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From:	Secretary-General of the European Commission, signed by Mr Jordi AYET PUIGARNAU, Director
date of receipt:	10 October 2018
To:	Mr Jeppe TRANHOLM-MIKKELSEN, Secretary-General of the Council of the European Union
No. Cion doc.:	C(2018) 6511 final Annex 1 Part 5/11
Subject:	ANNEX 1 Part 5/11 to the Commission Delegated Regulation amending Council Regulation (EC) No 428/2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items

Delegations will find attached document C(2018) 6511 final Annex 1 Part 5/11.

Encl.: C(2018) 6511 final Annex 1 Part 5/11

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ANNEX 1 – PART 5/11

ANNEX

to the

Commission Delegated Regulation

amending Council Regulation (EC) No 428/2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items

ANNEX I (PART V – Category 3)

CATEGORY 3 - ELECTRONICS

3A Systems, Equipment and Components

Note 1: *The control status of equipment and components described in 3A001 or 3A002, other than those described in 3A001.a.3. to 3A001.a.10., or 3A001.a.12. to 3A001.a.14., which are specially designed for or which have the same functional characteristics as other equipment is determined by the control status of the other equipment.*

Note 2: *The control status of integrated circuits described in 3A001.a.3. to 3A001.a.9., or 3A001.a.12. to 3A001.a.14. which are unalterably programmed or designed for a specific function for another equipment is determined by the control status of the other equipment.*

N.B. *When the manufacturer or applicant cannot determine the control status of the other equipment, the control status of the integrated circuits is determined in 3A001.a.3. to 3A001.a.9., and 3A001.a.12. to 3A001.a.14.*

3A001 Electronic items as follows:

a. General purpose integrated circuits, as follows:

Note 1: *The control status of wafers (finished or unfinished), in which the function has been determined, is to be evaluated against the parameters of 3A001.a.*

Note 2: *Integrated circuits include the following types:*

- *"Monolithic integrated circuits";*
- *"Hybrid integrated circuits";*
- *"Multichip integrated circuits";*
- *"Film type integrated circuits", including silicon-on-sapphire integrated circuits;*
- *"Optical integrated circuits";*
- *"Three dimensional integrated circuits";*
- *"Monolithic Microwave Integrated Circuits" ("MMICs").*

3A001.a. continued

1. Integrated circuits designed or rated as radiation hardened to withstand any of the following:

   a. A total dose of 5 x 10^3 Gy (silicon) or higher;

   b. A dose rate upset of 5 x 10^6 Gy (silicon)/s or higher; or

   c. A fluence (integrated flux) of neutrons (1 MeV equivalent) of 5 x 10^{13} n/cm^2 or higher on silicon, or its equivalent for other materials;

      Note: 3A001.a.1.c. does not control Metal Insulator Semiconductors (MIS).

2. "Microprocessor microcircuits", "microcomputer microcircuits", microcontroller microcircuits, storage integrated circuits manufactured from a compound semiconductor, analogue-to-digital converters, integrated circuits that contain analogue-to-digital converters and store or process the digitised data, digital-to-analogue converters, electro-optical or "optical integrated circuits" designed for "signal processing", field programmable logic devices, custom integrated circuits for which either the function is unknown or the control status of the equipment in which the integrated circuit will be used is unknown, Fast Fourier Transform (FFT) processors, Static Random-Access Memories (SRAMs), or 'non-volatile memories', having any of the following:

   a. Rated for operation at an ambient temperature above 398 K (125°C);

   b. Rated for operation at an ambient temperature below 218 K (-55°C); or

   c. Rated for operation over the entire ambient temperature range from 218 K (-55°C) to 398 K (125°C);

   Note: 3A001.a.2. does not control integrated circuits for civil automobiles or railway train applications.

   Technical Note:
   'Non-volatile memories' are memories with data retention over a period of time after a power shutdown.

3A001.a. continued

3. "Microprocessor microcircuits", "microcomputer microcircuits" and microcontroller microcircuits, manufactured from a compound semiconductor and operating at a clock frequency exceeding 40 MHz;

Note: 3A001.a.3. includes digital signal processors, digital array processors and digital coprocessors.

4. Not used;

5. Analogue-to-Digital Converter (ADC) and Digital-to-Analogue Converter (DAC) integrated circuits, as follows:

a. ADCs having any of the following:

N.B. SEE ALSO 3A101

1. A resolution of 8 bit or more, but less than 10 bit, with a "sample rate" greater than 1,3 Giga Samples Per Second (GSPS);

2. A resolution of 10 bit or more, but less than 12 bit, with a "sample rate" greater than 600 Mega Samples Per Second (MSPS);

3. A resolution of 12 bit or more, but less than 14 bit, with a "sample rate" greater than 400 MSPS;

4. A resolution of 14 bit or more, but less than 16 bit, with a "sample rate" greater than 250 MSPS; or

5. A resolution of 16 bit or more with a "sample rate" greater than 65 MSPS;

N.B. For integrated circuits that contain analogue-to-digital converters and store or process the digitized data, see 3A001.a.14.

Technical Notes:

1. A resolution of n bit corresponds to a quantisation of 2^n levels.

2. The resolution of the ADC is the number of bits of the digital output that represents the measured analogue input. Effective Number of Bits (ENOB) is not used to determine the resolution of the ADC.

3. For "multiple channel ADCs", the "sample rate" is not aggregated and the "sample rate" is the maximum rate of any single channel.

4. For "interleaved ADCs" or for "multiple channel ADCs" that are specified to have an interleaved mode of operation, the "sample rates" are aggregated and the "sample rate" is the maximum combined total rate of all of the interleaved channels.

3A001.a.5.a. continued

b. Digital-to-Analogue Converters (DAC) having any of the following:

1. A resolution of 10 bit or more with an 'adjusted update rate' of greater than 3 500 MSPS; or

2. A resolution of 12 bit or more with an 'adjusted update rate' of greater than 1 250 MSPS and having any of the following:

a. A settling time less than 9 ns to arrive at or within 0,024% of full scale from a full scale step; or

b. A 'Spurious Free Dynamic Range' (SFDR) greater than 68 dBc (carrier) when synthesising a full scale analogue signal of 100 MHz or the highest full scale analogue signal frequency specified below 100 MHz.

3A001.a.5.b. continued

Technical Notes:

1. 'Spurious Free Dynamic Range' (SFDR) is defined as the ratio of the RMS value of the carrier frequency (maximum signal component) at the input of the DAC to the RMS value of the next largest noise or harmonic distortion component at its output.

2. SFDR is determined directly from the specification table or from the characterisation plots of SFDR versus frequency.

3 A signal is defined to be full scale when its amplitude is greater than -3 dBfs (full scale).

4. 'Adjusted update rate' for DACs:

a. For conventional (non-interpolating) DACs, the 'adjusted update rate' is the rate at which the digital signal is converted to an analogue signal and the output analogue values are changed by the DAC. For DACs where the interpolation mode may be bypassed (interpolation factor of one), the DAC should be considered as a conventional (non-interpolating) DAC.

b. For interpolating DACs (oversampling DACs), the 'adjusted update rate' is defined as the DAC update rate divided by the smallest interpolating factor. For interpolating DACs, the 'adjusted update rate' may be referred to by different terms including:

- input data rate
- input word rate
- input sample rate
- maximum total input bus rate
- maximum DAC clock rate for DAC clock input.

3A001.a. continued

6. Electro-optical and "optical integrated circuits", designed for "signal processing" and having all of the following:

   a. One or more than one internal "laser" diode;

   b. One or more than one internal light detecting element; and

   c. Optical waveguides;

7. Field programmable logic devices having any of the following:

   a. A maximum number of single-ended digital input/outputs of greater than 700; or

   b. An 'aggregate one-way peak serial transceiver data rate' of 500 Gb/s or greater;

   Note: 3A001.a.7. includes:

   – *Complex Programmable Logic Devices (CPLDs)*

   – *Field Programmable Gate Arrays (FPGAs)*

   – *Field Programmable Logic Arrays (FPLAs)*

   – *Field Programmable Interconnects (FPICs)*

   N.B. For integrated circuits having field programmable logic devices that are combined with an analogue-to-digital converter, see 3A001.a.14.

   Technical Notes:

   1. Maximum number of digital input/outputs in 3A001.a.7.a. is also referred to as the maximum user input/outputs or maximum available input/outputs, whether the integrated circuit is packaged or bare die.

   2. 'Aggregate one-way peak serial transceiver data rate' is the product of the peak serial one-way transceiver data rate times the number of transceivers on the FPGA.

3A001.a. continued

8. Not used;

9. Neural network integrated circuits;

10. Custom integrated circuits for which the function is unknown, or the control status of the equipment in which the integrated circuits will be used is unknown to the manufacturer, having any of the following:

    a. More than 1 500 terminals;

    b. A typical "basic gate propagation delay time" of less than 0,02 ns; or

    c. An operating frequency exceeding 3 GHz;

11. Digital integrated circuits, other than those described in 3A001.a.3. to 3A001.a.10. and 3A001.a.12., based upon any compound semiconductor and having any of the following:

    a. An equivalent gate count of more than 3 000 (2 input gates); or

    b. A toggle frequency exceeding 1,2 GHz;

12. Fast Fourier Transform (FFT) processors having a rated execution time for an N-point complex FFT of less than $(N \log_2 N)$ /20 480 ms, where N is the number of points;

    Technical Note:
    When N is equal to 1 024 points, the formula in 3A001.a.12. gives an execution time of 500 µs.

13. Direct Digital Synthesizer (DDS) integrated circuits having any of the following:

    a. A Digital-to-Analogue Converter (DAC) clock frequency of 3,5 GHz or more and a DAC resolution of 10 bit or more, but less than 12 bit; or

    b. A DAC clock frequency of 1,25 GHz or more and a DAC resolution of 12 bit or more;

    Technical Note:
    The DAC clock frequency may be specified as the master clock frequency or the input clock frequency.

3A001.a. continued

14. Integrated circuits that perform or are programmable to perform all of the following:

a. Analogue-to-digital conversions meeting any of the following:

1. A resolution of 8 bit or more, but less than 10 bit, with a "sample rate" greater than 1,3 Giga Samples Per Second (GSPS);

2. A resolution of 10 bit or more, but less than 12 bit, with a "sample rate" greater than 1,0 GSPS;

3. A resolution of 12 bit or more, but less than 14 bit, with a "sample rate" greater than 1,0 GSPS;

4. A resolution of 14 bit or more, but less than 16 bit, with a "sample rate" greater than 400 Mega Samples Per Second (MSPS); or

5. A resolution of 16 bit or more with a "sample rate" greater than 180 MSPS; and

b. Any of the following:

1. Storage of digitised data; or

2. Processing of digitised data;

N.B.1. For analogue-to-digital converter integrated circuits see 3A001.a.5.a.

N.B.2. For field programmable logic devices see 3A001.a.7.

Technicals Notes:

1. A resolution of n bit corresponds to a quantisation of 2^n levels.

2. The resolution of the ADC is the number of bits of the digital output of the ADC that represents the measured analogue input. Effective Number of Bits (ENOB) is not used to determine the resolution of the ADC.

3. For integrated circuits with non-interleaving "multiple channel ADCs", the "sample rate" is not aggregated and the "sample rate" is the maximum rate of any single channel.

4. For integrated circuits with "interleaved ADCs "or with "multiple channel ADCs" that are specified to have an interleaved mode of operation, the "sample rates" are aggregated and the "sample rate" is the maximum combined total rate of all of the interleaved channels.

3A001 continued

b. Microwave or millimetre wave items as follows:

Technical Notes:

1. For purposes of 3A001.b., the parameter peak saturated power output may also be referred to on product data sheets as output power, saturated power output, maximum power output, peak power output, or peak envelope power output.

2. For purposes of 3A001.b.1., 'vacuum electronic devices' are electronic devices based on the interaction of an electron beam with an electromagnetic wave propagating in a vacuum circuit or interacting with radio-frequency vacuum cavity resonators. 'Vacuum electronic devices' include klystrons, travelling-wave tubes, and their derivatives.

1. 'Vacuum electronic devices' and cathodes, as follows:

Note 1: 3A001.b.1. does not control 'vacuum electronic devices' designed or rated for operation in any frequency band and having all of the following:

a. Does not exceed 31,8 GHz; and

b. Is "allocated by the ITU" for radio-communications services, but not for radio-determination.

Note 2: 3A001.b.1. does not control non-"space-qualified" 'vacuum electronic devices' having all of the following:

a. An average output power equal to or less than 50 W; and

b. Designed or rated for operation in any frequency band and having all of the following:

1. Exceeds 31,8 GHz but does not exceed 43,5 GHz; and

2. Is "allocated by the ITU" for radio-communications services, but not for radio-determination.

a. Travelling-wave 'vacuum electronic devices', pulsed or continuous wave, as follows:

1. Devices operating at frequencies exceeding 31,8 GHz;

2. Devices having a cathode heater with a turn on time to rated RF power of less than 3 seconds;

3A001.b. continued

3. Coupled cavity devices, or derivatives thereof, with a "fractional bandwidth" of more than 7% or a peak power exceeding 2,5 kW;

4. Devices based on helix, folded waveguide, or serpentine waveguide circuits, or derivatives thereof, having any of the following:

   a. An "instantaneous bandwidth" of more than one octave, and average power (expressed in kW) times frequency (expressed in GHz) of more than 0,5;

   b. An "instantaneous bandwidth" of one octave or less, and average power (expressed in kW) times frequency (expressed in GHz) of more than 1;

   c. Being "space-qualified"; or

   d. Having a gridded electron gun;

5. Devices with a "fractional bandwidth" greater than or equal to 10%, with any of the following:

   a. An annular electron beam;

   b. A non-axisymmetric electron beam; or

   c. Multiple electron beams;

b. Crossed-field amplifier 'vacuum electronic devices' with a gain of more than 17 dB;

c. Thermionic cathodes designed for 'vacuum electronic devices' producing an emission current density at rated operating conditions exceeding 5 A/cm^2 or a pulsed (non-continuous) current density at rated operating conditions exceeding 10 A/cm^2;

d. 'Vacuum electronic devices' with the capability to operate in a 'dual mode'.

Technical Note:
'Dual mode' means the 'vacuum electronic device' beam current can be intentionally changed between continuous-wave and pulsed mode operation by use of a grid and produces a peak pulse output power greater than the continuous-wave output power.

2. "Monolithic Microwave Integrated Circuits" ("MMIC") amplifiers that are any of the following:

N.B. *For "MMIC" amplifiers that have an integrated phase shifter see 3A001.b.12.*

a. Rated for operation at frequencies exceeding 2,7 GHz up to and including 6,8 GHz with a "fractional bandwidth" greater than 15%, and having any of the following:

1. A peak saturated power output greater than 75 W (48,75 dBm) at any frequency exceeding 2,7 GHz up to and including 2,9 GHz;

2. A peak saturated power output greater than 55 W (47,4 dBm) at any frequency exceeding 2,9 GHz up to and including 3,2 GHz;

3. A peak saturated power output greater than 40 W (46 dBm) at any frequency exceeding 3,2 GHz up to and including 3,7 GHz; or

4. A peak saturated power output greater than 20 W (43 dBm) at any frequency exceeding 3,7 GHz up to and including 6,8 GHz;

3A001.b. continued

b. Rated for operation at frequencies exceeding 6,8 GHz up to and including 16 GHz with a "fractional bandwidth" greater than 10%, and having any of the following:

1. A peak saturated power output greater than 10W (40 dBm) at any frequency exceeding 6,8 GHz up to and including 8,5 GHz; or

2. A peak saturated power output greater than 5W (37 dBm) at any frequency exceeding 8,5 GHz up to and including 16 GHz;

c. Rated for operation with a peak saturated power output greater than 3 W (34,77 dBm) at any frequency exceeding 16 GHz up to and including 31,8 GHz, and with a "fractional bandwidth" of greater than 10%;

d. Rated for operation with a peak saturated power output greater than 0,1 nW (-70 dBm) at any frequency exceeding 31,8 GHz up to and including 37 GHz;

e. Rated for operation with a peak saturated power output greater than 1 W (30 dBm) at any frequency exceeding 37 GHz up to and including 43,5 GHz, and with a "fractional bandwidth" of greater than 10%;

f. Rated for operation with a peak saturated power output greater than 31,62 mW (15 dBm) at any frequency exceeding 43,5 GHz up to and including 75 GHz, and with a "fractional bandwidth" of greater than 10%;

g. Rated for operation with a peak saturated power output greater than 10 mW (10 dBm) at any frequency exceeding 75 GHz up to and including 90 GHz, and with a "fractional bandwidth" of greater than 5%; or

h. Rated for operation with a peak saturated power output greater than 0,1 nW (-70 dBm) at any frequency exceeding 90 GHz;

3A001.b. continued

Note 1: *Not used.*

Note 2: *The control status of the "MMIC" whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 3A001.b.2.a. to 3A001.b.2.h., is determined by the lowest peak saturated power output threshold.*

Note 3: *Notes 1 and 2 in 3A mean that 3A001.b.2. does not control "MMICs" if they are specially designed for other applications, e.g., telecommunications, radar, automobiles.*

3. Discrete microwave transistors that are any of the following:

a. Rated for operation at frequencies exceeding 2,7 GHz up to and including 6,8 GHz and having any of the following:

1. A peak saturated power output greater than 400 W (56 dBm) at any frequency exceeding 2,7 GHz up to and including 2,9 GHz;

2. A peak saturated power output greater than 205 W (53,12 dBm) at any frequency exceeding 2,9 GHz up to and including 3,2 GHz;

3. A peak saturated power output greater than 115 W (50,61 dBm) at any frequency exceeding 3,2 GHz up to and including 3,7 GHz; or

4. A peak saturated power output greater than 60 W (47,78 dBm) at any frequency exceeding 3,7 GHz up to and including 6,8 GHz;

3A001.b. continued

b. Rated for operation at frequencies exceeding 6,8 GHz up to and including 31,8 GHz and having any of the following:

1. A peak saturated power output greater than 50 W (47 dBm) at any frequency exceeding 6,8 GHz up to and including 8,5 GHz;

2. A peak saturated power output greater than 15 W (41,76 dBm) at any frequency exceeding 8,5 GHz up to and including 12 GHz;

3. A peak saturated power output greater than 40 W (46 dBm) at any frequency exceeding 12 GHz up to and including 16 GHz; or

4. A peak saturated power output greater than 7 W (38,45 dBm) at any frequency exceeding 16 GHz up to and including 31,8 GHz;

c. Rated for operation with a peak saturated power output greater than 0,5 W (27 dBm) at any frequency exceeding 31,8 GHz up to and including 37 GHz;

d. Rated for operation with a peak saturated power output greater than 1 W (30 dBm) at any frequency exceeding 37 GHz up to and including 43,5 GHz;

e. Rated for operation with a peak saturated power output greater than 0,1 nW (-70 dBm) at any frequency exceeding 43,5 GHz;

Note 1: *The control status of a transistor whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 3A001.b.3.a. to 3A001.b.3.e., is determined by the lowest peak saturated power output threshold.*

Note 2: *3A001.b.3. includes bare dice, dice mounted on carriers, or dice mounted in packages. Some discrete transistors may also be referred to as power amplifiers, but the status of these discrete transistors is determined by 3A001.b.3.*

3A001.b. continued

4. Microwave solid state amplifiers and microwave assemblies/modules containing microwave solid state amplifiers, that are any of the following:

a. Rated for operation at frequencies exceeding 2,7 GHz up to and including 6,8 GHz with a "fractional bandwidth" greater than 15%, and having any of the following:

1. A peak saturated power output greater than 500 W (57 dBm) at any frequency exceeding 2,7 GHz up to and including 2,9 GHz;

2. A peak saturated power output greater than 270 W (54,3 dBm) at any frequency exceeding 2,9 GHz up to and including 3,2 GHz;

3. A peak saturated power output greater than 200 W (53 dBm) at any frequency exceeding 3,2 GHz up to and including 3,7 GHz; or

4. A peak saturated power output greater than 90 W (49,54 dBm) at any frequency exceeding 3,7 GHz up to and including 6,8 GHz;

b. Rated for operation at frequencies exceeding 6,8 GHz up to and including 31,8 GHz with a "fractional bandwidth" greater than 10%, and having any of the following:

1. A peak saturated power output greater than 70 W (48,54 dBm) at any frequency exceeding 6,8 GHz up to and including 8,5 GHz;

2. A peak saturated power output greater than 50 W (47 dBm) at any frequency exceeding 8,5 GHz up to and including 12 GHz;

3. A peak saturated power output greater than 30 W (44,77 dBm) at any frequency exceeding 12 GHz up to and including 16 GHz; or

4. A peak saturated power output greater than 20 W (43 dBm) at any frequency exceeding 16 GHz up to and including 31,8 GHz;

3A001.b. continued

c. Rated for operation with a peak saturated power output greater than 0,5 W (27 dBm) at any frequency exceeding 31,8 GHz up to and including 37 GHz;

d. Rated for operation with a peak saturated power output greater than 2 W (33 dBm) at any frequency exceeding 37 GHz up to and including 43,5 GHz, and with a "fractional bandwidth" of greater than 10%;

e. Rated for operation at frequencies exceeding 43,5 GHz and having any of the following:

1. A peak saturated power output greater than 0,2 W (23 dBm) at any frequency exceeding 43,5 GHz up to and including 75 GHz, and with a "fractional bandwidth" of greater than 10%;

2. A peak saturated power output greater than 20 mW (13 dBm) at any frequency exceeding 75 GHz up to and including 90 GHz, and with a "fractional bandwidth" of greater than 5%; or

3. A peak saturated power output greater than 0,1 nW (-70 dBm) at any frequency exceeding 90 GHz; or

f. Not used

N.B.1. For "MMIC" amplifiers see 3A001.b.2.

N.B.2. For 'transmit/receive modules' and 'transmit modules' see 3A001.b.12.

N.B.3. For converters and harmonic mixers, designed to extend the operating or frequency range of signal analysers, signal generators, network analysers or microwave test receivers, see 3A001.b.7.

3A001.b. continued

Note 1: *Not used.*

Note 2: *The control status of an item whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 3A001.b.4.a. to 3A001.b.4.e., is determined by the lowest peak saturated power output threshold.*

5. Electronically or magnetically tunable band-pass or band-stop filters, having more than 5 tunable resonators capable of tuning across a 1,5:1 frequency band (f_{max}/f_{min}) in less than 10 μs and having any of the following:

   a. A band-pass bandwidth of more than 0,5% of centre frequency; or

   b. A band-stop bandwidth of less than 0,5% of centre frequency;

6. Not used;

7. Converters and harmonic mixers that are any of the following:

   a. Designed to extend the frequency range of "signal analysers" beyond 90 GHz;

   b. Designed to extend the operating range of signal generators as follows:

      1. Beyond 90 GHz;

      2. To an output power greater than 100 mW (20 dBm) anywhere within the frequency range exceeding 43,5 GHz but not exceeding 90 GHz;

   c. Designed to extend the operating range of network analysers as follows:

      1. Beyond 110 GHz;

      2. To an output power greater than 31,62 mW (15 dBm) anywhere within the frequency range exceeding 43,5 GHz but not exceeding 90 GHz;

      3. To an output power greater than 1 mW (0 dBm) anywhere within the frequency range exceeding 90 GHz but not exceeding 110 GHz; or

   d. Designed to extend the frequency range of microwave test receivers beyond 110 GHz;

3A001.b. continued

8. Microwave power amplifiers containing 'vacuum electronic devices' specified in 3A001.b.1. and having all of the following:

   a. Operating frequencies above 3 GHz;

   b. An average output power to mass ratio exceeding 80 W/kg; and

   c. A volume of less than 400 cm^3;

   Note: 3A001.b.8. does not control equipment designed or rated for operation in any frequency band which is "allocated by the ITU" for radio-communications services, but not for radio-determination.

9. Microwave power modules (MPM) consisting of, at least, a travelling wave 'vacuum electronic device', a "monolithic microwave integrated circuit" ("MMIC") and an integrated electronic power conditioner and having all of the following:

   a. A 'turn-on time' from off to fully operational in less than 10 seconds;

   b. A volume less than the maximum rated power in Watts multiplied by 10 cm^3/W; and

   c. An "instantaneous bandwidth" greater than 1 octave ($f_{max} > 2f_{min}$) and having any of the following:

      1. For frequencies equal to or less than 18 GHz, an RF output power greater than 100 W; or

      2. A frequency greater than 18 GHz;

   Technical Notes:

   1. To calculate the volume in 3A001.b.9.b., the following example is provided: for a maximum rated power of 20 W, the volume would be: 20 W x 10 cm^3/W = 200 cm^3.

   2. The' turn-on time' in 3A001.b.9.a. refers to the time from fully-off to fully operational, i.e., it includes the warm-up time of the MPM.

3A001.b. continued

10. Oscillators or oscillator assemblies, specified to operate with a single sideband (SSB) phase noise, in dBc/Hz, less (better) than $-(126 + 20\log_{10}F - 20\log_{10}f)$ anywhere within the range of 10 Hz ≤ F ≤ 10 kHz;

Technical Note:
In 3A001.b.10., F is the offset from the operating frequency in Hz and f is the operating frequency in MHz.

11. 'Frequency synthesiser' "electronic assemblies" having a "frequency switching time" as specified by any of the following:

a. Less than 143 ps;

b. Less than 100 µs for any frequency change exceeding 2,2 GHz within the synthesised frequency range exceeding 4,8 GHz but not exceeding 31,8 GHz;

c. Not used;

d. Less than 500 µs for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 31,8 GHz but not exceeding 37 GHz;

e. Less than 100 µs for any frequency change exceeding 2,2 GHz within the synthesised frequency range exceeding 37 GHz but not exceeding 90 GHz; or

f. Not used;

g. Less than 1 ms within the synthesized frequency range exceeding 90 GHz;

Technical Note:
A 'frequency synthesiser' is any kind of frequency source, regardless of the actual technique used, providing a multiplicity of simultaneous or alternative output frequencies, from one or more outputs, controlled by, derived from or disciplined by a lesser number of standard (or master) frequencies.

N.B. For general purpose "signal analysers", signal generators, network analysers and microwave test receivers, see 3A002.c., 3A002.d., 3A002.e. and 3A002.f., respectively.

3A001.b. continued

12. 'Transmit/receive modules', 'transmit/receive MMICs', 'transmit modules', and 'transmit MMICs', rated for operation at frequencies above 2,7 GHz and having all of the following:

    a. A peak saturated power output (in watts), P_{sat}, greater than 505,62 divided by the maximum operating frequency (in GHz) squared [P_{sat}>505,62 W*GHz^2/f_{GHz}^2] for any channel;

    b. A "fractional bandwidth" of 5% or greater for any channel;

    c. Any planar side with length d (in cm) equal to or less than 15 divided by the lowest operating frequency in GHz [$d \leq 15cm*GHz*N/f_{GHz}$] where N is the number of transmit or transmit/receive channels; and

    d. An electronically variable phase shifter per channel.

    Technical Notes:

    1. A 'transmit/receive module': is a multifunction "electronic assembly" that provides bi-directional amplitude and phase control for transmission and reception of signals.

    2. A 'transmit module': is an "electronic assembly" that provides amplitude and phase control for transmission of signals.

    3. A 'transmit/receive MMIC': is a multifunction "MMIC" that provides bi-directional amplitude and phase control for transmission and reception of signals.

    4. A 'transmit MMIC': is a "MMIC" that provides amplitude and phase control for transmission of signals.

    *5. 2,7 GHz should be used as the lowest operating frequency (f_{GHz}) in the formula in 3A001.b.12.c. for transmit/receive or transmit modules that have a rated operation range extending downward to 2.7 GHz and below [d≤15cm*GHz*N/2,7 GHz].*

    6. 3A001.b.12. applies to 'transmit/receive modules' or 'transmit modules' with or without a heat sink. The value of d in 3A001.b.12.c. does not include any portion of the 'transmit/receive module' or 'transmit module' that functions as a heat sink.

    7. 'Transmit/receive modules', or 'transmit modules', or 'transmit/receive MMICs' or 'transmit MMICs' may or may not have N integrated radiating antenna elements where N is the number of transmit or transmit/receive channels.

3A001 continued

c. Acoustic wave devices as follows and specially designed components therefor:

1. Surface acoustic wave and surface skimming (shallow bulk) acoustic wave devices, having any of the following:

a. A carrier frequency exceeding 6 GHz;

b. A carrier frequency exceeding 1 GHz, but not exceeding 6 GHz and having any of the following:

1. A 'frequency side-lobe rejection' exceeding 65 dB;

2. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;

3. A bandwidth greater than 250 MHz; or

4. A dispersive delay of more than 10 µs; or

c. A carrier frequency of 1 GHz or less and having any of the following:

1. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;

2. A dispersive delay of more than 10 µs; or

3. A 'frequency side-lobe rejection' exceeding 65 dB and a bandwidth greater than 100 MHz;

Technical Note:
'Frequency side-lobe rejection' is the maximum rejection value specified in data sheet.

3A001.c. continued

2. Bulk (volume) acoustic wave devices which permit the direct processing of signals at frequencies exceeding 6 GHz;

3. Acoustic-optic "signal processing" devices employing interaction between acoustic waves (bulk wave or surface wave) and light waves which permit the direct processing of signals or images, including spectral analysis, correlation or convolution;

Note: *3A001.c. does not control acoustic wave devices that are limited to a single band pass, low pass, high pass or notch filtering, or resonating function.*

d. Electronic devices and circuits containing components, manufactured from "superconductive" materials, specially designed for operation at temperatures below the "critical temperature" of at least one of the "superconductive" constituents and having any of the following:

1. Current switching for digital circuits using "superconductive" gates with a product of delay time per gate (in seconds) and power dissipation per gate (in watts) of less than 10^{-14} J; or

2. Frequency selection at all frequencies using resonant circuits with Q-values exceeding 10 000;

e. High energy devices as follows:

1. 'Cells' as follows:

a. 'Primary cells' having any of the following at 20°C;

1. 'Energy density' exceeding 550 Wh/kg and a 'continuous power density' exceeding 50 W/kg; or

2. 'Energy density' exceeding 50 Wh/kg and a 'continuous power density' exceeding 350 W/kg; or

b. 'Secondary cells' having an 'energy density' exceeding 350 Wh/kg at 20°C;

3A001.e.1. continued

Technical Notes:

1. *For the purpose of 3A001.e.1., 'energy density' (Wh/kg) is calculated from the* nominal *voltage multiplied by the nominal capacity in ampere-hours (Ah) divided by the mass in kilograms. If the nominal capacity is not stated, energy density is calculated from the nominal voltage squared then multiplied by the discharge duration in hours divided by the discharge load in ohms and the mass in kilograms.*
2. *For the purpose of 3A001.e.1., a 'cell' is defined as an electrochemical device, which has positive and negative electrodes, an electrolyte, and is a source of electrical energy. It is the basic building block of a battery.*
3. *For the purpose of 3A001.e.1.a., a 'primary cell' is a 'cell' that is not designed to be charged by any other source.*
4. *For the purpose of 3A001.e.1.b., a 'secondary cell' is a 'cell' that is designed to be charged by an external electrical source.*
5. *For the purpose of 3A001.e.1.a., 'continuous power density' (W/kg) is calculated from the nominal voltage multiplied by the specified maximum continuous discharge current in ampere (A) divided by the mass in kilograms. 'Continuous power density' is also referred to as specific power.*

Note: 3A001.e.1. does not control batteries, including single-cell batteries.

3A001.e. continued

2. High energy storage capacitors as follows:

N.B. *SEE ALSO 3A201.a. and the Military Goods Controls.*

a. Capacitors with a repetition rate of less than 10 Hz (single shot capacitors) and having all of the following:

1. A voltage rating equal to or more than 5 kV;

2. An energy density equal to or more than 250 J/kg; and

3. A total energy equal to or more than 25 kJ;

b. Capacitors with a repetition rate of 10 Hz or more (repetition rated capacitors) and having all of the following:

1. A voltage rating equal to or more than 5 kV;

2. An energy density equal to or more than 50 J/kg;

3. A total energy equal to or more than 100 J; and

4. A charge/discharge cycle life equal to or more than 10 000;

3. "Superconductive" electromagnets and solenoids, specially designed to be fully charged or discharged in less than one second and having all of the following:

N.B. *SEE ALSO 3A201.b.*

Note: *3A001.e.3. does not control "superconductive" electromagnets or solenoids specially designed for Magnetic Resonance Imaging (MRI) medical equipment.*

a. Energy delivered during the discharge exceeding 10 kJ in the first second;

b. Inner diameter of the current carrying windings of more than 250 mm; and

c. Rated for a magnetic induction of more than 8 T or "overall current density" in the winding of more than 300 A/mm^2;

3A001.e. continued

4. Solar cells, cell-interconnect-coverglass (CIC) assemblies, solar panels, and solar arrays, which are "space-qualified", having a minimum average efficiency exceeding 20% at an operating temperature of 301 K (28°C) under simulated 'AM0' illumination with an irradiance of 1 367 watts per square metre (W/m^2);

Technical Note:
'AM0', or 'Air Mass Zero', refers to the spectral irradiance of sun light in the earth's outer atmosphere when the distance between the earth and sun is one astronomical unit (AU).

f. Rotary input type absolute position encoders having an "accuracy" equal to or less (better) than 1,0 second of arc and specially designed encoder rings, discs or scales therefor;

g. Solid-state pulsed power switching thyristor devices and 'thyristor modules', using either electrically, optically, or electron radiation controlled switch methods and having any of the following:

1. A maximum turn-on current rate of rise (di/dt) greater than 30 000 A/µs and off-state voltage greater than 1 100 V; or

2. A maximum turn-on current rate of rise (di/dt) greater than 2 000 A/µs and having all of the following:

a. An off-state peak voltage equal to or greater than 3 000 V; and

b. A peak (surge) current equal to or greater than 3 000 A.

3A001.g. continued

Note 1: *3A001.g. includes:*
- *Silicon Controlled Rectifiers (SCRs)*
- *Electrical Triggering Thyristors (ETTs)*
- *Light Triggering Thyristors (LTTs)*
- *Integrated Gate Commutated Thyristors (IGCTs)*
- *Gate Turn-off Thyristors (GTOs)*
- *MOS Controlled Thyristors (MCTs)*
- *Solidtrons*

Note 2: *3A001.g. does not control thyristor devices and 'thyristor modules' incorporated into equipment designed for civil railway or "civil aircraft" applications.*

Technical Note:
For the purposes of 3A001.g., a 'thyristor module' contains one or more thyristor devices.

h. Solid-state power semiconductor switches, diodes, or 'modules', having all of the following:

1. Rated for a maximum operating junction temperature greater than 488 K (215°C);

2. Repetitive peak off-state voltage (blocking voltage) exceeding 300 V; and

3. Continuous current greater than 1 A.

Note 1: *Repetitive peak off-state voltage in 3A001.h. includes drain to source voltage, collector to emitter voltage, repetitive peak reverse voltage and peak repetitive off-state blocking voltage.*

Note 2: *3A001.h. includes:*
- *Junction Field Effect Transistors (JFETs)*
- *Vertical Junction Field Effect Transistors (VJFETs)*
- *Metal Oxide Semiconductor Field Effect Transistors (MOSFETs)*
- *Double Diffused Metal Oxide Semiconductor Field Effect Transistor (DMOSFET)*
- *Insulated Gate Bipolar Transistor (IGBT)*
- *High Electron Mobility Transistors (HEMTs)*
- *Bipolar Junction Transistors (BJTs)*
- *Thyristors and Silicon Controlled Rectifiers (SCRs)*
- *Gate Turn-Off Thyristors (GTOs)*
- *Emitter Turn-Off Thyristors (ETOs)*
- *PiN Diodes*
- *Schottky Diodes*

3A001.h. continued

Note 3: *3A001.h. does not control switches, diodes, or 'modules', incorporated into equipment designed for civil automobile, civil railway or "civil aircraft" applications.*

Technical Note:
For the purposes of 3A001.h., 'modules' contain one or more solid-state power semiconductor switches or diodes.

i. Intensity, amplitude, or phase electro-optic modulators, designed for analogue signals and having any of the following:

1. A maximum operating frequency of more than 10 GHz but less than 20 GHz, an optical insertion loss equal to or less than 3 dB and having any of the following:

a. A 'half-wave voltage' ('Vπ') less than 2,7 V when measured at a frequency of 1 GHz or below; or

b. A 'Vπ' of less than 4 V when measured at a frequency of more than 1 GHz; or

2. A maximum operating frequency equal to or greater than 20 GHz, an optical insertion loss equal to or less than 3 dB and having any of the following:

a. A 'Vπ' less than 3,3 V when measured at a frequency of 1 GHz or below; or

b. A 'Vπ' less than 5 V when measured at a frequency of more than 1 GHz.

Note: 3A001.i. includes electro-optic modulators having optical input and output connectors (e.g., fibre-optic pigtails).

Technical Note:
For the purposes of 3A001.i., a 'half-wave voltage' ('Vπ') is the applied voltage necessary to make a phase change of 180 degrees in the wavelength of light propagating through the optical modulator.

3A002 General purpose "electronic assemblies", modules and equipment, as follows:

a. Recording equipment and oscilloscopes as follows:

1. Not used;

2. Not used;

3. Not used;

4. Not used;

5. Not used;

6. Digital data recorders having all of the following:

a. A sustained 'continuous throughput' of more than 6,4 Gbit/s to disk or solid-state drive memory; and

b. A processor that performs analysis of radio frequency signal data while it is being recorded;

Technical Notes:

1. For recorders with a parallel bus architecture, the 'continuous throughput' rate is the highest *word rate multiplied by the number of bits in a word.*

2. 'Continuous throughput' is the fastest data rate the instrument can record to disk or solid-state drive *memory without the loss of any information while sustaining the input digital data rate or digitizer conversion rate.*

7. Real-time oscilloscopes having a vertical root-mean-square (rms) noise voltage of less than 2% of full-scale at the vertical scale setting that provides the lowest noise value for any input 3dB bandwidth of 60 GHz or greater per channel;

Note: 3A002.a.7. does not control equivalent-time sampling oscilloscopes.

3A002 continued

b. Not used;

c. "Signal analysers" as follows:

1. "Signal analysers" having a 3 dB resolution bandwidth (RBW) exceeding 40 MHz anywhere within the frequency range exceeding 31,8 GHz but not exceeding 37 GHz;

2. "Signal analysers" having Displayed Average Noise Level (DANL) less (better) than -150 dBm/Hz anywhere within the frequency range exceeding 43,5 GHz but not exceeding 90 GHz;

3. "Signal analysers" having a frequency exceeding 90 GHz;

4. "Signal analysers" having all of the following:

a. 'Real-time bandwidth' exceeding 170 MHz; and

b. Having any of the following:

1. 100% probability of discovery with less than a 3 dB reduction from full amplitude due to gaps or windowing effects of signals having a duration of 15 μs or less; or

2. A 'frequency mask trigger' function with 100% probability of trigger (capture) for signals having a duration of 15 μs or less;

Technical Notes:

1. *'Real-time bandwidth' is the widest frequency range for which the analyser can continuously transform time-domain data entirely into frequency-domain results, using a Fourier or other discrete time transform that processes every incoming time point, without a reduction of measured amplitude of more than 3 dB below the actual signal amplitude caused by gaps or windowing effects, while outputting or displaying the transformed data.*
2. *Probability of discovery in 3A002.c.4.b.1. is also referred to as probability of intercept or probability of capture.*
3. *For the purposes of 3A002.c.4.b.1., the duration for 100% probability of discovery is equivalent to the minimum signal duration necessary for the specified level measurement uncertainty.*
4. *A 'frequency mask trigger' is a mechanism where the trigger function is able to select a frequency range to be triggered on as a subset of the acquisition bandwidth while ignoring other signals that may also be present within the same acquisition bandwidth. A 'frequency mask trigger' may contain more than one independent set of limits.*

Note: 3A002.c.4. does not control those "signal analysers" using only constant percentage bandwidth filters (also known as octave or fractional octave filters).

3A002.c. continued

5. Not used;

d. Signal generators having any of the following:

1. Specified to generate pulse-modulated signals having all of the following, anywhere within the frequency range exceeding 31,8 GHz but not exceeding 37 GHz:

a. 'Pulse duration' of less than 25 ns; and

b. On/off ratio equal to or exceeding 65 dB;

2. An output power exceeding 100 mW (20 dBm) anywhere within the frequency range exceeding 43,5 GHz but not exceeding 90 GHz;

3. A "frequency switching time" as specified by any of the following:

a. Not used;

b. Less than 100 µs for any frequency change exceeding 2,2 GHz within the frequency range exceeding 4,8 GHz but not exceeding 31,8 GHz;

c. Not used;

d. Less than 500 µs for any frequency change exceeding 550 MHz within the frequency range exceeding 31,8 GHz but not exceeding 37 GHz; or

e. Less than 100 µs for any frequency change exceeding 2,2 GHz within the frequency range exceeding 37 GHz but not exceeding 90 GHz;

f. Not used;

3A002.d. continued

4. Single sideband (SSB) phase noise, in dBc/Hz, specified as being any of the following:

   a. Less (better) than $-(126 + 20\log_{10}F - 20\log_{10}f)$ anywhere within the range of 10 Hz ≤ F ≤ 10 kHz anywhere within the frequency range exceeding 3,2 GHz but not exceeding 90 GHz; or

   b. Less (better) than $-(206 - 20\log_{10}f)$ anywhere within the range of 10 kHz< F≤ 100 kHz anywhere within the frequency range exceeding 3,2 GHz but not exceeding 90 GHz; or

   Technical Note:
   In 3A002.d.4., F is the offset from the operating frequency in Hz and f is the operating frequency in MHz;

5. A maximum frequency exceeding 90 GHz;

Note 1: *For the purpose of 3A002.d., signal generators include arbitrary waveform and function generators.*

Note 2: *3A002.d. does not control equipment in which the output frequency is either produced by the addition or subtraction of two or more crystal oscillator frequencies, or by an addition or subtraction followed by a multiplication of the result.*

Technical Notes:

1. The maximum frequency of an arbitrary waveform or function generator is calculated by dividing the sample rate, in samples/second, by a factor of 2,5.

2. For the purposes of 3A002.d.1.a, 'pulse duration' is defined as the time interval from the point on the leading edge that is 50% of the pulse amplitude to the point on the trailing edge that is 50% of the pulse amplitude.

3A002 continued

e. Network analysers having any of the following:

1. An output power exceeding 31,62 mW (15 dBm) anywhere within the operating frequency range exceeding 43,5 GHz but not exceeding 90 GHz;

2. An output power exceeding 1 mW (0 dBm) anywhere within the operating frequency range exceeding 90 GHz but not exceeding 110 GHz;

3. 'Nonlinear vector measurement functionality' at frequencies exceeding 50 GHz but not exceeding 110 GHz; or

Technical Note:
'Nonlinear vector measurement functionality' is an instrument's ability to analyse the test results of devices driven into the large-signal domain or the non-linear distortion range.

4. A maximum operating frequency exceeding 110 GHz;

f. Microwave test receivers having all of the following:

1. A maximum operating frequency exceeding 110 GHz; and

2. Being capable of measuring amplitude and phase simultaneously;

g. Atomic frequency standards being any of the following:

1. "Space-qualified";

2. Non-rubidium and having a long-term stability less (better) than 1×10^{-11}/month; or

3. Non-"space-qualified" and having all of the following:

a. Being a rubidium standard;

b. Long-term stability less (better) than 1×10^{-11}/month; and

c. Total power consumption of less than 1 W;

3A002 continued

h. "Electronic assemblies", modules, or equipment, specified to perform all of the following:

1. Analogue-to-digital conversions meeting any of the following:

a. A resolution of 8 bit or more, but less than 10 bit, with a "sample rate" greater than 1,3 Giga Samples Per Second (GSPS);

b. A resolution of 10 bit or more, but less than 12 bit, with a "sample rate" greater than 1,0 GSPS;

c. A resolution of 12 bit or more, but less than 14 bit, with a "sample rate" greater than 1,0 GSPS;

d. A resolution of 14 bit or more but less than 16 bit, with a "sample rate" greater than 400 Mega Samples Per Second (MSPS); or

e. A resolution of 16 bit or more with a "sample rate" greater than 180 MSPS; and

2. Any of the following:

a. Output of digitized data;

b. Storage of digitized data; or

c. Processing of digitized data;

N.B. *Digital data recorders, oscilloscopes, "signal analysers", signal generators, network* analysers *and microwave test receivers, are specified in 3A002.a.6., 3A002.a.7., 3A002.c., 3A002.d., 3A002.e. and 3A002.f., respectively.*

3A002.h continued

Technical Notes:

1. *A resolution of n bit corresponds to a quantisation of 2^n levels.*
2. *The resolution of the ADC is the number of bits of the digital output of the ADC that represents the measured analogue input. Effective Number of Bits (ENOB) is not used to determine the resolution of the ADC.*
3. *For non-interleaved multiple-channel "electronic assemblies", modules, or equipment, the "sample rate" is not aggregated and the "sample rate" is the maximum rate of any single-channel.*
4. *For interleaved channels on multiple-channel "electronic assemblies", modules, or equipment, the "sample rates" are aggregated and the "sample rate" is the maximum combined total rate of all the interleaved channels.*

Note: 3A002.h. includes ADC cards, waveform digitizers, data acquisition cards, signal acquisition boards and transient recorders.

3A003 Spray cooling thermal management systems employing closed loop fluid handling and reconditioning equipment in a sealed enclosure where a dielectric fluid is sprayed onto electronic components using specially designed spray nozzles that are designed to maintain electronic components within their operating temperature range, and specially designed components therefor.

3A101 Electronic equipment, devices and components, other than those specified in 3A001, as follows:

a. Analogue-to-digital converters, usable in "missiles", designed to meet military specifications for ruggedized equipment;

b. Accelerators capable of delivering electromagnetic radiation produced by bremsstrahlung from accelerated electrons of 2 MeV or greater, and systems containing those accelerators.

Note: 3A101.b. above does not specify equipment specially designed for medical purposes.

3A102 'Thermal batteries' designed or modified for 'missiles'.

Technical Notes:

1. In 3A102 'thermal batteries' are single use batteries that contain a solid non-conducting inorganic salt as the electrolyte. These batteries incorporate a pyrolytic material that, when ignited, melts the electrolyte and activates the battery.

2. In 3A102 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.

3A201 Electronic components, other than those specified in 3A001, as follows;

a. Capacitors having either of the following sets of characteristics:

1. a. Voltage rating greater than 1,4 kV;
   b. Energy storage greater than 10 J;
   c. Capacitance greater than 0,5 µF; and
   d. Series inductance less than 50 nH; or

2. a. Voltage rating greater than 750 V;
   b. Capacitance greater than 0,25 µF; and
   c. Series inductance less than 10 nH;

3A201 continued

b. Superconducting solenoidal electromagnets having all of the following characteristics:

1. Capable of creating magnetic fields greater than 2 T;

2. A ratio of length to inner diameter greater than 2;

3. Inner diameter greater than 300 mm; and

4. Magnetic field uniform to better than 1% over the central 50% of the inner volume;

Note: 3A201.b. does not control magnets specially designed for and exported 'as parts of' medical nuclear magnetic resonance (NMR) imaging systems. The phrase 'as part of' does not necessarily mean physical part in the same shipment; separate shipments from different sources are allowed, provided the related export documents clearly specify that the shipments are dispatched 'as part of' the imaging systems.

c. Flash X-ray generators or pulsed electron accelerators having either of the following sets of characteristics:

1. a. An accelerator peak electron energy of 500 keV or greater but less than 25 MeV; and

b. With a 'figure of merit' (K) of 0,25 or greater; or

2. a. An accelerator peak electron energy of 25 MeV or greater; and

b. A 'peak power' greater than 50 MW.

Note: 3A201.c. does not control accelerators that are component parts of devices designed for purposes other than electron beam or X-ray radiation (electron microscopy, for example) nor those designed for medical purposes.

3A201.c. continued

Technical Notes:

1. The 'figure of merit' K is defined as:

$K = 1,7 \times 10^3 V^{2,65} Q$

V is the peak electron energy in million electron volts.

If the accelerator beam pulse duration is less than or equal to 1 μs, then Q is the total accelerated charge in Coulombs. If the accelerator beam pulse duration is greater than 1 μs, then Q is the maximum accelerated charge in 1 μs.

Q equals the integral of i with respect to t, over the lesser of 1 μs or the time duration of the beam pulse ($Q = \int i dt$), where i is beam current in amperes and t is time in seconds.

2. 'Peak power' = (peak potential in volts) x (peak beam current in amperes).

3. In machines based on microwave accelerating cavities, the time duration of the beam pulse is the lesser of 1 μs or the duration of the bunched beam packet resulting from one microwave modulator pulse.

4. In machines based on microwave accelerating cavities, the peak beam current is the average current in the time duration of a bunched beam packet.

3A225 Frequency changers or generators, other than those specified in 0B001.b.13., usable as a variable or fixed frequency motor drive, having all of the following characteristics:

N.B. 1. "Software" specially designed to enhance or release the performance of a frequency changer or generator to meet the characteristics of 3A225 is specified in 3D225.

N.B. 2. "Technology" in the form of codes or keys to enhance or release the performance of a frequency changer or generator to meet the characteristics of 3A225 is specified in 3E225.

3A225 continued

a. Multiphase output providing a power of 40 VA or greater;

b. Operating at a frequency of 600 Hz or more; and

c. Frequency control better (less) than 0,2%.

Note: 3A225 does not control frequency changers or generators if they have hardware, "software" or "technology" constraints that limit the performance to less than that specified above, provided they meet any of the following:

1. They need to be returned to the original manufacturer to make the enhancements or release the constraints;

2. They require "software" as specified in 3D225 to enhance or release the performance to meet the characteristics of 3A225; or

3. They require "technology" in the form of keys or codes as specified in 3E225 to enhance or release the performance to meet the characteristics of 3A225.

Technical Notes:

1. Frequency changers in 3A225 are also known as converters or inverters.

2. Frequency changers in 3A225 may be marketed as Generators, Electronic Test Equipment, AC Power Supplies, Variable Speed Motors Drives, Variable Speed Drives (VSDs), Variable Frequency Drives (VFDs), Adjustable Frequency Drives (AFDs), or Adjustable Speed Drives (ASDs).

3A226 High-power direct current power supplies, other than those specified in 0B001.j.6., having both of the following characteristics:

a. Capable of continuously producing, over a time period of 8 hours, 100 V or greater with current output of 500 A or greater; and

b. Current or voltage stability better than 0,1% over a time period of 8 hours.

3A227 High-voltage direct current power supplies, other than those specified in 0B001.j.5., having both of the following characteristics:

a. Capable of continuously producing, over a time period of 8 hours, 20 kV or greater with current output of 1 A or greater; and

b. Current or voltage stability better than 0,1% over a time period of 8 hours.

3A228 Switching devices, as follows:

a. Cold-cathode tubes, whether gas filled or not, operating similarly to a spark gap, having all of the following characteristics:

1. Containing three or more electrodes;

2. Anode peak voltage rating of 2,5 kV or more;

3. Anode peak current rating of 100 A or more; and

4. Anode delay time of 10 μs or less;

Note: 3A228 includes gas krytron tubes and vacuum sprytron tubes.

b. Triggered spark-gaps having both of the following characteristics:

1. An anode delay time of 15 μs or less; and

2. Rated for a peak current of 500 A or more;

c. Modules or assemblies with a fast switching function, other than those specified in 3A001.g. or 3A001.h., having all of the following characteristics:

1. Anode peak voltage rating greater than 2 kV;

2. Anode peak current rating of 500 A or more; and

3. Turn-on time of 1 μs or less.

3A229 High-current pulse generators as follows:

N.B. *SEE ALSO MILITARY GOODS CONTROLS.*

a. Detonator firing sets (initiator systems, firesets), including electronically-charged, explosively-driven and optically-driven firing sets, other than those specified in 1A007.a., designed to drive multiple controlled detonators specified in 1A007.b.;

b. Modular electrical pulse generators (pulsers) having all of the following characteristics:

1. Designed for portable, mobile, or ruggedized-use;

2. Capable of delivering their energy in less than 15 μs into loads of less than 40 ohms;

3. Having an output greater than 100 A;

4. No dimension greater than 30 cm;

5. Weight less than 30 kg; and

6. Specified for use over an extended temperature range 223 K (-50°C) to 373 K (100°C) or specified as suitable for aerospace applications.

Note: *3A229.b. includes xenon flash-lamp drivers.*

c. Micro-firing units having all of the following characteristics:

1. No dimension greater than 35 mm;

2. Voltage rating of equal to or greater than 1 kV; and

3. Capacitance of equal to or greater than 100 nF.

3A230 High-speed pulse generators, and 'pulse heads' therefor, having both of the following characteristics:

a. Output voltage greater than 6 V into a resistive load of less than 55 ohms, and

b. 'Pulse transition time' less than 500 ps.

Technical Notes:

1. In 3A230, 'pulse transition time' is defined as the time interval between 10% and 90% voltage amplitude.

2. 'Pulse heads' are impulse forming networks designed to accept a voltage step function and shape it into a variety of pulse forms that can include rectangular, triangular, step, impulse, exponential, or monocycle types. 'Pulse heads' can be an integral part of the pulse generator, they can be a plug-in module to the device or they can be an externally connected device.

3A231 Neutron generator systems, including tubes, having both of the following characteristics:

a. Designed for operation without an external vacuum system; and

b. Utilizing any of the following:

1. Electrostatic acceleration to induce a tritium-deuterium nuclear reaction; or

2. Electrostatic acceleration to induce a deuterium-deuterium nuclear reaction and capable of an output of 3×10^9 neutrons/s or greater.

3A232 Multipoint initiation systems, other than those specified in 1A007, as follows:

N.B. SEE ALSO MILITARY GOODS CONTROLS.

N.B. See 1A007.b. for detonators.

a. Not used;

b. Arrangements using single or multiple detonators designed to nearly simultaneously initiate an explosive surface over an area greater than 5 000 mm^2 from a single firing signal with an initiation timing spread over the surface of less than 2,5 μs.

Note: 3A232 does not control detonators using only primary explosives, such as lead azide.

3A233 Mass spectrometers, other than those specified in 0B002.g., capable of measuring ions of 230 u or greater and having a resolution of better than 2 parts in 230, as follows, and ion sources therefor:

a. Inductively coupled plasma mass spectrometers (ICP/MS);

b. Glow discharge mass spectrometers (GDMS);

c. Thermal ionization mass spectrometers (TIMS);

d. Electron bombardment mass spectrometers having both of the following features:

1. A molecular beam inlet system that injects a collimated beam of analyte molecules into a region of the ion source where the molecules are ionized by an electron beam; and

2. One or more 'cold traps' that can be cooled to a temperature of 193 K (-80 °C);

e. Not used;

f. Mass spectrometers equipped with a microfluorination ion source designed for actinides or actinide fluorides.

Technical Notes:

1. Electron bombardment mass spectrometers in 3A233.d. are also known as electron impact mass spectrometers or electron ionization mass spectrometers.

2. In 3A233.d.2., a 'cold trap' is a device that traps gas molecules by condensing or freezing them on cold surfaces. For the purposes of 3A233.d.2., a closed-loop gaseous helium cryogenic vacuum pump is not a 'cold trap'.

3A234 Striplines to provide low inductance path to detonators with the following characteristics:

a. Voltage rating greater than 2 kV; and

b Inductance of less than 20 nH.

3B Test, Inspection and Production Equipment

3B001 Equipment for the manufacturing of semiconductor devices or materials, as follows and specially designed components and accessories therefor:

N.B. *SEE ALSO 2B226*

a. Equipment designed for epitaxial growth as follows:

1. Equipment designed or modified to produce a layer of any material other than silicon with a thickness uniform to less than ± 2,5% across a distance of 75 mm or more;

Note: *3B001.a.1. includes Atomic Layer Epitaxy (ALE) equipment.*

2. Metal Organic Chemical Vapour Deposition (MOCVD) reactors designed for compound semiconductor epitaxial growth of material having two or more of the following elements: aluminium, gallium, indium, arsenic, phosphorus, antimony, or nitrogen;

3. Molecular beam epitaxial growth equipment using gas or solid sources;

b. Equipment designed for ion implantation and having any of the following:

1. Not used;

2. Being designed and optimized to operate at a beam energy of 20 keV or more and a beam current of 10 mA or more for hydrogen, deuterium or helium implant;

3. Direct write capability;

4. A beam energy of 65 keV or more and a beam current of 45 mA or more for high energy oxygen implant into a heated semiconductor material "substrate"; or

5. Being designed and optimized to operate at a beam energy of 20 keV or more and a beam current of 10 mA or more for silicon implant into a semiconductor material "substrate" heated to 600°C or greater;

3B001 continued

c. Not used;

d. Not used;

e. Automatic loading multi-chamber central wafer handling systems having all of the following:

1. Interfaces for wafer input and output, to which more than two functionally different 'semiconductor process tools' specified in 3B001.a.1., 3B001.a.2., 3B001.a.3 or 3B001.b. are designed to be connected; and

2. Designed to form an integrated system in a vacuum environment for 'sequential multiple wafer processing';

Note: 3B001.e. does not control automatic robotic wafer handling systems specially designed for parallel wafer processing.

Technical Notes:

1. For the purpose of 3B001.e., 'semiconductor process tools' refers to modular tools that provide physical processes for semiconductor production that are functionally different, such as deposition, implant or thermal processing.

2. For the purpose of 3B001.e., 'sequential multiple wafer processing' means the capability to process each wafer in different 'semiconductor process tools', such as by transferring each wafer from one tool to a second tool and on to a third tool with the automatic loading multi-chamber central wafer handling systems.

3B001 continued

f. Lithography equipment as follows:

1. Align and expose step and repeat (direct step on wafer) or step and scan (scanner) equipment for wafer processing using photo-optical or X-ray methods and having any of the following:

a. A light source wavelength shorter than 193 nm; or

b. Capable of producing a pattern with a 'Minimum Resolvable Feature size' (MRF) of 45 nm or less;

Technical Note:
The 'Minimum Resolvable Feature size' (MRF) is calculated by the following formula:

$$MRF = \frac{(\text{an exposure light source wavelength in nm}) \times (\text{K factor})}{\text{numerical aperture}}$$

where the K factor = 0,35

2. Imprint lithography equipment capable of producing features of 45 nm or less;

Note: 3B001.f.2. includes:
- *Micro contact printing tools*
- *Hot embossing tools*
- *Nano-imprint lithography tools*
- *Step and flash imprint lithography (S-FIL) tools*

3. Equipment specially designed for mask making having all of the following:

a. A deflected focussed electron beam, ion beam or "laser" beam; and

b. Having any of the following:

1. A full-width half-maximum (FWHM) spot size smaller than 65 nm and an image placement less than 17 nm (mean + 3 sigma); or

2. Not used;

3. A second-layer overlay error of less than 23 nm (mean + 3 sigma) on the mask;

3B001.f. continued

4. Equipment designed for device processing using direct writing methods, having all of the following:

a. A deflected focused electron beam; and

b. Having any of the following:

1. A minimum beam size equal to or smaller than 15 nm; or

2. An overlay error less than 27 nm (mean + 3 sigma);

g. Masks and reticles, designed for integrated circuits specified in 3A001;

h. Multi-layer masks with a phase shift layer not specified in 3B001.g. and having any of the following:

1. Made on a mask "substrate blank" from glass specified as having less than 7 nm/cm birefringence; or

2. Designed to be used by lithography equipment having a light source wavelength less than 245 nm;

Note: 3B001.h. does not control multi-layer masks with a phase shift layer designed for the fabrication of memory devices not specified in 3A001.

i. Imprint lithography templates designed for integrated circuits specified in 3A001.

j. Mask "substrate blanks" with multilayer reflector structure consisting of molybdenum and silicon, and having all of the following:

1. Specially designed for 'Extreme Ultraviolet' ('EUV') lithography; and

2. Compliant with SEMI Standard P37.

Technical Note:
'Extreme Ultraviolet' ('EUV') refers to electromagnetic spectrum wavelengths greater than 5 nm and less than 124 nm.

3B002 Test equipment specially designed for testing finished or unfinished semiconductor devices as follows and specially designed components and accessories therefor:

a. For testing S-parameters of items specified in 3A001.b.3.;

b. Not used;

c. For testing items specified in 3A001.b.2.

3C Materials

3C001 Hetero-epitaxial materials consisting of a "substrate" having stacked epitaxially grown multiple layers of any of the following:

a. Silicon (Si);

b. Germanium (Ge);

c. Silicon carbide (SiC); or

d. "III/V compounds" of gallium or indium.

Note: *3C001.d. does not control a "substrate" having one or more P-type epitaxial layers of GaN, InGaN, AlGaN, InAlN, InAlGaN, GaP, GaAs, AlGaAs, InP, InGaP, AlInP or InGaAlP, independent of the sequence of the elements, except if the P-type epitaxial layer is between N-type layers.*

3C002 Resist materials as follows and "substrates" coated with the following resists:

a. Resists designed for semiconductor lithography as follows:

1. Positive resists adjusted (optimised) for use at wavelengths less than 193 nm but equal to or greater than 15 nm;

2. Resists adjusted (optimised) for use at wavelengths less than 15 nm but greater than 1 nm;

b. All resists designed for use with electron beams or ion beams, with a sensitivity of 0,01 μcoulomb/mm^2 or better;

c. Not used;

d. All resists optimised for surface imaging technologies;

e. All resists designed or optimised for use with imprint lithography equipment specified in 3B001.f.2. that use either a thermal or photo-curable process.

3C003 Organo-inorganic compounds as follows:

a. Organo-metallic compounds of aluminium, gallium or indium, having a purity (metal basis) better than 99,999%;

b. Organo-arsenic, organo-antimony and organo-phosphorus compounds, having a purity (inorganic element basis) better than 99,999%.

Note: 3C003 only controls compounds whose metallic, partly metallic or non-metallic element is directly linked to carbon in the organic part of the molecule.

3C004 Hydrides of phosphorus, arsenic or antimony, having a purity better than 99,999%, even diluted in inert gases or hydrogen.

Note: 3C004 does not control hydrides containing 20% molar or more of inert gases or hydrogen.

3C005 High resistivity materials as follows:

a. Silicon carbide (SiC), gallium nitride (GaN), aluminium nitride (AlN) or aluminium gallium nitride (AlGaN) semiconductor "substrates", or ingots, boules, or other preforms of those materials, having resistivities greater than 10 000 ohm-cm at 20°C;

b. Polycrystalline "substrates" or polycrystalline ceramic "substrates", having resistivities greater than 10 000 ohm-cm at 20°C and having at least one non-epitaxial single-crystal layer of silicon (Si), silicon carbide (SiC), gallium nitride (GaN), aluminium nitride (AlN), or aluminium gallium nitride (AlGaN) on the surface of the "substrate".

3C006 Materials, not specified in 3C001, consisting of a "substrate" specified in 3C005 with at least one epitaxial layer of silicon carbide, gallium nitride, aluminium nitride or aluminium gallium nitride.

3D Software

3D001 "Software" specially designed for the "development" or "production" of equipment specified in 3A001.b. to 3A002.h. or 3B.

3D002 "Software" specially designed for the "use" of equipment specified in 3B001.a. to f., 3B002 or 3A225

3D003 'Physics-based' simulation "software" specially designed for the "development" of lithographic, etching or deposition processes for translating masking patterns into specific topographical patterns in conductors, dielectrics or semiconductor materials.

Technical Note:
'Physics-based' in 3D003 means using computations to determine a sequence of physical cause and effect events based on physical properties (e.g., temperature, pressure, diffusion constants and semiconductor materials properties).

Note: Libraries, design attributes or associated data for the design of semiconductor devices or integrated circuits are considered as "technology".

3D004 "Software" specially designed for the "development" of equipment specified in 3A003.

3D101 "Software" specially designed or modified for the "use" of equipment specified in 3A101.b.

3D225 "Software" specially designed to enhance or release the performance of frequency changers or generators to meet the characteristics of 3A225.

3E Technology

3E001 "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials specified in 3A, 3B or 3C;

Note 1: *3E001 does not control "technology" for equipment or components specified in 3A003.*

Note 2: *3E001 does not control "technology" for integrated circuits specified in 3A001.a.3. to 3A001.a.12., having all of the following:*

a. Using "technology" at or above 0,130 µm; and

b. Incorporating multi-layer structures with three or fewer metal layers.

Note 3: *3E001 does not control 'Process Design Kits' ('PDKs') unless they include libraries implementing functions or technologies for items specified in 3A001.*

Technical Note:

A 'Process Design Kit' ('PDK') is a software tool provided by a semiconductor manufacturer to ensure that the required design practices and rules are taken into account in order to successfully produce a specific integrated circuit design in a specific semiconductor process, in accordance with technological and manufacturing constraints (each semiconductor manufacturing process has its particular 'PDK').

3E002 "Technology" according to the General Technology Note, other than that specified in 3E001,for the "development" or "production" of a "microprocessor microcircuit", "microcomputer microcircuit" or microcontroller microcircuit core, having an arithmetic logic unit with an access width of 32 bits or more and any of the following features or characteristics:

a. A 'vector processor unit' designed to perform more than two calculations on floating-point vectors (one-dimensional arrays of 32-bit or larger numbers) simultaneously;

Technical Note:
A 'vector processor unit' is a processor element with built-in instructions that perform multiple calculations on floating-point vectors (one-dimensional arrays of 32-bit or larger numbers) simultaneously, having at least one vector arithmetic logic unit and vector registers of at least 32 elements each.

b. Designed to perform more than four 64-bit or larger floating-point operation results per cycle; or

c. Designed to perform more than eight 16-bit fixed-point multiply-accumulate results per cycle (e.g., digital manipulation of analogue information that has been previously converted into digital form, also known as digital "signal processing").

Note 1: *3E002 does not control "technology" for multimedia extensions.*

Note 2: *3E002 does not control "technology" for micro-processor cores, having all of the following:*
a. Using "technology" at or above 0,130 µm; and
b. Incorporating multi-layer structures with five or fewer metal layers.

Note 3: *3E002 includes "technology" for the "development" or "production" of digital signal processors and digital array processors.*

3E003 Other "technology" for the "development" or "production" of the following:

a. Vacuum microelectronic devices;

b. Hetero-structure semiconductor electronic devices such as high electron mobility transistors (HEMT), hetero-bipolar transistors (HBT), quantum well and super lattice devices;

Note: 3E003.b. does not control "technology" for high electron mobility transistors (HEMT) operating at frequencies lower than 31,8 GHz and hetero-junction bipolar transistors (HBT) operating at frequencies lower than 31,8 GHz.

c. "Superconductive" electronic devices;

d. Substrates of films of diamond for electronic components.

e. Substrates of silicon-on-insulator (SOI) for integrated circuits in which the insulator is silicon dioxide;

f. Substrates of silicon carbide for electronic components;

g. 'Vacuum electronic devices' operating at frequencies of 31,8 GHz or higher.

3E101 "Technology" according to the General Technology Note for the "use" of equipment or "software" specified in 3A001.a.1. or 2., 3A101, 3A102 or 3D101.

3E102 "Technology" according to the General Technology Note for the "development" of "software"specified in 3D101.

3E201 "Technology" according to the General Technology Note for the "use" of equipment specified in 3A001.e.2., 3A001.e.3., 3A001.g., 3A201, 3A225 to 3A234.

3E225 "Technology", in the form of codes or keys, to enhance or release the performance of frequency changers or generators to meet the characteristics of 3A225.