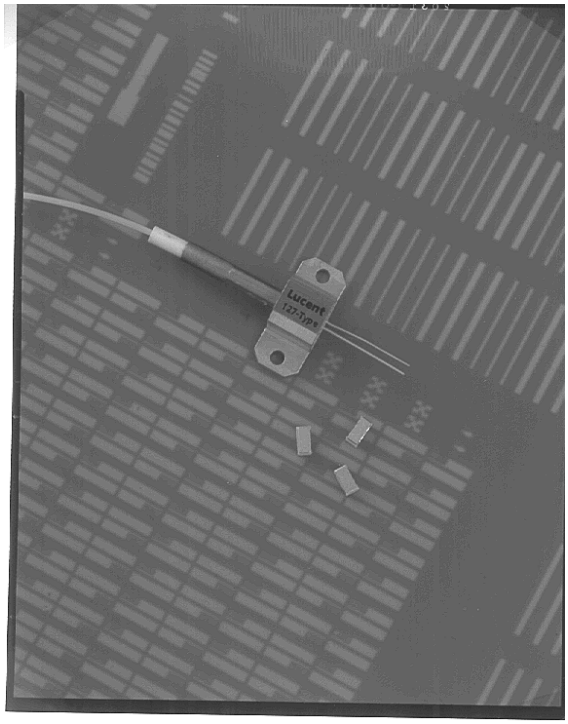
Data Sheet
September 1998

microelectronics group

Lucent Technologies
Bell Labs Innovations

127A/B/C InGaAs Avalanche Photodetectors



The 127A/B/C APDs are compatible with industry-standard packages.

Features

- High performance at both 1.3 µm and 1.5 µm.
- Suitable for use in harsh environments.
- Higher sensitivity and longer wavelength response than germanium APDs.
- Permanently locked fiber alignment and high coupling stability.
- Reliable planar structure with InGaAsP layer and dual guard ring for high-speed performance.
- Wide bandwidth:
  — >1.0 GHz (127A)
  — >1.8 GHz (127B)
  — >2.5 GHz (127C)
- Compatible with industry-standard packaging.
- Applications for high data rates: up to 1.5 Gbits/s (127A) or 2.5 Gbits/s (127B/C).
- Low capacitance.
- Standard pigtail is a multimode fiber with an FC/PC connector; other pigtails or connectors available on request.

Applications

- Telecommunications
  — High-speed, long-haul communication systems
  — High-speed metropolitan area networks
  — Submarine cable communication systems
- Military
  — Very low-noise receivers
  — Satellite transmission
  — Optical radar
  — Free-space optical communication systems

Description

The Lucent Technologies Microelectonics Group 127A/B/C InGaAs Avalanche Photodetectors (APDs) are high-performance optical devices that are sensitive at both 1.3 µm and 1.5 µm wavelengths. The APDs feature high sensitivity and wide bandwidths and are capable of data rates up to 2.5 Gbits/s.

The APD chip is fabricated by vapor-phase epitaxy and has a planar structure for high reliability. Common applications include long-distance lightwave telecommunication systems and extremely sensitive optical measurement systems.

The 127A/B/C APDs incorporate a hermetically sealed, ceramic package that is bonded within a metal flange. A multimode, fiber-optic pigtail, which is terminated with an FC/PC connector, is aligned with the photodetector chip by means of the metal flange. Other pigtails or connectors are available upon request. The 127A and 127B differ only in the bandwidth. The 127C has modified crystalline layers to provide an increased bandwidth.

Absolute Maximum Ratings

Stresses in excess of the Absolute Maximum Ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of the data sheet. Exposure to Absolute Maximum Ratings for extended periods can adversely affect device reliability.

Parameter	Symbol	Min	Max	Unit
Operating Case Temperature	T_c	–40	80	°C
Storage Case Temperature*	T_{stg}	–55	80	°C
Reverse Current	I_r	—	1	mA
Lead Soldering Temperature/Time	—	—	275/10	°C/s

* Upper storage temperature is limited by multimode fiber.

Electrical Characteristics

Table 1. General Electrical Characteristics

All measurements at 25 °C, 1.3 µm light.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Breakdown Voltage:						
127A	V_{br}	I_d = 10 µA	55	65	95	V
127B	V_{br}	I_d = 10 µA	55	65	95	V
127C	V_{br}	I_d = 10 µA	45	60	90	V
V_{br} Temperature Coefficient:						
127A	γ	—	0.15	0.20	0.30	%/°C
127B	γ	—	0.15	0.20	0.30	%/°C
127C	γ	—	0.12	0.15	0.20	%/°C
Maximum Gain:						
127A	M_{max}	—	30	—	—	—
127B	M_{max}	—	30	—	—	—
127C	M_{max}	—	30	—	—	—
Primary Dark Current:						
127A	I_{dp}	—	—	5	10	nA
127B	I_{dp}	—	—	5	10	nA
127C	I_{dp}	—	—	10	15	nA

Electrical Characteristics (continued)

Table 1. General Electrical Characteristics (continued)

All measurements at 25 °C, 1.3 µm light.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Total Dark Current:						
127A	I_{dm}	M = 12	—	50	100	nA
127B	I_{dm}	M = 12	—	50	100	nA
127C	I_{dm}	M = 12	—	100	150	nA
Bandwidth:						
127A	f_c	4 < M < 12	1.3	1.5	—	GHz
127B	f_c	4 < M < 12	1.8	2.0	—	GHz
127C	f_c	4 < M < 12	2.5	3.0	—	GHz
Excess Noise Factor:						
127A	F	M = 12	—	5	6	—
127B	F	M = 12	—	5	6	—
127C	F	M = 12	—	5	6	—
Capacitance:						
127A	C	M = 12	—	0.5	0.6	pF
127B	C	M = 12	—	0.5	0.6	pF
127C	C	M = 12	—	0.6	0.7	pF
Gain Coefficient:*						
127A	A	M > 3	50	60	70	V
127B	A	M > 3	50	60	70	V
127C	A	M > 3	30	40	60	V
Responsivity:†						
127A	R	M = 12	9.1	9.6	—	A/W
127B	R	M = 12	9.1	9.6	—	A/W
127C	R	M = 12	9.1	9.6	—	A/W

* The A coefficient and the breakdown voltage are given for each APD. The gain at any voltage (for M > 3) can be calculated from these parameters per: $M = A/(V_{br} - V)$.

† Responsivity = quantum efficiency x coupling efficiency x gain x (λ/1.24).

Characteristic Curves (T_A = 25 °C)

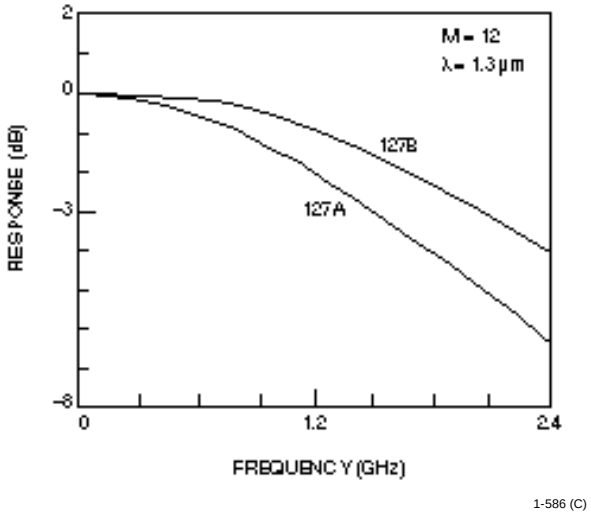


Figure 1. Frequency Response (127A/B)

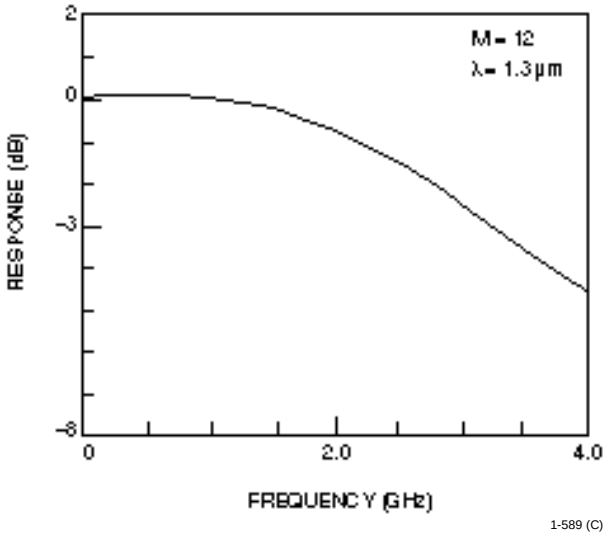
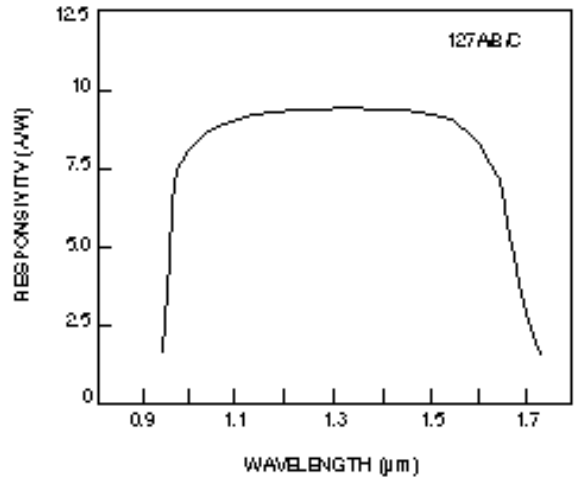


Figure 3. Frequency Response (127C)



Note: Responsivity = chip quantum efficiency x pigtail coupling efficiency x gain x λ (µm)/1.24. The minimum chip quantum efficiency is 80%, and the minimum pigtail coupling efficiency is 90%.

1-588 (C)

Figure 2. Responsivity vs. Wavelength for M = 12 and λ = 1.3 µm

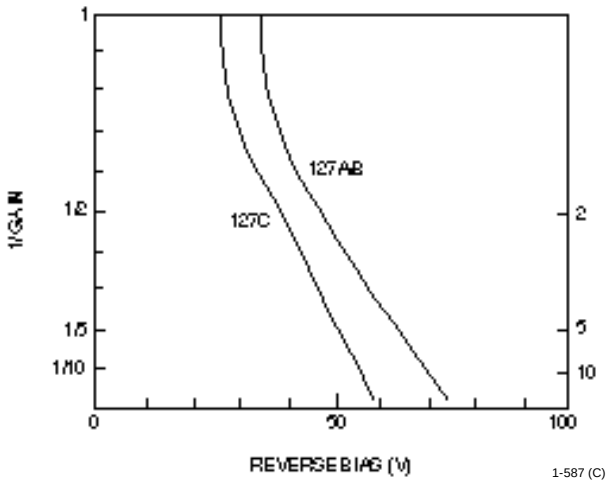


Figure 4. 1/Gain vs. Reverse Bias

Characteristic Curves (T_A = 25 °C) (continued)

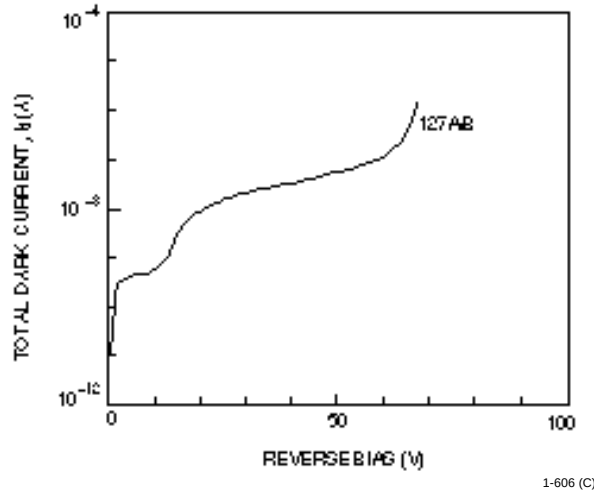


Figure 5. Dark Current vs. Reverse Bias (127A/B)

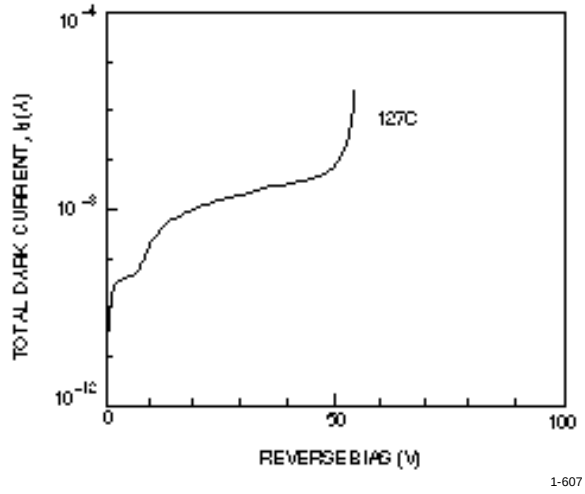


Figure 6. Dark Current vs. Reverse Bias (127C)

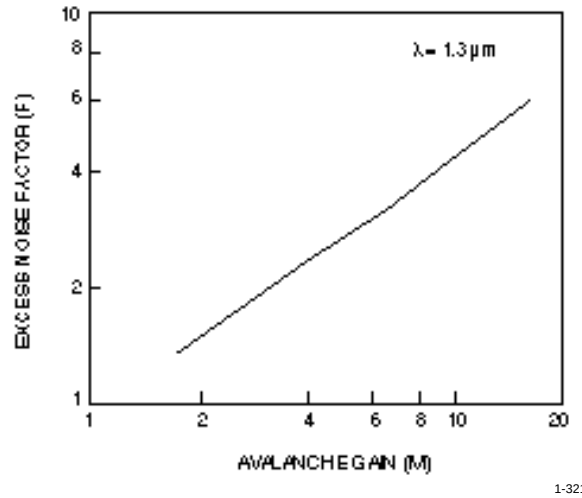


Figure 7. Excess Noise Factor vs. Gain

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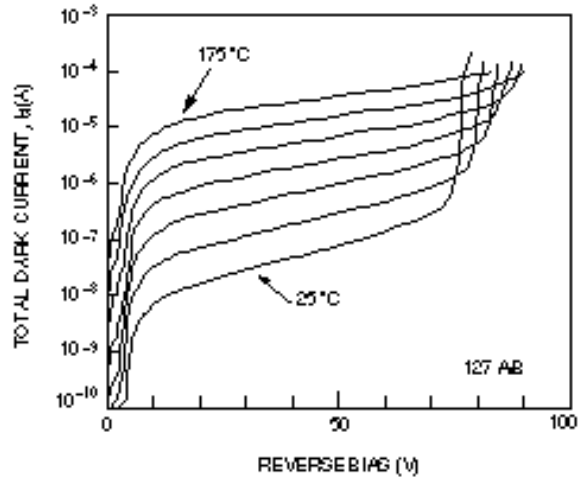


Note: The temperature dependence of the 127C dark current is the same as the 127A/B.

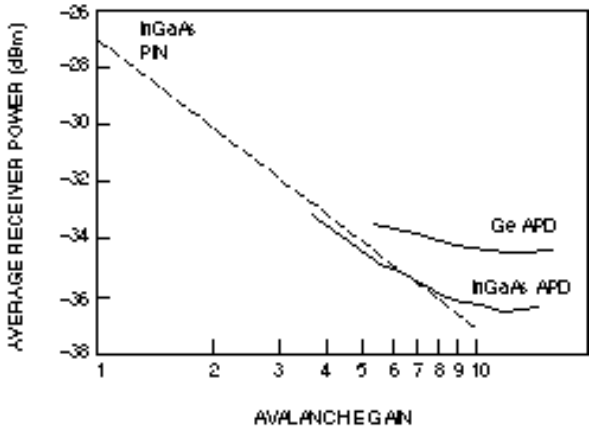
1-608 (C)

Figure 8. Dark Current vs. Voltage as a Function of Temperature at 25 °C Increments

Characteristic Curves (T_A = 25 °C) (continued)

APD Receiver Sensitivity

The following figure illustrates typical receiver sensitivity at a receiver rate of 1.7 Gbits/s and λ = 1.3 µm for an InGaAs PIN, Ge APD, and InGaAs APD.



1-491 (C)

Figure 9. APD Receiver Sensitivity

Qualification Information

The 127-Type APD Module has been subjected to the following qualification tests with the intent of meeting Bellcore TR-NWT-000468 requirements. Not all of the 468 tests have had to be performed specifically on the 127 due to its use of pieceparts from similar, already qualified designs. For example, the hermetic ceramic package in the 127 has already been qualified from previous APD products using the same part; therefore, a high-temperature operating bias test is not required. If some test parameters do not fully meet the 468 requirements, it is due to the limitations of the test equipment involved. For all of the indicated tests, the failure criteria includes a change in breakdown voltage greater than 1 V; an increase in the multiplied dark current greater than twice the original value, or a total of 600 nA.; a change in responsivity greater than 10%; or an increase in the primary dark current greater than twice the original, or a total of 5 nA.

Table 2. 127 APD Qualification Test Program

Test Name	Test Conditions	Sample Size/ No. of Failures
Temperature Cycle	100 cycles, –40 °C to +70 °C, air to air	10/0
Vibration	Max acceleration = 100 g, frequency range: 20 Hz min to 1500 Hz max, minimum cycle time = 4 min., 3 axes	10/0
Mechanical Shock	Acceleration = 1500 g, number of blows each direction = 5, shock pulse duration = 0.5 ms, number of axes = 6, ±x, ±y, ±z	10/0
Mechanical Sequence	Same as vibration and shock but administered sequentially on the same devices	10/0
High-Temperature Storage 1	T = 70 °C for 168 hours	10/0
High-Temperature Storage 2	T = 80 °C for 1000 hours, devices used are from high-temperature storage cell 1	10/0
Damp Heat	T = 85 °C, 85% RH, 4 devices for 864 hours 12 devices for 624 hours	16/0
Cyclic Moisture Resistance	10 cycles, 1 day/cycle, each cycle 25 °C to 65 °C, 90% to 100% RH	10/0
Fiber Pull	>3 N, 3 times parallel to feedthrough; same devices ~10 N, 3 times parallel to feedthrough	9/0
Resistance Soldering to Heat	T = 350 °C, 3.5 s, 2.5 mm from package body	4/0

Ordering Information

Description	Part Number	Comcode
InGaAs Avalanche Photodetector	127A	105742969
	127B	105742977
	127C	106186299

For additional information, contact your Microelectronics Group Account Manager or the following:

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