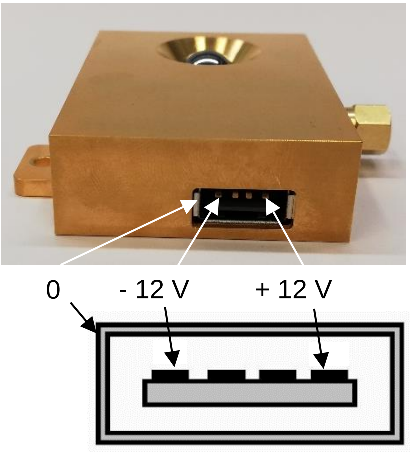
High-Responsivity Schottky Receiver #EK-000933

General

Schottky diodes operate as very sensitive incoherent terahertz receivers (i.e. terahertz power detectors). In contrast to photomixer receivers, they accomplish a direct measurement of the field intensity of the incident terahertz wave and are insensitive to its phase. A Schottky receiver thus proves useful for rapid measurements of the terahertz intensity, e.g. for beam profiling or terahertz imaging. In combination with a TeraScan system as tunable, single-frequency terahertz source, the Schottky receiver can also acquire terahertz spectra.

Schottky Diode	Receiver #EK-000933
	Zero-bias Schottky diode, high-responsivity model
Package	Si lens, ∅ 12 mm
	Integrated log-spiral antenna
	Electrical connector: SMA
	Output impedance: 50 Ω
Typical NEP	7 pW/$\sqrt{\text{Hz}}$ @ 100 GHz
	100 pW/$\sqrt{\text{Hz}}$ @ 1 THz
Typ. Responsivity	22000 V/W @ 100 GHz
	1100 V/W @ 1 THz
Amplifier	Integrated transimpedance amplifier
	Gain factor: 10^5 V/A
	Bandwidth 10 Hz – 1 MHz
Power Supply Unit	Output: + / -12 V
	Electrical connector: USB type A, with custom pin assignment



CAUTION!	**Schottky diodes are electrostatic-discharge sensitive devices!** **We recommend to always wear a high-impedance grounding strap for handling.**

Operation with TeraScan

The Schottky receiver #EK-000933 is compatible with TOPTICA's continuous-wave terahertz systems TeraScan 780 and TeraScan 1550 and provides an incoherent alternative to the standard photomixer receiver. The electrical connections between the Schottky diode and the TeraScan system are shown in Figure 1. Note that the module #EK-000933 comprises an integrated transimpedance amplifier, so the external one (PDA-S) is not needed. The Schottky diode does not need any optical connections. Similar to a photomixer though, the Schottky diode requires lock-in detection of the terahertz signal. To this end, the bias voltage of the photoconductive emitter is chopped, and the signal of the Schottky receiver is analyzed by the lock-in of the DLC smart.

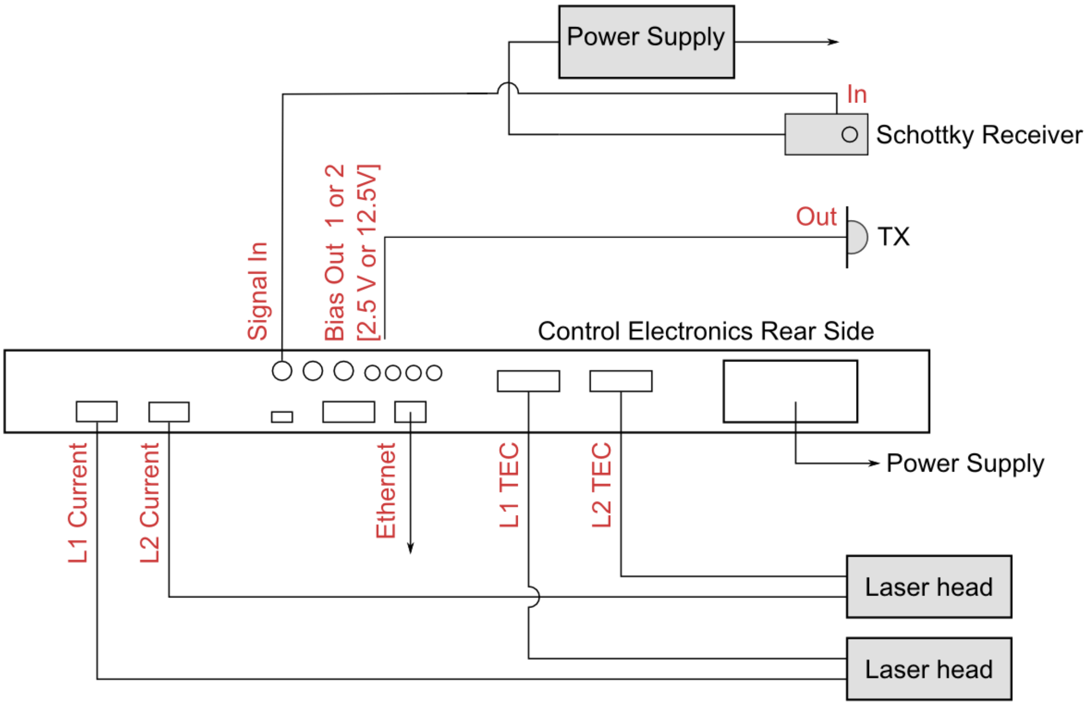


Figure 1: Electrical connections

Setup Procedure:

1. Start the TeraScan system as described in the manual.
2. Block the terahertz beam, e.g. by making sure the TX bias is switched off.
3. Connect the provided DC power supply unit to mains.
4. Connect the Schottky receiver to the provided external DC power supply unit (USB connector).
5. Connect the output signal of the Schottky receiver (SMA connector) to the “Signal Input” port of the DLC smart (SMA connector).
   Note: Do not use the external transimpedance amplifier (PDA-S) of the photoconductive receiver, as the Schottky receiver already comprises a built-in amplifier.
6. Adjust the software parameters as given in the next section.
7. Start the measurement as described in the TeraScan manual.
8. Note that the data representation in the software changes. The lower window in the main menu displays the measured raw data, which already represents the terahertz power spectrum. The online analysis feature in the upper graph is not necessary and can be disabled (refer to Figure 2).

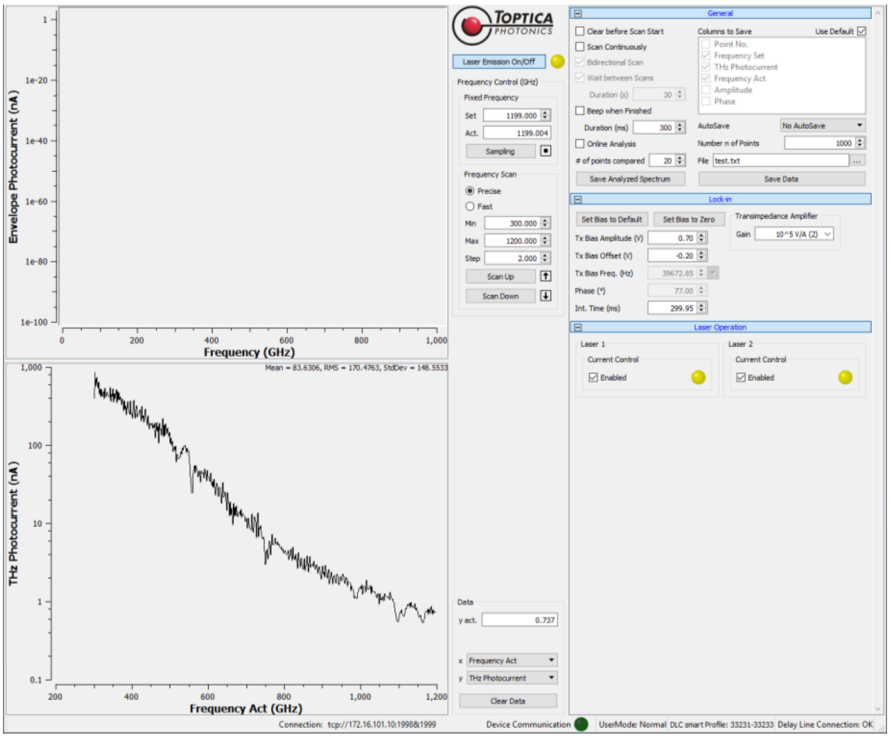


Figure 2: Electrical connections

Shutdown Procedure:

1. Block the terahertz beam, e.g. by switching off the TX bias.
2. Disconnect the Schottky receiver from the external DC power supply unit (USB connector) and unplug it from mains.
3. Disconnect the Schottky receiver (SMA connector) from the DLC smart (SMA connector).
4. Protect the SMA connector of the Schottky receiver with the SMA short circuit cap.
5. Shut down the TeraScan system as described in the manual.

Settings

Switching from a photomixer receiver to a Schottky diode requires a change in the software settings for lock-in detection and bias modulation.

TX Bias

TeraScan 1550 - InGaAs emitter:

TX Bias Offset and TX Bias Amplitude settings are given in the system datasheet, e.g. TX Bias Offset ± TX Bias Amplitude: -0.3 V ± 0.8 V

TeraScan 780 - GaAs emitter:

When the Schottky receiver is used in conjunction with a GaAs emitter, the bias needs to be chopped between zero and maximum voltage, and not between positive and negative bias amplitudes as with the photoconductive antennas.
If the maximum TX Bias voltage is, e.g., 10 V (in the system datasheet, this would show as: TX Bias Offset ± TX Bias Amplitude: 0 V ± 10 V),
then the settings for operation with the Schottky diode are:
TX Bias Offset ± TX Bias Amplitude: 5 V ± 5 V.

TX Bias Frequency 39672.85 Hz

TIA Gain Setting 2 (10^5 V/A)

Lock-in Phase Individual setting for each system (refer to datasheet)

Determining the Lock-In Phase:

The setting for the lock-in phase is specific for each system and needs to be determined once.

1. Start the measurement with the Schottky receiver as described above.
2. Set the lock-in phase parameter to a start value of 90° and check if there is a stable terahertz signal.
3. Change the lock-in phase parameter to a value of 180°. (Signal should then be close to zero.)
4. Vary the lock-in phase value until the signal equals zero.
5. Subtracting 90 degrees to this value yields the correct setting.

Optical Alignment

The Schottky module replaces the receiver antenna in the optical setup. TOPTICA offers two optomechanical setups compatible with the Schottky module using two or four parabolic mirrors (#BG-001481, see Fig. 3, and #BG-001784). A custom mount for the Schottky module is also available.

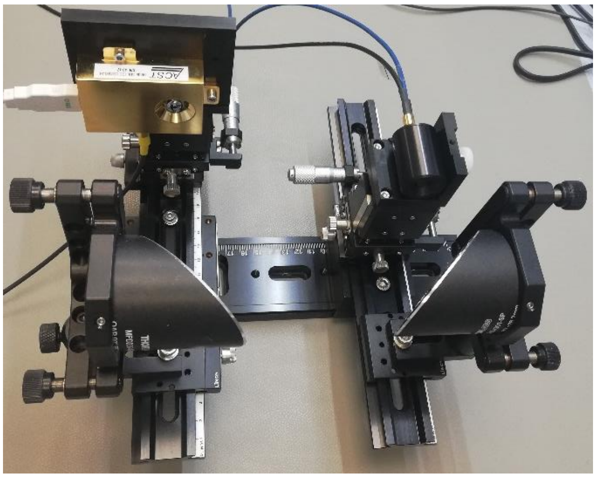


Figure 3: Optomechanical setup (#BG-001481) with Schottky diode receiver.

Setup:

1. Remove the photomixer receiver and its mount from the x-y-z-stage.
2. Place the mount for the Schottky diode onto the x-y-z-stage. The vertical part faces towards the last mirror.
3. Fix the Schottky diode onto the mount. Two mechanical stops enable an accurate placement. **The SMA-connector of the Schottky diode must be oriented downwards.** The horizontal and vertical positioning of the silicon lens should then approximately match the position of the lens on the photoconductive emitter.
4. Move the entire x-y-z-stage with the Schottky module further back on the rail. The silicon lens integrated in the Schottky module has a longer focal length than the one used for the photoconductive antennas. For a mirror with a focal length of 3” the distance to the mirror should be about 15 cm.
5. The basic procedure for the adjustment of the Schottky diode is similar to the photoconductive antenna (refer to sections 9.4 and 9.5 of the manual), the major difference being that detection with a Schottky diode is not phase sensitive. Since the signal displayed in the lower graph is proportional to the intensity of the terahertz radiation, it is always positive. It can be directly optimized by changing the alignment. It is not necessary to change the path length or terahertz frequency to get to a “fringe maximum” (step 1.7 in the manual).
6. A proven procedure for the alignment is to start at low frequencies, then increase the frequency gradually and improve the adjustment at every step (e.g.: 100 GHz; 200 GHz; 350 GHz; 500 GHz; 700 GHz; 1000 GHz).

An incorrect alignment of the optomechanical setup can result in measurement artefacts in the terahertz spectrum, like an apparently constant signal at higher frequencies, with missing water vapor absorption lines (red circle in the left graph of Figure 4). If the adjustment is carefully improved at higher frequencies, this signal increases and the water vapor lines start to appear (right graph in Figure 4).

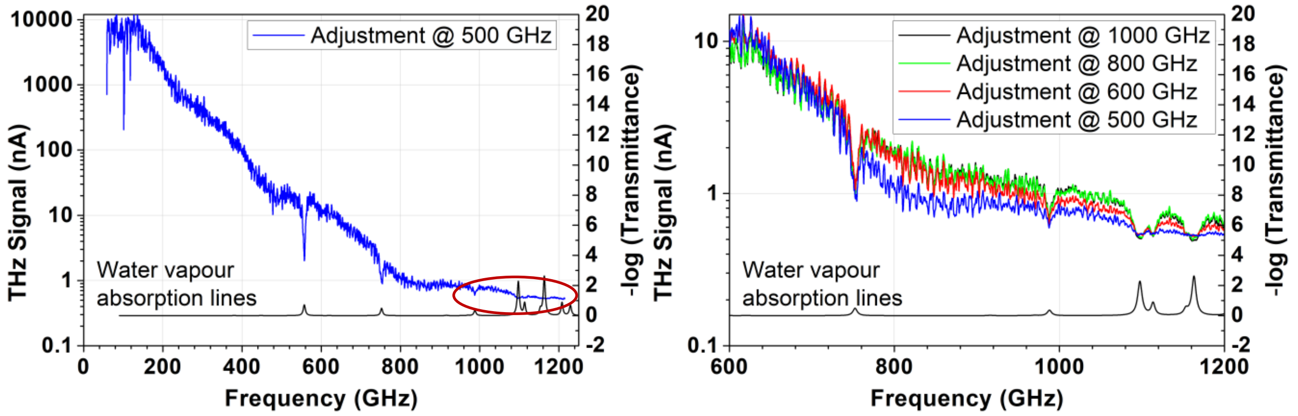


Figure 4: Terahertz spectra acquired with a Schottky diode receiver during adjustment of the optomechanical setup.