

**CATEGORY 4 - COMPUTERS**

**Note 1:** Computers, related equipment and “software” performing telecommunications or “local area network” functions must also be evaluated against the performance characteristics of Category 5, Part 1 (Telecommunications).

**Note 2:** Control units that directly interconnect the buses or channels of central processing units, “main storage” or disk controllers are not regarded as telecommunications equipment described in Category 5, Part 1 (Telecommunications).

**N.B:** For the control status of “software” specially designed for packet switching, see ECCN 5D001. (Telecommunications).

**Note 3:** Computers, related equipment and “software” performing cryptographic, cryptoanalytic, certifiable multi-level security or certifiable user isolation functions, or that limit electromagnetic compatibility (EMC), must also be evaluated against the performance characteristics in Category 5, Part 2 (“Information Security”).

**A. SYSTEMS, EQUIPMENT AND COMPONENTS**

**4A001 Electronic computers and related equipment, and “electronic assemblies” and specially designed components therefor.**

**License Requirements**

*Reason for Control:* NS, MT, AT, NP, XP

*Control(s)* Country Chart

NS applies to entire entry NS Column 2

MT applies to items in MT Column 1

4A001.a when the parameters in 4A101 are met or exceeded

AT applies to entire entry AT Column 1

NP applies, unless a License Exception is available. See §742.3(b) of the EAR for information on applicable licensing review policies.

XP applies to electronic computers with a CTP greater than 28,000 MTOPS, unless a License Exception is available. XP controls vary according to destination and end-user and end-use; however, XP does not apply to Canada. See §742.12 of the EAR for additional information.

**License Requirement Notes:** See §743.1 of the EAR for reporting requirements for exports under License Exceptions.

**License Exceptions**

- LVS: \$5000 for 4A001.a; N/A for MT and 4A001.b
- GBS: N/A
- CIV: N/A

**List of Items Controlled**

*Unit:* Equipment in number; parts and accessories in \$ value

●*Related Controls:* See also 4A101 and 4A994. Equipment designed or rated for transient ionizing radiation is subject to the export licensing authority of the U.S. Department of State, Directorate of Defense Trade Controls. (See 22 CFR part 121.)

*Related Definitions:* For the purposes of integrated circuits in 4A001.a.2,  $5 \times 10^3 \text{ Gy(Si)} = 5 \times 10^5 \text{ Rads (Si)}$ ;  $5 \times 10^6 \text{ Gy (Si)/s} = 5 \times 10^8 \text{ Rads (Si)/s}$ .

*Items:*

- a. Specially designed to have either of the

following characteristics:

a.1. Rated for operation at an ambient temperature below 228 K (-45°C) or above 358 K (85°C);

**Note:** 4A001.a.1. does not apply to computers specially designed for civil automobile or railway train applications.

a.2. Radiation hardened to exceed any of the following specifications:

a.2.a. A total dose of  $5 \times 10^3$  Gy (Si);

a.2.b. A dose rate upset of  $5 \times 10^6$  Gy (Si)/s; *or*

a.2.c. Single Event Upset of  $1 \times 10^7$  Error/bit/day;

b. Having characteristics or performing functions exceeding the limits in Category 5, Part 2 ("Information Security").

**4A003 “Digital computers”, “electronic assemblies”, and related equipment therefor, as follows, and specially designed components therefor.**

**License Requirements**

*Reason for Control:* NS, MT, CC, AT, NP, XP

<i>Control(s)</i>	<i>Country Chart</i>
NS applies to 4A003.b and .c	NS Column 1
NS applies to 4A003.a, .e, and .g	NS Column 2
MT applies to digital computers used as ancillary equipment for test	MT Column 1

facilities and equipment that are controlled by 9B005 or 9B006.

CC applies to “digital computers” for computerized finger-print equipment CC Column 1

AT applies to entire entry (refer to 4A994 for controls on “digital computers” with a CTP  $\geq 6$  but  $\leq$  to 190,000 MTOPS) AT Column 1

NP applies, unless a License Exception is available. See §742.3(b) of the EAR for information on applicable licensing review policies.

XP applies to “digital computers” with a CTP greater than 190,000 MTOPS, unless a License Exception is available. XP controls vary according to destination and end-user and end-use; however, XP does not apply to Canada. See §742.12 of the EAR for additional information.

*Note:* For all destinations, except those countries in Country Group E:1 of Supplement No. 1 to part 740 of the EAR, no license is required (NLR) for computers with a CTP not greater than 190,000 MTOPS and for “electronic assemblies” described in 4A003.c that are not capable of exceeding a CTP greater than 190,000 MTOPS in aggregation, except certain transfers as set forth in §746.3 (Iraq). Computers controlled in this entry for MT reasons are not eligible for NLR.

**License Exceptions**

- LVS: \$5000; N/A for MT, b. and .c.
- GBS: Yes, for 4A003.e, and .g and specially designed components therefor, exported separately or as part of a system.
- CTP: Yes, for computers controlled by 4A003.a or .b, and “electronic

assemblies” controlled by 4A003.c, to the exclusion of other technical parameters, with the exception of parameters specified as controlled for Missile Technology (MT) concerns and 4A003.e (equipment performing analog-to-digital conversions exceeding the limits of 3A001.a.5.a). See §740.7 of the EAR.

CIV: Yes, for .e, and .g.

### List of Items Controlled

*Unit:* Equipment in number; parts and accessories in \$ value

*Related Controls:* See also 4A994 and 4A980

*Related Definitions:* N/A

*Items:*

**Note 1:** 4A003 includes the following:

- a. Vector processors;
- b. Array processors;
- c. Digital signal processors;
- d. Logic processors;
- e. Equipment designed for “image enhancement”;
- f. Equipment designed for “signal processing”.

**Note 2:** The control status of the “digital computers” and related equipment described in 4A003 is determined by the control status of other equipment or systems provided:

a. The “digital computers” or related equipment are essential for the operation of the other equipment or systems;

b. The “digital computers” or related equipment are not a “principal element” of the other equipment or systems; and

**N.B. 1:** The control status of “signal processing” or “image enhancement” equipment specially designed for other equipment with functions limited to those required for the other equipment is determined by the control status of the other equipment even if it exceeds the “principal element” criterion.

**N.B. 2:** For the control status of “digital computers” or related equipment for telecommunications equipment, see Category 5, Part 1 (Telecommunications).

c. The “technology” for the “digital computers” and related equipment is determined by 4E.

a. Designed or modified for “fault tolerance”;

**Note:** For the purposes of 4A003.a., “digital computers” and related equipment are not considered to be designed or modified for “fault tolerance” if they utilize any of the following:

1. Error detection or correction algorithms in “main storage”;

2. The interconnection of two “digital computers” so that, if the active central processing unit fails, an idling but mirroring central processing unit can continue the system's functioning;

3. The interconnection of two central processing units by data channels or by use of shared storage to permit one central processing unit to perform other work until the second central processing unit fails, at which time the first central processing unit takes over in order to continue the system's functioning; or

4. The synchronization of two central

*processing units by “software” so that one central processing unit recognizes when the other central processing unit fails and recovers tasks from the failing unit.*

b. “Digital computers” having a “composite theoretical performance” (“CTP”) exceeding 190,000 million theoretical operations per second (MTOPS);

c. “Electronic assemblies” specially designed or modified to be capable of enhancing performance by aggregation of “computing elements” (“CEs”) so that the “CTP” of the aggregation exceeds the limit in 4A003.b.;

*Note 1: 4A003.c applies only to “electronic assemblies” and programmable interconnections not exceeding the limit in 4A003.b. when shipped as unintegrated “electronic assemblies”. It does not apply to “electronic assemblies” inherently limited by nature of their design for use as related equipment controlled by 4A003.d, or 4A003.e*

*Note 2: 4A003.c does not control “electronic assemblies” specially designed for a product or family of products whose maximum configuration does not exceed the limit of 4A003.b.*

d. [RESERVED]

e. Equipment performing analog-to-digital conversions exceeding the limits in 3A001.a.5;

f. [RESERVED]

g. Equipment specially designed to provide external interconnection of “digital computers” or associated equipment that allows communications at data rates exceeding 1.25 Gbyte/s.

*Note: 4A003.g does not control internal interconnection equipment (e.g., backplanes, buses) passive interconnection equipment, “network access controllers” or “communication*

*channel controllers”.*

**4A004 Computers, as follows (see List of Items Controlled) and specially designed related equipment, “electronic assemblies” and components therefor.**

**License Requirements**

*Reason for Control:* NS, AT

<i>Control(s)</i>	<i>Country Chart</i>
-------------------	----------------------

NS applies to entire entry	NS Column 2
----------------------------	-------------

AT applies to entire entry	AT Column 1
----------------------------	-------------

**License Exceptions**

LVS: \$5000

GBS: N/A

CIV: N/A

**List of Items Controlled**

*Unit:* Equipment in number; parts and accessories in \$ value

*Related Controls:* N/A

*Related Definitions:* N/A

*Items:*

a. “Systolic array computers”;

b. “Neural computers”;

c. “Optical computers”.

**4A101 Analog computers, “digital computers” or digital differential analyzers, other than those controlled by 4A001 designed or modified for use in “missiles”, having any of the following (see List of Items Controlled).**

**License Requirements**

*Reason for Control:* MT, AT

CC applies to entire entry

CC Column 1

*Control(s)*

*Country Chart*

AT applies to entire entry

AT Column 1

MT applies to entire entry

MT Column 1

**License Exceptions**

AT applies to entire entry

AT Column 1

LVS: N/A

GBS: N/A

CIV: N/A

**License Exceptions**

LVS: N/A

GBS: N/A

CIV: N/A

**List of Items Controlled**

*Unit:* Equipment in number

*Related Controls:* N/A

*Related Definitions:* N/A

*Items:*

**List of Items Controlled**

*Unit:* Equipment in number

*Related Controls:* N/A

*Related Definitions:* N/A

*Items:*

a. Rated for continuous operation at temperatures from below 228 K (-45° C) to above 328 K (+55°C); or

b. Designed as ruggedized or “radiation hardened”.

The list of items controlled is contained in the ECCN heading.

**4A994 Computers, “electronic assemblies”, and related equipment not controlled by 4A001 or 4A003, and specially designed components therefor.**

**License Requirements**

*Reason for Control:* AT

**●4A102 “Hybrid computers” specially designed for modelling, simulation or design integration of “missiles”. (These items are subject to the export licensing authority of the U.S. Department of State, Directorate of Defense Trade Controls. See 22 CFR part 121.)**

*Control(s)*

*Country Chart*

AT applies to entire entry

AT Column 1

**License Exceptions**

LVS: N/A

GBS: N/A

CIV: N/A

**4A980 Computers for fingerprint equipment, n.e.s.**

**License Requirements**

*Reason for Control:* CC, AT

**List of Items Controlled**

*Unit:* Equipment in number; parts and accessories in \$ value

*Related Controls:* N/A

*Related Definitions:* “Two dimensional vector

*Control(s)*

*Country Chart*

*rate*” is the number vectors generated per second that have 10 pixel poly line vectors, clip tested, randomly oriented, with either integer or floating point X-Y coordinate values (whichever produces the maximum rate) (see paragraph (g) of this ECCN).

*Items:*

*Note 1: The control status of the “digital computers” and related equipment described in 4A994 is determined by the control status of other equipment or systems provided:*

*a. The “digital computers” or related equipment are essential for the operation of the other equipment or systems;*

*b. The “digital computers” or related equipment are not a “principal element” of the other equipment or systems; and*

**N.B. 1:** *The control status of “signal processing” or “image enhancement” equipment specially designed for other equipment with functions limited to those required for the other equipment is determined by the control status of the other equipment even if it exceeds the “principal element” criterion.*

**N.B. 2:** *For the control status of “digital computers” or related equipment for telecommunications equipment, see Category 5, Part 1 (Telecommunications).*

*c. The “technology” for the “digital computers” and related equipment is determined by 4E.*

a. Electronic computers and related equipment, and “electronic assemblies” and specially designed components therefor, rated for operation at an ambient temperature above 343 K (70 °C);

b. “Digital computers” having a “composite theoretical performance” (“CTP”) equal to or

greater than 6 million theoretical operations per second (MTOPS);

c. “Electronic assemblies” that are specially designed or modified to enhance performance by aggregation of “computing elements” (“CEs”), as follows:

c.1. Designed to be capable of aggregation in configurations of 16 or more “computing elements” (“CEs”); or

c.2. Having a sum of maximum data rates on all channels available for connection to associated processors exceeding 40 million Byte/s;

**Note 1:** *4A994.c applies only to “electronic assemblies” and programmable interconnections with a “CTP” not exceeding the limits in 4A994.b, when shipped as unintegrated “electronic assemblies”. It does not apply to “electronic assemblies” inherently limited by nature of their design for use as related equipment controlled by 4A994.*

**Note 2:** *4A994.c does not control any “electronic assembly” specially designed for a product or family of products whose maximum configuration does not exceed the limits of 4A994.b.*

d. Disk drives and solid state storage equipment:

d.1. Magnetic, erasable optical or magneto-optical disk drives with a “maximum bit transfer rate” exceeding 25 million bit/s;

d.2. Solid state storage equipment, other than “main storage” (also known as solid state disks or RAM disks), with a “maximum bit transfer rate” exceeding 36 million bit/s;

e. Input/output control units designed for use with equipment controlled by 4A994.d;

f. Equipment for “signal processing” or “image

enhancement” having a “composite theoretical performance” (“CTP”) exceeding 8.5 million theoretical operations per second (MTOPS);

g. Graphics accelerators or graphics coprocessors that exceed a “three dimensional vector rate” of 400,000 or, if supported by 2-D vectors only, a “two dimensional vector rate” of 600,000;

*Note: The provisions of 4A994.g do not apply to work stations designed for and limited to:*

a. *Graphic arts (e.g., printing, publishing); and*

b. *The display of two-dimensional vectors.*

h. Color displays or monitors having more than 120 resolvable elements per cm in the direction of the maximum pixel density;

*Note 1: 4A994.h does not control displays or monitors not specially designed for electronic computers.*

*Note 2: Displays specially designed for air traffic control (ATC) systems are treated as specially designed components for ATC systems under Category 6.*

i. Equipment containing “terminal interface equipment” exceeding the limits in 5A991.

*Note: For the purposes of 4A994.i, “terminal interface equipment” includes “local area network” interfaces, modems and other communications interfaces. “Local area network” interfaces are evaluated as “network access controllers”.*

j. Equipment specially designed to provide external interconnection of “digital computers” or associated equipment that allows communications at data rates exceeding 80 Mbyte/s .

*Note: 4A994.j does not control internal*

*interconnection equipment (e.g., backplanes, buses) passive interconnection equipment, “network access controllers” or “communication channel controllers”.*

k. “Hybrid computers” and “electronic assemblies” and specially designed components therefor, as follows:

k.1. Containing “digital computers” controlled by 4A003;

k.2. Containing analog-to-digital converters having all of the following characteristics:

k.2.a. 32 channels or more; *and*

k.2.b. A resolution of 14 bit (plus sign bit) or more with a conversion rate of 200,000 conversions/s or more.

**B. TEST, INSPECTION AND PRODUCTION EQUIPMENT**

**4B994 Equipment for the “development” and “production” of magnetic and optical storage equipment.**

**License Requirements**

*Reason for Control:* AT

<i>Control(s)</i>	<i>Country Chart</i>
AT applies to entire entry	AT Column 1

**License Exceptions**

LVS: N/A  
 GBS: N/A  
 CIV: N/A

**List of Items Controlled**



NP applies, unless a License Exception is available. See §742.3(b) of the EAR for information on applicable licensing review policies.

XP applies to “software” for computers with a CTP greater than 190,000 MTOPS, unless a License Exception is available. XP controls vary according to destination and end-user and end-use; however, XP does not apply to Canada. See §742.12 of the EAR for additional information.

**License Requirement Notes:** See §743.1 of the EAR for reporting requirements for exports under License Exceptions.

**License Exceptions**

CIV: N/A

TSR: (a) N/A for:

- (1) “Software” for equipment or “software” requiring a license; *or*
- (2) “Software” described by TSR paragraph (b)(1)(ii) of this License Exception section, when exported or reexported to a destination not included in TSR paragraph (b)(1)(i) of this License Exception section.

(b) Yes for:

- (1) “Software”:
  - (i) Exported or reexported to Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, or the United Kingdom; and
  - (ii) Specially designed for the “development” or

“production” of any of the following:

- (A) “Digital” computers controlled by 4A003.b and having a CTP exceeding than 33,000 MTOPS; *or*
- (B) “Electronic assemblies” controlled by 4A003.c and capable of enhancing performance by aggregation of “computing elements” so that the CTP of the aggregation exceeds 33,000 MTOPS; *and*
- (2) All other “software” not described in TSR paragraphs (a) or (b)(1) of this License Exception section.

**List of Items Controlled**

*Unit:* \$ value

*Related Controls:* N/A

*Related Definitions:* N/A

*Items:*

- a. “Software” specially designed or modified for the “development”, “production” or “use” of equipment or “software” controlled by 4A001 to 4A004, or 4D (except 4D980, 4D993 or 4D994).
- b. “Software”, other than that controlled by the heading, specially designed or modified for the “development” or “production” of:
  - b.1. “Digital computers” having a “composite theoretical performance” (“CTP”) exceeding 28,000 MTOPS; or

b.2. “Electronic assemblies” specially designed or modified for enhancing performance by aggregation of “computing elements” (“CEs”) so that the “CTP” of the aggregation exceeds the limit in 4D001.b.1.

**4D002 “Software” specially designed or modified to support “technology” controlled by 4E (except 4E980, 4E992, and 4E993).**

**License Requirements**

*Reason for Control:* NS, AT, NP, XP

<i>Control(s)</i>	<i>Country Chart</i>
-------------------	----------------------

NS applies to entire entry	NS Column 1
----------------------------	-------------

AT applies to entire entry	AT Column 1
----------------------------	-------------

NP applies, unless a License Exception is available. See §742.3(b) of the EAR for information on applicable licensing review policies.

XP applies to "software" for computers with a CTP greater than 28,000 MTOPS, unless a License Exception is available. XP controls vary according to destination and end-user and end-use; however, XP does not apply to Canada. See §742.12 of the EAR for additional information.

**License Exceptions**

CIV: N/A  
 TSR: Yes, except N/A for “software” specifically designed or modified to support “technology” for computers requiring a license.

**List of Items Controlled**

*Unit:* \$ value  
*Related Controls:* N/A  
*Related Definitions:* N/A

*Items:*

The list of items controlled is contained in the ECCN heading.

**4D003 Specific “software”, as follows (see List of Items Controlled).**

**License Requirements**

*Reason for Control:* NS, AT

<i>Control(s)</i>	<i>Country Chart</i>
-------------------	----------------------

NS applies to entire entry	NS Column 1
----------------------------	-------------

AT applies to entire entry	AT Column 1
----------------------------	-------------

**License Exceptions**

CIV: N/A  
 TSR: Yes, except 4D003.c

**List of Items Controlled**

*Unit:* \$ value  
*Related Controls:* N/A  
*Related Definitions:* N/A  
*Items:*

a. Operating system “software”, “software” development tools and compilers specially designed for “multi-data-stream processing” equipment, in “source code”;

b. [RESERVED]

c. “Software” having characteristics or performing functions exceeding the limits in Category 5, Part 2 (“Information Security”);

**4D980 “Software” specially designed for the “development”, “production”, or “use” of items controlled by 4A980.**

**License Requirements**

*Reason for Control:* CC, AT

*Control(s)* Country Chart

CC applies to entire entry CC Column 1

AT applies to entire entry AT Column 1

**License Exceptions**

CIV: N/A

TSR: N/A

**List of Items Controlled**

*Unit:* \$ value

*Related Controls:* N/A

*Related Definitions:* N/A

*Items:*

The list of items controlled is contained in the ECCN heading.

**4D993 “Program” proof and validation “software”, “software” allowing the automatic generation of “source codes”, and operating system “software” specially designed for real time processing equipment.**

**License Requirements**

*Reason for Control:* AT

*Control(s)* Country Chart

AT applies to entire entry AT Column 1

**License Exceptions**

CIV: N/A

TSR: N/A

**List of Items Controlled**

*Unit:* \$ value

*Related Controls:* N/A

*Related Definitions:* “Global interrupt latency time” is the time taken by the computer system to recognize an interrupt due to the event, service the interrupt and perform a context switch to an alternate memory-resident task waiting on the interrupt.

*Items:*

a. “Program” proof and validation “software” using mathematical and analytical techniques and designed or modified for “programs” having more than 500,000 “source code” instructions;

b. “Software” allowing the automatic generation of “source codes” from data acquired on line from external sensors described in the Commerce Control List;

c. Operating system “software” specially designed for “real time processing” equipment that guarantees a “global interrupt latency time” of less than 20 microseconds.

**4D994 “Software” other than that controlled in 4D001 specially designed or modified for the “development”, “production”, or “use” of equipment controlled by 4A101, 4A994, 4B994, and materials controlled by 4C994.**

**License Requirements**

*Reason for Control:* AT

*Control(s)* Country Chart

AT applies to entire entry AT Column 1

**License Exceptions**

CIV: N/A

TSR: N/A

**List of Items Controlled**

*Unit:* \$ value  
*Related Controls:* N/A  
*Related Definitions:* N/A  
*Items:*

The list of items controlled is contained in the ECCN heading.

**E. TECHNOLOGY**

**4E001 “Technology” according to the General Technology Note, for the “development”, “production” or “use” of equipment or “software” controlled by 4A (except 4A980, 4A993 or 4A994) or 4D (except 4D980, 4D993, 4D994), and other specified technology, see List of Items Controlled.**

**License Requirements**

*Reason for Control:* NS, MT, CC, AT, NP, XP

<i>Control(s)</i>	<i>Country Chart</i>
NS applies to “technology” for commodities or software controlled by 4A001 to 4A004, 4D001 to 4D003	NS Column 1
MT applies to “technology” for items controlled by 4A001.a and 4A101 for MT reasons	MT Column 1
CC applies to “technology” for computerized fingerprint equipment controlled by 4A003 for CC reasons	CC Column 1
AT applies to entire entry	AT Column 1
NP applies, unless a License Exception is available. See §742.3(b) of the EAR for information on applicable licensing review	

policies.

XP applies to “technology” for computers with a CTP greater than 190,000 MTOPS, unless a License Exception is available. XP controls vary according to destination and end-user and end-use, however, XP does not apply to Canada. See §742.12 of the EAR for additional information.

**License Requirement Notes:** See §743.1 of the EAR for reporting requirements for exports under License Exceptions.

**License Exceptions**

- CIV: N/A
- TSR: (a) N/A for:
  - (1) “Technology” controlled for MT reasons; *or*
  - (2) “Technology” described by TSR paragraph (b)(2)(ii) of this License Exception, when exported or reexported to a destination not included in TSR paragraph (b)(2)(i) of this License Exception.
- (b) Yes for:
  - (1) “Technology” directly related to hardware eligible for export or reexport under a License Exception;
  - (2) “Technology”:
    - (i) Exported or reexported to Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, or the United Kingdom; and
    - (ii) For the “development” or “production” of any of the following:
      - (A) “Digital” computers controlled by

- 4A003.b and having a CTP exceeding 33,000 MTOPS;
- (B) “Electronic assemblies” controlled by 4A003.c and capable of enhancing performance by aggregation of “computing elements” so that the CTP of the aggregation exceeds 33,000 MTOPS; *or*
- (C) “Software” controlled by 4D001 and specially designed for the “development” or “production” of equipment listed in TSR paragraphs (b)(2)(ii)(A) or (b)(2)(ii)(B) of this License Exception section; *and*
- (3) All other “technology” not described in TSR paragraphs (a), (b)(1), or (b)(2) of this License Exception section.

**List of Items Controlled**

*Unit:* N/A  
*Related Controls:* N/A  
*Related Definitions:* N/A  
*Items:*

- a. “Technology” according to the General Technology Note, for the “development,” “production,” or “use” of equipment or “software” controlled by 4A (except 4A980, 4A993 or 4A994) or 4D (except 4D980, 4D993, 4D994).
- b. “Technology”, other than that controlled by 4E001.a, specially designed or modified for the “development” or “production” of:
- b.1. “Digital computers” having a “composite

theoretical performance” (“CTP”) exceeding 28,000 MTOPS; or

- b.2. “Electronic assemblies” specially designed or modified for enhancing performance by aggregation of “computing elements” (“CEs”) so that the “CTP” of the aggregation exceeds the limit in 4E001.b.1.

**4E980 “Technology” for the “development”, “production”, or “use” of items controlled by 4A980.**

**License Requirements**

*Reason for Control:* CC, AT

<i>Control(s)</i>	<i>Country Chart</i>
CC applies to entire entry	CC Column 1
AT applies to entire entry	AT Column 1

**License Exceptions**

CIV: N/A  
 TSR: N/A

**List of Items Controlled**

*Unit:* N/A  
*Related Controls:* N/A  
*Related Definitions:* N/A  
*Items:*

The list of items controlled is contained in the ECCN heading.

**4E992 “Technology” other than that controlled in 4E001 for the “development”, “production”, or “use” of equipment controlled by 4A994 and 4B994, materials controlled by 4C994, or “software” controlled by 4D993 or 4D994.**

**License Requirements**

*Reason for Control:* AT

*Control(s)* Country Chart

AT applies to entire entry AT Column 1

**License Exceptions**

CIV: N/A  
TSR: N/A

**List of Items Controlled**

*Unit:* N/A  
*Related Controls:* See also 4E994  
*Related Definitions:* N/A  
*Items:*

The list of items controlled is contained in the ECCN heading.

**4E993 Other “Technology” for the “development” or “production” of graphics accelerators or equipment designed for “multi-data-stream processing” and “technology” “required” for the “development” or “production” of magnetic hard disk drives.**

**License Requirements**

*Reason for Control:* AT

*Control(s)* Country Chart

AT applies to entire entry AT Column 1

**License Exceptions**

CIV: N/A  
TSR: N/A

**List of Items Controlled**

*Unit:* N/A  
*Related Controls:* N/A  
*Related Definitions:* N/A  
*Items:*

- a. “Technology” for the “development” or “production” of graphics accelerators;
- b. “Technology”, for the “development” or “production” of equipment designed for “multi-data-stream processing”;
- c. “Technology”, “required” for the “development” or “production” of magnetic hard disk drives with a “maximum bit transfer rate” (“MBTR”) exceeding 11 Mbit/s.

**EAR99 Items subject to the EAR that are *not* elsewhere specified in this CCL Category or in any other category in the CCL are designated by the number EAR99.**

**Information on How to Calculate “Composite Theoretical Performance (“CTP”)**

*N.B. See Interpretation 12: “Computers”, section 770.2(l)(3), to find guidance as to how to calculate the Composite Theoretical Performance (CTP) for computer systems with ‘Non-Uniform Memory Access’ (NUMA) architecture, and obtain a definition for NUMA.*

**Technical Note:**

**“COMPOSITE THEORETICAL PERFORMANCE” (“CTP”)**

*Abbreviations used in this Technical Note*

- “CE” “computing element”(typically an arithmetic logical unit)
- FP floating point

XP	fixed point
t	execution time
XOR	exclusive OR
CPU	central processing unit
TP	theoretical performance (of a single “CE”)
“CTP”	“composite theoretical performance” (multiple “CEs”)
R	effective calculating rate
WL	word length
L	word length adjustment
*	multiply

Execution time *t* is expressed in microseconds, TP and “CTP” are expressed in millions of theoretical operations per second (Mtops) and WL is expressed in bits.

*Outline of “CTP” calculation method*

“CTP” is a measure of computational performance given in Mtops. In calculating the “CTP” of an aggregation of “CEs” the following three steps are required:

1. Calculate the effective calculating rate *R* for each “CE”;

2. Apply the word length adjustment (*L*) to the effective calculating rate (*R*), resulting in a Theoretical Performance (TP) for each “CE”;

3. If there is more than one “CE”, combine the TPs, resulting in a “CTP” for the aggregation.

Details for these steps are given in the following sections.

**Note 1:** For aggregations of multiple “CEs” that have both shared and unshared memory subsystems, the calculation of “CTP” is completed hierarchically, in two steps: first, aggregate the groups of “CEs” sharing memory; second, calculate the “CTP” of the groups using the calculation method for multiple “CEs” not sharing memory.

**Note 2:** “CEs” that are limited to input/output and peripheral functions (e.g., disk drive, communication and video display controllers) are not aggregated into the “CTP” calculation.

The following table shows the method of calculating the Effective Calculating Rate R for each “CE”:

Step 1: *The effective calculating rate R*

For “CEs” Implementing: <b>Note:</b> Every “CE” must be evaluated independently.	Effective calculating Rate, R
XP only  $(R_{xp})$	$\frac{1}{3 * (t_{xp\ add})}$ if no add is implemented use: $\frac{1}{(t_{xp\ mult})}$ If neither add nor multiply is implemented use the fastest available arithmetic operation as follows: $\frac{1}{3 * t_{xp}}$ See Notes X & Z
FP only $(R_{fp})$	$\max \left( \frac{1}{t_{fp\ add}}, \frac{1}{t_{fp\ mult}} \right)$ See Notes X & Y
Both FP and XP $(R)$	Calculate both $R_{xp}, R_{fp}$
For simple logic processors not implementing any of the specified arithmetic operations.	$\frac{1}{3 * t_{log}}$ Where $t_{log}$ is the execute time of the XOR, or for logic hardware not implementing the XOR, the fastest simple logic operation. See Notes X & Z
For special logic processors not using any of the specified arithmetic or logic operations.	$R = R' * WL/64$ Where R' is the number of results per second, WL is the number of <i>bits</i> upon which the logic operation occurs, and 64 is a factor to normalize to a 64 bit operation.

**Note W:** For a pipelined “CE” capable of executing up to one arithmetic or logic operation every clock cycle after the pipeline is full, a pipelined rate can be established. The effective calculating rate (R) for such a “CE” is the faster of the pipelined rate or non-pipelined execution rate.

**Note X:** For a “CE” that performs multiple operations of a specific type in a single cycle (e.g., two additions per cycle or two identical logic operations per cycle), the execution time t is given by:

$$t = \frac{\text{cycle time}}{\text{the number of identical operations per machine cycle}}$$

“CEs” that perform different types of arithmetic or logic operations in a single machine cycle are to be treated as multiple separate “CEs” performing simultaneously (e.g., a “CE” performing an addition and a multiplication in one cycle is to be treated as two “CEs”, the first performing an addition in one cycle and the second performing a multiplication in one cycle). If a single “CE” has both scalar function and vector function, use the shorter execution time value.

**Note Y:** For the “CE” that does not implement FP add or FP multiply, but that performs FP divide:

$$R_{fp} = \frac{1}{t_{fp\text{divide}}}$$

If the “CE” implements FP reciprocal but not FP add, FP multiply or FP divide, then

$$R_{fp} = \frac{1}{t_{fp\text{reciprocal}}}$$

$t_{fp\text{reciprocal}}$

If none of the specified instructions is implemented, the effective FP rate is 0.

**Note Z:** In simple logic operations, a single instruction performs a single logic manipulation of no more than two operands of given lengths. In complex logic operations, a single instruction performs multiple logic manipulations to produce one or more results from two or more operands.

Rates should be calculated for all supported operand lengths considering both pipelined operations (if supported), and non-pipelined operations using the fastest executing instruction for each operand length based on:

1. Pipelined or register-to-register operations. Exclude extraordinarily short execution times generated for operations on a predetermined operand or operands (for example, multiplication by 0 or 1). If no register-to-register operations are implemented, continue with (2).
2. The faster of register-to-memory or memory-to-register operations; if these also do not exist, then continue with (3).
3. Memory-to-memory.

In each case above, use the shortest execution time certified by the manufacturer.

Step 2: *TP for each supported operand length WL*

Adjust the effective rate R (or R') by the word length adjustment L as follows:

$$TP = R * L, \text{ where } L = (1/3 + WL/96)$$

**Note:** The word length WL used in these calculations is the operand length in bits. (If an

operation uses operands of different lengths, select the largest word length.) The combination of a mantissa ALU and an exponent ALU of a floating point processor or unit is considered to be one “CE” with a Word Length (WL) equal to the number of bits in the data representation (typically 32 or 64) for purposes of the “CTP” calculation.

This adjustment is not applied to specialized logic processors that do not use XOR instructions. In this case  $TP = R$ .

Select the maximum resulting value of TP for:

Each XP-only “CE” ( $R_{xp}$ );

Each FP-only “CE” ( $R_{fp}$ );

Each combined FP and XP “CE” ( $R$ );

Each simple logic processor not implementing any of the specified arithmetic operations; *and*

Each special logic processor not using any of the specified arithmetic or logic operations.

Step 3: “CTP” for aggregations of “CEs”, including CPUs.

For a CPU with a single “CE”, “CTP” = TP (for “CEs” performing both fixed and floating point operations  
 $TP = \max (TP_{fp}, TP_{xp})$ )

“CTP” for aggregations of multiple “CEs” operating simultaneously is calculated as follows:

**Note 1:** For aggregations that do not allow all of the “CEs” to run simultaneously, the possible combination of “CEs” that provides the largest “CTP” should be used. The TP of each contributing “CE” is to be calculated at its maximum value theoretically possible before the

“CTP” of the combination is derived.

**N.B.:** To determine the possible combinations of simultaneously operating “CEs”, generate an instruction sequence that initiates operations in multiple “CEs”, beginning with the slowest “CE” (the one needing the largest number of cycles to complete its operation) and ending with the fastest “CE”. At each cycle of the sequence, the combination of “CEs” that are in operation during that cycle is a possible combination. The instruction sequence must take into account all hardware and/or architectural constraints on overlapping operations.

**Note 2:** A single integrated circuit chip or board assembly may contain multiple “CEs”.

**Note 3:** Simultaneous operations are assumed to exist when the computer manufacturer claims concurrent, parallel or simultaneous operation or execution in a manual or brochure for the computer.

**Note 4:** “CTP” values are not to be aggregated for “CE” combinations (inter)connected by “Local Area Networks”, Wide Area Networks, I/O shared connections/devices, I/O controllers and any communication interconnection implemented by “software”.

**Note 5:** “CTP” values must be aggregated for multiple “CEs” specially designed to enhance performance by aggregation, operating simultaneously and sharing memory,- or multiple memory/”CE”- combinations operating simultaneously utilizing specially designed hardware.

This aggregation does not apply to “electronic assemblies” described by 4A003.c.

$$\text{“CTP”} = TP_1 + C_2 * TP_2 + \dots + C_n * TP_n,$$

where the TPs are ordered by value, with TP<sub>1</sub> being the highest, TP<sub>2</sub> being the second highest, ..., and TP<sub>n</sub> being the lowest. C<sub>i</sub> is a coefficient determined by the strength of the interconnection between “CEs”, as follows:

For multiple “CEs” operating simultaneously and sharing memory:

$$C_2 = C_3 = C_4 = \dots = C_n = 0.75$$

**Note 1:** When the “CTP” calculated by the above method does not exceed 194 Mtops, the following formula may be used to calculate C<sub>i</sub>:

$$C_i = \frac{0.75}{\sqrt{m}} \quad (i = 2, \dots, n)$$

where m = the number of “CEs” or groups of “CEs” sharing access.

provided:

1. The TP<sub>1</sub> of each “CE” or group of “CEs” does not exceed 30 Mtops;
2. The “CEs” or groups of “CEs” share access to main memory (excluding cache memory) over a single channel; *and*
3. Only one “CE” or group of “CEs” can have use of the channel at any given time.

**N.B.:** This does not apply to items controlled under Category 3.

**Note 2:** “CEs” share memory if they access a common segment of solid state memory. This memory may include cache memory, main memory or other internal memory. Peripheral memory devices such as disk drives, tape drives or RAM disks are not included.

For Multiple “CEs” or groups of “CEs” not sharing memory, interconnected by one or more data channels:

$$\begin{aligned} C_i &= 0.75 * k_i \quad (i = 2, \dots, 32) \text{ (see Note below)} \\ &= 0.60 * k_i \quad (i = 33, \dots, 64) \\ &= 0.45 * k_i \quad (i = 65, \dots, 256) \\ &= 0.30 * k_i \quad (i > 256) \end{aligned}$$

The value of C<sub>i</sub> is based on the number of “CE”s, not the number of nodes.

where k<sub>i</sub> = min (S<sub>i</sub>/K<sub>r</sub>, 1), and  
 K<sub>r</sub> = normalizing factor of 20 MByte/s.  
 S<sub>i</sub> = sum of the maximum data rates (in units of MByte/s) for all data channels connected to the i<sup>th</sup> “CE” or group of “CEs” sharing memory.

When calculating a C<sub>i</sub> for a group of “CEs”, the number of the first “CE” in a group determines the proper limit for C<sub>i</sub>. For example, in an aggregation of groups consisting of 3 “CEs” each, the 22nd group will contain “CE”<sub>64</sub>, “CE”<sub>65</sub> and “CE”<sub>66</sub>. The proper limit for C<sub>i</sub> for this group is 0.60.

Aggregation (of “CEs” or groups of “CEs”) should be from the fastest-to-slowest; i.e.:

$$TP_1 \geq TP_2 \geq \dots \geq TP_n, \text{ and}$$

in the case of TP<sub>i</sub> = TP<sub>i+1</sub>, from the largest to smallest; i.e.:

$$C_i \geq C_{i+1}$$

**Note:** The k<sub>i</sub> factor is not to be applied to “CEs” 2 to 12 if the TP<sub>i</sub> of the “CE” or group of “CEs” is more than 50 Mtops; i.e., C<sub>i</sub> for “CEs” 2 to 12 is 0.75.