

# UNITROL<sup>®</sup> F

Excitation systems for synchronous machines  
with and without rotating exciter



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# UNITROL® F System Overview

**UNITROL F provides a comprehensive range of Automatic Voltage Regulators and Static Excitation Systems for high performance control of all kinds of synchronous machines.**

## Product range

The UNITROL F system is available as

- Automatic Voltage Regulator (**AVR**)
  - for 50/60 Hz supply using thyristor converter
  - for DC supply or higher frequency AC supply using IGBT converter
- Static Excitation System (**SES**) for 50/60 Hz supply using thyristor converter.

A wide selection of power components and software functions is available to provide a system which meets the most demanding technical requirements.

## Digital control

UNITROL F is a microprocessor-based system and thus fully digital. It provides high control accuracy (min.  $\pm 0.5\%$ ) and high initial response (approx. 20 ms). Its well-structured software offers a wide range of functions covering standard (e.g. limiters) and optional (e.g. PSS) functions.

## Local operation

UNITROL F includes a control panel for local operation and monitoring. With this panel it is also possible to modify system parameters and to make minor changes to the application programs on-line.

The operation and monitoring of the system can also be performed via PC using UNITROL F's optional "Commissioning and Maintenance Tools" (CMT).

## Communication

UNITROL F can be provided with a serial communication line supporting different protocols for remote operational control and monitoring. This is in addition to a set of I/O interfaces which is required for operation from control room. All I/O interfaces are electrically separated by means of relays and opto couplers.

## Diagnostics

Utilizing microprocessor technology provides the user with comprehensive diagnostics.

Troubleshooting is easily performed via the control panel or by a PC using CMT software tool.

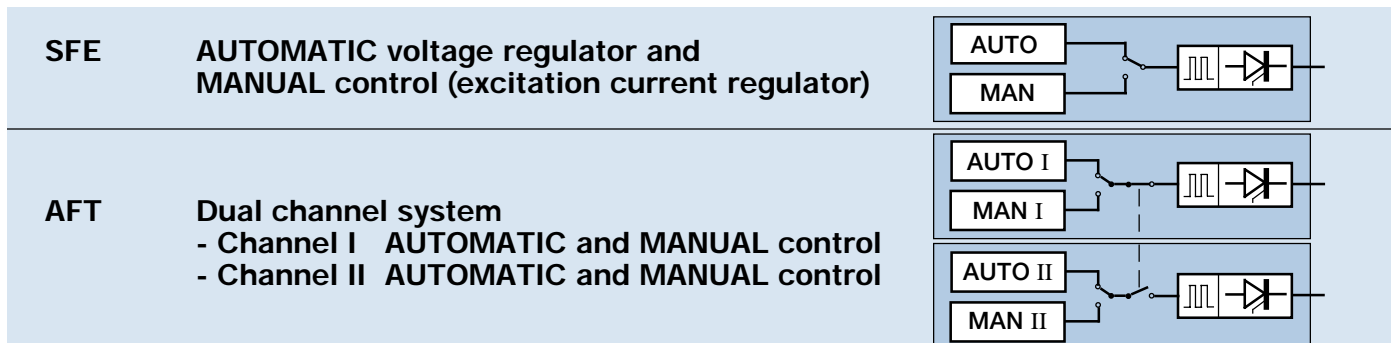
## System configurations (Fig. 1)

AVR and SES are available in the following configurations:

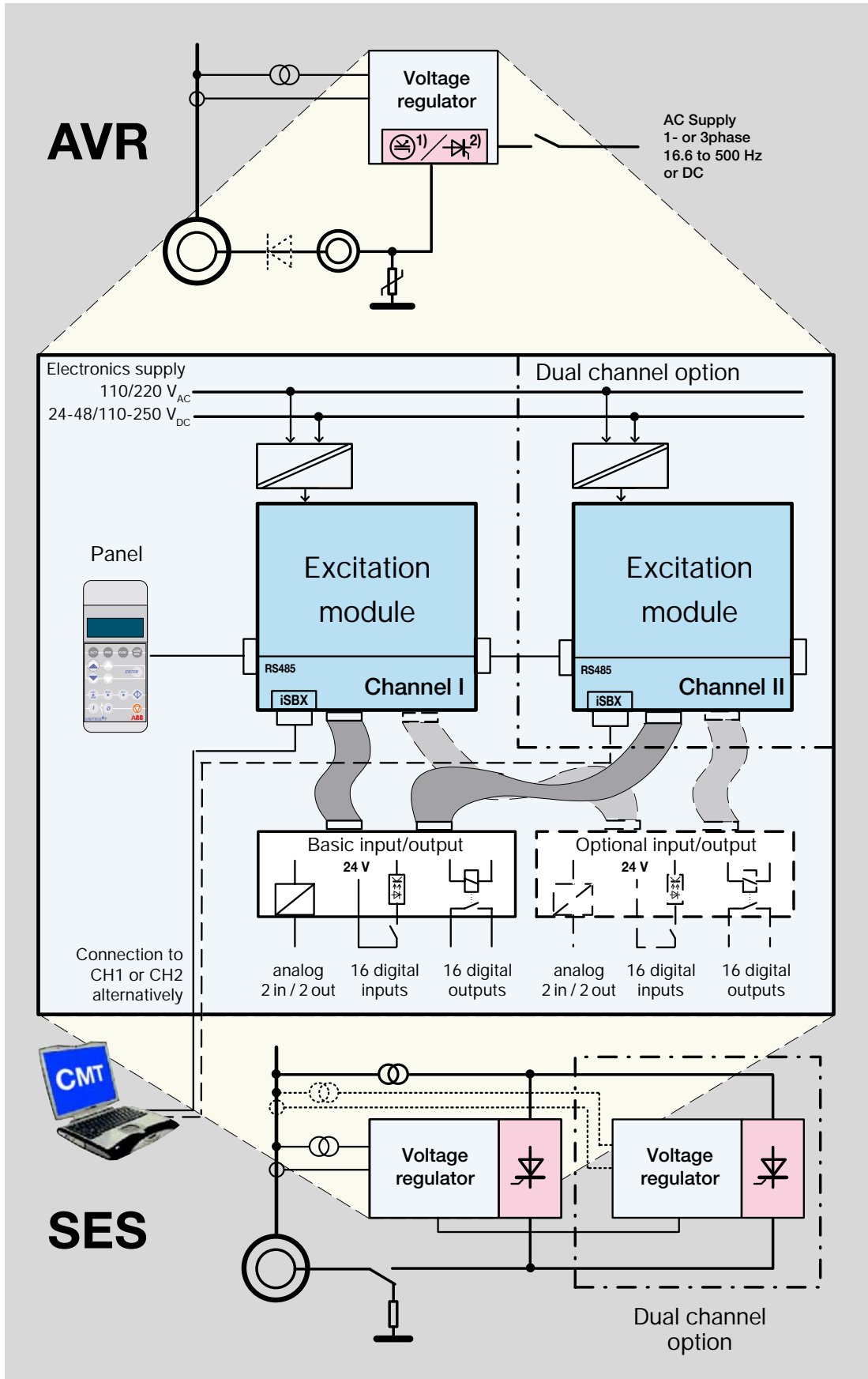
- Single automatic channel system (SFE) with one excitation module including one power converter and one controller for both AUTO and MAN control modes
- Dual automatic channel system (AFT) with two identical excitation modules each with power converter and controller. Each channel can operate in AUTO or MAN mode.

A follow-up control ensures a smooth change-over from one mode or one channel to another.

Fig. 1:  
Main configurations of  
the UNITROL F system



# UNITROL® F System Configuration



UNITROL F for excitation systems with rotating exciter using power converter either with

1) IGBT transistors for AC supply 16.6 to 600 Hz and DC supply

or

2) thyristors for AC supply 50 / 60 Hz

or

thyristors for AC supply upto 500 Hz

UNITROL F for static excitation systems (50 / 60 Hz supply)

Fig. 2: Interfaces of the UNITROL F system, single and dual channel configuration

**A well-structured and stable software with a wide range of function blocks enables users to tailor the system to their own needs.**

## Functionality of the standard program

This comprises the following excitation functions:

### Basic control functions

- Voltage regulator with PID filter (AUTO mode)
- Field current regulator with PI filter (MAN mode)
- Reactive and/or active current compensation
- Limiters for
  - maximum and minimum field current
  - maximum stator current (lead / lag)
  - underexcitation
  - Volts-per-Hertz
- Follow-up control
  - AUTO ↔ AUTO (for dual automatic channel systems only)
  - AUTO ↔ MAN
- Power factor / reactive current regulation
- Softstart function in AUTO mode
- MANUAL restrict.

### Optional control functions

- Power system stabilizer (IEEE - PSS2A).

### Basic protection and monitoring functions

- Field flashing time
- Overcurrent (instantaneous / inverse time) protection
- Loss of excitation protection
- Converter temperature monitoring
- Thyristor conduction monitoring
- Potential transformer monitoring
- Main supply undervoltage
- Auxiliary supply undervoltage.

### Optional protection and monitoring functions

- Rotating diodes monitoring
- Rotor temperature (for SES only)
- Volts per Hertz protection.

Monitoring and protection functions are categorized in three different action levels:

- Alarm only
- Change-over to the second channel (if provided) to avoid unnecessary trips
- Instantaneous excitation trip for protection purposes.

### Logic control

For standard sequences and interlocks there are fixed pre-programmed function blocks.

## Application function blocks

Besides the functions available in the standard program, there are additional function blocks of different kind which can be used for the application program. Well proven optional application procedures such as I/O extension, specific monitoring functions etc. are available.

## Data recording

The UNITROL F software also includes an **event logger** which stores up to 100 events and alarms with system's time stamp. They can be recalled via the control panel or the CMT software for event analysis.

Up to six different system measurements can be stored in UNITROL F's **data logger**. They can be displayed by the trending window of the CMT software for diagnostics.

## Processor monitoring

### Self test

After switching on the supply voltages of the control board, the processor starts a selftest program. During the initialization, both RAM and ROM (flash memories) are tested. The control board also monitors the different levels of power supply.

### Watchdog function

The control board contains an internal Watchdog which monitors the program execution.

# UNITROL® F Additional Functions

The functionality of the UNITROL F system can easily be extended. For some of those functions an additional hardware and software is required.

## Power System Stabilizer (PSS)

The purpose of the Power System Stabilizer is to use the generator excitation to improve the damping of power swings and the stability of the generator and the transmission system as a whole. The PSS operates by influencing the AVR's input – most effective with a static excitation system, but also successful for systems with rotating exciter (Fig. 3).

UNITROL F's power system stabilizer is based on IEEE PSS2A (i.e. with accelerat- ing power measuring).

A printed circuit board, which is plugged in a connector and fixed on the measuring processing board, is required, in addition to PSS software for the PSS function in UNITROL F.

## Supervision of rotating diodes

With this add-on component, open or short circuits in the branches of the rotating rectifier, used in brushless systems, can be detected selectively over a wide range of rotational speeds.

A filter of the 8<sup>th</sup> order, synchronized with the rotational speed, measures the harmonics with the frequency of the excitation machine from the excitation current signal. Depending on the amplitude relative to the excitation current, it is possible to distinguish between an open and a short circuit in the branch.

For this function a small printed circuit board is required which is plugged in a connector of the measuring processing board.

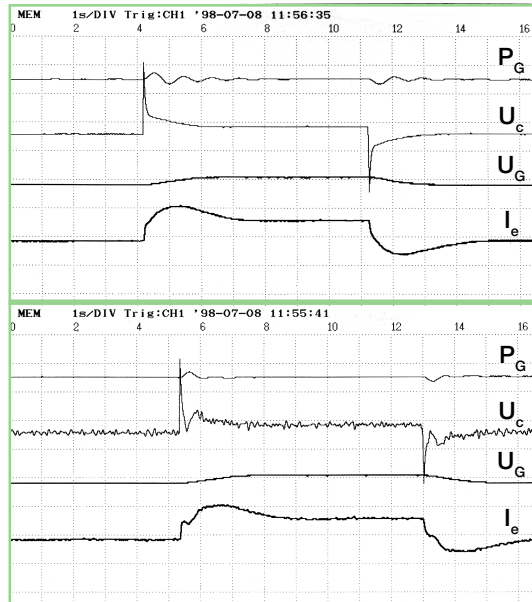


Fig. 3: Response without (above) and with PSS function (below) at an excitation system with rotating exciter for an 1140 MVA generator (P = 860 MVA, setpoint step-change 5%)

## Additional inputs/outputs

If additional digital inputs/outputs are required, an I/O extension for 16 input and 16 output interfaces is available. The extension consists of a printed circuit board which will be piggy-pegged on the main board in the excitation module and a second I/O board which is mounted on the frame in the cubicle.

With a second variant of the I/O extension the voltage regulating system can be expanded with another two analog inputs/outputs.



Fig. 4: Printed circuit boards for additional functions

Although UNITROL F equipment leave our factory with the functionality specified by the customer, modification on system functionality can easily be made later, if necessary.

The software of UNITROL F comprises two parts: Standard program and application program.

## Standard program

Our standard program is installed in every excitation module. If a function in this program is not required, it can be disabled by a parameter. However, each system will be configured with particular parameters specific to the installation in our factory. The control panel or a CMT can be used for enabling/disabling such functions as well as modification of the parameters, on-line or off-line.

## Application program

For certain applications it is necessary to extend the standard program. With this so-called application programming, standard program block connections can be changed and different application function blocks can be added.

## Engineering tool GAD

Graphic Application Design (GAD) is a PC tool for application programming. This tool offers the following features:

- Programming of the standard and application program
- Graphical editor for creating and modifying program diagrams (Fig. 5)
- User controlled outlook for documents
- Possibility to create new documentation symbols.

Application programs made with GAD have to be downloaded to the excitation module with the Commissioning and Maintenance Tool CMT.

## Programming with control panel

On-line changes to the standard or application programs can be made using the control panel, where the following functions are available:

- Activating program
- Connecting inputs and outputs of function blocks
- Modifying function block connections
- Adding or removing function blocks
- Changing function block execution order
- Displaying parameters of function blocks of the application program.

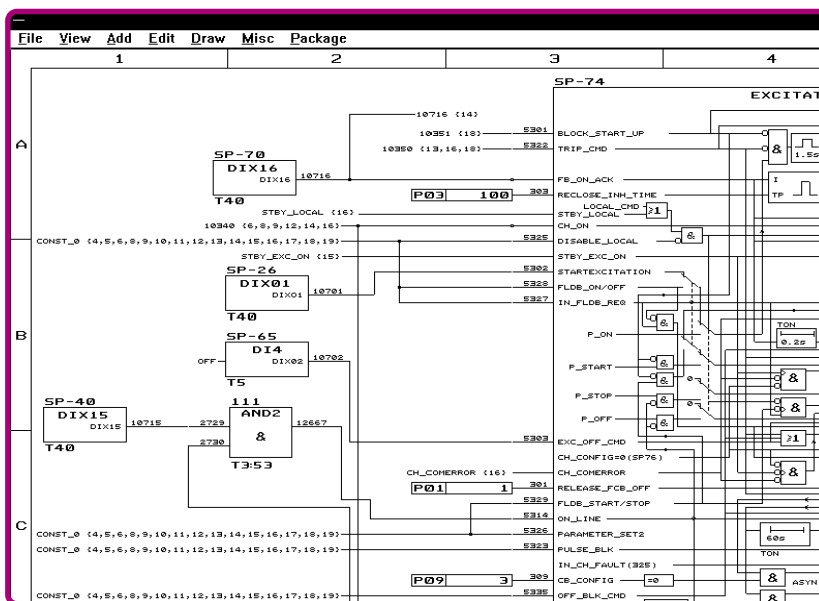


Fig. 5: GAD display, segment of an application program diagram

# UNITROL® F Commissioning and Maintenance

The “Commissioning and Maintenance Tool” CMT of UNITROL F is a software which can also be used for the operation and monitoring of excitation systems.

## Commissioning and Maintenance Tool (CMT)

With this tool the user can perform on-line changes to the application programs, observe the system function and change parameter values.

It also includes a control and status display to be used for operating the system and observing its status. This tool includes further functions as described in the following:

### Trending display

With this window, up to six real-time analog signals can be shown in trending form or to be recorded for later trending display (Fig. 6). The collection of measuring data can be subjected to an event (event driven). All signals available in the system can be selected for trending display. The selection of each signal including all required parameters for scaling and offset are available in a very user-friendly environment. The window shows trend line diagrams.

### Application program display

This window shows the function block diagram made with GAD (Fig. 7). The user can select and review the real-time values of selected points in this display.

### Parameters and signals display

This display enables the user to observe parameters or signals in a tabular format. The user can modify parameters if required. One feature is that the user can classify each parameter or signal into parameter or signal groups. Later, he can choose selected groups and watch or change parameters and signals allocated to this group only.

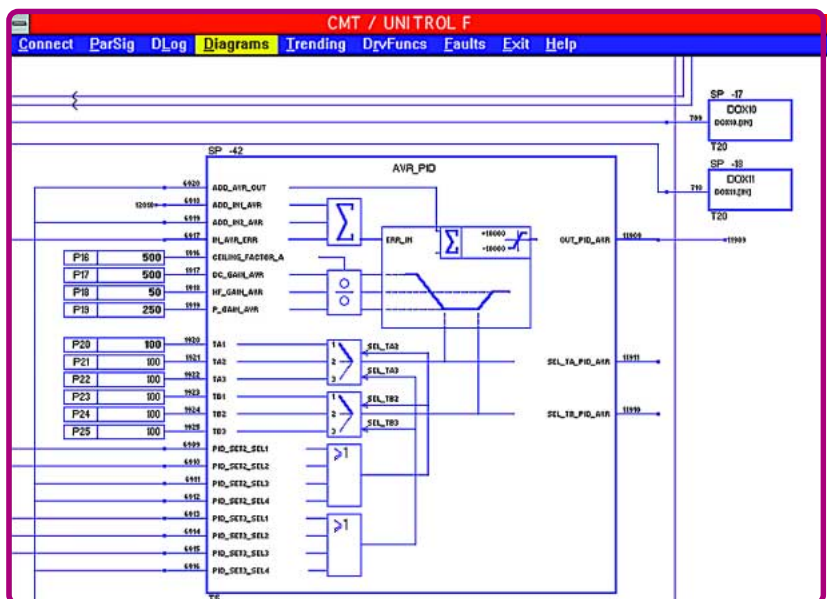
Fig. 7:  
Application program diagram of the CMT with parameter display

### Other displays

- **Alarm logger display**  
This display shows the last 99 events, alarms and fault signals in chronological order.
- **System functions**  
This display represents a copy of the service control panel.
- **Data logger display**  
This display shows the latest triggered data (six channels, 1000 data points each), updated in the data logger in chronological order.



Fig. 6:  
Trending window of the CMT/UNITROL F



# UNITROL® F System Communication

For internal data transfer, between the two channels and to the control panel, UNITROL F uses a serial communication line.

To provide a fast and reliable link for the CMT tool, the excitation module has an optical link connection to the PC (option).

Several communication protocols with corresponding bus adapters (options) are available for controlling and monitoring UNITROL F from a higher hierarchical control system.

## Panel bus

The panel bus is a serial link (MODBUS protocol) based on RS485 signal level with a transfer rate of 9600 Baud. The bus is used to connect the control panel as well as for the data transfer to the second excitation module of a dual-channel system, (see Fig. 8).

## Optical link for commissioning and maintenance

UNITROL F can also be connected through an optical link to an optional PC with an installed "Commissioning and Maintenance Tool". This enables a secure and fast communication to the excitation system. This feature allows utilization of all functions of CMT with a transfer speed of 1.5 MBaud and enables operation of the excitation system from the PC. To utilize this feature, a PC-Card for a Laptop or a SNAT 608 CMT ISA board for desktop PC is required. The connection board, SDCS-COM, can be ordered separately, which is installed in the excitation module.

## Serial communication to higher hierarchical control systems

Communication with a higher hierarchical system (hereinafter called Master) is also possible. Protocols for that are **MODBUS**, **MODBUS+** or **Profibus**. An extra bus adaptor is required for each channel of the excitation system for connecting the Master via RS485 multi-drop link. The link supports six data words (16 bit each) in either direction. For Master remote control, two data words in either direction are required. The remaining data words can easily be connected to any input and output signals by the user.

Fig. 8:  
System communication  
connections

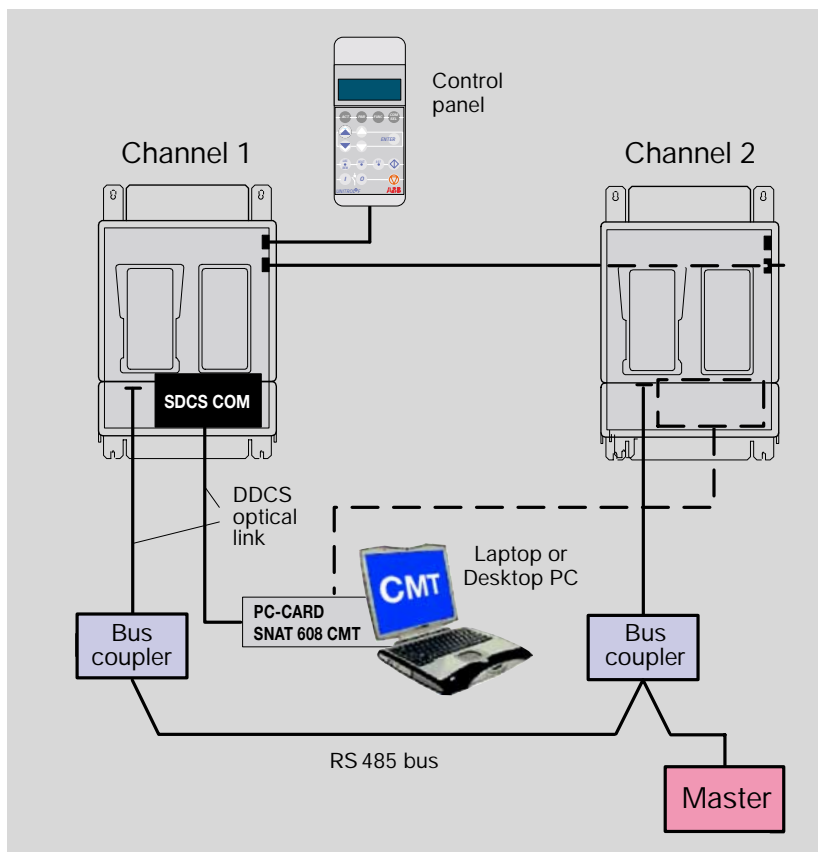


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