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DOCSIS Signal Generator

Specifications

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Definitions

General

Product data applies under the following conditions:

- Three hours storage at ambient temperature followed by 30 minutes warm-up operation
- Specified environmental conditions met
- Recommended calibration interval adhered to
- All internal automatic adjustments performed, if applicable

Specifications with limits

Represent warranted product performance by means of a range of values for the specified parameter. These specifications are marked with limiting symbols such as <, ≤, >, ≥, ±, or descriptions such as maximum, limit of, minimum. Compliance is ensured by testing or is derived from the design. Test limits are narrowed by guard bands to take into account measurement uncertainties, drift and aging, if applicable.

Specifications without limits

Represent warranted product performance for the specified parameter. These specifications are not specially marked and represent values with no or negligible deviations from the given value (e.g. dimensions or resolution of a setting parameter). Compliance is ensured by design.

Typical data (typ.)

Characterizes product performance by means of representative information for the given parameter. When marked with <, > or as a range, it represents the performance met by approximately 80 % of the instruments at production time. Otherwise, it represents the mean value.

Nominal values (nom.)

Characterize product performance by means of a representative value for the given parameter (e.g. nominal impedance). In contrast to typical data, a statistical evaluation does not take place and the parameter is not tested during production.

Measured values (meas.)

Characterize expected product performance by means of measurement results gained from individual samples.

Uncertainties

Represent limits of measurement uncertainty for a given measurand. Uncertainty is defined with a coverage factor of 2 and has been calculated in line with the rules of the Guide to the Expression of Uncertainty in Measurement (GUM), taking into account environmental conditions, aging, wear and tear.

Device settings and GUI parameters are designated with the format “parameter: value”.

Typical data as well as nominal and measured values are not warranted by Calian.

RF Characteristics

Frequency

Total frequency range, upstream	DOCSIS 3.1, ARB	5 MHz to 204 MHz
	DOCSIS 3.0	5 MHz to 85 MHz
Total frequency range, downstream	DOCSIS 3.1, DOCSIS 3.0, J.83/A/B/C, ARB	47 MHz to 1218 MHz
	with SFD-K3018, DOCSIS 3.1, ARB	47 MHz to 1794 MHz
Frequency accuracy, stability and aging		± 2 ppm
Step size of setting		1 Hz

Level

Downstream/upstream outputs

Level	DOCSIS 3.1,	39 to 59 dBmV
	DOCSIS 3.0[1], J.83/A/B/C, ARB	42 to 62 dBmV
Step size of setting		0.1 dB
Level uncertainty	max. level, 0 dB attenuation	typ. ± 0.25 dB, max. ≤ ± 1.0 dB
Maximum permissible DC voltage		± 16V

Spectral purity

SNR		> 57 dB[2]
Spurious (downstream)	50 MHz to 1000 MHz	≤ –63 dBc
	1000 MHz to 1794 MHz	≤ –59 dBc
Spurious (upstream)	5 MHz to 204 MHz	≤ –42 dBc
Single-sideband phase noise at 1794 MHz	1 kHz to 10 kHz	≤ –56 dBc
	10 kHz to 100 kHz	≤ –60 dBc
	100 kHz to 1 MHz	≤ –68 dBc
	1 MHz to 10 MHz	≤ –70 dBc
	10 MHz to 100 MHz	≤ –61 dBc

[1] Clipping free operation for S-CDMA upstream is guaranteed for levels up to and including 56 dBmV.

[2] Measured using a 192 MHz DOCSIS 3.1 channel at 59 dBmV, noise was measured 300 MHz from the center frequency.

Modulation systems

Downstream (SFD-K200 option)

DOCSIS 3.1

Modulation		COFDM
Bandwidth		24 MHz to 192 MHz
		can be set as the encompassed spectrum in MHz or by the first and last active subcarriers
Frequency		can be set as the frequency of the 0th subcarrier or as the channel center frequency
FFT size	50 kHz sub-carrier spacing	4k
	25 kHz sub-carrier spacing	8k
Guard subcarrier	FFT size = 4k (50 kHz offset from carrier)	148 to 1828
	FFT size = 8k (25 kHz offset from carrier)	296 to 3654
MER	192 MHz OFDM, internal reference	
	f < 600 MHz	≥ 50 dB, typ. 54 dB
	600 MHz ≤ f < 1002 MHz	≥ 47 dB, typ. 54 dB
	1002 MHz ≤ f < 1218 MHz	≥ 45 dB, typ. 53 dB
	1218 MHz ≤ f < 1794 MHz	≥ 45 dB, typ. 53 dB
	192 MHz OFDM, external reference, using Rohde and Schwarz FSW, 10 MHz output	
	f < 600 MHz	≥ 52 dB, typ. 57 dB
	600 MHz ≤ f < 1002 MHz	≥ 48 dB, typ. 57 dB
	1002 MHz ≤ f < 1218 MHz	≥ 47 dB, typ. 56 dB
	1218 MHz ≤ f < 1794 MHz	≥ 46 dB, typ. 55 dB
PLC location		settable, subcarrier index of lowest PLC carrier
PLC constellation		16QAM
PLC content	generated internally	timestamp MB, OCD, DPD, and null packets
	external feed	data over IP
NCP constellation		QPSK, 16QAM, 64QAM
Cyclic prefix		0 µs, 0.9375 µs, 1.25 µs, 2.5 µs, 3.75 µs, 5 µs
Windowing		0 µs, 0.3125 µs, 0.625 µs, 0.9375 µs, 1.25 µs
Exclusion band		up to 3 bands, each specified by start subcarrier and number of subcarriers

Continuous pilot parameter		48 to 120
Interleaver depth	FFT size = 4k (50 kHz subcarrier spacing)	max. 32
	FFT size = 8k (25 kHz subcarrier spacing)	max. 16
FEC codeword shortening		on/off, can be set for each profile
Number of profiles		1 to 4
Profile constellation		16QAM, 64QAM, 128QAM, 256QAM, 512QAM, 1024QAM, 2048QAM, 4096QAM
	overrange [3]	8192QAM, 16384QAM
Profile content	generated internally	MACLFSR (PRBS)
	external feed	data over IP
Advanced options		import and export of configuration files for complex channel configurations

Digital TV standards and DOCSIS 3.0

1. J.83/A (DVB-C)

Standard		ITU-T J.83 Annex A, EN 300429
Modulation		single-carrier QAM
Bandwidth		8 MHz
Constellation		64QAM, 256QAM
Symbol rate		5 Msymbol/s to 6.952 Msymbol/s
Roll-off		0.15
Interleaver		12, 17
MER	internal reference	≥ 44 dB, typ. 47 dB
	external reference, using Rohde and Schwarz FSW 10MHz output	≥ 45 dB, typ. 48 dB
Content	generated internally	PRBS, MPEG-2 transport stream
	external feed	MPEG-2 transport stream over SFP+

2. J.83/B

Standard		ITU-T J.83 Annex B
Modulation		single-carrier QAM
Bandwidth		6 MHz
Constellation		64QAM, 256QAM
Symbol rate		4 Msymbol/s to 5.37 Msymbol/s
Roll-off		0.12, 0.18
Interleaver		in line with ITU-T J.83 Annex B

[3] The SFD can generate signals with 8192QAM and 16384QAM. This might, however, violate some specifications of this data sheet.

MER	internal reference	≥ 44 dB, typ. 47 dB
	external reference, using Rohde and Schwarz FSW, 10 MHz output	≥ 45 dB, typ. 48 dB
Content	generated internally	PRBS, MPEG-2 transport stream
	external feed	MPEG-2 transport stream over SFP+

3. J.83/C (ISDB-C)

Standard		ITU-T J.83 Annex C
Modulation		single-carrier QAM
Bandwidth		6 MHz
Constellation		64QAM, 256QAM
Symbol rate		4 Msymbol/s to 5.325 Msymbol/s
Roll-off		0.13
Interleaver		12, 17
MER	internal reference	≥ 44 dB, typ. 47 dB
	external reference, using Rohde & Schwarz FSW 10 MHz output	≥ 45 dB, typ. 48 dB
Content	generated internally	PRBS, MPEG-2 transport stream
	external feed	MPEG-2 transport stream over SFP+

Analog TV standards

Standards		PAL, NTSC
Bandwidth	NTSC	6 MHz
	PAL	7 MHz, 8 MHz
Content		color bar test pattern with 1 kHz sinusoidal tone

Transport stream generator

The SFD comes with a built-in transport stream generator that can play back MPEG-2 transport stream files. The generated transport stream can be used as the content for a J.83/A/B/C channel.

Transport stream format	MPEG-2, SPTS with 1 PAT and 1 PMT
Packet size	188 byte
Transport stream file size	max. 188 Mbyte
File format	.trp, .ts, .mpg
Seamless loop playback	can be switched on and off for continuity counter, PCR/DTS/PTS, TDT/TOT
Bit rate	≤ bit rate of channel

Basic waveform library

Waveform files	FM	random noise, 22 carriers
	ATV, PAL B	color bars, AF 1 kHz, 2-tone, no pilot
	ATV, PAL DK, CHINA	color bars, AF 1 kHz, 1-tone
	ATV, PAL G	color bars, AF 1 kHz, 2-tone, no pilot
	ATV, PAL I	color bars, AF 1 kHz, 1-tone
	rectangle for CMX tests	15.675 kHz
	ATV, SECAM L	color bars, AF 1 kHz, 2-tone, no pilot

Enhanced functions for downstream (SFD-K201 option)

DOCSIS 3.1

Insertion of DOCSIS timestamps in downstream PLC		on/off
Flow rate indicator		display of transmission data rate for each profile of a DOCSIS 3.1 channel or each DOCSIS 3.0 carrier in bps
DOCSIS 3.1 PLC Mode	Standard/Rohde and Schwarz FSW compatibility	extended DOCSIS 3.1 PLC contents
	Rohde & Schwarz FSW compatibility mode	additional transmission of DPD messages for profiles B, C and D on the PLC

Upstream (SFD-K300 option)

All upstream modulation types

Load mini-slot duty cycle range		0 % to 100 % (can only be ON or OFF for A-TDMA)
Grant size	for PRBS only	1-255 mini-slots
Scheduled playout modes		dynamic, immediate, periodic, triggered

DOCSIS 3.1

Modulation		burst OFDMA
Burst timing		controlled via trigger input
FFT size	50 kHz subcarrier spacing	2k
	25 kHz subcarrier spacing	4k
Bandwidth	FFT size = 2k (50 kHz subcarrier spacing)	10 MHz to 96 MHz
	FFT size = 4k (25 kHz subcarrier spacing)	6.4 MHz to 96 MHz
		can be set as the encompassed spectrum in MHz or as the first and last active sub-carrier
Constellation		QPSK, 8QAM, 16QAM, 32QAM, 64QAM, 128QAM, 256QAM, 512QAM, 1024QAM, 2048QAM, 4096QAM
MER	internal reference	≥ 40 dB, typ. 46 dB
	external reference, using Rohde & Schwarz FSW, 10 MHz output	≥ 43 dB, typ. 47 dB
Cyclic prefix		0.9375 µs, 1.25 µs, 1.525 µs, 1.875 µs, 2.1875 µs, 2.5 µs, 2.8125 µs, 3.125 µs, 3.75 µs, 5 µs, 6.25 µs
Windowing		0 µs, 0.3125 µs, 0.625 µs, 0.9375 µs, 1.25 µs, 1.5625 µs, 1.875 µs, 2.1875 µs
Pilot structure	FFT size 2k (50 kHz offset from carrier)	1 to 7
	FFT size 4k (25 kHz offset from carrier)	8 to 14
	with pilot boosting	5 to 7 and 12 to 14
Burst types		data, initial ranging, fine ranging, bandwidth request, wideband probe

Settable parameters	data	pilot pattern, constellation, scrambler, scrambler seed, minislot loading duty cycle, content
	initial ranging	number of subcarriers, number of mini slots, starting mini slot, preamble pattern, preamble value offset, preamble length, MAC address, downstream channel ID, minislot loading duty cycle
	fine ranging	number of subcarriers, number of mini slots, starting mini slot, preamble pattern, preamble value offset, data (through user-defined file), minislot loading duty cycle
	bandwidth request	sub slot, requested number of bytes, SID, minislot in frame, minislot loading duty cycle
	wideband probe	start subcarrier, subcarrier skipping, symbols in frame, minislot loading duty cycle
Content		PRBS or SFP+ data

DOCSIS 3.0 A-TDMA

Modulation		burst A-TDMA
Burst timing		controlled via trigger input
Bandwidth		0.8 MHz, 1.6 MHz, 3.2 MHz, 6.4 MHz
Constellation		QPSK, DQPSK, 8QAM, 16QAM, D16QAM, 32QAM, 64QAM
MER (internal reference)	15 MHz ≤ f < 61 MHz	≥ 30 dB, typ. 44 dB
	10 MHz ≤ f < 15 MHz 61 MHz ≤ f < 71 MHz	≥ 27 dB, typ. 41 dB
	5 MHz ≤ f < 10 MHz 71 MHz ≤ f < 85 MHz	≥ 24 dB, typ. 34 dB
MER (external reference, using Rohde & Schwarz FSW, 10 MHz output)	15 MHz ≤ f < 61 MHz	≥ 32 dB, typ. 45 dB
	10 MHz ≤ f < 15 MHz 61 MHz ≤ f < 71 MHz	≥ 29 dB, typ. 42 dB
	5 MHz ≤ f < 10 MHz 71 MHz ≤ f < 85 MHz	≥ 25 dB, typ. 35 dB
Preamble pattern		programmable, up to 384 hex digits
Preamble length	integer number of QPSK symbols	up to 1536 bit
Preamble value offset		multiple of symbol size
Preamble type		QPSK0, QPSK1
Guard time between bursts		4 to 255 modulation intervals

Minislot size (T)		1, 2, 4, 8, 16, 32, 64, 128 (1 = 6.25 µsec)
Symbol rate		1, 2, 4, 8, 16, 32 (1 = 160 kHz)
FEC error correction parameter T	no FEC	T = 0
	FEC with 2 × T parity bytes	T = 1 to 16
FEC codeword information bytes	parameter k	16 to 253
Last codeword length		fixed, shortened
Reed-Solomon interleaver mode		disabled, fixed, dynamic
Reed-Solomon interleaver depth	interleaver mode = fixed	2 to (2048/(k + 2T))
Reed-Solomon interleaver block size	interleaver mode = dynamic	2 × (k + 2T) to 2048
Scrambler		on, off
Scrambler seed		15 bit from user-defined hex string
Content		PRBS or SFP+ data

DOCSIS 3.0 S-CDMA

Modulation		burst S-CDMA
Burst timing		controlled via trigger input
Bandwidth		1.6 MHz, 3.2 MHz, 6.4 MHz
Constellation		QPSK, 8QAM, 16QAM, 32QAM, 64QAM, TCM-QPSK, TCM-8QAM, TCM-16QAM, TCM-32QAM, TCM-64QAM, TCM-128QAM
Preamble pattern		user-defined hex string
Preamble length	integer number of QPSK symbols	up to 1536 bit
Preamble value offset		multiple of symbol size
Preamble type		QPSK0, QPSK1
Symbol rate		8, 16, 32 (1 = 160 kHz)
FEC error correction parameter T	no FEC	T = 0
	FEC with 2 × T parity bytes	T = 1 to 16
FEC codeword information bytes	parameter k	16 to 253
Last codeword length		fixed, shortened
Scrambler		on, off
Scrambler seed		15 bit from user-defined hex string
Spreading intervals per frame		1 to 32
Codes per mini slot		2 to 32
Active codes	mode 1	64 to 128
Symbol interleaver step size		1 to 31
Codes per subframe		1 to number of active codes (non-prime)
Code hopping seed		settable
Content		PRBS or SFP+ data

Arbitrary waveform generator

Frequency range		47 MHz to 1218 MHz 47 MHz to 1794 MHz with SFD-K3018
ARB bandwidth		≤ 200 MHz
Sample rate per waveform file		≤ 240 Msample/s
Number of samples per ARB waveform file		≤ 67.1 Msample (2^{26} samples)
File size		≤ 256 Mbyte
Value range		≤ ±32767
Burst timing		controlled via trigger input
ARB waveform files included (DS)	for analog TV	NTSC, PAL with 7 MHz bandwidth, PAL with 8 MHz bandwidth
	for digital TV and DOCSIS 3.0	DVB-C with 64QAM, DVB-C with 256QAM, J.83/B with 64QAM, J.83/B with 256QAM, J.83/C with 64QAM, J.83/C with 256QAM, C-DOCSIS 1024QAM, ISDB-T
	for DOCSIS 3.1	DOCSIS 3.1 with 192 MHz bandwidth
ARB waveform files included (UP)	for DOCSIS 3.0	A-TDMA with 1.6 MHz bandwidth, A-TDMA with 3.2 MHz bandwidth, A-TDMA with 6.4 MHz bandwidth, S-CDMA with 1.6 MHz bandwidth, S-CDMA with 3.2 MHz bandwidth, S-CDMA with 6.4 MHz bandwidth
	for DOCSIS 3.1	OFDMA initial ranging, OFDMA fine ranging, OFDMA wideband probe, OFDMA bandwidth request, OFDMA data packet

Operating modes

Since only one operating mode at a time can be active, the SFD cannot generate downstream and upstream signals simultaneously.

Signal generation

Downstream signal generation requires the SFD-K200 option.

Upstream signal generation requires the SFD-K300 option.

Operation mode	upstream (DOCSIS3.1/DOCSIS3.0) downstream (DOCSIS3.1/DOCSIS 3.0, J.83/A/B/C)

Trigger burst timing control

Signal timing	dynamic, immediate, periodic, triggered
Marker output delay	0 to 9999 µs
Marker output polarity	high or low
Trigger In sensitivity	rising or falling edge

DOCSIS timestamp timing control

Timestamp configuration	user configured
DOCSIS timestamps supported	normal, extended
Range of transmit offset	0 to 1 s
Resolution of timestamp settings	3.25 nsec

Signal interference simulation

All signal interference simulations require the SFD-K1050 option.

Bit error rate (SFD-K1050 option)

Bit error rate range	DOCSIS 3.0 upstream: errors do not affect preamble DOCSIS 3.1: errors on profile data only	1×10^{-2} to 1×10^{-6}

AWGN (SFD-K1050 option)

1 dB bandwidth	800 kHz to 200 MHz
Step size of setting	1 kHz
Center frequency	tied to the channel center frequency
Noise level	–5 dBc bis –50 dBc
Step size of setting	0.1 dB
Accuracy	± 1 dB
Reference quantity of C/N	absolute noise level

Phase noise (SFD-K1050 option) [4]

Format [5]		double-sideband noise, integrated via a frequency decade, referenced to the level of the carrier, in dBc
Offset from carrier		1 kHz to 100 MHz
Characteristic		user-defined in frequency decades
Setting range	1 kHz to 10 kHz offset from carrier	–65 dBc to –30 dBc
	10 kHz to 100 kHz offset from carrier	–65 dBc to –44 dBc
	100 kHz to 1 MHz offset from carrier	–65 dBc to –50 dBc
	1 MHz to 10 MHz offset from carrier	–65 dBc to –51 dBc
	10 MHz to 100 MHz offset from carrier	–65 dBc to –57 dBc
Step size of setting		0.1 dBc

[4] Available with FW version higher or equal V1.10.

[5] The DOCSIS 3.1 standard specifies the phase noise in this relatively unusual format. The SFD also uses this format, making it easy to set the specifications found in the DOCSIS 3.1 standard. The user manual describes how to convert the phase noise to the more common single sideband format with a normalized bandwidth of 1 Hz.

AC hum (SFD-K1050 option) [4]

The SFD simulates AC hum by superimposing amplitude modulation.

Mains frequency	47 Hz to 200 Hz
Step size of setting	0.1 Hz
AM modulation depth	0 % to 6 %
Step size of setting	0.1 %

Digital Tilt (SFD-K1050 option)

Digital tilt	DOCSIS 3.1 only, ± 1.5 dB accuracy	± 15 dB/GHz

Interfaces

RF outputs

The SFD comes with two F female/F female adapters. Calian recommends always leaving these adapters on the RF outputs of the SFD to prevent wear on these outputs.

Downstream

Connector type		F male, 75 Ω
Frequency range		47 MHz to 1794 MHz
Return loss	CW frequency ≤ 1100 MHz	
	47 MHz to 750 MHz	≥ 14 dB
	750 MHz to 870 MHz	≥ 13 dB
	870 MHz to 1218 MHz	≥ 12 dB
	1218 MHz to 1794 MHz	≥ 2 dB
	CW frequency > 1100 MHz	
	47 MHz to 750 MHz	≥ 2 dB
	750 MHz to 870 MHz	≥ 10 dB
	870 MHz to 1218 MHz	≥ 10 dB
	1218 MHz to 1794 MHz	≥ 10 dB

Upstream

Connector type		F male, 75 Ω
Frequency range		5 MHz to 204 MHz
Return loss		≥ 10 dB

Data and transport stream input

IP data input		SFP+ (1GbE or 10GbE) [6]

Control inputs and output

Reference input		BNC, female
Reference frequency		10 MHz, 10.24 MHz, 10 ppm
Trigger input		BNC female 0 V to 5.0 V V_{inH} (min) = 2.5 V V_{inL} (max) = 0.8 V

[6] Recommended adapters, see user manual chapter 5.2

Marker output		BNC female 0 V to 3.3 V (75 Ω output impedance) max. source/sink = ± 47 mA V_{outH} (min) 3.2 V (high impedance load) V_{outL} (max) 0.1 V (high impedance load)
LAN control interface		RJ-45
AUX Input	synchronization with receiver	RJ-45

General data

Environmental conditions		
Temperature	operating temperature range	0 °C to +45 °C
Operating humidity		0 % to 90 %, noncondensing
Mechanical resistance		
Vibration	operational	NEBS
	transport	NEBS transport 2B
Power rating		
Rated voltage		100 V to 240 V AC
Rated frequency		50 Hz/60 Hz
Rated power		200 VA
Product conformity		
Electromagnetic compatibility		EN 55011, EN 61326-1, EN 61326-2-2
		ICES-003
		Part 15 of FCC Rules
		radio interference class A und basic immunity requirements
Electrical safety	in line with EU low voltage directive 2006/95/EC	applied harmonized standard: EN 61010-1
	USA	UL 61010-1
	Canada	CAN/CSA-C22.2 No. 61010-1
Calibration interval		after 12 months, then every 36 months
Dimensions	W × H × D	233 mm × 107 mm × 372 mm (½ 19", 2 HU) (9.17 in × 4.21 × 14.65 in)
Weight		3,25 kg (7.16 lb)