N7752C and N776-C Family of Optical Attenuators

Accurate and stable automatic power control

Optical Power Equalization with Ease

The Keysight N7752C and N776-C family of variable optical attenuators enables highly efficient optical transceiver and network integration testing. The new attenuator generation sports an on-board graphical user interface for easy control without software installation, accessible via GbE LAN and USB 2.0 connections. N7752C is a two-channel model for single-mode fiber equipped with two additional, independent optical power meters. N7764C is a four-channel model for single mode fiber, and based, like N7752C, on electrically controlled variable optical attenuator (VOA) modules. N7768C is a four-channel model for 50/125 µm multimode fiber, based on a miniature rotating filter design optimized to provide an insertion loss of typically only 1.6 dB including connectors. The attenuating filter is positioned in a collimated beam to maintain the same modal distribution across the entire attenuation range.

Power Setting And Control Modes

In power setting mode, which is available on all N77-C variable optical attenuators, the power level at the attenuator output is set. The instrument uses the feedback signal from a photodiode after a monitor tap to control the desired power level at the optical output.

When power control is active, the instrument also automatically corrects for power changes at the input so that the output power level you set is maintained with ±0.02 dB typical repeatability.

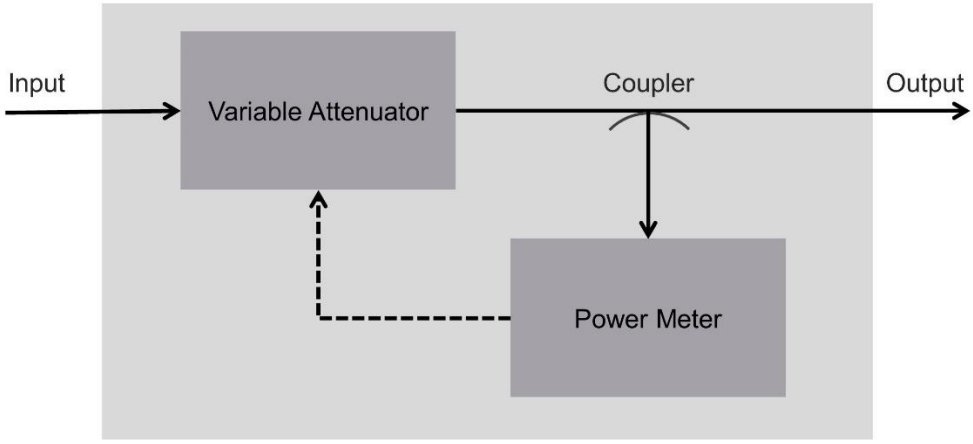

Figure 1. Optical attenuator with power control

The N7752C's additional power meters can be used to measure the absolute power level from an external fiber to calibrate the offset from the attenuator's output monitor, to correct for external insertion loss, like e.g. from connections, switches and couplers. Equipped with an analog voltage output, they can provide feedback for automated alignment applications, either linearly or logarithmically proportional to the optical power level. The new logarithmic mode is very helpful for tracking the signal level over a wide dynamic range, like during probe adjustment.

Attenuation setting mode

In attenuation mode, the calibrated value of attenuation in dB can be set directly, without use of the power monitor. This supports use with legacy software written for attenuators without power monitors or when the power monitor reading is impaired, as due to modulation or from a signal at another wavelength or in the reverse direction.

The N7768C multimode attenuator can best use the factory calibration for the mechanical position of the attenuator filter. On the N7752C and N7764C, a user attenuation calibration is recommended at the wavelength and polarization state of the signal to be used and an automated procedure is provided to make this calibration.

Advanced control of power change

Especially for testing devices that are sensitive to rapid power changes, the rate of change can be set on the instrument and applies to the attenuation mode. The N7768C rate can be set from 0.1 to 80 dB/s and to 1000 dB/s, the N7752C and N7764C can be set from 0.1 to 1000 dB/s. New with the N77-C attenuators is the ability to program a ramp of attenuation steps, including dwell time at each step, which can be either stepped automatically or synchronized with an external trigger. Trigger outputs are also available. This new functionality can be used instead of sending individual program commands for each step and aid in efficient synchronization with other instruments. In power control mode, during attenuation sweeps, as well as when activating the shutter mode, 1000 dB/s change rate is applied.

User Calibration Processes

Calibration offsets for external losses

Comprehensive offset functionality allows you to calibrate the optical path in various test set-ups. There is an offset for the attenuation factor, and an independent offset for the output power level, to calibrate for losses due to patch cords, connectors, and switches. Additionally, wavelength and offset value pairs can be stored in a table to compensate for wavelength-dependent effects in the optical path of the set-up. This allows you to precisely set the optical power level directly at the input interface of your device under test. With the extra optical power meter channel of the N7752C, calibration is even easier and more convenient. All power related offsets can be determined by a firmware function that reads a value from the reference power meter. The difference between the power value read by the reference power meter and the actual value of the attenuator is automatically stored as the offset.

User attenuation-mode calibration (new)

To calibrate the attenuation setting mode for a chosen source wavelength, a new self-calibration has been implemented. The calibration process, executed at the chosen wavelength and power higher than 0 dBm, and with the setup kept stable, will run for about 2 minutes. For using the attenuator at a different wavelength, the user calibration can be disabled, or the calibration can be executed at the new wavelength. The calibration data will be maintained after a preset or reboot but it must be reenabled. Alternatively, the configuration can be saved with enabled calibration.

Modal Fidelity for Multimode Fiber Systems

Signals in multimode fibers are distributed over a range of mode groups that can have different loss and delay in a link. For dependable multimode transceiver testing, the instrument used to set the power level should not change this modal distribution. The N7768C inherits the N7768A’s bulk-optic filter and collimated beam path which is highly acclaimed by users for its homogeneous attenuation of all input modes. Maintains beam profile of signals that comply with the encircled flux conditions of IEC 61280-4-1.

Definitions

Generally, all specifications are valid at the stated operating and measurement conditions and settings, with uninterrupted line voltage.

Specifications (guaranteed)

Describes warranted product performance that is valid under the specified conditions. Specifications include guard bands to account for the expected statistical performance distribution, measurement uncertainties changes in performance due to environmental changes and aging of components.

Typical values (characteristics)

Characteristics describe the product performance that is usually met but not guaranteed. Typical values are based on data from a representative set of instruments.

General characteristics

Give additional information for using the instrument. These are general descriptive terms that do not imply a level of performance.

Technical Specifications

The Keysight N7752C two-channel optical attenuator comes with two independent power meter channels, ideal for absolute optical power measurements as needed for optical receiver testing. The N7764C and N7768C four-channel optical attenuators can fit eight channels in a 19-inch, single-height-unit form factor when rack-mounted side-by-side.

Optical attenuator types

Model	Channel count, fiber type	Typical use cases
N7752C 	Two variable optical attenuators for single-mode fiber, two independent optical power meters	Single-box solution for optical receiver sensitivity testing with absolute power measurement
N7764C 	Four variable optical attenuators for single-mode fiber	Optical receiver sensitivity testing, general power control
N7768C 	Four variable optical attenuators for 50/125 µm multimode fiber	Multimode fiber receiver sensitivity testing, general power control while maintaining beam profile of signals that comply with the encircled flux conditions of IEC 61280-4-1

Technical details (preliminary)

	N7752C, N7764C
Fiber type	9/125 µm Single Mode Fiber
Connectivity	FC/APC – angled, narrow key (option 022) FC/PC – straight, regular key (option 021)
Wavelength range	1260 nm to 1640 nm
Power setting range	–50 dBm to +20 dBm
Attenuation range in power setting mode	0 dB to 40 dB; Typical 0 dB to 45 dB
Resolution	0.01 dB
Repeatability [1]	± 0.025 dB
Relative uncertainty [1, 2, 4]	± 0.05 dB ± 300 pW
Settling time [5, 6]	Typical 100 ms
Input path blocking [8]	Typical 45 dB
Insertion loss [7]	< 2.2 dB (1550 nm) Typical < 2.0 dB (1270, 1310, 1490, 1550, 1620 nm)
Attenuation transition speed	Selectable from 0.1 to 1000 dB/s
Relative uncertainty of monitor power meter [2, 4, 8, 9]	± 0.05 dB ± 300 pW
Relative uncertainty of monitor power meter due to polarization	< 0.25 dB peak-peak (1550 nm) Typical < 0.2 dB peak-peak (1270, 1310, 1490, 1550, 1620 nm)
Averaging time of monitor power meter	2 ms to 1 s
Return loss	Typical > 45 dB
Maximum safe input power	+27 dBm (applied to input or output port)

1. At constant operating conditions.
2. For unpolarized light. Temperature constant and between +23°C ± 5 K.
3. For (1310 ± 15) nm, (1490 ± 10) nm and (1550 ± 15) nm.
4. Output power > –40 dBm, input power < +10 dBm. For input power > +10 dBm add typ. ± 0.02 dB.
5. Output power > –30 dBm, input power < +10 dBm.
6. For 20 dB step.
7. Measured with Keysight reference connectors.
8. For (1550 ± 15) nm.
9. For ≤ 60% relative humidity.

Technical details (preliminary)

	N7768C-050	
Fiber type	50/125 µm Multimode fiber	
Connectivity	FC/PC – straight, regular key	
Wavelength range	800 nm to 1370 nm	
	Attenuation setting mode	**Power setting mode**
Range	0 dB to 35 dB	–35 dBm to +20 dBm
Resolution	0.03 dB	0.03 dB
Repeatability [1, 2, 5]	± 0.025 dB Typical ± 0.02 dB	± 0.025 dB Typical ± 0.02 dB
Uncertainty [1, 2, 3, 4, 5]	± 0.25 dB Typical ± 0.15 dB	n/a
Relative uncertainty [1, 2, 3, 4, 5, 6]	n/a	± 0.1 dB
Settling time (for 20 dB step)	Typical 200 ms	Typical 200 ms
Insertion loss [1, 2, 3, 4, 5]	≤ 1.8 dB, typical ≤ 1.6 dB, including connectors (850 nm, 1310 nm) ≤ 2.0 dB, typical ≤ 1.8 dB, including connectors (1050 nm)	
Attenuation transition speed	Selectable from 0.1 to 80 dB/s and 1000 dB/s	
Relative uncertainty of monitor power meter [1, 2, 3, 4, 5, 6]	± 0.1 dB	
Averaging time of monitor power meter	2 ms to 1 s	
Return loss [2, 5, 7]	Typical 25 dB	
Maximum safe input power [3, 8]	+23 dBm	
Optical path blocking	Typical 70 dB	

1. At constant operating conditions.
2. Effective spectral bandwidth of input signal > 30 nm.
3. For mode launch conditions from IEEE 802.3: encircled flux < 30% in 4.5 µm radius and > 86% inside 19 µm.
4. For unpolarized light. Temperature constant and within +23°C ± 5 K.
5. For (850 ± 15) nm, (1050 ± 25) nm and (1300 ± 20) nm.
6. For 2 ms averaging time. Output power > –30 dBm, input power < +10 dBm, attenuation setting ≤ 30 dB.
7. The return loss is primarily limited by the return loss of the front-panel connections.
8. Keysight assumes no responsibility for damage caused by scratched or poorly cleaned connectors.

Optical Power Meter Ports 5 and 6 in N7752C	
Sensor element	InGaAs
Wavelength range	1250 nm to 1650 nm (operating wavelength range) 1250 nm to 1625 nm (specification wavelength range)
Uncertainty at reference conditions [1, 3]	± 2.5%
Total uncertainty [2, 5, 6]	± 4.5%
Polarization dependent responsivity [3, 7]	< ± 0.015 dB (1520 nm to 1580 nm); Typical < ± 0.01 dB (1250 nm to 1580 nm)
Spectral ripple (due to interference) [9]	< ± 0.01 dB (1520 nm to 1625 nm); typical < ± 0.01 dB (1250 nm to 1520 nm)
Relative port to port uncertainty [1, 3, 4 10]	Typical ± 0.05 dB
Return loss [8]	> 50 dB (1520 nm to 1580 nm) Typical > 57 dB (1280 nm to 1580 nm)
Analog output	0 V to 2 V in to open, 600 Ω typical output impedance, max input voltage ±10 V
Data logging capability	2 buffers per port, each with capacity for 1 M measurement points
Averaging time	1 µs to 10 s
Applicable fiber type	Standard SM and MM ≤ 62.5 µm core diameter, NA ≤ 0.24

1. Reference conditions:
   Single mode fiber SMF 9 µm.
   Power level: –20 dBm to 0 dBm.
   On day of calibration (add ± 0.3% for aging over one year; add ± 0.6% for aging over two years).
   Spectral width of source < 10 nm full width half maximum (FWHM).
   Wavelength setting of power sensor corresponds to source wavelength ± 0.4 nm.
2. Operating conditions:
   Single mode fiber SMF. For multimode fiber, typical.
   Within one year of calibration; add ± 0.3% for second year.
   Spectral width < 10 nm FWHM.
   Wavelength setting of power sensor corresponds to source wavelength ± 0.4 nm.
3. Ambient temperature (23 ± 5) °C.
4. Temperature constant within ± 1 K after zeroing. Relative humidity ≤ 60%.
5. Excluding noise and offset drift.
6. Power range –60 dBm to +10 dBm.
7. Straight connector, SMF.
8. Connector 8° angled, ceramic ferrule, SMF.
9. For constant state of polarization, source linewidth < 100 MHz, angled connector 8°. Add ± 0.01 dB typical within specification wavelength range for straight connector with ceramic ferrule.
10. Same wavelength.

Optical Power Meter Ports 5 and 6 in N7752C			
Power range	–80 dBm to +10 dBm		
Maximum safe input power	+16 dBm		
Linearity [3, 4]	± 0.02 dB ± 3 pW at (23 ± 5) °C ± 0.04 dB ± 5 pW over operating temperature range		
Drift [2]	± 3.5 pW		
Noise peak-to-peak (dark) [1, 2]	< 3 pW (1 s averaging time, 300 s observation time)		
Noise 2σ [1] (100,000 samples)	Averaging time: 1 µs	25 µs	1 ms
PM range –30 dBm –20 dBm –10 dBm 0 dBm +10 dBm	Typical < 0.1 nW < 1.5 nW < 6 nW < 60 nW < 600 nW	Typical < 0.025 nW < 0.15 nW < 0.5 nW < 4 nW < 40 nW	Typical < 0.005 nW < 0.02 nW < 0.08 nW < 0.8 nW < 8 nW
Dynamic range [1, 2] (logging mode)	Averaging time: 1 µs	25 µs	1 ms
PM range –30 dBm –20 dBm –10 dBm 0 dBm +10 dBm	Typical > 43 dB > 43 dB > 46 dB > 46 dB > 43 dB	Typical > 48 dB > 53 dB > 57 dB > 57 dB > 54 dB	Typical > 56 dB > 61 dB > 62 dB > 63 dB > 59 dB
Port separation [2, 3]	> 85 dB (CW, one neighbor port with 0 dBm)		
Port separation, dynamic [2, 3, 5]	Typical > 70 dB (neighbor port with 0 dBm in 0 dBm power meter range)		
Frequency response –30 dBm range –20 dBm range –10 to +10 dBm range	3 dB cutoff frequency at 1 µs averaging time, typical 10 kHz 130 kHz 250 kHz		

1. Ambient temperature (23 ± 5) °C.
2. Temperature constant within ±1 K after zeroing. Relative humidity ≤ 60%.
3. Excluding noise and offset drift.
4. Power range –60 dBm to +10 dBm.
5. With analog output turned off.

General specifications

	N7752C, N7764C, N7768C
Line power	AC 100 V to 240 V ± 10%, 50/60 Hz, 60 VA max.
Operating temperature	+5 °C to +40 °C
Operating humidity	≤ 80%, non-condensing
Storage temperature	–40 °C to +70 °C
Max. operating altitude	2000 m
Warm-up time	20 minutes (N7752C, N7764C) 45 minutes (N7768C)
Recommended recalibration period	2 years
Dimensions	420 mm × 212 mm × 43 mm (excluding front and back rubber cushions and connectors)
Weight	3 kg (6 lbs)
User interface	**N7752C, N7764C, N7768C**
LAN Access (1 Gbit/s): HTTP Telnet VXI-11 SCPI-telnet SCPI-raw HISLIP	IPv4 and IPv6 Socket connection: http://<ip_address> or http://<host_name> port 23 port 111 (IPv4 only) port 5024 port 5025 port 4880
USB Access (USB 2.0)	Remote NDIS (virtual Ethernet link over USB); USB Mass Storage functions (read-only) USBTMC

Ordering Information

Product/option	Description
N7752C	Variable Optical Attenuator (2 Channel) with Optical Power Meter (2 Channel) – Single Mode
N7752C-021	Straight Connector
N7752C-022	Angled Connector
N7764C	Variable Optical Attenuator (4 Channel) - Single Mode
N7764C-021	Straight Connector
N7764C-022	Angled Connector
N7768C	Variable Optical Attenuator (4 Channel) - Multimode
N7768C-050	Multimode 50um
Product/option	**Recommended accessories**
N7799C-1CM	Rack Mount Kit for 2 half-width instruments, 1 Rack Height Unit, including low profile rails. Requires Filler Kit N7799C-0CM for mounting single instrument
N7799C-0CM	Filler Kit for N7799C-1CM. Required for single half-width instrument; includes front panel and base plate
N7799C-DOC	Documentation of N77-C Platform, Physical Medium
Product	**Connector Interfaces (2 required for the N7752C optical power meter inputs)**
N7742FI	Connector Interface FC
N7742KI	Connector Interface SC
N7742LI	Connector Interface LC
N7742VI	Connector Interface ST

User interface screen captures

The N77-C attenuators' graphical user interface provides detailed information about the actual output power level, as well as about relevant settings like the set power, offsets, the power monitor's averaging time and the wavelength. Responsive design ensures that the display adjusts to the browser window and the chosen zoom factor, allowing to comfortably arrange multiple instrument views on one screen. Operators can modify address settings and change channel labels to better differentiate optical paths. Power sweeps, progressed by time interval or by trigger signal, can be defined, downloaded, and uploaded, a convenient feature to spare time and effort to write control software.

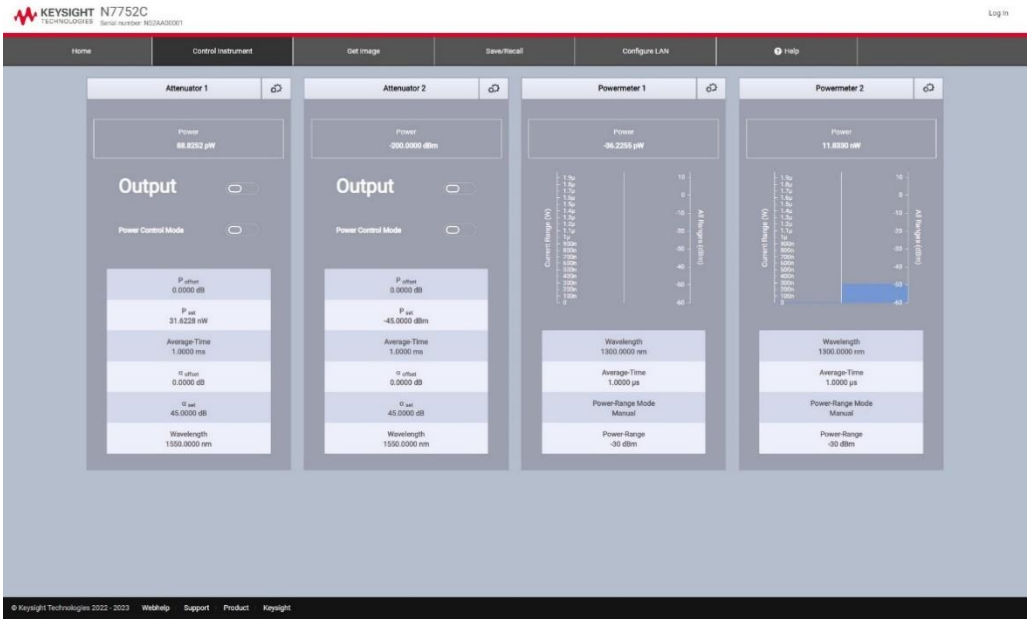

Figure 2. Web GUI of N7752C: two attenuators and two additional, independent power meters

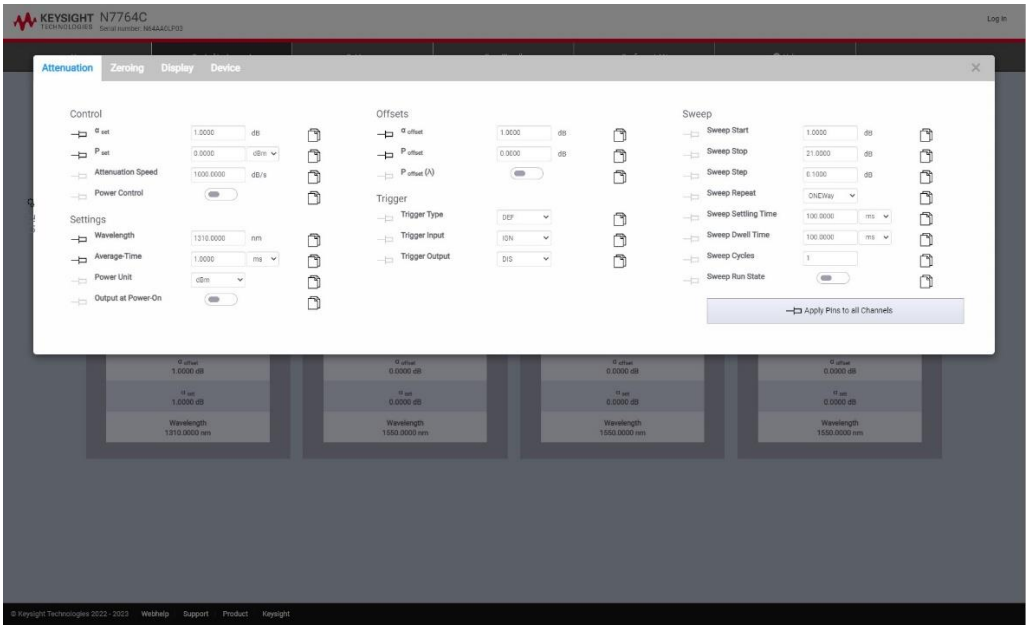

Figure 3. Web GUI (channel configuration) of N7764C and N7768C: four attenuators

For more information

To find more optical test instruments, check the following links:

Optical test instruments: www.keysight.com/find/oct

Optical signal conditioning products: www.keysight.com/find/voa

Optical multiport power meters: www.keysight.com/find/MPPM

Polarization solutions: www.keysight.com/find/pol

Tunable laser sources: www.keysight.com/find/tls

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Published in USA, July 3, 2023, 3123-1239.EN