Selection Technical Guide for Yageo Fuses

1. Factors to Consider in Selection

Rated Current, Rated Voltage, Ambient Temperature, Breaking Capacity, Surge Current, Safety Regulations, Product Dimensions

Definitions of Factors

2. Definitions of Factors

2.1 Rated Current (In)

The rated working current labeled on the fuse. This value is determined by the manufacturer and represents the maximum current that the fuse can carry. The rated current is usually recommended in standard increments, such as 1, 10, 100 amperes, etc. (Unit: A).

2.2 Rated Voltage

The rated value of the fuse should be equal to or greater than the effective circuit voltage. Care should be taken to distinguish between DC or AC voltages when selecting.

2.3 Ambient Temperature

Refers to the air temperature directly surrounding the fuse, and should not be confused with room temperature. In many practical situations, the temperature of the fuse can be quite high, for instance when the fuse is installed in an enclosed space, or near heat-generating components like resistors, transformers, inductor coils, etc.

2.4 Breaking Capacity

Also known as interrupting capacity or short-circuit rated capacity. This refers to the maximum current that a fuse can safely interrupt at a specified voltage. When transient overload currents that might pass through a fuse exceed its rated value, the fuse can shatter or explode, posing a risk. Therefore, it is required that a fuse maintains its integrity after protection action (no bursting or breaking). The breaking capacity of a fuse depends on its structure; fuses with low breaking capacities are mostly encapsulated in glass, while those with high breaking capacities typically use ceramic casings, many filled with pure granular quartz material.

2.5 Product Dimensions

Unless otherwise specified, dimensions are given in imperial units. Yageo's current standard fuse product sizes are in imperial 0603, 1206, 2410, 2822.

2.6 Safety Regulations

Fuses are safety devices, and their quality directly impacts personnel and property safety. Before shipping, they

must undergo safety certification. This certification examines the fuse product's appearance, performance, structure, and materials rigorously. Any changes must receive certification from safety agencies. Yageo's products have passed UL safety certification, and the table below lists the product safety certification numbers.

3. Selection Criteria and Examples

3.1 Rated Current

Product Series	JC28F	JB06F	JB12 Series	JC24 Series
UL Certificate Number	E533612	E531845	E531845	E531845

It is essential to notice the de-rating of current for different certification standards. As per the UL standard, the de-rating is 0.75, implying that the steady-state operating current should not exceed 75% of In. For fuses certified according to the UL standard, at a 25℃ condition, the operating current should not exceed 75% of the fuse's rated current to avoid influencing the blow-out. For instance, a fuse with a rated current of 10A is generally not recommended to operate at currents exceeding 7.5A at an ambient temperature of 25℃.

For the board's working current, the current at the lowest permissible voltage should be considered. For instance, if the rated voltage is -48—60V, allowing a 20% fluctuation, and the board's working current at -48V is 0.8A, due to the board's constant power, the working current at -38V voltage is approximately 1A. When choosing a fuse, 1A should be taken as the board's working current. This should be particularly noted in applications where the input voltage range is broad.

Furthermore, consider if the power module has an under-voltage protection feature. For instance, a -48V power module generally protects under-voltage at -35V. However, some power modules, like the Huadian AV10 series, can work at -12V, which may result in an input current three times or more than the usual case.

3.2 Rated Voltage

The rated voltage marked on the fuse indicates the maximum operating voltage at which the fuse can be used. Standard rated voltages typically are DC32V and DC85V. Fuses are sensitive to current changes, not voltage changes. They maintain their state at any voltage between zero and their maximum rated value, so fuses can be used at any voltage less than their rated voltage.

3.3 Ambient Temperature

The current-carrying capacity test of the fuse is conducted at an ambient temperature of 25℃, which is affected by temperature changes. As the ambient temperature rises, the working temperature of the fuse increases, shortening its lifespan. Conversely, operating at lower temperatures will extend the life of the fuse. Therefore,

when choosing the rated current of a fuse, adjust according to its actual working temperature.

Example:

If a board's normal operating current is 1.5A, and it uses a slow-blow fuse certified by the UL standard and operates at room temperature, then:

Selected fuse In = Normal operating current / Certification standard de-rating = 1.5 / 0.75 = 2.0A (Ambient temperature 25℃)

If the fuse operates at a high ambient temperature of 70℃, according to the graph below, it shows that the temperature de-rating at 70℃ is 80%. In this case, the selected fuse In = Normal operating current / (Certification standard de-rating * Working temperature de-rating) = 1.5 / (0.75 * 0.8) = 2.5A (Ambient temperature 70℃).

Comparison:

Actual working current	Ambient Temperature	Required Minimum In
1.5A	25℃	2.0A
1.5A	70℃	2.5A

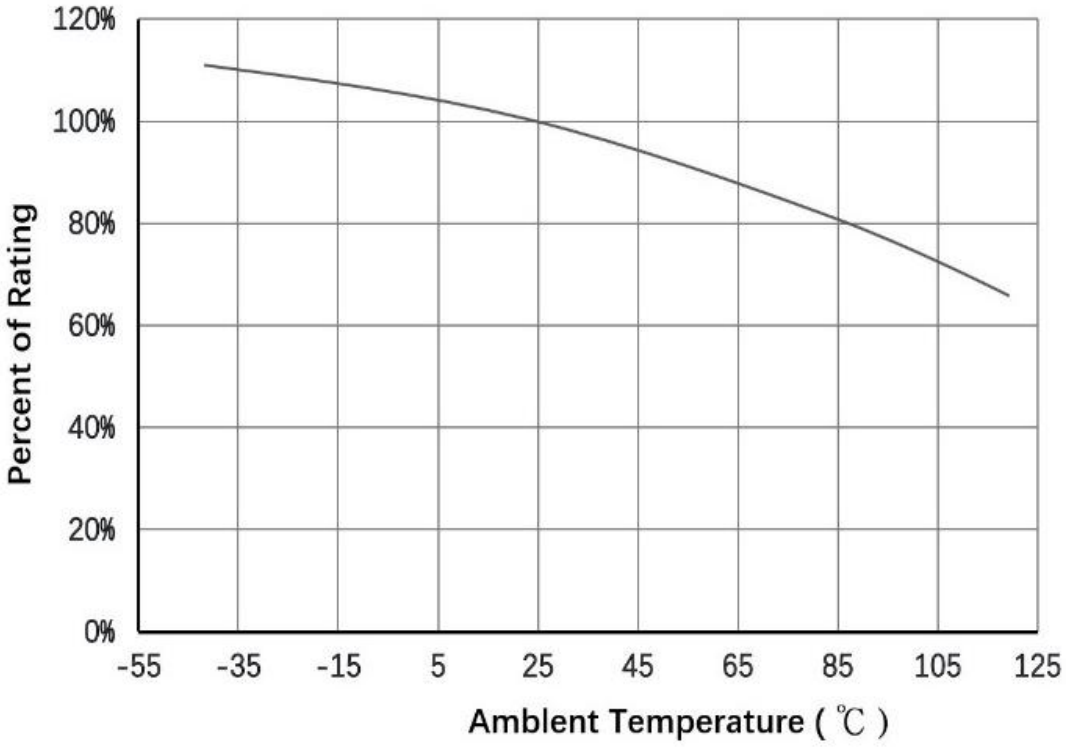


Figure 3.3-1: Curve showing the impact of ambient temperature on current-carrying capacity

3.4. Breaking Capacity

Different certification standard fuses have different breaking capacities. The rated breaking capacity of the fuse must meet or exceed the maximum fault current in the circuit. When the protected system is directly connected to the power input circuit and the fuse is placed in the power input section, a high breaking capacity fuse must be used. In most secondary circuits, especially when the voltage is lower than the power voltage, a low breaking capacity fuse will suffice.

3.5. Surge Capacity

For situations where the fuse must withstand high-energy currents, namely large current pulses with short durations, such as impact current, starting current, inrush current, and other "pulse" type transient values, the fuse should be able to bear the energy of such high-energy currents without experiencing abnormal breakage. The rated melting thermal energy (I2t) of the fuse is determined in the laboratory, and each fuse specification has only one such rated value.

In specific applications, for instance, if there are 1000 pulses, the rated melting thermal energy (I2t) of the fuse should be derated by 38%, meaning the rated I2t*38% should exceed the instantaneous energy (pulse) that might be encountered in actual use. For loop pulse numbers exceeding 1000, further derating calculations should be made according to Figure 3.5-1. At the same time, it should be considered that fuses with a smaller rated I2t can also withstand the corresponding pulse energy. For slow-start circuits, it is necessary to determine, based on actual testing, whether the fuse can withstand the impact of the starting current.

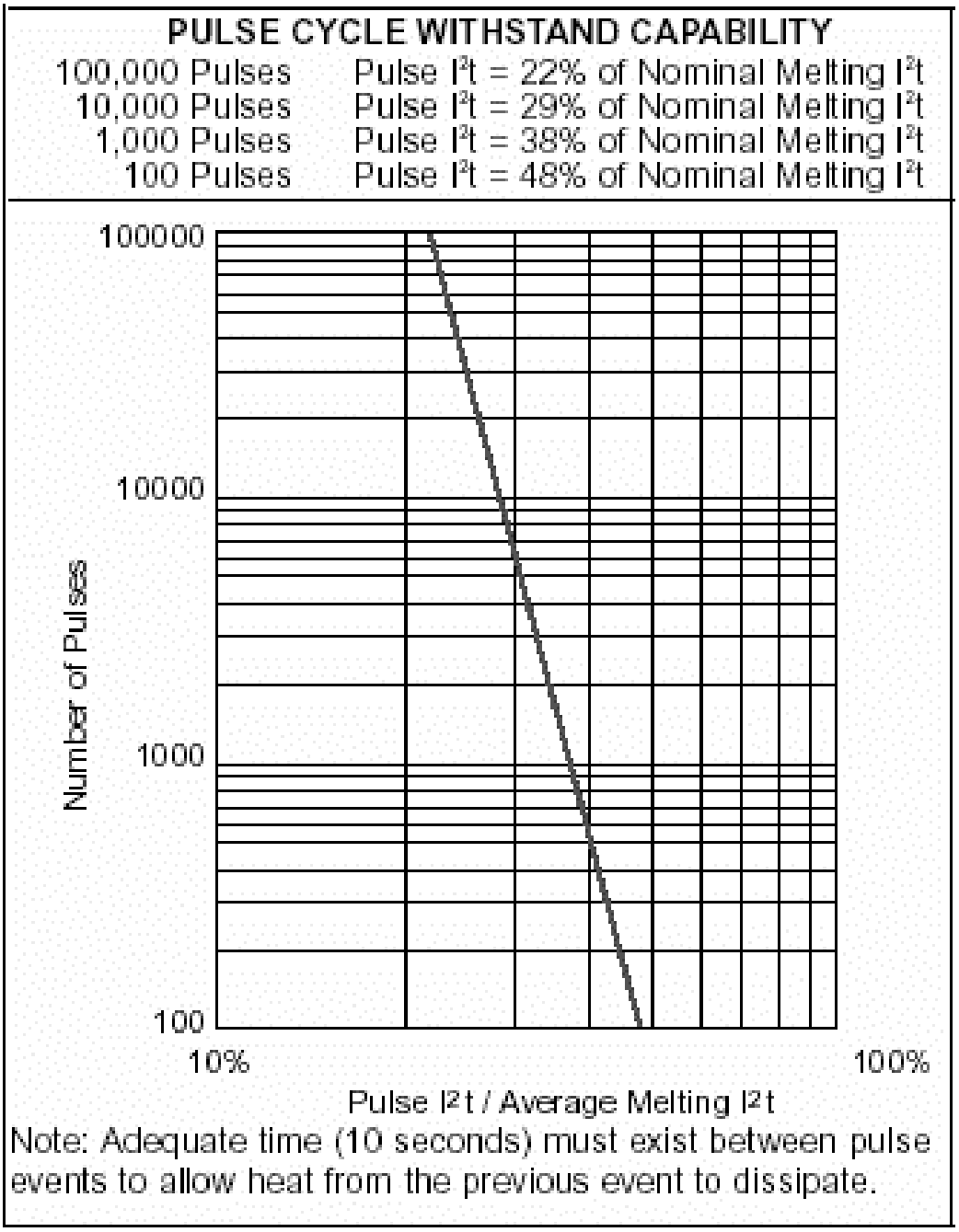


Figure 3.5-1. Pulse cycle withstand capability

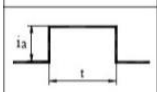
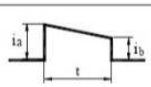
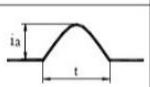
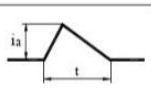
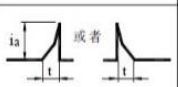
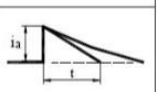
A	B	C	D	E	F
					
$I^2t = i_a^2 t$	$I^2t=(1/3)(i_a^2+i_a i_b+i_b^2)t$	$I^2t=(1/2)i_a^2 t$	$I^2t=(1/3)i_a^2 t$	$I^2t=(1/5)i_a^2 t$	$I^2t=(1/2)i_a^2 t$

Figure 3.5-2. Pulse waveform and approximate formula for I2T

3.6. Real-world Application Example:

Example 1: Suppose the target market of a product is North America, and the final product requires UL certification. The rated parameters of the board are: voltage DC-32V, designed rated current is 2A. The operating environment temperature of the equipment using the board ranges from -5℃ to +55℃, and the maximum operating temperature around the fuse will not exceed 75℃. During the operation of the board, it is not easily affected by external surges, and the load also does not have large capacitors and inductors. The steady-state fault current that may arise from internal faults on the board lies between 2A-35A. The board may experience power up/down and loop pulses during operation, parameters are shown in the table below. Please select a suitable fuse for this board.

To select a suitable fuse for this board, use the table below, which lists the required conditions, and analyzes the selection range:

Serial Number	Selection Factor	Design Requirement	Selection Range
1	Certification	The final product requires UL certification	☒UL standard certification
2	Fuse Type	Not easily affected by external surges; the load doesn't have large capacitors and inductors	☒Quick blow type; ☐Slow blow type
3	Rated Voltage	Rated -32V, 20% fluctuation	☐125V ☐250V ☒32V ☐63V ☐85V
4	Rated Current	Designed steady-state maximum current passing through the fuse is 1A	☒UL standard certification, derated to 0.75
5	Fuse Operating Temperature	Product operating temperature range: -5℃ to +55℃; Maximum operating temperature around the fuse: 75℃	Operating temperature derated to 0.8
6	Resistance and Voltage Drop	Fuse resistance <0.1ohm	Cold state resistance not exceeding 0.1ohm
7	Structure and Installation	Limited installation space	☒Surface mount
8	Time-Current Characteristics	Minimum fault current: 2.0A	Fuse time cannot exceed 5s at a fault current of 2A
9	Breaking Capacity	Maximum fault current: 32.0A	Breaking capacity of 50A, greater than the maximum fault current

Example 2:

To determine if the product Yageo JB06S2501R can meet the client's application requirements for 100,000 surge pulses.

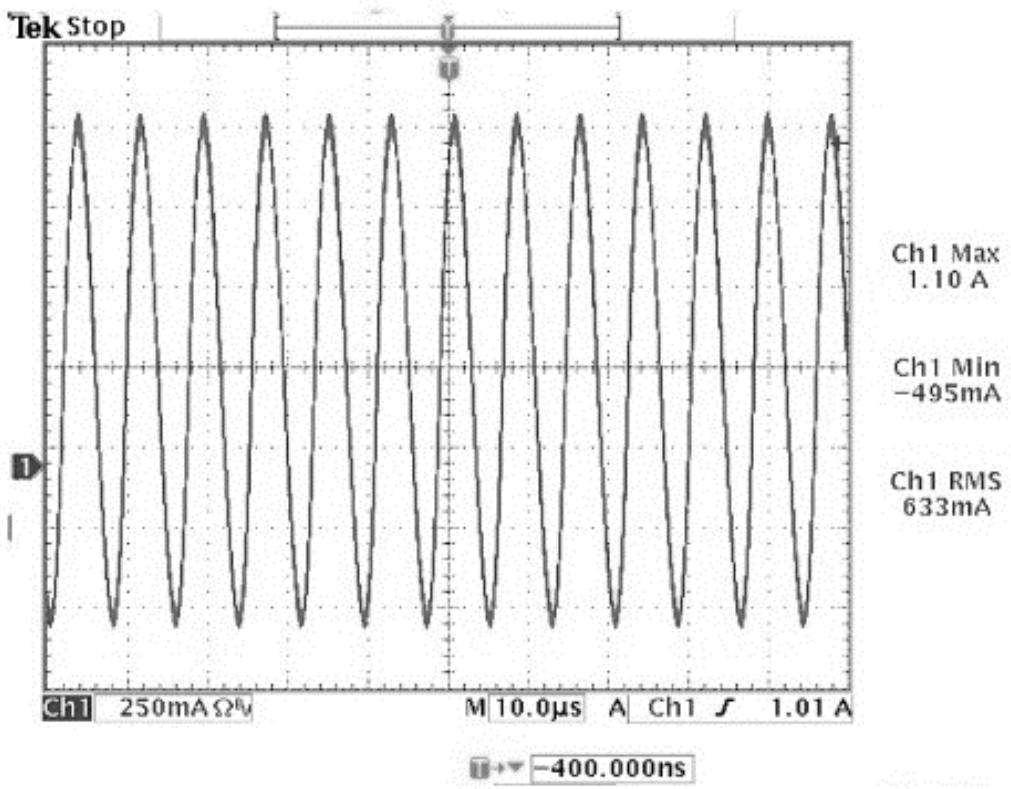


Figure 4-6-1 shows the client's steady-state output waveform.

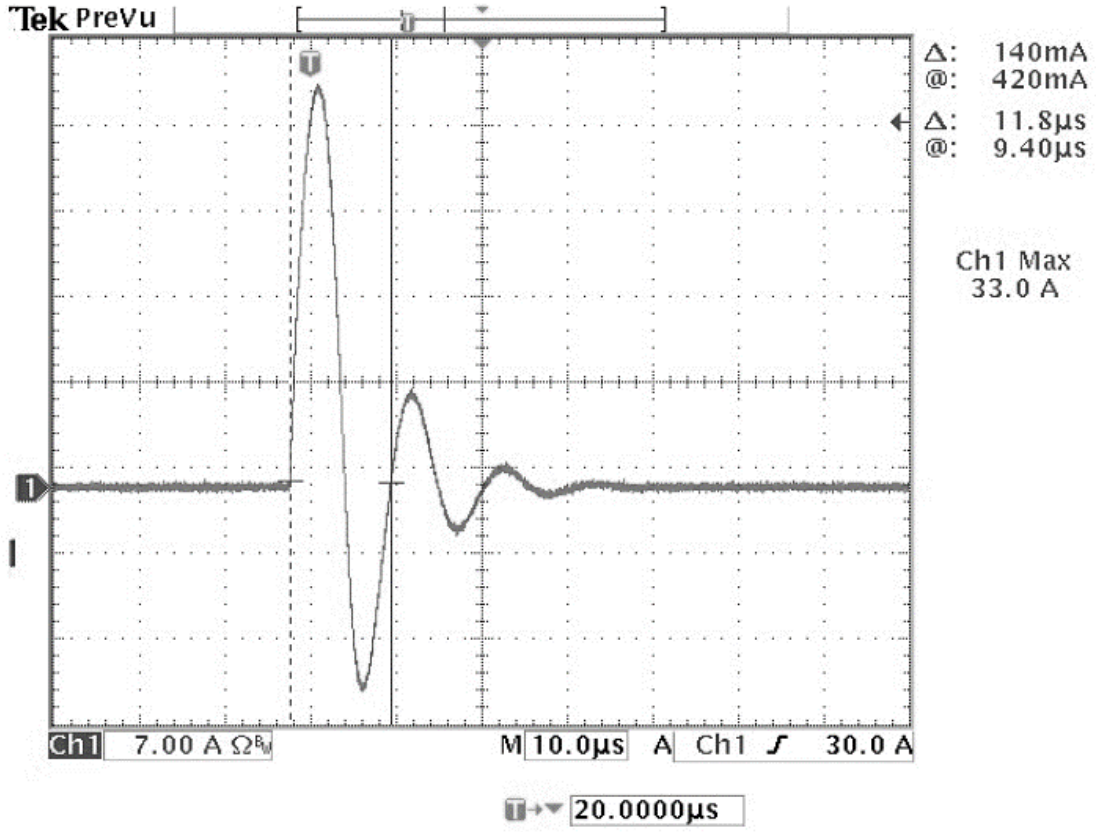


Figure 4-6-2 shows the client's Inrush waveform.

a. Steady Current: 1.1A, safety coefficient 0.75.

Fuse ambient temperature: 60℃.

Temperature derating coefficient is approximately 90 (refer to Figure 4.3.1).

Steady current value/(0.75 x temperature derating coefficient) < 2.5A.

Therefore, 1.1/(0.75x0.9) = 1.63.

Thus, JB06S2501R can withstand an ambient temperature of 60℃.

b. Inrush Joule Integral (I2T) calculation:

Inrush Current: 33A.

Inrush Time: 40us.

Actual Joule Integral (I2T) = IIt

= 33x33x0.00004 = 0.04356 (A2S).

The I2T of JB06S2501R = 0.4 (refer to the JB06S series specification sheet).

Therefore, 0.4(A2S) > 0.04356(A2S).

Thus, JB06S2501R can withstand the Inrush current generated by the client's product.