Appendix A: Staff Confirmatory Calculations

Introduction

The U.S. Nuclear Regulatory Commission (NRC) staff performed several confirmatory calculations to verify the numerical solution technique for several component models. The staff selected the Proportional Integrating Proportional (PIP), the Proportional Derivative Proportional (PDP), the Physical Derivative (DERIV), and the first order low pass filter (LOWP1) components. The confirmatory calculations compared the SAFIR numerical solution to the analytical solution for a given set of input and component parameters. The purpose of these confirmatory calculations is to verify the validity of the numerical solution technique for a wide scope of transfer functions.

Proportional Integrating Proportional Controller

For the PIP controller, the staff specified the following component parameters, where u(t) denotes the unit step function:

Table A-1 PIP Component Parameters

T1	2
T2	3
TS	0.05
K	5
IN	30 u(t)

For these comparisons, the units are arbitrary. For this set of parameters, the time response can be solved analytically using the Heaviside method and standard tables of inverse Laplace transforms.

Figure A-1 illustrates the comparison between the SAIFR numerical solution and the analytical solution. The agreement is excellent and in keeping with the degree of accuracy depicted for the Proportional Integrating controller verification presented in Section 4 of Supplement 3.

Proportional Derivative Proportional Controller

For the PDP controller, the staff specified the following component parameters, where u(t) denotes the unit step function:

Table A-2 PDP Component Parameters

T1	3
T2	2
TS	0.05
K	5
IN	30 u(t)

For these comparisons, the units are arbitrary. For this set of parameters, the time response can be solved analytically using the Heaviside method and standard tables of inverse Laplace transforms.
Figure A-2 illustrates the comparison between the SAIFR numerical solution and the analytical solution. The agreement is excellent and in keeping with the degree of accuracy depicted for the Proportional Integrating controller verification presented in Section 4 of Supplement 3.

Derivative Controller

For the DERIV controller, the staff specified the following component parameters, where u(t) denotes the unit step function:

Table A-3 DERIV Component Parameters

TF	3
TD	2
TS	0.05
K	5
IN	30 u(t)

For these comparisons, the units are arbitrary. For this set of parameters, the time response can be solved analytically using the Heaviside method and standard tables of inverse Laplace transforms.

Figure A-3 illustrates the comparison between the SAIFR numerical solution and the analytical solution. The agreement is excellent and in keeping with the degree of accuracy depicted for the Proportional Integrating controller verification presented in Section 4 of Supplement 3.

First Order Low Pass Filter Controller

For the LOWP1 controller, the staff specified the following component parameters, where u(t) denotes the unit step function:

Table A-4 LOWP1 Component Parameters

T	2
TS	0.05
K	5
IN	30 u(t)

For these comparisons, the units are arbitrary. For this set of parameters, the time response can be solved analytically using the Heaviside method and standard tables of inverse Laplace transforms.

Figure A-4 illustrates the comparison between the SAIFR numerical solution and the analytical solution. The agreement is excellent and in keeping with the degree of accuracy depicted for the Proportional Integrating controller verification presented in Section 4 of Supplement 3.

Conclusions

The NRC staff's independent confirmatory calculations confirm the validity of the SAFIR numerical solutions for several basic components. This provides the staff with reasonable assurance that the method performs adequately. It further provides a measure of assurance in the efficacy of the component verification process in the code stewardship and quality assurance procedures.

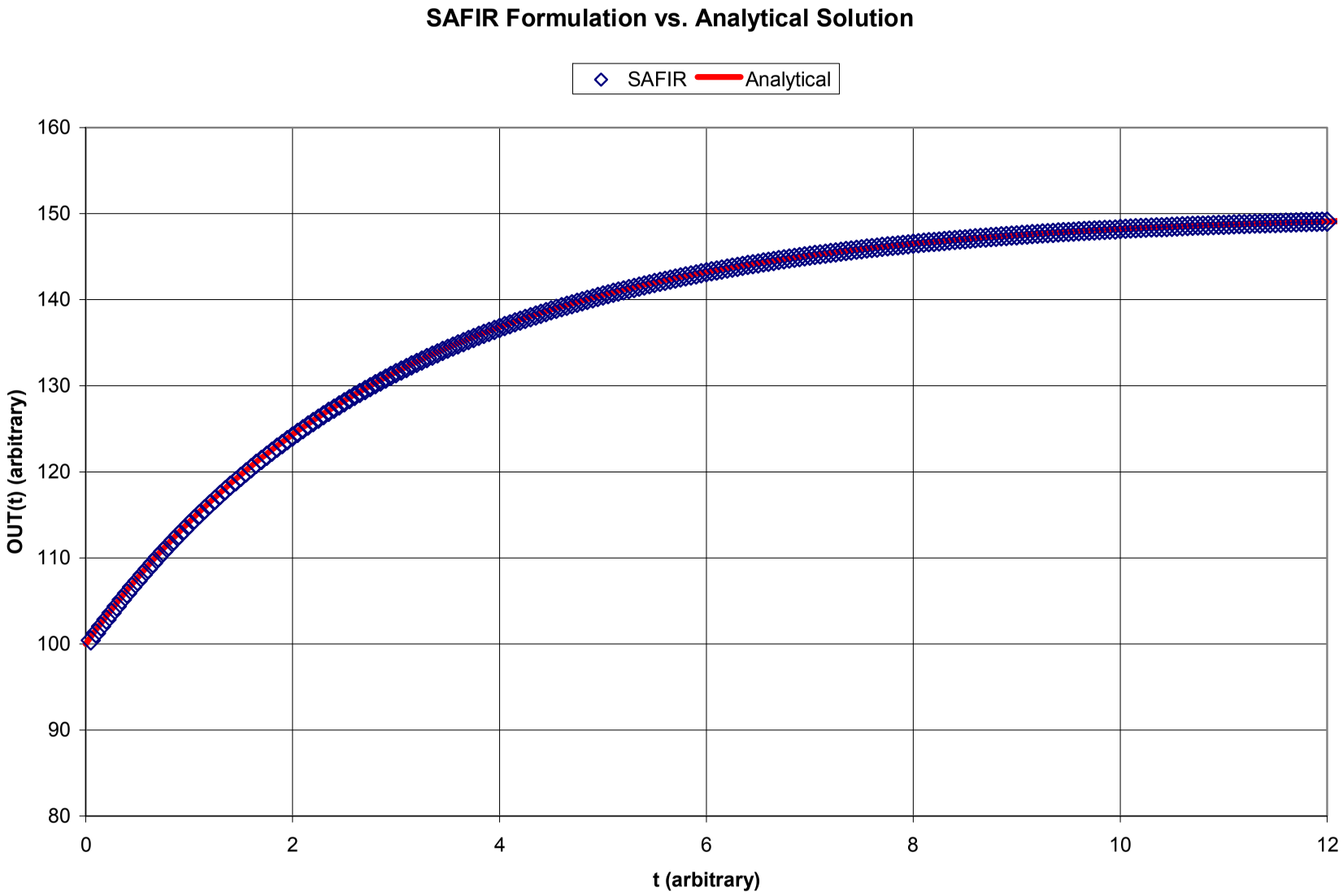

Figure A-1 Confirmatory calculation for PIP component

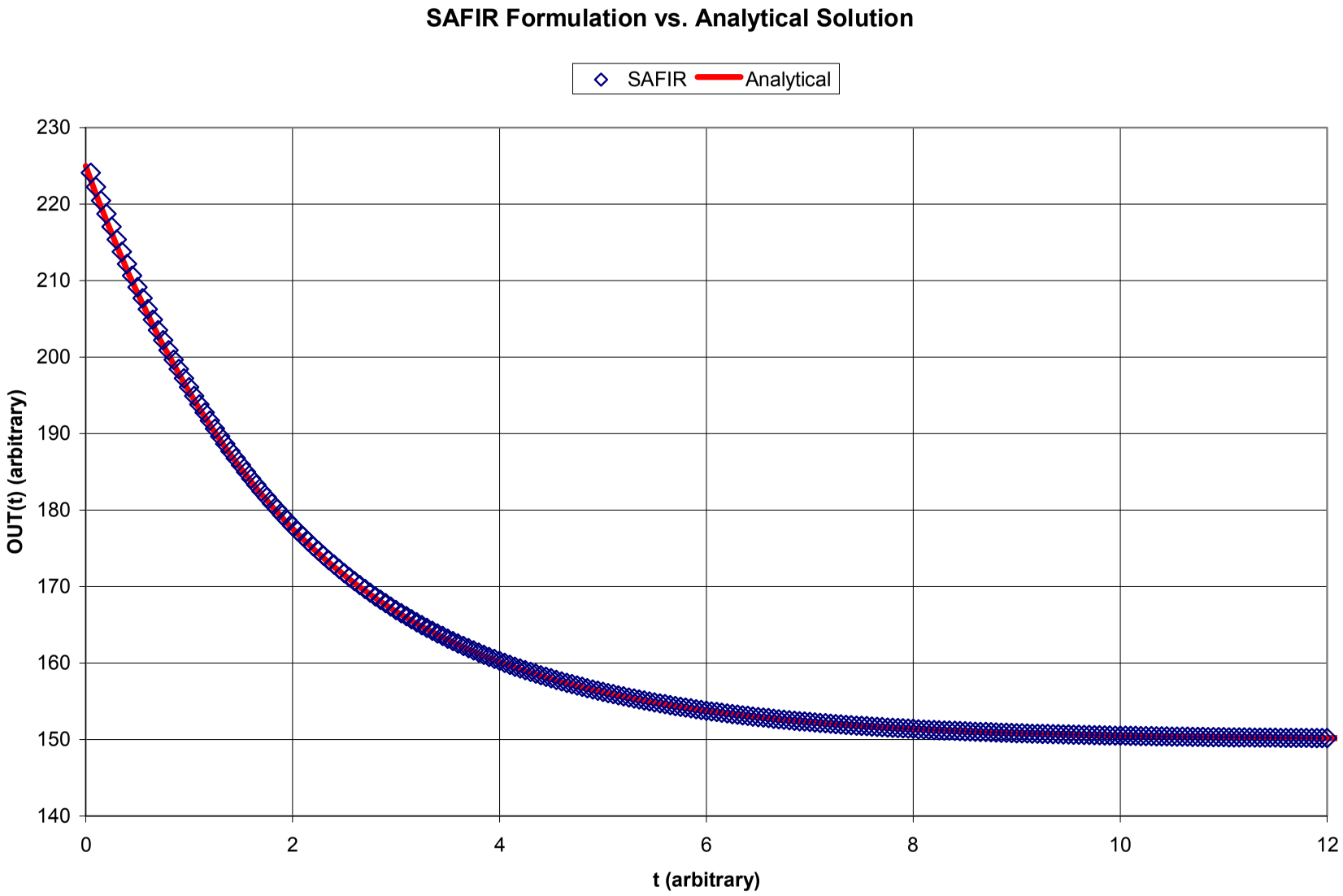

Figure A-2 Confirmatory calculation for PDP component

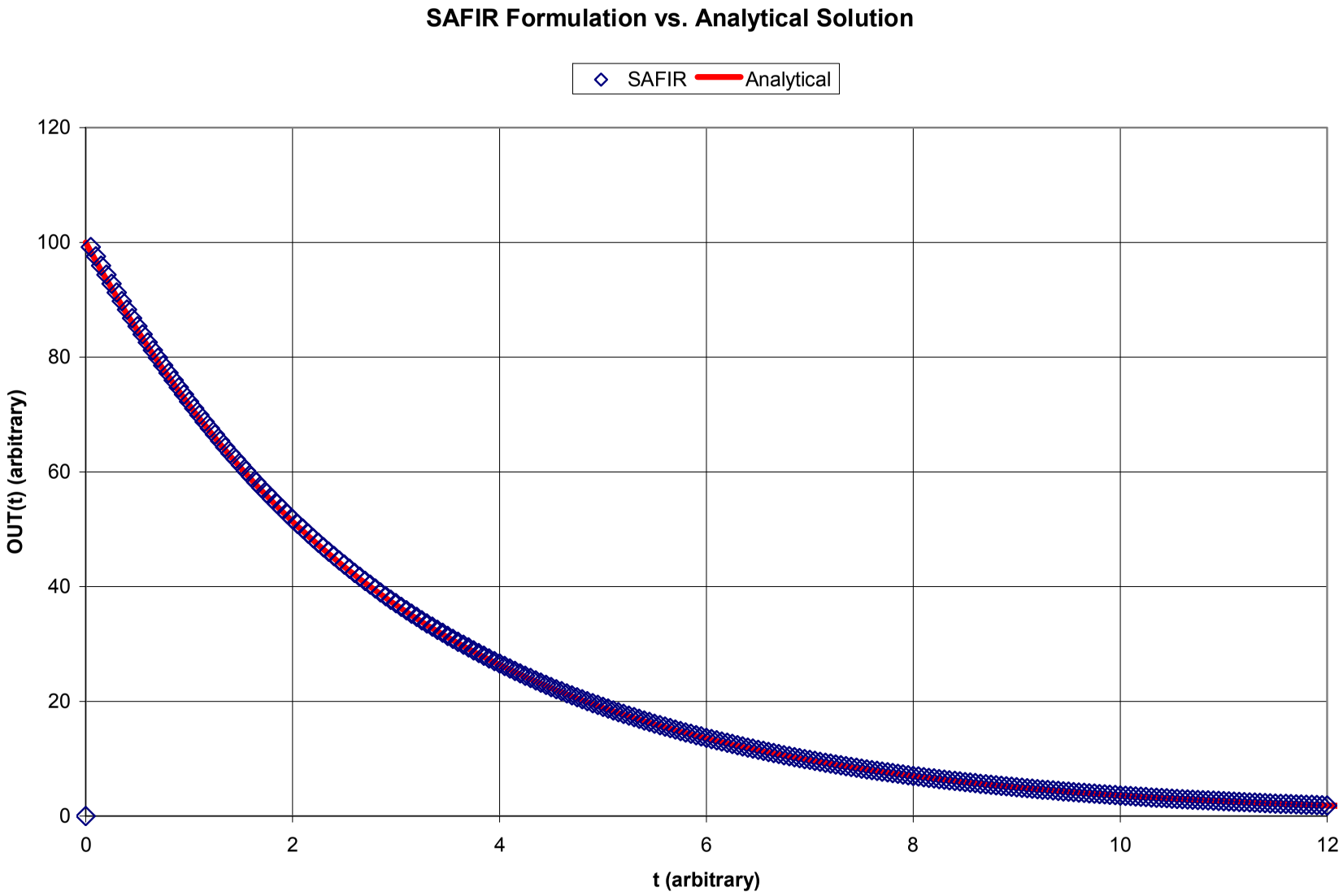

Figure A-3 Confirmatory calculation for DERIV component

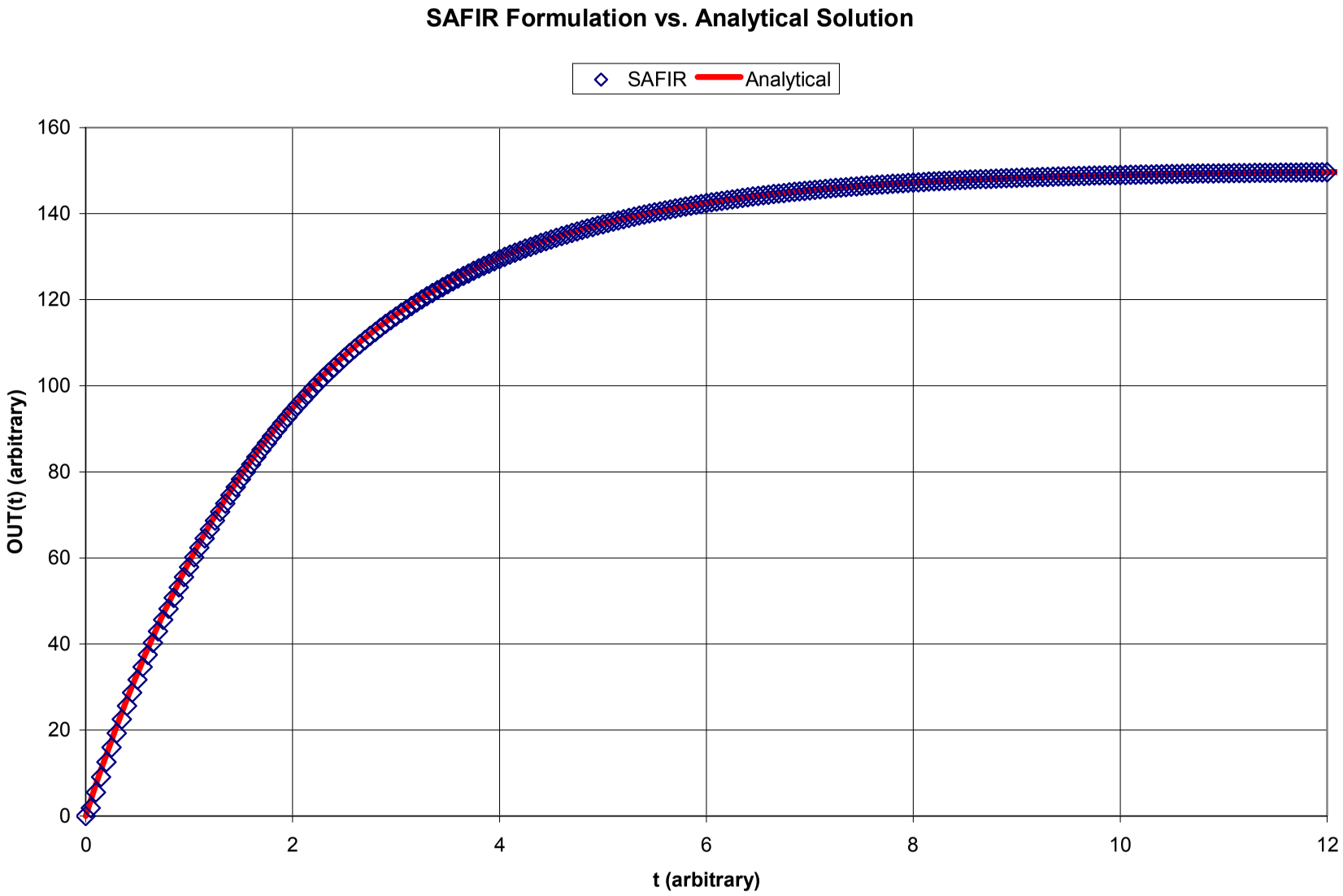

Figure A-4 Confirmatory calculation for LOWP1 component