Defining the stimulus current using the Ten Tusscher 2006 cell model

For the TT06 model to make sense, based on the units used in the papers, all of the current units should be in μA per μF and eqn 4 in 2004 or eqn 1 in 2006 paper should read:

$$C_m \frac{dV}{dt} = -(I_{ion} + I_{Stim})C_m \tag{1}$$

The addition of C_m on the left hand side converts the LHS to the same units as the RHS (it should be noted that with the assumption that $C_m = 1$ μF per cm^2 then this conversion does not change the values of the numbers , however, in both papers and the version of the code provided online C_m is not equal to 1.)

The definition of the stimulus current in different codes poses a major barrier to comparing electrophysiology tissue simulations.

In chaste the stimulus current is added to the RHS (spoke to Pras). For the monodomain equations this gives (ignoring the sign of the stimulus and diffusion term):

$$\chi \left(C_m \frac{dV}{dt} + (I_{ion}) \right) = I_{Stim} \tag{2}$$

In CHASTE χ is defined in cm^{-1} as 1400, C_m is defined in μF cm^{-2}, V is in mV and t is in ms. Given that F = C per V and A = C per S, then:

$$\frac{1}{[cm]} \left(\frac{[nC]}{[mV]} \frac{1}{[cm^2]} \frac{[mV]}{[ms]} + \frac{[\mu A]}{[cm^2]} \right) = I_{Tissue_Stim} \tag{3}$$

$$\frac{[\mu A]}{[cm^3]} = I_{Tissue_Stim} \tag{4}$$

NOTE: This was confirmed by going through CHASTE 1.0 source and looking at defintion of: ComputeNonlinearSourceTermAtNode.
In Chaste for the Ten Tusscher cell model the stimulus is 50,000 μAcm^{-3}.

Considering that a stimulus of (I_{Cell_Stim}) 52 pA per pF, or μA per μF, is the stimulus current applied within the cellml version of the model (downloaded 05/05/2010 coded by Penny Noble). Then this can be converted to $\frac{[\mu A]}{[cm^3]}$ by:

$$I_{Cell_Stim} \times C_m \times \chi = I_{Tissue_Stim} \tag{5}$$

So the tissue stimulus should be on the order of $52\mu A\mu F^{-1} \times 1\mu F cm^{-2} \times 1400cm^{-1} = 72800\mu Acm^{-3}$.

Summary

In the single cell a stimulus current of $72800\mu Acm^{-3}$ is applied.
In CHASTE a stimulus of $50000\mu Acm^{-3}$. is applied.