

Resonance Prominence (RP): A Normalized Resonance Evaluation Parameter for RLC Circuits

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Abstract: Resonance is an important phenomenon in electrical and electronic systems, especially in resonant circuits used in communication, filtering, oscillation, and wireless power transfer. Traditionally, the Quality Factor (Q) is used to measure resonance sharpness and selectivity. However, the Q -factor can vary from very small to extremely large values, making comparison and visualization difficult. This paper proposes a normalized parameter called Resonance Prominence (RP) that converts the Quality Factor into a bounded range between 0 and 1. The proposed parameter simplifies resonance analysis and graphical representation while maintaining the physical behaviour of resonance characteristics. Numerical examples and graphical interpretation are presented to validate the proposed method.

Keywords: Resonance, Quality Factor, Resonance Prominence, RLC Circuit, Normalization, Frequency Response

I. INTRODUCTION

Resonance occurs when the frequency of an applied signal matches the natural frequency of a system. In electrical engineering, resonance is widely used in RLC circuits, communication systems, oscillators, and filters. The Quality Factor (Q) is commonly used to determine resonance sharpness and energy efficiency.

Although Q -factor is effective, it has certain limitations:

It can become very large.

Comparison between systems becomes difficult.

Graphical plotting is inconvenient for large ranges.

To overcome these problems, this paper introduces a normalized parameter called Resonance Prominence (RP).

The proposed formula is:

$$RP = \frac{Q}{1 + Q}$$

The RP parameter transforms resonance values into a simple range between 0 and 1.

Quality Factor of Resonant Circuits

For a series RLC circuit, the Quality Factor is given by:

$$Q = \frac{1}{R} \sqrt{\frac{L}{C}}$$



where:

R = resistance

L = inductance

C = capacitance

Higher Q-factor indicates:

- stronger resonance
- sharper frequency selectivity
- lower damping

Proposed Resonance Prominence Parameter

The proposed normalized resonance parameter is:

$$RP = \frac{Q}{1 + Q}$$

Properties of RP

$$0 \leq RP < 1$$

When $Q \rightarrow 0$, $RP \rightarrow 0$

When $Q \rightarrow \infty$, $RP \rightarrow 1$

RP is dimensionless and normalized

II. LITERATURE SURVEY

Several researchers and authors have studied resonance phenomena and quality factor analysis in electrical and electronic circuits.

Alexander and Sadiku explained the importance of resonance in RLC circuits and discussed how the Quality Factor (Q) determines the sharpness and selectivity of resonance. Higher Q-factor values indicate lower energy loss and better resonance characteristics.

Hayt discussed the mathematical behaviour of resonant circuits and highlighted the role of damping and frequency response in communication and filter applications. Boyles tad presented resonance applications in oscillators, amplifiers, and wireless systems, showing that resonant circuits are widely used in practical electronic engineering.

Dorf and Nilsson explained that although Q-factor is an effective resonance measurement parameter, very high or very low values make comparison difficult during analysis and graphical plotting. Existing literature mainly focuses on direct Q-factor evaluation without normalization methods.

The proposed Resonance Prominence (RP) parameter introduces a normalized representation of resonance strength between 0 and 1. This simplifies comparison, visualization, and engineering interpretation while preserving the physical behaviour of resonant systems. The normalization approach improves resonance evaluation for practical communication, RF, and filter applications.

III. NUMERICAL ANALYSIS

Numerical Example 1

Given:

- $R = 10 \Omega$
- $L = 0.1 H$
- $C = 100 \mu F$

Step 1: Calculate Q-factor

$$Q = \frac{1}{10} \sqrt{\frac{0.1}{100 \times 10^{-6}}}$$



$$Q = 0.1 \times \sqrt{1000}$$

$$Q = 3.162$$

Step 2: Calculate RP

$$RP = \frac{3.162}{1 + 3.162}$$

$$RP = 0.759$$

Numerical Example 2

Given:

- $R = 5 \Omega$
- $L = 0.2 H$
- $C = 50 \mu F$

Step 1: Calculate Q-factor

$$Q = \frac{1}{5} \sqrt{\frac{0.2}{50 \times 10^{-6}}}$$

$$Q = 0.2 \times \sqrt{4000}$$

$$Q = 12.649$$

Step 2: Calculate RP

$$RP = \frac{12.649}{1 + 12.649}$$

$$RP = 0.927$$

Numerical Example 3

Given:

$$R = 20 \Omega$$

$$L = 0.05 H$$

$$C = 200 \mu F$$

Step 1: Calculate Q-factor

$$Q = \frac{1}{20} \sqrt{\frac{0.05}{200 \times 10^{-6}}}$$

$$Q = 0.05 \times \sqrt{250}$$

$$Q = 0.790$$

Step 2: Calculate RP

$$RP = \frac{0.790}{1 + 0.790}$$

$$RP = 0.441$$

Result Table

Example	Q-Factor	Resonance Prominence (RP)
1	3.162	0.759
2	12.649	0.927
3	0.790	0.441



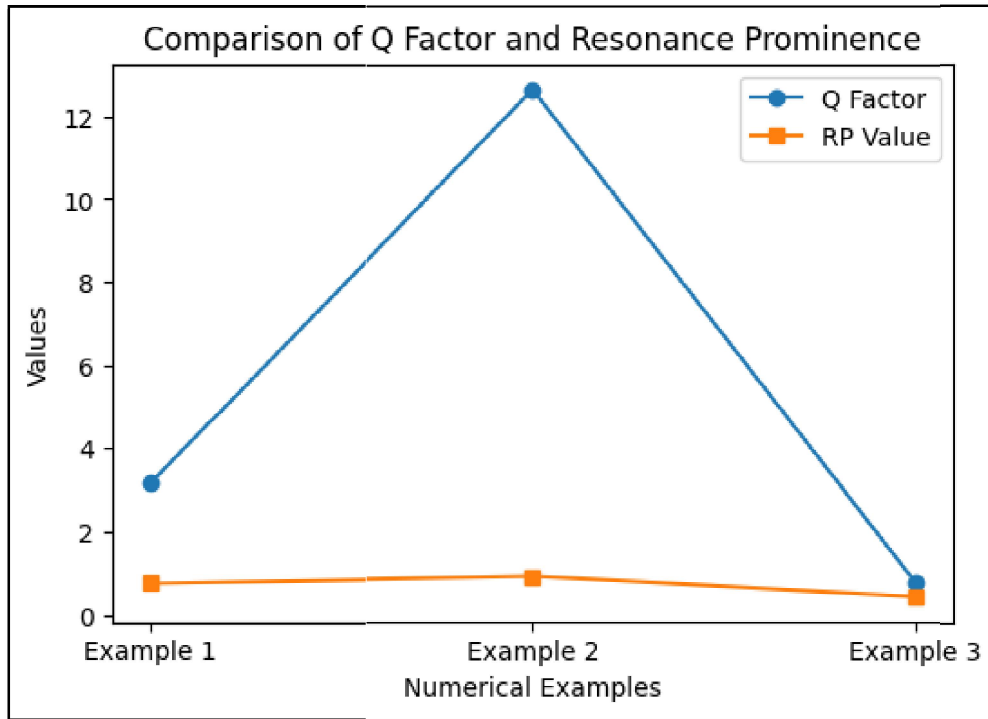


Fig. 1 A sample line graph using colors

The graph represents the comparison between the traditional Quality Factor (Q) and the proposed Resonance Prominence (RP) values for the three numerical examples.

The Q-factor values vary over a large range, from 0.790 to 12.649, which makes direct comparison and graphical visualization difficult. In contrast, the RP values remain within the normalized range of 0 to 1. This normalization compresses large resonance variations on a simpler and more interpretable scale.

From the graph, it can be observed that higher Q-factor values produce RP values closer to 1, indicating stronger resonance characteristics. Lower Q-factor values produce smaller RP values, representing weaker resonance. Therefore, the graph demonstrates that RP preserves the behavior of resonance while providing easier visualization, comparison, and practical analysis of resonant systems.

Graphical Interpretation

The RP values remain within the normalized range:

$$0 \leq RP < 1$$

This makes:

- plotting easier
- comparison simpler
- visualization clearer

Unlike the Q-factor, which can become extremely large, RP always remains bounded.

Higher RP values indicate:

- stronger resonance
- better selectivity
- lower damping



Lower RP values indicate:

- weak resonance
- higher damping
- broader response

IV. ADVANTAGES OF RP

Simplified Visualization

Graphs become easier to interpret because values remain between 0 and 1.

Better Comparative Analysis

Different resonant systems can be compared directly.

Practical Engineering Use

RP can be applied in:

- RF communication
- filter design
- oscillators
- wireless power transfer
- sensor systems

V. CONCLUSION

This paper introduced a normalized resonance parameter called Resonance Prominence (RP) derived from the Quality Factor of resonant circuits. The RP parameter transforms resonance behavior into a bounded range between 0 and 1, simplifying graphical representation and comparative analysis. Numerical examples demonstrated the effectiveness of the proposed parameter in representing resonance strength. The proposed method can improve resonance evaluation in practical electrical and electronic applications.

VI. ACKNOWLEDGMENT

We would like to express our sincere gratitude to all the team members whose dedicated efforts, cooperation, and technical contributions helped in the successful completion of this research work on Resonance Prominence (RP). The teamwork, continuous discussions, and collaborative problem-solving played an important role in developing the proposed resonance evaluation parameter and completing the numerical and graphical analysis presented in this paper.

We also appreciate the commitment and coordination among the team members throughout the research process, including theoretical analysis, calculations, data interpretation, and documentation. Their collective contribution made this work possible and meaningful.

REFERENCES

1. Alexander, C. K., & Sadiku, M. N. O., Fundamentals of Electric Circuits, McGraw-Hill.
2. Hayt, W. H., Engineering Circuit Analysis, McGraw-Hill.
3. Boylestad, R., Introductory Circuit Analysis, Pearson Education.
4. Dorf, R. C., Introduction to Electric Circuits, Wiley.
5. Nilsson, J. W., Electric Circuits, Pearson.

