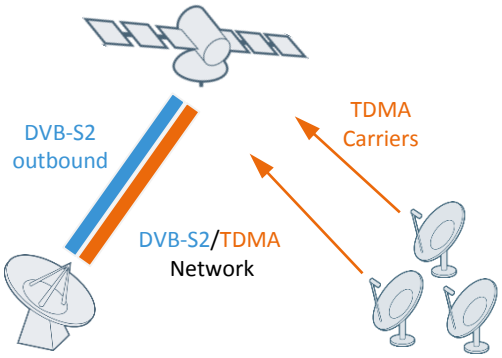
ND SATCOM

SKYWAN 5G DVB
ADVANCING DVB-S2 & TDMA TECHNOLOGY

The SKYWAN 5G DVB solution is a two-way broadband satellite communication network for high quality services using the widely adopted DVB-S2/S2X transmission standard and the ND SatCom MF-TDMA technology.
SKYWAN 5G DVB comprises a DVB-S2 outbound link and one or several TDMA carriers. SKYWAN 5G DVB performs content-based routing and leverages DVB-S2/S2X and TDMA satellite access for highly-efficient bandwidth utilization to best fit the end users' applications.

The multi-service platform offers transmission of broadcast services, interactive services like Internet or database access, data content distribution, and trunking.
The fully IP-based system provides seamless integration to terrestrial IP networks on both ends, the central hub, and the remote terminals.



PLUG AND PLAY

- Simple integration of DVB Gateway at hub or any other terminal or site
- Remote DVB-S2 receiver configuration based on simple NMS Web-UI
- Automatic ACM configuration
- Automatic terminal registration at central site
- Automatic path selection over broadband DVB-S2/S2X or TDMA link controlled by hub router

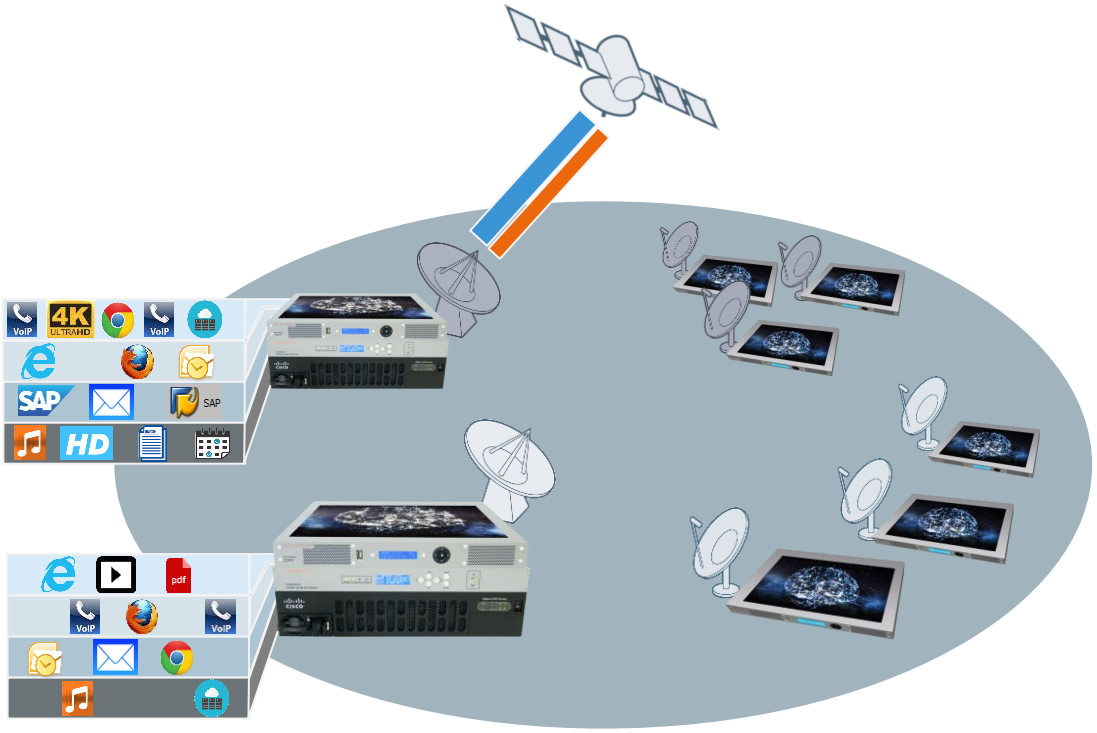
Key Features

- Multi-service IP platform
- Built-in Dual Demodulator (DVB-S2 & TDMA) in each SKYWAN 5G remote terminal
- Fast ACM control loop
- System design enables and supports multiple DVB outbounds independent of site location
- DVB-S2/S2X: Statistical multiplex in outbound is very efficient for point-to-multipoint applications
- TDMA: Statistical multiplex for both out- and inbound – flexible, efficient, high-quality service
- Content or application-based routing based on administrative rules

DVB-S2 & TDMA Solution Overview

If traffic analysis shows the need for broadband point-to-multipoint links in SKYWAN 5G networks, one can simply add these connections based on DVB-S2 links.
DVB-S2 links within SKYWAN 5G networks may be established by deploying one or multiple DVB traffic hub sites in a network. Each DVB traffic hub supports a unidirectional data connection to a dedicated group of SKYWAN 5G remote stations with a potentially very high data rate. Since every SKYWAN 5G indoor unit contains a DVB-S2 receiver, every SKYWAN 5G station in the network can be configured to be a DVB remote station. Data traffic from the remote stations to the hub or between remote stations will use the TDMA satellite link. This is also true for the network management connection and the signaling between hub and remote stations, making these data connections independent from the DVB link. Therefore, it is also possible to reconfigure the DVB links from the central Network Management System at any time.

Customers thus benefit from the synergy of both satellite data-transfer methods:
1) the flexibility and network efficiency of MF-TDMA and 2) the spectral efficiency of DVB-S2, both resulting in an optimal use of costly satellite bandwidth.



DVB Traffic Hub

The following three devices form a DVB traffic hub:

- IP router or layer-3 switch supporting the dynamic routing protocols BGP and OSPF
- DVB/IP Gateway ODG 200
- SKYWAN 5G

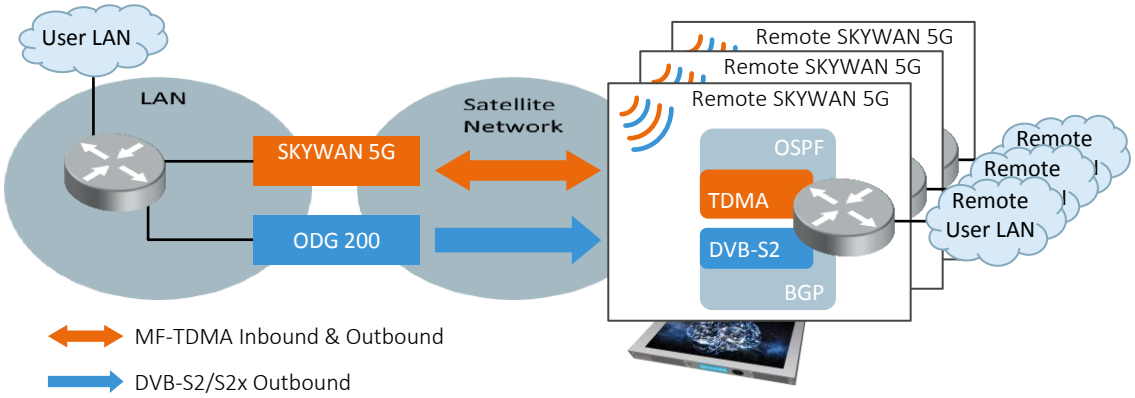
The hub IP router forwards to the DVB Gateway the user traffic that will be transferred over the DVB-S2 broadband link to the remote sites. The hub IP router forwards to the attached user LAN the user traffic coming from the remote networks via the hub SKYWAN station.If the DVB link fails, the dynamic routing protocols allow for automatic rerouting of user traffic to the remote networks via the SKYWAN TDMA link.
The DVB Gateway encapsulates IP traffic received from the hub router in a DVB MPEG2 Transport Stream using either Multiprotocol Encapsulation over DVB (MPE) or Unidirectional Lightweight Encapsulation (ULE) and forwards it over the DVB-S2 satellite link.
The SKYWAN 5G IDU within the hub station forwards to the hub router data traffic received from the remote stations via the SKYWAN TDMA satellite link. It also forwards management and signaling data to the remote stations and may forward real-time user traffic over this TDMA outbound.

DVB Network Topology

The SKYWAN 5G DVB Solution stands out in the market through the synergy of the MF-TDMA core network and the integrated alternative transport method DVB-S2/S2X. The fully IP-based WAN transfer network is transparent to the users and seamlessly integrates to the customer's LAN by utilizing standards well known in terrestrial networks:

- Ethernet as LAN interface
- OSPF for dynamic routing within autonomous systems
- BGP to exchange routing and reachability information among autonomous systems

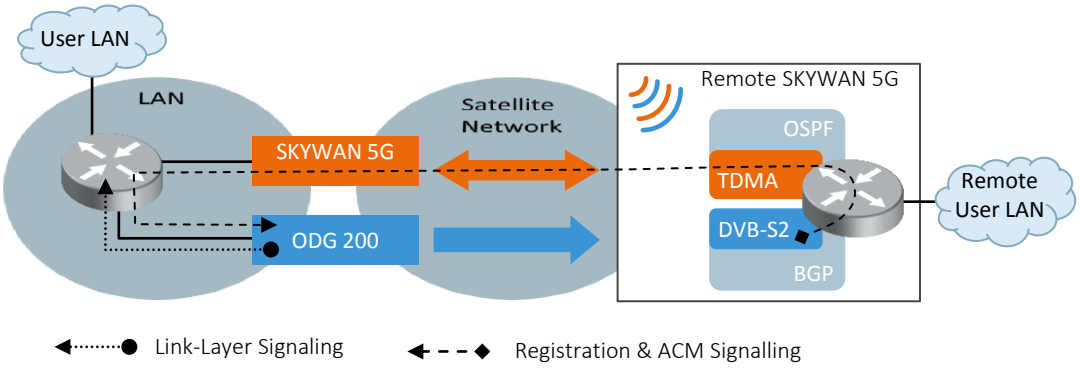
The hub router interconnects the user LAN with the SKYWAN 5G and the Open DVB Gateway based on Ethernet connections. The hub router selects the forwarding path to the remote user LAN.



Network Benefits

The MF-TDMA core network carries user traffic and signaling data, thus providing a wide range of network advantages:

- Automatic registration of the DVB remote terminal at Open DVB Gateway ODG200
- DVB service provision and configuration changes for the point-to-multipoint connections that are enabled any-time
- Immediate detection of link issues and reaction to it based on dynamic routing protocols
- Fast ACM loop (100ms…1s) based on feedback from the remote terminals to select optimum ModCod for transmission
- Policy-Based Routing using best transport link for the service



Auto Registration, Link-Layer Signaling

Once the remote SKYWAN 5G is authenticated in the MF-TDMA network, the built-in DVB-S2 receiver automatically registers itself at the DVB Gateway. Based on the registered terminals, the DVB Gateway responds to ARP requests from the hub IP router and forwards user data to the remote networks.

Adaptive Coding and Modulation (ACM)

ACM allows the transmission parameters to be changed on a frame-by-frame basis, depending on the particular delivery path conditions for each individual user. ACM signaling between the remote DVB receivers and the DVB Gateway is exchanged automatically on a regular basis. The ODG200 ACM controller keeps track of each modem's feedback and resolves problems arising from, e.g., fast changing reception quality ("feedback implosion") or single modems constantly reporting bad reception quality ("crying baby"). The ACM controller provides the necessary information for adaptive coding and modulation to the IP/DVB transmission stack so the modulator utilizes the optimum ModCod for transmission to the respective remote terminal or group of terminals.

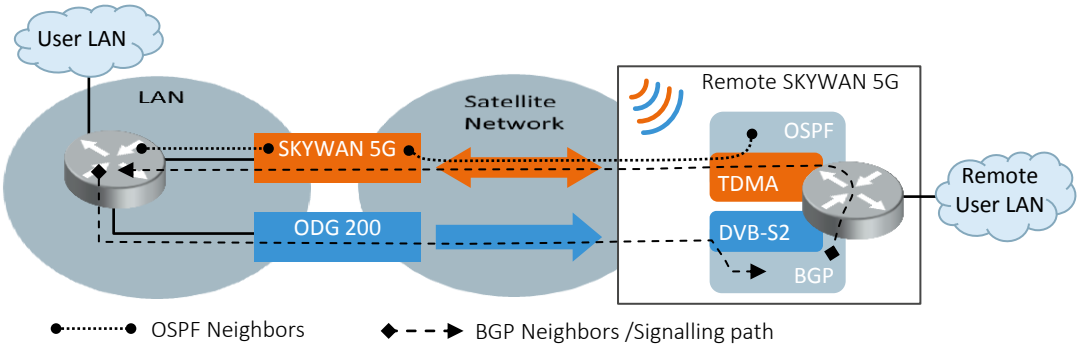
Other vendors' DVB Gateways or DVB modulators can operate with the SKYWAN 5G DVB-S2 receiver in a static set-up without the benefit of auto registration, ACM, and signaling of receiver availability.

User Traffic Forwarding, Path Selection

The hub IP router selects the forwarding path based on routing information maintained by OSPF, BGP, and administrative rules (Policy Based Routing) to use the link that best fits the application. Traffic requiring minimum guaranteed datarates or strict real-time voice forwarding should use the TDMA link. It is crucial that delay- and jitter-sensitive applications such as voice always take the best path through the network, i.e. the TDMA link. Data traffic, on the other hand, can be offloaded through the bigger DVB pipe and benefit from its spectral efficiency.

In the TDMA network and the attached data network, OSPF is used to dynamically learn the topology, detect the link status, and adapt to link failures within seconds. The DVB link routes are propagated using BGP where the remote SKYWAN 5G modem is peering with the hub router. The unidirectional DVB link routes are only propagated if the DVB link is established. Thus, if the BGP peer session breaks, the hub router has a clear indication that the DVB link is unavailable and can forward the user data on the TDMA link as backup. In this case the SKYWAN 5G QoS function ensures that important traffic is prioritized.

Note:
- A BGP license is not required to enable and operate the DVB service on SKYWAN 5G
- The DVB Gateway is operating in bridge mode.



DVB-S2/S2X Link and Service Characteristics

DVB is a widely adopted transmission standard that multiplexes IP data for one or multiple destinations into a single TDM outbound. It uses a powerful FEC system based on concatenation of BCH with LDPC inner coding to deliver performance that approaches the theoretical Shannon limit. The focus on spectral efficiency using an outer block code adds extra processing time in the forwarding path, which is negligible for most services.
DVB-S2 defines two FEC Frame sizes, namely short (16200 Bit) and normal (64800 Bit), whereas DVB-S2X introduces an additional medium FEC Frame (32400 Bit).

DVB-S2/S2X is best suited for:
- Star type networks
- Broadcast services
- Interactive services like Internet or database access
- Data content distribution
- Trunking

MF-TDMA Link and Service Characteristics

SKYWAN 5G uses the MF-TDMA access scheme for outbound and inbound, delivering the highest quality to users with superior performance based on Turbo-Φ coding. Turbo-Φ sequentially encodes and decodes data without adding extra processing time in the forwarding path. The FEC Frame size is set individually per carrier and can range from 1600 Bit up to 24000 Bit. The optimum FEC Frame size is based on the transferred services and is designed with the TDMA calculator tool.

MF-TDMA links are best suited for:
- Voice and video
- Real time services requiring QoS, low jitter (< 4 ms)
- Exceptional VoIP service quality (e.g. MOS 4.0 for G.729, proven with Spirent TestCenter SPT-3U with Hypermetrics Extension Card)
- Carrier grade links
- Services with guaranteed datarates – no throttling, i.e., fading during bad weather is compensated by raising power

Glossary			
DVB	Digital Video Broadcasting	BGP	Border Gateway Protocol, RFC 4271
DVB-S2/S2X	EN 302307-1 / EN 302307-2	OSPF	Open Shortest Path First, RFC 2328
ACM	Adaptive Coding and Modulation	ARP	Address Resolution Protocol, RFC 826
FEC	Forward Error Correction	QoS	Quality of Service, RFC 2475 DiffServ / 2597 Assured Forwarding / 3246 Expedited Forwarding
ModCod	Modulation and Coding	TDMA	Time Division Multiple Access
ULE	Unidirectional Lightweight Encapsulation	MF-TDMA	Multi Frequency TDMA
MPE	Multi Protocol Encapsulation	TDM	Time Division Multiplex
GSE	Generic Stream Encapsulation	MOS	Mean Opinion Score
BCH	Bose-Chaudhuri-Hocquenghem	LDPC	Low Density Parity Check

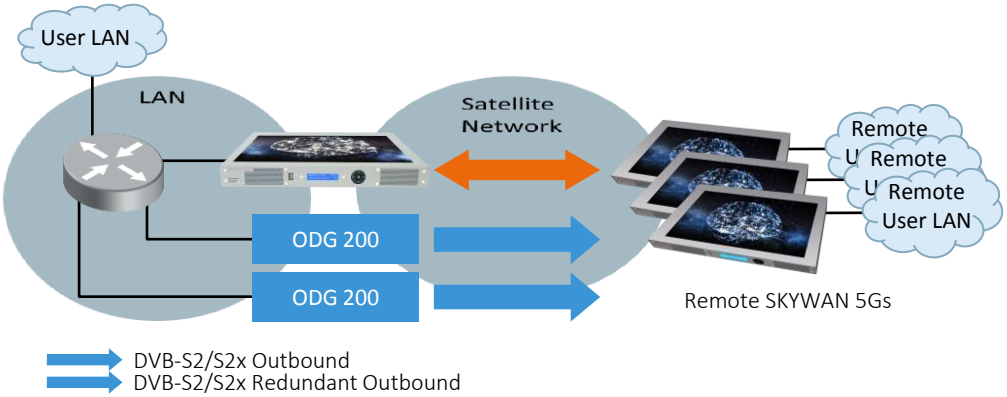
Growth Scenarios: Network Extensions, Options

The SKYWAN 5G DVB solution architecture is scalable and offers a high degree of flexibility for network extensions. The folllowing are a few examples.

1. Multiple DVB Outbounds, Redundancy

With an additional DVB Gateway installed at a site, one can implement redundancy or use it as just another DVB-S2/S2X outbound in parallel to address more users.

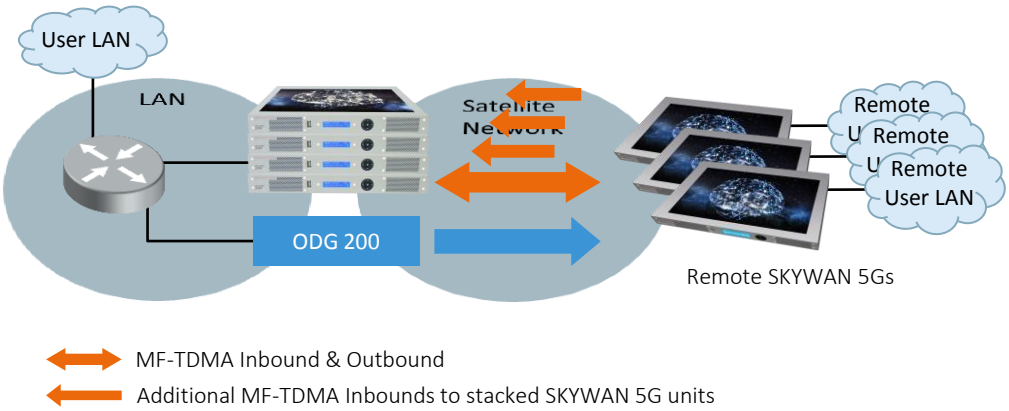
In the case of hot and standby gateways located in the same LAN, redundancy switching using the Virtual Router Redundancy Protocol (VRRP) is implemented.



2. Increased Return Link Capacity

When the network is growing and the number of users is increasing, one may require the need for higher return link capacity to the data hub.

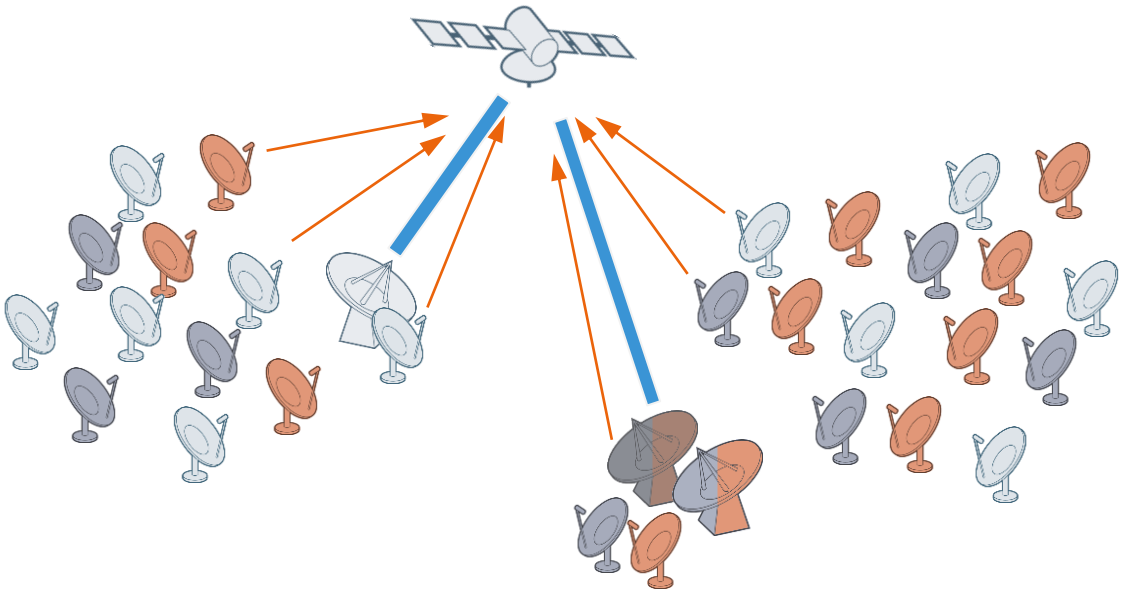
SKYWAN 5G units can be stacked easily to increase the inbound data throughput from 20 Mbps up to 80 Mbps per TDMA stack.



3. Network Example

With SKYWAN 5G DVB, networks can grow from one MF-TDMA network segment with one DVB traffic gateway to multiple MF-TDMA network segments with several locations for application-driven DVB traffic injection points.

Such highly complex networks are typical of larger companies with multiple affiliates and several regional headquarters. This is also the case for organizations where connectivity to Internet or Cloud services requires more than one DVB Gateway for both security and traffic volume reasons.
With the existing routing protocol support, sub-organizations and affiliates may use individual MF-TDMA networks and also share a global infrastructure implemented by the DVB-S2/S2X outbound links.




Traffic Hub serving a group


Traffic Hub serving two groups


Hot-Standby Traffic Hub serving two groups

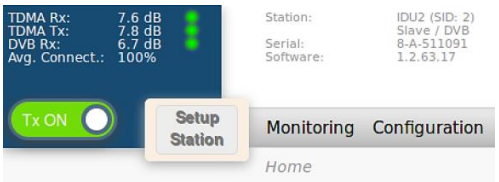
DVG Gateways transmitting to multiple TDMA network segments benefit from the redundancy capability while each TDMA network segment uses SKYWAN Master/ Backup Master to ensure 100% availability.

SKYWAN 5G – The ONE

MF-TDMA Core Network & DVB-S2 Remote

The SKYWAN 5G [1] satellite router provides the MF-TDMA core network and is used in the hub and at all remote locations. The SKYWAN 5G NMS manages the DVB outbound and the built-in DVB-S2 receivers. The SKYWAN 5G software supports DVB services and the built-in DVB receiver.
Terminals with active DVB receiver combine and forward IP traffic to the user LAN. The return traffic always uses MF-TDMA.
The seamless integration and automated processes allow for easy configuration and operation of the DVB service.

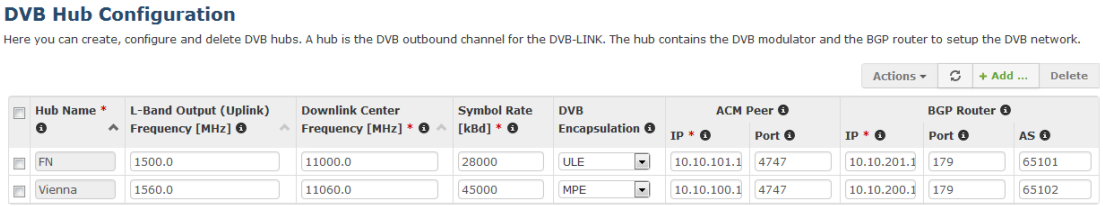
SKYWAN 5G: Front side & back side



SKYWAN 5G Web-UI showing status information for DVB and TDMA links

DVB Service Provision

Using the SKYWAN 5G NMS, only two easy steps are required to activate the DVB service and bind a terminal to its hub. The first step: the DVB Gateway transmitter parameters, the encapsulation, ACM, IP addresses, and BGP are defined. Multiple DVB gateways can be specified and used in the network. The NMS configures the DVB Gateway transmitter parameters using the ODG200 management IP interface.



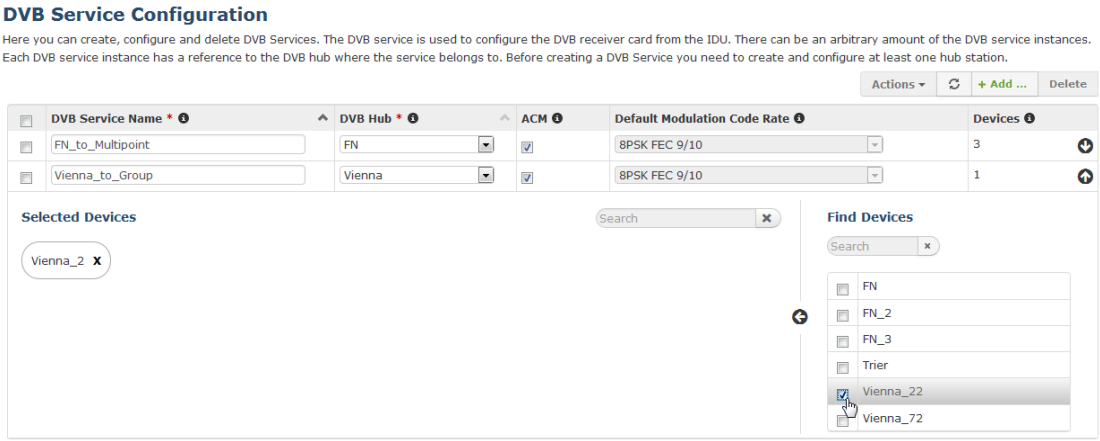
DVB Hub Configuration

Here you can create, configure and delete DVB hubs. A hub is the DVB outbound channel for the DVB-LINK. The hub contains the DVB modulator and the BGP router to setup the DVB network.

Actions | + Add ... | Delete

Hub Name *	L-Band Output (Uplink) Frequency [MHz]	Downlink Center Frequency [MHz] *	Symbol Rate [kBd] *	DVB Encapsulation	ACM Peer IP *	ACM Peer Port	BGP Router IP *	BGP Router Port	BGP Router AS
FN	1500.0	11000.0	28000	ULE	10.10.101.1	4747	10.10.201.1	179	65101
Vienna	1560.0	11060.0	45000	MPE	10.10.100.1	4747	10.10.200.1	179	65102

The second step: the remote SKYWAN 5G built-in DVB receivers are assigned to the desired hub in the DVB Service Configuration simply by point and click. Setup and changes to the DVB service can be done on the fly anytime as all SKYWAN 5G units stay connected over the MF-TDMA core network.



DVB Service Configuration

Here you can create, configure and delete DVB Services. The DVB service is used to configure the DVB receiver card from the IDU. There can be an arbitrary amount of the DVB service instances. Each DVB service instance has a reference to the DVB hub where the service belongs to. Before creating a DVB Service you need to create and configure at least one hub station.

Actions | + Add ... | Delete

DVB Service Name *	DVB Hub *	ACM	Default Modulation Code Rate	Devices
FN_to_Multipoint	FN	✓	8PSK FEC 9/10	3
Vienna_to_Group	Vienna	✓	8PSK FEC 9/10	1

Selected Devices: Vienna_2 x

Search

Find Devices: FN, FN_2, FN_3, Trier, Vienna_22, Vienna_72

Technical Specifications: SKYWAN 5G [1]

General		
Ethernet	4 onboard GbE, RJ-45	
User Data Throughput	Tx 20 Mbps/Rx up to 80 Mbps per stack, plus 40 Mbps receive on DVB-S2 Switching packet rate up to 65,000 pps	
Ordering Options		**Order Code**
SKYWAN 5G	THE ONE hardware fits any location.	E-11B14129
Software licenses	No BGP license is required to enable and operate the DVB service on SKYWAN 5G. Required software features are based on engineering.	

[1] For full specification refer to the SKYWAN 5G datasheet

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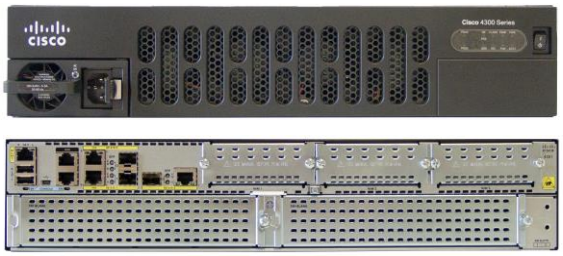
Traffic Hub IP Router

ND SatCom offers a Cisco 4000 Series Integrated Services Router (ISR) as hub IP router. The specific model is a Cisco ISR 4351.



Cisco ISR 4351: Front side & back side

The Cisco 4351 is validated as hub IP router in the SKYWAN 5G DVB solution.
The hub router is responsible for:

- Outbound traffic analysis
- Outbound path selection (TDMA or DVB)
- Dynamic routing on DVB receiver availability

Mandatory Router Characteristics & Functions

- 3 LAN Ethernet ports
- BGP (RFC 4271)
- OSPF (RFC 2328)
- Consistent performance for concurrent services
- Policy-Based Routing

Benefits with Cisco ISR 4351

- ISR model 4351 is validated
- Can easily expand your branch offices with these industry-leading router capabilities:
  - Networking, services, computing, and storage integrated into a single form factor
  - Consistent, gigabit performance while multiple services run concurrently
  - Modular Cisco IOS® XE Software that quickly adapts to changing needs
  - Integrated Cisco Intelligent WAN features, including application awareness, quality of service, and WAN optimization
  - SDN-based automation of IWAN feature configuration with IWAN app
  - Comprehensive security with VPN options, threat defense services, and consistent policy enforcement
  - Trust Anchor Technologies protects against modern cyberattacks as well as counterfeit and unauthorized modification of hardware and software
  - A range of WAN access connectivity options such as 4G LTE, T1/E1, T3/E3, xDSL, serial, and fiber Gigabit Ethernet
  - Auto-configuration of Cisco Intelligent WAN features helps deliver software-defined, wide-area networking (SD WAN) to enterprise networks

Technical Specifications: Cisco ISR 4351 [1]

General Features			
Ethernet	3 onboard GbE, RJ-45		
Aggregate Throughput	200 Mbps to 400 Mbps (license upgrade)		
Default memory DDR3	4 GB		
Physical / Environmental			
Dimensions (H x W x D)	88.9 x 438.15 x 469.9 mm (2RU, width 19", rack-mountable)		
Weight (no modules)	13.1 kg (packaging adds 2.9 kg)		
Input Power / Frequency	100 to 240 VAC autoranging, 47 to 63 Hz		
Typical Power (no modules)	48 Watt		
Temperature	Operational: 0°to 40° C	Storage: -40° to 70° C	
Relative Humidity	Operational: 5% to 85%	Storage: 5% to 95%	
Ordering Options			**Order Code**
Cisco Router 4351	External router with BGP support for automatic path routing between Gateway and IDU; provides 3 LAN ports		F-30B16254

[1] For full specification refer to Cisco webpage

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Open DVB Gateway ODG200

The ODG200 DVB Gateway combines an IP encapsulator, which supports state-of-the-art encapsulations such as ULE or GSE [1], and a fully DVB-S2/S2X compliant modulator. The SKYWAN 5G remote DVB-S2X [2] receivers support ACM feedback.

The ODG200 DVB link in the SKYWAN 5G solution transmits data on an outbound link after automatic authentication and registration of the SKYWAN 5G remotes. DVB link availability information from the ODG200 enables the hub IP router to perform dynamic service-based routing either using TDMA links or the DVB-S2/S2X link.

The ODG 200 is an encapsulator and traffic shaper that combines real-time traffic shaping functionalities with robust and efficient IP encapsulation software. It is also a high-quality, wide-output range DVB-S2/S2X modulator. This high integration level allows for easy installation of the ODG200 at the hub side of a DVB-S2/S2X enabled IP network.

A direct interface to the modulator gives the ODG200 full control over modulation and coding parameters on a per-frame basis, which allows for optimum operation in VCM/ACM mode, where the included ACM controller implements the ACM feedback interface. The ACM controller monitors the signal reception conditions at the remote sites of the network and selects either automatically or based on operator constraints the most efficient modulation and coding parameters for each BB-Frame. The satellite link budget is therefore always used most effectively.

Traffic-shaping policy is applied to the dedicated data input interface of the ODG200, consisting of a hierarchical, priority-based shaper, that organizes traffic on a per-user or group-of-users basis. The shaping algorithm manages different traffic classes such as constant bit rates (CBR), variable bit rates (VBR), and best effort (BE), allowing for an adaptive, equal, or weighted bandwidth distribution.

The ODG200 meets the highest production quality standards and includes local redundancy for fast and seamless switchover through the Virtual Router Redundancy Protocol (VRRP).

Key Features

- ODG200 firmware optimized for integration with SKYWAN 5G (ACM, auto registration, path selection)
- Constant Coding and Modulation (CCM), Variable Coding and Modulation (VCM), and Adaptive Coding and Modulation (ACM) operation modes
- Carrier ID support
- DVB-S2 and DVB-S2X compliant (EN 301421, EN 302307)
- Wide L-Band output range from 950 – 2150 MHz
- QPSK / 8PSK / 16APSK / 32APSK modulation
- 15/30/45 Msps output rates, field upgradable
- Support for MPE, ULE, and GSE encapsulation (MPE section packing, ULE & GSE extensions)
- Full IPv4 / IPv4 multicast4 / IPv6 support [3]
- Adaptive traffic shaping and policing
- Automated interfacing with remote SKYWAN 5G receivers supporting ACM
- Web based device configuration
- Management and configuration
  - LCD front panel
  - Operator console
  - Web interface
- SKYWAN 5G NMS controls RF parameters
- Monitoring
  - SNMP
  - Alarm output with dual switch contacts

Technical Specifications: ODG200

DVB-S2/S2X Output Characteristics	
IF Output Frequency	950 to 2150 MHz
IF Output Characteristics	Frequency Resolution: 1 Hz Impedance: 50 Ω Return Loss: >20 dB Output Power: -30 dBm to 0 dBm, 0.1 dB steps Accuracy: ± 0.5 dB Stability: ± 0.5 dB Output Power muted: < -85 dBm
IF Monitoring Output	Impedance: 50 Ω Return Loss: >20 dB Output Power: -20 dB of IF Output
Spurious Outputs (signal related)	< -70 dBc (unmodulated carrier, 950 to 1900 MHz) < -55 dBc (unmodulated carrier, 1900 to 2150 MHz) < -45 dBc (unmodulated carrier, out of band)
Phase Noise	10 Hz: -65 dBc/Hz 100 Hz: -75 dBc/Hz 1 kHz: -88 dBc/Hz 10 kHz: -90 dBc/Hz 100 kHz: -100 dBc/Hz 1 MHz: -115 dBc/Hz
Frequency Stability	± 5 x 10^{-8} (-30°C to 60°C); aging: ± 1 x 10^{-9} per day, ± 1 x 10^{-7} per year
Symbol Rate	Up to 45 Msps (depending on order code[4]); Step size: 1 Sym/s
Clock Stability	± 5 x 10^{-8} (-30°C to 60°C); aging: ± 1 x 10^{-9} per day, ± 1 x 10^{-7} per year
Data Rate	3 KBit/s to 115 MBit/s (depending on order code)
Modulation/Encoding in DVB-S2	Outer Coding: short and long frames (16200 and 64800 bits) Inner Coding (LDPC) [1]: QPSK: 1/4, 1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5, 5/6, 8/9 8PSK: 3/5, 2/3, 3/4, 5/6, 8/9, 9/10 16APSK: 2/3, 3/4, 4/5, 5/6, 8/9, 9/10 32APSK: 3/4, 4/5, 5/6, 8/9, 9/10
Signal Spectrum Mask	DVB-S2: α = 0.35, 0.25, 0.20 DVB-S2X: α = 0.35, 0.25, 0.20, 0.15, 0.10, 0.05

Interfaces	
IF Output	2x SMA female
Control Network	GbE, RJ-45
Data Network	GbE, RJ-45
Local Control & Management	2x USB2.0, VGA, LCD / operation keys
Alarm	Dual change over switch contacts, DSUB-9 (F)
Power	IEC-60320-C14 style Connector, 2P+E (single phase)

Physical / Environmental	
Dimensions (H x W x D)	44 x 482 x 365 mm (1RU, width 19", rack-mountable)
Weight	4.6 kg
Temperature Ranges	Operational: 0°to 40° C Storage: 0° to 70° C
Input Power, Power Consumption	100 to 240 V AC with 50 to 60 Hz, < 50 Watt
Input Current	<0.8 A (RMS) at 230 V AC , <1.3 A (RMS) at 115 V AC
Compliance	Fully CE compliant with RoHS and REACH, Fully EMC compliant

Ordering Options		Order Code
ODG 200 DVB-S2X Gateway with 15 Msps	includes MPE and ULE, ACM support, ACM Controller, DVB-S2X support up to 32APSK, working in bridge mode	E-11B14267
ODG 200 DVB-S2X Gateway with 30 Msps	includes MPE and ULE, ACM support, ACM Controller, DVB-S2X support up to 32APSK, working in bridge mode	E-11B14268
ODG 200 DVB-S2X Gateway with 45 Msps	includes MPE and ULE, ACM support, ACM Controller, DVB-S2X support up to 32APSK, working in bridge mode	E-11B14269

[1] Depending on SKYWAN 5G
[2] Partly compliant
[3] Future release
[4] License upgrade for symbolrate