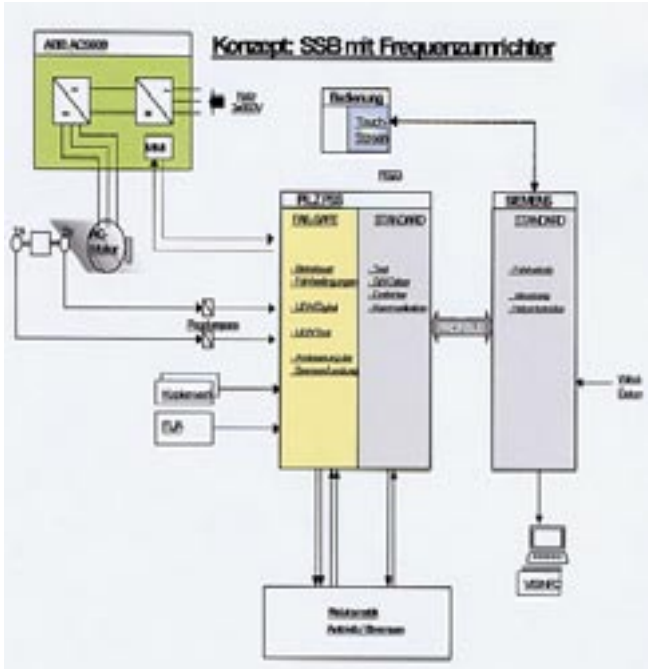
Drive Controls means Information Handling

Times have passed, when a carriage on a rope was pulled up a mountain on rumbling rails. Today, a funicular car is a highly complex system closely connected with the drive controls. Until recently, functions have been monitored mechanically, today these functions are monitored electronically thus the safety functions have become much more complex.

200 passengers are transported from 1557 m up to 2218m a.s.l. in 253 s. Nominal power of 1250kW is required for that.

Based on different operation modes, there are a number of possibilities to control this tram. The various operation modes and operational functions are selected, co-ordinated and monitored in the control room of the drive station. In "Remote Mode" all controls and supervisions are handled by the car attendants. For this purpose, a main control stand is placed in the top compartment and a stand-by control box is located in the lowest compartment of each car. Remote control is achieved through an inductively coupled telecomand system with a way side induction loop.
All control- supervision- and monitoring signals including telephone communication are transmitted through this single induction loop cable.
Already above few sentences show that the engineer designing this system must handle a number of communication problems!
As heard from the Davos Parsenn management, the solutions of all these problems have been found to the liking of all involved personnel.

The picture above right shows the principal building blocks of the control system.



A clear concept of the drive and control systems.

Modern Frequency Converter Drive

…with optimal power efficiency

The funicular is driven by a speed regulated squirrel cage ac motor (picture below). The variable frequency ac drive allows speed- and torque regulation in four quadrant mode, fully motoring and re-generating mode in both directions.
This system provides smooth acceleration and deceleration in any load condition and to very low creep speed.

AC drive squirrel cage motor with gear box..

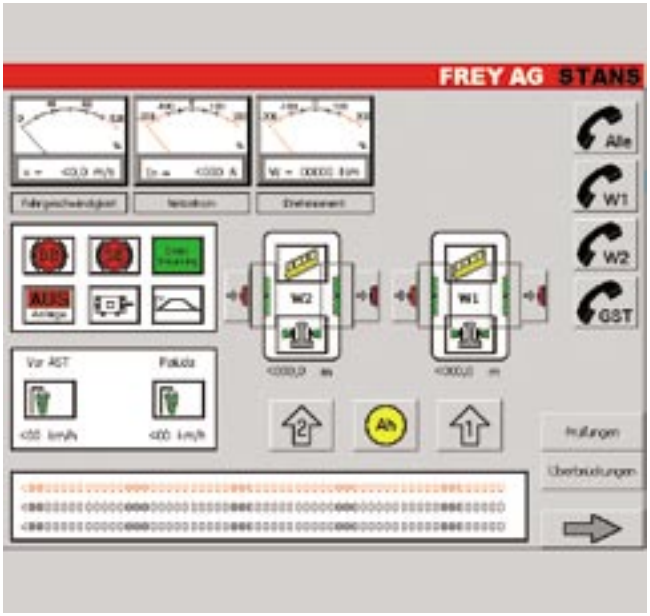
The power section of this drive consists of two inverters with 1 line side inverter (ISU) operating as a rectifier and a motor side inverter (INU) operating as a voltage and frequency converter.
This concept pleases with an optimum efficiency and with minute power distortion by harmonics.

.. and economy program

Especially during the summer operation or at low demand periods. a so called economy program can be selected. The aim by this program is to avoid power peaks and to reduce mechanical wear.
Maximum speed is limited to 7.5 m/s and acceleration and deceleration are reduced which will result in a slightly longer travel time of 6.5 minutes.
Even then, a start and acceleration in the steepest section will demand a power peak of 2 MW!

Simple, operator-friendly handling

Actual operation of the system controls uses an industrial monitor with touch panel functions. The full-graphic colour display provides a comfortable working platform, which supports operation and monitoring of the whole drive system with optimum clarity. All actual values are displayed in real time and some are displayed in graphic form.



Clear and simple designed operators panel in the control room in the top station. Fault indication at the bottom in clear text messages.

Operational controls and visualisation have been separated intentionally on two different monitors, so that important monitoring of the actual operation of the system is not overfilled with (at the moment) unimportant information. This separation is possible because the visualisation ("Visinfo3") is used mainly for test functions, fault location, brake graph display but not necessarily for actual control functions of the drive.

Operational Controls (right) and Visualisation (left) are separated intentionally to keep the operations monitor as clear and simple as possible

PSS 3000 the core piece of a new control generation

Main Drive Control

The actual core piece of the new control generation, the so called PSS3000 of Pilz in Germany is a modular system, providing various safety components depending on the various control tasks to be fulfilled in a tramway control system. (see picture below)
This PLC (PSS) allows computing of all safety related functions without wear and with continuous status monitoring of all functions.
We believe that only such a fail safe PLC provides the high demand on safety and reliability. While Pilz provides the hardware firmware and software for the safety functions on module basis, Frey AG designs the custom functions to provide a tramway control system.
Actual tests of the hardware and software modules are done prior to delivery at the workshop of Frey AG.

A view inside the control panel. Left, the fail safe PLC (yellow) and the Remote Supervision System rack on the right.

SafetyBUS p- Connection Drive to Lower Station

Safety relevant signals between drive station controls and lower station are realized with a SafetyBUS p connection, the fail safe open bus system by PILZ. The signals are transmitted through a data hybrid cable containing fiber optic conductors. The safety bus uses this fiber optic conductors. Besides all safety functions in the counter station various other control signals and information can be transmitted through this link allowing remote monitoring of the whole drive control system.

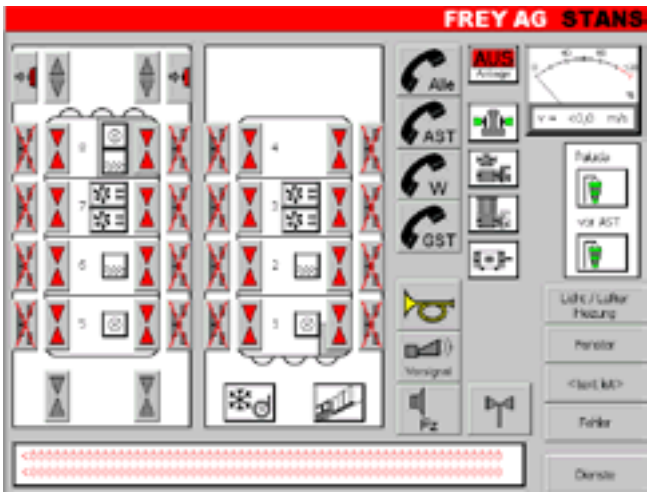
SafetyBUS p- Connection in the cars

As a first, also the connections within the cars compartments are realized with a safety bus (pictures below) The main arguments to use this technology were the substantial reduction of cabling but nonetheless the possibility to monitor all 140 safety related inputs per car (track brake switches, doors etc.).
A PSS3006 was used as the safety bus controller and as an interface to a profibus allowing first fault detection and fault display in a clear text message.

ASafety Bus system allows processing of all 140 safety functions in the car.

Control station with touch panel in the upper drivers compartment.

Clear layout and information on drivers controls - thanks to touch panel



Monitor display in the cars. The operator sees all important information including a first fault text display

ProfiBus connection in the cars …and in the main drive

Besides SafetyBUS also a ProfiBus system is used. This bus is used for system controls for not safety related functions such as light, compressor controls, windscreen wiper, window and compartment heaters, flange wheel lubrication, PA system etc.
Such an amount of equipment to be controlled require a large amount of devices and mounting hardware - even when connected with a bus system,
see below pictures

Remote I/O modules (yellow) in the roof compartments for door and compartment controls.

Control cabinet in upper drivers compartment with PSS I/O modules, S7 Profibus controller and common vehicle electric. Layout is clear and maintenance friendly.

In an emergency - a panel in lower compartment

Should the video monitoring of the downhill side of the car be malfunctioning, the driver can go to the lowest compartment and use the small emergency panel to control the system when travelling downhill.

Downhill side emergency control station with touch panel and important controls and indications. This control station is normally locked..

Remote Control and Supervision System (RSS)

Drive - Car 1 / 2

The remote control and supervision system is the "safe" connection between cars and drive controls. Communication of the signals is provided inductively, without galvanic contact, via an isolated induction loop which is placed near the rails or in the rail foot. A transmitter antenna on the car is inducing a current signal in the loop. This signal is received in the drive station, filtered and amplified and then it's frequency content is decoded to remote control signals. The remote control signals are then processed in the drive control system. In reversed direction, the signal is applied to the induction loop in the drive station producing a current in the isolated loop wires. These signals are sensed with ferrite antennas on the car, filtered, amplified and decoded and processed in the cars control system. Each "user" on the loop works on it's own frequency band, therefore various signals can be transmitted and received parallel.

Haul Rope Monitoring

A low frequency monitoring voltage is applied to the rope in car 1. In a rope capacitor, a simple pipe around the haul rope, in the drive station, this low frequency signal is de-coupled, filtered and amplified. A fail safe level monitor detects a ground fault of the haul rope and a service stop of the tram will result. Should the haul rope monitor be by-passed, maximum speed is automatically limited to 6 m/s.

Telephonesystem

A telephone system connects the two cars with each other and with the drive station and the lower station, thus the telephone system works as a "party line system". All stations can communicate with each other simultaneously. Even these signals use the single induction loop!

PA system to the cars

PA messages can be sent individually to each car using the telephone system. The remote control system enables the appropriate loudspeaker system in the cars. Controls are on the touch screen in the drive station. A digital memory system in the drive station provides pre-recorded messages which can be "sent" to the cars. 6 memories with 30 seconds each are available.

Walkie-Talkie with compartments

The car driver has the possibility to talk to the customers in each compartment. Each compartment is equipped with a microphone and a "SOS button". Once one of the "SOS buttons" has been pushed an LED will illuminate in the drivers compartment indicating which button was activated. The driver can now communicate with that particular compartment in a walkie-talkie fashion, whereas the guest does not need to reactivate any button.

An Alarm button is mounted in each compartment. Activation will alert the driver.

Outlook in the Future

Frey AG Stans has gained basic know how with the fail safe PLC "PSS" first hand on an aerial tramway project Pic du Midi in 1999. Many other projects followed and all project engineers have now extensive knowledge on all different tram systems. "Practical use is the best teacher" as Markus Christen our project manager for the Parsenn Tram explained!

The control concept is under continuous development. Periodically meetings and discussions are held with the PSS manufacturer as well as with the government inspectors of the BAV. New generations of PLC systems with more memory and higher speeds are under continuous development, although the pace is somewhat slower as in the common PC world,
due to the main task of the PSS: SAFETY FIRST

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