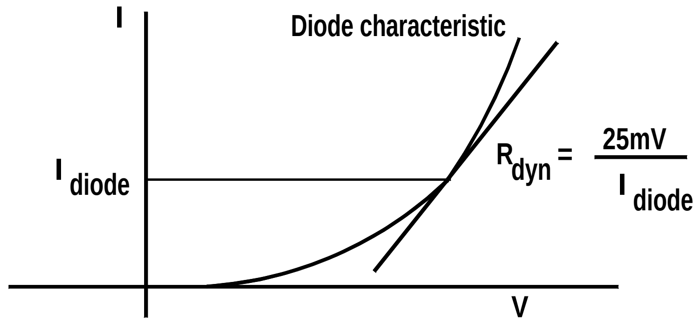
When a diode is operated in the small signal region, the dynamic resistance or change of voltage across the diode for a change of current through the diode is given by:—

$$\frac{dV}{dI} = \frac{25mV}{I}$$



$$I = I_0 \exp\left(\frac{V}{25mV}\right)$$

where V is the voltage across the diode and 25 millivolts is the calculated value of $\frac{kT}{e}$ at room temperature.

Avoid large diode currents,
then the effect of the bulk resistance of the diode can be neglected since it is small compared to the junction effects.
Valid when the voltage across the diode does not exceed the knee voltage.

Differentiate the diode current equation to obtain the change of current with voltage.

$$\begin{aligned}\frac{dI}{dV} &= \frac{d}{dV}\left(I_0 \exp\left(\frac{V}{25mV}\right)\right) \\ &= \frac{I_0}{25mV}\exp\left(\frac{V}{25mV}\right) \\ &= \frac{I}{25mV}\end{aligned}$$

The dynamic resistance is the reciprocal

$$R_{dyn} = \frac{dV}{dI} = \frac{25mV}{I}$$

which, in words, is 25 millivolts divided by the DC current through the diode.

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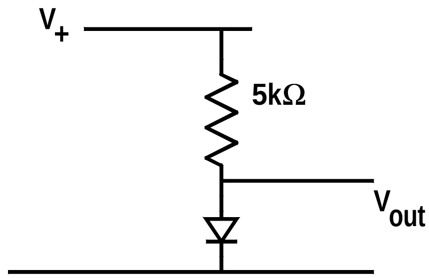
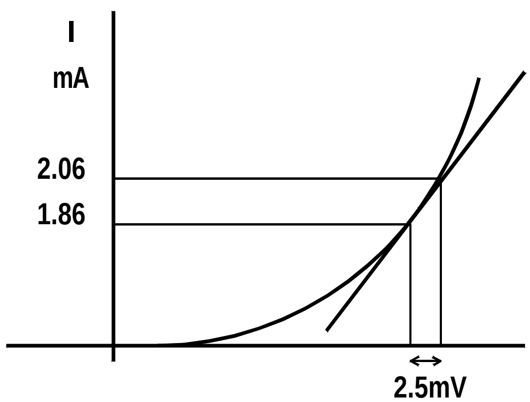
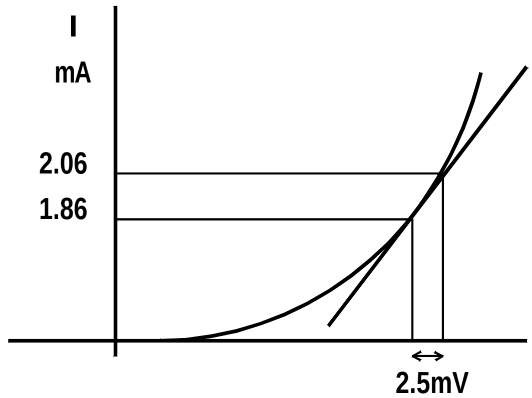
25 millivolts divided by the DC current through the diode.

This equation for the dynamic resistance is a key tool in the analysis of diode and transistor circuits.



Calculate the change in the voltage across the diode if the setting of the power supply voltage, V_+, is changed from +10V to +11V.





We first make the approximation that the DC voltage across the diode is 0.7V.

This gives the basic equation as:—

$$10V = 0.7 + I \times 5k\Omega$$

and therefore
$$I_{10} = \frac{10 - 0.7}{5k\Omega} = 1.86mA$$

For a supply voltage of 11V we get

$$I_{11} = \frac{11 - 0.7}{5k\Omega} = 2.06mA$$

The average DC current is 1.96mA $\approx$ 2mA.

The dynamic resistance is then:—

$$\frac{25mV}{I} = \frac{25mV}{2mA} = 12.5\Omega$$

The change in current is $2.06 - 1.86 = 0.2mA$.

So the change in voltage across the diode is given by

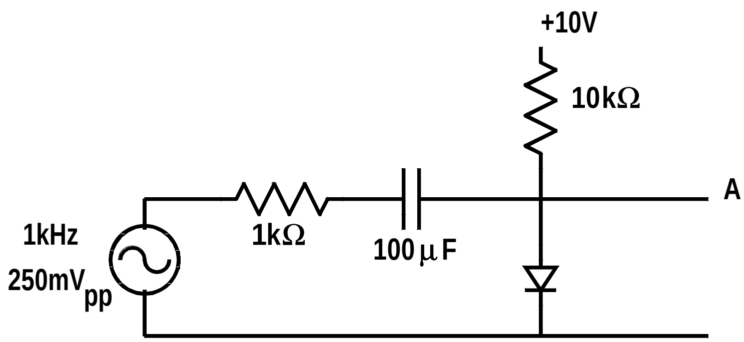
$$12.5\Omega \times 0.2mA = 2.5mV$$

The alternative exact approach involves solving equations of the form:—

$$V_{supply} = 5k\Omega \times I_0 \exp\left(\frac{V_{diode}}{25mV}\right) + V_{diode}$$

for the V_{diode} for supply voltages of 10V and 11V and then getting the difference of the two diode voltages. Not easy!

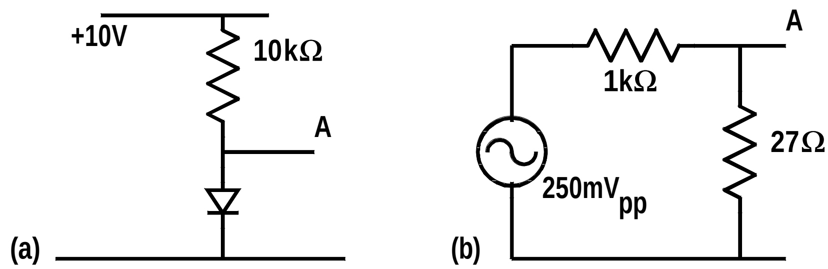
The linearised approach used above is significantly simpler to calculate!



Calculate the output voltage waveform which would be observed on an oscilloscope connected to point A

Use the principle of superposition
Calculate the DC component and
The AC component separately

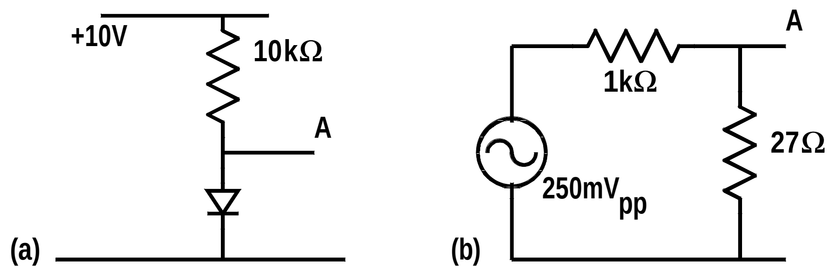
Then combine the two components at the end using the principle of superposition.



Calculate the DC component

Forward biased diode therefore the DC voltage at the output is 0.7V.
The DC current through the diode is

$$\frac{10V - 0.7V}{10k\Omega} = 0.93mA$$



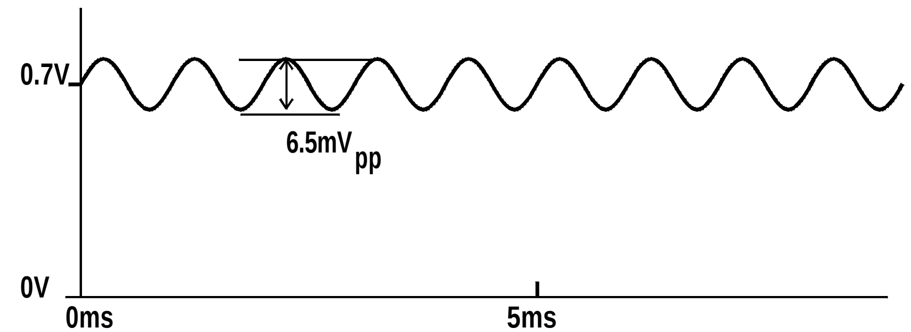
Effective circuit for the AC component of signal
The impedance of the 100μF capacitor at 1kHz is

$$|Z_C| = \frac{1}{2\pi f C} = 1.6\Omega$$

Negligible compared to the 1$k\Omega$
The dynamic resistance of the diode is

$$R_{dyn} = \frac{25mV}{I_{DC}} = \frac{25mV}{0.93mA} = 27\Omega$$

The dynamic resistance of the diode and the 1$k\Omega$ form a potential divider
The effective circuit is shown



The AC component of the output is therefore:—

$$V_{out\ AC} = \frac{27}{1k + 27} \times 250V_{pp} = 6.5mV_{pp}$$

The signal which would be observed on an oscilloscope connected to the output at point A is a

0.7V DC with a superimposed

$6.5mV_{pp}$, 1kHz AC component