

257xR Preheat, Glow, Transition and Strike Timing and Level Measurements using a Tube Load

The preheat, glow, transition, and strike detection system used in the 257xR, when configured for tube loads, is described in this document. For simplicity, this document does not describe the Xitron re-strike measurements.

Note: the detection system is independent for each tube.

Glow, Transition and Strike Detection State Machine

A state machine controls the glow, transition, and strike detection system as follows.

- **DORMANT.** This state is entered whenever the STARTUP chart is cleared and armed to run, i.e. following reset, when a line switch is turned on (in General Purpose mode), or by an INRUSH test step (in Test Sequence Mode). Entry into this state is not dependent on the present state.
- **DETECT START.** This state is entered from the DORMANT state when the STARTUP chart starts and the user-configured inrush period has elapsed, i.e. a user-set delay after the peak line current exceeds the user-configured line inrush detection level. **Note:** if the user-configured inrush period is non-zero, then the user-configured delay plus one cycle of line is used for this purpose, otherwise there is no delay.
- **STARTED.** This state is entered from the DETECT START state when the peak tube voltage exceeds 30Vpk, or when (for 4-pin tubes only) either of the filament voltages exceeds 0.3Vrms.
- **GLOWING.** This state is entered from the STARTED state when the RMS tube current exceeds 2.5mA_{rms}.
- **TRANSITION.** This state is entered from the GLOWING state when the RMS tube current, or the total tube power (dependent on the method configured by the user), exceeds the user-configured level for transition detection. This state is also entered from the STRUCK state if the RMS tube current, or the total tube power (dependent on the method configured by the user), falls below the user-configured level for strike detection continuously for more than 10ms and the STARTUP chart is still running.
- **STRUCK.** This state is entered from the TRANSITION state when the peak tube current, or the total tube power (dependent on the method configured by the user), exceeds the user-configured level for strike detection.

Note: the 257xR performs all state transitions based upon 1ms timing increments, and multiple state transitions can occur in the same time increment.

Glow, Transition and Strike Detection Timing Measurements

All timing measurements made by the 257xR regarding strike are obtained from the following “base” timing measurements.

- **t0.** This is set when the transition from the DORMANT state to the DETECT START state occurs.
- **t1.** This is set when the transition from the DETECT START state to the STARTED state occurs.
- **tglow.** This is set when the transition from the STARTED state to the GLOWING state occurs.
- **t2.** This is set when the transition from the GLOWING state to the TRANSITION state occurs.
- **tstrike.** This is set when the transition from the TRANSITION state to the STRUCK state occurs. This is cleared if there is a transition from the STRUCK state to the TRANSITION state.

The reported timing measurements are calculated from these as follows. The interface data request code is shown for each data with the General Purpose and Test Sequence mode descriptions in brackets.

- **BALLAST-START** (Output Startup or Start Delay) : $t1 - t0$
- **TUBE-GLOW** (Tube Glow or Glow Period) : $t2 - t1$
- **TUBE-STARTING** (Tube Starting or Starting Time) : $tstrike - tglow$
- **TUBE-TRANSITION** (Tube Transition or Transition) : $tstrike - t2$
- **STRIKE-DELAY** (Tube Strike or Strike Delay) : $tstrike - t0$

Note:

- ✓ All timing results have 1ms resolution.
- ✓ All timing results are reported as invalid when the DORMANT state is entered.
- ✓ If multiple states occur within the same 1ms timing period, then the results for each of those states are updated.
- ✓ If t2 or t1 are invalid, then TUBE-GLOW is reported as invalid.
- ✓ If tstrike or tglow are invalid, then TUBE-STARTING is reported as invalid.
- ✓ If tstrike or t2 is invalid, then TUBE-TRANSITION is reported as invalid.
- ✓ If tstrike is invalid, then STRIKE-DELAY is reported as invalid.

- **GLOW-V.** This is the average RMS tube voltage measured during the GLOWING state. The average tube voltage crest factor is also maintained during the GLOWING state.
- **STRIKE-A.** This is the highest tube current measured during the STRUCK state. The highest PEAK and RMS data are separately maintained.
- **GLOW-A.** This is the average RMS tube current measured during the GLOWING state.
- **GLOW-F.** This is the average tube frequency measured during the GLOWING state.

Note: If multiple states occur within the same 1ms timing period, then the results for each of those states are updated.

Preheat Detection State Machine

The preheat detection system is controlled by separate state machines for each filament, of each tube configured as having four pins, as follows.

- **DORMANT_PREHEAT.** This state is entered whenever the glow, transition, and strike state machine for this tube is in the DORMANT or DETECT START states.
- **MEASURE_PREHEAT.** This state is entered from the DORMANT_PREHEAT state when the glow, transition, and strike state machine for this tube is not in either of the DORMANT or DETECT START states and either
 - a) the preheat detection method is user-configured for “Strike Period” or
 - b) the preheat detection method is not user-configured for “Strike Period” and all enabled filament measurements are above their respective user-configured detection levels (using filtered or unfiltered measurements as selected by the preheat detection method).
- **STOP_PREHEAT.** This state is entered from the MEASURE_PREHEAT state either when
 - a) the preheat detection method is user configured for “Strike Period” and the glow, transition, and strike state machine for this tube is in the STRUCK state or
 - b) the preheat detection method is not user-configured for “Strike Period” and no enabled filament measurement is above its respective user configured detection level (using filtered or unfiltered measurements as selected by the preheat detection method).

Preheat Detection Timing Measurements

All timing measurements made by the 257xR regarding preheat are obtained from the following “base” timing measurements.

- **tpstart (tp1 in 257xR reports).** This is set when the transition from the DORMANT_PREHEAT state to the MEASURE_PREHEAT state occurs.
- **tpend (tp2 in 257xR reports).** This is set when the transition from the MEASURE_PREHEAT state to the STOP_PREHEAT state occurs.

The reported timing measurements are calculated from these and the glow, transition, and strike timing results for that tube as follows. The interface data request code is shown for each data with the General Purpose and Test Sequence mode descriptions in brackets.

- **PREHEAT-PERIOD** (Preheat Period or Preheat Time) : $t_{pend} - t_{pstart}$
- **PREHEAT-DELAY** (Preheat Delay) : $t_{pstart} - t_0$
- **PREHEAT-DWELL** (Preheat Dwell) : $t_{pend} - t_{strike}$

Note:

- ✓ All timing results have 1ms resolution.
- ✓ All timing results are reported as invalid when the DORMANT_PREHEAT state is entered or t_{pstart} is invalid.
- ✓ If multiple states occur within the same 1ms timing period, then the results for each of those states are updated.
- ✓ If t_{pend} is invalid then PREHEAT-PERIOD and PREHEAT-DWELL are reported as invalid.
- ✓ If t_{strike} is invalid then PREHEAT-DWELL is invalid.
- ✓ If $t_{strike} > t_{pend}$ then PREHEAT-DWELL is invalid.

Preheat Detection Amplitude Measurements

The reported amplitude measurements are updated under the control of the state machine as follows. The interface data request code is shown for each available data.

- **PREHEAT-V**. This is the average RMS filament voltage while in the MEASURE_PREHEAT state.
- **PREHEAT-A**. This is the average RMS filament current while in the MEASURE_PREHEAT state.
- **PREHEAT-W**. This is the average filament power while in the MEASURE_PREHEAT state.