

TABLE I. Time series algebra expression mapping rules.

ID	SQL expression	Time Series Algebra	Explanation
1	$T < c$	$T_{vc} = \{(t, v) t \in \mathbb{T}, v \in (-\infty, c)\}$	Select elements in T where values are $< c$.
2	$T > c$	$T_{vc} = \{(t, v) t \in \mathbb{T}, v \in (c, \infty)\}$	Select elements in T where values are $> c$.
3	$T = c$	$T_{vc} = \{(t, v) t \in \mathbb{T}, v \in [c, c]\}$	Select elements in T where values are $= c$.
4	$T \leq c$	$T_{vc} = \{(t, v) t \in \mathbb{T}, v \in (-\infty, c]\}$	Select elements in T where values are $\leq c$.
5	$T \geq c$	$T_{vc} = \{(t, v) t \in \mathbb{T}, v \in [c, \infty)\}$	Select elements in T where values are $\geq c$.
6	$T \neq c$	$T_{vc} = \{(t, v) t \in \mathbb{T}, v \neq c\}$	Select elements in T where values are $\neq c$.
7	<i>true</i>	$T_{vc} = \{(t, v) t \in \mathbb{T}\}$	Select all elements.
8	<i>false</i>	$T_{vc} = \emptyset$	Select no elements.
9	$T \text{ IS NOT NULL}$	$T_{vc} = \{(t, v) t \in \mathbb{T}, v \neq \text{null}\}$	Select elements in T where values are not null.
10	$T \text{ IS NULL}$	$T_{vc} = \{(t, v) t \in \mathbb{T}, v = \text{null}\}$	Select elements in T where values are null.
11	$T \text{ BETWEEN } a \text{ AND } c$	$T_{vc} = \{(t, v) t \in \mathbb{T}, v \in [a, c]\}$	Select elements in T where values are between a and c .
12	$T \text{ IN } (a, b, c, \dots)$	$T_{vc} = \{(t, v) t \in \mathbb{T}, v \in (a, b, c \dots)\}$	Select elements in T where values are in $(a, b, c \dots)$.
13	$+T$	$T = +T$	Select elements in T where values are $= + v$.
14	$-T$	$T = -T$	Select elements in T where values are $= - v$.
15	$T_b + T_c$	$T_a = T_b + T_c$	Adds the values of T_b and T_c .
16	$T_b - T_c$	$T_a = T_b - T_c$	Subtracts the value of T_b from T_c .
17	$T_b * T_c$	$T_a = T_b * T_c$	Multiplies the values of T_b and T_c .
18	T_b / T_c	$T_a = T_b / T_c$	Divides the value of T_b by T_c .
19	$T_b \text{ mod } T_c$	$T_a = T_b \text{ mod } T_c$	Returns the remainder after dividing T_b by T_c .
20	$T_{bc} \text{ AND } T_{cc}$	$T_{ac} = T_{bc} \cap T_{cc}$	Compute the intersection of T_{bc} and T_{cc} , where T_{bc} and T_{cc} are constraints and T_{ac} is the result.
21	$T_{bc} \text{ OR } T_{cc}$	$T_{ac} = T_{bc} \cup T_{cc}$	Compute the union of T_{bc} and T_{cc} .
22	$\text{NOT } T_{bc}$	$T_{ac} = \neg T_{bc}$	Compute the complement of constraint T_{bc} .
23	$\text{ABS}(T)$	$T = \text{ABS}(T)$	Returns the absolute value of T , which is its non-negative magnitude.
24	$\text{ACOS}(T)$	$T = \text{ACOS}(T)$	Computes the inverse cosine of T , returning an angle (in radians) whose cosine is T .
25	$\text{ASIN}(T)$	$T = \text{ASIN}(T)$	Computes the inverse sine of T , returning an angle (in radians) whose sine is T .
26	$\text{ATAN}(T)$	$T = \text{ATAN}(T)$	Computes the inverse tangent of T , returning an angle (in radians) whose tangent is T .
27	$\text{SQRT}(T)$	$T = \text{SQRT}(T)$	Computes the non-negative square root of T .
28	$W_SUM(T)$	$T_{ac} = W_SUM(T)$	Calculate the cumulative sum of columns T within the time window.
29	$W_COUNT(T)$	$T_{ac} = W_COUNT(T)$	Counts the number of rows in the time window.
30	$W_AVG(T)$	$T_{ac} = W_AVG(T)$	Calculate the arithmetic mean of column T within the time window.
31	$W_SPEAD(T)$	$T_{ac} = W_SPEAD(T)$	Calculate the extreme difference (the difference between the maximum and minimum values) of column T within the time window.
32	$W_STDDEV_POP(T)$	$T_{ac} = W_STDDEV_POP(T)$	Calculate the overall standard deviation (based on the standard deviation of the whole data) of column T within the time window.
33	$W_VAR_POP(T)$	$T_{ac} = W_VAR_POP(T)$	Calculate the overall variance, i.e., the square of the overall standard deviation, for column T within the time window.

34	$W_MAX(T)$	$T_{ac} = W_MAX(T)$	Returns the maximum value of column T within the time window.
35	$W_MIN(T)$	$T_{ac} = W_MIN(T)$	Returns the minimum value of column T within the time window.
36	$W_FIRST(T)$	$T_{ac} = W_FIRST(T)$	Returns the first non-null value of column T in the time window (in chronological order).
37	$W_LAST(T)$	$T_{ac} = W_LAST(T)$	Returns the last non-null value of column T in the time window (in chronological order).
38	$T_F_CSUM(T)$	$T_{ac} = T_F_CSUM(T)$	Computes the cumulative sum of column T over a time-ordered sequence.
39	$T_F_DIFF(T)$	$T_{ac} = T_F_DIFF(T)$	Computes the discrete difference between the current value of T and its previous value in the time sequence.
40	$T_F_DERIVATIVE(T)$	$T_{ac} = T_F_DERIVATIVE(T)$	Computes the rate of change (derivative) of T over time, i.e., the difference in T divided by the time interval.
41	$T_F_MAVG(T)$	$T_{ac} = T_F_MAVG(T)$	Computes the moving average (rolling average) of column T over the last N time-ordered values.
42	$T_F_STATECOUNT(T)$	$T_{ac} = T_F_STATECOUNT(T)$	Counts the number of consecutive occurrences where column T meets a specified condition (e.g., $T > \text{threshold}$) in the time sequence.
43	$T_F_STATEDURATION(T)$	$T_{ac} = T_F_STATEDURATION(T)$	Computes the total duration (in specified time unit, e.g., seconds) during which column T satisfies a condition in the time sequence.