# Six Sigma Quick Switching Variables Sampling System Indexed by Six Sigma Quality Levels

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***Abstract:-*** Motorola corporation introduced the concept of Six Sigma is a method for improving overall quality and production. If this concept of Six Sigma adopted in an organization it can results in 3.4 or lower defects per million opportunities in the long run. In recent days many companies in developed and developing countries started working beyond Six Sigma level and thereby the performance level increases with number of defectives reduced to near zero level. In this Paper, Six Sigma Quick Switching Variables Sampling System [SSQSVSS (n; $k_N$, $k_T$)] indexed by Six Sigma Quality Level's presented. Tables are also constructed for the selection of parameters of known and unknown standard deviations of SSQSVSS for a given Six Sigma acceptable quality level (SSAQL) and Six Sigma limiting quality level (SSLQL).

**Key Words: Quick Switching Sampling System, Variable Sampling Plan, OC Function, SSAQL and SSLQL**

## I. Introduction

Statistical Quality Control gives more different quality levels in both attribute and variables sampling plan. This inspection of quality levels used for both consumers and producers in industries. Variable sampling plans cover a major area of acceptance sampling inspection, and often a single sampling plan is less complicate to use, when compared to other plans. Variable sampling plan is generally used when the characteristic of significance is measurable and normally distributed with mean (μ) and standard deviation (σ). Quick Switching Sampling System were originally proposed by Dodge (1967). The quick switching systems consist of two inspection sampling plan along with a set of switching rules between them. The first sampling plan, called normal inspection plan proposed for using periods of good quality. It has a smaller sample size to reduce inspection costs. The second sampling plan, called tightened inspection plan proposed for use when problems encountered. It gives high level of protection. The switching rules make sure that the correct plan used. They designed to easy to use and to react quickly to changes in quality. QSSs concentrate one's inspection effort where it will do the most good. Further, for processes running at low levels of defects, QSSs can designed that have a low-level of inspection but that react severely to the first hint of a problem.

Romboski (1969) studied the QSS with the single sampling plan as a reference plan. He introduced a system designated as QSS (n, $c_N$, $c_T$), where the single sampling normal plan has a sample size n and acceptance number $c_N$ and the tightened single sampling plan has the same sample size as the normal but with acceptance number $c_T$. Govindaraju (1991), Deveraj Arumainayagam (1991) and Taylor (1996) investigated how to evaluate and select Quick Switching Systems. Soundarajan and Palanivel (1997 & 2000) have investigated on Quick Switching Variables Simple Sampling (QSVSS) Systems. Radhakrishnan and Sivakumaran (2008) developed the Procedure for the Construction of Six Sigma RGS plans of type (n1, n2:c) indexed by Six Sigma Quality Levels with attributes sampling plan as a reference plan.

In this Paper, Six Sigma Quick Switching Variables Sampling System [SSQSVSS (n; $k_N$, $k_T$)] indexed by Six Sigma Quality Level's presented. Tables are also constructed for the selection parameters of known and unknown standard deviation Six Sigma Quick Switching Variables Sampling System for a given Six Sigma acceptable quality level (SSAQL) with the producer's risk $\alpha^*$=3.4x10$^{-6}$ and Six Sigma limiting quality level (SSLQL) with the consumer's risk $\beta^* \geq m\alpha^*$, where m=2.

## II. Six Sigma Quick Switching Variables Sampling System of type SSQSVSS ($n;k_1,k_2$)

The conditions and the assumptions under which the SSQSVSS scheme can be applied are as follows:

### a. Conditions for application

The following assumptions should be valid for the application of the variables QSVSS plan.

(i) Lots are submitted for inspection serially, in the order of production from a process that turns out a constant proportion of non-conforming items.

(ii) The consumer has confidence in the supplier and there should be no reason to believe that a particular lot is poorer than the preceding lots.

In addition, the usual conditions for the application of single sampling variables plans, with known or unknown standard deviation, should also be valid.

### b. Assumptions

- The Quality Characteristic x has a normal distribution with a known or unknown standard deviation.
- A Unit is Defective if $x > U$ or $x < L$, where U and L are the upper and lower specification limits respectively.
- The purpose is to control the fraction defective p in large lots submitted for inspection.

### c. Operating Procedure

**Step 1** Take a random sample of size $n_\sigma$, say ($X_1, X_2,\ldots X_{n\sigma}$) and compute

$$v=\frac{(U-\overline{X})}{\sigma}, \text{ where } \overline{X}=\frac{1}{n_\sigma}\sum_{i=1}^{n_\sigma} X_i.$$

**Step 2** Accept the lot if $v \geq k_1$ and reject the lot if $v < k_2$. ($k_2 < k_1$)

**Step 3** If $k_1 \leq v < k_2$ then repeat the steps 1, 2.

Thus, the SSQSVSS has the parameters of the sample size $n_\sigma$, and the acceptable criterion $k_1$ and $k_2$.

### d. Operating Characteristic Function

According Romboski(1969), the OC function of SSQSVSS, which gives the proportion of lots that are expected to be accepted for given product quality, p is given by

$$P_a(p) = \frac{P_1}{1-P_2+P_1} = \frac{\Pr(v \geq k_1)}{1-\Pr(v < k_2)+\Pr(v \geq k_1)} \quad (1)$$

where $P_1=\Pr(v \geq k_1)$ is the probability of accepting a lot based on a single sample with parameters ($n_\sigma$, $k_{1\sigma}$) and $P_2=\Pr(v < k_2)$ is the probability of rejecting a lot based on a single sample with parameters ($n_\sigma$, $k_{2\sigma}$).

The fraction non-conforming in a lot will be determined as

$$p = 1-\phi\left(\frac{U-\mu}{\sigma}\right) = 1-\phi(v) = \phi(-v) \quad (2)$$

where $\Phi(y)$ is given by

$$\phi(y) = \int_{-\infty}^{y} \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-z^2}{2}\right) dz \quad (3)$$

provided that the quality characteristic of interest is normally distributed with mean $\mu$ and standard deviation $\sigma$, and the unit is classified as non-conforming if it exceeds the upper specification limit U. Then its probability of acceptance is written as

$$P_a(p) = \frac{\phi(w_1)}{1-\phi(w_1)+\phi(w_2)} \quad (4)$$

where $$P_1(p) = \int_{-\infty}^{w_1} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz$$

and $$P_2(p) = \int_{-\infty}^{w_2} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz$$

$$w_1 = \sqrt{n_\sigma}\,(U-k_1-\mu)/\sigma = (v-k_1)\sqrt{n_\sigma}$$

$$w_2 = \sqrt{n_\sigma}\,(U-k_2-\mu)/\sigma = (v-k_2)\sqrt{n_\sigma}$$

$$v = (U-\mu)/\sigma$$

If SSAQL, SSLQL, the producer's risk 1-α and the consumer's risk β are prescribed then we have

$$\frac{\phi(w_1)}{1-\phi(w_1)+\phi(w_2)} = 1-\alpha \quad \text{and}$$

$$\frac{\phi(w_1)}{1-\phi(w_1)+\phi(w_2)} = \beta_1 \tag{5}$$

Here, The value of $w_N$ at $p = p_1$, The value of $w_T$ at $p = p_2$. That is,

$$w_1 = \sqrt{n_\sigma}\,(U-k_1-\mu)/\sigma = (v_1-k_1)\sqrt{n_\sigma}$$

$$w_2 = \sqrt{n_\sigma}\,(U-k_2-\mu)/\sigma = (v_2-k_2)\sqrt{n_\sigma} \tag{6}$$

By fixing the probability of acceptance of the lot, $P_a(p)$ as 1-3.4 x $10^{-6}$ with normal distribution, where $ssv_1$ is the value of $v_1$ at SSAQL and $ssv_2$ is the value of $v_2$ at SSLQL. For example, if $p_1$ and $p_2$ are prescribed, then the corresponding value of $ssv_1$ and $ssv_2$ will be fixed and if Pa( $p_1$) and Pa( $p_2$) are fixed at 99.99966% and more than 0 .00068% respectively, then we have

$$\frac{\phi(w_1)}{1-\phi(w_1)+\phi(w_2)} = 0.9999966 \quad \text{and}$$

$$\frac{\phi(w_1)}{1-\phi(w_1)+\phi(w_2)} \geq 0.0000068 \tag{7}$$

For given SSAQL and SSLQL, the parametric values of the SSQSVSS plan namely $k_{1\sigma}$, $k_{2\sigma}$ and the sample size $n_\sigma$ are determined by using a computer search.

## III. Six Sigma Quick Switching Variables Sampling Scheme with Unknown Sigma

Whenever the standard deviation is unknown, we should use the sample standard deviation S instead of σ. In this case, the plan operates as follows.

**Step 1** Take a random sample of size $n_\sigma$, say ($X_1, X_2, \ldots X_{n\sigma}$) and compute

$$v = \frac{(U-\overline{X})}{S}, \text{ where } \overline{X} = \frac{1}{n_\sigma}\sum_{i=1}^{n_\sigma} X_i. \text{ and } S = \sqrt{\frac{\Sigma(x-\overline{x})^2}{n-1}}$$

**Step 2** Accept the lot if $v \geq k_1$ and reject the lot if $v < k_2$. ($k_2 < k_1$)

**Step 3** If $k_1 \leq v < k_2$ then repeat the steps 1, 2.

Thus, the SSQSVSS has the parameters of the sample size $n_\sigma$, and the acceptable criterion $k_1$ and $k_2$. Under the assumptions for Six Sigma Repetitive Group Variables Sampling Plan stated, the probability of acceptance $P_a$ (p), of a lot is given in the equation (1) and $P_1$ and $P_2$ respectively are

$$P_1 = \int_{-\infty}^{w_1} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz$$

and $$P_2 = \int_{-\infty}^{w_2} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz$$

with $$w_1 = \frac{U-k_1S-\mu}{S} \cdot \frac{1}{\sqrt{\left(\frac{1}{n_s}+\frac{k_1^2}{2n_s}\right)}}$$

$$w_2 = \frac{U-k_2S-\mu}{S} \cdot \frac{1}{\sqrt{\left(\frac{1}{n_s}+\frac{k_2^2}{2n_s}\right)}}$$

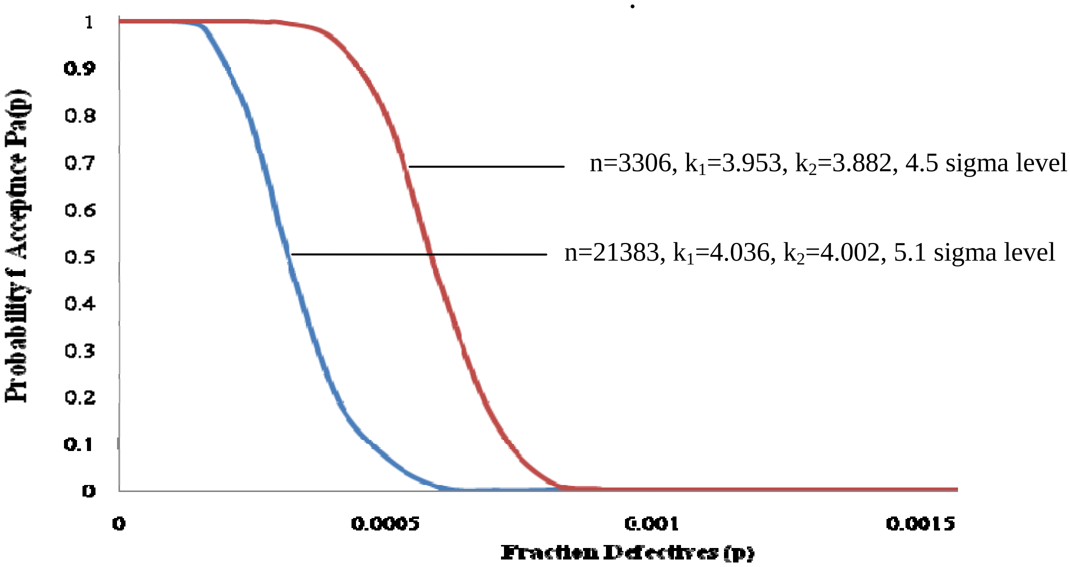


Figure 1. OC Curves of SSQSVSS with n=21383, $k_1$=4.036, $k_2$=4.002, 35.1 sigma level and n=3306, $k_1$=3.953, $k_2$=3.882, 4.5 sigma level.

### a. Behaviour of OC curves of SSQSVSS-(n; $k_1$, $k_2$) schemes

Figure 1 shows the OC Curves of SSQSVSS with n=3306, $k_1$=3.953, $k_2$=3.882, 4.5 sigma level and n= 21383, $k_1$=4.036, $k_2$=4.002, 5.1 sigma level. It can be observed that the plan OC curves at a good quality, i.e., for very smaller values of fraction defective with more sigma level.

## IV. Selection of Six Sigma Quick Switching Variable System Indexed by SSAQL and SSLQL

### a. SSQSVSS with known σ variable plan as the reference plan

Table 1 can be used to determine SSQSVSS ($n_\sigma$, $k_1$, $k_2$) for specified values of SSAQL and SSLQL. For example, if it is desired to have a SSQSVSS ($n_\sigma$, $k_1$, $k_2$) for given

$p_{ssv1}$ = 0.000002 and $p_{ssv2}$ = 0.000005, $\alpha^*$= 3.4x$10^{-6}$, $\beta^* \geq m\alpha_1$, where m = 2. Table 1 gives n = 1803, $k_1$ = 4.319, $k_2$ = 4.211 as desired scheme parameters, which is associated with 4.3 sigma level.

### b. SSQSVSS with unknown σ variable plan as the reference plan

Table 1 can be used to determine SSQSVSS ($n_s$, $k_1$, $k_2$) for specified values of SSAQL and SSLQL. For example, if it is desired to have a SSQSVSS ($n_s$, $k_{1s}$, $k_{2s}$) for given $p_{ssv1}$ = 0.000005 and $p_{ssv2}$ = 0.000009, $\alpha^*$= 3.4x$10^{-6}$, $\beta^* \geq m\alpha_1$, where m = 2. Table 1 gives n = 23208, $k_1$ = 3.795, $k_2$ = 3.721 as desired scheme parameters, which is associated with 5.1 sigma level.

## V. Construction of Table

The OC function of SSQSVSS (n, $k_1$, $k_2$) is given by the equation (1) for as a specified ($p_{ssv1}$, $\alpha^*$) and ($p_{ssv2}$, $\beta^*$).

The equation (1) results in

$$P_a(ssv_1) = \frac{\phi(w_1)}{1-\phi(w_2)+\phi(w_1)} = 1-\alpha^* \quad (7)$$

and

$$P_a(ssv_2) = \frac{\phi(w_1)}{1-\phi(w_2)+\phi(w_1)} = \beta^* \quad (8)$$

where

$$w_1 = (v_1 - k_1)\sqrt{n_\sigma} \quad \text{and}$$
$$w_2 = (v_2 - k_2)\sqrt{n_\sigma}$$

Equation (7) and (8) are solved for n, $k_T$ and $k_N$ (known standard deviation) for as specified pair of points, say, $p_{ssv1}=\alpha^*$ and $p_{ssv2}=\beta^*$ on the OC Curve. To identified Six Sigma Quick Switching Variable Sampling Plan SSQSVSS (n, $k_1$, $k_2$), a computer search routine was used for given set of ($p_{ssv1}$, $\alpha^*$) and ($p_{ssv2}$, $\beta^*$). The plan is identified are tabulated in Table 1. A procedure for finding the parameters of unknown standard deviation method plan from known standard deviation method plan with parameter ($n_S$, $k_1$ $k_2$), where desired using Hamaker (1979) approximation as follows

$$n_s = n_\sigma(1+k^2/2), \text{ where } \quad k = (k_{1\sigma} + k_{2\sigma})/2$$

$$k_{1s} = k_{1\sigma}(4n_s - 4)/(4n_s - 5) \quad \text{and} \quad k_{2s} = k_{2\sigma}(4n_s - 4)/(4n_s - 5)$$

Table 1 provided the values of $n_s$, $k_{1s}$ and $k_{2s}$ which satisfying the equations (7) & (8). The sigma (SD) value is calculated using the process sigma calculator (http://www.isixsigma.com/) for given n, $k_1$ and $k_2$ for known standard deviation and unknown standard deviation methods.

## VI. Conclusion

Conventionally, Six Sigma Quick Switching Variable Sampling System has wide potential applications in industries to ensure a higher standard of quality attainment and increased customer satisfaction. Here, an attempt made to apply the concept of Quick Switching Variable Sampling System to propose a new plan designated as Six Sigma Quick Switching Variable Sampling System of type SSQSVSS-1 in which disposal of a lot on the basis of normal and tightened plan. The present development would be a valuable addition to the literature and a useful device to the quality practitioners. The concept of this article may used for assistance to quality control engineers and plan designers in further plans development, which were useful and tailor made for industrial shop-floor situations.

## References


[1] Abramowitz and Stegun,” Handbook of mathematical functions with Formulas, Graphs, and Mathematical Tables”. 1964

[2] S. Devaraj Arumainayagam, “Contributions to the study of Quick Switching System(QSS) and its Applications”. Doctoral Dissertation, Bharathiar University, Coimbatore, Tamil Nadu, India,1991.

[3] H.F. Dodge, “A New Dual System of Acceptance Sampling Technical Report No.16”, The Statistics Center, Rutgers – The State University, New Brunswick, NJ, 1967.

[4] K. Govindaraju, “Procedures and tables for the selection of Zero Acceptance Number Quick Switching System for Compliance testing”. Communications in Statistics – Simulation and Computation, vol.20, No.1, pp. 157-172, 1991.

[5] H.C. Hamaker, “ Acceptance Sampling for Percent Defective and by Attributes”, Journal of Quality Technology, 11, pp.138-148, 1979.

[6] R. Radhakrishnan, and P.K. Sivakumaran, “Construction of Six Sigma Repetitive Group Sampling Plans”, International Journal of Mathematics and Computation, vol.1, 2008.

[7] L.D. Romboski, “An investigation of Quick Switching Acceptance Sampling System”. Doctoral Dissertation, Rutgers – The state University, New Brunswick, New Jersey, 1969.

[8] V. Soundarajan and M. Palanivel, “Quick Switching Variables Single Sampling (QSVSS) System indexed by AQL and LQL Acceptance Criterion Tightening”. Journal of Applied Statistics Science, Vol.6 (1): 45-57, 1997.

[9] V. Soundarajan and M. Palanivel, “Quick Switching Variables Single Sampling (QSVSS) System indexed by AQL and AOQL”. Journal of Applied Statistics. Vol.27 (7): 771-778, 2000.

[10] W. A. Taylor, “Quick Switching Systems. Journal of Quality Technology, Vol.28, No.4, pp. 460-472, 1996.

Table 1. SSQSVSS(n, k, σ – level) with known and unknown statndard deviation indexed by SSAQL and SSLQL ($\alpha_1$=3.4 x $10^{-6}$ and $\beta^* \geq m\alpha^*$, where m = 2 ).

| $p_1$ | $p_2$ | $n_\sigma$ | $k_{T\sigma}$ | $k_{N\sigma}$ | σ - Level | $n_s$ | $k_{Ts}$ | $k_{Ns}$ | σ - Level |
|---|---|---|---|---|---|---|---|---|---|
| 0.000001 | 0.000002 | 3907 | 4.706 | 4.686 | 4.5 | 46986 | 4.706 | 4.686 | 5.2 |
| | 0.000003 | 1780 | 4.527 | 4.403 | 4.3 | 19523 | 4.527 | 4.403 | 5.0 |
| | 0.000004 | 1718 | 4.458 | 4.304 | 4.3 | 18205 | 4.458 | 4.304 | 5.0 |
| | 0.000005 | 1674 | 4.404 | 4.226 | 4.3 | 17258 | 4.404 | 4.226 | 5.0 |
| | 0.000006 | 1635 | 4.359 | 4.161 | 4.3 | 16471 | 4.359 | 4.161 | 5.0 |
| | 0.000007 | 1602 | 4.32 | 4.106 | 4.3 | 15819 | 4.320 | 4.106 | 5.0 |
| | 0.000008 | 1576 | 4.287 | 4.106 | 4.3 | 15453 | 4.287 | 4.106 | 5.0 |
| | 0.000009 | 1551 | 4.257 | 4.014 | 4.3 | 14814 | 4.257 | 4.014 | 5.0 |
| | 0.00001 | 1527 | 4.23 | 3.976 | 4.3 | 14380 | 4.230 | 3.976 | 4.9 |
| | 0.00002 | 1386 | 4.048 | 3.715 | 4.3 | 11827 | 4.048 | 3.715 | 4.9 |
| | 0.00003 | 1302 | 3.937 | 3.557 | 4.3 | 10442 | 3.937 | 3.557 | 4.9 |
| | 0.00004 | 1241 | 3.856 | 3.442 | 4.3 | 9503 | 3.856 | 3.442 | 4.9 |
| | 0.00005 | 1199 | 3.793 | 3.351 | 4.3 | 8848 | 3.793 | 3.351 | 4.9 |
| | 0.00006 | 1160 | 3.74 | 3.276 | 4.2 | 8298 | 3.740 | 3.276 | 4.8 |
| | 0.00007 | 1129 | 3.694 | 3.211 | 4.2 | 7858 | 3.694 | 3.211 | 4.8 |
| | 0.00008 | 1105 | 3.654 | 3.155 | 4.2 | 7509 | 3.654 | 3.155 | 4.8 |
| | 0.00009 | 1080 | 3.618 | 3.104 | 4.2 | 7180 | 3.618 | 3.104 | 4.8 |
| | 0.0001 | 1058 | 3.586 | 3.059 | 4.2 | 6898 | 3.586 | 3.059 | 4.8 |
| | 0.0002 | 924 | 3.368 | 2.751 | 4.2 | 5249 | 3.368 | 2.751 | 4.7 |
| | 0.0003 | 845 | 3.234 | 2.563 | 4.2 | 4395 | 3.234 | 2.563 | 4.7 |
| | 0.0004 | 789 | 3.135 | 2.425 | 4.2 | 3838 | 3.135 | 2.425 | 4.7 |
| | 0.0005 | 749 | 3.058 | 2.316 | 4.2 | 3453 | 3.058 | 2.316 | 4.7 |
| | 0.0006 | 715 | 2.992 | 2.225 | 4.2 | 3148 | 2.992 | 2.225 | 4.6 |
| | 0.0007 | 687 | 2.936 | 2.147 | 4.2 | 2906 | 2.936 | 2.147 | 4.6 |
| | 0.0008 | 665 | 2.887 | 2.078 | 4.2 | 2714 | 2.887 | 2.078 | 4.6 |
| | 0.0009 | 643 | 2.843 | 2.017 | 4.2 | 2541 | 2.843 | 2.017 | 4.6 |
| | 0.001 | 624 | 2.803 | 1.961 | 4.2 | 2394 | 2.803 | 1.961 | 4.6 |
| | 0.002 | 508 | 2.528 | 1.582 | 4.1 | 1581 | 2.528 | 1.582 | 4.5 |
| | 0.003 | 443 | 2.357 | 1.344 | 4.1 | 1201 | 2.357 | 1.344 | 4.5 |
| | 0.004 | 398 | 2.229 | 1.168 | 4.1 | 972 | 2.230 | 1.168 | 4.4 |
| | 0.005 | 368 | 2.127 | 1.088 | 4.1 | 843 | 2.128 | 1.088 | 4.4 |

Table 1 (Continued…)

| $p_1$ | $p_2$ | $n_\sigma$ | $k_{T\sigma}$ | $k_{N\sigma}$ | σ - Level | $n_s$ | $k_{Ts}$ | $k_{Ns}$ | σ - Level |
|---|---|---|---|---|---|---|---|---|---|
| 0.000002 | 0.000003 | 7160 | 4.442 | 4.389 | 4.7 | 76958 | 4.442 | 4.389 | 5.4 |
| | 0.000004 | 2395 | 4.372 | 4.29 | 4.4 | 24857 | 4.372 | 4.290 | 5.1 |
| | 0.000005 | 1803 | 4.319 | 4.211 | 4.3 | 18201 | 4.319 | 4.211 | 5.0 |
| | 0.000006 | 1760 | 4.273 | 4.147 | 4.3 | 17357 | 4.273 | 4.147 | 5.0 |
| | 0.000007 | 1724 | 4.235 | 4.091 | 4.3 | 16663 | 4.235 | 4.091 | 5.0 |
| | 0.000008 | 1696 | 4.202 | 4.043 | 4.3 | 16108 | 4.202 | 4.043 | 5.0 |
| | 0.000009 | 1668 | 4.172 | 4 | 4.3 | 15592 | 4.172 | 4.000 | 5.0 |
| | 0.00001 | 1644 | 4.144 | 3.961 | 4.3 | 15144 | 4.144 | 3.961 | 5.0 |
| | 0.00002 | 1490 | 3.962 | 3.7 | 4.3 | 12424 | 3.962 | 3.700 | 4.9 |
| | 0.00003 | 1398 | 3.851 | 3.542 | 4.3 | 10949 | 3.851 | 3.542 | 4.9 |
| | 0.00004 | 1333 | 3.77 | 3.427 | 4.3 | 9964 | 3.770 | 3.427 | 4.9 |
| | 0.00005 | 1286 | 3.706 | 3.335 | 4.3 | 9255 | 3.706 | 3.335 | 4.9 |
| | 0.00006 | 1245 | 3.653 | 3.26 | 4.3 | 8682 | 3.653 | 3.260 | 4.9 |
| | 0.00007 | 1210 | 3.607 | 3.195 | 4.3 | 8208 | 3.607 | 3.195 | 4.8 |
| | 0.00008 | 1183 | 3.567 | 3.139 | 4.3 | 7833 | 3.567 | 3.139 | 4.8 |
| | 0.00009 | 1157 | 3.532 | 3.089 | 4.3 | 7497 | 3.532 | 3.089 | 4.8 |
| | 0.0001 | 1133 | 3.499 | 3.043 | 4.3 | 7194 | 3.499 | 3.043 | 4.8 |
| | 0.0002 | 987 | 3.28 | 2.734 | 4.2 | 5449 | 3.280 | 2.734 | 4.8 |
| | 0.0003 | 902 | 3.146 | 2.545 | 4.2 | 4554 | 3.146 | 2.545 | 4.7 |
| | 0.0004 | 842 | 3.046 | 2.407 | 4.2 | 3972 | 3.046 | 2.407 | 4.7 |
| | 0.0005 | 799 | 2.968 | 2.297 | 4.2 | 3568 | 2.968 | 2.297 | 4.7 |
| | 0.0006 | 761 | 2.902 | 2.206 | 4.2 | 3243 | 2.902 | 2.206 | 4.7 |
| | 0.0007 | 731 | 2.845 | 2.128 | 4.2 | 2991 | 2.845 | 2.128 | 4.6 |
| | 0.0008 | 707 | 2.796 | 2.058 | 4.2 | 2789 | 2.796 | 2.058 | 4.6 |
| | 0.0009 | 683 | 2.752 | 1.997 | 4.2 | 2608 | 2.752 | 1.997 | 4.6 |
| | 0.001 | 662 | 2.712 | 1.941 | 4.2 | 2454 | 2.712 | 1.941 | 4.6 |
| | 0.002 | 537 | 2.465 | 1.559 | 4.2 | 1624 | 2.465 | 1.559 | 4.5 |
| | 0.003 | 467 | 2.262 | 1.32 | 4.2 | 1216 | 2.262 | 1.320 | 4.5 |
| | 0.004 | 420 | 2.134 | 1.144 | 4.2 | 984 | 2.135 | 1.144 | 4.4 |
| | 0.005 | 388 | 2.03 | 1.068 | 4.2 | 853 | 2.031 | 1.068 | 4.4 |
| 0.000003 | 0.000004 | 13431 | 4.282 | 4.242 | 4.9 | 135416 | 4.282 | 4.242 | 5.5 |
| | 0.000005 | 4184 | 4.228 | 4.164 | 4.6 | 41017 | 4.228 | 4.164 | 5.2 |
| | 0.000006 | 2245 | 4.1837 | 4.099 | 4.4 | 21497 | 4.184 | 4.099 | 5.0 |

Table 1 (Continued…)

| $p_1$ | $p_2$ | $n_\sigma$ | $k_{T\sigma}$ | $k_{N\sigma}$ | σ - Level | $n_s$ | $k_{Ts}$ | $k_{Ns}$ | σ - Level |
|---|---|---|---|---|---|---|---|---|---|
| 0.000003 | 0.000007 | 1825 | 4.144 | 4.043 | 4.3 | 17116 | 4.144 | 4.043 | 5.0 |
| | 0.000008 | 1793 | 4.111 | 3.995 | 4.3 | 16520 | 4.111 | 3.995 | 5.0 |
| | 0.000009 | 1756 | 4.081 | 3.952 | 4.3 | 15920 | 4.081 | 3.952 | 5.0 |
| | 0.00001 | 1740 | 4.054 | 3.912 | 4.3 | 15542 | 4.054 | 3.912 | 5.0 |
| | 0.00002 | 1571 | 3.871 | 3.652 | 4.3 | 12685 | 3.871 | 3.652 | 4.9 |
| | 0.00003 | 1476 | 3.76 | 3.493 | 4.3 | 11182 | 3.760 | 3.493 | 4.9 |
| | 0.00004 | 1407 | 3.679 | 3.378 | 4.3 | 10166 | 3.679 | 3.378 | 4.9 |
| | 0.00005 | 1353 | 3.615 | 3.287 | 4.3 | 9410 | 3.615 | 3.287 | 4.9 |
| | 0.00006 | 1312 | 3.562 | 3.212 | 4.3 | 8837 | 3.562 | 3.212 | 4.9 |
| | 0.00007 | 1275 | 3.516 | 3.147 | 4.3 | 8351 | 3.516 | 3.147 | 4.9 |
| | 0.00008 | 1243 | 3.476 | 3.09 | 4.3 | 7942 | 3.476 | 3.090 | 4.8 |
| | 0.00009 | 1218 | 3.44 | 3.04 | 4.3 | 7611 | 3.440 | 3.040 | 4.8 |
| | 0.0001 | 1192 | 3.408 | 2.994 | 4.3 | 7299 | 3.408 | 2.994 | 4.8 |
| | 0.0002 | 1034 | 3.188 | 2.685 | 4.3 | 5492 | 3.188 | 2.685 | 4.8 |
| | 0.0003 | 946 | 3.053 | 2.496 | 4.3 | 4587 | 3.053 | 2.496 | 4.7 |
| | 0.0004 | 882 | 2.954 | 2.357 | 4.2 | 3992 | 2.954 | 2.357 | 4.7 |
| | 0.0005 | 833 | 2.875 | 2.247 | 4.2 | 3565 | 2.875 | 2.247 | 4.7 |
| | 0.0006 | 797 | 2.81 | 2.156 | 4.2 | 3254 | 2.810 | 2.156 | 4.7 |
| | 0.0007 | 763 | 2.753 | 2.077 | 4.2 | 2988 | 2.753 | 2.077 | 4.7 |
| | 0.0008 | 735 | 2.703 | 2.008 | 4.2 | 2774 | 2.703 | 2.008 | 4.6 |
| | 0.0009 | 713 | 2.658 | 1.946 | 4.2 | 2602 | 2.658 | 1.946 | 4.6 |
| | 0.001 | 691 | 2.618 | 1.89 | 4.2 | 2446 | 2.618 | 1.890 | 4.6 |
| | 0.002 | 556 | 2.437 | 1.268 | 4.2 | 1510 | 2.437 | 1.268 | 4.5 |
| | 0.003 | 485 | 2.167 | 1.268 | 4.2 | 1200 | 2.167 | 1.268 | 4.5 |
| | 0.004 | 436 | 2.038 | 1.091 | 4.2 | 970 | 2.039 | 1.091 | 4.4 |
| | 0.005 | 399 | 1.934 | 1.067 | 4.2 | 848 | 1.935 | 1.067 | 4.4 |
| 0.000004 | 0.000005 | 21383 | 4.036 | 4.002 | 5.1 | 194076 | 4.036 | 4.002 | 5.6 |
| | 0.000006 | 6380 | 3.99 | 3.937 | 4.7 | 56493 | 3.990 | 3.937 | 5.3 |
| | 0.000007 | 3306 | 3.953 | 3.882 | 4.5 | 28674 | 3.953 | 3.882 | 5.1 |

Table 1 (Continued…)

| $p_1$ | $p_2$ | nσ | $k_{T\sigma}$ | $k_{N\sigma}$ | σ - Level | ns | $k_{Ts}$ | $k_{Ns}$ | σ - Level |
|---|---|---|---|---|---|---|---|---|---|
| 0.000004 | 0.000008 | 2134 | 3.919 | 3.83 | 4.4 | 18152 | 3.919 | 3.830 | 5.0 |
| | 0.000009 | 1900 | 3.889 | 3.79 | 4.4 | 15905 | 3.889 | 3.790 | 5.0 |
| | 0.00001 | 1871 | 3.862 | 3.751 | 4.4 | 15426 | 3.862 | 3.751 | 5.0 |
| | 0.00002 | 1686 | 3.679 | 3.49 | 4.4 | 12517 | 3.679 | 3.490 | 4.9 |
| | 0.00003 | 1577 | 3.568 | 3.332 | 4.3 | 10962 | 3.568 | 3.332 | 4.9 |
| | 0.00004 | 1501 | 3.487 | 3.216 | 4.3 | 9931 | 3.487 | 3.216 | 4.9 |
| | 0.00005 | 1444 | 3.422 | 3.125 | 4.3 | 9181 | 3.422 | 3.125 | 4.9 |
| | 0.00006 | 1396 | 3.369 | 3.05 | 4.3 | 8586 | 3.369 | 3.050 | 4.9 |
| | 0.00007 | 1355 | 3.323 | 2.984 | 4.3 | 8092 | 3.323 | 2.984 | 4.9 |
| | 0.00008 | 1323 | 3.283 | 2.928 | 4.3 | 7703 | 3.283 | 2.928 | 4.9 |
| | 0.00009 | 1291 | 3.247 | 2.878 | 4.3 | 7345 | 3.247 | 2.878 | 4.8 |
| | 0.0001 | 1264 | 3.215 | 2.832 | 4.3 | 7041 | 3.215 | 2.832 | 4.8 |
| | 0.0002 | 1092 | 2.995 | 2.523 | 4.3 | 5248 | 2.995 | 2.523 | 4.8 |
| | 0.0003 | 992 | 2.86 | 2.333 | 4.3 | 4336 | 2.860 | 2.333 | 4.7 |
| | 0.0004 | 923 | 2.76 | 2.194 | 4.3 | 3755 | 2.760 | 2.194 | 4.7 |
| | 0.0005 | 873 | 2.681 | 2.084 | 4.3 | 3351 | 2.681 | 2.084 | 4.7 |
| | 0.0006 | 830 | 2.615 | 1.992 | 4.3 | 3032 | 2.615 | 1.992 | 4.7 |
| | 0.0007 | 794 | 2.558 | 1.913 | 4.3 | 2778 | 2.558 | 1.913 | 4.7 |
| | 0.0008 | 767 | 2.509 | 1.844 | 4.3 | 2584 | 2.509 | 1.844 | 4.6 |
| | 0.0009 | 740 | 2.464 | 1.782 | 4.3 | 2408 | 2.464 | 1.782 | 4.6 |
| | 0.001 | 716 | 2.423 | 1.726 | 4.3 | 2257 | 2.423 | 1.726 | 4.6 |
| | 0.002 | 575 | 2.145 | 1.342 | 4.2 | 1449 | 2.145 | 1.342 | 4.5 |
| | 0.003 | 497 | 1.971 | 1.102 | 4.2 | 1084 | 1.971 | 1.102 | 4.5 |
| | 0.004 | 446 | 1.841 | 1.036 | 4.2 | 907 | 1.842 | 1.036 | 4.5 |
| 0.000005 | 0.000006 | 30931 | 3.897 | 3.867 | 5.2 | 263995 | 3.897 | 3.867 | 5.7 |
| | 0.000007 | 8964 | 3.858 | 3.812 | 4.8 | 74882 | 3.858 | 3.812 | 5.4 |
| | 0.000008 | 4543 | 3.825 | 3.763 | 4.6 | 37240 | 3.825 | 3.763 | 5.2 |
| | 0.000009 | 2879 | 3.795 | 3.721 | 4.5 | 23208 | 3.795 | 3.721 | 5.1 |
| | 0.00001 | 2052 | 3.768 | 3.682 | 4.4 | 16288 | 3.768 | 3.682 | 5.0 |

Table 1 (Continued…)

| $p_1$ | $p_2$ | $n_\sigma$ | $k_{T\sigma}$ | $k_{N\sigma}$ | σ - Level | $n_s$ | $k_{Ts}$ | $k_{Ns}$ | σ - Level |
|---|---|---|---|---|---|---|---|---|---|
| 0.000005 | 0.00002 | 1734 | 3.585 | 3.42 | 4.4 | 12370 | 3.585 | 3.420 | 4.9 |
| | 0.00003 | 1623 | 3.473 | 3.261 | 4.4 | 10823 | 3.473 | 3.261 | 4.9 |
| | 0.00004 | 1542 | 3.393 | 3.146 | 4.4 | 9784 | 3.393 | 3.146 | 4.9 |
| | 0.00005 | 1462 | 3.328 | 3.055 | 4.4 | 8908 | 3.328 | 3.055 | 4.9 |
| | 0.00006 | 1433 | 3.275 | 2.98 | 4.4 | 8441 | 3.275 | 2.980 | 4.9 |
| | 0.00007 | 1390 | 3.229 | 2.914 | 4.3 | 7947 | 3.229 | 2.914 | 4.9 |
| | 0.00008 | 1353 | 3.189 | 2.858 | 4.3 | 7537 | 3.189 | 2.858 | 4.9 |
| | 0.00009 | 1324 | 3.153 | 2.808 | 4.3 | 7205 | 3.153 | 2.808 | 4.8 |
| | 0.0001 | 1295 | 3.121 | 2.762 | 4.3 | 6897 | 3.121 | 2.762 | 4.8 |
| | 0.0002 | 1113 | 2.9 | 2.452 | 4.3 | 5098 | 2.900 | 2.452 | 4.8 |
| | 0.0003 | 1013 | 2.765 | 2.262 | 4.3 | 4213 | 2.765 | 2.262 | 4.7 |
| | 0.0004 | 942 | 2.666 | 2.123 | 4.3 | 3643 | 2.666 | 2.123 | 4.7 |
| | 0.0005 | 887 | 2.586 | 2.012 | 4.3 | 3231 | 2.586 | 2.012 | 4.7 |
| | 0.0006 | 843 | 2.52 | 1.921 | 4.3 | 2921 | 2.520 | 1.921 | 4.7 |
| | 0.0007 | 809 | 2.493 | 1.862 | 4.3 | 2727 | 2.493 | 1.862 | 4.7 |
| | 0.0008 | 777 | 2.414 | 1.773 | 4.3 | 2480 | 2.414 | 1.773 | 4.6 |
| | 0.0009 | 749 | 2.369 | 1.711 | 4.3 | 2308 | 2.369 | 1.711 | 4.6 |
| | 0.001 | 728 | 2.329 | 1.655 | 4.3 | 2172 | 2.329 | 1.655 | 4.6 |
| | 0.002 | 580 | 2.049 | 1.27 | 4.3 | 1379 | 2.049 | 1.270 | 4.5 |
| | 0.003 | 501 | 1.874 | 1.03 | 4.3 | 1029 | 1.874 | 1.030 | 4.5 |
| 0.00001 | 0.00002 | 2266 | 3.607 | 3.518 | 4.5 | 16645 | 3.607 | 3.518 | 5.0 |
| | 0.00003 | 2116 | 3.475 | 3.339 | 4.4 | 14397 | 3.475 | 3.339 | 5.0 |
| | 0.00004 | 2011 | 3.394 | 3.224 | 4.4 | 13021 | 3.394 | 3.224 | 5.0 |
| | 0.00005 | 1932 | 3.33 | 3.195 | 4.4 | 12214 | 3.330 | 3.195 | 5.0 |
| | 0.00006 | 1866 | 3.276 | 3.057 | 4.4 | 11221 | 3.276 | 3.057 | 4.9 |
| | 0.00007 | 1810 | 3.23 | 2.992 | 4.4 | 10569 | 3.230 | 2.992 | 4.9 |
| | 0.00008 | 1765 | 3.105 | 2.855 | 4.4 | 9602 | 3.105 | 2.855 | 4.9 |
| | 0.00009 | 1722 | 3.074 | 2.804 | 4.4 | 9159 | 3.074 | 2.804 | 4.9 |

Table 1 (Continued…)

| $p_1$ | $p_2$ | $n_\sigma$ | $k_{T\sigma}$ | $k_{N\sigma}$ | σ - Level | $n_s$ | $k_{Ts}$ | $k_{Ns}$ | σ - Level |
|---|---|---|---|---|---|---|---|---|---|
| 0.00001 | 0.0001 | 1684 | 3.041 | 2.759 | 4.4 | 8765 | 3.041 | 2.759 | 4.9 |
| | 0.0002 | 1448 | 2.82 | 2.448 | 4.4 | 6471 | 2.820 | 2.448 | 4.8 |
| | 0.0003 | 1312 | 2.684 | 2.257 | 4.4 | 5316 | 2.684 | 2.257 | 4.8 |
| | 0.0004 | 1218 | 2.584 | 2.118 | 4.4 | 4584 | 2.584 | 2.118 | 4.8 |
| | 0.0005 | 1149 | 2.505 | 2.007 | 4.4 | 4073 | 2.505 | 2.007 | 4.8 |
| | 0.0006 | 1092 | 2.439 | 14.915 | 3.9 | 42201 | 2.439 | 14.915 | 5.0 |
| | 0.0007 | 1043 | 2.381 | 1.836 | 4.4 | 3361 | 2.381 | 1.836 | 4.7 |
| | 0.0008 | 1005 | 2.331 | 1.767 | 4.4 | 3115 | 2.331 | 1.767 | 4.7 |
| | 0.0009 | 969 | 2.286 | 1.704 | 4.4 | 2897 | 2.286 | 1.704 | 4.7 |
| | 0.001 | 937 | 2.246 | 1.648 | 4.4 | 2713 | 2.246 | 1.648 | 4.7 |
| | 0.002 | 748 | 1.964 | 1.262 | 4.4 | 1721 | 1.964 | 1.262 | 4.6 |
| | 0.003 | 645 | 1.789 | 1.024 | 4.4 | 1283 | 1.789 | 1.024 | 4.6 |
| 0.00005 | 0.00006 | 19853 | 2.961 | 2.93 | 5.1 | 105975 | 2.961 | 2.930 | 5.5 |
| | 0.00007 | 5738 | 2.916 | 2.864 | 4.8 | 29700 | 2.916 | 2.864 | 5.2 |
| | 0.00008 | 5388 | 2.875 | 2.808 | 4.8 | 27140 | 2.875 | 2.808 | 5.2 |
| | 0.00009 | 4850 | 2.84 | 2.757 | 4.8 | 23842 | 2.840 | 2.757 | 5.2 |
| | 0.0001 | 4531 | 2.806 | 2.711 | 4.7 | 21770 | 2.806 | 2.711 | 5.2 |
| | 0.0002 | 3975 | 2.584 | 2.4 | 4.7 | 16318 | 2.584 | 2.400 | 5.1 |
| | 0.0003 | 3356 | 2.447 | 2.208 | 4.7 | 12446 | 2.447 | 2.208 | 5.1 |
| | 0.0004 | 3012 | 2.346 | 2.068 | 4.7 | 10347 | 2.346 | 2.068 | 5.0 |
| | 0.0005 | 2851 | 2.267 | 1.957 | 4.7 | 9210 | 2.267 | 1.957 | 5.0 |
| | 0.0006 | 2683 | 2.2 | 1.864 | 4.7 | 8222 | 2.200 | 1.864 | 5.0 |
| | 0.0007 | 2361 | 2.141 | 1.783 | 4.6 | 6905 | 2.141 | 1.783 | 4.9 |
| | 0.0008 | 2131 | 2.091 | 1.714 | 4.6 | 5988 | 2.091 | 1.714 | 4.9 |
| | 0.0009 | 1989 | 2.046 | 1.651 | 4.6 | 5387 | 2.046 | 1.651 | 4.9 |
| | 0.001 | 1758 | 2.004 | 1.594 | 4.6 | 4603 | 2.004 | 1.594 | 4.9 |
| | 0.002 | 1584 | 1.719 | 1.203 | 4.6 | 3275 | 1.719 | 1.203 | 4.8 |
| | 0.003 | 1377 | 1.54 | 1.02 | 4.6 | 2505 | 1.540 | 1.020 | 4.8 |

Table 1 (Continued…)

| $p_1$ | $p_2$ | $n_\sigma$ | $k_{T\sigma}$ | $k_{N\sigma}$ | σ - Level | $n_s$ | $k_{Ts}$ | $k_{Ns}$ | σ - Level |
|---|---|---|---|---|---|---|---|---|---|
| 0.0001 | 0.0002 | 6253 | 2.62 | 2.522 | 4.8 | 26919 | 2.620 | 2.522 | 5.2 |
| | 0.0003 | 5656 | 2.484 | 2.331 | 4.8 | 22047 | 2.484 | 2.331 | 5.2 |
| | 0.0004 | 5242 | 2.383 | 2.19 | 4.8 | 18945 | 2.383 | 2.190 | 5.2 |
| | 0.0005 | 4959 | 2.302 | 2.078 | 4.8 | 16851 | 2.302 | 2.078 | 5.2 |
| | 0.0006 | 4680 | 2.235 | 1.985 | 4.8 | 15098 | 2.235 | 1.985 | 5.1 |
| | 0.0007 | 4471 | 2.177 | 1.905 | 4.8 | 13783 | 2.177 | 1.905 | 5.1 |
| | 0.0008 | 4296 | 2.126 | 1.834 | 4.8 | 12717 | 2.126 | 1.834 | 5.1 |
| | 0.0009 | 4241 | 2.08 | 1.772 | 4.8 | 12107 | 2.080 | 1.772 | 5.1 |
| | 0.001 | 4004 | 2.039 | 1.714 | 4.8 | 11054 | 2.039 | 1.714 | 5.1 |
| | 0.002 | 3165 | 1.753 | 1.323 | 4.8 | 6908 | 1.753 | 1.323 | 5.0 |
| | 0.003 | 2724 | 1.573 | 1.077 | 4.8 | 5115 | 1.573 | 1.077 | 5.0 |
| 0.0005 | 0.0006 | 5389 | 2.224 | 1.974 | 4.9 | 17260 | 2.224 | 1.974 | 5.2 |
| | 0.0007 | 4961 | 2.166 | 1.894 | 4.8 | 15183 | 2.166 | 1.894 | 5.1 |
| | 0.0008 | 4583 | 2.115 | 1.823 | 4.8 | 13467 | 2.115 | 1.823 | 5.1 |
| | 0.0009 | 4220 | 2.069 | 1.761 | 4.8 | 11958 | 2.069 | 1.761 | 5.1 |
| | 0.001 | 3953 | 2.028 | 1.703 | 4.8 | 10831 | 2.028 | 1.703 | 5.1 |
| | 0.002 | 3555 | 1.742 | 1.312 | 4.8 | 7700 | 1.742 | 1.312 | 5.0 |
| | 0.003 | 3170 | 1.562 | 1.066 | 4.8 | 5907 | 1.562 | 1.066 | 5.0 |