Injection control by neural network approach for Pulse-magnet of Taiwan Light Source

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Abstract

Top-up operation has been started since many years ago at Tai-wan Light Source Storage Ring (TLS-SR). To realize the operation of the ring by top-up injection mode, a coherent oscillation of the stored beam is one of serious problem. This phenomena is exited in every injection period due to error in the injection pulse-magnets. For this operation it is important to reduce the beam injections should not excite the oscillation of stored beams. Artificial neural network (ANN) technology was used to analyze and optimize the injection pulse-magnets parameters of the storage ring. The results of this research are discussed in this study. .

Research Process

Experimental analysis

After calculating the ANN model construction, we obtained the "cross-validation" error convergence curve, as shown in (Figs. 1) The representative model construction was ideal be-cause they appear to converge after approximately 500 computations.

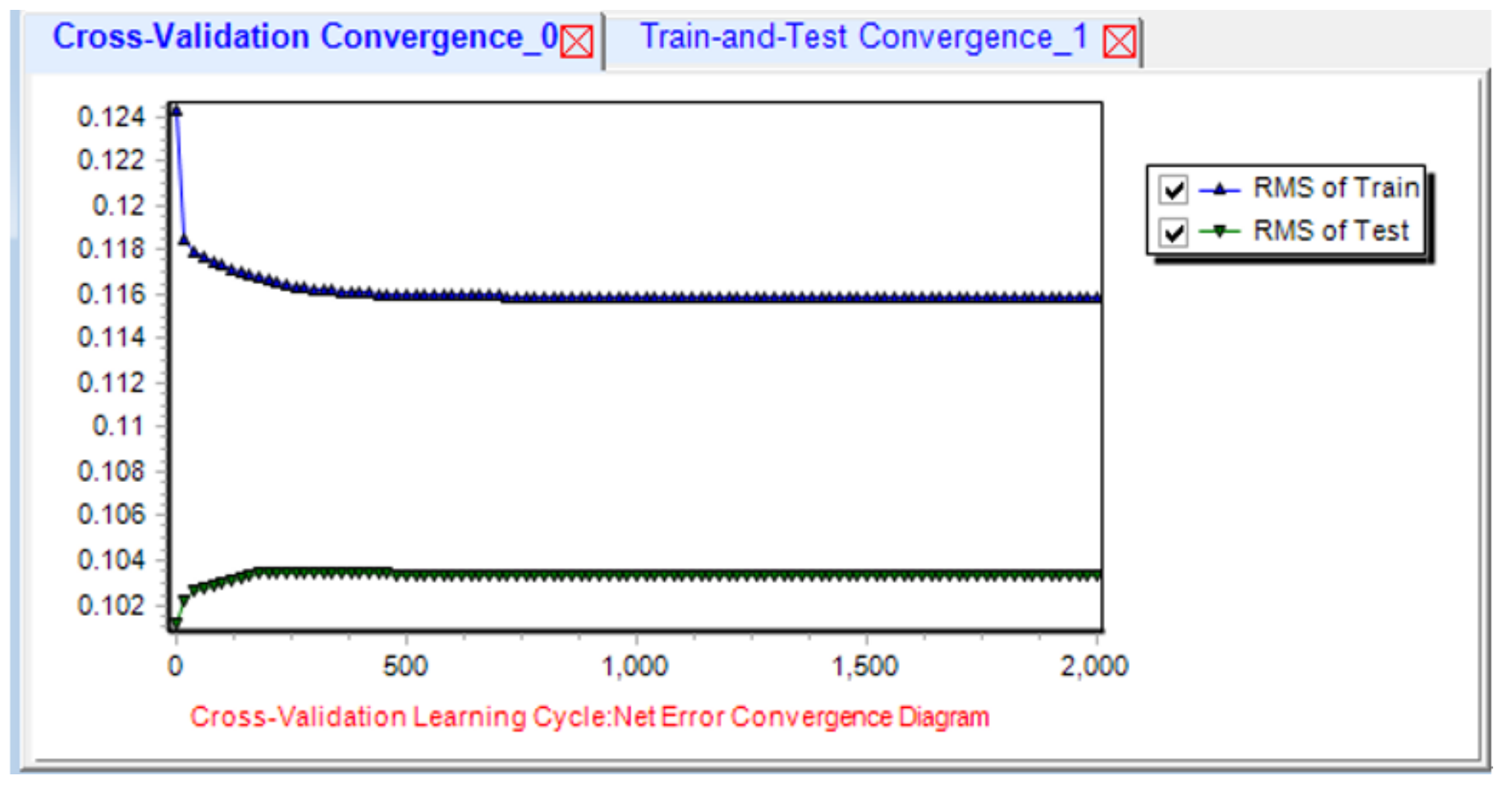


Figure 1 The "cross-validation" error convergence curve.

The "cross validation" scatter plots for the training and test samples are shown in (Figs. 2 and 3), respectively. The predictive ability of the representative model was also ideal.

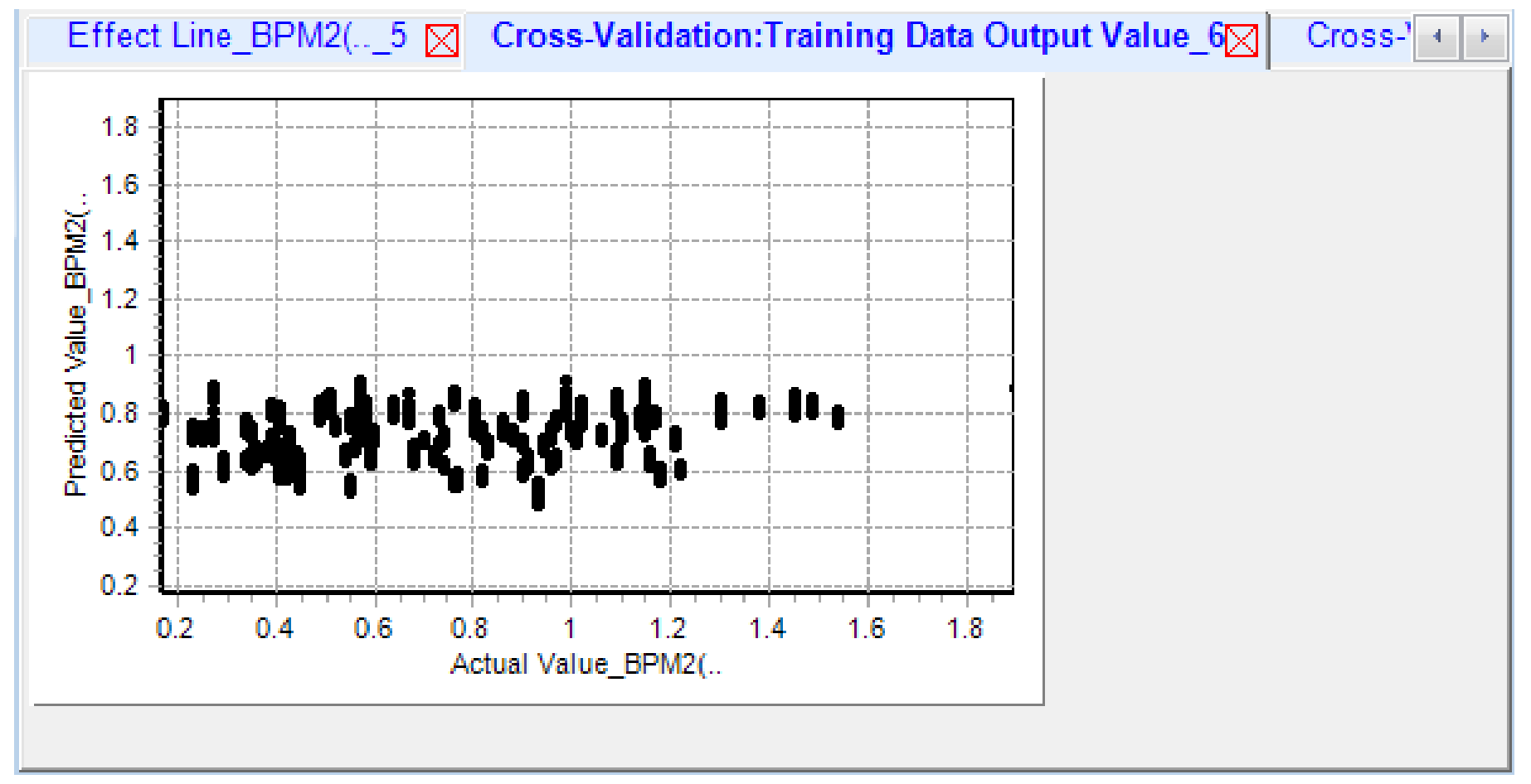


Figure 2 The "cross-validation" scatter plot of the training samples.

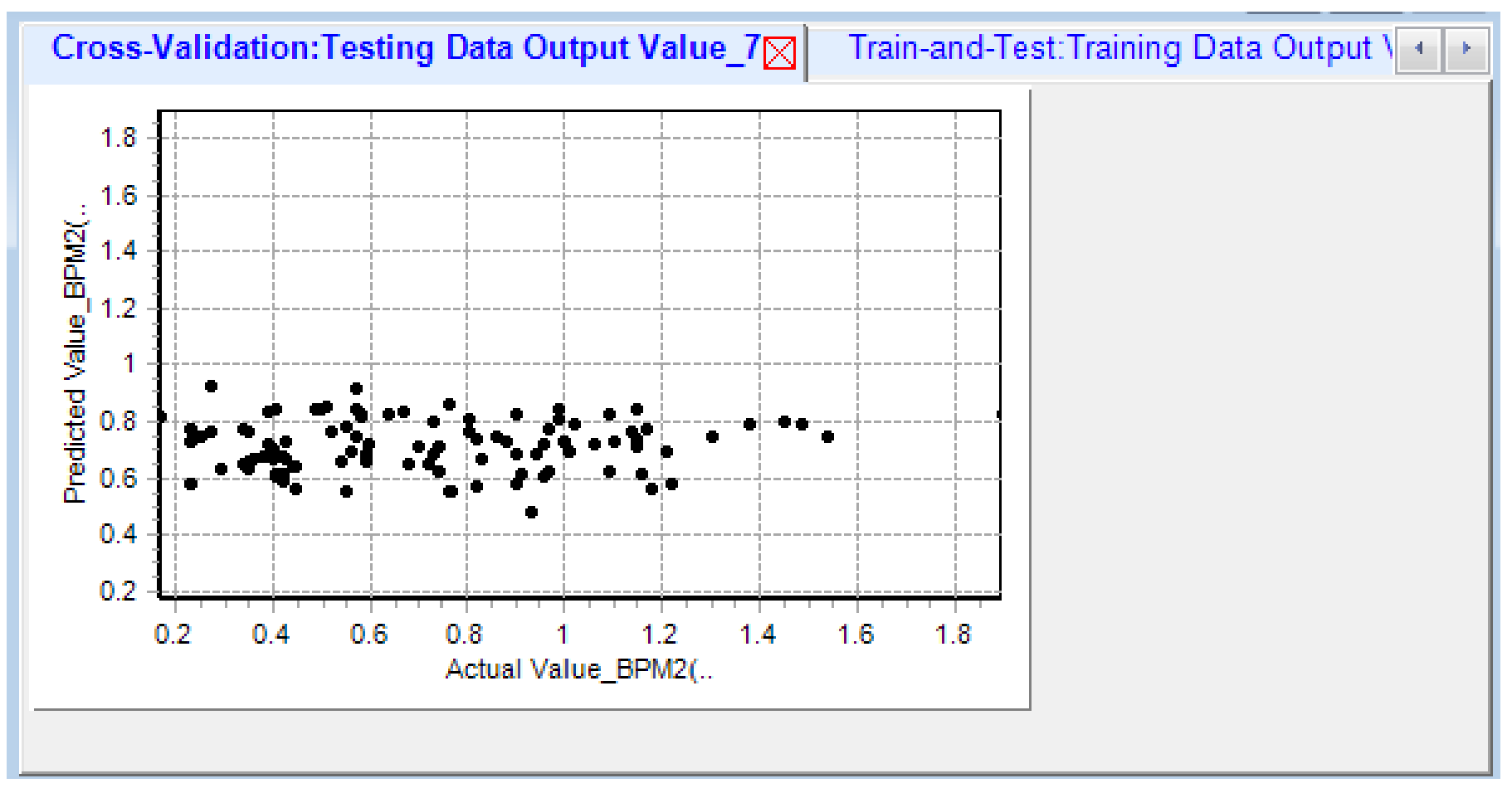


Figure 3 The "cross-validation" scatter plot of the test samples.

Analysis of the experimental results included sensitivity analysis and influence line analysis. Sensitivity analysis was conducted using weight value analysis graphs, and influence line analysis was conducted using a main effect diagram with status. The sensitivity analysis results revealed the significance of quality factors, as shown in (Figs. 4 and 5). We found that two quality factors had the highest significance, of which, the kicker 1 voltage setting (K1) was the most significant.

- **The weight of the kicker 1 voltage setting (K1) was 0.055.**
- **The weight of the kicker 2 voltage setting (K2) was 0.032.**
- **The weight of the kicker 4 voltage setting (K4) was 0.011.**

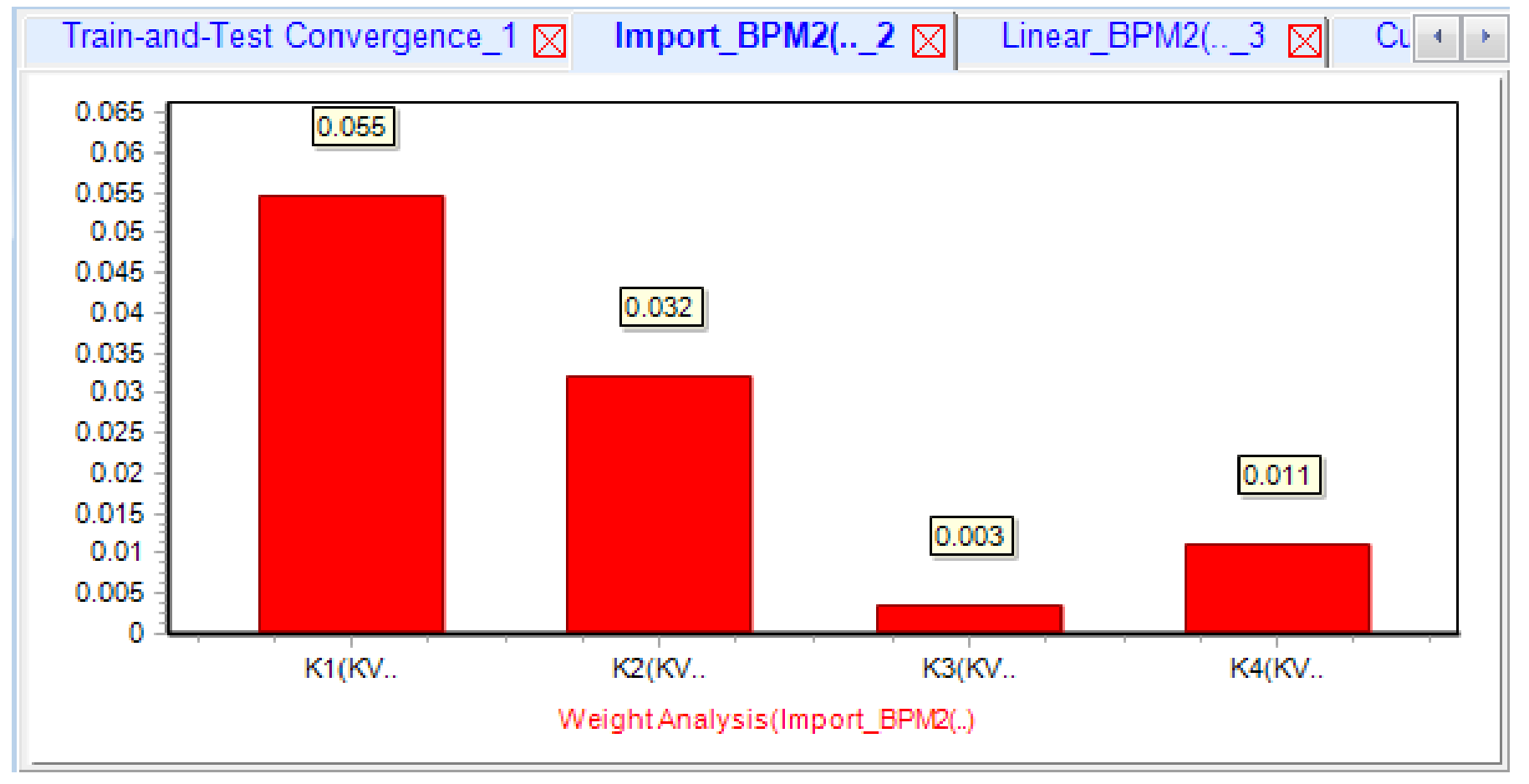


Figure 4 A bar graph of Y significance.

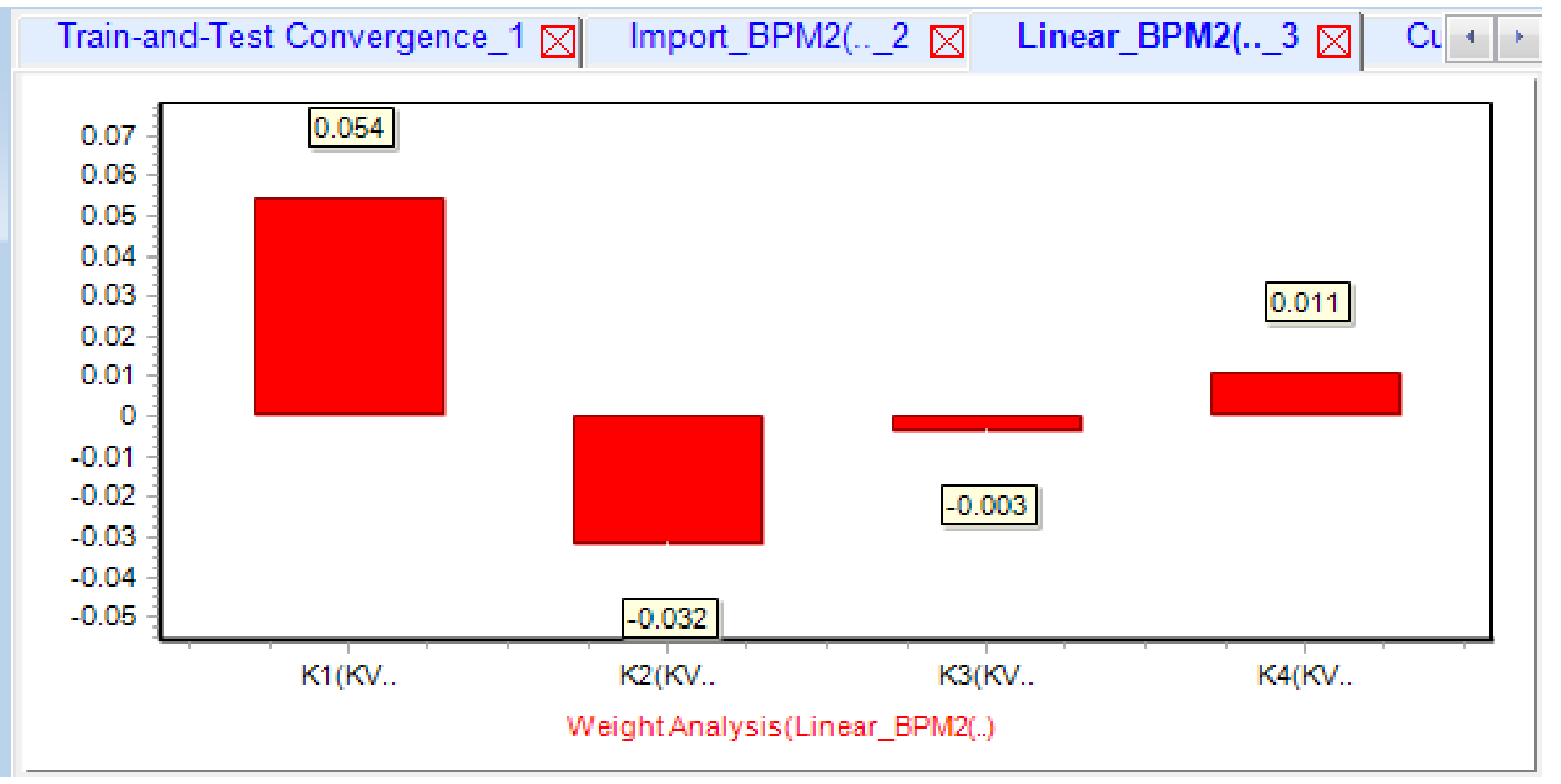


Figure 5 A bar graph of Y linear sensitivity.

Research Result

Experimental result

Analysis of the results clearly showed the curved figure and significance of the quality factors (Fig. 6).

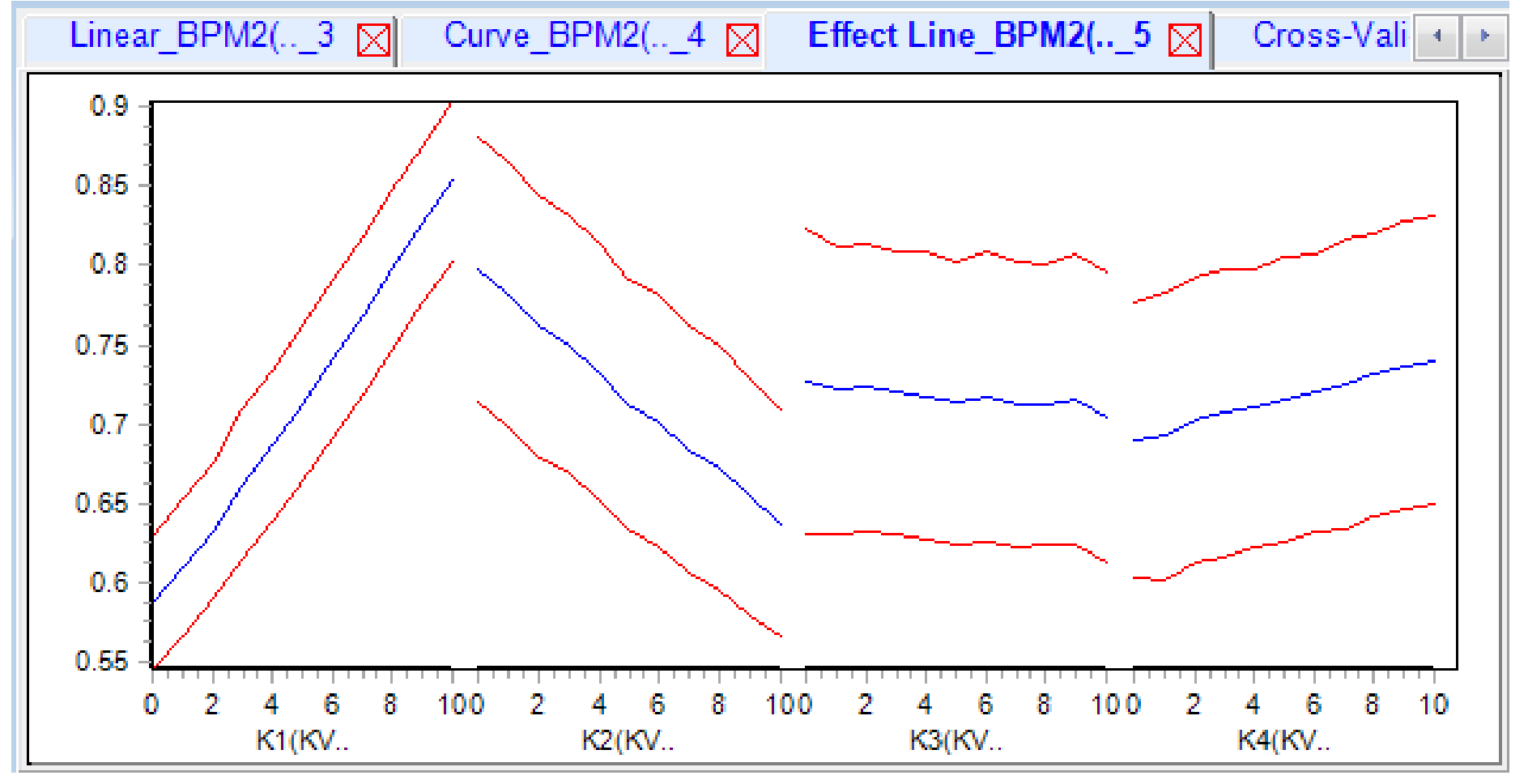
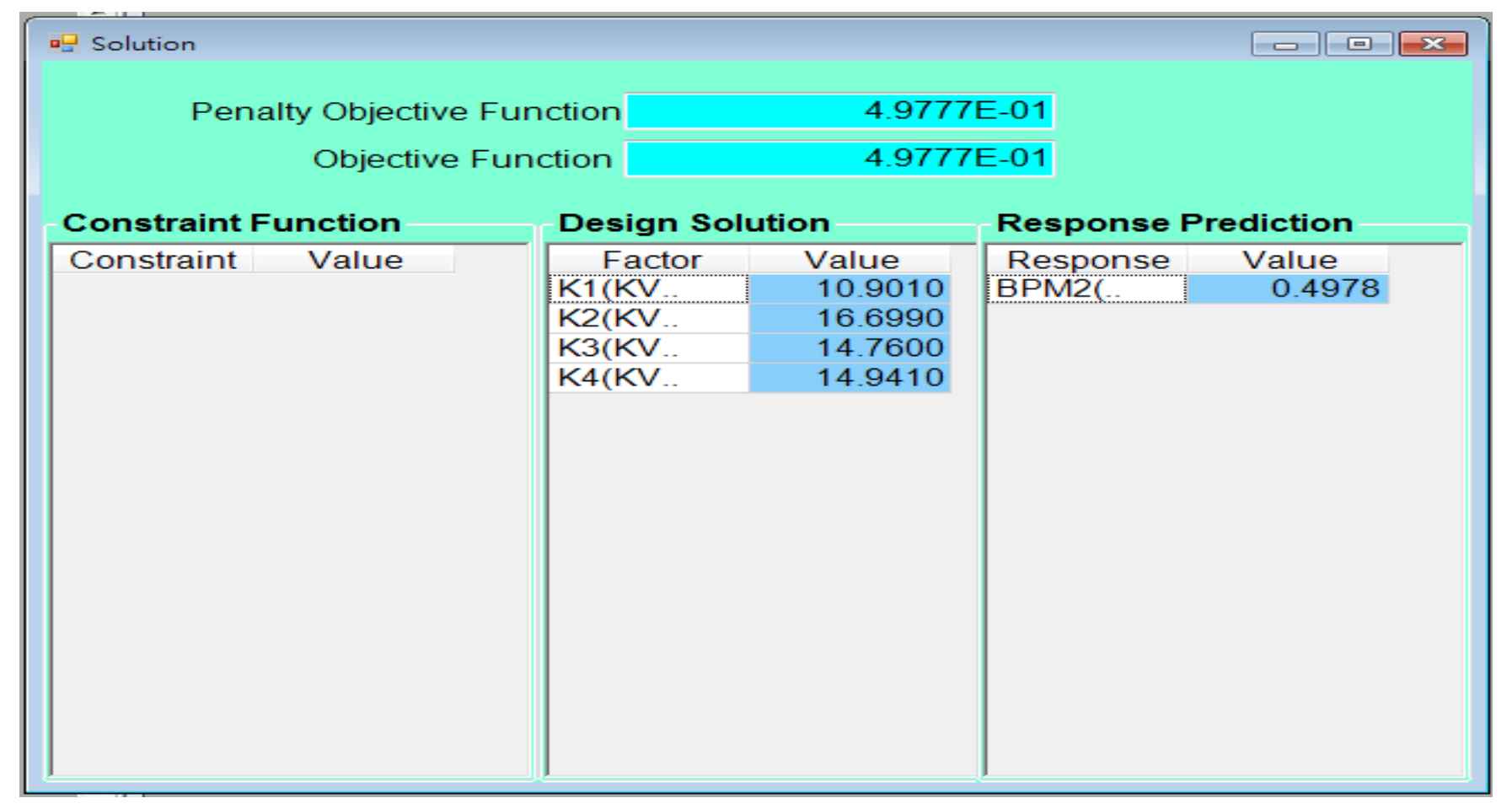


Figure 6 Status effect diagram.

After programming the quality factors for optimization, the ANN-optimized parameter solution was found. The ANN-optimized parameter solution is shown in (Fig. 7). We aimed to identify the main influential the injection pulse-magnets parameters of the storage ring and, through optimization, develop the injection pulse-magnets parameters of the storage ring adjustment program that best matching and minimizes injection transverse beam oscillations. The turn-by-turn Beam Position Monitor (BPM) system amplitude value was estimated as 0.4978 mm.



Solution

Penalty Objective Function: 4.9777E-01

Objective Function: 4.9777E-01

Constraint Function

Constraint	Value

Design Solution

Factor	Value
K1(KV..	10.9010
K2(KV..	16.6990
K3(KV..	14.7600
K4(KV..	14.9410

Response Prediction

Response	Value
BPM2(..	0.4978

Figure 7 Optimal solution settings for ANN-optimized quality factors.

Through experiment verification, the injection pulse-magnets parameters best matching and minimizes injection transverse beam oscillations could be reduced to from an average of ap-proximately 2mm to approximately 0.3mm, as shown in (Figs. 8 and 9).

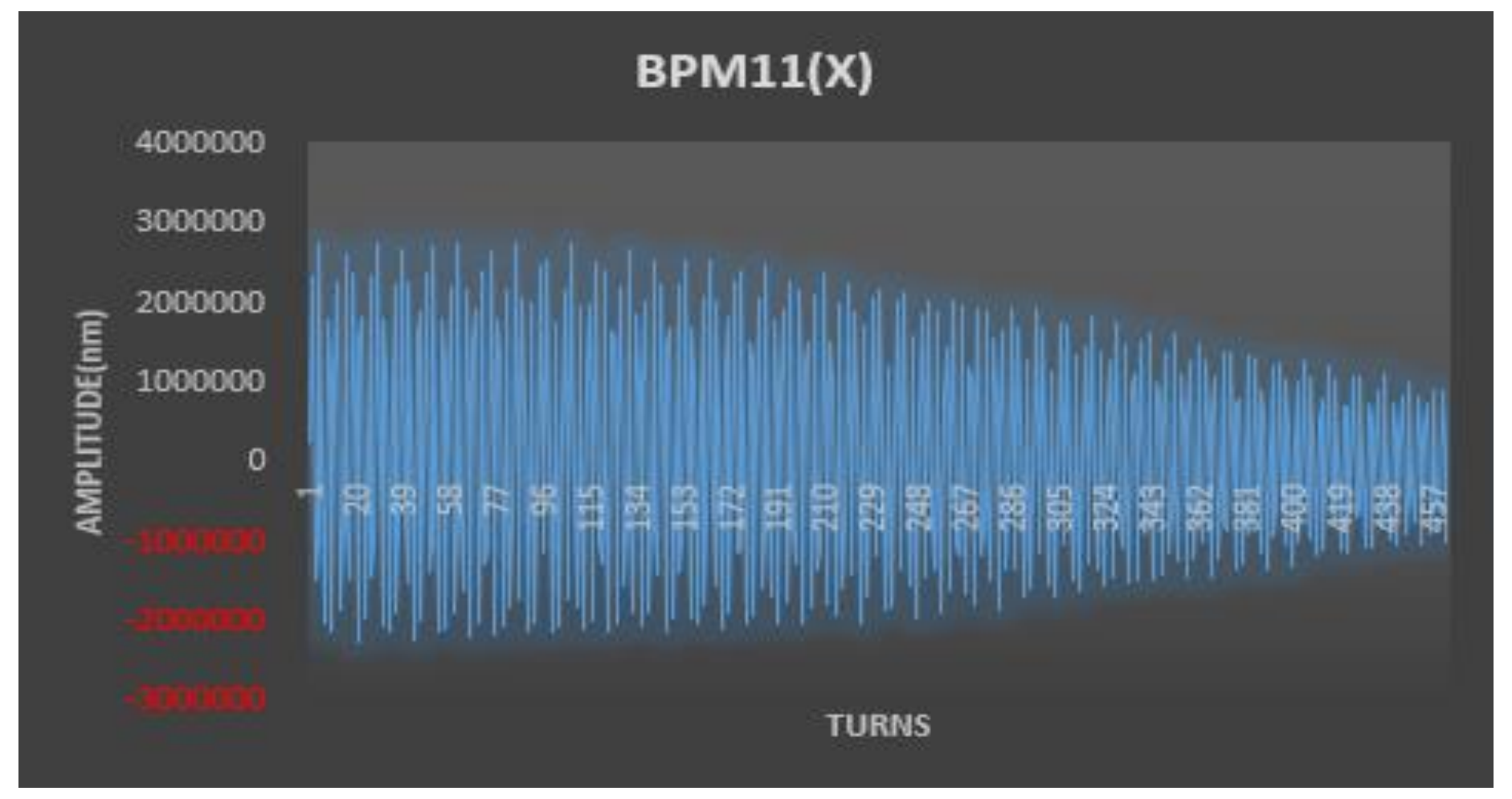


Figure 8 Current turn-by-turn (BPM11X)

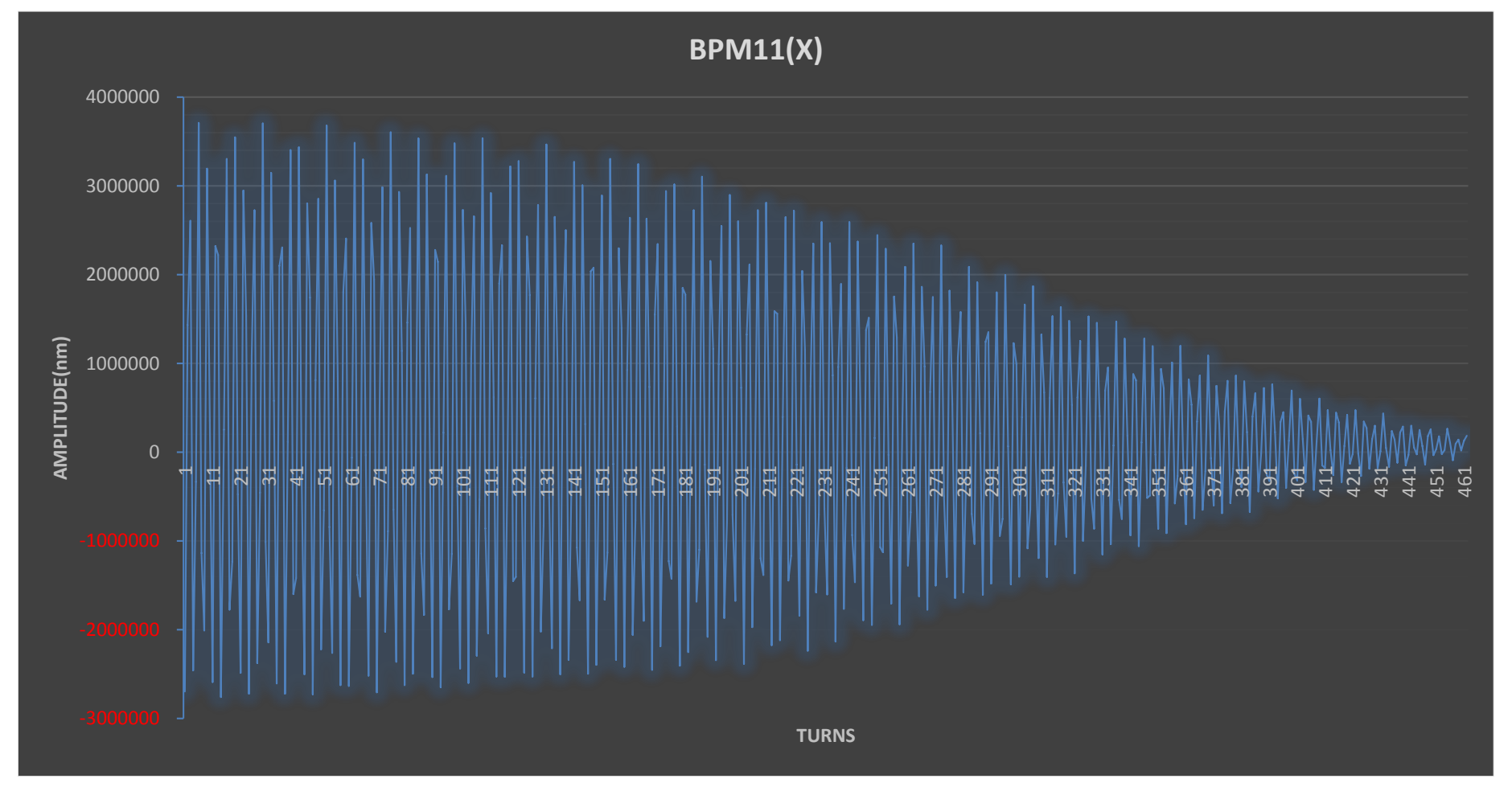


Figure 9 Optimal turn-by-turn (BPM11X)

Conclusion

This study aimed to minimize injection transverse beam oscillations of the Taiwan Light Source Storage Ring (TLS-SR). Using ANN experiment methods to analyze and optimize the injection pulse-magnets parameters of the storage ring. The turn-by-turn Beam Position Monitor (BPM) system amplitude value was estimated as 0.4978 mm. Analysis of the experimental results. Using BPN for analysis and the cross-validation experiment method to effectively estimate the generalization error, Through experiment verification, the injection pulse-magnets parameters best matching and minimizes injection transverse beam oscillations could be reduced to from an average of approximately 2mm to approximately 0.3mm.These results demonstrate the significant benefits of using ANN parameter optimization theory to enhance accelerator operation quality.