

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

<i>Control(s)</i>	<i>Country Chart</i>
NS applies to entire entry	NS Column 2
MT applies to items in 4A001.a when the	MT Column 1

parameters in 4A101 are met or exceeded

AT applies to entire entry AT Column 1

NP applies to electronic computers with a CTP greater than 6,500 Mtops, 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 6,500 Mtops, unless a License Exception is available. XP controls vary according to destination and end-user and end-use. 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, Office of Defense Trade Controls. (See 22 CFR part 121.) See also 4A101.

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

a.2.b. A dose rate upset of 5×10^6 Gy (Si)/s;

a.2.c. Single Event Upset of 1×10^{-7} Error/bit/day;

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

4A002 "Hybrid computers" 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 hybrid computers combined with specially designed "software", for modeling, simulation, or design integration of complete rocket systems and

Unmanned air vehicle systems that are usable in systems

controlled for MT reasons

AT applies to entire entry AT Column 1

NP applies to hybrid computers with a CTP greater than 6,500 Mtops, unless a License Exception is available. See §742.3(b) of the EAR for information on applicable licensing review policies.

XP applies to hybrid computers with a CTP greater than 6,500 Mtops, unless a License Exception is available. XP controls vary according to destination and end-user and end-use. See §742.12 of the EAR for additional information.

License Exceptions

LVS: \$5000; N/A for MT

GBS: N/A

CIV: N/A

List of Items Controlled

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

Related Controls: See also 4A102 and 4A994

Related Definitions: N/A

Items:

a. Containing "digital computers" controlled by 4A003;

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

b.1. 32 channels or more; *and*

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

4A003 "Digital computers", "electronic assemblies", and related equipment therefor, and specially designed components therefor.

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 6,500 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

from below 228 K (-45° C) to above 328 K (+55°C); *or*

b. Designed as ruggedized or "radiation hardened".

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, Office of Defense Trade Controls. See 22 CFR part 121.)

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

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

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:

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

4A994 Computers, "electronic assemblies", and related equipment not controlled by

4A001, 4A002, or 4A003, and specially designed components therefor.

License Requirements

Reason for Control: AT

Control(s) Country Chart

AT applies to entire entry AT Column 1

License Exceptions

LVS: N/A
 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: "Two dimensional vector 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:

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".

B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

4B994 Equipment for the "development" and "production" of magnetic and optical storage

NP, XP

Control(s) *Country Chart*
 NS applies to "software" for NS Column 1
 commodities or software
 controlled by 4A001 to 4A004,
 4D001 to 4D003

MT applies to "software" MT Column 1
 for equipment controlled by
 4A001 to 4A003 for MT reasons

CC applies to "software" CC Column 1
 for computerized
 finger-print equipment
 controlled by 4A003 for
 CC reasons

AT applies to entire entry AT Column 1

NP applies to "software" for computers with a CTP greater than 6,500 Mtops, 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 6,500 Mtops, unless a License Exception is available. XP controls vary according to destination and end-user and end-use. 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: Yes, except for the following:
 - (1) "Software" controlled for MT reasons;
 - (2) "Software" for equipment or "software" requiring a license; or
 - (3) Exports and reexports to destinations outside of Austria,

Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, the Netherlands, Portugal, Spain, Sweden, or the United Kingdom of "software" specially designed for the "development" or "production" of equipment controlled as follows:
 (a) "Digital" computers controlled by 4A003.b and having a CTP exceeding 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.

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.

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

License Requirements

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

<i>Control(s)</i>	<i>Country Chart</i>
NS applies to entire entry	NS Column 1
MT applies to "software" for equipment controlled by 4E for MT reasons	MT Column 1

AT applies to entire entry AT Column 1

the EAR for reporting requirements for exports under License Exception.

NP applies to "software" for computers with a CTP greater than 2,000 Mtops, unless a License Exception is available. See §742.3(b) of the EAR for information on applicable licensing review policies.

License Exceptions

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

XP applies to "software" for computers with a CTP greater than 2,000 Mtops, unless a License Exception is available. See §742.3(b) of the EAR for information on applicable licensing review policies.

List of Items Controlled

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

License Exceptions

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

- a. Operating system "software", "software" development tools and compilers specially designed for "multi-data-stream processing" equipment, in "source code";
- b. "Expert systems" or "software" for "expert system" inference engines providing both:

- b.1. Time dependent rules; *and*

- b.2. Primitives to handle the time characteristics of the rules and the facts;

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

- d. Operating systems specially designed for "real time processing" equipment that guarantees a "global interrupt latency time" of less than 20 s.

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

Control(s) Country Chart

NS applies to entire entry NS Column 1

AT applies to entire entry AT Column 1

License Requirement Notes: See §743.1 of

4D102 "Software" specially designed or modified for the "development", "production" or "use" of equipment controlled by 4A101.

License Requirements

Reason for Control: MT, AT

Control(s) Country Chart

MT applies to entire entry MT Column 1

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

AT applies to entire entry AT Column 1

License Exceptions

CIV: N/A

TSR: N/A

4D993 "Program" proof and validation "software", "software" allowing the automatic generation of "source codes", and operating system "software" not controlled by 4D003 that are specially designed for real time processing equipment.

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.

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

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

List of Items Controlled

Unit: \$ value

Related Controls: N/A

Related Definitions: N/A

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" not controlled by 4D003 that are specially designed for "real time processing" equipment that guarantees a "global interrupt latency time" of less than 30 microseconds.

License Exceptions

CIV: N/A

TSR: N/A

List of Items Controlled

Unit: \$ value

Related Controls: N/A

Related Definitions: N/A

Items:

4D994 "Software" specially designed or modified for the "development", "production", or "use" of equipment controlled by 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).

License Requirements

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

Control(s) Country Chart

NS applies to "technology" NS Column 1

Export Administration Regulations

for commodities or software controlled by 4A001 to 4A004, 4D001 to 4D003

MT applies to "technology" MT Column 1 for items controlled by 4A001 to 4A003 4A101, 4D001, 4D102 or 4D002 for MT reasons

CC applies to "technology" CC Column 1 for computerized fingerprint equipment controlled by 4A003 for CC reasons

AT applies to entire entry AT Column 1

NP applies to "technology" for computers with a CTP greater than 6,500 Mtops, 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 6,500 Mtops, unless a License Exception is available. XP controls vary according to destination and end-user and end-use. 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: Yes for "technology" directly related for hardware exported under a License Exception.

N/A for the following:

- (1) "Technology" controlled for MT reasons; or
- (2) Exports and reexports to destinations outside of Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan,

Luxembourg, the Netherlands, Portugal, Spain, Sweden, or the United Kingdom of "technology" for the "development" or "production" of the following items:

- (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" specially designed for the "development" or "production" of equipment listed in paragraphs (a) or (b) above.

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.

4E980 "Technology" 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: N/A
Related Controls: N/A
Related Definitions: N/A
Items:

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

4E992 "Technology" 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.

any other category in the CCL are designated by the number *EAR99*.

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.

Information on How to Calculate "Composite Theoretical Performance" ("CTP")

License Requirements

Reason for Control: AT

Technical Note:

"COMPOSITE THEORETICAL PERFORMANCE" ("CTP")

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

Abbreviations used in this Technical Note

License Exceptions

CIV: N/A
TSR: N/A

"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

List of Items Controlled

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

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.

- 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.

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:

EAR99 Items subject to the EAR that are *not* elsewhere specified in this CCL Category *or* in

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: Note: 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:

$$R_{fp} = \frac{1}{t_{fpdivide}}$$

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

$$R_{fp} = \frac{1}{t_{fpreciprocal}}$$

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.

$$"CTP" = TP_1 + C_2 * TP_2 + \dots + C_n * TP_n,$$

where the TPs are ordered by value, with TP_1 being the highest, TP_2 being the second highest, ..., and TP_n being the lowest. C_i 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_i :

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

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

provided:

1. The TP₁ 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:

$$C_i = 0.75 * k_i \quad (i = 2, \dots, 32) \text{ (see Note below)}$$

$$= 0.60 * k_i \quad (i = 33, \dots, 64)$$

$$= 0.45 * k_i \quad (i = 65, \dots, 256)$$

$$= 0.30 * k_i \quad (i > 256)$$

The value of C_i is based on the number of "CE"s, not the number of nodes.

where k_i = min (S_i/K_r, 1), and
 K_r = normalizing factor of 20 MByte/s.
 S_i = sum of the maximum data rates (in units of MByte/s) for all data channels connected to the ith "CE" or group of "CEs" sharing memory.

When calculating a C_i for a group of "CEs", the number of the first "CE" in a group determines the proper limit for C_i. For example, in an aggregation of groups consisting of 3 "CEs" each, the 22nd group will contain "CE"₆₄, "CE"₆₅ and "CE"₆₆. The proper limit for C_i 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_i = TP_{i+1}, from the largest to smallest; i.e.:

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

Note: The k_i factor is not to be applied to "CEs" 2 to 12 if the TP_i of the "CE" or group of "CEs" is more than 50 Mtops; i.e., C_i for "CEs" 2 to 12 is 0.75.