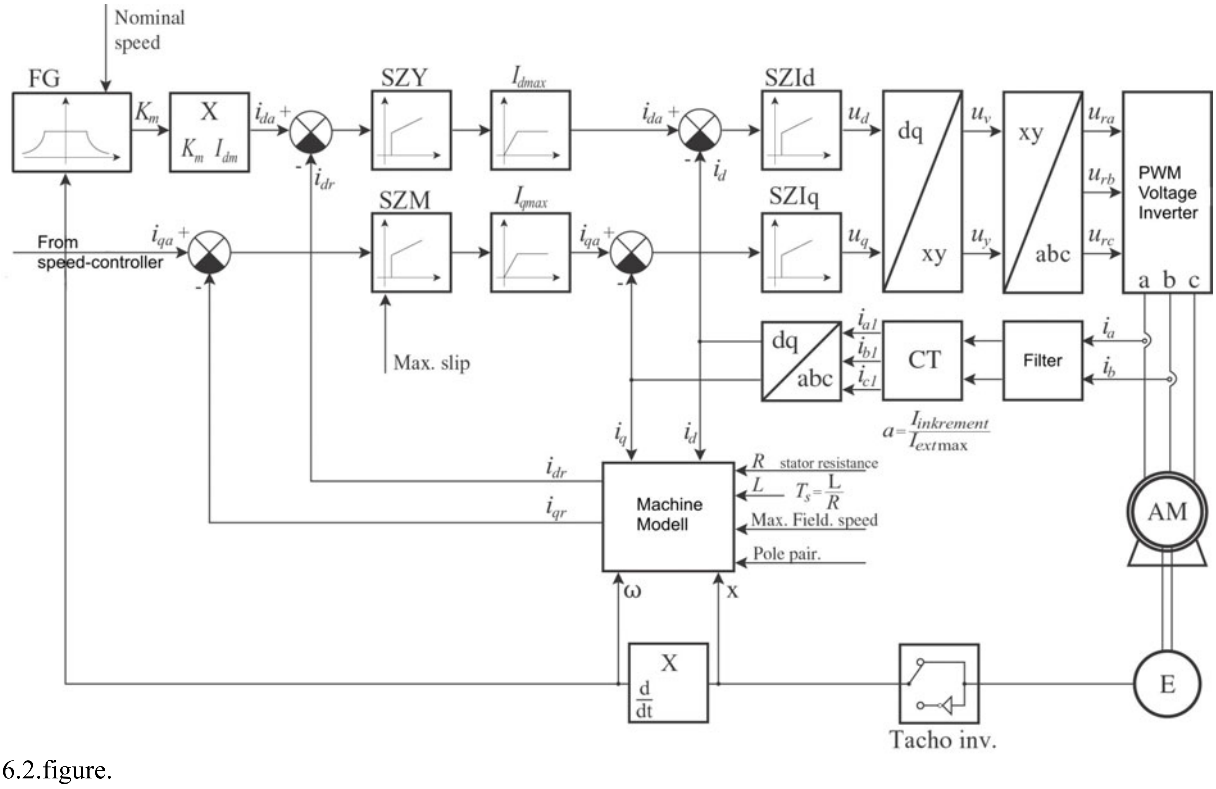
6. The NCT servo amplifiers control technique block diagram



6.1.figure.

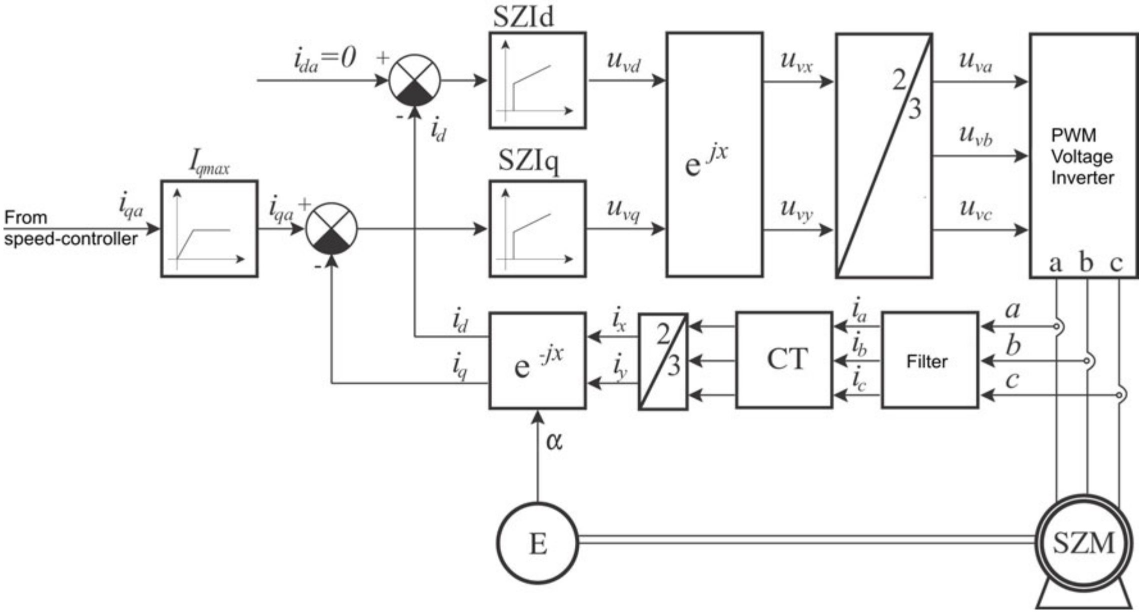
6.1. The control technique block diagram of current controller

6.1.1. Asynchronous servo drive



6.2.figure.

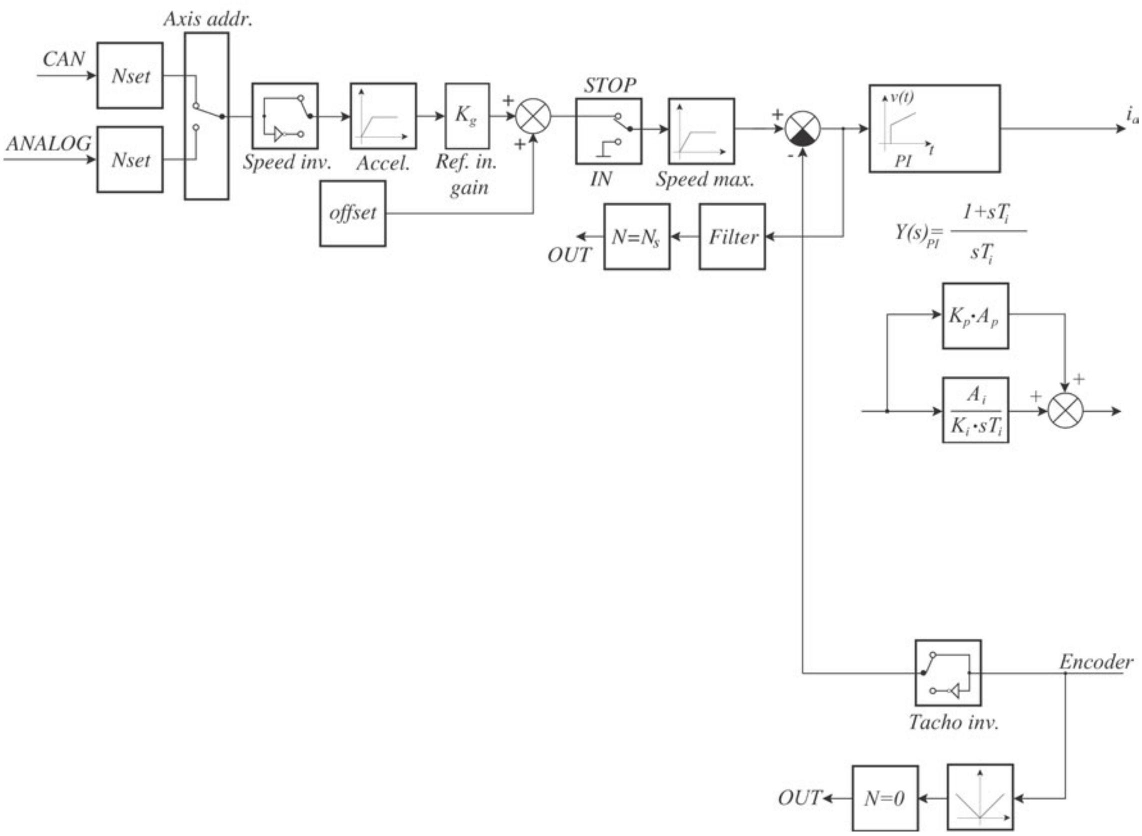
6.1.2. Sinusoidal field synchronous servo drive



6.3.figure.

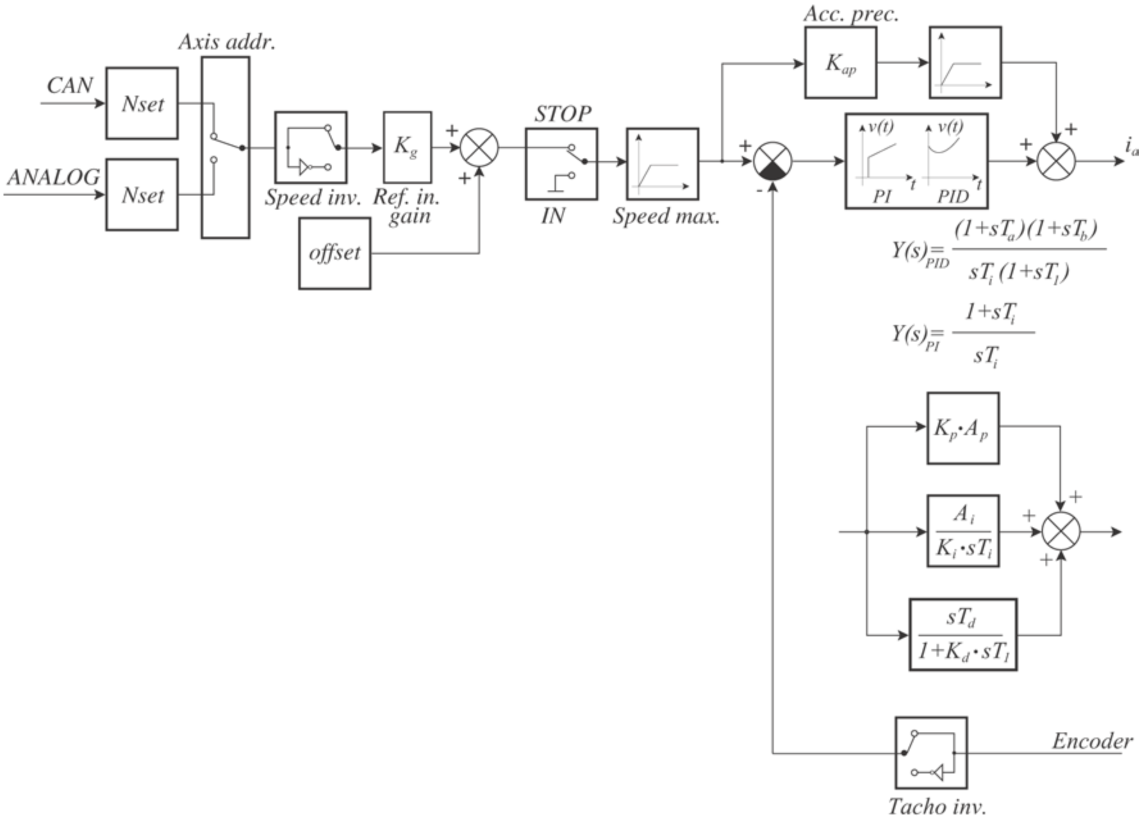
6.2. The control technique block diagram of speed controller

6.2.1. Asynchronous servo drive



6.4.figure.

6.2.2. Sinusoidal field synchronous servo drive



6.5.figure.

7. Adjustment of NCT servo drives

The manufacturer reports adjusting for certain drives and motors, these can be chosen from the parameter adjustment programme, and can be burnt into drive. In case of these parameter kits only the speed-controller has to be modified from time to time and the drive is ready for the appropriate operation of the motor. If we want to use another kind of motor by the drive we should act as it is written below.

We separated the parameters of the NCT servo drives into different groups. The groups are founded according to the parameter functions. The adjusting of drives always begins with the adjusting of the second parameter group which contains the parameters of the drive's inverter card. Usually these are adjusted by the manufacturer and after adjusting they are made protected. If the user changes these parameters, he can do it for his own responsibility, because the incorrect adjusting of these parameters would cause the defect of the servo drive.

Then it is worth continuing by the adjustment of the first parameter group. General parameters for the operation of the drive can be found here. Here we can adjust every parameter that are concerned with the drive, with the drive peripheral, with the motor an with the encoder of the motor.

After all this it is practical to carry on with the adjusting of the parameters of the motor (5^{th} group). In these parameters we must find the data which are on the name plate of the motor, and the maximum value counted from these. It is worth to adjust the parameters of the encoder at the same time (6^{th} group).

The parameters of the 2 control-loop should be adjusted last. It is worth starting with the parameters of the current controller (4^{th} group), then adjust the parameter of the speed-controller at last.

7.1. Adjustment of motor parameters

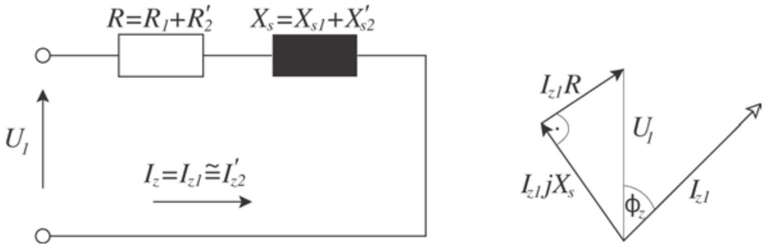
7.1.1. Adjustment of asynchronous motor parameters

For basis of the adjustment of motor parameters we get the nameplate of the motor. First we fill in the name plate data, then the data counted from these.

- The first one is the pair of poles number of the motor which is very important to be adjusted correctly otherwise the turning magnetic field in the motor won't be able to develop correctly. In these cases the servo amplifier gives bigger current to the motor as it would be usual and above a certain speed the motor suddenly speeds up and its speed can not be controlled. We can not find the pair of poles number on the name plate of the motor. So we have to determine this number according to the $p=60*f_1/n_n$ formula. We get an odd number for the value of the p, of which we should only consider the even part. This value should be given in the parameter.
- For the power factor and the nominal current of the motor we should write the data stated on the name plate.
- We can determine the resistance of the stator-coil by measuring results. We measure the resistance of the coils on the terminals of the motor with the help of an instrument, where the motor cable connects. We take the arithmetical average of the measuring results and write the sum in the table.
- We have to define the maximum field speed of the motor during the parameter adjustments. This value can be 4-5 times bigger than the nominal speed, in ideal case. It depends on the motor a lot, … we cannot allow too big field reduction because the motor is unable to provide torque any more, in certain cases it does not accelerates to the appropriate speed. The determined maximum value of the speed multiplied by $1/(1-s_{max})$

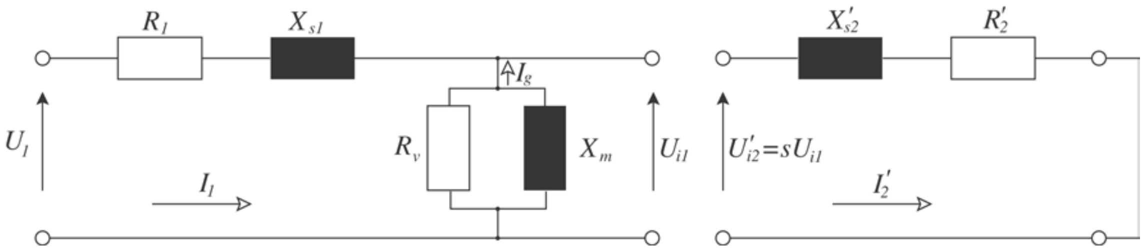
has to be written in the parameter table. s_{max} is the value of the slip connected to the maximum torque. If we decrease the maximum field speed more than the allowed maximum rotor speed then the speed of the motor becomes on controllable, and will accelerates till the maximum field speed and the servo amplifier will give an abnormally lot current to the motor.

- The coil time constant of the motor can be determined according to blocked rotor measuring results, if it is not stated among the catalogue data of the motor. In the parameter the value should be given in millisecond. During blocked rotor measures we can calculate from the terminal voltage and the blocked rotor current the Z_s serial impedance on the basis of the $Z_s=U_1/I_{z1}$ formula. Z_s serial impedance can be disintegrated into two parts. These two parts are the ohmic component pointing towards the current and the other component which is perpendicular to the latter one. Determining the phase angle between the voltage and the current we get the 2 components with the help of these 2 formulas $R_s=Z_s*cos\varphi_z$, $X_s=Z_s*sin\varphi_z$. After determining the 2 components using the $L_s=X_s/2\pi f_1$ formula we get the serial inductivity from the serial reactance. The electric time constant can be calculated according to the $T_s=L_s/R_s$ formula, and we get the sum in second. Multiplying this sum by 1000 we get the final parameter value in millisecond.



7.1.figure. Equivalent circuit diagram and vector diagram of asynchronous motors in case of blocked rotor.

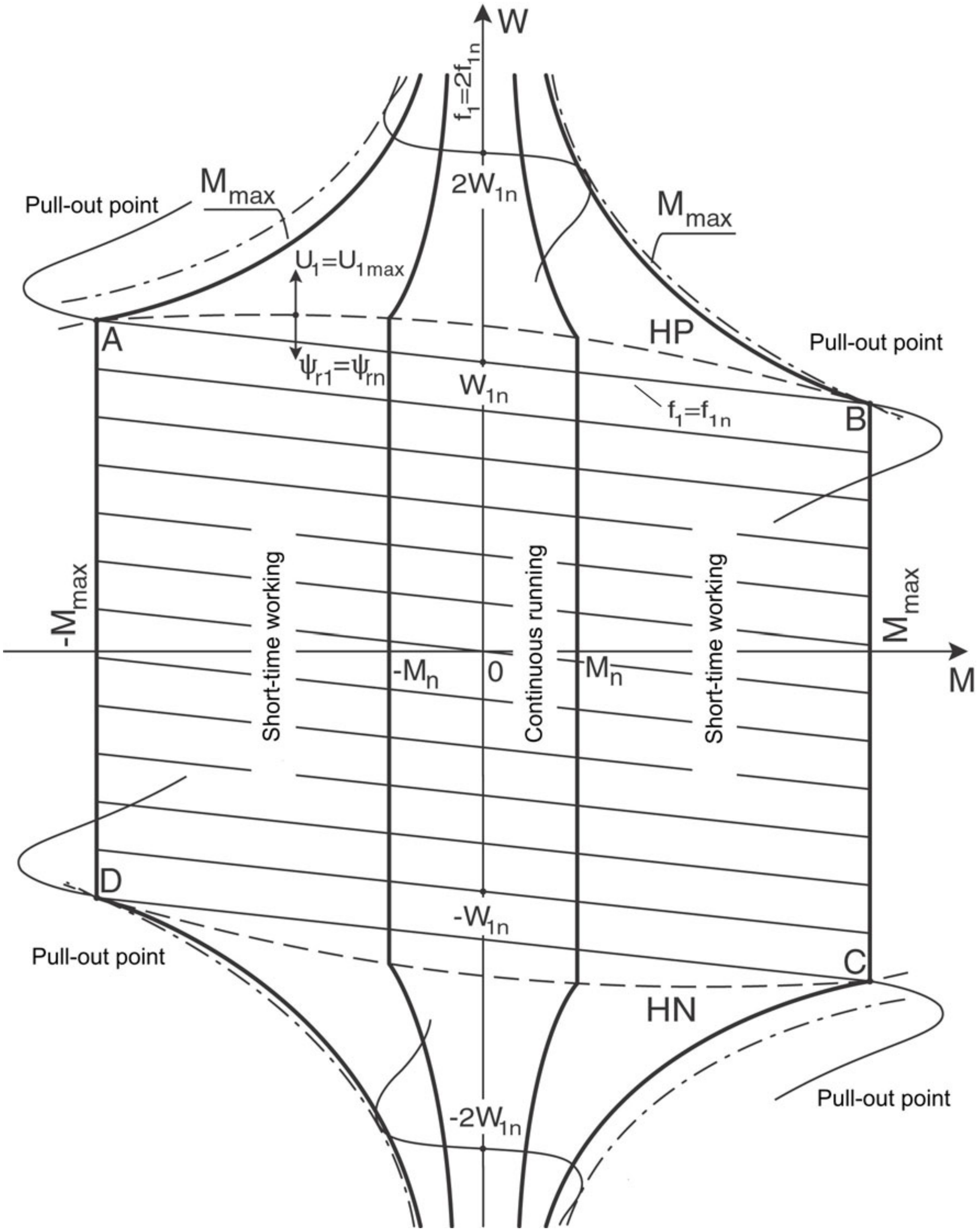
The electromotive force of the motor, i.e. its internal induced voltage is determined from the terminal voltage of the motor. We can do that in a way that we substract the voltages related to the serial impedance per phase of the stator-coil from the terminal voltage.



7.2.figure. Equivalent circuit diagram of asynchronous motors with the indication of induced voltage

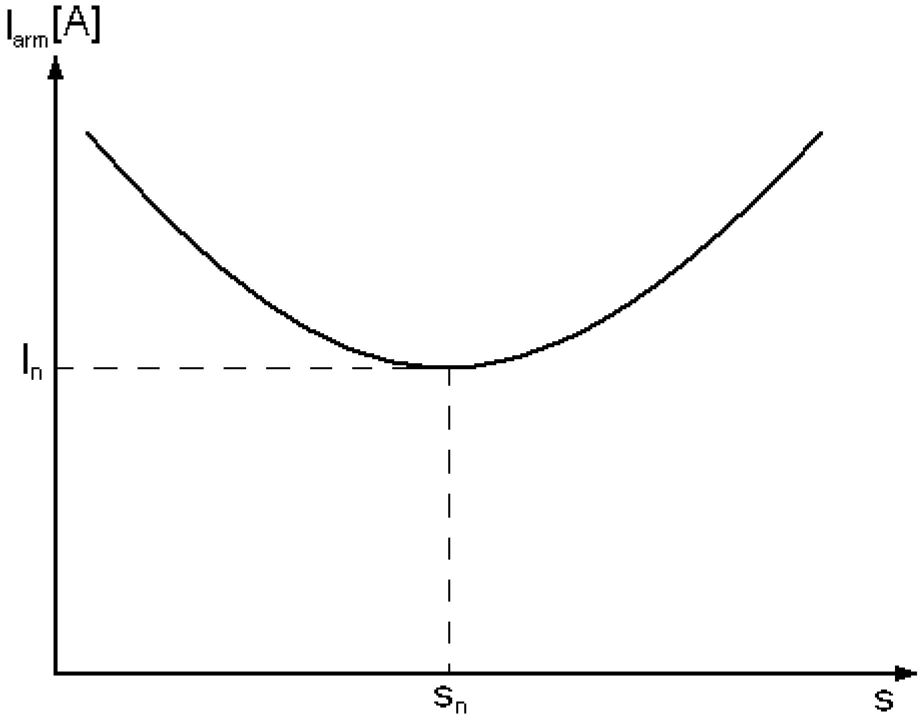
- The programme in the servo amplifier models the thermal time constant of the motor by a single capacity element. In the parameter that time should be given in seconds after which the servo amplifier stops the motor with an overheat message in case of 1.5 overload.
- The magnetizing current of the motor and its nominal speed are dominal parameters in field reduction state. During the parameter variation the nominal speed is stated on the name plate of the asynchronous machine and this can be regarded as base value. The magnetizing current of the motor is not a name plate data, but its value usually not more than the half of the nominal current of the motor. The magnetizing current is determined by the formula $I_m=0,36*I_n$, this sum is acceptable in practice, usually. If we make the magnetizing current too low, that is for the disadvantage of the motor. If we make the magnetizing current too high, the speed becomes swinging in field reduction state, if we get it even higher than this, at a certain

speed the motor won’t accelerate any more. If we make the magnetizing current too low it is for the disadvantage of the motor’ dynamics. We can see in 7.2.figure. that the motor in field reduction state loses intensively from its load capacity. Practically the motor can deliver its nominal torque only until nominal speed. If in field reduction state the speed of the motor becomes swinging then either value of nominal speed or values of the magnetizing current should be decreased.



7.3.figure. Torque-speed characteristic of asynchronous motor in case of different speed

- At the adjustment of the slip connecting to the maximum torque we always have to consider that the motor should be able to deliver the nominal torque till the nominal speed in a way that the current, picked up by the motor, won’t exceed too much the nominal current of the motor. The magnetizing current has a role in it of course. If the value of the slip and the magnetizing current is set properly then the above mentioned condition will apply. The value of the maximum slip can be determined from the nominal slip by using $s_{max}=s_n*I_{s1max}/I_n*1,3$ formula.



7.4.figure. Current-slip diagram

The diagram demonstrates that if an asynchronous motor is loaded with nominal torque then how the current picked up by the motor changes at the parameter value of the slip.

7.1.2. Adjustment of synchronous servo motor parameters

Synchronous servomotors' adjustment differs from that of the asynchronous servomotors that neither slip nor magnetizing current shouldn't be adjusted. These parameters do not exist in case of synchronous motors. The pair of poles number of the motor can be determined with the help of $p=60*f/n_n$ formula, where the even part of the received sum is the pair of poles number. The frequency of the sinusoidal current signal given out by the servo amplifier also can be determined by the formula $f=n_n*p/60$. The maximum speed of the field has to be the same as the allowed maximum speed of the rotor. The adjustment of the other motor parameters is the same as in the previous chapter.

7.2. Adjustment of encoder parameters

At present, we only use the encoder resolution from the parameters of the encoder. The number of impulses during circulation should be given in the parameter.

7.3. The adjustment of the current controller parameters

Among the parameters of the current controller the maximum d and q axis current should be given. The current vector in the direction of the d axis provides the excitation for the asynchronous motor, while the perpendicular q directional current is proportional to the delivered torque when the motor is loaded. The parameters determine the value of the maximum current basic-sign received on the input of the current controller. The value of the q directional current basic-sign is determined in practice by the formula $I_{s1qmax}=(1,4\ldots1,8)*I_n$ while the d directional component by the formula $I_{s1dmax}=(0.4\ldots0.5)*I_n$. Then comes the adjustment of the control-loop. The current controller is a controller of a classical PI type implemented in digital form. The P component is a multiplicator determines the strengthening of the controlling-loop, while I is the integral time its fundamental unit is the 1/8 of the millisecond. At the adjustment of the control-loop we should consider chapter 5.1.

7.4. Adjustment of the speed controller parameters

PI and PID components also can be used as speed controllers. PID components can only be used in case of digital basic signal input, because in case of analogue input the derivation will have incalculable consequences.

7.4.1. At asynchronous motor

We should start the adjustment of the speed controller with determining the maximum value of the basic signal input. This sum is has to be smaller than the maximum speed of field, its value can be calculated by the formula $n_{max}=(1-s)*n_{0max}$, where the n_{0max} is the maximum speed of the turning magnetic field in the motor. We should continue the adjustment with the acceleration parameter, which confides the ramp up/down value of the basic signal. Its value is given in increments, i.e. during a cycle how much can the value of the basic signal input change as a maximum. The offset parameter is only significant in case of analogue basic signal input, it does the offset compensation of the input. The adjustment of the gain of the basic signal is used for the co-ordination with the conductor. In this case the loop-gain of position controller can be adjusted with this parameter. The adjustment of the PI component of the speed controller should be done as it is written in the chapter 5.2.1.

7.4.2. At synchronous servo motor

The speed controller of the synchronous servo amplifier is different from the control circle of the asynchronous servo amplifier in a way that while there is a PI controller in the asynchronous amplifier, it is a PID in the synchronous servo amplifier. The value of the D differential component is a multiplicator factor, which multiplies the derivation of the error signal of the speed by the written sum, supposing permanent derivational time. The differential element has an effect only at digital basic signal input. At the adjustment of PID controllers we should do as it is told in chapter 5.2.2.

7.5. Adjustment of the other parameter

8. Parameters of asynchronous servo amplifiers

8.1. Regulator type

Determines the operation of the drive. Its value can be 0 (the drive gets a speed basic signal, and runs speed control), or 1(the drive gets a position basic signal, and runs the position control). This parameter can be used if the basic signal is not analogue i.e. Axis address parameter is not 0.

Parameter group = "1"

8.2. Axis address

In certain amplifier it is a parameter which serves to choose the source of the basic signal. If its value is 0 then the servo amplifier expects the basic signal from the analogue input. If it is positive whole number different from 0, then the drive expects the basic signal at the digital (CAN) input. The sum written in determines the logical address on the CAN-BUS.

Parameter group = "1"

8.3. Speed inverse

Sets the circulation direction connected to the basic signal.

Parameter group = "1"

8.4. Tacho inverse

Determines the sign of the feedback-loop in the speed controller, which can be a positive or negative feedback. The speed sign coming from the motor can either point to the direction of the speed of the motor or it can be in the opposition. This parameter is used for the compensation. In case of a closed speed control circuit the motor runs away at a positive feedback.

Parameter group = "1"

8.5. Rep. enc. error

The error check of the signal levels of the encoder (A, #A, B #B, C, #C). Its value determines the number of the error states sensed, after which the drive shows encoder error. Suggested adjustment value: 5. In case of 0 the error check is in switched off position.

Parameter group = "1"

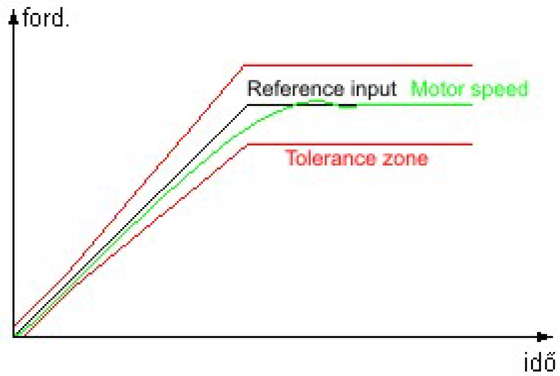
8.6. Servo ready type

A parameter control the availability signal of the servo amplifier. If its value is 0 and the drive does not sense any error after switching it on, then the availability signal is sent out. If the value of the parameter is 1 then the drive only gives out availability signal if it is allowed.

Parameter group = "1"

8.7. N=Ns

It …. The momentary motor speed to the momentary basic signal and checks that it is in the tolerance limit given in percentage in the parameter. A relay switch output is provided with the parameter. If the speed of the motor is within the tolerance limit, the relay output is in a closed state. If it is not within the tolerance limit, the relay output is in an open state. The parameter is used only in asynchronous drives, in case of synchronous drives its value is not significant.



Parameter group = "1"

8.8. N=0

It checks the 0 value of the momentary motor speed. A relay switch is ordered to the parameter. If the motor is not working then the relay output is closed. If the motor operates with a speed higher then given in the parameter then the relay switch is in an open state. The parameter is used only in asynchronous drives, in case of synchronous drives its value is not significant.

Parameter group = "1"

8.9. DC BUS minimum

If the power supply voltage of the servo amplifiers is smaller then the value given in the parameter, then the drive loses its operation. If the value of the parameter is 0 then the monitoring is in switched off state.

Parameter group = "1"

8.10. Unipolar/bipolar

The parameter is significant only in case of analogue signal. Its value gives how to interpret the analogue signal by the servo amplifier. If the parameter value is 0 the drive operates the motor in the direction of the sign of the signal. If its value is 1 the drive expects an analogue signal with positive sign. Then the circulation direction can be determined by one of the interface inputs (M3/M4) of the drive.

Parameter group = "1"

8.11. PTC resistance

The value of the parameter gives that resistance threshold which, if the resistance value of the thermal sensor in the motor reaches, then the drive stops with motor overheating error and loses its operation.

Parameter group = "1"

8.12. Thermo protection

This parameter determines the thermo protection method of the motor. If its value is 0, the drive takes no notice of the temperature of the motor. If its value is 1 the drive determines in order to an inner temperature model, whether the motor is in an overheated state or not. The temperature model starts operating if the current of the

motor is overweighed the adjusted nominal current. If the value of the parameter is 2 then the drive pays attention to the motor temperature with the help of an external temperature sensor (PTC) element. The sensitivity can be set in the PTC resistance parameter.
Parameter group = "1"

8.13. PWM frequency

The value of the parameter determines the pulse width modulation switching frequency which is provided by the output of the servo amplifier.
Parameter group = "2"

8.14. DC BUS voltage

The value of the parameter should be the same as the nominal voltage of the servo amplifier high current input.
Parameter group = "2"

8.15. I increment

This parameter and the I ext. max. parameter gives the ratio of the current transformer in the drive. The value of this parameter determines the sum which is connected to the parameter value in the I ext. max. parameter.
Parameter group = "2"

8.16. I ext. max.

The maximum current, until the current transformer is not saturated.
Parameter group = "2"

8.17. U increment

This parameter and the U ext. max. parameter gives the ratio of the voltage transformer in the drive. The value of this parameter determines what sum should connect to the voltage value stated in U ext. max. parameter.
Parameter group = "2"

8.18. U ext. max.

It is the maximum bus voltage that can be measured by the voltage transformer.
Parameter group = "2"

8.19. U BUS maximum

The parameter value gives that voltage maximum measured on the input (DC bus) above which the servo amplifier has the error-signal and the drive loses its operation and the allowed state of the drive is closed.
Parameter group = "2"

8.20. U BUS threshold

The value of the parameter determines the DC bus voltage above which the servo drive decreases the break-current so that the bus voltage won’t increase any more.
Parameter group = "2"

8.21. I peak

The value of the parameter determines the value of the maximum peak current delivered on the power output. If the servo amplifier measures bigger momentary value at its output then the value given in the parameter then it stops with error signal and at the same time it loses its operation. Its value should be made 10% smaller than the maximum current of the current transformer (I ext. max. parameter).

Parameter group = "2"

8.22. Speed integrator tm. const.

The value of the parameter determines the time constant of the speed-controller's integrator.

Parameter group = "parameters of the speed-controller"

8.23. Speed proportional gain

The value of the parameter determines the proportional element of the speed-controller.

Parameter group = "parameters of the speed-controller"

8.24. Ref. in. gain

The value of the parameter determines the gain of the input basic signal.

Parameter group = "parameters of the speed-controller"

8.25. Offset

In case of analogue signal offset compensation can be done with the parameter i.e. if the value of the signal is not 0 then with this parameter we can set what should be regarded as zero signal by the servo amplifier.

Parameter group = "parameters of the speed-controller"

8.26. Speed maximum

The value of the parameter determines the allowed maximum field speed of the motor.

Parameter group = "parameters of the speed-controller"

8.27. Accel

A parameter that confines the size of the basic signal change (limit of the ramp up/down ratio). The value of the parameter determines the maximum of the speed change by cycle in increments.

Parameter group = "parameters of the speed-controller"

8.28. Current proportional gain

The value of the parameter determines the proportional element of the current controller.

Parameter group = "parameters of the current controller"

8.29. Current integrator tm. const.

The value of the parameter determines the integral time constant of the current controller.

Parameter group = "parameters of the current controller"

8.30. I s1q max

The value of the current basic signal to the biggest torque of the motor.

$$I_{s1q\max} = \frac{M_{\max}}{k \times \Phi}$$

Its value in practice: Is1qmax = 1,4…1,8 * Motor nominal current

$$I_{peak} > \sqrt{2} \times \frac{3}{2} \times \sqrt{I_{s1q\max}{}^2 + I_{s1d\max}{}^2}$$

Parameter group = "parameters of the current controller"

8.31. I s1d max

The biggest value of the adjustable excitation current.

Its value in practice: Is1dmax = 0,6 * Motor nominal current

$$I_{peak} > \sqrt{2} \times \frac{3}{2} \times \sqrt{I_{s1q\max}{}^2 + I_{s1d\max}{}^2}$$

Parameter group = "parameters of the current controller"

8.32. S1 current

Not used at the moment.

Parameter group = "parameters of the current controller"

8.33. Motor pole pair

The pole pair number of the motor has to be given in the parameter, name plate data.

Parameter group = "motor parameters"

8.34. Nominal speed

The nominal speed of the motor should be given in the parameter, name plate data.

Parameter group = "motor parameters"

8.35. Max speed

In the parameter that value of speed should be given in cycle/min, with what the motor would turn in case of a maximal incoming signal. In case of analogue signal this value is connected to the 10V basic signal.

Parameter group = "motor parameters"

8.36. Motor thermo const.

The value of the parameter determines the time constant of the algorithm which models the thermal inertia of the motor.

Parameter group = "motor parameters"

8.37. Motor back EMF

It is the induced voltage of the motor at 1000 cycle/min speed applied to phase values.

Parameter group = "motor parameters"

8.38. Motor nominal current

The nominal current of the motor should be given in this parameter, name plate data.

Parameter group = "motor parameters"

8.39. Motor stator resistance

The resistance of the stator coil of the motor measured in ohm dimension. The value is based on measured sum or it is a catalogue data. The value measured in between the terminals of the motor should be written in.

Parameter group = "motor parameters"

8.40. Motor cos(fi)

The power factor of the motor should be given in the parameter, name plate data.

Parameter group = "motor parameters"

8.41. Motor Ts

The transient time constant of the motor winding.

$$T_s = \frac{L_s'}{R'}$$

Parameter group = "motor parameters"

8.42. Motor Tm

Not used at the moment.

Parameter group = "motor parameters"

8.43. Magnetizing current

The value of the parameter determines the magnetizing current of the asynchronous motor. In case of synchronous servo motors its value is 0. In an asynchronous motor its value is approximately 0,36 * Motor nominal current.

Parameter group = "motor parameters"

8.44. Max slip

The value of the slip connected to the maximum torque should be given.

A maximális szlip értéke : $s_{max} = \frac{n_0 - n_{Mmax}}{n_0}$

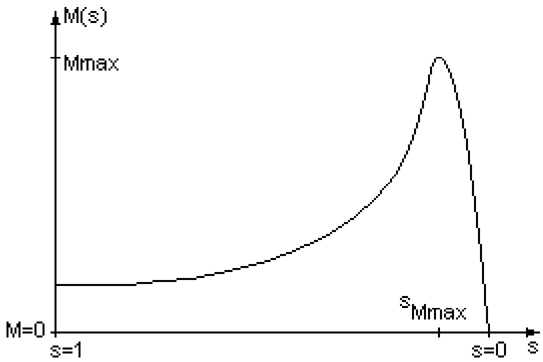
A szinkron fordulatszám : $n_0 = \frac{60 \times f}{p}$

p : a póluspárok száma

f : a motor névlegesfrekvenciája

n_{Mmax} : a motor maximális nyomatékához tartozó fordulatszám

Torque-slip diagram of a current generator feed asynchronous motor:



Parameter group = "motor parameters"

8.45. Encoder line count

Its value is the resolution of the encoder.

Parameter group = "parameters of the encoder"

8.46. Direction

Not used at the moment.

Parameter group = "parameters of the encoder"

9. Parameters of the sinusoidal field synchronous servo amplifiers

9.1. Regulator mode

Determines the operation of the drive. Its value can be 0 (the drive gets a speed basic signal and makes speed-control) or 1 (the drive gets position basic signal and makes position control). This parameter can be used if the basic signal is not analogue i.e. the Axis address parameter is not 0.

Parameter group = "1"

9.2. Axis address

In certain servo amplifiers it is a parameter which is to choose the source of the basic signal. If its value is 0, then the servo amplifier expects the basic signal from the analogue input. If its an integer number different from 0, then the drive expects the basic signal at the digital (CAN) input, and the value written in determines its logical address on the CAN-bus.

Parameter group = "1"

9.3. Speed inverse

Sets the direction of rotation connected to the basic signal.

Parameter group = "1"

9.4. Tacho inverse

Determines the sign of the feedback loop, which can be positive or negative feedback. The direction of the speed signal coming from the motor can be pointing towards the speed of the motor or opposite sign. This parameter is used to compensate this. In case of a closed speed control loop at positive feedback the motor overruns.

Parameter group = "1"

9.5. Rep. enc. error

The error monitoring of the signal levels of the encoder (A, #A, B #B, C, #C). Its value determines the number of sensed error states after which the drive should shown encoder error. Suggested setting value: 5. In case of 0 the error monitoring is in switched off state.

Parameter group = "1"

9.6. Rep. hall. error

The error check of the commutating signals of the encoder (S1, S2, S3). Its value determines the number of error states sensed in order after which the drive reports encoder error. Suggested adjustment value: 5. In case of 0 value the error monitoring is in switched off state. In case of asynchronous drive it is 0.

Parameter group = "1"

9.7. Servo ready mode

This parameter control the operation signal output of the servo amplifier. If its value is 0 and the drive does not sense any error after the switch on then the operation signal is sent out. If the value of the parameter is 1 then the drive would only give out operation signal if it is allowed.

Parameter group = "1"

9.8. Unipolar/bipolar

This parameter is only significant in case of analogue basic signal. Its value determines how the received analogue basic signal should be understood by the servo amplifier. If the value of the parameter is 0 the drive moves the motor in the direction of the sign of the basic signal. If its value is 1 the drive expects a positive sign analogue basic signal. The direction of the rotation is can be determined by one of the interface of the drive (M3/M4).

Parameter group = "1"

9.9. PTC resistance

The value of the parameter gives that resistance threshold of which value is reached by the value of the temperature sensor PTC resistance, then the drive stops with motor overheating error and loses its operation.

Parameter group = "1"

9.10. Thermo protection code

This parameter determines the thermo protection mode of the motor. If its value 0, the drive does not pay attention to the temperature of the motor. If its value is 1 the drive decides in accordance to an inner temperature model, whether the motor is in an overheated state or not. The temperature model comes to operation if the current of the motor overdone the adjusted nominal current. If the value of the parameter if 2 then the drive examines the actual temperature of the motor with the help of an external temperature sensor (PTC). The sensitivity can be adjusted in the PTC resistance parameter.

Parameter group = "1"

9.11. PWM frequency

The value of the parameter determines the pulse width modulation switching frequency which is provided by the output of the servo amplifier.

Parameter group = "2"

9.12. DC BUS voltage

The value of the parameter should be the same as the nominal voltage of the servo amplifier high current input.

Parameter group = "2"

9.13. I increment

This parameter and the I ext. max. parameter gives the ratio of the current transformer in the drive. The value of this parameter determines the sum which is connected to the parameter value in the I ext. max. parameter.

Parameter group = "2"

9.14. I ext. max.

The maximum current, until the current transformer is not saturated.

Parameter group = "2"

9.15. U increment

This parameter and the U ext. max. parameter gives the ratio of the voltage transformer in the drive. The value of this parameter determines what sum should connect to the voltage value stated in U ext. max. parameter.

Parameter group = "2"

9.16. U ext. max.

It is the maximum bus voltage that can be measured by the voltage transformer.

Parameter group = "2"

9.17. U BUS maximum

The parameter value gives that voltage maximum measured on the input (DC bus) above which the servo amplifier has the error-signal and the drive loses its operation and the allowed state of the drive is closed.

Parameter group = "2"

9.18. U BUS threshold

The value of the parameter determines the DC bus voltage above which the servo drive decreases the break-current so that the bus voltage won't increase any more.

Parameter group = "2"

9.19. I peak

The value of the parameter determines the value of the maximum peak current delivered on the power output. If the servo amplifier measures bigger momentary value at its output then the value given in the parameter then it stops with error signal and at the same time it loses its operation. Its value should be made 10% smaller than the maximum current of the current transformer (I ext. max. parameter).

Parameter group = "2"

9.20. Speed I gain

The value of the parameter determines the time constant of the speed-controller's integrator.

Parameter group = "parameters of the speed-controller"

9.21. Speed P gain

The value of the parameter determines the proportional element of the speed-controller.

Parameter group = "parameters of the speed-controller"

9.22. Speed D gain

The value of the parameter determines the differential element of the speed-controller. This element can only be used in case of digital basic signal input.

Parameter group = „ parameters of the speed-controller"

9.23. Ref. in. gain

The value of the parameter determines the gain of the input basic signal.

Parameter group = "parameters of the speed-controller"

9.24. Offset

In case of analogue signal offset compensation can be done with the parameter i.e. if the value of the signal is not 0 then with this parameter we can set what should be regarded as zero signal by the servo amplifier.

Parameter group = "parameters of the speed-controller"

9.25. Current proportional gain

The value of the parameter determines the proportional element of the current controller.

Parameter group = "parameters of the current controller"

9.26. Current integrator tm. const.

The value of the parameter determines the integral time constant of the current controller.

Parameter group = "parameters of the current controller"

9.27. I arm max

The value of the current basic signal to the biggest torque of the motor.

Parameter group = "parameters of the current controller"

9.28. Motor pole pair

The pole pair number of the motor has to be given in the parameter, name plate data.

Parameter group = "motor parameters"

9.29. Nominal speed

The nominal speed of the motor should be given in the parameter, name plate data.

Parameter group = "motor parameters"

9.30. Max speed

In the parameter that value of speed should be given in cycle/min, with what the motor would turn in case of a maximal incoming signal. In case of analogue signal this value is connected to the 10V basic signal.

Parameter group = "motor parameters"

9.31. Motor thermo const.

The value of the parameter determines the time constant of the algorithm which models the thermal inertia of the motor.

Parameter group = "motor parameters"

9.32. Motor back EMF

It is the induced voltage of the motor at 1000 cycle/min speed applied to phase values.

Parameter group = "motor parameters"

9.33. Motor nominal current

The nominal current of the motor should be given in this parameter, name plate data.

Parameter group = "motor parameters"

9.34. Motor stator resistance

The resistance of the stator coil of the motor measured in ohm dimension. The value is based on measured sum or it is a catalogue data. The value measured in between the terminals of the motor should be written in.

Parameter group = "motor parameters"

9.35. Motor Ts

$$T_s = \frac{L_s'}{R'}$$

The transient time constant of the motor winding.

Parameter group = "motor parameters"

9.36. Motor Tm

Not used at the moment.

Parameter group = "motor parameters"

9.37. Encoder line count

Its value is the resolution of the encoder.

Parameter group = "parameters of the encoder"

9.38. Direction

Not used at the moment.

Parameter group = "parameters of the encoder"

9.39. Max. speed [incr]

This parameter define the maximum speed of the servo motor in increment/cycle time.

$$Max.speed[incr] = \frac{Encoderlinecount * n_{max}[1/\min]}{PWMfreq\,[kHz]} * \frac{544}{60000}$$

Parameter group = "parameters of the encoder"