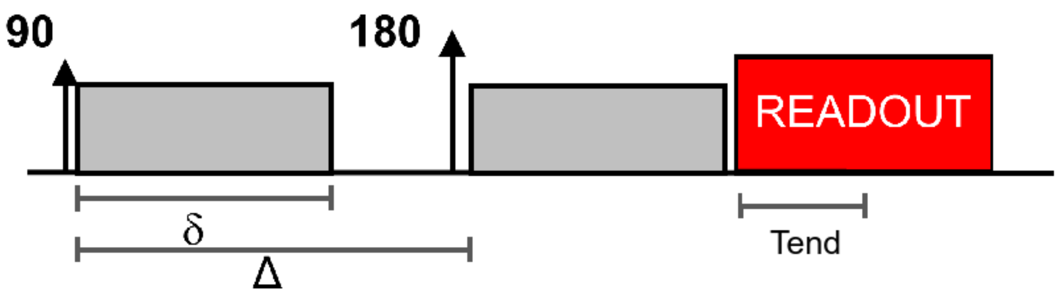
Calculation of δ for an EPI sequence

The b-value derives from the landmark 1965 paper (Stejskal and Tanner):

$b = (\gamma\,\delta\,G)^2 \times (\Delta - \delta/3)$

For an EPI sequence, assuming that the 90° and 180° pulses are instantaneous and the readout starts immediately after the second gradient (no gap):



Then:

$\Delta = \delta + \text{Tend}$,

where Tend is the time from the start of the readout to the center of the k-space. Replacing in the first expression gives:

$b = 1/3 \times (\gamma\,\delta\,G)^2 \times (2\delta + 3\text{Tend})$

Solving the above expression, the approximated solution for δ of an EPI sequence is then:

In[3]:=
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Clear[b, G, γ, δ, Tend, s];
s = Solve[((γ * δ * G)^2) / 3 * (2 * δ + 3 * Tend) == b, δ]
```

Out[4]=

$$\left\{\left\{\delta \to \frac{1}{2}\left(-\text{Tend} + \frac{G^2\,\text{Tend}^2\,\gamma^2}{\left(6\,b\,G^4\,\gamma^4 - G^6\,\text{Tend}^3\,\gamma^6 + 2\sqrt{3}\,\sqrt{3\,b^2\,G^8\,\gamma^8 - b\,G^{10}\,\text{Tend}^3\,\gamma^{10}}\right)^{1/3}} + \frac{\left(6\,b\,G^4\,\gamma^4 - G^6\,\text{Tend}^3\,\gamma^6 + 2\sqrt{3}\,\sqrt{3\,b^2\,G^8\,\gamma^8 - b\,G^{10}\,\text{Tend}^3\,\gamma^{10}}\right)^{1/3}}{G^2\,\gamma^2}\right)\right\},\right.$$

$$\left\{\delta \to -\frac{\text{Tend}}{2} - \frac{\left(1 + i\sqrt{3}\right)G^2\,\text{Tend}^2\,\gamma^2}{4\left(6\,b\,G^4\,\gamma^4 - G^6\,\text{Tend}^3\,\gamma^6 + 2\sqrt{3}\,\sqrt{3\,b^2\,G^8\,\gamma^8 - b\,G^{10}\,\text{Tend}^3\,\gamma^{10}}\right)^{1/3}} - \frac{\left(1 - i\sqrt{3}\right)\left(6\,b\,G^4\,\gamma^4 - G^6\,\text{Tend}^3\,\gamma^6 + 2\sqrt{3}\,\sqrt{3\,b^2\,G^8\,\gamma^8 - b\,G^{10}\,\text{Tend}^3\,\gamma^{10}}\right)^{1/3}}{4\,G^2\,\gamma^2}\right\},$$

$$\left.\left\{\delta \to -\frac{\text{Tend}}{2} - \frac{\left(1 - i\sqrt{3}\right)G^2\,\text{Tend}^2\,\gamma^2}{4\left(6\,b\,G^4\,\gamma^4 - G^6\,\text{Tend}^3\,\gamma^6 + 2\sqrt{3}\,\sqrt{3\,b^2\,G^8\,\gamma^8 - b\,G^{10}\,\text{Tend}^3\,\gamma^{10}}\right)^{1/3}} - \frac{\left(1 + i\sqrt{3}\right)\left(6\,b\,G^4\,\gamma^4 - G^6\,\text{Tend}^3\,\gamma^6 + 2\sqrt{3}\,\sqrt{3\,b^2\,G^8\,\gamma^8 - b\,G^{10}\,\text{Tend}^3\,\gamma^{10}}\right)^{1/3}}{4\,G^2\,\gamma^2}\right\}\right\}$$

The third solution was implemented in the Matlab code. This was due to the fact that substituting the variables G , b and Tend with realistic values in all solutions, only the third solution resulted in positive δ‘s.