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., 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. 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.*
If the integrated circuit is a silicon-based "microcomputer microcircuit" or microcontroller microcircuit described in 3A001.a.3. having an operand (data) word length of 8 bit or less, the control status of the integrated circuit is determined in 3A001.a.3.

3A001 Electronic components, 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".

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

   a. A total dose of 5×10^3 Gy (silicon) or higher;
   b. A dose rate upset of 5×10^6 Gy (silicon)/s or higher; or
   c. A fluence (integrated flux) of neutrons (1 MeV equivalent) of 5×10^{13} n/cm^2 or higher on silicon, or its equivalent for other materials;

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

2. "Microprocessor microcircuits", "microcomputer microcircuits", microcontroller microcircuits, storage integrated circuits manufactured from a compound semiconductor, analogue-to-digital converters, digital-to-analogue converters, electro-optical or "optical integrated circuits" designed for "signal processing", field programmable logic devices, neural network integrated circuits, 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, electrical erasable programmable read-only memories (EEPROMs), flash memories or static random-access memories (SRAMs), 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 apply to integrated circuits for civil automobiles or railway train applications.*

3. "Microprocessor microcircuits", "micro-computer 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. Storage integrated circuits manufactured from a compound semiconductor;

5. Analogue-to-digital and digital-to-analogue converter integrated circuits, as follows:
   a. Analogue-to-digital converters having any of the following:
      N.B. SEE ALSO 3A101
      1. A resolution of 8 bit or more, but less than 10 bit, with an output rate greater than 500 million words per second;
      2. A resolution of 10 bit or more, but less than 12 bit, with an output rate greater than 200 million words per second;
      3. A resolution of 12 bit with an output rate greater than 105 million words per second;
      4. A resolution of more than 12 bit, but equal to or less than 14 bit, with an output rate greater than 10 million words per second; or
      5. A resolution of more than 14 bit with an output rate greater than 2.5 million words per second;

b. Digital-to-analogue converters with a resolution of 12 bit or more, and a "settling time" of less than 10 ns;

Technical Notes:

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

2. The number of bits in the output word is equal to the resolution of the analogue-to-digital converter.

3. The output rate is the maximum output rate of the converter, regardless of the architecture or oversampling. Vendors may also refer to the output rate as sampling rate, conversion rate or throughput rate. It is often specified in megaghertz (MHz) or mega samples per second (MSPS).

4. For the purpose of measuring output rate, one output word per second is equivalent to one Hertz or one sample per second.

6. Electro-optical and "optical integrated circuits" designed for "signal processing" 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. An equivalent usable gate count of more than 30,000 (2 input gates);
   b. A typical "basic gate propagation delay time" of less than 0.1 ns; or
   c. A toggle frequency exceeding 133 MHz;

   Note: 3A001.a.7. includes:
   - *Simple Programmable Logic Devices (SPLDs)*
   - *Complex Programmable Logic Devices (CPLDs)*
   - *Field Programmable Gate Arrays (FPGAs)*
   - *Field Programmable Logic Arrays (FPLAs)*
   - *Field Programmable Interconnects (FPICs)*

   N.B.: Field programmable logic devices are also known as field programmable gate or field programmable logic arrays.

8. Deleted;

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 1,000 terminals;
    b. A typical "basic gate propagation delay time" of less than 0.1 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 3000 (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.

b. Microwave or millimetre wave components, as follows:

1. Electronic vacuum tubes and cathodes, as follows:
   Note 1: *3A001.b.1. does not control tubes designed or rated for operation in any frequency band which meets all of the following characteristics:*
   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" tubes which meet all of the following characteristics:*
   a. An average output power equal to or less than 50 W; and
   b. Designed or rated for operation in any frequency band which meets all of the following characteristics:
   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 tubes, pulsed or continuous wave, as follows:
      1. Operating at frequencies exceeding 31.8 GHz;
      2. Having a cathode heater element with a turn on time to rated RF power of less than 3 seconds;
      3. Coupled cavity tubes, or derivatives thereof, with a "fractional bandwidth" of more than 7% or a peak power exceeding 2.5 kW;
      4. Helix tubes, or derivatives thereof, with any of the following characteristics:
         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; or
         c. Being "space qualified";

b. Crossed-field amplifier tubes with a gain of more than 17 dB;

c. Impregnated cathodes designed for electronic tubes producing a continuous emission current density at rated operating conditions exceeding 5 A/cm^2;

2. Microwave monolithic integrated circuits (MMIC) power amplifiers having any of the following:
   a. Rated for operation at frequencies exceeding 3.2 GHz up to and including 6 GHz and with an average output power greater than 4W (36 dBm) with a "fractional bandwidth" greater than 15%;
   b. Rated for operation at frequencies exceeding 6 GHz up to and including 16 GHz and with an average output power greater than 1W (30 dBm) with a "fractional bandwidth" greater than 10%;
   c. Rated for operation at frequencies exceeding 16 GHz up to and including 31.8 GHz and with an average output power greater than 0.8W (29 dBm) with a "fractional bandwidth" greater than 10%;
   d. Rated for operation at frequencies exceeding 31.8 GHz up to and including 37.5 GHz;
   e. Rated for operation at frequencies exceeding 37.5 GHz up to and including 43.5 GHz and with an average output power greater than 0.25W (24 dBm) with a "fractional bandwidth" greater than 10%; or
   f. Rated for operation at frequencies exceeding 43.5 GHz.

   Note 1: *3A001.b.2. does not control broadcast satellite equipment designed or rated to operate in the frequency range of 40.5 GHz to 42.5 GHz.*

   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.f., is determined by the lowest average output power control threshold.*

   Note 3: *Notes 1 and 2 in the chapeau to Category 3 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 having any of the following:
   a. Rated for operation at frequencies exceeding 3.2 GHz up to and including 6 GHz and having an average output power greater than 60W (47.8 dBm);
   b. Rated for operation at frequencies exceeding 6 GHz up to and including 31.8 GHz and having an average output power greater than 20W (43 dBm);
   c. Rated for operation at frequencies exceeding 31.8 GHz up to and including 37.5 GHz and having an average output power greater than 0.5W (27 dBm);

d. Rated for operation at frequencies exceeding 37.5 GHz up to and including 43.5 GHz and having an average output power greater than 1W (30 dBm); or
e. Rated for operation at frequencies exceeding 43.5 GHz.

Note: *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 3A001b.3.e., is determined by the lowest average output power control threshold.*

4. Microwave solid state amplifiers and microwave assemblies/modules containing microwave amplifiers, having any of the following:
   a. Rated for operation at frequencies exceeding 3.2 GHz up to and including 6 GHz and with an average output power greater than 60W (47.8 dBm) with a "fractional bandwidth" greater than 15%;
   b. Rated for operation at frequencies exceeding 6 GHz up to and including 31.8 GHz and with an average output power greater than 15W (42 dBm) with a "fractional bandwidth" greater than 10%;
   c. Rated for operation at frequencies exceeding 31.8 GHz up to and including 37.5 GHz;
   d. Rated for operation at frequencies exceeding 37.5 GHz up to and including 43.5 GHz and with an average output power greater than 1W (30 dBm) with a "fractional bandwidth" greater than 10%;
   e. Rated for operation at frequencies exceeding 43.5 GHz; or
   f. Rated for operation at frequencies above 3.2 GHz and having all of the following:
      1. An average output power (in watts), P, greater than 150 divided by the maximum operating frequency (in GHz) squared [$P>150\ W*GHz^2/f_{GHz}^2$];
      2. A fractional bandwidth of 5% or greater; and
      3. Any two sides perpendicular to one another with length d (in cm) equal to or less than 15 divided by the lowest operating frequency in GHz [$d\leq 15cm*GHz/ f_{GHz}$].

         Technical Note:

         3.2 GHz should be used as the lowest operating frequency (f_{GHz}) in the formula in 3A001.b.4.f.3., for amplifiers that have a rated operating range extending downward to 3.2 GHz and below [$d\leq 15cm*GHz/3.2\ GHz$].

N.B.: *MMIC power amplifiers should be evaluated against the criteria in 3A001.b.2.*

Note 1: *3A001.b.4. does not control broadcast satellite equipment designed or rated to operate in the frequency range of 40.5 to 42.5 GHz.*

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 average output power control 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 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. Deleted;

7. Mixers and converters designed to extend the frequency range of equipment described in 3A002.c., 3A002.e. or 3A002.f. beyond the limits stated therein;

8. Microwave power amplifiers containing tubes specified in 3A001.b. and having all of the following:
   a. Operating frequencies above 3 GHz;
   b. An average output power density 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 tube, a microwave monolithic integrated circuit and an integrated electronic power conditioner, having all of the following characteristics:
   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 any of the following:
      1. For frequencies equal to or less than 18 GHz, an RF output power greater than 100 W; or
      2. Having a frequency greater than 18 GHz.

   Technical Notes:

   1. To calculate the control 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.

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

1. Surface acoustic wave and surface skimming (shallow bulk) acoustic wave devices (i.e., "signal processing" devices employing elastic waves in materials), having any of the following:
   a. A carrier frequency exceeding 2.5 GHz;
   b. A carrier frequency exceeding 1 GHz, but not exceeding 2.5 GHz, and having any of the following:
      1. A frequency side-lobe rejection exceeding 55 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, 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 55 dB and a bandwidth greater than 50 MHz;

2. Bulk (volume) acoustic wave devices (i.e., "signal processing" devices employing elastic waves) which permit the direct processing of signals at frequencies exceeding 1 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;

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, with 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 an 'energy density' exceeding 550 Wh/kg at 20°C;

      b. 'Secondary cells' having an 'energy density' exceeding 250 Wh/kg

      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 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, and 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.*

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

2. High energy storage capacitors, as follows:
   N.B.: SEE ALSO 3A201.a.
   a. Capacitors with a repetition rate of less than 10 Hz (single shot capacitors) 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) 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, 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;

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 shaft absolute position encoders having any of the following:
   1. A resolution of better than 1 part in 265,000 (18 bit resolution) of full scale; or
   2. An accuracy better than ± 2.5 seconds of arc.

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

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

3A002 General purpose electronic equipment, as follows:

a. Recording equipment, as follows, and specially designed test tape therefor:

   1. Analogue instrumentation magnetic tape recorders, including those permitting the recording of digital signals (e.g. using a high density digital recording (HDDR) module), having any of the following:
      a. A bandwidth exceeding 4 MHz per electronic channel or track;
      b. A bandwidth exceeding 2 MHz per electronic channel or track and having more than 42 tracks; or

c. A time displacement (base) error, measured in accordance with applicable IRIG or EIA documents, of less than ± 0.1 μs;

Note: Analogue magnetic tape recorders specially designed for civilian video purposes are not considered to be instrumentation tape recorders.

2. Digital video magnetic tape recorders having a maximum digital interface transfer rate exceeding 360 Mbit/s;

Note: 3A002.a.2. does not control digital video magnetic tape recorders specially designed for television recording using a signal format, which may include a compressed signal format, standardised or recommended by the ITU, the IEC, the SMPTE, the EBU, the ETSI or the IEEE for civil television applications.

3. Digital instrumentation magnetic tape data recorders employing helical scan techniques or fixed head techniques, having any of the following:
   a. A maximum digital interface transfer rate exceeding 175 Mbit/s; or
   b. Being "space qualified";

   Note: 3A002.a.3. does not control analogue magnetic tape recorders equipped with HDDR conversion electronics and configured to record only digital data.

4. Equipment, having a maximum digital interface transfer rate exceeding 175 Mbit/s, designed to convert digital video magnetic tape recorders for use as digital instrumentation data recorders;

5. Waveform digitisers and transient recorders having all of the following:
   a. Digitising rate equal to or more than 200 million samples per second and a resolution of 10 bit or more; and
   b. A continuous throughput of 2 Gbit/s or more;

   Technical Note:
   For those instruments with a parallel bus architecture, the continuous throughput rate is the highest word rate multiplied by the number of bits in a word.
   Continuous throughput is the fastest data rate the instrument can output to mass storage without the loss of any information whilst sustaining the sampling rate and analogue-to-digital conversion.

8. Digital instrumentation data recorders, using magnetic disk storage technique, having all of the following:
   a. Digitising rate equal to or more than 100 million samples per second and a resolution of 8 bit or more; and
   b. A continuous throughput of 1 Gbit/s or more;

b. "Frequency synthesiser" "electronic assemblies" having a "frequency switching time" from one selected frequency to another of less than 1 ms;

Note: *The control status of signal analysers, signal generators, network analysers, and microwave test receivers as stand-alone instruments is determined by 3A002.c., 3A002.d., 3A002.e., and 3A002.f., respectively.*

c. Radio frequency "signal analysers", as follows:
   1. "Signal analysers" capable of analysing frequencies exceeding 31.8 GHz but but not exceeding 37.5 GHz and having a 3 dB resolution bandwidth (RBW) exceeding 10 MHz;
   2. "Signal analysers" capable of analysing frequencies exceeding 43.5 GHz;
   3. "Dynamic signal analysers" having a "real-time bandwidth" exceeding 500 kHz;
      Note: *3A002.c.3. does not control those "dynamic signal analysers" using only constant percentage bandwidth filters (also known as octave or fractional octave filters).*

d. Frequency synthesised signal generators producing output frequencies, the accuracy and short term and long term stability of which are controlled, derived from or disciplined by the internal master reference oscillator, and having any of the following:
   1. A maximum synthesised frequency exceeding31.8 GHz but not exceeding 43.5 GHz and rated to generate a 'pulse duration' of less than 100 ns;
   2. A maximum synthesised frequency exceeding 43.5 GHz;
   3. A "frequency switching time" from one selected frequency to another as specified by any of the following:
      a. Less than 10 ns;
      b. Less than 100 µs for any frequency change exceeding 1.6 GHz within the synthesised frequency range exceeding 3.2 GHz but not exceeding 10.6 GHz;
      c. Less than 250 µs for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 10.6 GHz but not exceeding 31.8 GHz;
      d. Less than 500 µs for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 31.8 GHz but not exceeding 43.5 GHz; or
      e. Less than 1 ms within the synthesised frequency range exceeding 43.5 GHz; or
   4. A single sideband (SSB) phase noise better than $-(126 + 20 \log_{10}F - 20 \log_{10}f)$ in dBc/Hz, where F is the off-set from the operating frequency in Hz and f is the operating frequency in MHz;

   Note 1: *For the purpose of 3A002.d., the term frequency synthesised signal generators includes 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. *Arbitrary waveform and function generators are normally specified by sample rate (e.g., GSample/s), which is converted to the RF domain by the Nyquist factor of two. Thus, a 1 GSample/s arbitrary waveform has a direct output capability of 500 MHz. Or, when oversampling is used, the maximum direct output capability is proportionately lower.*
2. *For the purposes of 3A002.d.1., 'pulse duration' is defined as the time interval between the leading edge of the pulse achieving 90% of the peak and the trailing edge of the pulse achieving 10% of the peak.*

e. Network analysers with a maximum operating frequency exceeding 43.5 GHz;

f. Microwave test receivers having all of the following:
   1. A maximum operating frequency exceeding 43.5 GHz; and
   2. Being capable of measuring amplitude and phase simultaneously;

g. Atomic frequency standards having any of the following:
   1. Long-term stability (aging) less (better) than 1×10^{-11}/month; or
   2. Being "space qualified".

   Note: 3A002.g.1. does not control non-"space qualified" rubidium standards.

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, not controlled 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, not controlled 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;

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:*

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, not controlled in 0B001.b.13., having all of the following characteristics:

a. Multiphase output capable of providing a power of 40 W or greater;
b. Capable of operating in the frequency range between 600 and 2000 Hz;
c. Total harmonic distortion better (less) than 10%; and
d. Frequency control better (less) than 0.1%.

Technical Note:
Frequency changers in 3A225 are also known as converters or inverters.

3A226 High-power direct current power supplies, not controlled 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, not controlled 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., 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 Firing sets and equivalent high-current pulse generators as follows:
N.B.: SEE ALSO ML4.b.

a. Explosive detonator firing sets designed to drive multiple controlled detonators specified in 3A232;

b. Modular electrical pulse generators (pulsers) having all of the following characteristics:
   1. Designed for portable, mobile, or ruggedized-use;
   2. Enclosed in a dust-tight enclosure;
   3. Capable of delivering their energy in less than 15 µs;
   4. Having an output greater than 100 A;
   5. Having a 'rise time' of less than 10 µs into loads of less than 40 ohms;
   6. No dimension greater than 254 mm;
   7. Weight less than 25 kg; and
   8. 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.*
   Technical Note:
   In 3A229.b.5. 'rise time' is defined as the time interval from 10% to 90% current amplitude when driving a resistive load.

3A230 High-speed pulse generators 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 Note:

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

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

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

b. Utilizing electrostatic acceleration to induce a tritium-deuterium nuclear reaction.

3A232 Detonators and multipoint initiation systems, as follows:

N.B.: SEE ALSO ML4.b.

a. Electrically driven explosive detonators, as follows:
   1. Exploding bridge (EB);
   2. Exploding bridge wire (EBW);
   3. Slapper;
   4. Exploding foil initiators (EFI);

b. Arrangements using single or multiple detonators designed to nearly simultaneously initiate an explosive surface over 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.

Technical Note:

In 3A232 the detonators of concern all utilise a small electrical conductor (bridge, bridge wire or foil) that explosively vapourises when a fast, high-current electrical pulse is passed through it. In nonslapper types, the exploding conductor starts a chemical detonation in a contacting high-explosive material such as PETN (Pentaerythritoltetranitrate). In slapper detonators, the explosive vapourisation of the electrical conductor drives a flyer or slapper across a gap and the impact of the slapper on an explosive starts a chemical detonation. The slapper in some designs is driven by a magnetic force. The term exploding foil detonator may refer to either an EB or a slapper-type detonator. Also, the word initiator is sometimes used in place of the word detonator.

3A233 Mass spectrometers, not controlled in 0B002.g., capable of measuring ions of 230 atomic mass units 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 which have a source chamber constructed from, lined with or plated with materials resistant to UF_6;

e. Molecular beam mass spectrometers having either of the following characteristics:
   1. A source chamber constructed from, lined with or plated with stainless steel or molybdenum and equipped with a cold trap capable of cooling to 193 K (-80°C) or less; or
   2. A source chamber constructed from, lined with or plated with materials resistant to UF_6;

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

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:

a. Equipment designed for epitaxial growth, as follows:
   1. Equipment capable of producing 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;
   2. Metal organic chemical vapour deposition (MOCVD) reactors specially designed for compound semiconductor crystal growth by the chemical reaction between materials specified in 3C003 or 3C004;
   3. Molecular beam epitaxial growth equipment using gas or solid sources;

b. Equipment designed for ion implantation, having any of the following:
   1. A beam energy (accelerating voltage) exceeding 1MeV;
   2. Being specially designed and optimised to operate at a beam energy (accelerating voltage) of less than 2 keV;
   3. Direct write capability; or
   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";

c. Anisotropic plasma dry etching equipment, as follows:
   1. Equipment with cassette-to-cassette operation and load-locks, and having any of the following:
      a. Designed or optimised to produce critical dimensions of 180 nm or less with ± 5% 3 sigma precision; or
      b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 μm in diameter;
   2. Equipment specially designed for equipment specified in 3B001.e. and having any of the following:
      a. Designed or optimised to produce critical dimensions of 180 nm or less with ± 5% 3 sigma precision; or
      b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 μm in diameter;

d. Plasma enhanced CVD equipment, as follows:
   1. Equipment with cassette-to-cassette operation and load-locks, and designed according to the manufacturer's specifications or optimised for use in the production of semiconductor devices with critical dimensions of 180 nm or less;

   2. Equipment specially designed for equipment controlled by 3B001.e. designed according to the manufacturer's specifications or optimised for use in the production of semiconductor devices with critical dimensions of 180 nm or less;

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 pieces of semiconductor processing equipment are 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 not designed to operate in a vacuum environment.*

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, having any of the following:

      a. A light source wavelength shorter than 245 nm; or
      b. Capable of producing a pattern with a 'minimum resolvable feature' size of 180 nm or less;
         Technical Note:
         The 'minimum resolvable feature' size is calculated by the following formula:

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

         where the K factor = 0.45
         MRF = minimum resolvable feature size

   2. Imprint lithography equipment capable of producing features of 180 nm or less;
      Note: *3B001.f.2. includes:*
      a. Micro contact printing tools
      b. Hot embossing tools
      c. Nano-imprint lithography tools
      d. Step and flash imprint lithography (S-FIL) tools

   3. Equipment specially designed for mask making or semiconductor device processing using deflected focussed electron beam, ion beam or "laser" beam, having any of the following:
      a. A spot size smaller than 0.2 µm;
      b. Being capable of producing a pattern with a feature size of less than 1 µm; or
      c. An overlay accuracy of better than ± 0.20 µm (3 sigma);

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

h. Multi-layer masks with a phase shift layer;
   Note: *3B001.h. does not control multi-layer masks with a phase shift layer designed for the fabrication of memory devices not controlled by 3A001.*

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

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 transistor devices at frequencies exceeding 31.8 GHz;

b. Deleted;

c. For testing microwave integrated circuits 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;
b. Germanium;
c. Silicon carbide; or
d. III/V compounds of gallium or indium.

Technical Note:
III/V compounds are polycrystalline or binary or complex monocrystalline products consisting of elements of groups IIIA and VA of Mendeleyev's periodic classification table (e.g., gallium arsenide, gallium-aluminium arsenide, indium phosphide).

3C002 Resist materials, as follows, and "substrates" coated with controlled resists:

a. Positive resists designed for semiconductor lithography specially adjusted (optimised) for use at wavelengths below 245 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. All resists designed for use with X-rays, with a sensitivity of 2.5 mJ/mm^2 or better;

d. All resists optimised for surface imaging technologies, including 'silylated' resists.
Technical Note:
'Silylation' techniques are defined as processes incorporating oxidation of the resist surface to enhance performance for both wet and dry developing.

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 Silicon carbide (SiC) wafers having a resistivity of more than 10,000 ohm-cm.

3D Software

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

3D002 "Software" specially designed for the "use" of any of the following:

a. Equipment specified in 3B001.a. to f.; or
b. Equipment specified in 3B002.

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 the equipment specified in 3A003.

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

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 the "production" of equipment or components controlled by 3A003.

Note 2: 3E001 does not control "technology" for the "development" or "production" of integrated circuits specified in 3A001.a.3. to 3A001.a.12., having all of the following:
a. Using "technology" of 0.5 µm or more; and
b. Not incorporating 'multi-layer structures'.

Technical Note:
The term 'multi-layer structures' does not include devices incorporating a maximum of three metal layers and three polysilicon layers.

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 processing 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.

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

c. Designed to perform more than four 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: 3E002.c. does not control technology for multimedia extensions.

Note 1: 3E002 does not control "technology" for the "development" or "production" of 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 2: 3E002 includes "technology" for digital signal processors and digital array processors.

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

a. Vacuum microelectronic devices;
b. Hetero-structure semiconductor 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.

3E003 continued

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. Electronic vacuum tubes 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 3A233.