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# Experimental Research on Power Quality Improvement using Capacitor Bank for 500 kVA Three-Phase Transformer

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## ABSTRACT

This research is to improve the power quality for 500kVA three-phase transformer using capacitor bank at Technological University (Mandalay). The main purpose of installing a capacitor bank is to compensate the reactive power consumption and reduce the line losses for power quality improvement. The required value of capacitor bank rating for transformer is calculated in this paper. And then the results for loss reduction and reactive power compensation are also compared without and with capacitor bank. In this research, 150 kVAR of capacitor bank is installed to improve the power factor up to 0.99, to decrease reactive power from 138.47 to 0.75kVAR, apparent power from 169.47kVA to 101.93kVA, and percent loss reduction up to 69.14. So, the simple model of reactive power compensation with 150kVAR capacitor bank is helpful for 500 kVA transformer at Technological University (Mandalay) to reduce reactive power consumption.

***KEYWORDS:*** *Power quality; Power factor; Capacitor bank; Reactive power compensation; apparent power*

## INTRODUCTION

Power quality has always been a major concern in any electrical power system design. Power Factor (PF) is one of the measures of the overall power quality and must be considered in a system that has a large amount of capacitive and inductive loads which can cause poor power factor such as leading and lagging power factors. In electrical engineering, power factor is only related to AC circuits. There is no power factor in DC circuits due to zero frequency.

The power factor of a system is composed of two elements, active power and apparent power. Active power is the useful power. Apparent power is the aggregate of active power and reactive power. This ratio is also equal to the cosine of the angle between the voltage and the current of the system. When the overall power factor of a generating station's load is low, the system is inefficient and the cost of electricity corresponding high [1]. To overcome this, and at the same time ensure that the generators and cables are not loaded with the wattles current, the supply authorities often impulse penalties for low power factor [2] [3].

Depending on load, power factor can be classified as lagging power factor, leading power factor and unity power factor. Poor PF like lagging power factor and leading power factor can lead to excessive current requirements and may also cause operating issues with electric generators, motors, transformers, the generation and the distribution systems. It makes the electrical system less efficient, and has the potential to damage the machines. To accommodate these issues, various devices are used to balance the reactive power being provided or absorbed. Today, the most common way to improve a poor "lagging" PF in any plant due to inductive loads is to install "PF improvement capacitors"[4]. This method is a time proven means for correction provided at a reasonable cost and with typically good reliability when there were not many non-linear loads. However, modern electrical systems design concepts as well as advancements in power electronic technologies may shift the design philosophy for implementing PF correction.

## POWER FACTOR CORRECTION TECHNIQUES

If reactive power compensator is supplied near the load, the line current, power losses can be reduced or minimized and voltage regulation can also be improved at the load terminals. The reactive power elements which can control the reactive power distribution and flows are [5][6][7]:

1. Synchronous condenser
2. Shunt capacitor
3. Series capacitor
4. Shunt reactor
5. Static Var compensator
6. Saturable transformer
7. Tap-staggered transformer

Among these types, reactive power compensation can be implemented with the capacitor bank connected in parallel or in series with the load simply and effectively. Moreover, two types of capacitor bank can be classified as follow [7]:

1. Fixed type capacitor bank
2. Automatic type capacitor bank

### A. Fixed Type Capacitor Bank

The reactive power supplied by the fixed capacitor bank is constant irrespective of any variations in the power factor and the load of the receivers. These capacitor banks are switched on either manually by a remote-controlled contactor.

This type of capacitor bank can be used in the following application:

1. Where the load factor is reasonably constant.
2. Electrical installations with constant load operating 24 hours a day
3. Reactive compensation of transformers
4. Individual compensation of the motors
5. Where the kVAR rating of the capacitors is less than, or equal to 15% of the supply transformer rating, a fixed value of compensation is appropriate.
6. Size of Fixed Capacitor bank $Q_c \leq$ 15% kVA transformer

### B. Automatic Type Capacitor Bank

The reactive power supplied by the capacitor bank can be adjusted according to variations in the power factor and the load of the receivers. The equipment is applied at points in an installation where the active-power or reactive power variations are relatively large, for example:

1. At the bus bars of a main distribution switch-board,
2. At the terminals of a heavily-loaded feeder cable.

The advantages of automatic power factor correction are as follows [8][9]:

1. Consistently high power factor under fluctuating loads
2. Prevention of leading power factor
3. Elimination of power factor penalty
4. Lower energy consumption by reducing losses
5. Continuously sensing and monitoring the load
6. Ensures easy user interface
7. Automatically switch on/off relevant capacitors steps for consistent power factor.

In this research, automatic type capacitor bank is used for the proposed area, TU (Mandalay), as it is situated under high load fluctuation.

## MATHEMATICAL FORMULATION

The power factor controller can be programmed with many additional features. To protect the capacitors, the regulators are equipped with an automatic shutdown facility in the event of excess voltage or excess harmonics. The regulators should have digital display of PF, current, volts, active power, reactive power and kVAR required to achieve target power factor. The following equations can be applied for sizing of capacitor bank [10][11][12].'

$$P = S \cos\phi \quad (1)$$

For Three Phase, $P = \sqrt{3} VI \cos\phi$ (2)

$$S = VI \quad (3)$$

Apparent Power,

$$S = \sqrt{(\text{Real power})^2 + (\text{Reactive power})^2} \quad (4)$$

(or)

$$S = \sqrt{(P)^2 + (Q)^2} \quad (5)$$

$$Q = \sqrt{3}\, V I \sin\phi \quad (6)$$

(or)

$$\text{Reactive Power} = \sqrt{(\text{Apparent Power})^2 - (\text{Real Power})^2} \quad (7)$$

(or)

$$Q = \sqrt{(S)^2 - (P)^2} \quad (8)$$

$$S = P + jQ \text{ (where j is the imaginary unit)} \quad (9)$$

$$\text{Capacitor Rating} = \text{Multiplying Power Factor} \times \text{kW Demand} \quad (10)$$

(or)

$$\text{Capacitor Rating} = \text{kVAR (Uncorrected)} - \text{kVAR (Corrected)} \quad (11)$$

$$\%\ \text{Line Current Reduction} = 100\left[1 - \frac{\text{Present Power Factor}}{\text{Improved Power Factor}}\right]^2 \quad (12)$$

$$\%\ \text{Power Losses} = 100\left[\frac{\text{Present Power Factor}}{\text{Improved Power Factor}}\right]^2 \quad (13)$$

$$\%\ \text{Loss Reduction} = 100\left[1 - \left[\frac{\text{Present Power Factor}}{\text{Improved Power Factor}}\right]^2\right] \quad (14)$$

%Voltage improvement

$$= \frac{\text{Capacitor kVAR} \times \%\ \text{Transformer Reactance}}{\text{Transformer kVA}} \quad (15)$$

Where,

V = Voltage (V)

I = Current (A)

P = Real Power (kW)

S = Apparent Power (kVA)

Q = Reactive Power (kVAR)

cos Ø = Power factor

## DESIGN SPECIFICATIONS

The selected location is Technological University (Mandalay) which is located in Mandalay Division. This University is supplied the power from a main transformer (500kVA, 11/0.4 kV). The incoming line is 11 kV transmission line from Patheingyi substation.

| | |
|---|---|
| kVA rating | = 500 kVA |
| Number of phase | = Three phase |
| Frequency | = 50 Hz |
| Transformer reactance | = 6 % |
| Efficiency | = 98.56 % |
| High voltage | = 11 kV |
| Low voltage | = 400 V |
| Type of connection | = Delta-star |

The following data are obtained from Technological University (Mandalay) to design automatic shunt capacitor bank for power factor correction. This can be conveniently done by considering the load as follows:

**TABLE1. SURVEY OF TU (MANDALAY) LOAD PATTERN IN JUNE, 2018**

| Time | Real Power (kW) | Reactive Power (kVAR) | Apparent Power (kVA) | Power Factor (P.F) |
|---|---|---|---|---|
| 1:00 AM | 30.55 | 18.04 | 36.56 | 0.85 |
| 2:00 AM | 32.23 | 20.11 | 37.72 | 0.83 |
| 3:00 PM | 31.45 | 25.12 | 40.11 | 0.81 |
| 4:00 PM | 45.23 | 34.04 | 55.43 | 0.8 |
| 5:00 PM | 43.16 | 40.02 | 58.01 | 0.75 |
| 6:00 AM | 71.33 | 110.34 | 129.75 | 0.55 |
| 7:00 AM | 75.76 | 98.11 | 123.42 | 0.60 |
| 8:00 AM | 76.3 | 109.00 | 131.78 | 0.58 |
| 9:00 AM | 97.76 | 102.10 | 140.56 | 0.7 |
| 10:00 AM | 95.78 | 96.88 | 136.22 | 0.7 |
| 11:00 AM | 97.76 | 145.70 | 175.00 | 0.56 |
| 12:00 PM | 99.63 | 108.00 | 145.11 | 0.7 |
| 1:00 PM | 90.67 | 93.45 | 130.55 | 0.69 |
| 2:00 PM | 100.24 | 106.90 | 146.03 | 0.7 |
| 3:00 PM | 100.20 | 106.02 | 143.77 | 0.69 |
| 4:00 PM | 100.08 | 138.47 | 169.47 | 0.55 |
| 5:00 PM | 43.1 | 59.00 | 72.88 | 0.6 |
| 6:00 PM | 65.67 | 100.01 | 116.99 | 0.57 |
| 7:00 PM | 74.22 | 82.91 | 110.71 | 0.68 |
| 8:00 PM | 73.34 | 77.79 | 104.79 | 0.7 |
| 9:00 PM | 60.78 | 62.90 | 88.90 | 0.69 |
| 10:00 PM | 51.42 | 50.82 | 73.99 | 0.7 |
| 11:00 PM | 45.77 | 45.71 | 63.66 | 0.7 |
| 12:00 PM | 30.15 | 32.09 | 43.09 | 0.7 |

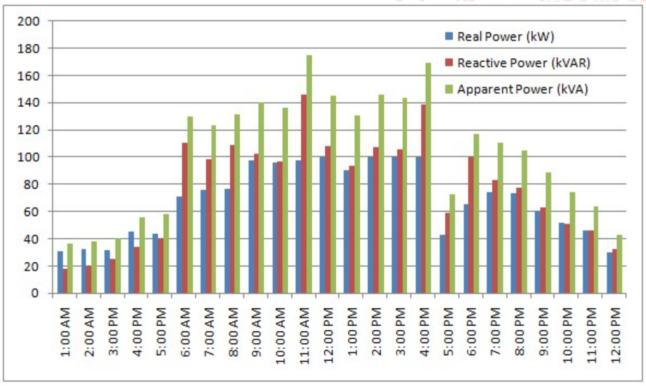


**Fig.1 Load Pattern of TU(Mandalay)**

**SIZING OF CAPACITOR BANK**

The multiplier table can be used for capacitor selection straight away when the present load, present power factor and desired power factor are known. To properly selected capacitor rating required to increase power factor from 0.55 to 0.99, the steps must be followed as stated.

Step 1: Find the present power factor in column
Step 2: Read across to optimum power factor column
Step 3: Multiply that number by kW demand from table 2.

The following data are obtained from 4PM:

Present kW = 100 kW
Present kVA = 169.47 kVA
Present kVAR = 138.47 kVAR
Present power factor = 0.55
Desired power factor = 0.99
Multiplying factor = 1.376 (From table)

Therefore,

Capacitor Rating =Multiplying Factor × kW Demand
= 1.376 × 100
= 137.6 kVAR
=150kVAR (Around)

Actually, 0.95 power factor is reasonable for application but 0.99 power factor is considered for future load expansion. So, 150kVAR automatic shunt type capacitor bank is installed at the secondary side of the transformer.

**EXPERIMENTAL SET-UP**

To correct entire University's loads, 150kVAR (5 × 30 kVAR) automatic capacitor bank are installed at the secondary side of the transformer. The system maintains the power factor at 0.99 with considering the future load demand as that university. It eliminates too much kVAR at light-load periods and undesirable over-voltages.

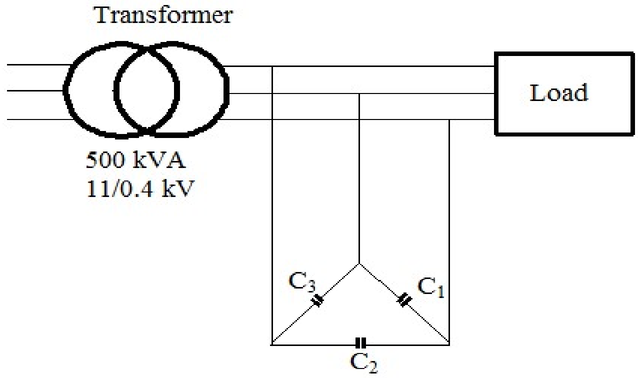


**Fig.2 Connection Diagram of 150kVAR Capacitor Bank**

TU (Mandalay) has variable load conditions and inductive loads. So, automatic capacitor banks are used for power factor correction of this university. The following figures 3(a), (b) and (c) are complete installation diagrams of five numbers of 30 kVAR ( 30kVAR×5=150kVAR) automatic capacitor bank for power factor correction. Figure 2 shows the connection diagram of 150kVAR capacitor bank for 500 kVA three-phase transformer for TU (Mandalay).

(a)

(b)

(c)

**Fig.3 Complete Installation Diagram of 150kVAR capacitor bank for 500 kVA three-phase transformer for TU (Mandalay)**

## EXPERIMENTAL RESULTS

In the experiment, three types of experiment are tested to obtain the power factor improvement and these are showed below.

### A. Experiment 1

In the experiment 1, three numbers of 30kVAR (90kVAR) automatic capacitor are on and the remaining two capacitors are off. Under this condition, the following experiment results are obtained. Table 2 shows not only the experiment but also the calculation results using equations 1 to 15.

**TABLE2. EXPERIMENTAL AND CALCULATION RESULTS OF EXPERIMENT 1**

| Experiment Results | |
|---|---|
| Capacitor Bank (kVAR) | 90 |
| Power factor | 0.85 (Penalty PF) |
| $Q_{remain}$(kVAR) | 49.71 |
| P (kW) | 100 |
| S (kVA) | 113.17 |
| **Calculation Results** | |
| % Line Current Reduction | 12.47 |
| % Power Losses | 41.87 |
| % Loss Reduction | 58.13 |

### B. Experiment 2

In the experiment 2, four numbers of 30kVAR (120 kVAR) automatic capacitor are on and the remaining one capacitors are off. The experiment and calculation results are shown in table 3.

**TABLE3. EXPERIMENTAL AND CALCULATION RESULTS OF EXPERIMENT 2**

| Experiment Results | |
|---|---|
| Capacitor Bank (kVAR) | 120 |
| Power factor | 0.95 |
| $Q_{remain}$(kVAR) | 21.05 |
| P (kW) | 100 |
| S (kVA) | 101.93 |
| **Calculation Results** | |
| % Line Current Reduction | 17.73 |
| % Power Losses | 33.52 |
| % Loss Reduction | 66.48 |

### C. Experiment 3

When all of 30kVAR (5×30kVAR=150kVAR) automatic capacitor are on in the experiment 3, the following experimental and calculation results shown in table 4 are obtained. Experimental Result for 0.99 of power improvement is also illustrated in figure 4.

**TABLE4. EXPERIMENTAL AND CALCULATION RESULTS OF EXPERIMENT 3**

| Experiment Results | |
|---|---|
| Capacitor Bank (kVAR) | 150 |
| Power factor | 0.99 |
| $Q_{remain}$(kVAR) | 0.75 |
| P (kW) | 100 |
| S (kVA) | 101.93 |
| **Calculation Results** | |
| % Line Current Reduction | 19.75 |
| % Power Losses | 30.86 |
| % Loss Reduction | 69.14 |

Fig. 4 Experimental Result for 0.99 of Power Improvement

## COMPARISON RESULTS FOR WITH AND WITHOUT CAPACITOR BANK

The table below is to illustrate some variables obtained from power factor changes. Capacitor rating added to improve power factor can be determined. Capacitor rating is the difference between kVAR ratings of original power factor and desired power factor. From Table 5, 120 kVAR capacitor bank is needed to improve power factor from 55 % to 95 %.

The higher the power factor improves, the less the transformer loading. Consequently, load amperes drop. In turn, the lower the power factor, the more the transformer loading. Thus, load currents increase. In this paper, load variables with constant load 100 kW at 95 % power factor are 101.93 kVA and 21.05 kVAR.

**TABLE5. COMPARISON RESULTS FOR WITH AND WITHOUT CAPACITOR BANK**

| Specification | Without CB | With CB | | |
|---|---|---|---|---|
| Power factor | 0.55 | 0.85 (Penalty PF) | 0.95 | 0.99 |
| Capacitor Bank (kVAR) | - | 90 | 120 | 150 |
| $Q_{remain}$(kVAR) | 138.47 | 49.71 | 21.05 | 0.75 |
| P (kW) | 100 | 100.09 | 103.42 | 101.14 |
| S (kVA) | 169.47 | 113.17 | 101.93 | 101.93 |
| % Line Current Reduction | - | 12.47 | 17.73 | 19.75 |
| % Power Losses | - | 41.87 | 33.52 | 30.86 |
| % Loss Reduction | - | 58.13 | 66.48 | 69.14 |

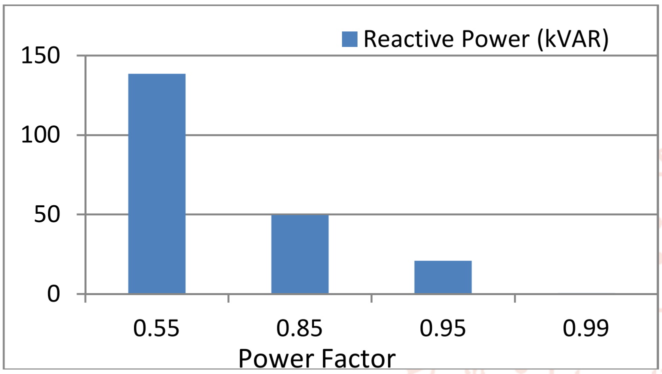


Fig.5 Reduction of Reactive Power with Power Factor Improvement

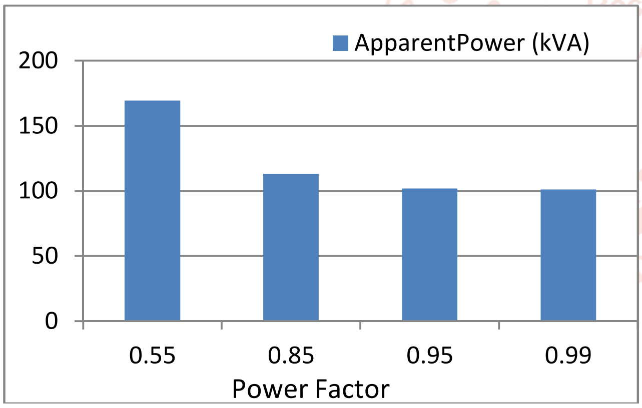


Fig.6 Reduction of Apparent Power with Power Factor Improvement

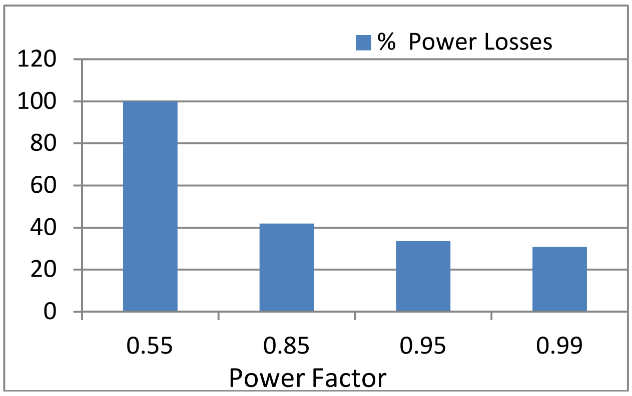


Fig.7 Reduction of Power Losses Percentage with Power Factor Improvement

From the figures 5, 6 and 7, the %power lossess, reactive power and apparent power are directly proportional to the power factor. The power factor approaches to 1, the net apparent power is nearly equal to real power.

In the international policy, the electricity bill payment system is based on the apparent power, S(kVA). By improving the quality of power factor, the consumer based on international policy will reduce the electricity bill significantly. The formula including active power, apparent power and power factor is P= S cosϕ. The apparent power is inversely proportional to the power factor. The magnitude of the current flowing through the device is less on the electrical devices. So, users can get the better life time of the electrical devices.

In Myanmar, the electricity bill payment system is based on the real power, P(kW). Although the consumers improve the power factor quality, the users will not be reduced the electricity bill significantly. By installing Capacitor Bank, the reactive power, Q(kVAR) and the apparent power, S(kVA), will be decreased. By improving power factor, it is better for electrical appliances and can improve the lifetime of the electrical devices.

In the consumer's point of view, the consumers can get more reliable on the electrical devices. By improving the power factor, the users can achieve the better lifetime on electrical devices and reduce for the maintenance costs. The less of the current flowing through to the electrical devices, the more increased the life time of the equipments.

## CONCLUSION

Poor PF in any power system operation is not only undesirable, but it can also cause serious issues that lead to additional consumer costs when not corrected properly. In today's power systems, common and more traditional methods of applying PF correction by using shunt capacitors must be reconsidered. More harmonic generating devices are present in modern electrical systems and special consideration should be taken into account when designing PF correction systems. Factors such as system resonance, PF penalties in the utility billing, and the flexibility of the PF correction systems greatly influence.

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## APPENDIX

| Original Power Factor | Corrected Power Factor | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.80 | 0.81 | 0.82 | 0.83 | 0.84 | 0.85 | 0.86 | 0.87 | 0.88 | 0.89 | 0.90 | 0.91 | 0.92 | 0.93 | 0.94 | 0.95 | 0.96 | 0.97 | 0.98 | 0.99 | 1.0 |
| **0.50** | 0.982 | 1.008 | 1.034 | 1.060 | 1.086 | 1.112 | 1.139 | 1.165 | 1.192 | 1.220 | 1.248 | 1.276 | 1.306 | 1.337 | 1.369 | 1.403 | 1.440 | 1.481 | 1.529 | 1.589 | 1.732 |
| **0.51** | 0.937 | 0.962 | 0.989 | 1.015 | 1.041 | 1.067 | 1.094 | 1.120 | 1.147 | 1.175 | 1.203 | 1.231 | 1.261 | 1.292 | 1.324 | 1.358 | 1.395 | 1.436 | 1.484 | 1.544 | 1.687 |
| **0.52** | 0.893 | 0.919 | 0.945 | 0.971 | 0.997 | 1.023 | 1.050 | 1.076 | 1.103 | 1.131 | 1.159 | 1.187 | 1.217 | 1.248 | 1.280 | 1.314 | 1.351 | 1.392 | 1.440 | 1.500 | 1.643 |
| **0.53** | 0.850 | 0.876 | 0.902 | 0.928 | 0.954 | 0.980 | 1.007 | 1.033 | 1.060 | 1.088 | 1.116 | 1.144 | 1.174 | 1.205 | 1.237 | 1.271 | 1.308 | 1.349 | 1.397 | 1.457 | 1.600 |
| **0.54** | 0.809 | 0.835 | 0.861 | 0.887 | 0.913 | 0.939 | 0.966 | 0.992 | 1.019 | 1.047 | 1.075 | 1.103 | 1.133 | 1.164 | 1.169 | 1.230 | 1.267 | 1.308 | 1.356 | 1.416 | 1.559 |
| **0.55** | 0.769 | 0.795 | 0.821 | 0.847 | 0.873 | 0.899 | 0.926 | 0.952 | 0.979 | 1.007 | 1.035 | 1.063 | 1.093 | 1.124 | 1.156 | 1.190 | 1.227 | 1.268 | 1.316 | 1.376 | 1.519 |
| **0.56** | 0.730 | 0.756 | 0.782 | 0.808 | 0.834 | 0.860 | 0.887 | 0.913 | 0.940 | 0.968 | 0.996 | 1.024 | 1.054 | 1.085 | 1.117 | 1.151 | 1.188 | 1.229 | 1.277 | 1.337 | 1.480 |
| **0.57** | 0.692 | 0.718 | 0.744 | 0.770 | 0.796 | 0.822 | 0.849 | 0.875 | 0.902 | 0.930 | 0.958 | 0.986 | 1.016 | 1.047 | 1.079 | 1.113 | 1.150 | 1.191 | 1.239 | 1.299 | 1.442 |
| **0.58** | 0.655 | 0.681 | 0.707 | 0.733 | 0.759 | .785 | 0.812 | 0.838 | 0.865 | 0.893 | 0.921 | 0.949 | 0.979 | 1.010 | 1.042 | 1.076 | 1.113 | 1.154 | 1.202 | 1.262 | 1.405 |
| **0.59** | 0.619 | 0.645 | 0.671 | 0.697 | 0.723 | 0.749 | 0.776 | 0.802 | 0.829 | 0.857 | 0.885 | 0.913 | 0.943 | 0.974 | 1.006 | 1.040 | 1.077 | 1.118 | 1.166 | 1.226 | 1.369 |
| **0.60** | 0.583 | 0.609 | 0.635 | 0.661 | 0.687 | 0.713 | 0.740 | 0.766 | 0.793 | 0.821 | 0.849 | 0.877 | 0.907 | 0.938 | 0.970 | 1.004 | 1.041 | 1.082 | 1.130 | 1.190 | 1.333 |
| **0.61** | 0.549 | 0.575 | 0.601 | 0.627 | 0.653 | 0.679 | 0.706 | 0.732 | 0.759 | 0.787 | 0.815 | 0.843 | 0.873 | 0.904 | 0.936 | 0.970 | 1.007 | 1.048 | 1.096 | 1.156 | 1.299 |
| **0.62** | 0.516 | 0.542 | 0.568 | 0.594 | 0.620 | 0.646 | 0.673 | 0.699 | 0.726 | 0.754 | 0.782 | 0.810 | 0.840 | 0.871 | 0.903 | 0.937 | 0.974 | 1.015 | 1.063 | 1.123 | 1.266 |
| **0.63** | 0.483 | 0.509 | 0.535 | 0.561 | 0.587 | 0.613 | 0.640 | 0.666 | 0.693 | 0.721 | 0.749 | 0.777 | 0.807 | 0.838 | 0.870 | 0.904 | 0.941 | 0.982 | 1.030 | 1.090 | 1.233 |
| **0.64** | 0.451 | 0.474 | 0.503 | 0.529 | 0.555 | 0.581 | 0.608 | 0.634 | 0.661 | 0.689 | 0.717 | 0.745 | 0.775 | 0.806 | 0.838 | 0.872 | 0.909 | 0.950 | 0.998 | 1.068 | 1.201 |
| **0.65** | 0.419 | 0.445 | 0.471 | 0.497 | 0.523 | 0.549 | 0.576 | 0.602 | 0.629 | 0.657 | 0.685 | 0.713 | 0.743 | 0.774 | 0.806 | 0.840 | 0.877 | 0.918 | 0.966 | 1.026 | 1.169 |
| **0.66** | 0.388 | 0.414 | 0.440 | 0.466 | 0.492 | 0.518 | 0.545 | 0.571 | 0.598 | 0.626 | 0.654 | 0.682 | 0.712 | 0.743 | 0.775 | 0.809 | 0.846 | 0.887 | 0.935 | 0.995 | 1.138 |
| **0.67** | 0.358 | 0.384 | 0.410 | 0.436 | 0.462 | 0.488 | 0.515 | 0.541 | 0.568 | 0.596 | 0.624 | 0.652 | 0.682 | 0.713 | 0.745 | 0.779 | 0.816 | 0.857 | 0.905 | 0.965 | 1.108 |
| **0.68** | 0.328 | 0.354 | 0.380 | 0.406 | 0.432 | 0.458 | 0.485 | 0.511 | 0.538 | 0.566 | 0.594 | 0.622 | 0.652 | 0.683 | 0.715 | 0.749 | 0.786 | 0.827 | 0.875 | 0.935 | 1.078 |
| **0.68** | 0.299 | 0.325 | 0.351 | 0.377 | 0.403 | 0.429 | 0.456 | 0.482 | 0.509 | 0.537 | 0.565 | 0.593 | 0.623 | 0.654 | 0.686 | 0.720 | 0.757 | 0.798 | 0.846 | 0.906 | 1.049 |
| **0.70** | 0.270 | 0.296 | 0.322 | 0.348 | 0.374 | 0.400 | 0.427 | 0.453 | 0.480 | 0.508 | 0.536 | 0.564 | 0.594 | 0.625 | 0.657 | 0.691 | 0.728 | 0.769 | 0.817 | 0.877 | 1.020 |
| **0.71** | 0.242 | 0.268 | 0.294 | 0.320 | 0.346 | 0.372 | 0.399 | 0.425 | 0.452 | 0.480 | 0.508 | 0.536 | 0.566 | 0.597 | 0.629 | 0.663 | 0.700 | 0.741 | 0.789 | 0.849 | 0.992 |
| **0.72** | 0.214 | 0.240 | 0.266 | 0.292 | 0.318 | 0.344 | 0.371 | 0.397 | 0.424 | 0.452 | 0.480 | 0.508 | 0.538 | 0.569 | 0.601 | 0.635 | 0.672 | 0.713 | 0.761 | 0.821 | 0.964 |
| **0.73** | 0.186 | 0.212 | 0.238 | 0.264 | 0.290 | 0.316 | 0.343 | 0.369 | 0.396 | 0.424 | 0.452 | 0.480 | 0.510 | 0.541 | 0.573 | 0.607 | 0.644 | 0.685 | 0.733 | 0.793 | 0.936 |
| **0.74** | 0.159 | 0.185 | 0.211 | 0.237 | 0.263 | 0.289 | 0.316 | 0.342 | 0.369 | 0.397 | 0.425 | 0.453 | 0.483 | 0.514 | 0.546 | 0.580 | 0.617 | 0.658 | 0.706 | 0.766 | 0.909 |
| **0.75** | 0.132 | 0.158 | 0.184 | 0.210 | 0.236 | 0.262 | 0.289 | 0.315 | 0.342 | 0.370 | 0.398 | 0.426 | 0.456 | 0.487 | 0.519 | 0.553 | 0.590 | 0.631 | 0.679 | 0.739 | 0.882 |
| **0.76** | 0.105 | 0.131 | 0.157 | 0.183 | 0.209 | 0.235 | 0.262 | 0.288 | 0.315 | 0.343 | 0.371 | 0.399 | 0.429 | 0.460 | 0.492 | 0.526 | 0.563 | 0.604 | 0.652 | 0.712 | 0.855 |
| **0.77** | 0.079 | 0.105 | 0.131 | 0.157 | 0.183 | 0.209 | 0.236 | 0.262 | 0.289 | 0.317 | 0.345 | 0.373 | 0.403 | 0.434 | 0.466 | 0.500 | 0.537 | 0.578 | 0.626 | 0.685 | 0.829 |
| **0.78** | 0.052 | 0.078 | 0.104 | 0.130 | 0.156 | 0.182 | 0.209 | 0.235 | 0.262 | 0.290 | 0.318 | 0.346 | 0.376 | 0.407 | 0.439 | 0.473 | 0.510 | 0.551 | 0.599 | 0.659 | 0.802 |
| **0.79** | 0.026 | 0.052 | 0.078 | 0.104 | 0.130 | 0.156 | 0.183 | 0.209 | 0.235 | 0.264 | 0.292 | 0.320 | 0.350 | 0.381 | 0.413 | 0.447 | 0.484 | 0.525 | 0.573 | 0.633 | 0.776 |
| **0.80** | 0.000 | 0.026 | 0.052 | 0.078 | 0.104 | 0.130 | 0.157 | 0.183 | 0.210 | 0.238 | 0.266 | 0.294 | 0.324 | 0.355 | 0.387 | 0.421 | 0.458 | 0.499 | 0.547 | 0.609 | 0.750 |
| **0.81** | | 0.000 | 0.026 | 0.052 | 0.078 | 0.104 | 0.131 | 0.157 | 0.184 | 0.212 | 0.240 | 0.268 | 0.298 | 0.329 | 0.361 | 0.395 | 0.432 | 0.473 | 0.521 | 0.581 | 0.724 |
| **0.82** | | | 0.000 | 0.026 | 0.052 | 0.078 | 0.105 | 0.131 | 0.158 | 0.186 | 0.214 | 0.242 | 0.272 | 0.303 | 0.335 | 0.369 | 0.406 | 0.447 | 0.495 | 0.555 | 0.698 |
| **0.83** | | | | 0.000 | 0.026 | 0.052 | 0.079 | 0.105 | 0.132 | 0.160 | 0.188 | 0.216 | 0.246 | 0.277 | 0.309 | 0.343 | 0.380 | 0.421 | 0.469 | 0.529 | 0.672 |
| **0.84** | | | | | 0.000 | 0.026 | 0.053 | 0.079 | 0.106 | 0.134 | 0.162 | 0.190 | 0.220 | 0.251 | 0.283 | 0.317 | 0.354 | 0.395 | 0.443 | 0.503 | 0.646 |
| **0.85** | | | | | | 0.000 | 0.027 | 0.053 | 0.080 | 0.108 | 0.136 | 0.164 | 0.194 | 0.225 | 0.257 | 0.291 | 0.328 | 0.369 | 0.417 | 0.477 | 0.260 |
| **0.86** | | | | | | | 0.000 | 0.026 | 0.053 | 0.081 | 0.109 | 0.137 | 0.167 | 0.198 | 0.230 | 0.264 | 0.301 | 0.342 | 0.390 | 0.450 | 0.593 |
| **0.87** | | | | | | | | 0.000 | 0.027 | 0.055 | 0.083 | 0.111 | 0.141 | 0.172 | 0.204 | 0.238 | 0.275 | 0.316 | 0.364 | 0.424 | 0.567 |
| **0.88** | | | | | | | | | 0.000 | 0.028 | 0.056 | 0.084 | 0.114 | 0.145 | 0.177 | 0.211 | 0.248 | 0.289 | 0.337 | 0.397 | 0.540 |
| **0.89** | | | | | | | | | | 0.000 | 0.028 | 0.056 | 0.086 | 0.117 | 0.149 | 0.183 | 0.220 | 0.261 | 0.309 | 0.369 | 0.512 |
| **0.90** | | | | | | | | | | | 0.000 | 0.028 | 0.058 | 0.089 | 0.121 | 0.155 | 0.192 | 0.233 | 0.281 | 0.341 | 0.484 |
| **0.91** | | | | | | | | | | | | 0.000 | 0.030 | 0.061 | 0.093 | 0.127 | 0.164 | 0.205 | 0.253 | 0.313 | 0.456 |
| **0.92** | | | | | | | | | | | | | 0.000 | 0.031 | 0.063 | 0.097 | 0.134 | 0.175 | 0.223 | 0.283 | 0.426 |
| **0.93** | | | | | | | | | | | | | | 0.000 | 0.032 | 0.066 | 0.103 | 0.144 | 0.192 | 0.252 | 0.395 |
| **0.94** | | | | | | | | | | | | | | | 0.000 | 0.034 | 0.071 | 0.112 | 0.160 | 0.220 | 0.363 |
| **0.95** | | | | | | | | | | | | | | | | 0.000 | 0.037 | 0.079 | 0.126 | 0.186 | 0.329 |
| **0.96** | | | | | | | | | | | | | | | | | 0.000 | 0.041 | 0.089 | 0.149 | 0.292 |
| **0.97** | | | | | | | | | | | | | | | | | | 0.000 | 0.048 | 0.108 | 0.251 |
| **0.98** | | | | | | | | | | | | | | | | | | | 0.000 | 0.060 | 0.203 |
| **0.99** | | | | | | | | | | | | | | | | | | | | 0.000 | 0.143 |
| | | | | | | | | | | | | | | | | | | | | | 0.000 |

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