1. Equations A – 11 to A – 14, as defined by boundary conditions (A) in the Appendix.

```
D0 / Rp^2 == C1 * Rp + D1 / Rp^2

C1 * Rm + D1 / Rm^2 == C2 * Rm + D2 / Rm^2

C2 * rp + D2 / rp^2 == C3 * rp + D3 / rp^2

C3 * rm + D3 / rm^2 == C4 * rm
```

2. Equations A – 15 to A – 18, as defined by boundary conditions (B) in the Appendix.

```
S0 * (M + 2 * D0 / Rp^3) == S1 * (M + 2 * D1 / Rp^3 – C1)

S1 * (M + 2 * D1 / Rm^3 – C1) == S2 * (M + 2 * D2 / Rm^3 – C2)

S2 * (M + 2 * D2 / rp^3 – C2) == S3 * (M + 2 * D3 / rp^3 – C3)

S3 * (M + 2 * D3 / rm^3 – C3) == S4 * (M – C4)
```

3. Solve equations A – 11 to A – 18 to obtain the unknown coefficients D0 – D3 and C1 – C4.

```
Solve[{D0 / Rp^2 == C1 * Rp + D1 / Rp^2,
  C1 * Rm + D1 / Rm^2 == C2 * Rm + D2 / Rm^2,
  C2 * rp + D2 / rp^2 == C3 * rp + D3 / rp^2,
  C3 * rm + D3 / rm^2 == C4 * rm,
  S0 * (M + 2 * D0 / Rp^3) == S1 * (M + 2 * D1 / Rp^3 – C1),
  S1 * (M + 2 * D1 / Rm^3 – C1) == S2 * (M + 2 * D2 / Rm^3 – C2),
  S2 * (M + 2 * D2 / rp^3 – C2) == S3 * (M + 2 * D3 / rp^3 – C3),
  S3 * (M + 2 * D3 / rm^3 – C3) == S4 * (M – C4)},
 {D0, C1, D1, C2, D2, C3, D3, C4}]
```

D0

$$\Big(M\,Rp^3\Big(-rm^3\Big(2\,Rm^6\,(S0+2\,S1)\,(S1-S2)\,(S2-S3)+2\,rp^3\,Rp^3\,(S0-S1)\,(S1-S2)\,(S2+2\,S3)+ Rm^3\Big(2\,Rp^3\,(S0-S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0+2\,S1)\,(S1+2\,S2)\,(S2+2\,S3)\Big)\Big)\,(S3-S4)- rp^3\Big(2\,rp^3\,Rp^3\,(S0-S1)\,(S1-S2)\,(S2-S3)+Rm^6\,(S0+2\,S1)\,(S1-S2)\,(2\,S2+S3)+ Rm^3\Big(rp^3\,(S0+2\,S1)\,(S1+2\,S2)\,(S2-S3)+Rp^3\,(S0-S1)\,(2\,S1+S2)\,(2\,S2+S3)\Big)\Big)\,(2\,S3+S4)\Big)\Big)\Big/ \Big(2\,rm^3\Big(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+ Rm^3\Big(Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\Big)\Big)\,(S3-S4)+ rp^3\Big(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+ Rm^3\Big(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)+Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(2\,S2+S3)\Big)\Big)\,(2\,S3+S4)\Big)$$

C1

$$\Big(M\,(S0-S1)\Big(2\,rm^3\Big(2\,Rm^6\,(S1-S2)\,(S2-S3)-rp^3\,Rp^3\,(S1-S2)\,(S2+2\,S3)+ Rm^3\Big(-Rp^3\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S1+2\,S2)\,(S2+2\,S3)\Big)\Big)\,(S3-S4)+ rp^3\Big(-2\,rp^3\,Rp^3\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S1-S2)\,(2\,S2+S3)+ Rm^3\Big(2\,rp^3\,(S1+2\,S2)\,(S2-S3)-Rp^3\,(2\,S1+S2)\,(2\,S2+S3)\Big)\Big)\,(2\,S3+S4)\Big)\Big)\Big/ \Big(2\,rm^3\Big(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+ Rm^3\Big(Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\Big)\Big)\,(S3-S4)+ rp^3\Big(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+ Rm^3\Big(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)+Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(2\,S2+S3)\Big)\Big)\,(2\,S3+S4)\Big)$$

D1

$$-\left(3\,M\,Rm^3\,Rp^3\,S0\left(rm^3\left(2\,Rm^3\,(S1-S2)\,(S2-S3)+rp^3\,(S1+2\,S2)\,(S2+2\,S3)\right)(S3-S4)+rp^3\left(rp^3\,(S1+2\,S2)\,(S2-S3)+Rm^3\,(S1-S2)\,(2\,S2+S3)\right)(2\,S3+S4)\right)\right)/\left(2\,rm^3\left(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+Rm^3\left(Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\right)\right)(S3-S4)+rp^3\left(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+Rm^3\left(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)+Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(2\,S2+S3)\right)\right)(2\,S3+S4)\right)$$

C2

$$\left(M\left(2\,rm^3\left(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+Rm^3\left(-Rp^3\,(S0\,(5\,S1-2\,S2)-S1\,(2\,S1+S2))\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\right)\right)(S3-S4)+rp^3\left(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+Rm^3\left(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)-Rp^3\,(S0\,(5\,S1-2\,S2)-S1\,(2\,S1+S2))\,(2\,S2+S3)\right)\right)(2\,S3+S4)\right)\right)/\left(2\,rm^3\left(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+Rm^3\left(Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\right)\right)(S3-S4)+rp^3\left(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+Rm^3\left(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)+Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(2\,S2+S3)\right)\right)(2\,S3+S4)\right)$$

D2

$$-\left(9\,M\,Rm^3\,rp^3\,Rp^3\,S0\,S1\left(rm^3\,(S2+2\,S3)\,(S3-S4)+rp^3\,(S2-S3)\,(2\,S3+S4)\right)\right)/\left(2\,rm^3\left(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+Rm^3\left(Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\right)\right)(S3-S4)+rp^3\left(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+Rm^3\left(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)+Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(2\,S2+S3)\right)\right)(2\,S3+S4)\right)$$

C3

$$\left(M\left(2\,rm^3\left(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+Rm^3\left(Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\right)\right)(S3-S4)+rp^3\left(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+Rm^3\left(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)+Rp^3\,(S1\,(2\,S1+S2)\,(2\,S2+S3)+S0\,(2\,S2\,(2\,S2+S3)+S1\,(-19\,S2+4\,S3)))\right)\right)(2\,S3+S4)\right)\right)/\left(2\,rm^3\left(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+Rm^3\left(Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\right)\right)(S3-S4)+rp^3\left(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+Rm^3\left(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)+Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(2\,S2+S3)\right)\right)(2\,S3+S4)\right)$$

D3

$$\left(27\,M\,rm^3\,Rm^3\,rp^3\,Rp^3\,S0\,S1\,S2\,(-S3+S4)\right)/\left(2\,rm^3\left(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+Rm^3\left(Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\right)\right)(S3-S4)+rp^3\left(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+Rm^3\left(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)+Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(2\,S2+S3)\right)\right)(2\,S3+S4)\right)$$

C4

$$\left(M \left(2\,rm^3 \left(2\,Rm^6 (S0-S1)(S1-S2)(S2-S3) + rp^3\,Rp^3 (2\,S0+S1)(S1-S2)(S2+2\,S3) + Rm^3 \left(Rp^3 (2\,S0+S1)(2\,S1+S2)(S2-S3) + rp^3 (S0-S1)(S1+2\,S2)(S2+2\,S3)\right)\right)(S3-S4) + rp^3 \left(2\,rp^3\,Rp^3 (2\,S0+S1)(S1-S2)(S2-S3)(2\,S3+S4) + 2\,Rm^6 (S0-S1)(S1-S2)(2\,S2+S3)(2\,S3+S4) + Rm^3 \left(2\,rp^3 (S0-S1)(S1+2\,S2)(S2-S3)(2\,S3+S4) + Rp^3 \left(S1 (2\,S1+S2)(2\,S2+S3)(2\,S3+S4) + S0 \left(2\,S2 (2\,S2+S3)(2\,S3+S4) + S1 \left(-65\,S2\,S3 + 8\,S3^2 + 8\,S2\,S4 + 4\,S3\,S4\right)\right)\right)\right)\right)\right) \Big/ \left(2\,rm^3 \left(2\,Rm^6 (S0-S1)(S1-S2)(S2-S3) + rp^3\,Rp^3 (2\,S0+S1)(S1-S2)(S2+2\,S3) + Rm^3 \left(Rp^3 (2\,S0+S1)(2\,S1+S2)(S2-S3) + rp^3 (S0-S1)(S1+2\,S2)(S2+2\,S3)\right)\right)(S3-S4) + rp^3 \left(2\,rp^3\,Rp^3 (2\,S0+S1)(S1-S2)(S2-S3) + 2\,Rm^6 (S0-S1)(S1-S2)(2\,S2+S3) + Rm^3 \left(2\,rp^3 (S0-S1)(S1+2\,S2)(S2-S3) + Rp^3 (2\,S0+S1)(2\,S1+S2)(2\,S2+S3)\right)\right)(2\,S3+S4)\right)$$

4. Transmembrane potential on the cytoplasmic membrane

```
V1 = C1 * xx + D1 / xx^2
```

```
Vm = (C1 * Rm + D1 / Rm^2) - (C1 * Rp + D1 / Rp^2)
```

```
Simplify[Vm]
```

$$\left(M \left(3\,Rm^3\,Rp\,S0 \left(rm^3 \left(2\,Rm^3 (S1-S2)(S2-S3) + rp^3 (S1+2\,S2)(S2+2\,S3)\right)(S3-S4) + rp^3 \left(rp^3 (S1+2\,S2)(S2-S3) + Rm^3 (S1-S2)(2\,S2+S3)\right)(2\,S3+S4)\right) - 3\,Rm\,Rp^3\,S0 \left(rm^3 \left(2\,Rm^3 (S1-S2)(S2-S3) + rp^3 (S1+2\,S2)(S2+2\,S3)\right)(S3-S4) + rp^3 \left(rp^3 (S1+2\,S2)(S2-S3) + Rm^3 (S1-S2)(2\,S2+S3)\right)(2\,S3+S4)\right) + Rm (S0-S1) \left(2\,rm^3 \left(2\,Rm^6 (S1-S2)(S2-S3) - rp^3\,Rp^3 (S1-S2)(S2+2\,S3) + Rm^3 \left(-Rp^3 (2\,S1+S2)(S2-S3) + rp^3 (S1+2\,S2)(S2+2\,S3)\right)\right)(S3-S4) + rp^3 \left(-2\,rp^3\,Rp^3 (S1-S2)(S2-S3) + 2\,Rm^6 (S1-S2)(2\,S2+S3) + Rm^3 \left(2\,rp^3 (S1+2\,S2)(S2-S3) - Rp^3 (2\,S1+S2)(2\,S2+S3)\right)\right)(2\,S3+S4)\right) - Rp (S0-S1) \left(2\,rm^3 \left(2\,Rm^6 (S1-S2)(S2-S3) - rp^3\,Rp^3 (S1-S2)(S2+2\,S3) + Rm^3 \left(-Rp^3 (2\,S1+S2)(S2-S3) + rp^3 (S1+2\,S2)(S2+2\,S3)\right)\right)(S3-S4) + rp^3 \left(-2\,rp^3\,Rp^3 (S1-S2)(S2-S3) + 2\,Rm^6 (S1-S2)(2\,S2+S3) + Rm^3 \left(2\,rp^3 (S1+2\,S2)(S2-S3) - Rp^3 (2\,S1+S2)(2\,S2+S3)\right)\right)(2\,S3+S4)\right)\right) \Big/ \left(2\,rm^3 \left(2\,Rm^6 (S0-S1)(S1-S2)(S2-S3) + rp^3\,Rp^3 (2\,S0+S1)(S1-S2)(S2+2\,S3) + Rm^3 \left(Rp^3 (2\,S0+S1)(2\,S1+S2)(S2-S3) + rp^3 (S0-S1)(S1+2\,S2)(S2+2\,S3)\right)\right)(S3-S4) + rp^3 \left(2\,rp^3\,Rp^3 (2\,S0+S1)(S1-S2)(S2-S3) + 2\,Rm^6 (S0-S1)(S1-S2)(2\,S2+S3) + Rm^3 \left(2\,rp^3 (S0-S1)(S1+2\,S2)(S2-S3) + Rp^3 (2\,S0+S1)(2\,S1+S2)(2\,S2+S3)\right)\right)(2\,S3+S4)\right)$$

5. Transmembrane potential on the internal membrane

```
Vinternal = (C3 * rm + D3 / rm^2) - (C3 * rp + D3 / rp^2)
```

Simplify[Vinternal]

$$\Big(M \Big(27\,rm^3\,Rm^3\,rp\,Rp^3\,S0\,S1\,S2\,(S3-S4)+27\,rm\,Rm^3\,rp^3\,Rp^3\,S0\,S1\,S2\,(-S3+S4)+ rm\Big(2\,rm^3\Big(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+ Rm^3\Big(Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\Big)\Big)\,(S3-S4)+ rp^3\Big(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+ Rm^3\Big(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)+ Rp^3\,(S1\,(2\,S1+S2)\,(2\,S2+S3)+S0\,(2\,S2\,(2\,S2+S3)+S1\,(-19\,S2+4\,S3)))\Big)\Big)\,(2\,S3+S4)\Big)- rp\Big(2\,rm^3\Big(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+ Rm^3\Big(Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\Big)\Big)\,(S3-S4)+ rp^3\Big(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+ Rm^3\Big(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)+Rp^3\,(S1\,(2\,S1+S2)\,(2\,S2+S3)+ S0\,(2\,S2\,(2\,S2+S3)+S1\,(-19\,S2+4\,S3)))\Big)\Big)\,(2\,S3+S4)\Big)\Big)\Big)\Big/ \Big(2\,rm^3\Big(2\,Rm^6\,(S0-S1)\,(S1-S2)\,(S2-S3)+rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2+2\,S3)+ Rm^3\Big(Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(S2-S3)+rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2+2\,S3)\Big)\Big)\,(S3-S4)+ rp^3\Big(2\,rp^3\,Rp^3\,(2\,S0+S1)\,(S1-S2)\,(S2-S3)+2\,Rm^6\,(S0-S1)\,(S1-S2)\,(2\,S2+S3)+ Rm^3\Big(2\,rp^3\,(S0-S1)\,(S1+2\,S2)\,(S2-S3)+Rp^3\,(2\,S0+S1)\,(2\,S1+S2)\,(2\,S2+S3)\Big)\Big)\,(2\,S3+S4)\Big)$$