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AMENDMENT 1
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**Information technology — Security
techniques — Random bit generation**

**AMENDMENT 1: Deterministic random
bit generation**

*Technologies de l'information — Techniques de sécurité —
Génération de bits aléatoires*

AMENDEMENT 1: Génération déterministe de bits aléatoires

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Information technology — Security techniques — Random bit generation

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Add a new Annex K.

Annex K (informative) Example cases for MQ_DRBG

K.1 General

Annex K and its supporting files provides example cases for 14 settings listed in ISO/IEC 18031:2011, Table C.5. The supporting files are available at the following URL:

<http://standards.iso.org/iso/18031/>

In each of the 14 settings described in Annex K, the bitstring P provides a randomly selected system of multivariate quadratic equations that complies with the selection rules of C.5.2.5. The rank distribution resulting from the verification of rank conditions is detailed for each setting.

P is given in the format described in C.5.2.4 which is recalled below. Each example case also includes a sequence of consecutive input-output pairs for the **Evaluate_MQ(...)** function.

K.1.1 Format for representing field elements

Each system coefficient is an element of the binary field $\text{GF}(2^{\text{field_size}})$ and is a univariate polynomial over $\text{GF}(2)$ modulo the irreducible polynomial given in Table C.6. A field element is handled as a bitstring of field_size bits composed of its $\text{GF}(2)$ coefficients ordered by decreasing degree. For example, the polynomial $x^3 + x + 1$ in $\text{GF}(2^4)$ is represented as the bitstring 1011.

K.1.2 Format for representing a single multivariate quadratic equation

The quadratic system used in MQ_DRBG operates on $n = \text{state_length} / \text{field_size}$ variables and contains $n + m$ equations where $m = \text{block_length} / \text{field_size}$. A quadratic equation is written as the concatenation of its coefficients in lexicographic order and by decreasing degree. Therefore the coefficient of the monomial x_1x_1 appears first, followed by that of x_1x_2 and so forth, up to the coefficient of x_1x_n . The coefficient of the monomial x_2x_2 appears next, followed by that of x_2x_3 and so forth, until the last quadratic coefficient $x_{n-1}x_n$ is reached. Then linear coefficients appear, starting with the coefficient of the monomial x_1 and ending with that of x_n . When $\text{field_size} = 1$, the linear coefficients are omitted since the underlying field is $\text{GF}(2)$ and $x_ix_i = x_i$. The string ends with the constant coefficient of the quadratic equation.

K.1.3 Format for representing a complete system of quadratic equations

The quadratic system encoded into the bitstring P contains its $n + m$ quadratic equations concatenated in sequential order, starting with the coefficients of the first equation and ending with those of the $(n+m)$ -th equation. P is formed by the resulting bit string of length system_length .

K.1.4 Format for representing inputs and outputs

The input x to **Evaluate_MQ**(P, x) is a vector of n field elements and is given as a bitstring formed by concatenating their bitstring representations, starting with x_1 and ending with x_n . Similarly, the output $y || z$ is a vector of $n + m$ field elements represented in the same format.

K.1.5 Summary of example cases

Table K.1 summarizes the 14 example cases.

Table K.1 — Summary of example cases

requested_strength	block_length			
	112	128	192	256
80	K.2 Binary field GF(2) $n = 112$ $m = 112$ $min_weight = 4$ $min_rank \geq 106$	K.4 Binary field GF(2 ⁴) $n = 32$ $m = 32$ $min_weight = 5$ $min_rank \geq 30$	K.7 Binary field GF(2 ⁶) $n = 32$ $m = 32$ $min_weight = 5$ $min_rank \geq 30$	K.11 Binary field GF(2 ⁸) $n = 32$ $m = 32$ $min_weight = 5$ $min_rank \geq 30$
112	K.3 Binary field GF(2) $n = 120$ $m = 112$ $min_weight = 4$ $min_rank \geq 114$	K.5 Binary field GF(2) $n = 128$ $m = 128$ $min_weight = 4$ $min_rank \geq 122$	K.8 Binary field GF(2 ⁴) $n = 48$ $m = 48$ $min_weight = 5$ $min_rank \geq 44$	K.12 Binary field GF(2 ⁴) $n = 64$ $m = 64$ $min_weight = 5$ $min_rank \geq 60$
128		K.6 Same as K.5	K.9 Binary field GF(2 ³) $n = 64$ $m = 64$ $min_weight = 5$ $min_rank \geq 60$	K.13 Same as K.12
192			K.10 Binary field GF(2) $n = 200$ $m = 192$ $min_weight = 4$ $min_rank \geq 192$	K.14 Binary field GF(2 ²) $n = 128$ $m = 128$ $min_weight = 5$ $min_rank \geq 124$
256				K.15 Binary field GF(2) $n = 272$ $m = 256$ $min_weight = 4$ $min_rank \geq 264$

K.2 Example case for requested_strength = 80 and block_length = 112

K.2.1 System of multivariate quadratic equations

The bitstring P containing the system coefficients is provided in digital form in the file “coefficients-BL-112-Sec-80-F2.bin” in accordance with the format described in K.1.3.

The file contains 177212 bytes and its SHA-1 checksum in hexadecimal form is

95d78546df132777af932886a887da96aa9afa46

The ranks are distributed as follows:

106: 4561

108: 2213145

110: 58156950

112: 43613144

Sum: 103987800

K.2.2 Inputs and outputs

The bitstrings x , y and z are provided in digital form in accordance with the format described in K.1.4. Their hexadecimal values are:

$x = 00000000000000000000000000000001$

$y = \text{bb8cf180cbc3a6002c19c770ed0d}$

$z = 7847b864cfadf70fb359203e06d8$

$x = \text{bb8cf180cbc3a6002c19c770ed0d}$

$y = \text{a1e0811b5b7733113ca8e22dd2b1}$

$z = 57d27f7b0fc67aec0d5e8115cd93$

$x = \text{a1e0811b5b7733113ca8e22dd2b1}$

$y = 634ae5294dbc4cc79ce11cfb1d7$

$z = \text{e42c5cc5b5b61396df3fcf7a4e2b}$

$x = 634ae5294dbc4cc79ce11cfb1d7$

$y = 36701faea23130a0407a44f5e420$

$z = \text{bf3ddd3cbb141fcd96cbba66ebb9}$

$x = 36701faea23130a0407a44f5e420$

$y = 74b5baa1095f61eb6b15d317d5ed$

$z = 7f4ad5787a0c5451bddcf2aef533$

$x = 74b5baa1095f61eb6b15d317d5ed$

$y = 62804addbe9da290c38e9de0fe71$

$z = 5f1f209b62cce21f75d9d03607a9$

$x = 62804addbe9da290c38e9de0fe71$

$y = 7d0892da52eed7facc377af1918f$

$z = 69d5bef53c03fa33a0273cf44c21$

$x = 7d0892da52eed7facc377af1918f$

$y = 8ee43a16842345d4cd182852cdea$

$z = ed479a677e6c2a3cffbbada0e765$

$x = 8ee43a16842345d4cd182852cdea$

$y = 2eb8cc9185445b2bab3f4b504aaf$

$z = 9407f0fe9393fa335051ac2bf414$

$x = 2eb8cc9185445b2bab3f4b504aaf$

$y = 8deb10cb70bc3818209a576fb5cb$

$z = 6106cb8aa8e9a7de949a506b2278$

K.3 Example case for *requested_strength* = 112 and *block_length* = 112

K.3.1 System of multivariate quadratic equations

The bitstring P containing the system coefficients is provided in digital form in the file “coefficients-BL-112-Sec-112-F2.bin” in accordance with the format described in K.1.3.

The file contains 210569 bytes and its SHA-1 checksum in hexadecimal form is

ae1c4ea33afc96e3aa421f6456055a7c7ee33989

The ranks are distributed as follows:

114: 5239

116: 2551294

118: 66936700

120: 50200265

Sum: 119693498

K.3.2 Inputs and outputs

The bitstrings x , y and z are provided in digital form in accordance with the format described in K.1.4. Their hexadecimal values are:

$x = 00000000000000000000000000000001$

$y = 46609cda28057a917a08b60a1d969d$

$z = a06fe3e456a8c24315dfde6088bd$

$x = 46609cda28057a917a08b60a1d969d$

$y = 37d12de7b69f2170ba8717e96f0f43$

$z = 8fb9899c9e2d4ef33056aadf946d$

$x = 37d12de7b69f2170ba8717e96f0f43$

$y = 463860297cec60797650c4897563d4$

$z = 89745528548d7bd3a2c9e5afd3fc$

$x = 463860297cec60797650c4897563d4$

$y = 6a4c5b16c156738e9b07c4c2c2818e$

$z = 5f9f14194e601f48657164f34e34$

$x = 6a4c5b16c156738e9b07c4c2c2818e$

$y = 289c50a28bb48a685703eb425597dd$

$z = c9dae7a3c32a01648a32d91b8728$

$x = 289c50a28bb48a685703eb425597dd$

$y = 4d96224af4aeaac54d8472374f645d$

$z = cf7a6cc73793049241497ee26603$

$x = 4d96224af4aeaac54d8472374f645d$

$y = df5ac81223125d967056d5dcdba088$

$z = 3d9741ec702076fe8473b7181aa9$

$x = df5ac81223125d967056d5dcdba088$

$y = 41a1df8cc57c402f520d671464b728$

$z = 285d6b741e417e417b9f8fa87356$

$x = 41a1df8cc57c402f520d671464b728$

$y = 0af3539a48bc07e3afb00d3c529ff5$

$z = e6d4d36dcc2cca4826b94e76be10$

$x = 0af3539a48bc07e3afb00d3c529ff5$

$y = e2f7d8f01d2ae145a643b9351ada76$

$z = 29bdd54840cf84027f20e48ce195$

K.4 Example case for *requested_strength* = 80 and *block_length* = 128

K.4.1 System of multivariate quadratic equations

The bitstring P containing the system coefficients is provided in digital form in the file “coefficients-BL-128-Sec-80-F16.bin” in accordance with the format described in K.1.3.

The file contains 17952 bytes and its SHA-1 checksum in hexadecimal form is

d6614e19bd953ca88ff49f016b80f5ac17b7dab1

The ranks are distributed as follows:

30: 520948

32: 7782684

Sum: 8303632

K.4.2 Inputs and outputs

The bitstrings x , y and z are provided in digital form in accordance with the format described in K.1.4. Their hexadecimal values are:

$x = 00000000000000000000000000000001$

$y = f719e81ed992ca7c793258b5251d0534$

$z = 66092272f74a85ecaef639d78ed9831f$

$x = f719e81ed992ca7c793258b5251d0534$

$y = 37614b89b9bbd6eea4560ecb3bdb8807$

$z = 96b4c1aeb27aa47fbc7a3b1464343736$

x = 37614b89b9bbd6eea4560ecb3bdb8807
 y = 136bf7d8fbcabd37a2baa321a5d94f7
 z = 29141359d8099496eaf84ae3d863591a

x = 136bf7d8fbcabd37a2baa321a5d94f7
 y = bc6316205ac244b4fc8dcee70f423874
 z = d8005ccef012118820cf02c9eb4328d

x = bc6316205ac244b4fc8dcee70f423874
 y = 64d8adbf03a6418fa549f235e5f84bcd
 z = 9c0aad312ef00336d0f055e81f2b3677

x = 64d8adbf03a6418fa549f235e5f84bcd
 y = 3ac1c733b68ca734550343d950649d5a
 z = 1f07210c4a6d4fd784ee0f9f9789c5ab

x = 3ac1c733b68ca734550343d950649d5a
 y = 1a22cbbe771e641373700306718dbf6e
 z = ba8064102a7e8d714e92e0dfddf607

x = 1a22cbbe771e641373700306718dbf6e
 y = fa2eabf2c9794f6b9bac6561409aab0d
 z = 7e2bae34daaf284557bbe5ae48e54d26

x = fa2eabf2c9794f6b9bac6561409aab0d
 y = 46f6f74d23504a64565b2c35cd0036df
 z = c6285e77cbf16150457d03bfc6015ef7

x = 46f6f74d23504a64565b2c35cd0036df
 y = 729bc30c32fd7fec1ccb95bc4aabfa27
 z = 963bda8ab7dc84ee2dd5a60a9c4392cd

K.5 Example case for *requested_strength* = 112 and *block_length* = 128

K.5.1 System of multivariate quadratic equations

The bitstring P containing the system coefficients is provided in digital form in the file “coefficients-BL-128-Sec-112-F2.bin” in accordance with the format described in K.1.3.

The file contains 264224 bytes and its SHA-1 checksum in hexadecimal form is

fcd983e78ddd489a9425be58b8139e04c89fb6c6

The ranks are distributed as follows:

122: 7704

124: 3783524

126: 99303857

128: 74493971

Sum: 177589056

K.5.2 Inputs and outputs

The bitstrings x , y and z are provided in digital form in accordance with the format described in K.1.4. Their hexadecimal values are:

$x = 00000000000000000000000000000001$

$y = c04f664eb59219b1e6b0d0e0fc5ae660$

$z = 894f5e21cc208ce73ebb136c0c7b6e47$

$x = c04f664eb59219b1e6b0d0e0fc5ae660$

$y = 10da311bd87ba42fd89a17f45b0b0931$

$z = f3561e3a42a23037d04b7991e44f98d0$

$x = 10da311bd87ba42fd89a17f45b0b0931$

$y = c42c14916632d8518f435796c069a381$

$z = 461593a9b73573772cf8f8a93020eada$

$x = c42c14916632d8518f435796c069a381$

$y = 325ebb605c4037b6092a7952adedd16d$

$z = 3f80f69b2f81f012994189125cba6b00$

$x = 325ebb605c4037b6092a7952adedd16d$

$y = 596cdd4392413988fa7a15fa7fb5d74b$

$z = 8ec0f223da49f826f6faf8d25b54b231$

$x = 596cdd4392413988fa7a15fa7fb5d74b$

$y = 17790ac47b8112312631c0e3b0066fd0$

$z = 8d98258ade35f74057a98542c0d7d937$

$x = 17790ac47b8112312631c0e3b0066fd0$

$y = d76a00f9e3318091e0f113b48f0cb752$

$z = 8b9664e30122848541b91743171b4812$

$x = d76a00f9e3318091e0f113b48f0cb752$

$y = 4ffffdf6def93bb391d90312a801ece5$

$z = d17acb75d2f57976df164061716601e0$

$x = 4ffffdf6def93bb391d90312a801ece5$

$y = 89b596d08123105f5994679f5e428136$

$z = 1de72c77e98fa45090197c81e4d2a3a3$

$x = 89b596d08123105f5994679f5e428136$

$y = 7294da76d6d2bf9dfb9d2c1d03ca4928$

$z = 96cea7ffad3bc8be151106cd4c067565$

K.6 Example case for *requested_strength* = 128 and *block_length* = 128

The example case is the same as in K.5.

K.7 Example case for *requested_strength* = 80 and *block_length* = 192

K.7.1 System of multivariate quadratic equations

The bitstring P containing the system coefficients is provided in digital form in the file “coefficients-BL-192-Sec-80-F64.bin” in accordance with the format described in K.1.3.

The file contains 26928 bytes and its SHA-1 checksum in hexadecimal form is

dad206d21189e0b9aaa5bb60298e0cf3f918ae81

The ranks are distributed as follows:

30: 129895

z = 3b6ed30bfac7560230730efa2befd0b63c610ddc84579b47

x = efd8d72753ca6319ad85e8632a2731082e24851cb496517b

y = 6817118a48c2faae74cd95654416f072c44dfd2309bb216d

z = e2dd5934948ac3f16f4dcd5e1343104e8a69fc004e700ae1

x = 6817118a48c2faae74cd95654416f072c44dfd2309bb216d

y = 668a844f1fd85b03eb5ace651179ba6adb6080dda180dfc0

z = 78f8d2f16f0c1cdb96b7eeef95e8d852267d2599bfd0a3a5

x = 668a844f1fd85b03eb5ace651179ba6adb6080dda180dfc0

y = 84f988e9a1335ceaa21e526bd1df380d137a7470ad2167fb

z = d459b9f5ac1ab0622e324994bd1c70038e1e500d6ed21c87

x = 84f988e9a1335ceaa21e526bd1df380d137a7470ad2167fb

y = 5f3263e90c40060d975443ca13dc9388f01bec3c3f3d28ea

z = b427e405b17d64c91a9e8622a896d20c7c75a8ad5139ccbf

x = 5f3263e90c40060d975443ca13dc9388f01bec3c3f3d28ea

y = 7f4a9db932fff536a7f5df253d8e974ae6852866d2558629

z = b23c1c8f7fff065e9b9827b65b6f3d156d4c8bc1343b173c

x = 7f4a9db932fff536a7f5df253d8e974ae6852866d2558629

y = 5e1395441cb914d8ad706f7c9c03ccc73e5780c2e44f5504

z = 284e181d513eb5e9bebde7d78f6c8ed52bec0ffda2a96634

x = 5e1395441cb914d8ad706f7c9c03ccc73e5780c2e44f5504

y = 9a28d4de9d2a5dae64c38a936c672072e90f60f71fa1cbf9

z = e41bb6b73ba2052d035d07f8dc5cb40d15f1eca51fbd6e0e

x = 9a28d4de9d2a5dae64c38a936c672072e90f60f71fa1cbf9

y = 66660d18cf3651da98e89f566bf00355cca6c0baf9a2d1c1

z = 601c8b113003889e0348566729e8e0751f53c294f5dbe000

y = 15f0f194a952f1c98eb5d4449a3b21d8dfa0b068982b19df
z = 71f515a88870778b7194870180fb7bd963960c44d43fc4f0

x = 15f0f194a952f1c98eb5d4449a3b21d8dfa0b068982b19df
y = bce241c8b0ea940679bad3c259860ff978d7efaad313aed7
z = 0a37faed572b12a1a0fb5167a69bab22d1093a051cbeb725

x = bce241c8b0ea940679bad3c259860ff978d7efaad313aed7
y = fe7bf955dbd9b517d516ce81584985f54bc93229bd0baf97
z = b29254189ef82d3cb673c2c17ded8378a3effbc323e09095

x = fe7bf955dbd9b517d516ce81584985f54bc93229bd0baf97
y = 3b0ab7a9534dc16df8dbc8f921049bf24163009c7a468684
z = c7d85ea5c1adc569c435db47135c20c63ae525b18fe6d5b0

x = 3b0ab7a9534dc16df8dbc8f921049bf24163009c7a468684
y = 421b005096b17b479d04215fdd7262e86460fe7c0e439949
z = bf3f9480e4f1fb02ad22f94e24063349d68600394a9c2ed4

x = 421b005096b17b479d04215fdd7262e86460fe7c0e439949
y = 9cfd31b93ea12da49b9c176710f7830b43803b20fab8bd51
z = 55a2eee9251283d70798708e1d65e7c23a2f4f06d5841d75

K.10 Example case for *requested_strength* = 192 and *block_length* = 192

K.10.1 System of multivariate quadratic equations

The bitstring *P* containing the system coefficients is provided in digital form in the file “coefficients-BL-192-Sec-192-F2.bin” in accordance with the format described in K.1.3.

The file contains 984949 bytes and its SHA-1 checksum in hexadecimal form is

3d71baf6bdf23781f11540b36f9f393746902a08

The ranks are distributed as follows:

192: 4

194: 42773

196: 20853635

z = 92f38812133684f0c24cd8a1852df8edd0eaa91828011f3e1b5e2bf5def130d9

x = 99dc7f54302df0c04b075e7db6c3c10fbe70a18edf9852b7896f31aa18788192

y = bf6202d53d315b60b8263a77faf610926d5f479e33bcd899713ae123bb0f5769

z = 7f1d0a9e2895c40c03fe7153e4afc4738ea041593e11adc0eed00749cfc22b04

x = bf6202d53d315b60b8263a77faf610926d5f479e33bcd899713ae123bb0f5769

y = 0ce571d57cc82cb8ab65ad61a2d98af5fd32b0a6315e1cb68c43a6da4b5569f0

z = 9b89a9dba6ae9e51fd4d31fe1a2d0b6396aadae62f1125d9f050f38ef445c704

x = 0ce571d57cc82cb8ab65ad61a2d98af5fd32b0a6315e1cb68c43a6da4b5569f0

y = 3b1210b59b739b1dd0b376ff8db7cc8623892f285f6d3e3608c34a5718318ea1

z = e6f5e3fc89ae09a9658d8518d42f163102f87dc57e779d46b442e11516345ec2

x = 3b1210b59b739b1dd0b376ff8db7cc8623892f285f6d3e3608c34a5718318ea1

y = 2fd0bc4dfdb228a972df094d412cb8369ea68a8ce3c81d7a431bc1264842895e

z = 2e424cdf55c87e859648db33578b025c2ede28e4c822382cd2784e8320f49436

x = 2fd0bc4dfdb228a972df094d412cb8369ea68a8ce3c81d7a431bc1264842895e

y = f73335a5e4fdc5ebe31adf389c1346a7968361b745ad5b69f781bae0eefc54b0

z = 74d2d21284d3deaca76009f5633c33cbd6808cd3bf239b5aab8969034db1ed1f

x = f73335a5e4fdc5ebe31adf389c1346a7968361b745ad5b69f781bae0eefc54b0

y = d64a1e12e8574169dfba54b856415289fafbfae8e7f605af72a15c89b4cf203f

z = 3863991897b5c3f7a0d8adba26abf061e6c4c5532e0514c5029c6c6a20a399d

x = d64a1e12e8574169dfba54b856415289fafbfae8e7f605af72a15c89b4cf203f

y = 011fd95e7497a73cc21e2fd30a6f14a2b3e37e9716e238893e3a81e8a0ff7334

z = 7541b2e6d273efc5d2481b2d9154e92b6c90e73b0fca4e090576a91574c4e9fe

x = 011fd95e7497a73cc21e2fd30a6f14a2b3e37e9716e238893e3a81e8a0ff7334

y = 141bb711f4996dff29382dbb1083e5c30d60d022f65603eb42907a467c934c42

z = 55b876a9a19dad4caeb1c5c4c04efb6e93da1f065c3dee4771d2de484c3180bc

