DiSEqC 2.0 for Technicians

1 Preface

Today, you can page through technical journals or brochures featuring satellite reception and you will find in almost every one an article on the subject of DiSEqC. This report is different from previous publications and will be an aid for the technician who wants to install DiSEqC components for the customer and to acquire basic technical background knowledge about DiSEqC. Although this paper contains a great deal of technical information, it should be easily understood by non-technicians, too; It contains only the most important information of various DiSEqC specification documents.
This document is an updated translation of the leaflet "DiSEqC für Techniker" available from SPAUN electronic.

2 Background

If you have actively observed the development of satellite reception, then you will have noticed the extent to which switching criteria has changed. Control signals are needed to select the polarization levels, the frequency range, and satellite position, as well as to control steerable dishes, which are usually equipped with a separate polarizer. The interfacing is non standard and sometimes is even used for opposite purposes. In addition, transfer errors and voltage level drops occur, as well as electromagnetic interference caused by unshielded control cables.
In Europe, another conflict in the use of remote control signals came about with the introduction of the Hot Bird satellite system from EUTELSAT and the expansion of the ASTRA satellite system of SES. While ASTRA specified the 22 kHz tone to switch between the lower and the new upper frequency band within the LNB, EUTELSAT at first supported this to choose a satellite system with a multi-feed antenna. Some manufacturers started to develop receivers with additional company specific frequencies for yet another switching criterion, which led to more incompatibility and technical problems.
Phillips recognized this weakness and considered a new, flexible and reasonably priced system to control the total antenna periphery like LNBs and multiswitches, including polarizers and steerable antenna systems. EUTELSAT refined and finally specified the system under the name DiSEqC (Digital Satellite Equipment Control). DiSEqC is an open and unlicensed industrial standard available to anyone and is coordinated by EUTELSAT. DiSEqC is a trademark of EUTELSAT.

3 Introduction

With DiSEqC, a system has been created with more capacity than required for today's uses. Although all currently conceivable applications have been considered and specified, additional functions can be implemented at any time due to the flexibility of the system.
DiSEqC defines a uniform and brand neutral standard, which is set to eventually replace the available analog and sometimes company specific control systems. In order to ensure a smooth transition, DiSEqC may also be installed in addition to available analog switching criteria.
During the development of DiSEqC much attention was paid to a cost-effective implementation. Most satellite receivers can give DiSEqC commands with only small software changes in the existing microprocessor. In comparison, more expenditure is necessary in the periphery components. Here, a small mask-programmed microcontroller (83C750) must be incorporated, which nevertheless, can replace a part of the previous detection logic.
DiSEqC is designed for two-way communications, i.e. a multiswitch can confirm the execution of a switch command (automatic error search, if required) or the receiver can “ask” the LNB for the available local oscillator frequencies (automatic receiver installation). Problems with the threshold levels due to voltage drops in the downlead cables are eliminated since the signaling is independent of voltage levels. In addition, the receivers‘ power supplies will become more economical due to the constant remote voltage in future. Furthermore, considerable energy savings are made possible by reducing the voltage. DiSEqC is a "single master / multi slave – system“, which means the signal traces are structured in a way that multiple DiSEqC masters (receivers) never access the same slave. Therefore in a multiswitch, each active output has its own slave assigned. On the other hand, a master can control several slaves (LNBs, multiswitches etc.). This concept precisely complies with the distribution structure of SAT-IF. All DiSEqC activities go out with the master, which means that a slave can only send data when prompted by the master.

4 Going Digital

With DiSEqC, the switching signals are transferred in series as encrypted digital words. Standard in computer technology, eight bits make one byte (increasing order), followed by one parity bit (odd). The DiSEqC data word contains a frame byte, an address byte and a command byte, which can be followed by a data byte.

Frame	P	Address	P	Command	P	(Data)	P

When requesting an answer from the slave, it consists of a frame byte for “protocolling” and attached data when needed.

Frame	P	(Data)	P	(Data)	P

4.1 The Frame Byte

After the bit flow sequence for the synchronization of reception, the frame byte contains the protocol data and direction identity.

Frame byte	Binary Data	Definition
E0	1110 0000	Command from master, no reply required, first transmission
E1	1110 0001	Command from master, no reply required, repeated transmission
E2	1110 0010	Command from master, reply required, first transmission
E3	1110 0011	Command from master, reply required, repeated transmission
E4	1110 0100	Reply from slave, ok, no errors found
E5	1110 0101	Reply from slave, command not supported
E6	1110 0110	Reply from slave, Parity error, repeat requested
E7	1110 0111	Reply from slave, Command not recognized, repeat necessary

4.2 The Address Byte

The DiSEqC components are addressed differently according to their function.
Similar types of components are compiled in address groups (families). The first four bits of the address indicate the family, while the last four define variations within the family.

Address	Binary Data	Family or Type
00	0000 0000	All families (universal address)
10	0001 0000	All IF switching components
11	0001 0001	LNB (low noise block converter)
12	0001 0010	Loop-through LNB
14	0001 0100	Multiswitches
15	0001 0101	Switches with loop through (relays)
18	0001 1000	SMATV
20	0010 0000	All polarizers
30	0011 0000	All antenna positioners (steerables)
40	0100 0000	All installation aids
41	0100 0001	Signal strength display
60	0110 0000	Alternative area if double addresses appear
70	0111 0000	Interface for multimaster adapter
Fx	1111 xxxx	Further expansion

4.3 The Command Byte

The actual control commands are transferred in the command byte. The following is a very small extract listing the commands:

Hex Byte	Command	Function
00	Reset	Restarts the slave micro controller
02	Standby	Makes device fall into standby mode
03	Power on	Makes device awake from standby mode
07	Address	Reading of slave address
10	Status	Reading of status register
11	Config	Reading of Configuration register
14	Switch 0	Reading of available switches and current switch states
20	Set Lo	Selection of low band
21	Set VR	Selection of vertical polarization (or right circular)
22	Set Pos A	Selection of satellite system A
23	Set S0A	Options switch state A

24	Set Hi	Selection of high band
25	Set HL	Selection of horizontal polarisation (or left circular)
26	Set Pos B	Selection of satellite system B
27	Set S0B	Options switch state B
38	Write N0	Command to describe the entire IF path
50	LO string	Reading of the local oscillator frequency (BCD Value)
51	LO now	Reading of current local oscillator frequency
52	LO Lo	Reading of low local oscillator frequency
53	LO Hi	Reading of high local oscillator frequency

4.4 The Optional Data Byte

Some DiSEqC commands require the transmission of additional data, which is then transferred in the data byte (bytes). For example: the data byte for command 38 contains the complete "path description“ for the IF path (see example in 9.2.1).

5 Configuration Data

Since DiSEqC is equipped to communicate bidirectionally, a DiSEqC master can ask a slave for its performance capability, from which certain functions can be concluded. For this, status-, configuration and switch status bytes are available (example follows in 7).

5.1 The Status Byte

The slave replies the status register in response to command 10. The register contains information about bus collisions, resets, supply voltage, and stand-by mode.

Bit Number	Status
.7	Bus Collision bit is set
.6	Stand-by mode is selected
.5	-open-
.4	External voltage supply available
.3	-open-
.2	Remote voltage is above 15V
.1	-open-
.0	Reset flag

5.2 The Configuration Byte

In the configuration byte, which is requested with the command 11, contains more precise information of the component.

Bit Number	Components can...
.7	...set an analog control signal
.6	...be put in stand-by mode
.5	...turn a steerable antenna
.4	...be supplied with an external voltage
.3	...loop through IF signals
.2	- open -
.1	...switch signals
.0	...transmit back oscillator frequencies

5.3 The Committed Switches Byte

The reply to command 14 is called committed switches byte. It displays what switches are available, what switches are fixed and which current settings have been selected (example in 7).

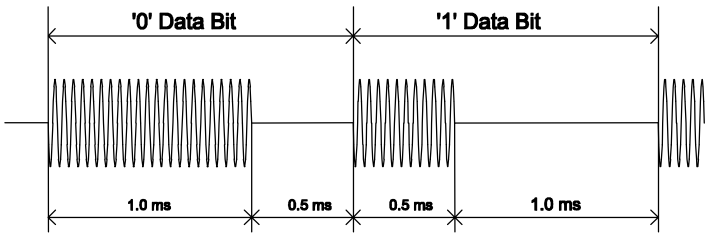
Bit Number	Switch Setting
.7	Optional switch is on "B“
.6	Satellite position "B“ is selected
.5	Horizontal polarization is selected
.4	High band is selected
.3	Option switch available
.2	Satellite position is selectable
.1	Polarization is selectable
.0	Frequency band is selectable

6 The Bus Modem

Similar to a computer, the transfer of digital DiSEqC data requires a ‘"modem" in order to modulate and receive the data first on the remote voltage of the satellite receiver and then on the existing coax cable.

6.1 DiSEqC Data Transfer

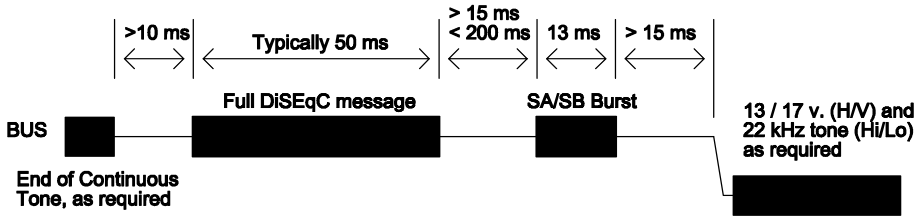
The transfer of the DiSEqC data bits results in series by switching on and off the 22kHz tone (PWK) with an amplitude of approximately 0.5 Vpp.



6.2 Hardware

Since DiSEqC can be implemented as an unidirectional (DiSEqC 1.X) as well as bi-directional system (DiSEqC 2.X), there are different versions of bus modems, with a major difference between bus powering master device modems and remote powered slave modems.
In a unidirectional DiSEqC system the existing satellite receiver hardware used for applying the 22kHz tone can be used for modulating the DiSEqC data.
In the Slave a single transistor amplifier lifts the burst packets amplitude from 300mVpp up to TTL level for the slave microcontroller.
For the bi-directional data communication somewhat more hardware is necessary. The power supply of DiSEqC 2.X receivers contains a RLC combination, which determines power pack impedance to 15Ω (at 22kHz). The transmitters in master and slave are realised as pulsed current sinks, which pulls 22kHz pulses with about 45mA from the remote power rail. The voltage drop occurring over the RLC impedance modulates the bus voltage with approximately 0.5Vpp.
The DiSEqC receiver in the master is identical to the one in the DiSEqC slave.

6.3 Ordered Co-Existence



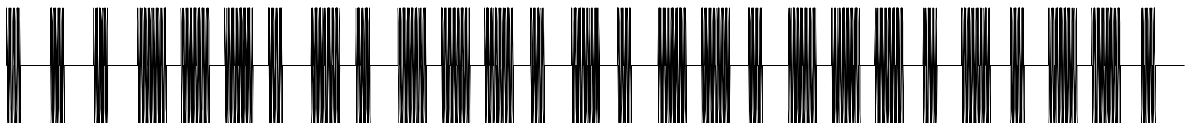
Since it is necessary for a transition phase, to continue to transmit conventional switching criteria in addition to DiSEqC commands, the following sequence is recommended. First, the 22kHz tone, if present, is interrupted. After a pause, the DiSEqC information follows, after another pause, the tone burst (SA/SB burst, will be described in 8.1) and after a third pause the 22kHz tone is switched on again if needed. The remote fed voltage can, as depicted, also be switched before or after the tone burst. The pause after the DiSEqC message must last so long that a slave can send its reply to the DiSEqC 2.0 receiver in time before the ToneBurst.

7 Example of a DiSEqC Data Transfer

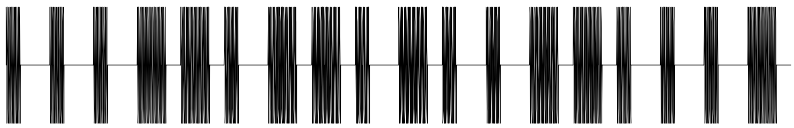
1. The satellite receiver would like to question the connected multiswitch about its switch settings.
2. The frame byte of the master is called E2, the address of the multiswitch is 14 and the command to request the switch settings is also 14. The DiSEqC data is therefore E2 14 14.
3. The bit flow, converted into single bits and containing the parity bits, looks as follows:

1 1 1 0. 0 0 1 0.(1) 0 0 0 1. 0 1 0 0.(1) 0 0 0 1. 0 1 0 0.(1)

4. The resulting PWK bursts look like this:



5. The slave answers as follows:



6. The answer converted in bits is:

1 1 1 0. 0 1 0 0.(1) 0 1 1 0. 0 1 1 1.(0)

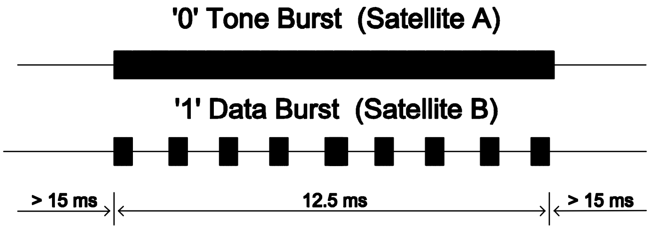
7. The parity bits of the answer are tested and found valid.
8. The hexadecimal answer is E4 67.
9. The slave confirms with E4 the validity of the request.
10. The committed switches byte is analyzed (see 5.0):
    - "Polarization," "Band" and "Position" are selectable
    - "Option" is fixed (nonselectable)
    - Current selection is "horizontal polarization," "low-band," "satellite system B"
    - "Option" is (fixed) at A

8 Compatibility with Dated Equipment

Since non- DiSEqC receivers should still be able to operate with modern periphery components, DiSEqC components must be compatible with analog control signals. DiSEqC components react to the corresponding analog control signals until a valid DiSEqC command is received. After that all analog control signals are ignored.

8.1 The Analog Control Signals

For the selection of the polarisation plane the height of the remote supply voltage is used, about 14V for vertical and 18V for the horizontal polarisation plane. The threshold level is between 15V and 15.5V.
The frequency band (Low band from 10,7 to 11.7GHz, High band from 11,7 to 12.75GHz) is selected using a tone signal (22kHz, 0.5Vpp) modulated onto the remote power, the tone selects the High band.
The third standard analog control signal (to select the satellite system) is a special feature. In the beginning development stages of DiSEqC, the industry demanded to first define a further, very simple analog criterion to be able to select the satellite system with dual feed installations. The control signal should be added into a receiver as easily as possible and should be compatible with DiSEqC. The result was a tone burst that had the approximate form of a one byte long DiSEqC command. This is where the term "Simple-one-Byte DiSEqC" first appeared. But since slave components were offered under the misleading description "DiSEqC compatible" which only detect the tone burst but not the actual DiSEqC information (see DiSEqC level), the marketing aid "DiSEqC" was retracted from the pulse sequence. The correct description of the signal is "ToneBurst."



8.2 DiSEqC Control

DiSEqC commands are directly named after their use and are compatible with the previous standardized analog switch criteria. The basic switch criterion is called "polarization." In order for the analog polarization switching to continue to function, slave components contain an additional comparator which checks the level of remote fed voltage and informs the DiSEqC slave microcontroller of it.
The control for selecting the frequency band is called "band" and is compatible with the 22kHz tone. Since DiSEqC transfer is also based on the 22kHz tone, the bus modem and the slave microcontroller can detect the continuous tone without additional hardware, too.
Since the ToneBurst used to switch between the satellites of two orbital positions is based on the 22kHz tone as well, it can be detected directly from the slave, too. The corresponding DiSEqC command is called "position."
DiSEqC 1.0/2.0 makes a further control signal available; the designation is “Option“. Within most receivers the “Option” bit is used to extend the “Position” control up to 4 full-band satellite systems (example in 9.2.1).

9 Combination of DiSEqC Components

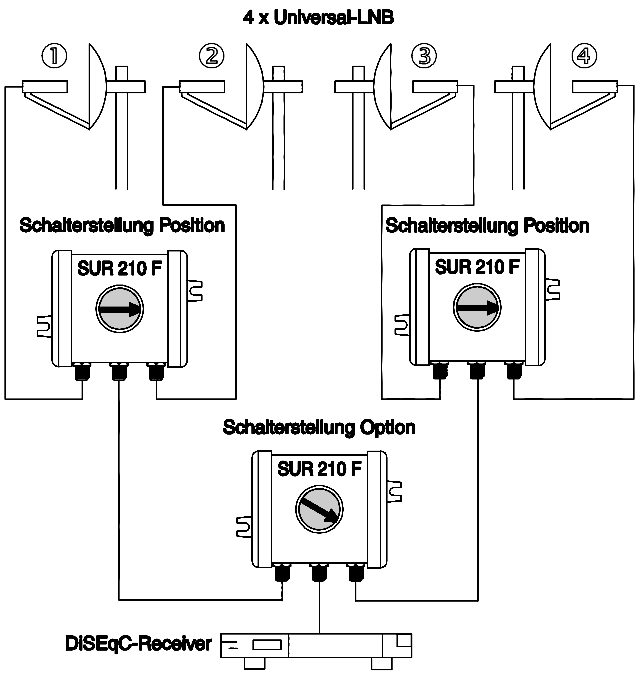
Since it is possible with DiSEqC to control all available receiving satellite components, it is possible for several DiSEqC components to be installed in one system. In therory, parallel and cascaded operation is feasible.

9.1 Parallel Operation

When using parallel operation, all of the components are always connected to the bus; therefore special administration is necessary. Since it may occur that several identical components (with the same address and function) are connected simultaneously to the bus, collision recognition is implemented in the system. Additional address space is available to readdress the components. To control all this the DiSEqC master (satellite receiver) must have a very complex software code. Also, the distribution of the high frequency has its problems.

9.2 Cascaded Operation

The simplest way to connect several components to the receiver is to cascade with loop-through components. By doing so, the signal path from the receiver is distributed in each component. Since the components mostly differ in the switching criterion, a general family address is often possible. But it must be noted at this point that the slaves located behind the first changeover switch "do not respond“ to the first DiSEqC command. It is therefore necessary that the satellite receiver either puts out the various DiSEqC commands in the right order or repeats the complete path description (command 38) often enough. Up to three cascaded components are supported in DiSEqC systems.



9.2.1 Example

Cascade operation can be studied in the four-satellite example system to the right. A program is received from the fourth antenna, which is in high band and vertical. This results in the following:

Option = 1
Position = 1
Polarization =0
Band = 1

Command 38 should be used for control. Its data byte is comprised of the first nibble to erase the previous condition byte and the second nibble, which forms the new condition bits. When the second half byte contains the complete IF-path description, all "old" condition bits can be erased with the nibble byte for simplification. The nibble becomes "F." The example bits for setting are put together in decreasing order (1101) result in the nibble "D." "FD" results as a data byte.
Let’s say we are on antenna 2 and want to switch to antenna 4, the receiver sends the DiSEqC message E0 10 38 FD, which is received by all components in the path to LNB 2. LNB 2 and the left universal relay can respond to the message if need be, but the bottom relay - which is configured as an option switch and therefore only evaluates the option bit - switches the IF path to the right relay.

Since the right universal relay (configured as position changeover switch) was only switched to the IF path after the DiSEqC message, it is still in its initial position. The path leads therefore to LNB 3.
The receiver must now send the DiSEqC message a second time. This is simultaneously received by the bottom and right universal relay, as well as by LNB 3. The bottom universal relay again finds the option bit set and keeps its switch position. The right relay receives the position bit and switches to LNB 4. After the second DiSEqC message the remote voltage is switched over and the 22kHz audio tone is switched on (for high band selection, as in the example). With DiSEqC LNBs, the DiSEqC message is sent a third time before that.
Receivers with the DiSEqC logo must be able to repeat the messages. The number of repeats often can be set in the installation menu of the satellite receiver and must at least equal the number of cascading levels, but too many repeats slow down switching.

10 DiSEqC Level

To classify the various DiSEqC components according to their performance, various DiSEqC levels were defined.

10.1 Slave Components

Slave components are all DiSEqC components e.g. LNBs, relays and multiswitches.
Components, which are unfortunately named “**DiSEqC compatible**“, can analyse only the ToneBurst, not however real DiSEqC commands.

- **DiSEqC 1.0** components react to the committed DiSEqC commands (Band, Polarisation, Position, Option), however the Slave cannot send a reply to the receiver.
- **DiSEqC 1.1** components react to the uncommitted switches, which are four additional control signals so that up to 256 IF signals can be controlled.
- **DiSEqC 1.2** components can control steerable dishes.
- **DiSEqC 2.0** components react to the DiSEqC commands for the committed switches and can send a reply for acknowledgement. Additionally the configuration bytes of the components can be read out, which enables an automatic receiver installation.
- **DiSEqC 2.1** are as 1.1, but reply possible.
- **DiSEqC 2.2** are as 1.2, but reply possible.

10.2 Master Components

Also for the DiSEqC master (the receiver) different DiSEqC levels are defined:

- **DiSEqC 1.0** receiver can create all four fundamental DiSEqC commands (polarisation, band, position, option; the committed switches), but are unable to recognise a slave reply.
- **DiSEqC 1.1** receivers can in addition to the level 1.0 commands create a further four further DiSEqC control signals (uncommitted switches).
- **DiSEqC 1.2** receiver can control in addition to the level 1.1 a steerable dish.
- **DiSEqC 2.x** receivers have the same control possibilities as DiSEqC 1.x receivers, however bi-directional communication between receiver and the Slave component is possible, e.g. for automatic installation or error diagnosis.

11 System Compatibility

A system can only be successful when the components of various manufacturers function with one another without problems. EUTELSAT manages a library of components from all manufacturers, so that all possible combinations can be adjusted. In addition, all manufacturers of DiSEqC components have a “DiSEqC reference test tool”, with which all systems parameters can be tested. In the case of an occurring incompatibility despite these measures, all manufacturers using the protected DiSEqC logo are obligated to correct this on a practical technical level.

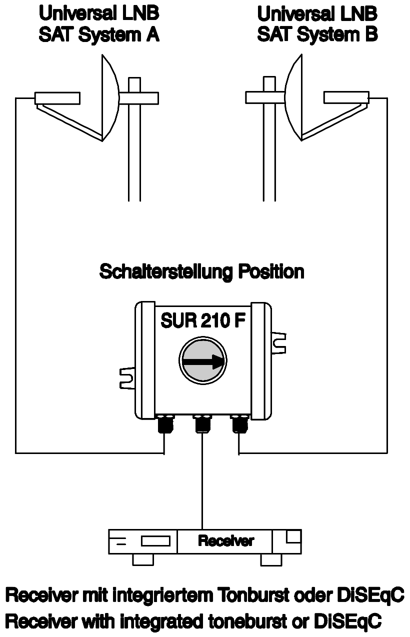
12 Conclusion

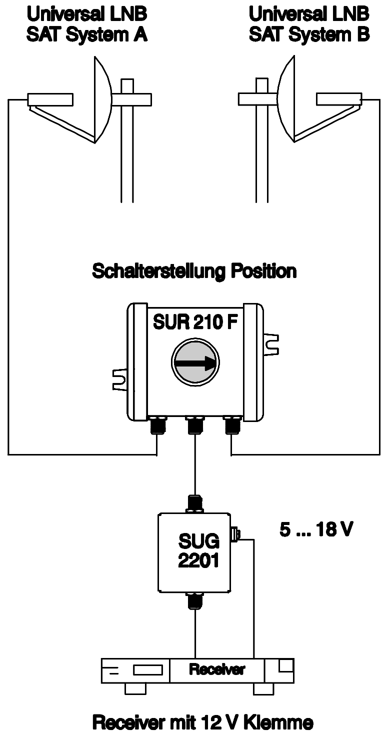
A very flexible, efficient, and cost-effective system supported by all well known manufacturers, DiSEqC has successfully set the standard for satellite reception components. It is important, however, that dealers and installers also be informed about DiSEqC and its potential in order to understand the new technology and to use it effectively to keep the customer happy. Eventually, the analogue control signals will have the same fate as the mechanical polarizer has in Ku-band transmissions: standard only some years ago, but almost forgotten today.

If you would like to obtain more information about DiSEqC, complete specifications documents may be downloaded from the Internet (http://www.eutelsat.org/press/diseqc.html).

DiSEqC™ is a trademark of EUTELSAT.

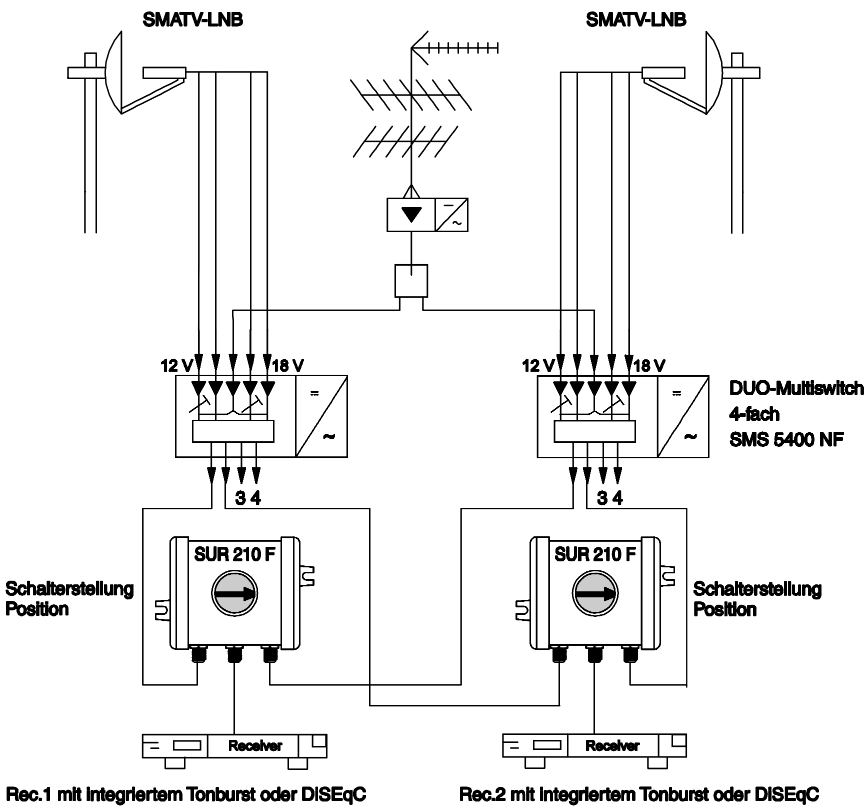
Examples of How SPAUN-Products are Used:
Single Reception System



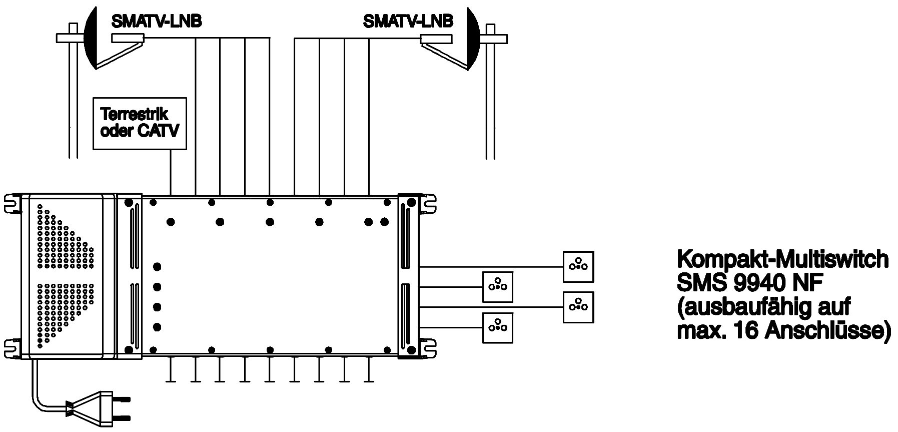


Multi Distribution System

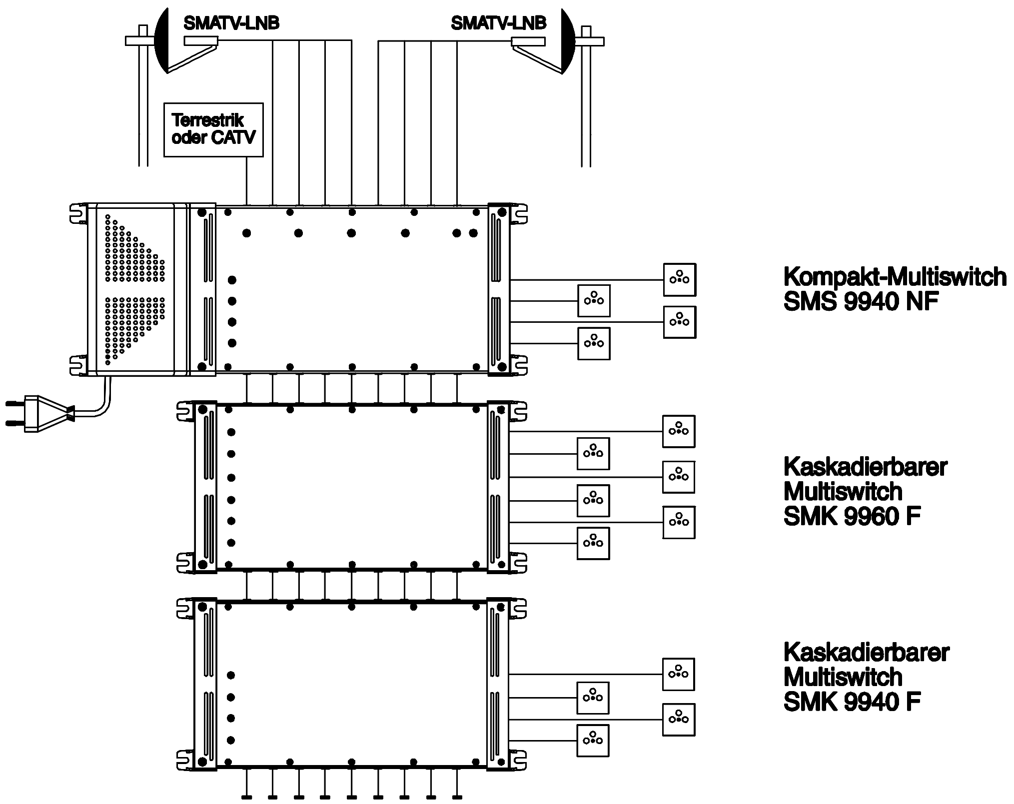
Increase from 4 to 8 levels:



Multi Distribution System for 4 Receivers



Multi Distribution System for 14 Receivers



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