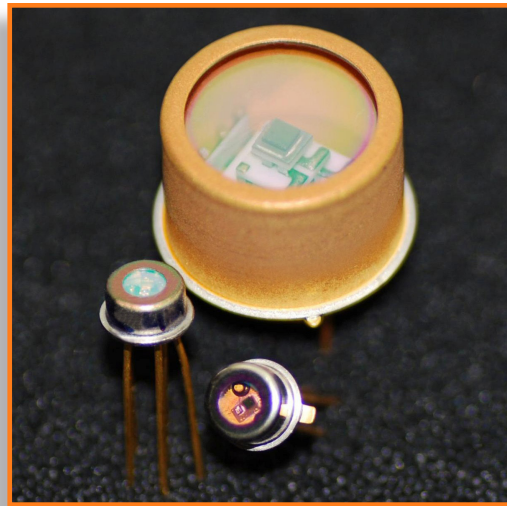


**Deschutes™ Packaged APDs**  
**Reduced-excess-noise APD in TO-46 or TO-8**  
**with optional 3-stage thermoelectric cooler**

**Features**

- **Low-capacitance mesa architecture**
- **Back-illuminated for high sensitivity**
- **Wide spectral response - 950-1700 nm**
- **Less (4x lower) excess noise than other commercial APDs**
- **Low noise gain;  $M > 20$**



**Model VFC1-xCAA Packaged APD (TO-46)**  
**Model VFC1-xKAB Packaged APD (TO-8)**

Reduced-excess-noise avalanche photodiodes (APDs) in hermetic TO-46 or TO-8 packages allow users to easily integrate Voxel's 950 – 1700-nm-response APDs into high-performance electro-optical systems. The TO-8 package allows for a 3-stage thermo-electric cooler, which can provide a 100 °C temperature differential from ambient (packages rated down to -40°C.)

Voxel's VFC-1000 series APDs are designed to deliver the best possible sensitivity for high-bandwidth near infrared (NIR) and short-wavelength infrared (SWIR) optical applications. With low avalanche noise and high quantum efficiency over the 950 – 1700-nm spectral band, including the eyesafe wavelengths beyond 1400 nm, the VFC-1000 InGaAs APDs provide enhanced responsivity relative to p-i-n photodiodes, with lower noise than conventional NIR APD designs.

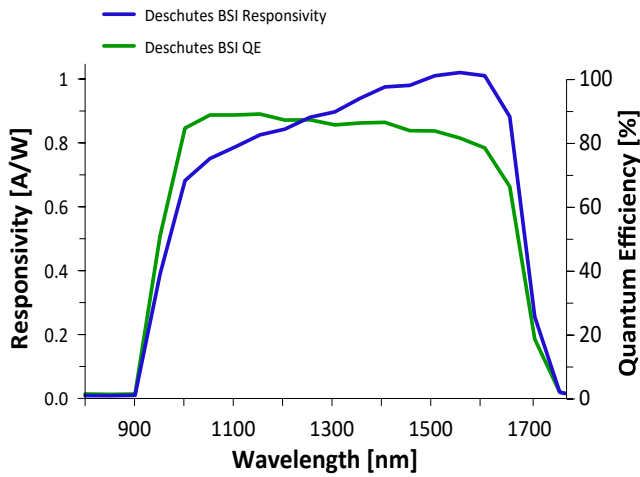
Voxel's thin InAlAs multiplication region InGaAs APD technology suppresses the excess multiplication noise associated with the avalanche process, improving the signal-to-noise ratio of the detector. Contemporary APDs achieve high responsivity through internal current gain, but the usefulness of the gain of these APDs is undermined by the accompanying noise. Voxel's APDs can be operated at relatively high gain with a smaller noise penalty, providing a significant advantage. Coupling the APD to a low-noise amplifier produces a receiver with superior noise equivalent power (sensitivity).

**Applications**

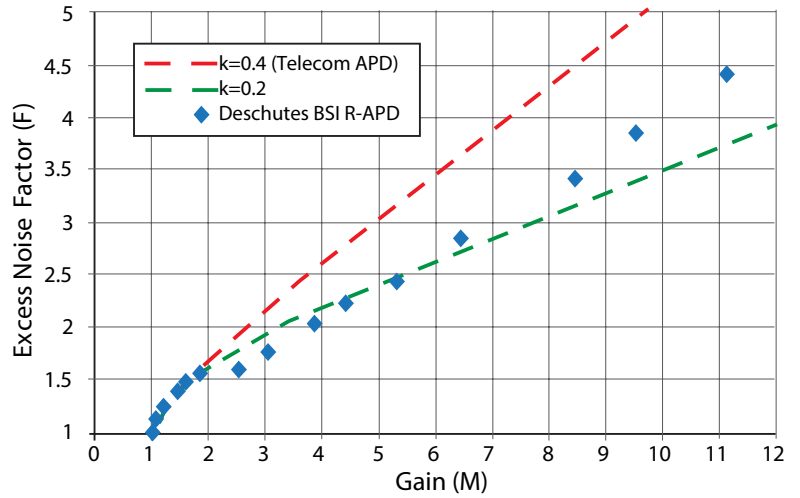
- **Lasercom**
- **Laser ranging**
- **LADAR/LIDAR**
- **Fluorescence studies**

## VFC-1000 Series

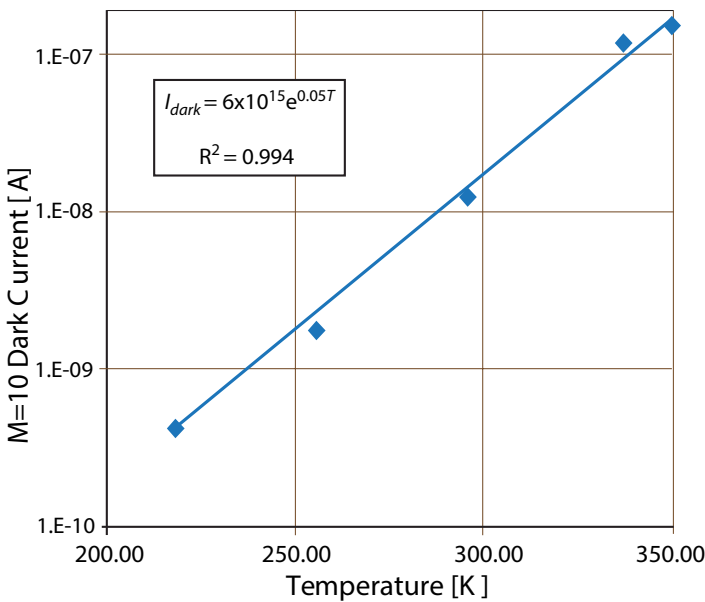
## Model VFC1-xCAA/xKAB



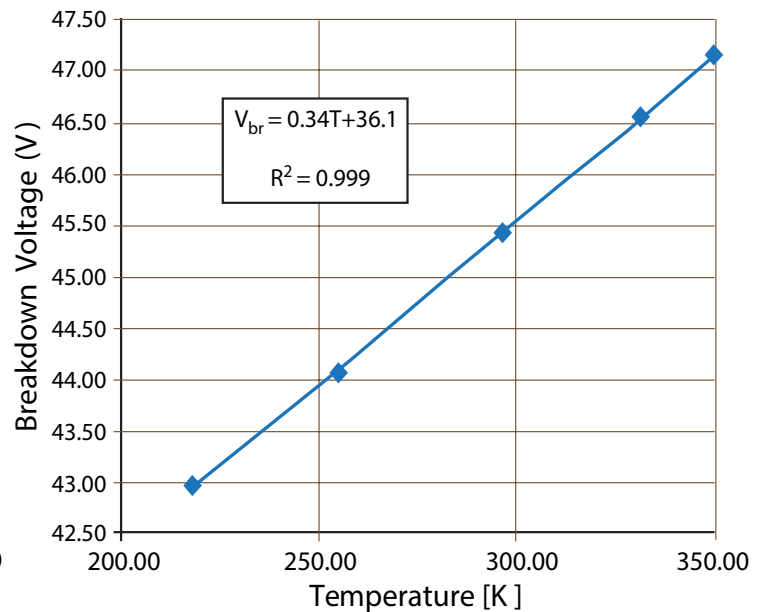
**Spectral responsivity and quantum efficiency of 200µm APD @ 298K**



**Excess noise of the Deschutes APD,  $k \sim 0.2$**



**Effects of temperature on dark current and breakdown voltage of a 200-µm Deschutes APD at M=10**

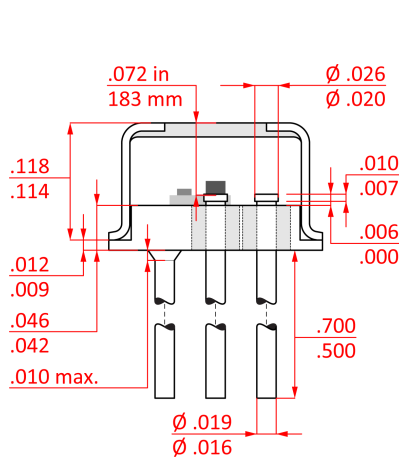


**Model VFC1-xCAA/xKAB**

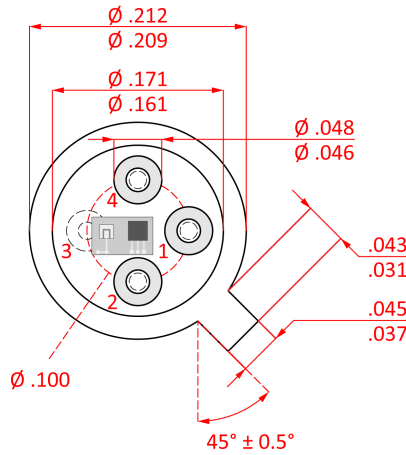
**VFC-1000 Series**

**Mechanical Information**

**TO-46 Package**



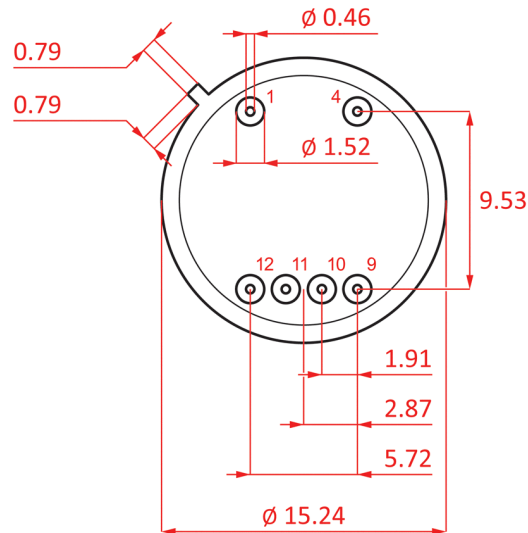
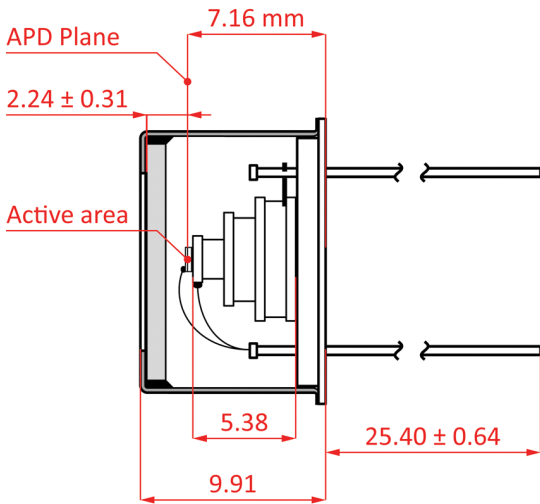
**SIDE VIEW  
with cap**



**TOP VIEW  
header only**

- Pinout**
- 1) APD Cathode
  - 2) APD Anode
  - 3) Ground, T Sense -
  - 4) T Sense +

**TO-8 Package**



- Pinout**
- 1) TEC -
  - 4) TEC +
  - 9) Temp Sense -
  - 10) Temp Sense +
  - 11) APD Anode (p)
  - 12) APD Cathode (r)

## Models VFC1-JCAA (TO-46) and VFC1-JKAB (TO-8 w/3-stage TEC) 75-micron APD, 2.0 GHz on ceramic submount

### Specifications

Parameter	Min	Typical	Max	Units
Spectral Range, $\lambda$	950	1000–1600	1750	nm
Active Diameter		75		$\mu\text{m}$
APD Operating Gain, $M$	1	10	20	
Responsivity at $M=1$	.66 .91	.73 1.01	.78 1.04	A / W $\lambda=1064$ nm $\lambda=1550$ nm
Excess Noise Factor, $F(M,k)$		3.4 4.3		$M=10$ $M=15$
Noise Spectral Density @ $M=10$		0.48		$\text{pA} / \text{Hz}^{1/2}$
Dark Current @ $M=1^i$	0.8	1.9	2.5	nA
Total Capacitance <sup>ii</sup>		0.76		pF
Bandwidth		2.0		GHz
Breakdown Voltage, $V_{BR}^{iii}$	44	49	55	V
$\Delta V_{BR}/\Delta T$	30	34	39	mV / K
Minimum Internal Temperature	-40			°C
TE cooler rating <sup>iv</sup>			1.9 / 1.2	V / A
Temperature Sensing Diode Voltage and $\Delta V/K^v$	0.48	0.50 -2.18 mV / K	0.51	V
Maximum Instantaneous Input Power <sup>vi</sup>			1	mW

*i Gain normalized from  $M=10$ ,  $T=298$  K*

*ii  $M>3$*

*iii  $T=298$  K;  $I_{dark}>0.1$  mA*

*iv For VFC1-xKAB devices, package at 298 K*

*v Sourcing 10  $\mu\text{A}$ ,  $T=298$  K*

*vi 10 ns, 1064 nm signal at a 20 Hz PRF with an APD multiplication gain of  $M=10$*

## Models VFC1-NCAA (TO-46) and VFC1-NKAB(TO-8 w/3-stage TEC) 200-micron APD, 500 MHz on ceramic submount

### Specifications

Parameter	Min	Typical	Max	Units
Spectral Range, $\lambda$	950	1000–1600	1750	nm
Active Diameter		200		$\mu\text{m}$
APD Operating Gain, $M$	1	10	20	
Responsivity at $M=1$	.66 .91	.73 1.01	.78 1.04	A / W $\lambda=1064$ nm $\lambda=1550$ nm
Excess Noise Factor, $F(M,k)$		3.9 7.9		$M=10$ $M=20$
Noise Spectral Density @ $M=10$		1.01		$\text{pA} / \text{Hz}^{1/2}$
Dark Current @ $M=1^i$	6	8.1	10.0	nA
Total Capacitance <sup>ii</sup>		2.5		pF
Bandwidth		500		MHz
Breakdown Voltage, $V_{BR}^{iii}$	44	49	55	V
$\Delta V_{BR}/\Delta T$	30	34	39	mV / K
Minimum Internal Temperature	-40			°C
TE cooler rating <sup>iv</sup>			1.9 / 1.2	V / A
Temperature Sensing Diode Voltage and $\Delta V/K^v$	0.48	0.50 -2.18 mV / K	0.51	V
Maximum Instantaneous Input Power <sup>vi</sup>			5	mW

*i* Gain normalized from  $M=10$ ,  $T=298$  K

*ii*  $M>3$

*iii*  $T=298$  K;  $I_{\text{dark}}>0.1$  mA

*iv* For VFC1-xKAB devices, package at 298 K

*v* Sourcing 10  $\mu\text{A}$ ,  $T=298$  K

*vi* 10 ns, 1064 nm signal at a 20 Hz PRF with an APD multiplication gain of  $M=10$

## Models VFC1-PKAB(TO-8 w/3-stage TEC) 500-micron APD, 100 MHz on ceramic submount

### Specifications

Parameter	Min	Typical	Max	Units
Spectral Range, $\lambda$	950	1000–1600	1750	nm
Active Diameter		500		$\mu\text{m}$
APD Operating Gain, $M$	1	10	20	
Responsivity at $M=1$	.66 .91	.73 1.01	.78 1.04	A / W $\lambda=1064\text{ nm}$ $\lambda=1550\text{ nm}$
Excess Noise Factor, $F(M,k)$		3.9 7.9		$M=10$ $M=20$
Noise Spectral Density @ $M=10$		2.74		$\text{pA} / \text{Hz}^{1/2}$
Dark Current @ $M=1^i$	40	60	90	nA
Total Capacitance <sup>ii</sup>		12.5		pF
Bandwidth	90	100	200	MHz
Breakdown Voltage, $V_{BR}^{iii}$	44	49	55	V
$\Delta V_{BR}/\Delta T$	30	34	39	mV / K
Minimum Internal Temperature	-40			°C
TE cooler rating <sup>iv</sup>			1.9 / 1.2	V / A
Temperature Sensing Diode Voltage and $\Delta V/K^v$	0.48	0.50 -2.18 mV / K	0.51	V
Maximum Instantaneous Input Power <sup>vi</sup>			20	mW

*i* Gain normalized from  $M=10$ ,  $T=298\text{ K}$

*ii*  $M>3$

*iii*  $T=298\text{ K}$ ;  $I_{\text{dark}}>0.1\text{ mA}$

*iv* For VFC1-xKAB devices, package at  $298\text{ K}$

*v* Sourcing  $10\ \mu\text{A}$ ,  $T=298\text{ K}$

*vi*  $10\text{ ns}$ ,  $1064\text{ nm}$  signal at a  $20\text{ Hz}$  PRF with an APD multiplication gain of  $M=10$

**Ordering Information for VFC-1000 Series APD Products**

V	F	C	1	-	-	A	-
Device	Device Type	Detector	Detector	Diameter	Package	Window	Revision
V = APD	F = Linear mode	C = Deschutes APD	1 = Single Element	E=30 μm H=50 μm J=75 μm N=200 μm P=500 μm	C=TO-46 K=TO-8 w/3-stage TE-Cooler	A=Flat B=Epoxy Fill	

Not all combinations of product features are available. Please contact Voxel for specific ordering information and parts availability.

**Caution During APD Operation**

If an APD is operated above its breakdown voltage without some form of current protection, it can draw enough current to permanently damage the device. To guard against this, the user can add either a protective resistor to the bias circuit or a current-limiting circuit in the supporting electronics.

The breakdown voltage of an APD is dependent upon its temperature: the breakdown voltage decreases when the APD is cooled. Consequently, a reverse bias operating point that is safe at room temperature may put the APD into breakdown at low temperature. The approximate temperature dependence of the breakdown voltage is published in the spec sheet for the part, but caution should be exercised when an APD is cooled.

Low-noise readout circuits usually have high impedance, and an unusually strong current pulse from the APD could generate a momentary excessive voltage that is higher

than the readout's supply voltage, possibly damaging the input to the amplifier. To prevent this, a protective circuit should be connected to divert excessive voltage at the inputs to a power supply voltage line.

As noted in the specification, another consideration is that the APD gain changes depending on temperature. When an APD is used over a wide temperature range, it is necessary to use some kind of temperature compensation to obtain operation at a stable gain. This can be implemented as either regulation of the applied reverse bias according to temperature, feedback temperature control using a thermoelectric cooler (TEC) or other refrigerator, or both.

Upon request, Voxel will gladly assist customers in implementing the proper controls to ensure safe and reliable operation of APDs in their system.