"MiniRFE-1G"

Miniaturized High-Sensitivity Optical InGaAs APD Receiver Frontend for Free-Space Gigabit-Ethernet Data Reception

Manual

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Change history:	V0.1: first version of this manual

Content

Summary of Technical Data

Parameter		Unit	Value	Condition
Typical sensitivity (mean Rx-power)		nW	250	1.25Gbps, BER=1E-6, PRBS=2^7-1
Typical minimum optical power		nW	100	1.25Gbps, BER=1E-3, PRBS=2^7-1
Maximum optical power		µW	50	damage may occur above, not tested
InGaAs-APD diameter		µm	200	
usable wavelength		µm	1 .. 1.7	
Supply voltage		V	5.5 ... 7	use lowest possible supply voltage to avoid unnecessary heating of receiver module (reduces sensitivity)
Supply current typical		mA	390	all outputs terminated with 50R
Size		mm	60 x 40 x 38	
weight	alumnium V2A	g	143 335	housing, and assembled PCB, without any cables

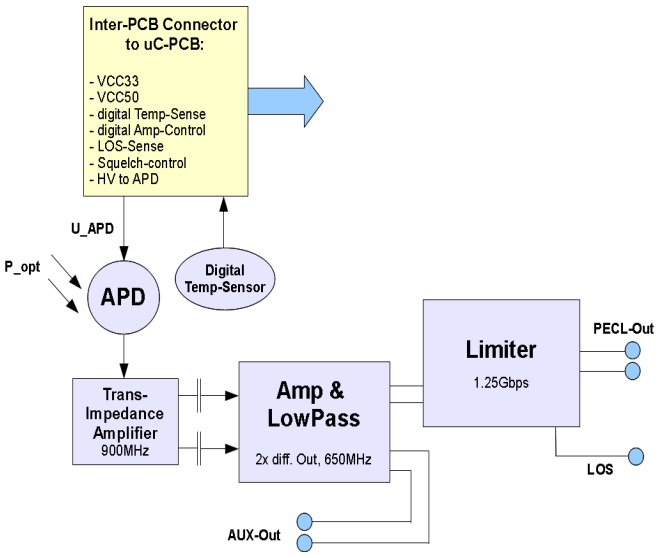
Functional Description of MiniRFE-1G

The *MiniRFE-1G* comprises a high-sensitive differential InGaAs-APD receiver frontend with a micro-controller for temperature compensated high-voltage (HV) regulation and digital interfacing via RS-232. Every devide is individually temperature calibrated. The device can be controlled from a Windows Graphical User Interface (GUI) or it can be used stand-alone in automatic HV-control mode. In manual control mode, the APD-voltage can be set via the GUI.

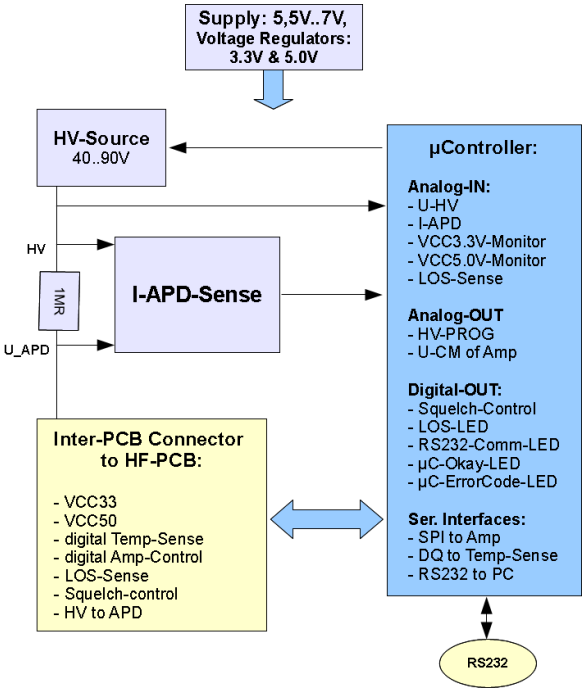
The InGaAs-APD is connected to a transimpedance amplifier which converts the photo current into a voltage signal. This signal is AC-coupled and low-pass filtered for noise-reduction and amplified with an amplifier that features two differential output ports. One differential output pair can be monitored as „AUX-Out“ and so allows direct control of the received signal amplitude and quality. This AUX-out can be dissabled to save power. The other differential amplifier output is converted by a limiting amplifier to standard differential 50R PECL outputs.

A LOS-signal (Loss-Of-Signal) is provided as SMA-output, indicated by a red LED and via the digital interface. A squelch-functionality ("PECL signals off" during LOS) can be selected via the GUI.

The PCB was produced compliant to RoHS.



High-Frequency (HF) Board Diagram



Microcontroller (uC) Board Diagram

Getting Started

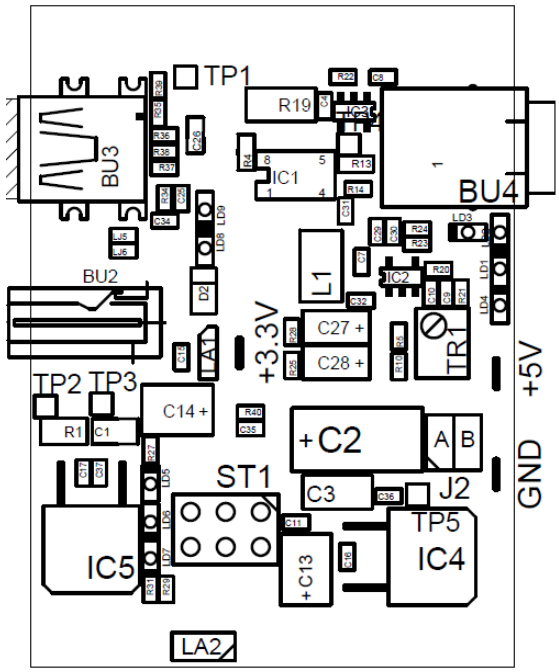
Stand-Alone Mode:

- mount device with APD in focus of the optical intensity-modulated data signal
- connect HF-BU1 to Oscilloscope (terminate with 50R) to observe analog signal quality
- connect HF-BU4 to digital data receiver, terminate with 50R
- connect HF-BU5 to high-impedance signal input to observe LOS-state
- terminate all unused SMA-plugs with 50R except for LOS-out (is high-impedance)
- connect +6V / 500mA DC power supply to BU2 (best to use laboratory power supply)
- µC will boot and signal-output starts after ~1s, LD3 blinks once per second

with GUI-Control:

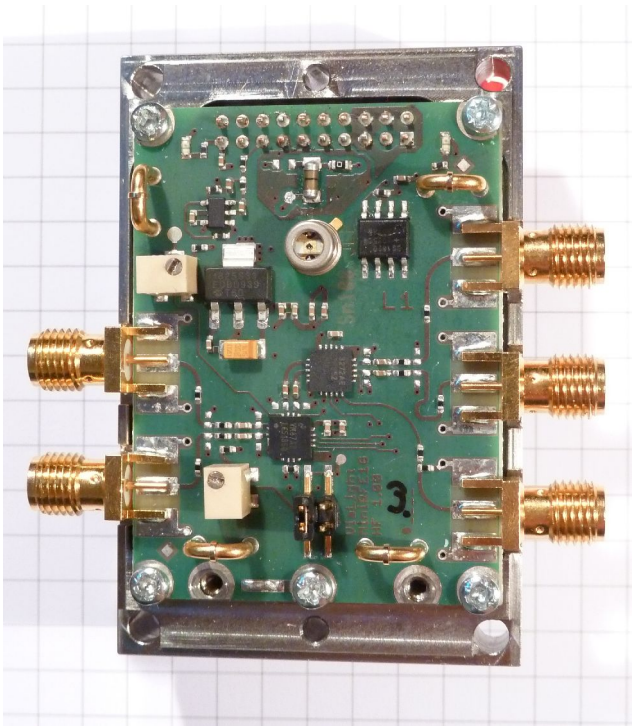
- execute all steps as described above
- connect RS232-Interface to a PC
- unpack all files of „GUI.zip“ into one directory and start „GUI.exe“
- select correct RS232 port number in GUI, press „open“
- check the description of the GUI

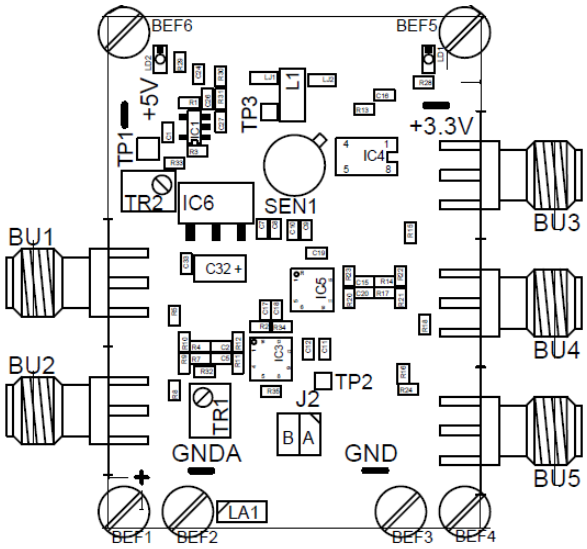
Interfaces and Controls – µController-PCB (uC)



View onto the rear PCB „uC“ (BackSide cover with the LED-ports removed)

Element	Name in Schematic	Function
Power	BU2	voltage supply input 5.5V..7V, typical: ~6V, ~400mA for connector type: power supply plug, e.g. Lumberg 1636 01 for plug with inner hole diameter: 0.7 mm, outer diameter: 2.35mm
RS232-interface	BU4	connect to PC via custom RS232-Cable (connector is type 4-wire Firewire)
HV-ctrl jumper	J2	A: control HV manually via TR1 B: control HV via µC or from PC via RS232 (default)
manual HV-ctrl	TR1	sets HV manually when J2-A; ***turn left to increase HV*** accessible via hole in the housing
Test Point 1	TP1	measure APD-HV here
PGM-connector	ST1	connector to flash new µC-Software
RS232-data	LD1	on when RS232 is sending data to PC
	LD2	µC-error, red
	LD3	µC-alive signal
	LD4	on when LOS , yellow
	LD5	power-supply on, green
	LD6	VCC-5.0V Okay, green
	LD7	VCC-3.3V Okay, green
5 screw holes		make sure to connect the GND-layer to the housing and to the HF-PCB via the screws at the bottom of the PCB





View onto the APD-side PCB „HF“ (FrontSide housing removed)

Element	Name in Schematic	Function
AUX-OUT(+)	BU1	analog monitoring output
AUX-OUT(-)	BU2	analog monitoring output
DIG-OUT(-)	BU3	negative PECL-out
DIG-OUT(+)	BU4	positive PECL-out
!LOS-signaling	BU5	high (~1V) when a sufficient signal level is detected, terminate into >10kR
Offset-Jumper	J2	controls internal Offsets, needs to be set to „B“ (left)
detector	SEN1	InGaAs-APD, 200µm diameter
	BEF1..4	screw connectors for GND to housing and uC-PCB

Typical Signals as seen on Oscilloscope

Typical Output Signals with (upper) P_{Rx}=2µW and (lower) P_{Rx}=250nW, datarate is 1.25Gbps with PRBS 2^7-1 (all lines terminated into 50R)

upper channel: positive analog out (HF-BU1), 50mV/ in upper picture, 20mV/ in lower
second channel: negative analog out (HF-BU2), 50mV/ in upper picture, 20mV/ in lower
lower channel: negative PECL-out (HF-BU3), 200mV/ in both pictures

Typical Performance Measurements of MiniRFE-1G

All measurements with 1.25Gbps, PRBS=2^7-1, wavelength=1550nm

	P-Rx /nW	Temp_APD/°C	U_APD /V	U_HV /V	I_APD /µA	Amp_AUX /mv	BER
manual-HV	103	35.8	51.5	58.6	7.1	14	1,2E-3
	162	35.8	51.5	60.4	8.9	27	1.3E-5
	287	35.2	51.4	65.2	13.8	50	2,0E-7
	646	36.3	50.5	71.1	20.0	68	0,0E+0
automatic-HV	103	25.0	49.5	54.6	3.1	9.6	2,0E-3
	103	33.8	50.8	56.5	3.8	12	1,0E-3
	162	22.5	49.1	56.0	4.9	14	7,0E-4
	287	22.9	49.2	59.8	8.4	30	4,0E-7
	287	34.1	50.7	62.4	9.5	36	1,0E-7
	287	38.4	51.2	62.5	9.2	32	3,0E-7
	646	23.1	49.2	69.6	18.5	64	0,0E+0
	646	33.3	50.6	73.4	20.6	74	0,0E+0
	2584	24.0	49.4	84.4	33.0	106	0,0E+0

Graphical User Interface

Screenshot of the Graphical User Interface for the MiniRFE-1G

The Graphical User Interface can be used under Windows XP/Vista/7. To install the GUI, the supplied archive-file must be extracted. Subsequent to this step, the GUI can be started by running the contained executable file. Please note that also library files are supplied within the archive file. Without these libraries, the GUI might not be able to run.

The connection to a MiniRFE-1G can be initiated by selecting a proper Serial Port, followed by a click on the „Open“ Button. All relevant functionalites of the MiniRFE-1G can be controlled via the GUI. This includes:

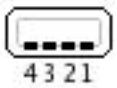
- **Flags**
  Enable/Disable Squelch Functionality
  Enable/Disable Auxiliary Signal Output
  Enable/Disable High Voltage Module
  Automatic/Manual Control of High Voltage
- **High Voltage Control (Manual Mode Only)**
  In case the MiniRFE-1G is operated in manual High-Voltage Control Mode, the High Voltage can be selected here
- **Status**
  A green light indicates if the given value is activated or not.
- **Measured Values**

A Number of values are displayed in this section:

U_APD / V	Voltage measured at the Avalanche Photodiode
I_APD / µA	Photocurrent of the Avalanche Photodiode
HV / V	High Voltage at the Output of the High-Voltage Generation Module
Temp / °C	APD-Temperature in Degrees Celsius
Vcc 3.3V / V	Current Status of 3.3V Supply Voltage
Vcc 5.0V / V	Current Status of 5.0V Supply Voltage

RS232-Cable (Firewire Connector)

A Standard Firewire-Connector is used on the PCB to connect the MiniRFE-1G via RS232 to a PC. The MiniRFE-1G is supplied with a cable converting the firewire-connector to a standard Sub-D-9 RS232 Connector.

	1 - Ground 2 - RXD 3 - TXD 4 - NC
Pinout of the Firewire Connector	

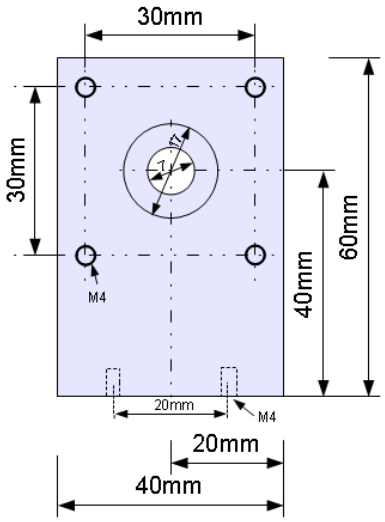
Direct Control via a standard RS232 Terminal Programm

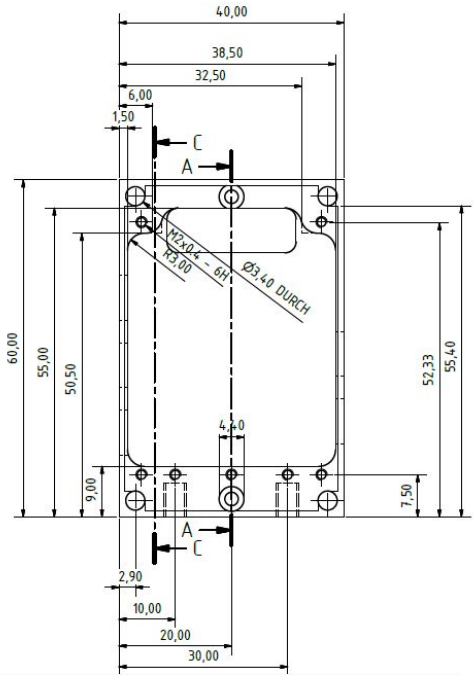
The parameters of the MiniRFE-1G visible in the GUI can also be accessed over a standard terminal program. The terminal program needs to be set up with the parameters: 9600baud, 8 Databits, 1 Stopbit, No FlowControl. After initiating the connection, a self-explaining clear text output is provided.

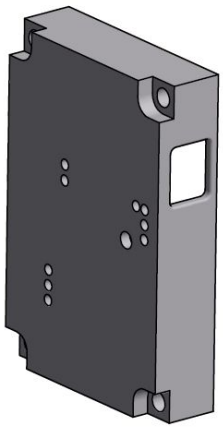
Please note that it is ***not recommended*** to use a standard terminal program to directly access the MiniRFE-1G's parameters, as this mode of operation allows the adjustment of parameters that were preset in the factory for optimum performance. Programming wrong parameters can damage the APD through obvervoltage. Do use the provided GUI instead. The MiniRFE-1G has been optimized in a way that all specifications are guaranteed over the full temperature range, and under normal operation conditions an adjustment of these parameters is not necessary.

Thus it is recommended to use the GUI for normal operation of the MiniRFE-1G.

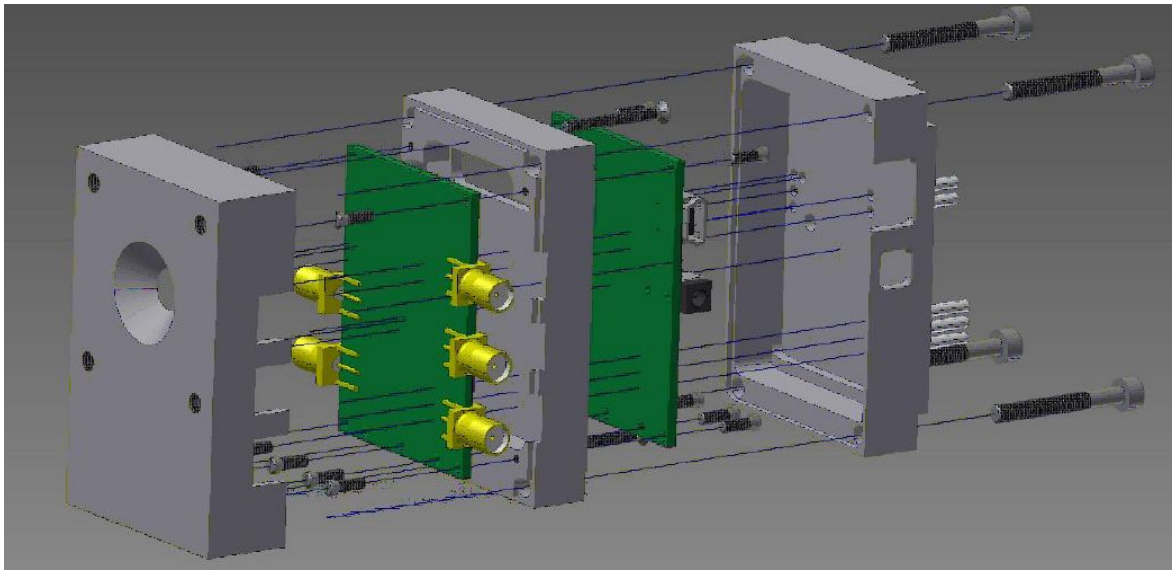
Housing







FrontSide MiddlePart BackSide



Advices / Remarks

- The RFE is optimized for a data rate of 1.25Gbps. Serial data between 125Mbps and 1.4Gbps can be received in general but at lower photons-per-bit sensitiviy.
- The AUX-Out-amplitude does not rise linearly to the received power due to the current-limiting HV-supply circuit which protects the APD from photo current overload.
- If available, the device should be used with a good quality laboratory power supply at 6V / 450mA. With a small wall power supply, the sensitivity might decrease due to increased supply voltage ripple.
- terminate all unused signal-outputs into 50R (but not BU5, which is high-impedance and shall be left open when not used)

Abbreviations

APD	Avalanche Photo Diode
HV	High Voltage (for APD)
HF	High-Frequency-PCB
uC	Micro-Controller-PCB
µC	Micro-Controller
PCB	Printed Circuit Board