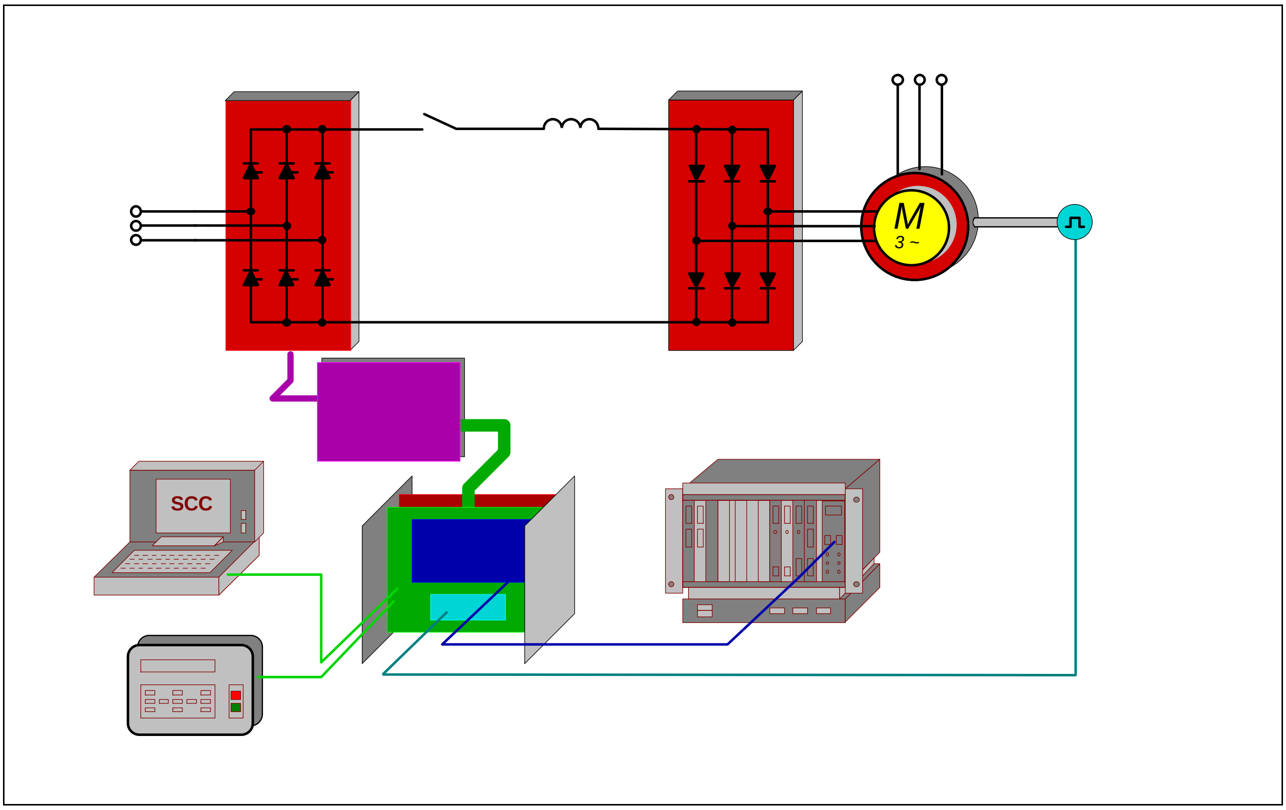


Subsynchronous Converter Cascade SCC

Technical Information

1. General

The advantages of an asynchronous AC motor compared with a DC motor, which cannot be denied, have created very early the desire to use the AC machine also for variable-speed drives.

Apart from speed adjustment through variable rotor resistors, cascade connections with secondary machines (Kraemer and Scherbius cascades) have been developed and used.

When introducing the converter equipment, these types of cascades were superseded by subsynchronous converter cascades (S.C.C.).

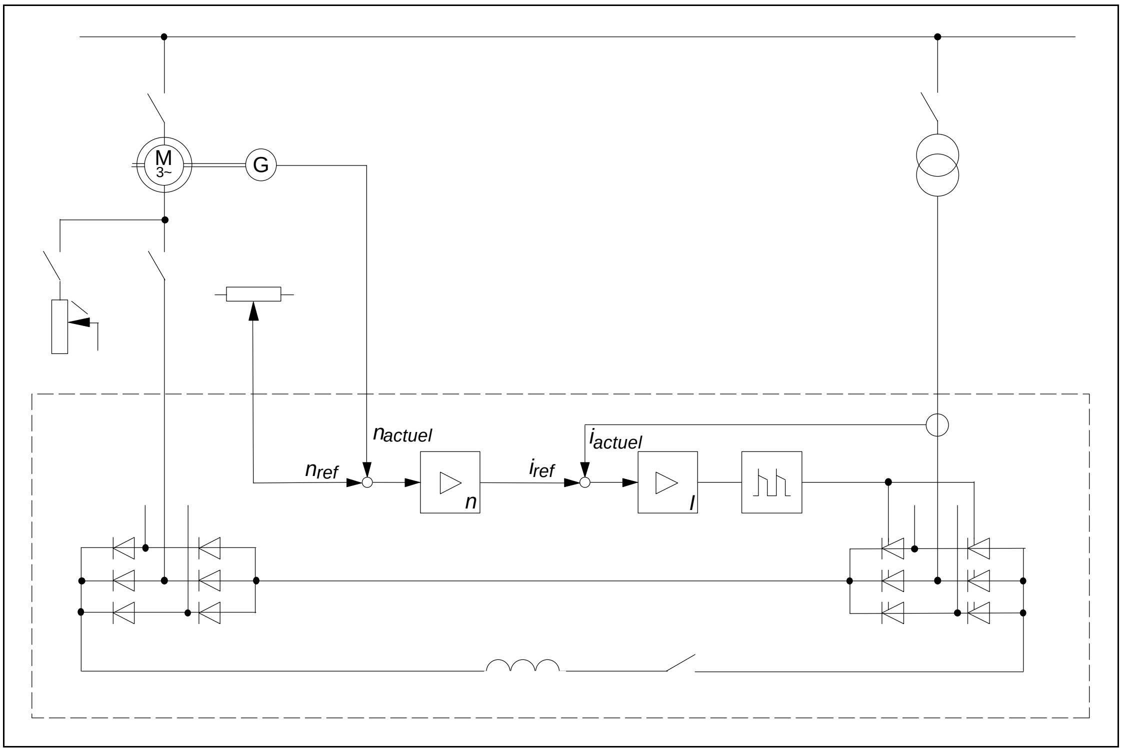
Cascade, that is the connection in series of an uncontrolled and a controlled converter in the rotor circuit of the asynchronous AC motor to feed the slip power back into the supplying system.

Basically, the S.C.C. can be used in all branches of industry, but is preferred to be used in those cases where the DC motor is unwanted because of the necessary maintenance of the commutator and where a limited speed setting range would be sufficient, which is true for drives of centrifugal compressors, blowers and rotating pumps.

The application of a S.C.C. as compared with speed adjustment through reactors will save energy by 50 % and more. Same applies also to speed adjustment using additional rotor resistors.

It is a particular advantage that slipring motor drives already existing in a plant can be modified with a subsynchronous converter cascade if the motor has a power reserve of 10 %:

Circuit Principle of S.C.C.



2. A drive system using a SCC offers its user the following advantages:

- Application of slipring asynchronous machines which are cheaper and more sturdy than DC machines
- Small size, low weight, little loss
- Requiring little maintenance only
- Converter rating lower than motor rating, thus making possible the application up to very high motor ratings.

The AC motor rating should be 500 kW minimum; only then, in principle, is the energy saving profitable with respect to the original price.

3. Applications

The S.C.C can be used for closed-loop drive control in all branches of industry, as far as a limited speed setting range (approx. between 0.5 ...0.95 times the nominal speed) is sufficient.

Which is true for drives of:
- *Centrifugal compressors,*
- *Blowers and*
- *Rotating pumps*

since in these cases the power output will reduce to 1/8 of its rated value at half the speed already.

Moreover, this type of closed-loop drive control can be used for drives of materials processing and handling equipment, as here the reduction of speed down to 50 % would be sufficient in most cases.

This equipment comprises, for example:
- *Cement raw mills, Tube mills*
- *Mixers*
- *Briquetting presses*
- *Worm extruders*
- *Conveyor belts,*

Digging elements of hauling equipment

4. Operation Principle

The S.C.C. is a variable-speed AC drive using an asynchronous AC slipring motor, the slip power of which is fed back to the system through rectifier and line-commutated inverter.

The slip power is produced by the rotor voltage falling in linear mode with increasing speed and by the rotor current which is directly proportional to the counter-torque.

In the current link, the voltage balance is determined by two inverse components, the transformed rotor voltage on the one hand, and, the inverter voltage of reversed sign on the other hand. The inverter voltage can be set to any value between zero and an admissible maximum value by means of phase control.

The rotor voltage must follow this value until the voltage balance in the current link will be established again.

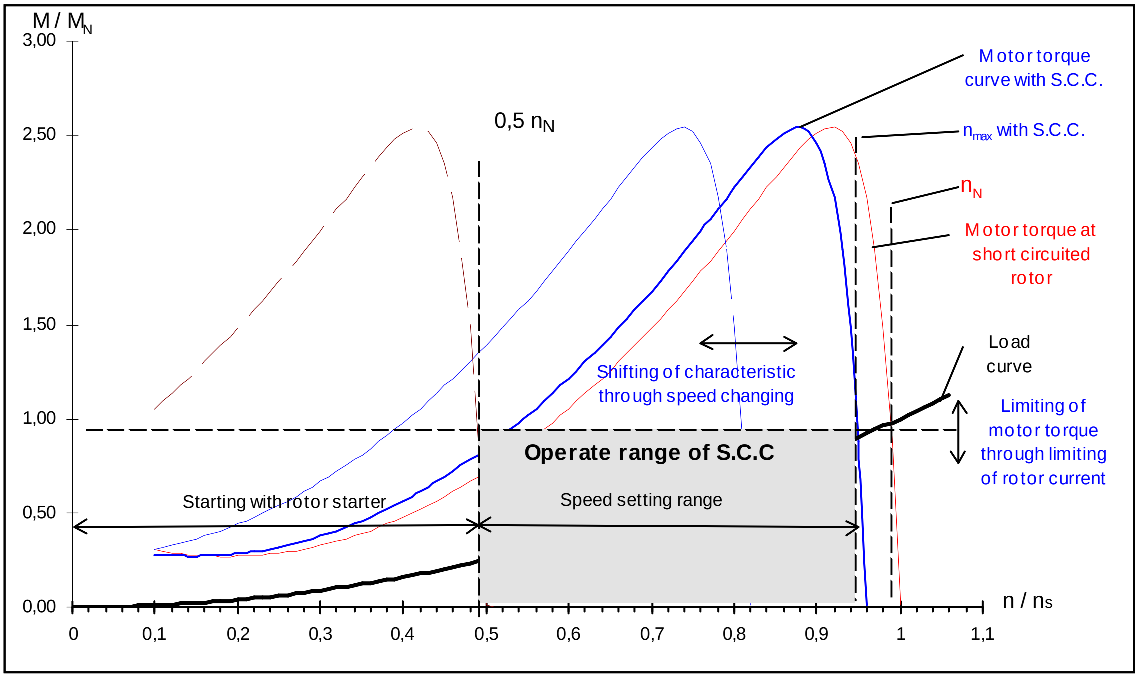
This process will be controlled with two superposed control loops.

The converter interferes into the rotor circuit as soon as the motor has started through the conventional resistor starter control.

With the S.C.C., the rotor current, hence the torque, will be limited to an adjustable value, thus providing electrical and mechanical overload protection. A load torque, the value of which is higher than the maximum value will reduce the speed down to the lowest limit of the setting range.

The speed-torque curves show shunt characteristics throughout the whole speed setting range.

Speed-Torque Curve of Subsysnchronous Converter Cascade



5. Application Conditions

The energy which can be recovered from the slip power by means of the S.C.C. using the inverter depends on the following conditions:

- Speed setting range
- Mechanical characteristics

of the driven machine.

The rating of the driving motor should be 500 kW minimum.

Only then, in principle, is the energy saving profitable with respect to the original price.

As the unit rating of the S.C.C. is proportional to the chosen speed setting range, drives should be preferred here, the speed of which in the setting range is higher than half the synchronous speed. The upper limit of the speed setting range should be around 0.9 times the synchronous speed to be able to recover energy at all when considering the losses in the S.C.C.

From the above conditions follows a profitable speed setting range of the subsynchronous converter cascade within the limits of

$$0{,}5\ n_{nom} \leq n \leq 0.95\ n_{nom}$$

6. Notes for Selection

Since the converter cascade must not be overloaded it shall be rated to suit the rotor voltage prevailing at minimum speed and the rotor current at maximum load torque.

The rotor standstill voltage has a considerable influence on the converter rating. Motors of low rotor voltages and/or the reduction of the required slip allow sometimes for the use of a low-priced frequency converter.

If the driving motor already exists the values of minimum speed and maximum torque possible can be calculated from the rating plate data according to the following equations:

Minimum speed

$$n_{min} = n_N \cdot \left(1 - \frac{U_{Lmax}}{U_{Lo}}\right) \cdot [rpm]$$

Maximum torque

$$M_{dmax} = M_{dN} \cdot \frac{I_{Lmax}}{I_{LN}} \cdot [Nm]$$

Whereby:

n_N	Nominal speed [rpm]
U_{Lo}	Rotor standstill voltage [V]
M_{dN}	Nominal motor torque [Nm]
I_{LN}	Nominal rotor current [A]
U_{Lmax}	Admissible maximum rotor voltage [V] *)
I_{Lmax}	Admissible maximum rotor current [A] *)

*) Values dependent on converter rating (e.g. 315 V at U_N = 400 V)

7. Technical Data

The subsynchronous converter cascade can be subdivided into 2 sections:

- Information section comprising the units for closed-loop and common control of the S.C.C., being delivered in standard design for any energy recovering set;

and

- Power section comprising the units for recovery of rotor energy.

Degree of protection:	IP20
Temperature range:	0 to + 40 °C
Place of installation:	electrical operating area
Type of installation:	isolated

Drive Engineering

Subsynchronous Converter Cascade for Speed Control of Slipring Motors

Notes for Ordering

If you have any question, fill in the questionnaire please and send it back to us. The information given will enable us to consider your requests in the best way possible and to give you expert advice in selecting an economically efficient plant.

1.	**Data of driven machine**		
1.1	Load curve M = f(n)		
1.2	Load profile M = f(t)		
1.3	Nominal torque	M_N	= .... Nm
1.4	Maximum torque occuring	Mmax	= .... Nm
1.5	Speed setting range	from to	.... rpm .... rpm
2.	**Motor data**		
2.1	Rating	P_N	= .... kW
2.2	Nominal speed	n_N	= .... rpm
2.3	Stator voltage and frequency	U_S f_S	= .... V = ... Hz
2.4	Nominal stator current	I_{Sn}	= .... A
2.5	Rotor standstill voltage	U_{Lo}	= V
2.6	Nominal rotor current	I_{Ln}	= .... A
2.7	Power factor in rated operation	$\cos\varphi_N$	= ....
2.8	Efficiency in rated operation	η	= ....
2.9	Magnetizing current or idle current and power factor	$I\mu$ I_o $\cos\varphi_o$	= .... A = ... A = ... A
3.	**Data about the system into which the energy is fed back**		
3.1	Voltage and frequency	U_N f_N	= .... V = ... Hz
3.2	Voltage fluctuations	ΔU	= .... %
3.3	Short-circuit power	S_k''	= .... MVA

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