SINAMICS DCM

DC converters from 6 kW to 2500 kW for variable-speed direct-current drives

Master-slave switchover application

Edition 01 - 03/2011

SINAMICS drives

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SINAMICS DCM
Master-slave switchover application

Compact User Manual

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

NOTICE
indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation for the specific task, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be adhered to. The information in the relevant documentation must be observed.

C98130-A7066-A503-01-7619, 03/2011

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1 Instructions

Note

This application document does not claim to contain all details and versions of units, or to take into account all conceivable operational cases and applications.

The standard applications do not represent specific customer solutions, but are only intended to provide support in the implementation of typical applications. The operator is responsible for the correct operation of the products described.

Should you require further information or encounter specific problems which have not been handled in enough detail, please contact your local Siemens office.

The contents of this application document are not part of an earlier or existing contract, agreement or legal relationship, nor do they change such contracts, agreements or legal relationships. The contract of sale in each case outlines all the obligations of the I DT Drive Technologies Division of Siemens AG. The warranty conditions specified in the contract between the parties are the only warranty conditions accepted by the I DT Drive Technologies Division. Any statements contained herein neither create new warranties nor modify the existing warranty.

⚠ WARNING

The units listed here contain dangerous electric voltages, dangerous rotating machine parts (fans) and control rotating mechanical parts (drives). Failure to follow the relevant Operating Instructions may result in death, serious injury or extensive material damage.

Technical Support

You can also find help for technical issues through our Technical Support:
www.siemens.de/automation/support-request (German)
www.siemens.com/automation/support-request (English)

2 Applications

This document deals with the interaction between two or more SINAMICS DCM - units for various technological requirements.

Closed-loop current control

- For two or more coupled machines that are operated in the armature control range
- Also when switching over between master and slave drives

Torque control

- For two or more coupled machines, which are also operated in the field weakening range.
- Also when switching over between master and slave drives

Droop

- For two or more **uncoupled** machines, connected to the same load, with the same master setpoint

CAUTION

- The following information always refers to the application "Torque control", since here, the application "Current control" is included and torque control is also possible without field weakening.
  The "current control" application differs only in that the field control range of the motor (field weakening) is not utilized and the motor torque is proportional to the armature current of the complete speed range. The required parameter changes (p50169, p50170) can be found in the List Manual.
- Align the master and slaves so that they always operate at the same speeds!
- Using external interlocks it must be ensured that a controller enable of the slaves is always realized together with the associated master drive; this means that only after all of the line contactors have pulled in, that their auxiliary contacts connected in series energize terminal X177.13 of the master drive.

3 Master-slave drives for rigidly coupled motors

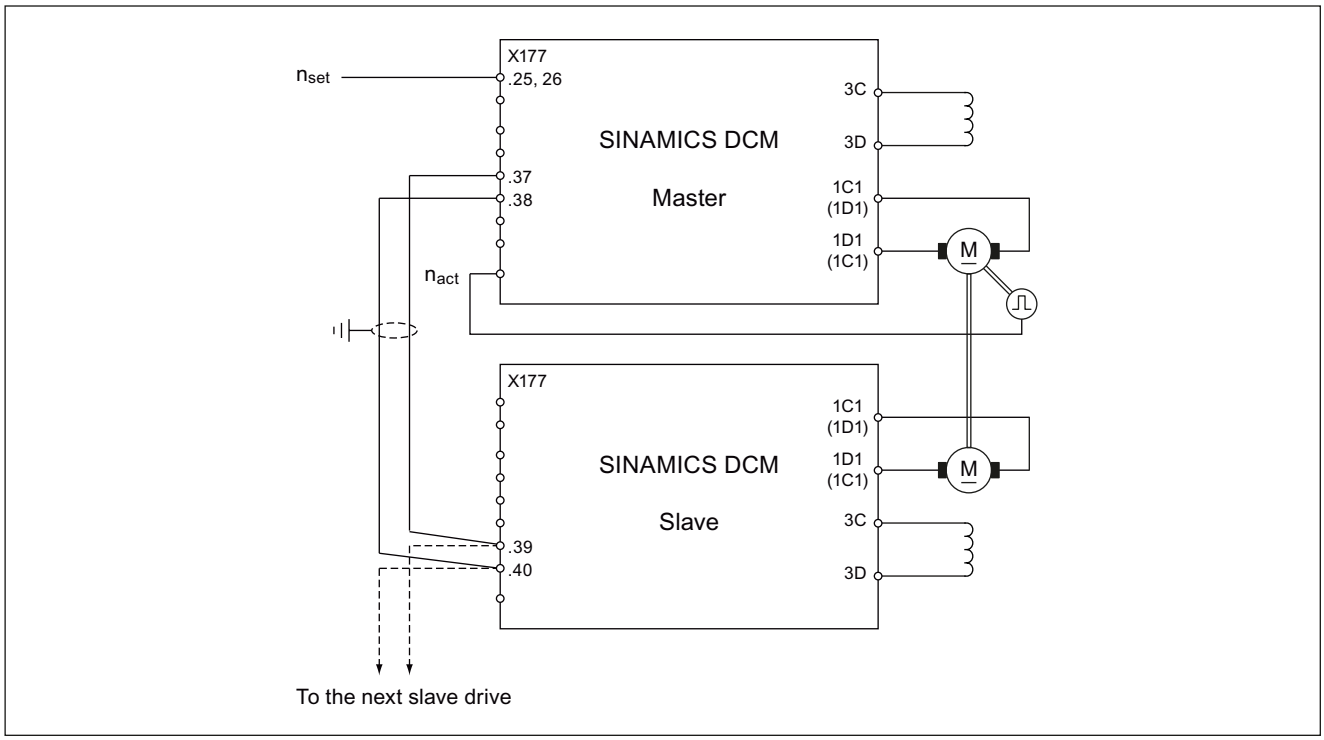
3.1 Application

- In the case of two or several coupled motors, the master drive is operated closed-loop speed controlled
- The slave drives operate with closed-loop current control (or closed-loop torque control) and receive their current setpoint (or torque setpoint), speed actual value as well as control word 1 from the master drive via the peer-to-peer connection
- For example, a gearbox with two or more inputs

3.2 Recommended circuit

We only recommend the circuit shown in the following for rigidly coupled motors. The assignment of the connections not shown, power supply, protection (fusing), etc. depend on the particular units and should be taken from the operating instructions.

The master is operated in the closed-loop speed-controlled mode and generates a torque setpoint, which supplies its own current controller as well as that of the slaves. The slaves are switched-on via control word 1 of the master. The speed actual value is routed via the peer-to-peer connection to all units in order to also allow a field characteristic to be plotted for the slaves. Ramp-function generator and speed controller of the slaves are not active. When braking, all of the drives are ramped-down using the down ramp of the master as well as common shutdown at $n < n_{min}$.



3.3 Parameter settings

The converters are commissioned corresponding to the associated operating instructions up to but not including the optimization runs (rated data, current limits, etc.)

The following additional parameters must then be set:

Master drive		**Slave drives 1...n**	
p50081=1	Field weakening possible	p50081=1	Field weakening possible
p50083=2	Operation with incremental encoder	p50083=4	Freely wired actual value
p50169=0	Torque control	p50169=0	Torque control
p50170=1	Torque control	p50170=1	Torque control
		p50503=xx	Adaptation of the torque setpoint for different motor-unit assignments $xx = \frac{I_{MOTFA} \times I_{GERLA}}{I_{MOTLA} \times I_{GERFA}} [\%]$ I_{MOTFA}= motor current, slave drive I_{MOTLA}= motor current, master drive I_{GERFA}= unit current, slave drive I_{GERLA}= unit current, master drive
		p50500=52602	Torque setpoint from the Master
		p50609=52603	Speed actual value from the master
		p00840=52606.0	On/Off1 via word 1.0 peer-to-peer
		p00852=52606.03	Enable operation using word 1.03 peer-to-peer
		p50687=1	Switchover to slave drive
p50790=5	Peer-to-peer	p50790=5	Peer-to-peer
p50791=3	Number of words transferred	p50791=3	Number of words transferred
p50793=8	Baud rate	p50793=8	Baud rate
p50794[0]=00898	Control word 1		
p50794[1]=52148	Torque setpoint		
p50794[2]=52167	Speed actual value		
		p50795=1	Bus terminating resistor peer-to-peer ON at the last slave
p50797=2 s	Telegram failure time	p50797=2 s	Telegram failure time

3.4 Optimization runs

Individually perform the optimization runs.

<1> master drive

- Open the coupling between the gear unit and load.
- Set **p50171, p50172** (current limits) at the **slave drive** to zero. This means that only the master drive is active.
- Perform the optimization run for the precontrol and current controller at the **master drive**
- Perform the optimization run for the speed controller (without load!) at the **master drive**. This is done to create stable speed relationships when plotting the field characteristic.
- Perform the optimization run for field weakening at the **master drive**.
- Set **p50171, p50172** at the **slave drive** back to the original values.

<2> slave drive

- Set **p50171, p50172** (current limits) at the **master drive** to zero. This means that only the slave drive is active.
- Perform the optimization run for the precontrol and current controller at the **slave drive**
- Perform the optimization run for field weakening at the **slave drive**. This is possible as the torque setpoint is received from the already optimized speed controller of the master drive.
- Set **p50171, p50172** at the **master drive** back to the original values.

<3> master drive + slave drive

- Re-couple the load.
- Perform the optimization run for the speed controller with a coupled load.

4 Master-slave switchover

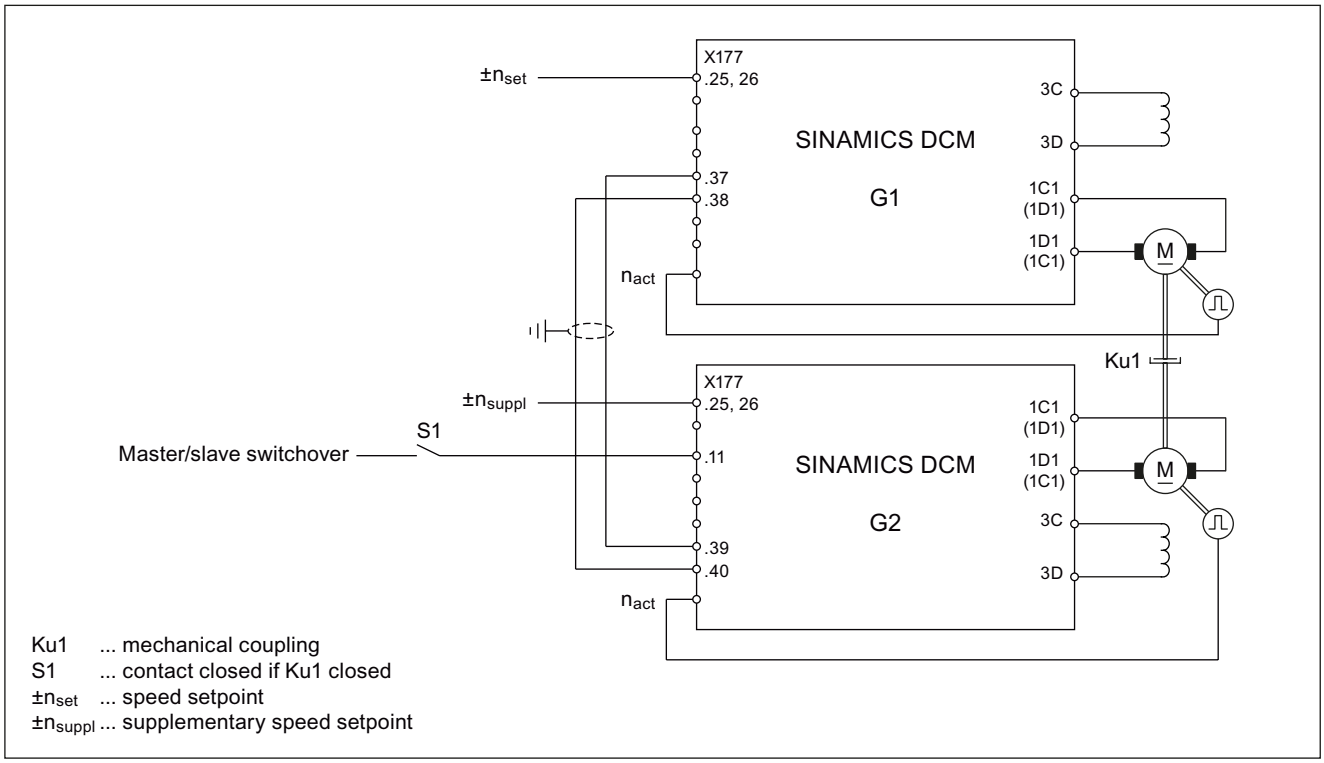
4.1 Application

- For speed-controlled master drive with slave drive, which can be optionally operated as master drive.
- For example, printing machines

4.2 Recommended circuit

The hardware circuit is the same for both of the following versions, the only difference is in the parameterization.

The assignment of the connections not shown, power supply, protection (fusing), etc. depend on the particular units and should be taken from the operating instructions.



4.3 Version 1

4.3.1 Operating mode of the master-slave drive

Coupling Ku1 is closed.

G1 is the Master and is operated in the closed-loop speed-controlled mode. The speed setpoint $\pm n_{set}$ is connected to G1 at terminal X177.25 /26. G2 is the slave, is operated in the closed-loop current controlled mode and receives a current or torque setpoint from G1.

In this operating mode it is absolutely essential to ensure that Ku1 is closed, as otherwise, drive G2 can accelerate uncontrollably as there is no closed-loop speed control and the load torque < motor torque.

4.3.2 Separate operation

Coupling Ku1 is open.

G1 and G2 are separately operated using their own speed controller. They are switched on together. They accelerate via the ramp-function generator of G1. The speed setpoint $\pm n_{set}$ is connected at G1 to terminal X177.25 /26, and is transferred via the peer-to-peer connection to G2. When required, the speed at G2 can be influenced via $\pm n_{suppl}$ (at X177.25/26).

4.3.3 Parameter settings

The converters are commissioned corresponding to the associated operating instructions up to but not including the optimization runs (rated data, current limits, etc.)

The following additional parameters must then be set:

G1		G2	
p50081=1	Field weakening possible	p50081=1	Field weakening possible
p50083=2	Operation with incremental encoder	p50083=2	Operation with incremental encoder
p50169=0	Torque control	p50169=0	Torque control
p50170=1	Torque control	p50170=1	Torque control
		p50503=xx	Adaptation of the torque setpoint for different motor-unit assignments $xx = \frac{I_{MOTFA} \times I_{GERLA}}{I_{MOTLA} \times I_{GERFA}} [\%]$ I_{MOTFA}= motor current, slave drive I_{MOTLA}= motor current, master drive I_{GERFA}= unit current, slave drive I_{GERLA}= unit current, master drive
		p50500=52602	Torque setpoint from G1
		p50634[0]=52603	Speed setpoint from G1
		p50634[1]=52011	Supplementary speed setpoint
		p00840=52606.0	On/Off 1 from the master
		p00852=52606.03	Enable operation from the master
		p50687=53010.00	Switchover to slave drive terminal 11
p50790=5	Peer-to-peer	p50790=5	Peer-to-peer
p50791=3	Number of words transferred	p50791=3	Number of words transferred
p50793=8	Baud rate	p50793=8	Baud rate
p50794[0]=00898	Control word 1		
p50794[1]=52148	Torque setpoint		
p50794[2]=52170	Speed actual value		
		p50795=1	Bus terminating resistor peer-to-peer ON
p50797=2 s	Telegram failure time	p50797=2 s	Telegram failure time

4.3.4 Optimization runs

With the coupling open, the two drives can be optimized independently of one another according to the operating instructions.

4.4 Version 2

NOTICE
It must be noted that due to the selected structure of the closed-loop control, operation in only one direction of rotation (with a positive setpoint) is possible. If operation with two directions of rotation is required, then Version 1 (Page 7) must be selected.

4.4.1 Operating mode of the master-slave drive

Coupling Ku1 is closed.

The speed setpoint $\pm n_{set}$ is connected at G1 to terminal X177.25 /26, and is transferred via the peer-to-peer connection to G2. G1 and G2 are operated closed-loop speed-controlled. However, the speed controller of G2 is overcontrolled with a fixed value (e.g. 5 %), and therefore tends towards the direction of the positive torque limit. By additionally entering the torque setpoint from G1 as torque limit for the slave drive, this limit can be shifted as required between $+M_{max}$ and $-M_{max}$, therefore setting the torque the same as the torque from G1.

If, in this operating mode, Ku1 is mistakenly open, then the speed of G2 only increases by the overcontrol value, as then the speed controller intervenes.

The intervention of $\pm n_{suppl}$ is suppressed.

4.4.2 Separate operation

Coupling Ku1 is open.

The speed setpoint $\pm n_{set}$ is connected at G1 to terminal X177.25 /26, and is transferred via the peer-to-peer connection to G2. G1 and G2 are separately operated using their own speed controller. They are switched on together. They accelerate via the ramp-function generator of G1. When required, the speed at G2 can be influenced via $\pm n_{suppl}$ (at X177.25/26).

4.4.3 Parameter settings

The converters are commissioned corresponding to the associated operating instructions up to but not including the optimization runs (rated data, current limits, etc.)

The following additional parameters must then be set:

G1		G2	
p50081=1	Field weakening possible	p50081=1	Field weakening possible
p50083=2	Operation with incremental encoder	p50083=2	Operation with incremental encoder
p50169=0	Torque control	p50169=0	Torque control
p50170=1	Torque control	p50170=1	Torque control
		p50171=xx	Adaptation of the torque setpoint for different motor-unit assignments $xx = \frac{I_{GERLA}}{I_{MOTLA}} [\%]$ I_{GERLA}= unit current, master drive I_{MOTLA}= motor current, master drive
		p50430[0]=53010.00	Input of the torque setpoint from G1 with terminal 11
		p50430[1]= 53010.01	Input of a fixed setpoint for n closed-loop control
		p50431[0] = 52602	Torque setpoint from G1
		p50431[1] = 52002	Torque enable for n closed-loop control
		p50605[0]=52204	Torque limit
		p50621=52015	Overcontrol, speed controller

G1		G2	
		p50634[0]=52603	Speed setpoint from G1
		p50634[1]=52011	Supplementary speed setpoint
		p00840=52606.0	On/Off 1 from the master
		P00852=52606.03	Enable operation from the master
		p50706=53010.01	Enable supplementary speed setpoint
		p50712=+5 %	Overcontrol setpoint for n-controller
		p50716=53010.01	Input, overcontrol setpoint
p50790=5	Peer-to-peer	p50790=5	Peer-to-peer
p50791=3	Number of words transferred	p50791=3	Number of words transferred
p50793=8	Baud rate	p50793=8	Baud rate
p50794[0]01= 00898	Control word 1		
p50794[1]02= 52148	Torque setpoint		
p50794[2]=52170	Speed actual value		
		p50795=1	Bus terminating resistor peer-to-peer ON
p50797=2 s	Telegram failure time	p50797=2 s	Telegram failure time

4.4.4 Optimization runs

With the coupling open, the two drives can be optimized independently of one another according to the operating instructions.

5 Master-slave switchover for several drives

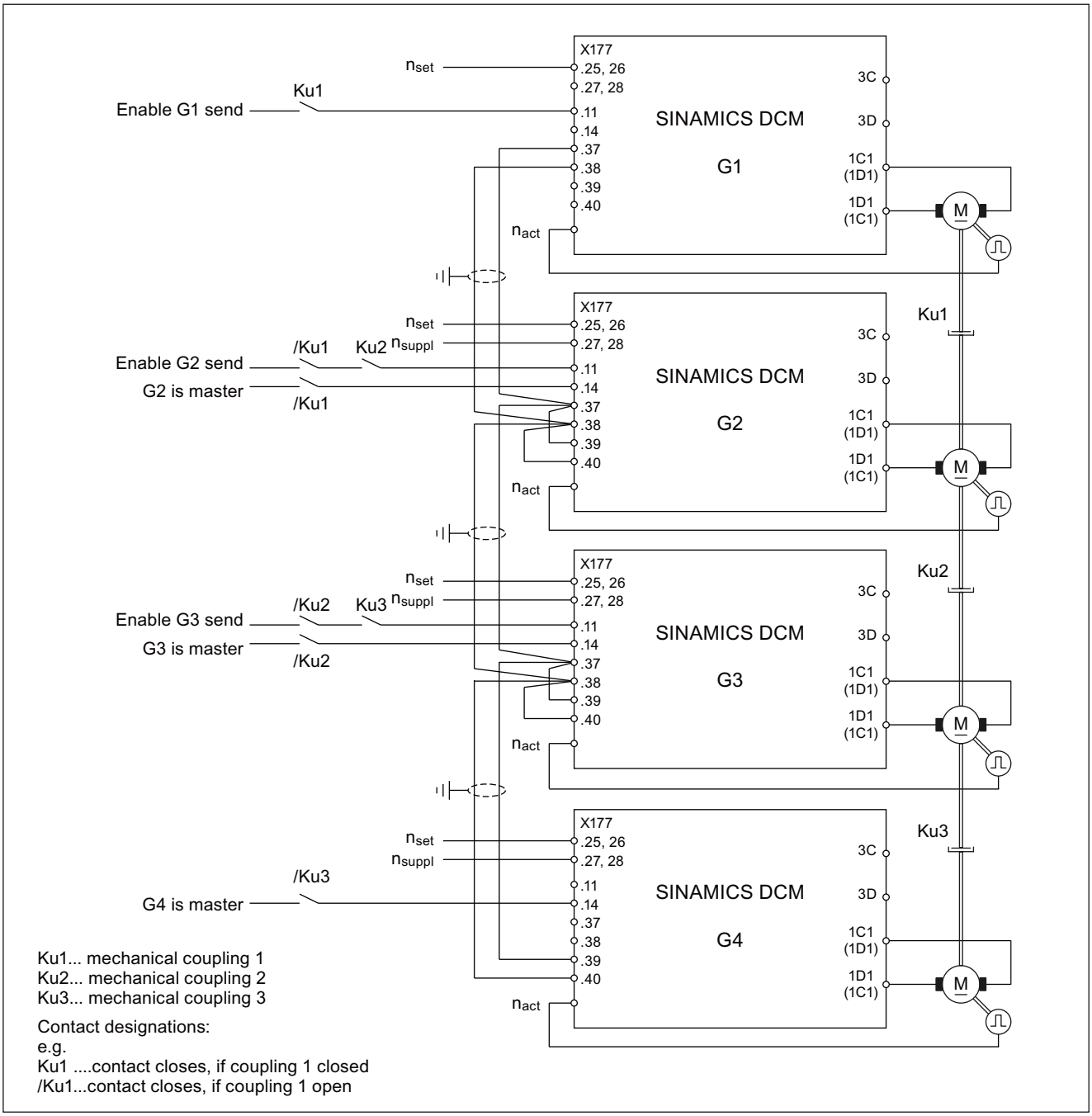
5.1 Application

- For several motors connected to a shaft
- Each drive can be the master drive for the following one

5.2 Recommended circuit

In the following, a constellation with four SINAMICS DCM drive units will be explained as an example.

The assignment of the connections not shown, power supply, protection (fusing), etc. depend on the particular units and should be taken from the operating instructions.



Due to the feedback signals of the coupling states, in the drive units, the correct marshaling is realized for the peer-to-peer connections. The following table is intended to show this.

Ku1	Ku2	Ku3	G1	G2	G3	G4
Closed	Closed	Closed	Master send M_{set}	Slave of G1	Slave of G1	Slave of G1
Open	Closed	Closed	Master	Master send M_{set}	Slave of G2	Slave of G2
Open	Open	Closed	Master	Master	Master send M_{set}	Slave of G3
Open	Open	Open	Master	Master	Master	Master

5.3 Version 1

5.3.1 Description of functions

A master is always closed-loop speed controlled. A slave is always torque controlled and receives its torque setpoint from the immediately preceding master.

The external speed setpoint is connected to G1 to G4 (at X177.25 /26), whereby for each drive that is the master, then its own ramp-function generator is active.

If required, the speed of drives G2 to G4 can be separately influenced using $\pm n_{suppl}$at X177.27 /28).

In order that each drive can be separately switched on, this must be realized individually for each drive using an external control, e.g. at terminals X177.12 /13 (see the operating instructions).

In this mode, it must be guaranteed again that there really is a rigid mechanical connection to the "master" when "slave" is selected, as otherwise the drive could uncontrollably accelerate.

5.3.2 Parameter settings

Commission the converter units according to the associated operating instructions - also including the separate optimization runs with the couplings in the open state.

The parameterization is in principle the same for all drives; the exceptions are explained separately in the tables.

G1 to G4	
p50081=1	Field weakening possible
p50083=2	Operation with incremental encoder
p50169=0	Torque control
p50170=1	Torque control
p50500=52204	Torque setpoint
p50644=52601	Input torque setpoint for the slave drive
p50645=52015	Supplementary speed setpoint Only connect the supplementary setpoint for drives G2 to G4.
p51655=52148	Torque setpoint from its own n-controller
p50687=53010.07	Switchover to slave drive
p50716=53010.06	Enable supplementary setpoint
p50790=5	Peer-to-peer
p50791=1	Number of words transferred
p50793=8	Baud rate
p50794[0]=52452	Torque setpoint to Slave
p50795=1	Bus terminating resistor peer-to-peer ON Only set for the last drive
p50797=2 s	Telegram failure time
p50816=53010.07	Enable receive
P819=53010.00	Enable send
p51652=xx	Adaptation of the torque setpoint for different motor-unit assignments $xx = \frac{I_{GER}}{I_{MOT}} [\%]$ I_{GER} = unit current I_{MOT} = motor current

5.4 Version 2

5.4.1 Description of functions

Master and slaves are operated closed-loop speed-controlled. However, the speed controller of each slave is overcontrolled with a fixed value (e.g. +5 %), and therefore tends towards the direction of the positive torque limit. By additionally entering the torque setpoint of the master as torque limit for the slaves, this limit can be shifted as required between $+M_{max}$ and $-M_{max}$, therefore setting the torque the same as the torque of the master.

In this operating mode, if there is mistakenly no rigid mechanical connection between the master and slaves, then the speed of the slaves only increases by the overcontrol value, as then their own speed controller intervenes.

The external speed setpoint is connected to G1 to G4 (at X177.25 /26), whereby for each drive that is the master, then its own ramp-function generator is active.

If required, the speed of drives G2 to G4 can be separately influenced using $\pm n_{suppl}$at X177.27 /28).

In order that each drive can be separately switched on, this must be realized individually for each drive using an external control, e.g. at terminals X177.12 /13 (see the operating instructions).

5.4.2 Parameter settings

G1 to G4	
p50081=1	Field weakening possible
p50083=2	Operation with incremental encoder
p50169=0	Torque control
p50170=1	Torque control
p50430[0]=53010.07	input, torque setpoint
p50430[1]=53010.06	Input of a fixed setpoint for n closed-loop control
p50431[0] = 52601	Torque setpoint from the previous master
p50431[1] = 52002	Torque enable for n closed-loop control
p50605[0]=52204	Torque setpoint
p50621=52017	Overcontrol setpoint for the n controller Set this parameter for all of the drives except the first drive (G1). The factory setting is kept for the first drive.
p50644=52011	Speed setpoint from term. 25/26. Set this parameter for all drives.
p50645=52015	Supplementary speed setpoint, terminal 27/28. Set for G2 to G4
p51655=52148	Torque setpoint from its own n-controller
p50716=53010.06	Enable supplementary speed setpoint Only set the parameter for drives different than G1, otherwise keep the factory setting.
p50722=+5 %	Overcontrol setpoint for n-controller
p50726=53010.07	Input, overcontrol setpoint
p50790=5	Peer-to-peer
p50791=1	Number of words transferred
p50793=8	Baud rate
p50794[0]=52452	Torque setpoint to Slave
p50795=1	Bus terminating resistor peer-to-peer ON Only set for the first and last drive
p50797=2 s	Telegram failure time
p50816=53010.07	Enable receive
p50817=53010.00	Enable send
p51652=xx	Adaptation of the torque setpoint for different motor-unit assignments $xx = \frac{I_{GER}}{I_{MOT}} [\%]$ I_{GER} = unit current I_{MOT} = motor current

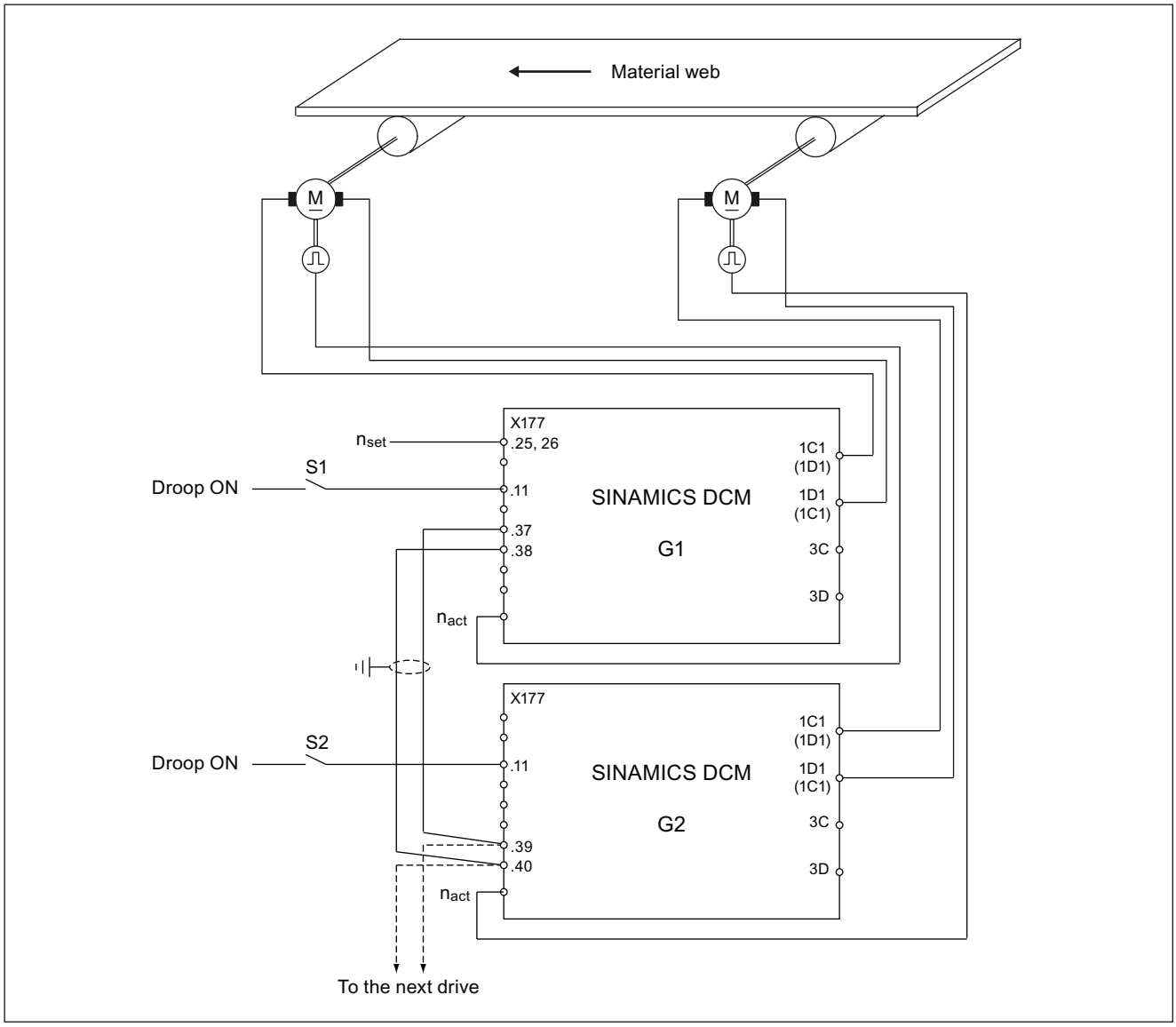
6 Current distribution using the droop function

6.1 Application

- The "droop" function can be used to distribute the load between converter units for two or several drives without a rigid connection between them.
- For example, guide rollers on a material web running with an impressed velocity

6.2 Recommended circuit

The assignment of the connections not shown, power supply, protection (fusing), etc. depend on the particular units and should be taken from the operating instructions.



6.3 Description of functions

For load distribution, the speed controller output (torque setpoint), which can be adjusted using parameter p50227, is fed back to the input and used as auxiliary variable for the current distribution. For some drives it can be beneficial if the droop function is only be activated if there is already a frictional connection to the material web.

The setting of 10% droop function ensures that for 100 % controller output, the actual speed deviates by 10% from the setpoint (this function "softens" the control). Switch on and enable operation of the units via terminals X177.12 /13 (optionally also parameterizable for G2 to Gn via peer-to-peer)

6.4 Parameter assignment

Commission the converters separately according to the associated operating instructions including the optimization runs - but with the droop function not activated.

The parameterization is in principle the same for all drives; the exceptions are explained separately in the table.

Drives G1 to Gn	
p50081=1	Field weakening possible
p50083=2	Operation with incremental encoder
p50169=0	Torque control
p50170=1	Torque control
p50227= e.g. 5 %	Droop
p50634[0]=52601	Speed setpoint from G1 Set this parameter for all drives with the exception of the first drive (G1).
p50684=53010.00	Switch-on the droop function
p50790=5	Peer-to-peer
p50791=1	Number of words transferred
p50793=8	Baud rate
p50794[0]=52190	Speed setpoint after the ramp-function generator Only set this parameter for drive G1.
p50795=1	Bus terminating resistor peer-to-peer ON Only set for the last drive.
p50797=2 s	Telegram failure time

6.5 Final setting

- Activate droop for all drives.
- In operation and with a frictional connection to the continuous material web p50227, adjust until the load distribution between the units has reached the desired value.
- If the setting range of p50227 (0...10 %) is not sufficient, then adjust the speed using p2000 until p50227 intervenes.

Siemens AG
Industry Sector
Postfach 48 48
90026 NÜRNBERG

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C98130-A7066-A503-01-7619, 03/2011

Siemens AG
Industry Sector
P.O. Box 48 48
90026 NUREMBERG
GERMANY

Subject to change
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