

Specifications

The HFS 9000 family of high-speed logic signal source instruments have a modular architecture with factory-configurable cards. The channels are digitally synthesized from a common clock resulting in highly accurate independent placement of rising and falling edges. The instruments are optimized for digital device characterization with unique triggering capabilities and a variety of pulse outputs. The product family also features low RMS jitter, the ability to compensate for external cable skews, and an easy-to-use graphical human interface.

This section contains the complete specifications for the HFS 9000 Stimulus System and Modules. These specifications are classified as either nominal traits, warranted characteristics, or typical characteristics.

Nominal Traits

Nominal traits are described using simple statements of fact such as “+2.6 V” for the trait “Maximum high level,” rather than in terms of limits that are performance requirements.

Table 1-1: Nominal Traits — HFS 9PG1 Output Performance

Each channel and complement driving a 50 Ω load to ground, except as noted.

Name	Description
Maximum high level	+2.6 V
Minimum low level	-2.00 V
Maximum amplitude	3.00 V
Minimum amplitude	0.50 V
Level resolution	0.01 V
Operation when terminated through 50 Ω to -2 V	Output levels will be approximately 1 V more negative than the values programmed, specified, and displayed. Actual output levels more negative than -2 V may cause malfunction. Level accuracy specifications do not apply when terminating to -2 V. Both true and complement outputs must be terminated to the same voltage.

Table 1-1: Nominal Traits — HFS 9PG1 Output Performance (Cont.)

Each channel and complement driving a 50 Ω load to ground, except as noted.

Name	Description
Operation when terminated to high impedance loads	Output level range will double until certain internal limits are achieved. Since the programmed, specified, and displayed output levels do not match the actual output levels, level accuracy specifications do not apply when terminating to a high impedance load. Because of the larger voltage swings associated with doubled level range, output transition time specifications do not apply when driving a high impedance load.
Output limits	One high limit and one low limit may be enabled or disabled together.

Table 1-2: Nominal Traits — HFS 9PG2 Output Performance

Each channel and complement driving a 50 Ω load to ground, except as noted.

Name	Description
Maximum high level	+5.50 V
Minimum low level	-2.00 V
Maximum amplitude	5.50 V
Minimum amplitude	0.50 V
Level resolution	0.01 V
Operation when terminated through 50 Ω to -2 V	Output levels will be approximately 1 V more negative than the values programmed, specified, and displayed. Actual output levels more negative than -2 V may cause malfunction. Level accuracy specifications do not apply when terminating to -2 V. Both true and complement outputs must be terminated to the same voltage.
Transition time 20% to 80%	Variable from 800 ps to 5 ns
Transition time resolution	10 ps
Output limits	One high limit and one low limit may be enabled or disabled together.

Table 1-3: Nominal Traits — HFS 9DG1 Output Performance

Each channel and complement driving a 50 Ω load to ground, except as noted.

Name	Description
Maximum high level	+5.0 V
Minimum low level	-2.5 V
Maximum amplitude	3.00 V
Minimum amplitude	0.01 V
Level resolution	0.01 V
Operation when terminated through 50 Ω to -2 V	Output levels will be approximately 1 V more negative than the values programmed, specified, and displayed. Actual output levels more negative than -2 V may cause malfunction. Level accuracy specifications do not apply when terminating to -2 V. Both true and complement outputs must be terminated to the same voltage.
Operation when terminated to high impedance loads	Output level range will double until certain internal limits are achieved. Since the programmed, specified, and displayed output levels do not match the actual output levels, level accuracy specifications do not apply when terminating to a high impedance load. Because of the larger voltage swings associated with doubled level range, output transition time specifications do not apply when driving a high impedance load.
Output limits	One high limit and one low limit may be enabled or disabled together.

Table 1-4: Nominal Traits — HFS 9DG2 Output Performance

Each channel and complement driving a 50 Ω load to ground, except as noted.

Name	Description
Maximum high level	+5.50 V
Minimum low level	-2.00 V
Maximum amplitude	5.50 V
Minimum amplitude	0.01 V
Level resolution	0.01 V
Operation when terminated through 50 Ω to -2 V	Output levels will be approximately 1 V more negative than the values programmed, specified, and displayed. Actual output levels more negative than -2 V may cause malfunction. Level accuracy specifications do not apply when terminating to -2 V. Both true and complement outputs must be terminated to the same voltage.
Transition time 20% to 80%	Variable from 800 ps to 6 ns

Table 1–4: Nominal Traits — HFS 9DG2 Output Performance (Cont.)

Each channel and complement driving a 50 Ω load to ground, except as noted.

Name	Description
Transition time resolution	10 ps
Output limits	One high limit and one low limit may be enabled or disabled together.

Table 1–5: Nominal Traits — Time Base

Name	Description
Frequency range	HFS 9PG1, HFS 9DG1: 50 kHz to 630 MHz HFS 9PG2, HFS 9DG2: 50 kHz to 300 MHz ¹
Frequency resolution	$\leq 0.1\%$ of frequency setting
Minimum frequency setting when using half, quarter, or eighth pulse rate modes ²	half pulse rate: 100 kHz quarter pulse rate: 200 kHz eighth pulse rate: 400 kHz
Number of pulse periods in burst or auto-burst modes	User selectable from 1 to 65,536

¹ If the HFS 9PG2 or HFS 9DG2 is operated in half pulse rate mode, frequency can be extended to 600 MHz for the HFS 9PG2 and 630 MHz for the HFS 9DG2.

² All pulse rate modes result in 50 kHz output frequency.

Table 1–6: Nominal Traits — Performance to External Frequency Reference

Name	Description
PHASE LOCK IN input characteristic	0.1 μ F DC blocking capacitor followed by 50 Ω termination to ground
Phase lock output frequency range	Any 2 ⁿ multiple or sub-multiple of the phase lock frequency that is within the allowed frequency range for the card being used
FRAME SYNC IN	Initiates a burst when using phase lock mode
FRAME SYNC IN input characteristic	50 Ω terminated to -2 V

Table 1–7: Nominal Traits — Output Edge Placement Performance¹

Name	Description
Channel deskew (Chan Delay) range, channels relative to time zero reference	–60 ns to 2.0 μ s
Channel deskew (Chan Delay) resolution	HFS 9PG1, HFS 9PG2: 5 ps HFS 9DG1, HFS 9DG2: 1 ps
Delay (Lead Delay) adjustment range	Zero to 20 μ s
Delay (Lead Delay, Trail Delay) adjustment resolution	HFS 9PG1, HFS 9PG2: 5 ps HFS 9DG1, HFS 9DG2: 1 ps
Pulse width adjustment range	HFS 9PG1, HFS 9PG2: Zero to (one period – 790 ps) inclusive HFS 9DG1, HFS 9DG2: Zero to (one period \times 65,536) inclusive
Pulse width adjustment resolution	HFS 9PG1, HFS 9PG2: 5 ps HFS 9DG1, HFS 9DG2: 1 ps
Fine knob resolution of timing	5 ps

¹ **Measured at 50% levels, each channel independent.**

Table 1–8: Nominal Traits — Transducer In Performance

Name	Description
TRANSDUCER IN input characteristic	HFS 9PG1: 1000 pF DC blocking capacitor followed by 50 Ω termination to ground HFS 9PG2: 100 pF DC blocking capacitor followed by 50 Ω termination to ground

Table 1–9: Nominal Traits — Skew Cal In Performance

Name	Description
SKEW CAL IN usage	Calibration use only. No signal, except from a channel OUTPUT connector during the calibration process, should ever be applied to this input.

Table 1-10: Nominal Traits — Trigger In Performance

Name	Description
Input Voltage range	±5 V maximum
Trigger level range	±4.70 V
Trigger level resolution	100 mV

Table 1-11: Nominal Traits — Trigger Out Performance

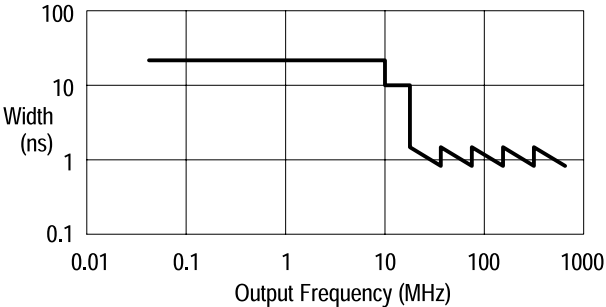
Name	Description
Pretrigger range, TRIGGER OUT before time zero reference	Zero to 70 ns
TRIGGER OUT pulse width in auto mode	 <p>The graph plots pulse width in nanoseconds (ns) on a logarithmic y-axis (0.1 to 100) against output frequency in MHz on a logarithmic x-axis (0.01 to 1000). The pulse width is constant at approximately 20 ns for frequencies from 0.01 MHz to 10 MHz. Above 10 MHz, the pulse width drops to about 1 ns and exhibits a sawtooth pattern, indicating a maximum pulse width of 1 ns at 1000 MHz.</p>

Table 1-12: Nominal Traits — Power Requirements

Name	HFS 9003 Description	HFS 9009 Description
Fuse ratings	5 A, 250 V, type 3AG, (Tektronix part 159-0014-00), and 4 A, 250 V, type 3AG, fast blow, (Tektronix part 159-0017-00)	15 A, 250 V, type 3AG, fast blow, (Tektronix part 159-0256-00)

Table 1-13: Nominal Traits — System Memory Performance

Name	Description
Non-volatile memory retention time	Instrument settings and calibration constants are retained in non-volatile memory for 5 years or more. Card identification is retained for 10 years. Extended storage above 50° C may degrade the life of all non-volatile memory.

Table 1–14: Nominal Traits — HFS 9003 Mechanical

Name	Description	
Weight, in 12-channel configuration. (Shipping weight includes all standard accessories.)	Cabinet	Rackmount
	Net weight: 45 lbs. (20.5 kg)	51 lbs. (23.2 kg)
	Shipping weight: 60 lbs. (27.3 kg)	66 lbs. (30.0 kg)
Overall Dimensions	Cabinet	Rackmount
	Width: 16.3 in. (414 mm)	19.0 in. (483 mm)
	Height: 7.0 in. (178 mm)	7.0 in. (178 mm)
	Depth: 24.75 in. (629 mm)	24.75 in. (629 mm)
	Depth behind rack flange: —	22.0 in. (559 mm)
Cooling Method	Forced-air circulation with no air filter, maximum 318 cfm	
Construction Material	Chassis parts are constructed of aluminum alloy; bezel is glass-filled polycarbonate with Lexan plastic inserts; cabinet is aluminum with textured epoxy paint.	

Table 1–15: Nominal Traits — HFS 9009 Mechanical

Name	Description	
Weight, in 36-channel configuration. (Shipping weight includes all standard accessories.)	Rackmount	
	Net weight: 81 lbs. (33.7 kg)	
	Shipping weight: 100 lbs. (45.3 kg)	
Overall Dimensions	Rackmount	
	Width: 16.75 in. (425.79 mm)	
	Height: 14.00 in. (355.89 mm)	
	Depth: 24.00 in. (610.11 mm)	
Cooling Method, mainframe	Forced-air circulation with air filter, maximum 318 cfm	
Cooling Method, power supply	Forced-air circulation, maximum 106 cfm	
Construction Material	Chassis parts are constructed of aluminum alloy with Lexan plastic inserts; cabinet is aluminum with textured epoxy paint.	

Warranted Characteristics

Warranted characteristics are described in terms of quantifiable performance limits which are warranted. Names of characteristics that appear in boldface type have checks for verifying the specifications in the *Check Procedures* section.

Table 1-16: Warranted Characteristics — HFS 9PG1 Output Performance

Name	Description
High level accuracy (amplitude ≥ 1 V or high level ≥ 0 V)¹	$\pm 2\%$ of level, ± 50 mV
Low level accuracy (amplitude ≥ 1 V or high level ≥ 0 V)¹	$\pm 2\%$ of high level, $\pm 2\%$ of amplitude, ± 50 mV
Transition time 20% to 80% (amplitude ≤ 1 V)	≤ 200 ps

¹ If amplitude < 1 V and high level < 0 V, accuracy typically meets the specification but is not guaranteed

Table 1-17: Warranted Characteristics — HFS 9PG2 Output Performance

Name	Description
High level accuracy	$\pm 2\%$ of level, ± 50 mV
Low level accuracy	$\pm 2\%$ of high level, $\pm 2\%$ of amplitude, ± 50 mV
Transition time accuracy 20% to 80% (amplitude ≤ 1 V)	$\pm 10\%$ of setting, ± 300 ps

Table 1-18: Warranted Characteristics — HFS 9DG1 Output Performance

Name	Description
High level accuracy (amplitude ≥ 0.5 V)¹	$\pm 2\%$ of level, ± 50 mV
Low level accuracy (amplitude ≥ 0.5 V)¹	$\pm 2\%$ of high level, $\pm 2\%$ of amplitude, ± 50 mV
Transition time 20% to 80% (amplitude ≤ 1 V)	≤ 250 ps

¹ If amplitude < 0.5 V, accuracy typically meets the specification but is not guaranteed

Table 1–19: Warranted Characteristics — HFS 9DG2 Output Performance

Name	Description
High level accuracy (amplitude ≥ 0.5 V) ¹	$\pm 2\%$ of level, ± 50 mV
Low level accuracy (amplitude ≥ 0.5 V) ¹	$\pm 2\%$ of high level, $\pm 2\%$ of amplitude, ± 50 mV
Transition time accuracy 20% to 80% (amplitude ≤ 1 V)	$\pm 10\%$ of setting, ± 300 ps

¹ If amplitude < 0.5 V, accuracy typically meets the specification but is not guaranteed.

Table 1–20: Warranted Characteristics — Time Base

Name	Description
Frequency accuracy	$\pm 1\%$

Table 1–21: Warranted Characteristic — Performance to External Frequency Reference

Name	Description
PHASE LOCK IN frequency range	6 MHz to 630 MHz

Table 1–22: Warranted Characteristics — Output Edge Placement Performance¹

Name	Description
Delay of pulses relative to time zero reference (Lead Delay) accuracy	HFS 9PG1, HFS 9PG2: 1% of (Lead Delay + Chan Delay) ± 300 ps HFS 9DG1, HFS 9DG2: 1% of (Lead Delay + Chan Delay) ± 50 ps
Pulse width accuracy	HFS 9PG1: 1% of width ± 300 ps HFS 9PG2: 1% of width ± 300 ps [for widths ≥ 20 ns]; 1% of width + 300 ps, -500 ps [for widths < 20 ns] HFS 9DG1: 1% of width + 50 -75 ps HFS 9DG2: 1% of width + 50 ps, -250 ps [for widths ≥ 20 ns]; 1% of width + 50 ps, -450 ps [for widths < 20 ns]

¹ Measured at 50% levels, each channel independent.

Table 1–23: Warranted Characteristics — Trigger Out Performance

Name	Description
TRIGGER OUT signal levels	Amplitude ≥ 300 mV (-0.5 V \geq offset ≥ -1.5 V, driving 50Ω to ground)

Table 1–24: Warranted Characteristics — Power Requirements

Name	Description
Primary circuit dielectric break-down voltage	1500 VAC _{RMS} , 60 Hz for 10 seconds without breakdown
Primary Grounding	0.1 Ω maximum from chassis ground and protective earth ground

Table 1–25: Warranted Characteristics — Environmental and Safety

Name	HFS 9003 Description	HFS 9009 Description
Temperature	Operating: 0° C to +50° C (32° F to 122° F) Non-operating (storage): -40° C to +75° C (-40° F to 167° F)	Operating: 0° C to +40° C (32° F to 104° F) Non-operating (storage): -40° C to +75° C (-40° F to 167° F)
Altitude	Operating: 4 hours at 3,048 m (10,000 feet). Derate maximum operating temperature by -1° C (-1.8° F) for each 304.8 m (1,000 feet) above 1,524 m (5,000 feet) Non-operating: 2 hours at 12,192 m (40,000 feet)	
Humidity	Operating: < 95% RH, non-condensing, from 0° C to 30° C (32° F to 86° F) < 75% RH, non-condensing, from 31° C to 40° C (88° F to 104° F) (MIL-T-28800E, para 4.5.5.1.2.2, Type III, Class 5)	
Shock (non-operating)	MIL-T-28800E, para 4.5.5.4.1, Type III, Class 5	
Resistance to mishandling during bench use (operating)	MIL-T-28800E, para 4.5.5.4.3, Type III, Class 5	
Resistance to packaged transportation vibration, sinusoidal, in shipping package	Drops of 36 inches on all edges, faces, and corners National Safe Transit Association, test procedure 1A-B-2	
Resistance to packaged transportation vibration, sinusoidal, in shipping package	Packaged sinusoidal vibration National Safe Transit Association, test procedure 1A-B-1	
Resistance to packaged transportation random vibration	MIL-STD-810D, method 514.3, category I, Figure 514.3-1	

Table 1–25: Warranted Characteristics — Environmental and Safety (Cont.)

Name	HFS 9003 Description	HFS 9009 Description
Safety	Listed to UL1244 Certified to CAN/CSA-C22.2 No. 231–M89	
IEC Specifications	Installation Category II Pollution Degree 2 Safety Class I	

Typical Characteristics

Typical characteristics are described in terms of typical or average performance. Typical characteristics are not warranted.

Table 1–26: Typical Characteristics — Time Base

Name	Description
RMS jitter	15 ps, $\pm 0.05\%$ of interval
Recovery time between bursts or auto-bursts	15 μ s

Table 1–27: Typical Characteristics — HFS 9PG1 Output Performance

Name	Description
Transition time 20% to 80%	Amplitude ≤ 1 V: 150 ps 1 V < Amplitude ≤ 2 V: 190 ps 2 V < Amplitude ≤ 3 V: 225 ps
Output aberrations (beginning 200 ps after 50% point of transition)	Overshoot: +15%, +20 mV Undershoot: –10%, –20 mV

Table 1–28: Typical Characteristics — HFS 9PG2 Output Performance

Name	Description
Operation when terminated to high impedance loads	Output level range will double until certain internal limits are achieved. Since the programmed, specified, and displayed output levels do not match the actual output levels, level accuracy specifications do not apply when terminating to a high impedance load. Because of the larger voltage swings associated with doubled level range, output transition time specifications do not apply when driving a high impedance load.
Transition time accuracy 20% to 80%	±10% of setting, ±300 ps
Output aberrations	Overshoot: +15%, +20 mV Undershoot: -10%, -20 mV

Table 1–29: Typical Characteristics — HFS 9DG1 Output Performance

Name	Description
Transition time 20% to 80%	Amplitude ≤ 1 V: ≤ 250 ps, 250 ps 1 V < Amplitude < 2 V: 250 ps 2 V ≤ Amplitude ≤ 3 V: 260 ps
Output aberrations	Overshoot: +15%, +20 mV Undershoot: -10%, -20 mV

Table 1–30: Typical Characteristics — HFS 9DG2 Output Performance

Name	Description
Operation when terminated to high impedance loads	Output level range will double until certain internal limits are achieved. Since the programmed, specified, and displayed output levels do not match the actual output levels, level accuracy specifications do not apply when terminating to a high impedance load. Because of the larger voltage swings associated with doubled level range, output transition time specifications do not apply when driving a high impedance load.
Transition time accuracy 20% to 80%	±10% of setting, ±300 ps
Output aberrations	Overshoot: +15%, +20 mV Undershoot: -10%, -20 mV

Table 1–31: Typical Characteristics — Performance to External Frequency Reference

Name	Description
PHASE LOCK IN amplitude range	0.8 V to 1.0 V peak-to-peak
PHASE LOCK IN transition time requirement	20% to 80% in ≤ 10 ns
FRAME SYNC IN signal level	$-1.810\text{ V} \leq V_{\text{low}} \leq -1.475\text{ V}$ $-1.165\text{ V} \leq V_{\text{high}} \leq -0.810\text{ V}$ (standard 100 K ECL levels)
Setup time, rising edge of FRAME SYNC IN signal to rising edge of PHASE LOCK IN	650 ps minimum
Hold time, high level of FRAME SYNC IN after rising edge of PHASE LOCK IN	650 ps minimum
Time from frame sync qualified phase lock clock cycle to time-zero reference	70 ns minimum, 130 ns

Table 1–32: Typical Characteristics — Transducer In Performance

Name	Description
TRANSDUCER IN useful frequency range	HFS 9PG1: 25 MHz to > 1 GHz HFS 9PG2: 5 MHz to 300 MHz
TRANSDUCER IN amplitude requirement	1.0 V to 1.5 V peak-to-peak

Table 1–33: Typical Characteristics — Trigger In Performance

Name	Description
Input resistance	50 Ω
Trigger level accuracy	$\pm 100\text{ mV} \pm 5\%$ of trigger level
Trigger input rise/fall time requirement	≤ 10 ns
Minimum trigger input pulse width	1 ns
Trigger sensitivity	$\leq 500\text{ mV}$
Time from trigger in to time-zero reference	70 ns minimum, 130 ns typical

Table 1–34: Typical Characteristics — Trigger Out Performance

Name	Description
Pretrigger resolution	250 ps

Table 1–35: Typical Characteristics — Power Requirements

Name	HFS 9003 Description	HFS 9009 Description
Line Voltage	90 VAC _{RMS} to 130 VAC _{RMS} or 180 VAC _{RMS} to 250 VAC _{RMS} , range switched automatically	90 VAC _{RMS} to 104 VAC _{RMS} with maximum 7 cards installed, 104 VAC _{RMS} to 132 VAC _{RMS} with maximum 9 cards installed, or 180 VAC _{RMS} to 250 VAC _{RMS} , range switched automatically
Line frequency	48 Hz to 63 Hz	
Power consumption	540 W maximum	1190 W with maximum of 9 cards installed
Inrush surge current	50 A maximum up to 40 ms at 110 VAC 100 A maximum up to 40 ms at 220 VAC	