ISL73847SLH

Neutron Test Results of the ISL73847SLH Radiation Hardened Single/Dual Phase Current Mode PWM Controller

Introduction

This report documents the results of 1MeV equivalent neutron testing of the ISL73847SLH, a synchronous buck controller that can operate as a single or dual phase controller. The testing was conducted to provide an assessment of the displacement damage (DD) hardness of the parts caused by neutron or proton environments. Neutron fluences ranged from $5 \times 10^{11} n/cm^2$ to $1 \times 10^{13} n/cm^2$.

Product Description

The ISL73847SLH is a synchronous buck controller that can operate as a single or dual phase controller. It is intended to work with the ISL73847SLH (half bridge GaN FET driver) to generate Point-Of-Load voltage rails for commercial space applications.

It accepts an input voltage range of 4.5V to 19V with a programmable output switching frequency between 250kHz and 1.5MHz with a single resistor. The output can regulate a voltage upwards of 600mV and is limited on the top end by the minimum off time and selected switching frequency.

The wide input voltage range makes it a suitable power supply option for a high current FPGA core and other general purpose power solutions. The ISL73847SLH uses current mode modulation which simplifies loop compensation and provides excellent power supply rejection. Additionally, the output is remotely sensed to compensate for any voltage drop in the load conditions. All of this put together results in a robust power supply solution that requires minimal components while achieving high current density.

The ISL73847SLH also features a tri-level output which provides excellent protection against faults by driving a mid-scale voltage to signal the power stage to enter a Hi-Z condition.

The ISL73847SLH is available in a 24 Ld WSOIC (300 mils). The package and pin assignments for the ISL73847SLH is shown in Figure 1.

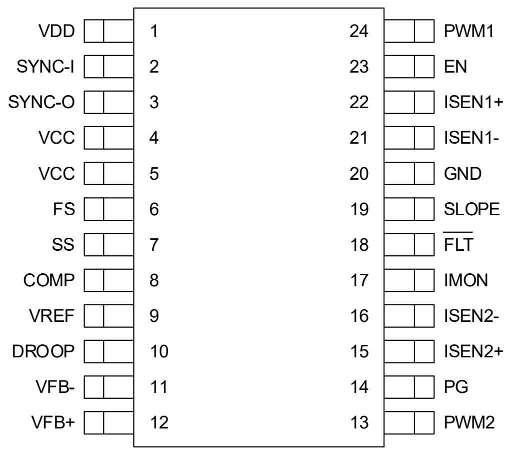

Figure 1. Pin Assignments

The pin descriptions are shown in Table 1.

Table 1. Pin Descriptions

Pin Number	Pin Name	Description
1	VDD	The power supply input to the IC. The voltage range on this pin is 4.5V to 19V. Connect a 2.2µF or larger capacitor and a 100nF capacitor from the VDD pin to GND.
2	SYNC-I	This pin is an input that accepts 2x the required PWM output switching frequency (regardless of single or dual phase). Internally the IC divides the clock down to get two clocks 180° from each other for each phase. *Note:* This pin has an internal pull down, leave it floating if SYNC function is not needed.
3	SYNC-O	This pin can output either 1x or 2x the PWM output switching frequency depending on the loading present on the pin during power up (before soft-start). When outputting 1x, the SYNC-O is 180° out of phase with phase 1 clock. The 2x SYNC-O output is in phase with the SYNC-I. 100kΩ to VCC: SYNC-O outputs 1x PWM output switching frequency. 100kΩ to GND: SYNC-O outputs 2x PWM output switching frequency.
4, 5	VCC	Output of internal LDO for analog circuity. Short pins 4 and 5 together. Connect a 1µF ceramic capacitor from VCC to GND.
6	FS	This pin sets the frequency for the internal oscillator between 0.5MHz and 3MHz. This sets the output between 0.25 MHz and 1.5MHz for each phase. When FS is tied to VCC the internal oscillator frequency (f_{OSC}) is 1MHz. To adjust the internal oscillator frequency between 0.5MHz and 3MHz (0.25MHz to 1.5MHz PWM switching frequency), use a resistor between FS and GND. If SYNC-I is being used to sync to an external clock, FS needs to be set such that the internal oscillator frequency is 15% less than the external frequency. Use Equation 3 in the datasheet to find which resistor is needed for a given frequency.
7	SS	This is the soft-start pin. Connect a ceramic capacitor from SS to GND to set the soft-start ramp. The soft-start time is adjustable between 2ms and 200ms. Equation 24 in the datasheet shows the relationship between the soft-start capacitor and soft-start time.
8	COMP	The output of the error amplifier. Connect a resistor and capacitor in series to ground for type 2 compensation adjustment. For type-3 compensation, add an additional capacitor in parallel with the type-2 series RC components.
9	VREF	The output of the internal voltage reference. Insert a resistor between VREF and DROOP to enable droop regulation. Short VREF and DROOP pin together to disable droop regulation.
10	DROOP	This pin is a current mirrored version of the output of the current sense amp output (sum of both phases). This output can be tied to the VREF pin through a resistor to enable droop regulation. The voltage created by the mirrored current and the resistor between VREF and DROOP sets the droop level.
11	VFB-	This pin is the negative input for differential voltage feedback.
12	VFB+	This pin is the positive input for differential voltage feedback.
13	PWM2	This pin is the PWM output for the secondary phase. This pin needs a 100kΩ to GND.
14	PG	This pin is the power-good indicator. It is an open-drain output. Limit the sink current through this pin to below 7.2mA.
15	ISEN2+	This pin is the positive input for the secondary phase current sense amplifier.
16	ISEN2-	This pin is the negative input for the secondary phase current sense amplifier.
17	IMON	This pin outputs the summed average of the current sense amplifiers outputs for telemetry purposes.
18	$\overline{FLT}$	This pin sequences the startup between the ISL73847SLH and compatible drivers. On the ISL73847SLH, this pin operates as a bi-directional I/O during power up (before soft-start) and as an input while switching (during and after soft-start). This pin's input threshold voltage is $V_{\overline{FLT}MID}$. A logic low on this pin indicates that either the ISL73847SEH or compatible driver has encountered a fault or is not ready to start switching. A logic high indicates that there are not faults for either device. Because $\overline{FLT}$ is an open-drain output, use a 4.99kΩ typical pull-up resistor to VCC for a proper high level.
19	SLOPE	This pin adjusts the slope compensation of the ISL73847SLH. Place a resistor in the range of 25kΩ to 100kΩ to adjust slope compensation.
20	GND	This is the ground reference for the ISL73847SLH.
21	ISEN1-	This pin is the negative input for the primary phase current sense amplifier.
22	ISEN1+	This pin is the positive input for the primary phase current sense amplifier.

Table 1. Pin Descriptions (Cont.)

Pin Number	Pin Name	Description
23	EN	This pin is the chip enable for the ISL73847SLH.
24	PWM1	This pin is the PWM output for the primary phase. This pin needs a 100kΩ to GND.

Related Literature

For a full list of related documents, visit our website:

- ISL73847SLH device page
- MIL-STD-883 Test Method 1017

Contents

1. Test Description

1.1 Irradiation Facilities

Neutron fluence irradiations were performed on the test samples on May 27, 2025, at the University of Massachusetts, Lowell (UMASS Lowell) fast neutron irradiator per Mil-STD-883G, Method 1017.2, with each part unpowered during irradiation. The target irradiation levels were 5×10^{11}n/cm^2, 2×10^{12}n/cm^2, and 1×10^{13}n/cm^2. The parts were shipped back to Renesas (Palm Bay, FL) for post-irradiation electrical testing.

1.2 Test Fixturing

No formal irradiation test fixturing is involved, as these DD tests are bag tests in the sense that the parts are irradiated with all leads unbiased.

1.3 Radiation Dosimetry

Table 2 shows dosimetry from UMASS Lowell indicating the total accumulated gamma dose and actual neutron fluence exposure levels for each set of samples.

Table 2. Neutron Fluence Dosimetry Data

Irradiation	Requested Fluence (n/cm^2)	Reactor Power (kW)	Time (s)	Flux (n/cm^2-s)[1],[2]	Gamma Dose (rad(Si))[3]	Measured Fluence (n/cm^2)[4]
CRF#98191-C	5.00E+11	40	262	3.06E+09	119	6.12E+11
CRF#98191-D	2.00E+12	80	531	6.12E+09	484	2.38E+12
CRF#98191-E	1.00E+13	800	266	6.12E+10	2424	1.19E+13

1. Dosimetry method: ASTM E-265
2. The neutron fluence rate is determined from *Initial Testing of the New Ex-Core Fast Neutron Irradiator at UMass Lowell* (6/18/02). Validated on 6/07/2011 under the Trident II D5LE neutron facility study by Navy Crane. Reaffirmed 8/1/17 using SACRR transistor transfer calibration based on ASTM E1855 – 15.
3. Based on reactor power at 1000kW, the gamma dose is 41 ±5.3% krad(Si)/hr as mapped by TLD-based dosimetry.
4. Validated by S-32 flux monitors

1.4 Characterization Equipment and Procedures

Electrical testing was performed before and after irradiation using the Renesas production automated test equipment (ATE). All electrical testing was performed at room temperature.

1.5 Experimental Matrix

Testing proceeded in general accordance with the guidelines of MIL-STD-883 TM 1017. The experimental matrix consisted of 5 samples to be irradiated at 5×10^{11}n/cm^2, 5 to be irradiated at 2×10^{12}n/cm^2, and 5 to be irradiated at 1×10^{13}n/cm^2. The actual levels achieved, which are shown in Table 2, were 6.12×10^{11}n/cm^2, 2.38×10^{12}n/cm^2, and 1.19×10^{13}n/cm^2. Three control units were used.

The ISL73847SLH samples were drawn from Lot V6C685. Samples were packaged in the 24 Ld WSOIC.

2. Test Results

Neutron testing of the ISL73847SLH is complete and the results are reported in the balance of this report. It should be understood when interpreting the data that each neutron irradiation was performed on a different set of samples; this is not total dose testing, where the damage is cumulative. Each marker represents a different set of five samples. The line connecting them is for trend visualization only.

2.1 Attributes Data

Table 3 shows the ISL73847SLH attributes data.

Table 3. Attributes Data

1MeV Fluence, (n/cm^2)		Sample Size	Pass[1]	Fail	Notes
Planned	Actual				
5×10^{11}	6.12E+11	5	5	0	All passed
2×10^{12}	2.38E+12	5	5	0	All passed
1×10^{13}	1.19E+13	5	5	0	All passed

1. A Pass indicates a sample that passes all post-irradiation datasheet limits.

2.2 Key Parameter Variables Data

The plots in Figure 2 through Figure 68 illustrate the neutron irradiation response of the selected parameters shown in Table 4 in the Appendix. The plots show the average tested values of the parameters as a function of neutron fluence. The plots also include error bars at each down-point, representing the minimum and maximum measured values of the samples, although in some plots the error bars might not be visible due to their values compared to the scale of the graph.

Each Current Sense Amp on the ISL73847SLH has triple redundancy for improved SEE tolerance and therefore has three current sense measurements. These are shown as LA, LB, LC (Low Side) in Figure 38 and Figure 39 and HA, HB, HC (High Side) in Figure 40 through Figure 43.

The irradiated parts passed all parameters up to the highest actual fluence of 1.19×10^{13}n/cm^2.

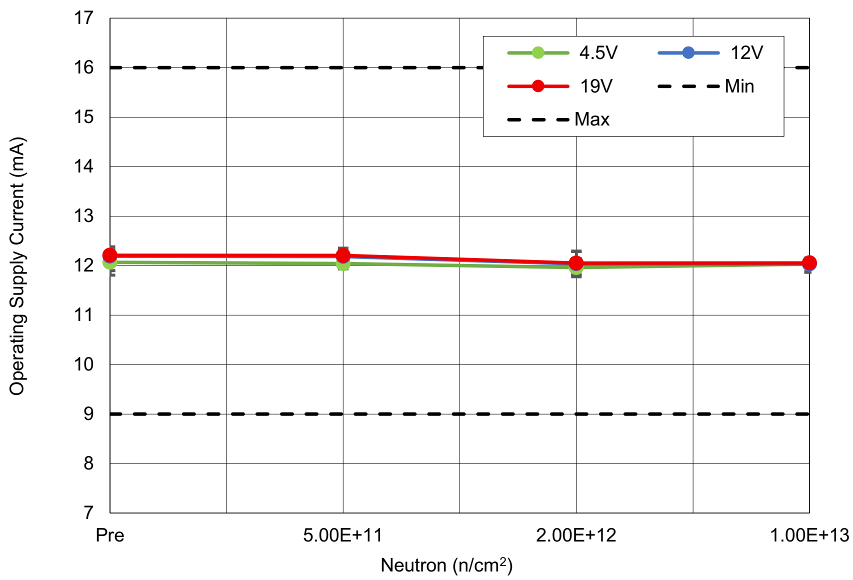

Figure 2. Operating supply current (I_{DDO}) at V_{DD} = 4.5V, 12V and 19V; EN = 3.3V; f_{SW} = 500kHz and C_L = 100pF, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 9mA minimum and 16mA maximum.

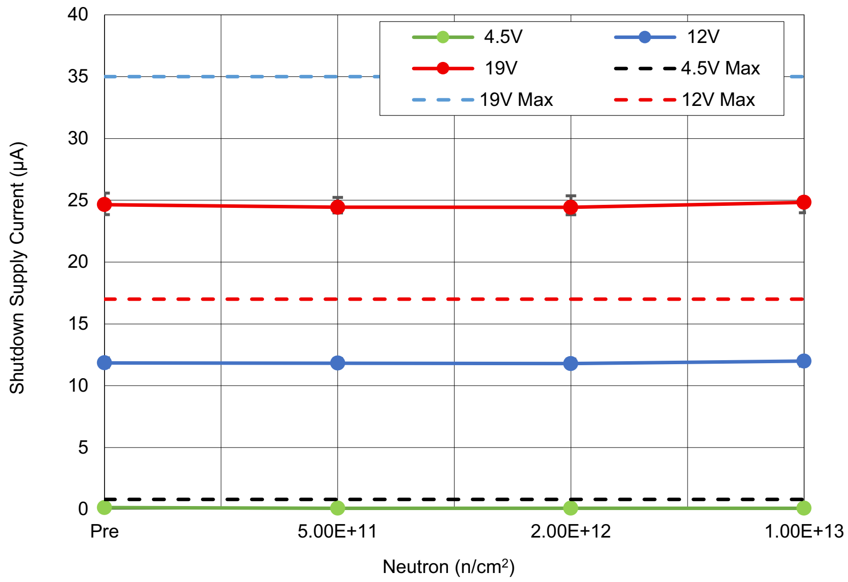

Figure 3. Shutdown supply current (I_{DDSD}) at V_{DD} = 4.5V, 12V and 19V; EN = GND, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limit is 35µA maximum at 19V, 17µA maximum at 12V and 0.8µA maximum at 4.5V.

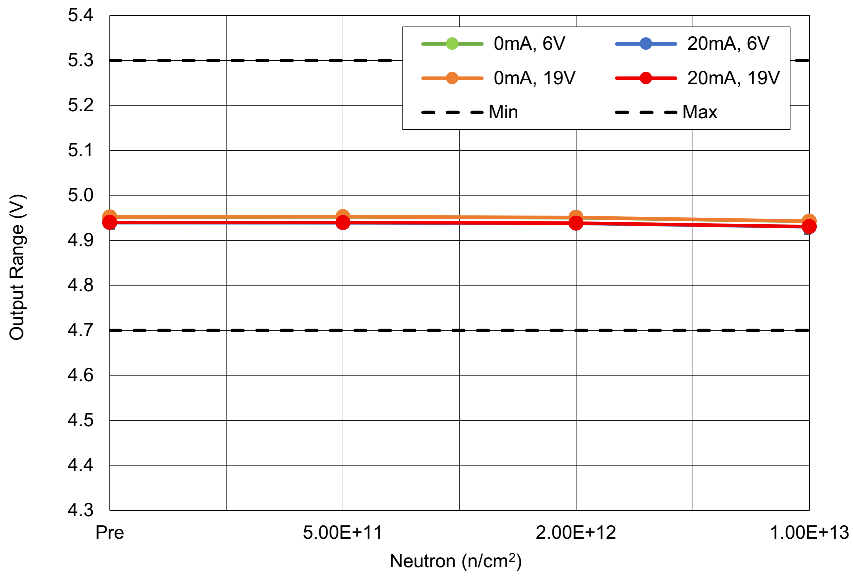

Figure 4. LDO output voltage range (V_{CC}) at V_{DD} = 6V and 19V; I_{OUT} = 0mA and 20mA, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 4.7V minimum and 5.3V maximum.

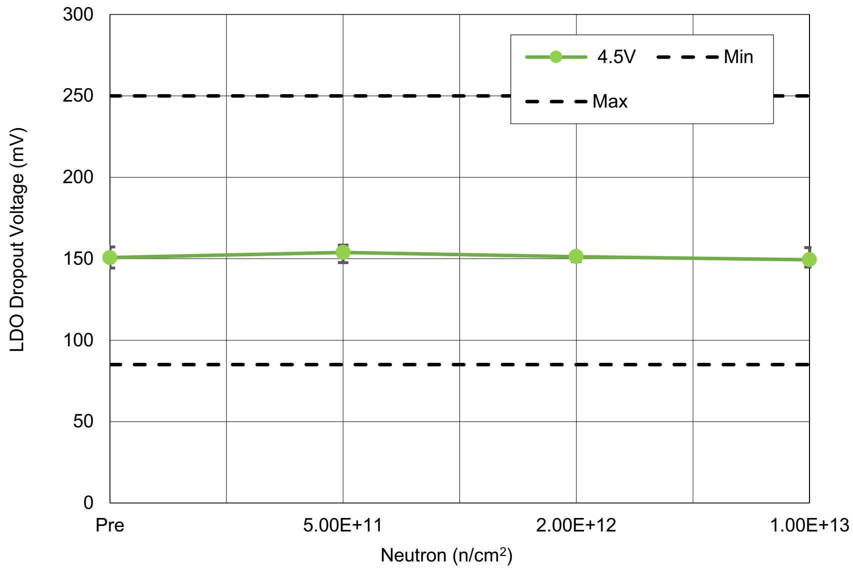

Figure 5. LDO dropout voltage (VCC_{DO}) at V_{DD} = 4.5V; I_{OUT} = 50mA, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 85mV minimum and 250mV maximum.

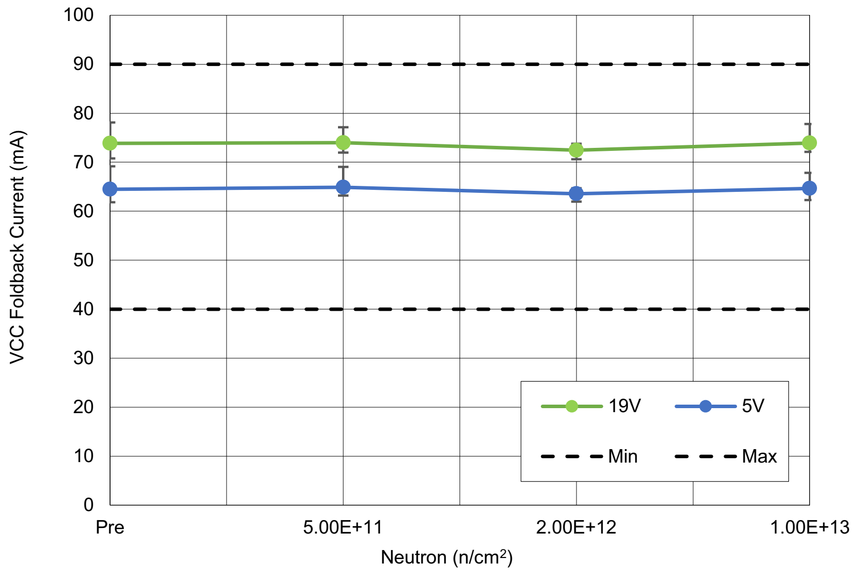

Figure 6. V_{CC} foldback current (I_{CC-SC}) at V_{DD} = 5.5V and 19V; V_{CC} = 0V; EN = 1.6V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 40mA minimum and 90mA maximum.

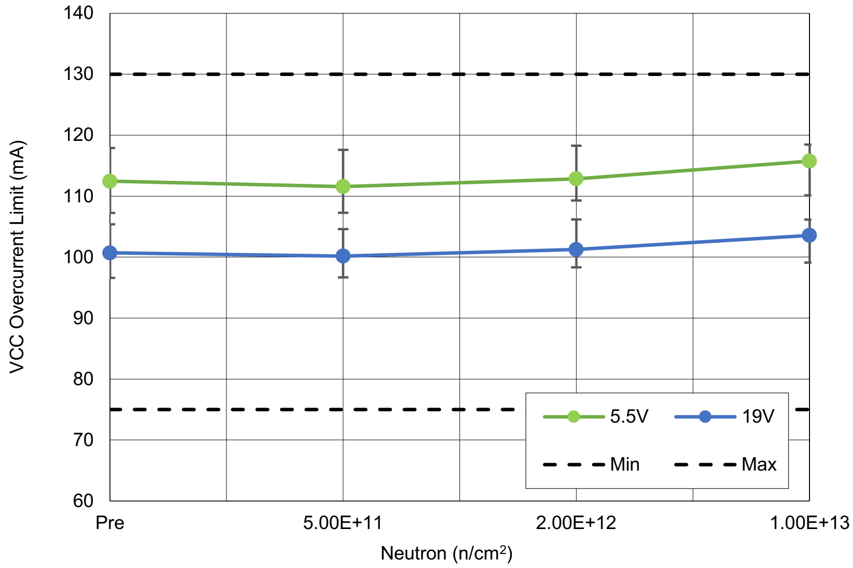

Figure 7. V_{CC} overcurrent limit ($I_{CC\text{-}CL}$) at V_{DD} = 5.5V and 19V; V_{CC} = 4.3V; EN = 1.6V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 75mA minimum and 130mA maximum.

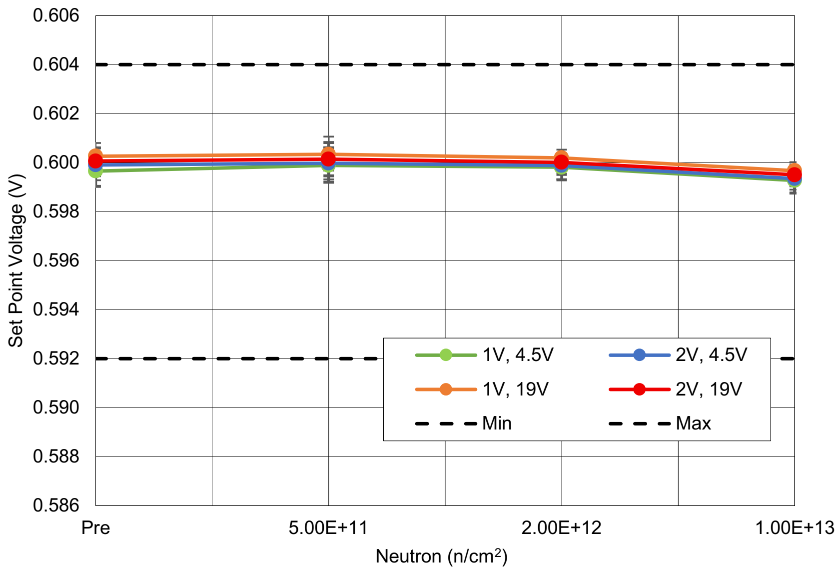

Figure 8. Set point voltage (V_{FB+}), at V_{DD} = 4.5V and 19V; V_{REF} = V_{DROOP} = 1V and 2V; V_{SEN1} = V_{SEN2} = 0mV, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.592V minimum and 0.605V maximum.

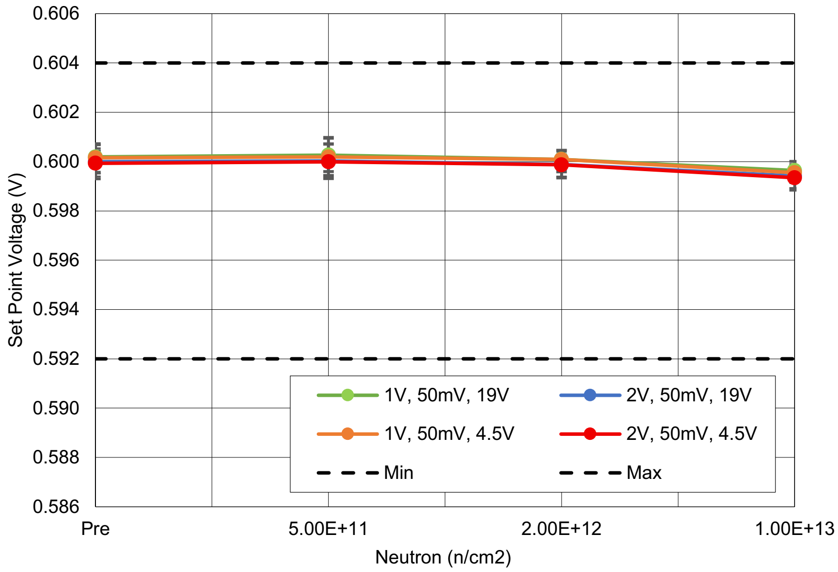

Figure 9. Set point voltage (V_{FB+}) at V_{DD} = 4.5V and 19V; V_{REF} = V_{DROOP} = 1V and 2V; V_{SEN1} = V_{SEN2} = 50mV, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.592V minimum and 0.605V maximum.

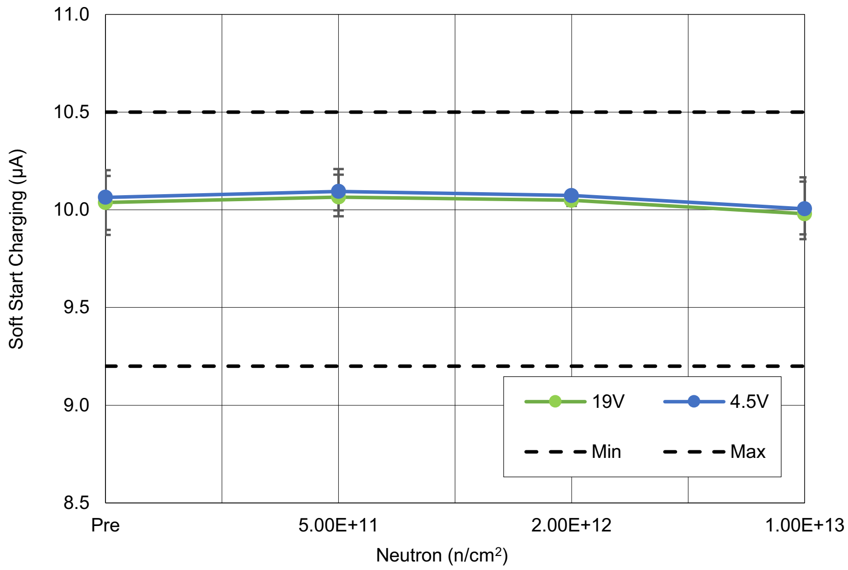

Figure 10. Soft-start sourcing current ($I_{SOFTSTART}$) at V_{DD} = 4.5V and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 9.2µA minimum and 10.5µA maximum.

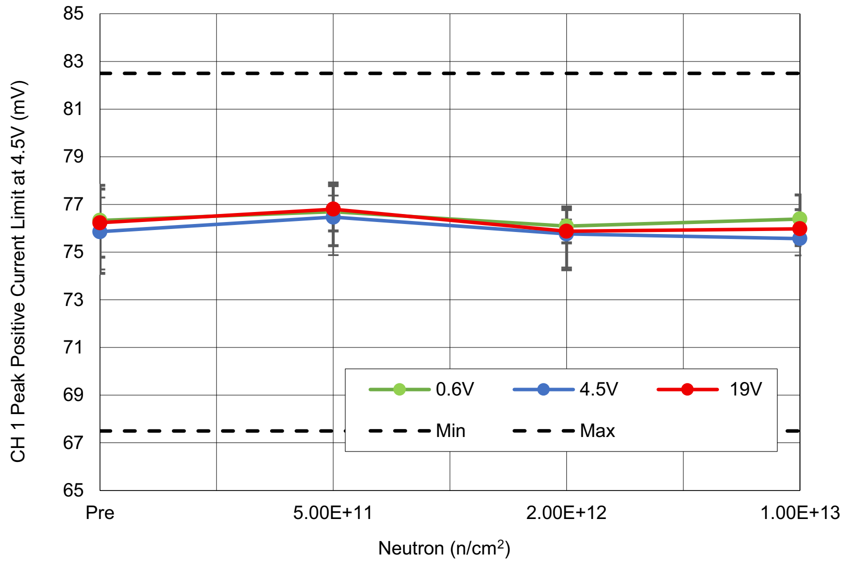

Figure 11. Channel 1 peak positive current limit (V_{PCL}) with V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 67.5mV minimum and 82.5mV maximum.

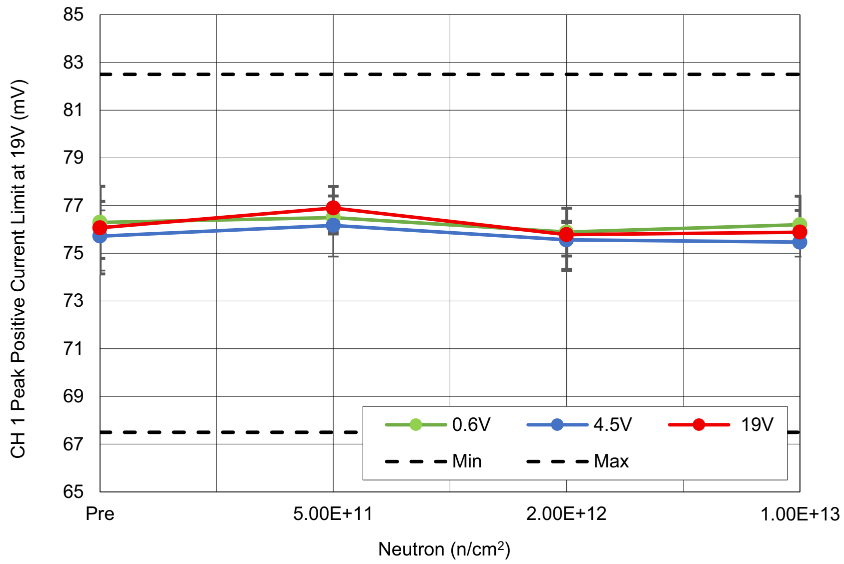

Figure 12. Channel 1 peak positive current limit (V_{PCL}) with V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 67.5mV minimum and 82.5mV maximum.

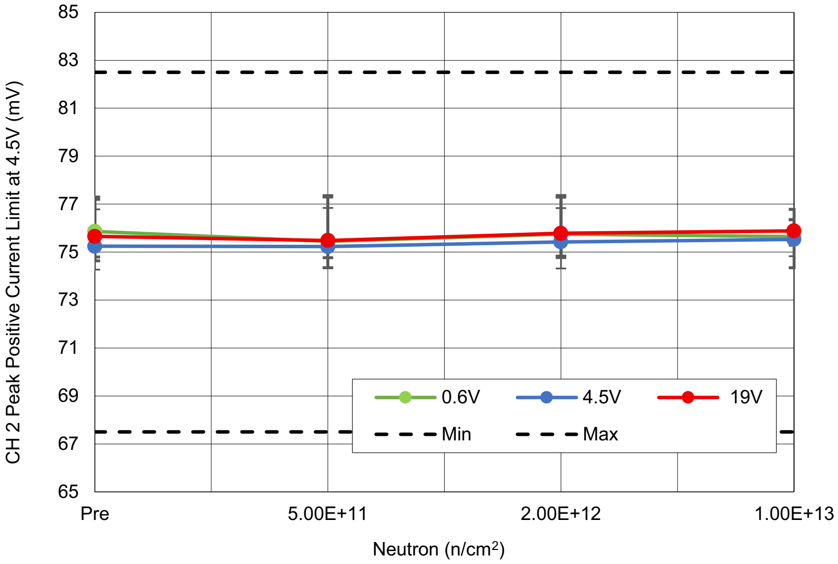

Figure 13. Channel 2 peak positive current limit (V_{PCL}) with V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 67.5mV minimum and 82.5mV maximum.

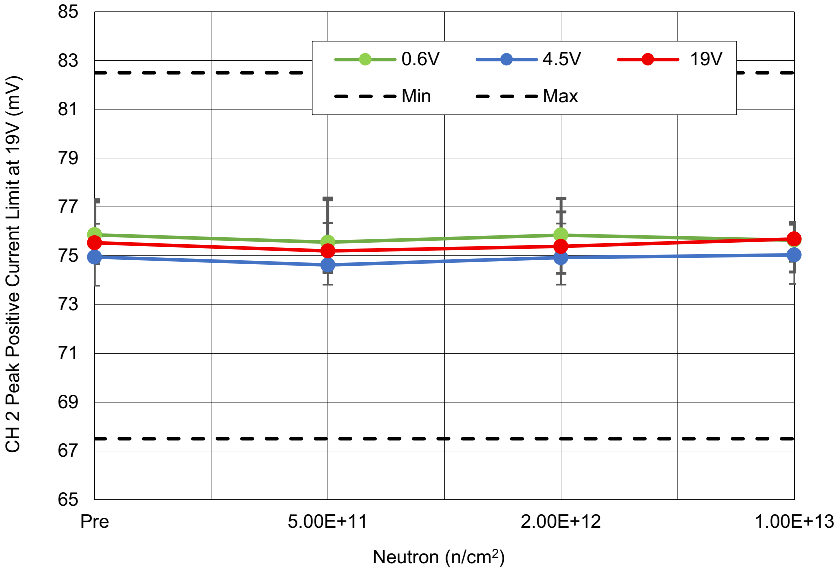

Figure 14. Channel 2 peak positive current limit (V_{PCL}) with V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 67.5mV minimum and 82.5mV maximum.

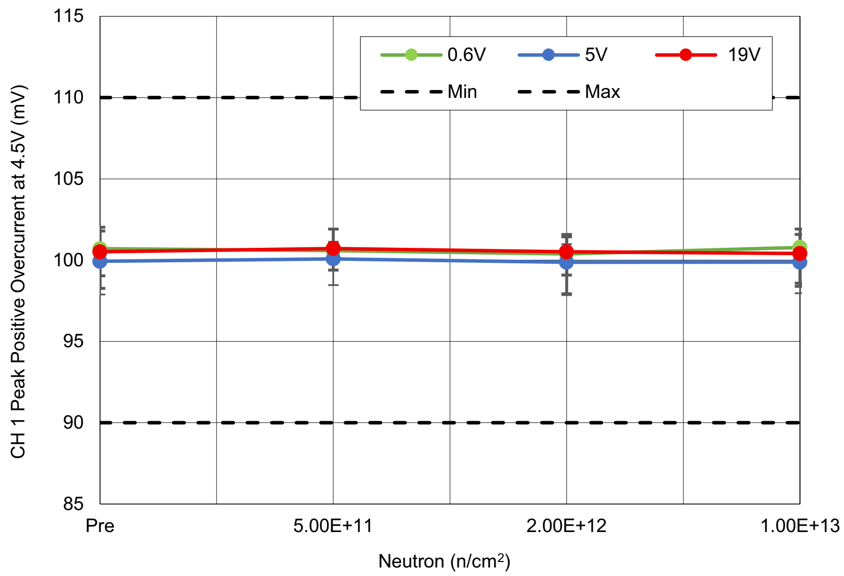

Figure 15. Channel 1 peak positive overcurrent (V_{POC}) with V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 90mV minimum and 110mV maximum.

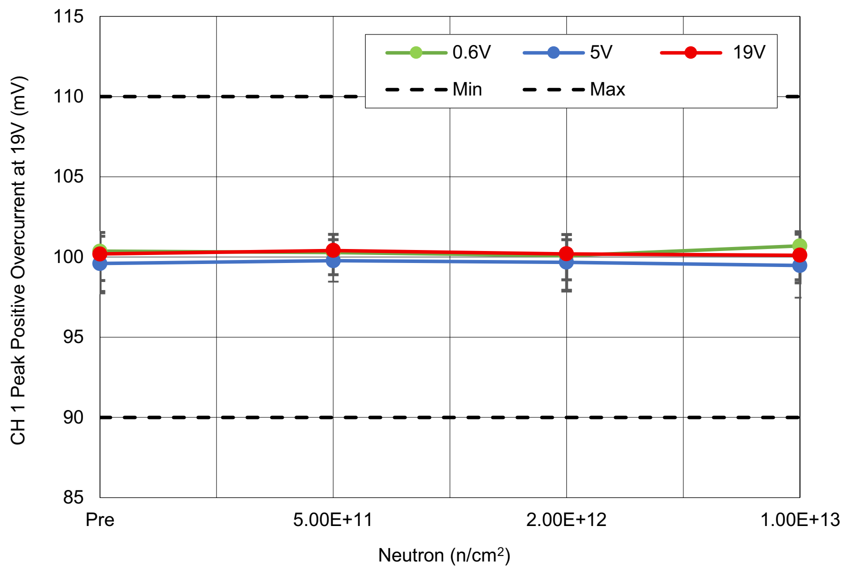

Figure 16. Channel 1 peak positive overcurrent (V_{POC}) with V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 90mV minimum and 110mV maximum.

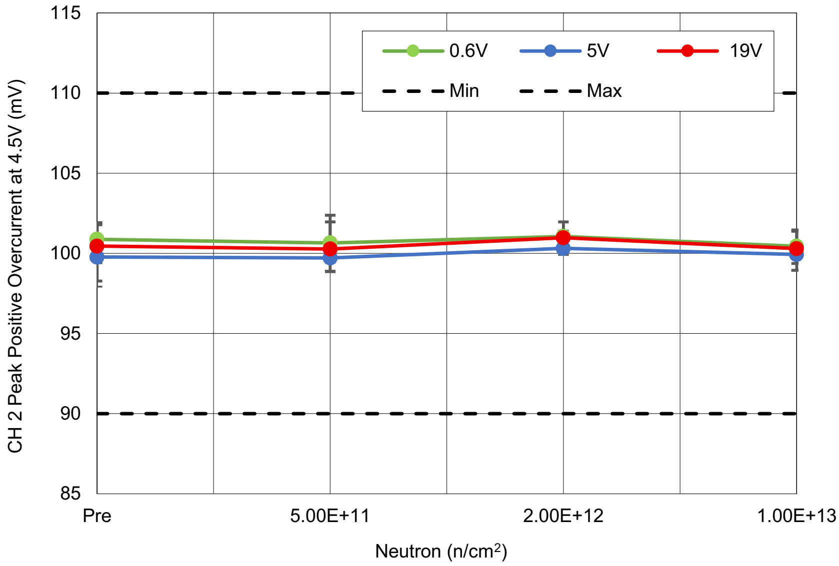

Figure 17. Channel 2 peak positive overcurrent (V_{POC}) with V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 90mV minimum and 110mV maximum.

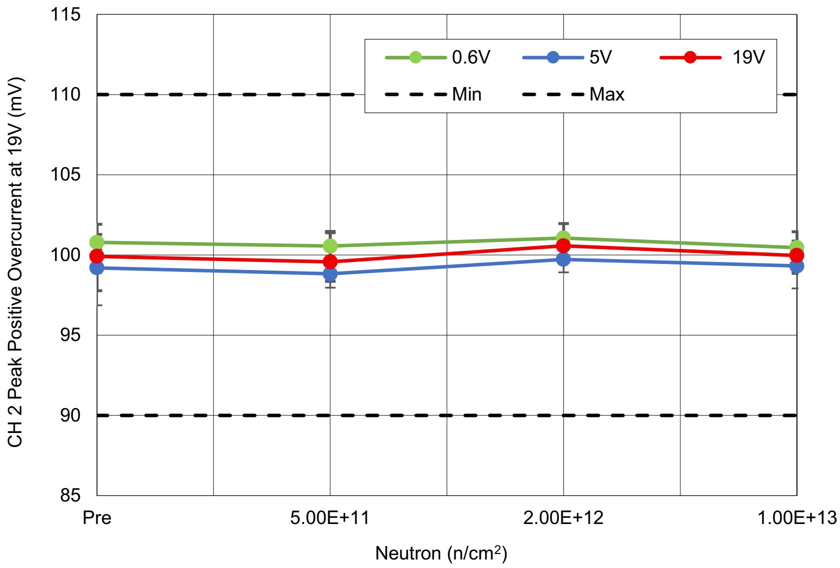

Figure 18. Channel 2 peak positive overcurrent (V_{POC}) with V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 90mV minimum and 110mV maximum.

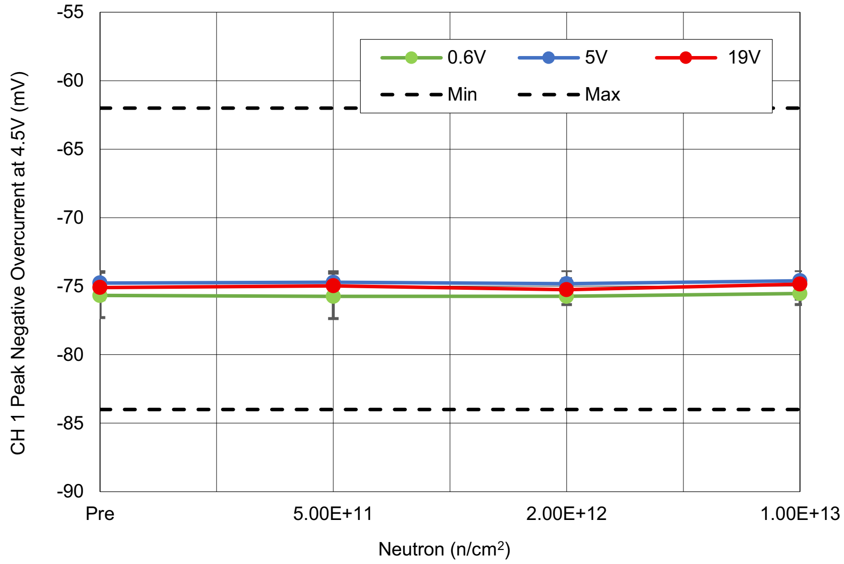

Figure 19. Channel 1 peak negative overcurrent (V_{NOC}) with V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are -84mV minimum and -62mV maximum.

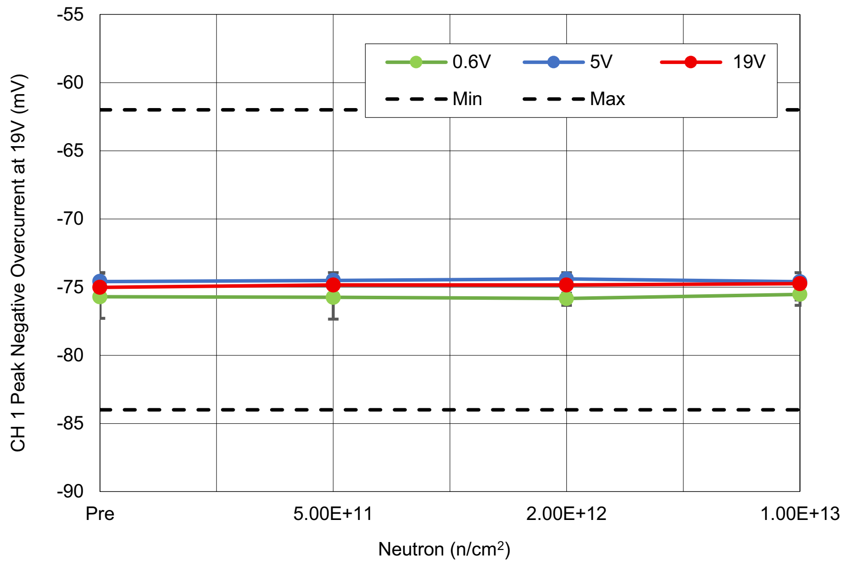

Figure 20. Channel 1 peak negative overcurrent (V_{NOC}) with V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are -84mV minimum and -62mV maximum.

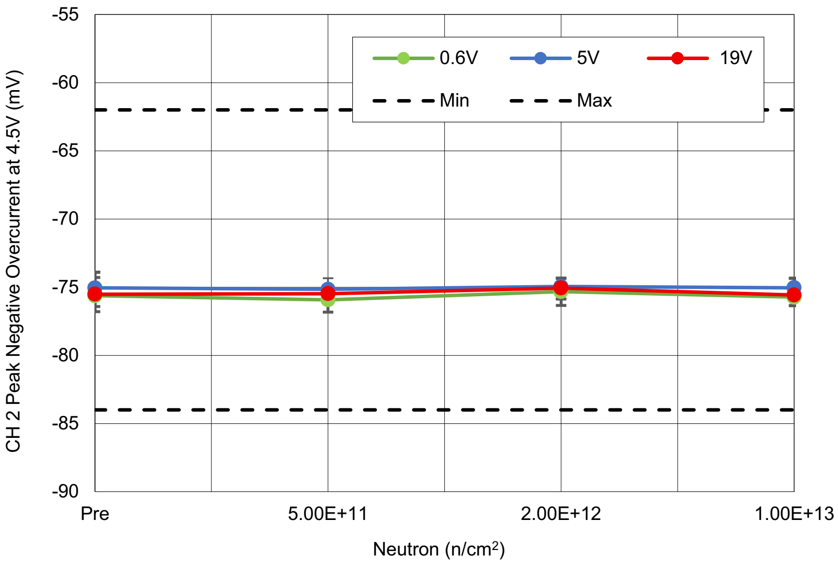

Figure 21. Channel 2 peak negative overcurrent (V_{NOC}) with V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are -84mV minimum and -62mV maximum.

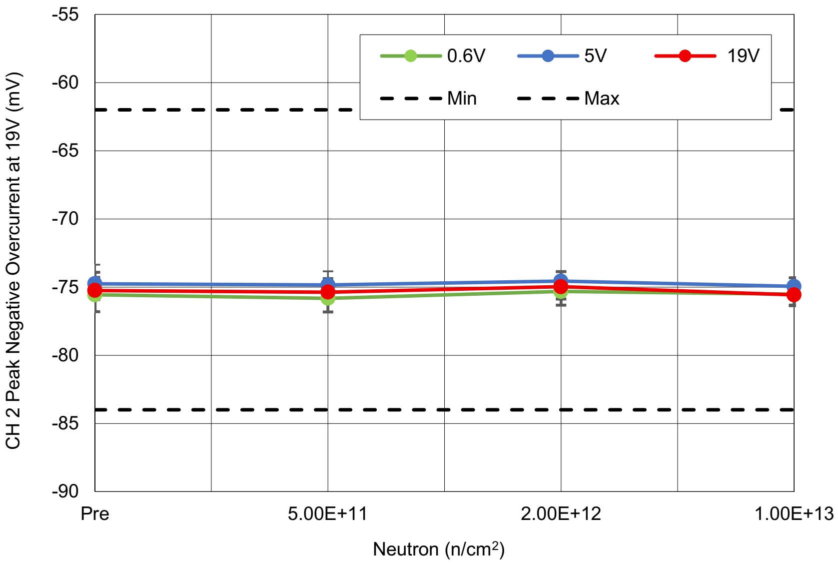

Figure 22. Channel 2 peak negative overcurrent (V_{NOC}) with V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are -84mV minimum and -62mV maximum.

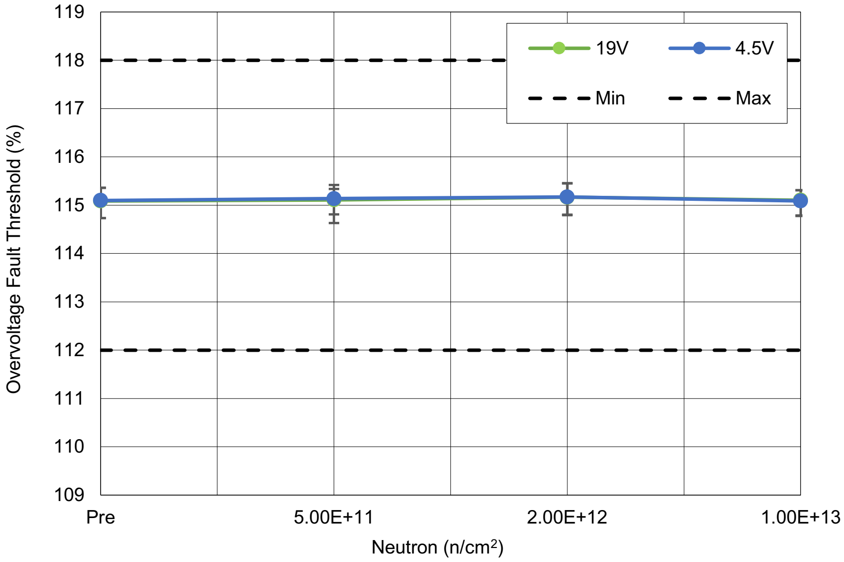

Figure 23. Overvoltage fault threshold ($V_{FB, OV}$) with V_{DD} = 4.5V and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 112% minimum and 118% maximum.

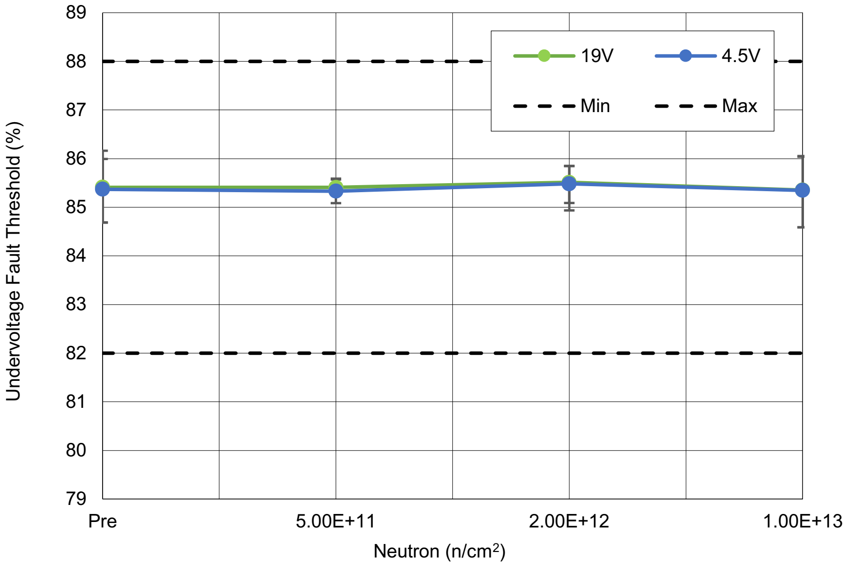

Figure 24. Undervoltage fault threshold ($V_{FB, UV}$) with V_{DD} = 4.5V and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 82% minimum and 88% maximum.

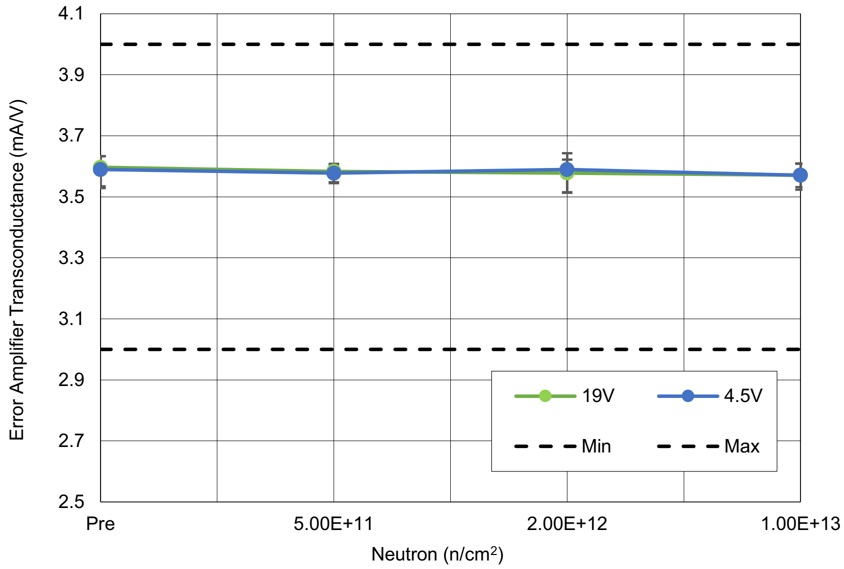

Figure 25. Error amplifier transconductance ($g_{m\text{-}EA}$) with V_{DD} = 4.5V and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 3mA/V minimum and 4mA/V maximum.

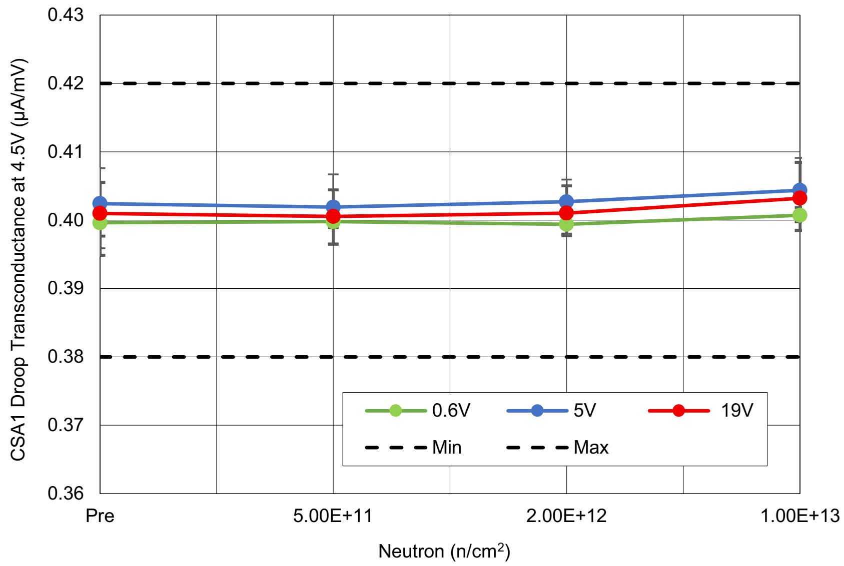

Figure 26. CSA1 droop transconductance ($g_{m(CSA,\ DRP)}$) with V_{DD} = 4.5V; $V_{(ISEN+\ -\ ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.38µA/mV minimum and 0.42µA/mV maximum.

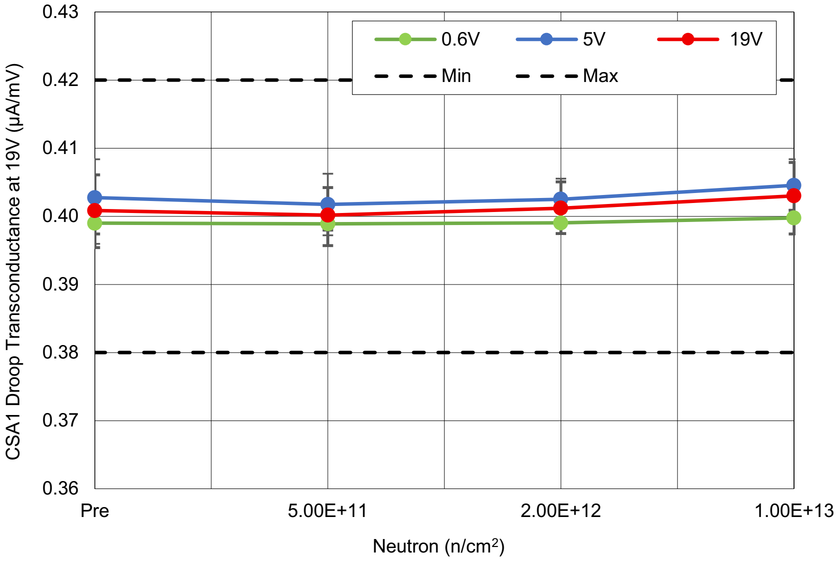

Figure 27. CSA1 droop transconductance ($g_{m(CSA,DRP)}$) with V_{DD} = 19V; $V_{(ISEN+ - ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.38µA/mV minimum and 0.42µA/mV maximum.

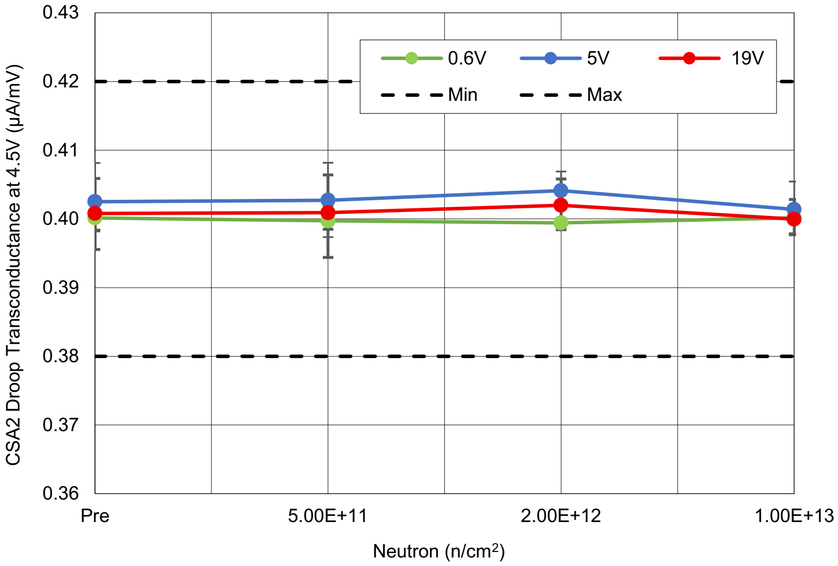

Figure 28. CSA2 droop transconductance ($g_{m(CSA,DRP)}$) with V_{DD} = 4.5V; $V_{(ISEN+ - ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.38µA/mV minimum and 0.42µA/mV maximum.

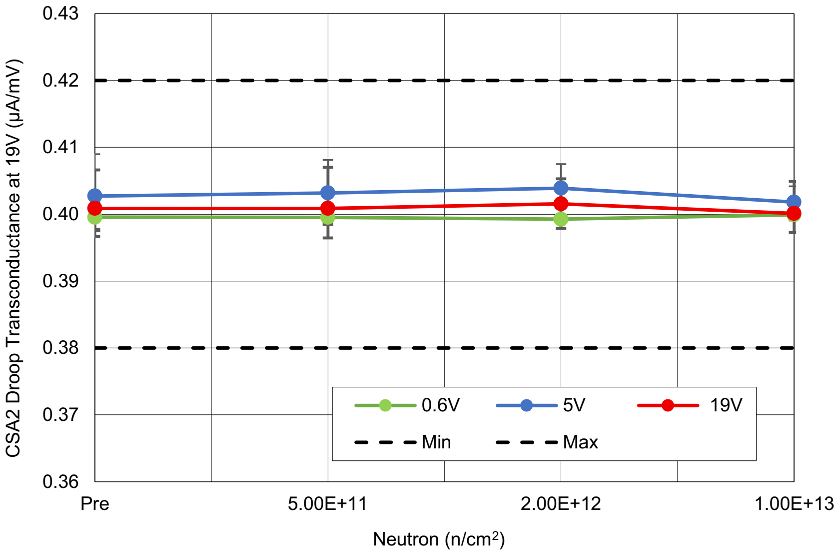

Figure 29. CSA2 droop transconductance ($g_{m(CSA,DRP)}$) with V_{DD} = 19V; $V_{(ISEN+ - ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.38µA/mV minimum and 0.42µA/mV maximum.

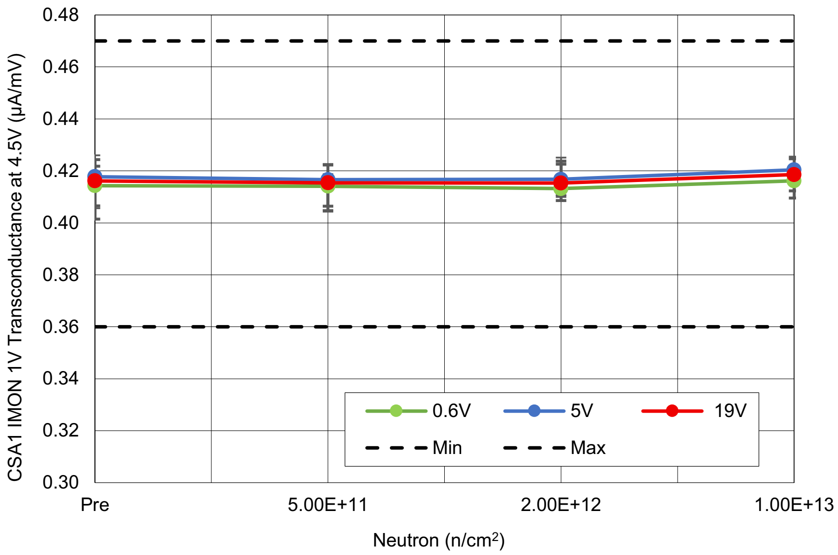

Figure 30. CSA1 IMON 1V transconductance ($g_{m(CSA, IMON)}$) with V_{DD} = 4.5V; $V_{(ISEN+ - ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.36µA/mV minimum and 0.47µA/mV maximum.

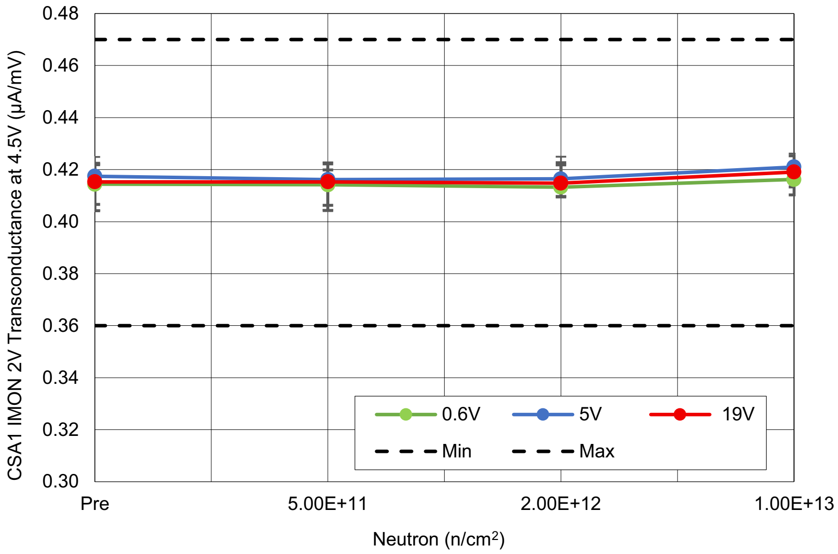

Figure 31. CSA1 IMON 2V transconductance ($g_{m(CSA,\ IMON)}$) with V_{DD} = 4.5V; $V_{(ISEN+\ -\ ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.36µA/mV minimum and 0.47µA/mV maximum.

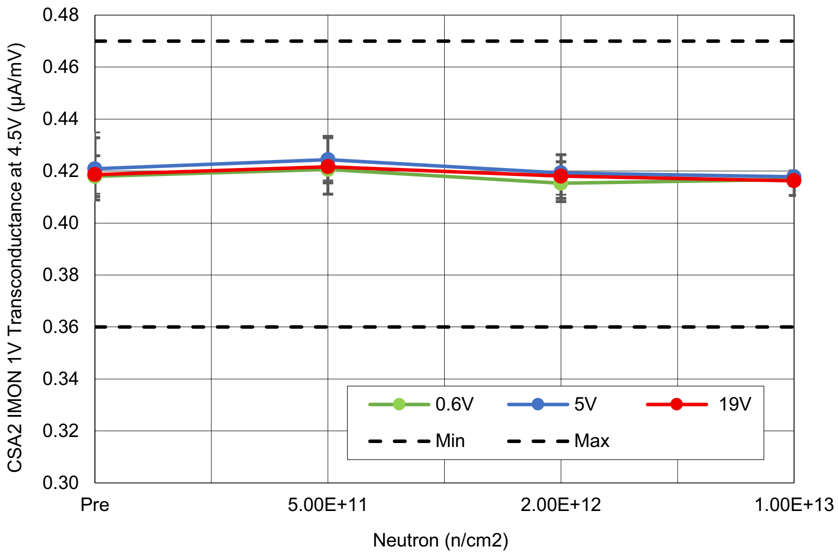

Figure 32. CSA2 IMON 1V transconductance ($g_{m(CSA,\ IMON)}$) with V_{DD} = 4.5V; $V_{(ISEN+\ -\ ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.36µA/mV minimum and 0.47µA/mV maximum.

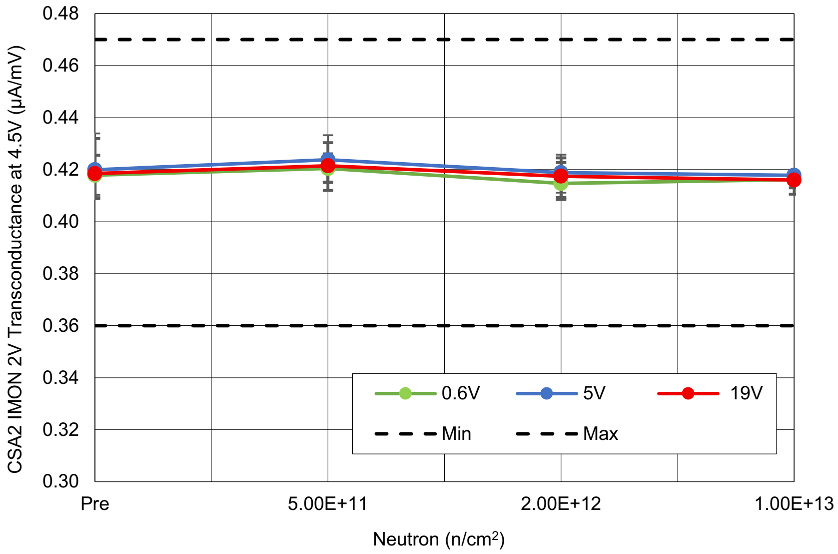

Figure 33. CSA2 IMON 2V transconductance ($g_{m(CSA,\ IMON)}$) with V_{DD} = 4.5V; $V_{(ISEN+\ -\ ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.36µA/mV minimum and 0.47µA/mV maximum.

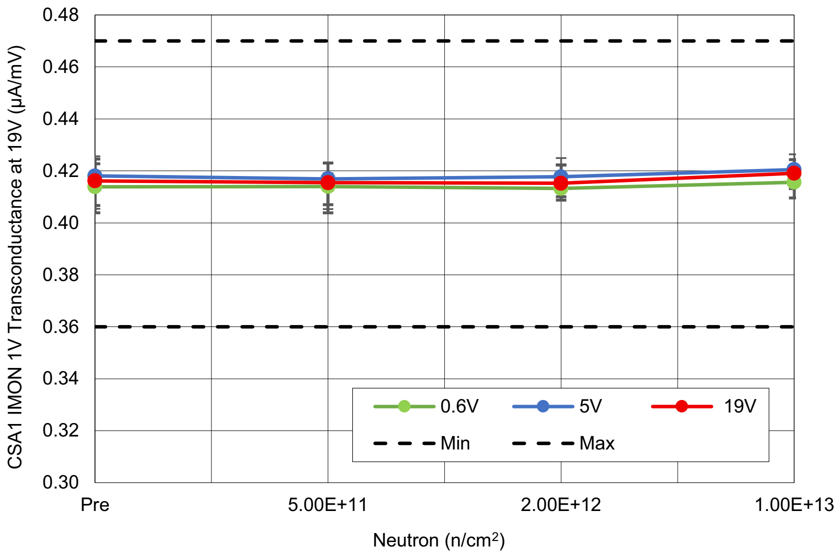

Figure 34. CSA1 IMON 1V transconductance ($g_{m(CSA,\ IMON)}$) with V_{DD} = 19V; $V_{(ISEN+\ -\ ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.36µA/mV minimum and 0.47µA/mV maximum.

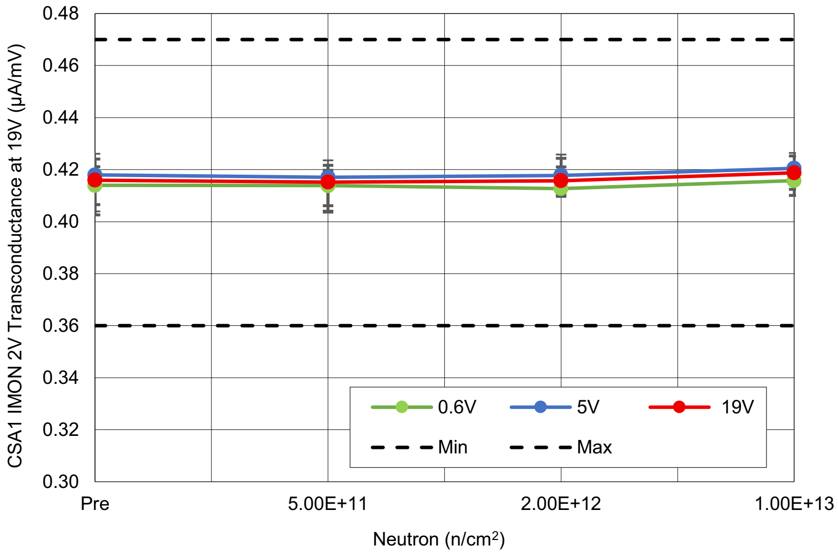

Figure 35. CSA1 IMON 2V transconductance ($g_{m(CSA,IMON)}$) with V_{DD} = 19V; $V_{(ISEN+\ -\ ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.36µA/mV minimum and 0.47µA/mV maximum.

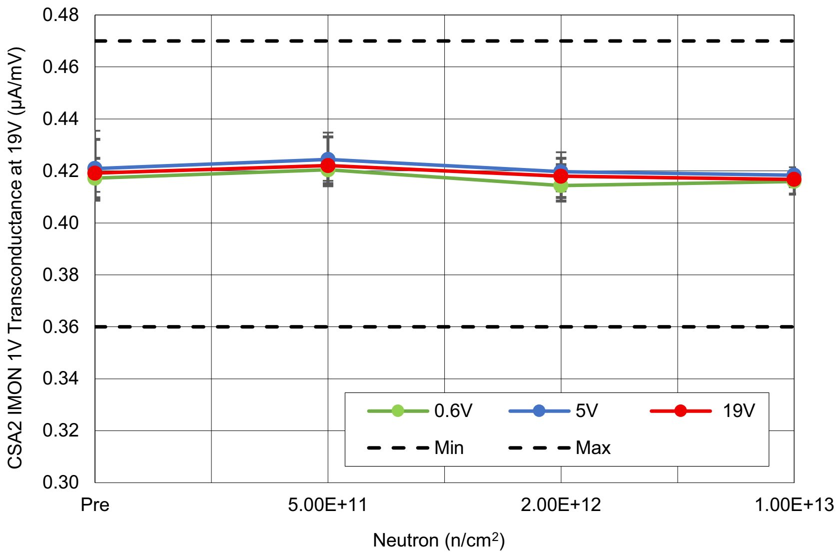

Figure 36. CSA2 IMON 1V transconductance ($g_{m(CSA,IMON)}$) with V_{DD} = 19V; $V_{(ISEN+\ -\ ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.36µA/mV minimum and 0.47µA/mV maximum.

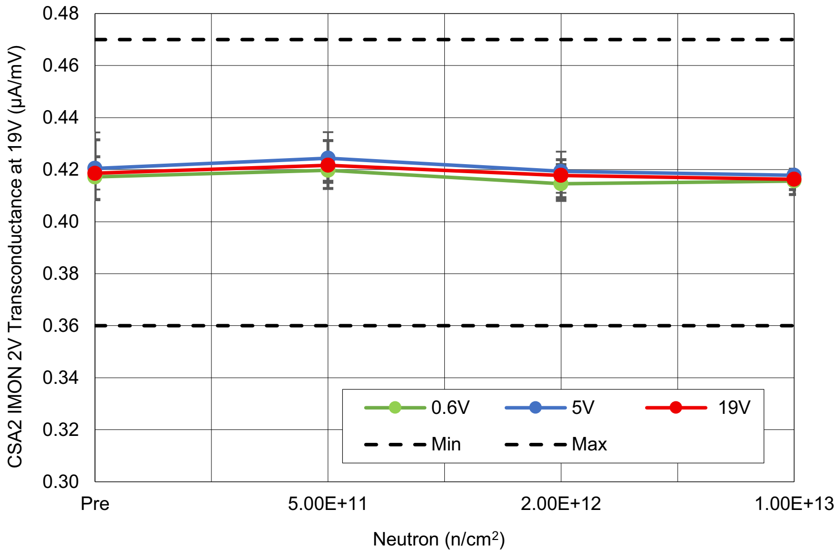

Figure 37. CSA2 IMON 2V transconductance ($g_{m(CSA,IMON)}$) with V_{DD} = 19V; $V_{(ISEN+ - ISEN-)}$ = 10mV and 50mV, V_{CM} = 0.6V, 5.0V, and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.36µA/mV minimum and 0.47µA/mV maximum.

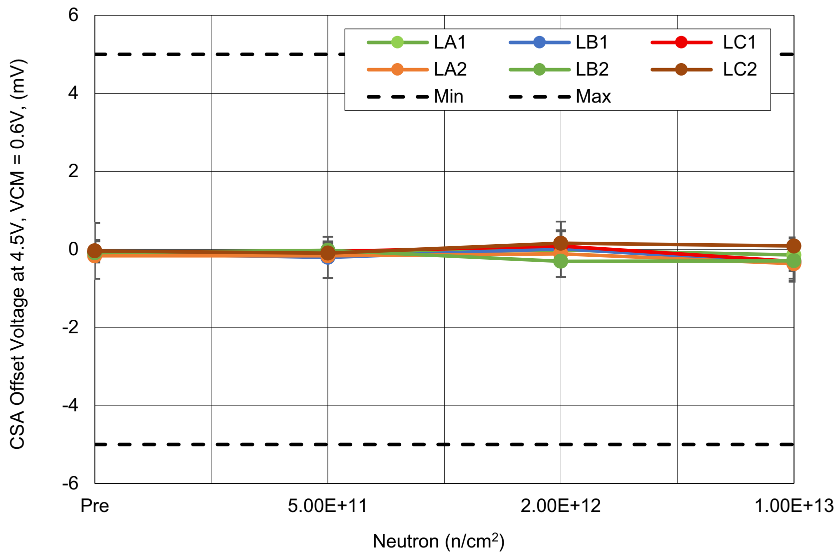

Figure 38. CSA (CSA1 = LA1, LB1, LC1; CSA2 = LA2, LB2, LC2) offset voltage ($V_{OS(CSA)}$) with V_{DD} = 4.5V; $V_{(ISEN+ - ISEN-)}$ = 0mV, V_{CM} = 0.6V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are -5mV minimum and 5mV maximum.

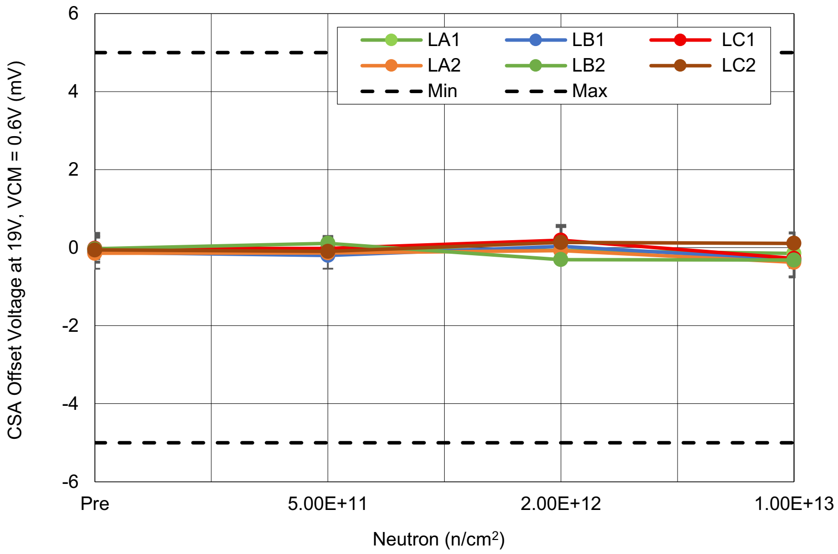

Figure 39. CSA (CSA1 = LA1, LB1, LC1; CSA2 = LA2, LB2, LC2) offset voltage ($V_{OS(CSA)}$) with V_{DD} = 19V; $V_{(ISEN+ - ISEN-)}$ = 0mV, V_{CM} = 0.6V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are -5mV minimum and 5mV maximum.

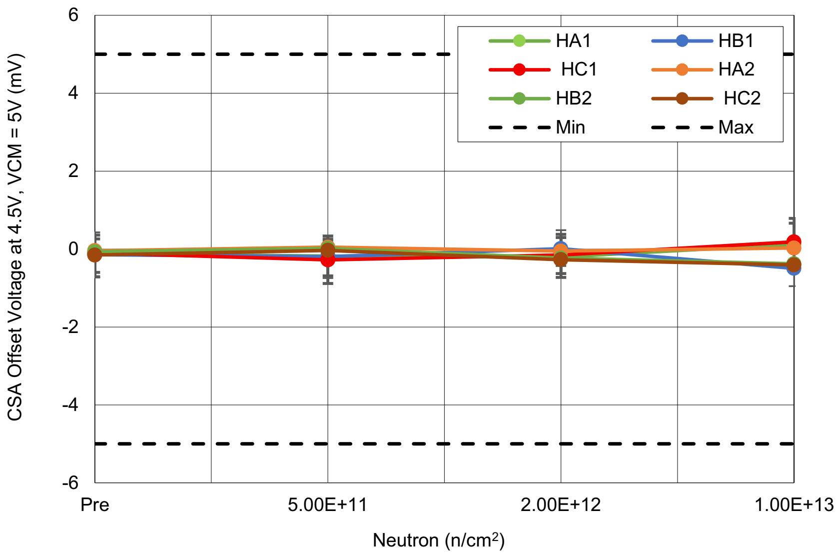

Figure 40. CSA (CSA1 = HA1, HB1, HC1; CSA2 = HA2, HB2, HC2) offset voltage ($V_{OS(CSA)}$) with V_{DD} = 4.5V; $V_{(ISEN+ - ISEN-)}$ = 0mV, V_{CM} = 5V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are -5mV minimum and 5mV maximum.

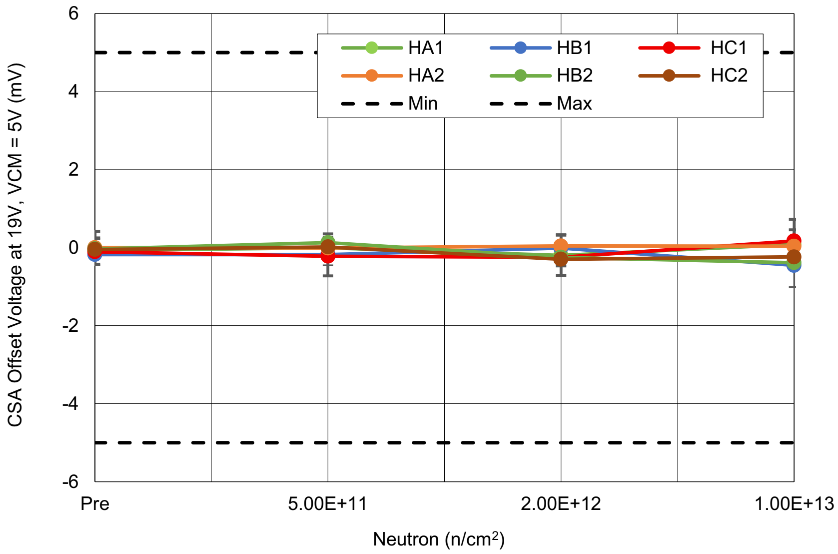

Figure 41. CSA (CSA1 = HA1, HB1, HC1; CSA2 = HA2, HB2, HC2) offset voltage ($V_{OS(CSA)}$) with V_{DD} = 19V; $V_{(ISEN+ - ISEN-)}$ = 0mV, V_{CM} = 5V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are -5mV minimum and 5mV maximum.

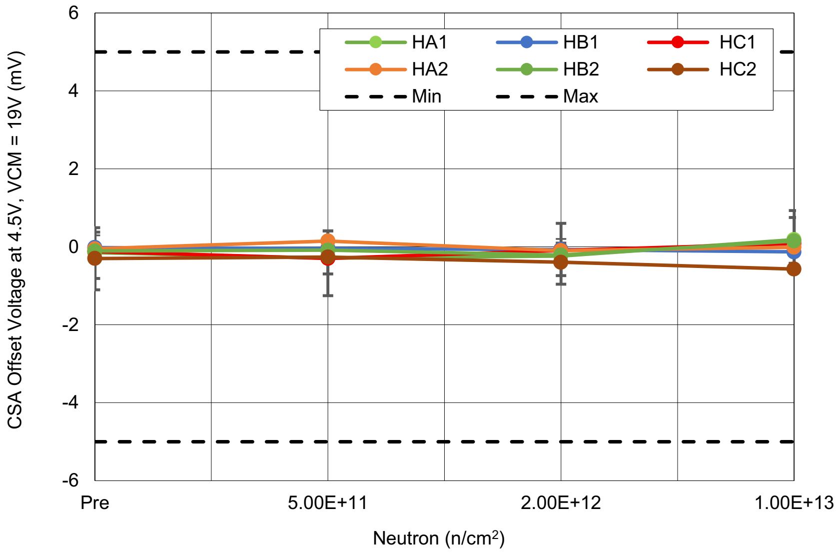

Figure 42. CSA (CSA1 = HA1, HB1, HC1; CSA2 = HA2, HB2, HC2) offset voltage ($V_{OS(CSA)}$) with V_{DD} = 4.5V; $V_{(ISEN+ - ISEN-)}$ = 0mV, V_{CM} = 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are -5mV minimum and 5mV maximum.

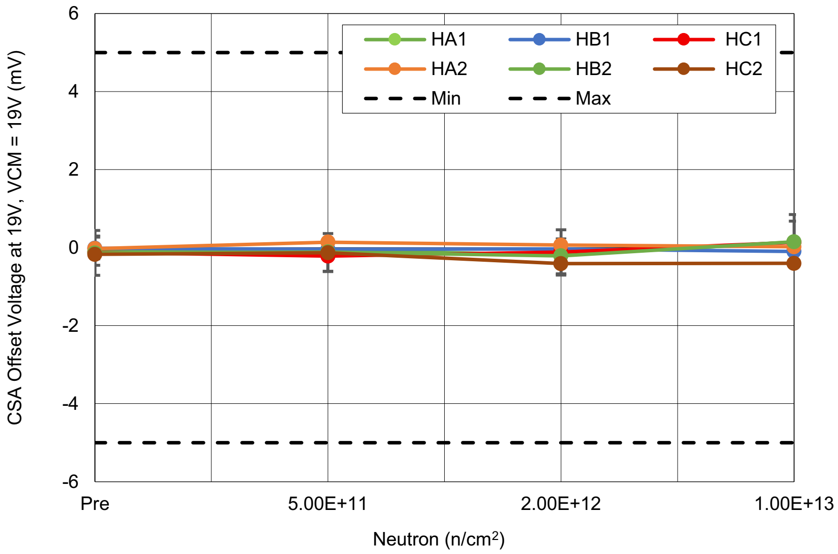

Figure 43. CSA (CSA1 = HA1, HB1, HC1; CSA2 = HA2, HB2, HC2) offset voltage ($V_{OS(CSA)}$) with V_{DD} = 19V; $V_{(ISEN+ - ISEN-)}$ = 0mV, V_{CM} = 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are -5mV minimum and 5mV maximum.

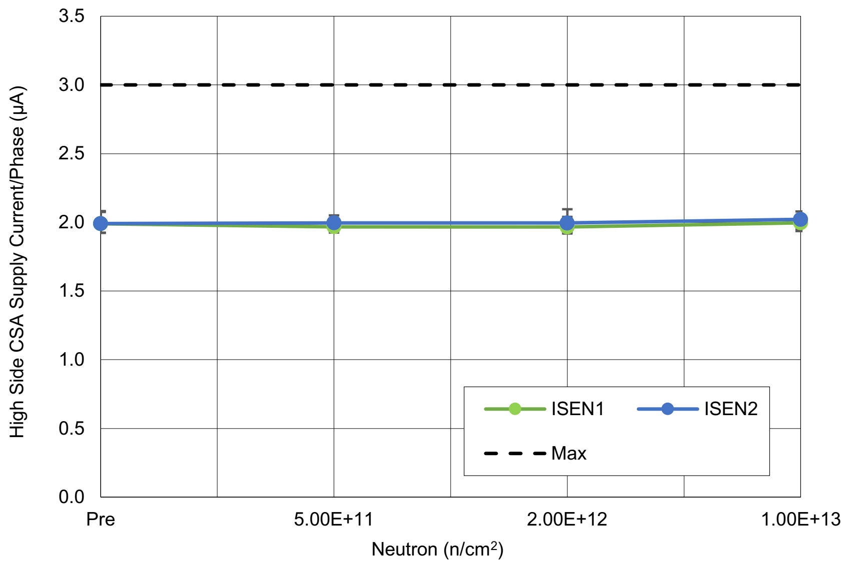

Figure 44. High-side CSA supply current per phase (I_{CSA}) with V_{DD} = 19V, EN = 3.3V, V_{CM} = 2.7V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limit is 3µA maximum.

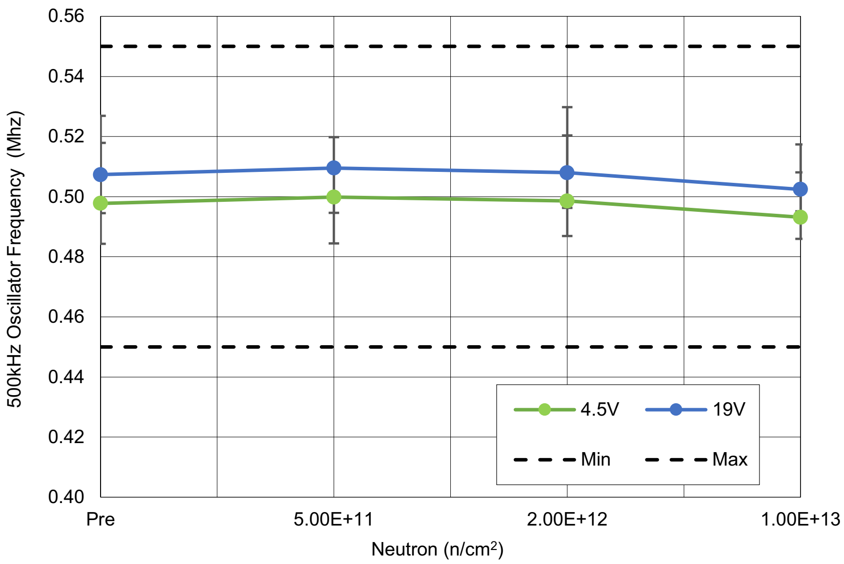

Figure 45. Frequency range for 500kHz Oscillator ($f_{OSC-0.5M}$) with V_{DD} = 4.5V and 19V; R_{FS} = 205kΩ; EN = 3.3V; R_{SYNC-O} = 100kΩ to GND, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.45MHz minimum and 0.55MHz maximum.

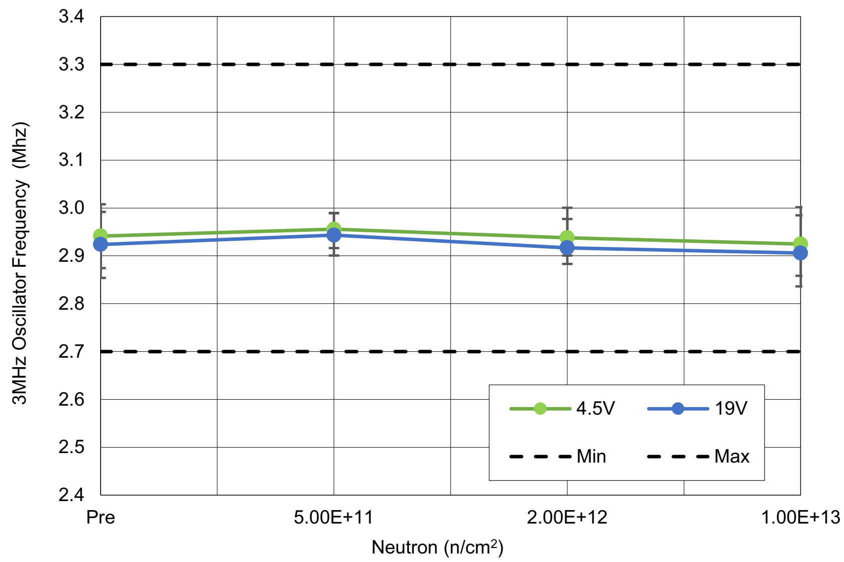

Figure 46. Frequency range for 3MHz Oscillator (f_{OSC-3M}) with V_{DD} = 4.5V and 19V; R_{FS} = 16.7kΩ; EN = 3.3V; R_{SYNC-O} = 100kΩ to GND, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 2.7MHz minimum and 3.3MHz maximum.

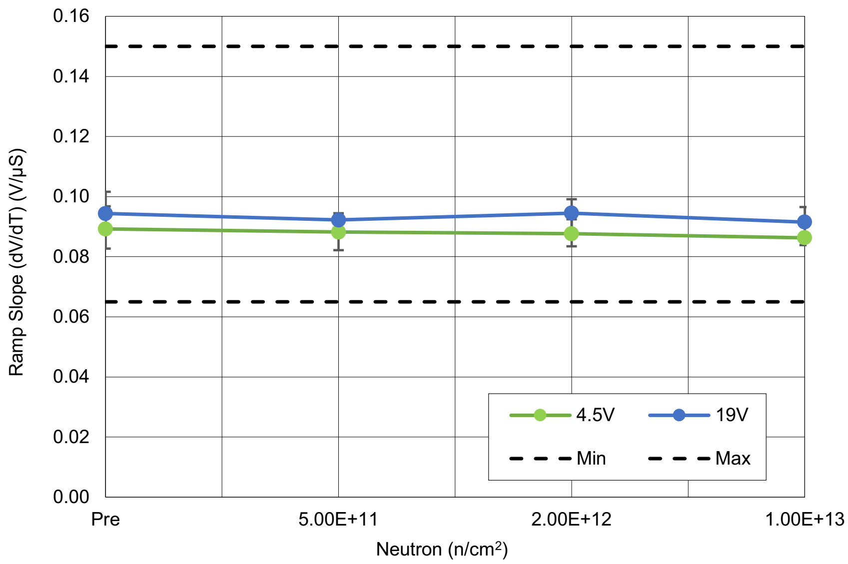

Figure 47. Slope generator ramp slope ($V_{RAMP-SLOPE}$) with V_{DD} = 4.5V and 19V; f_{SW} = 500kHz; V_{SLOPE} = 0.4V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.065V/µs minimum and 0.115V/µs maximum.

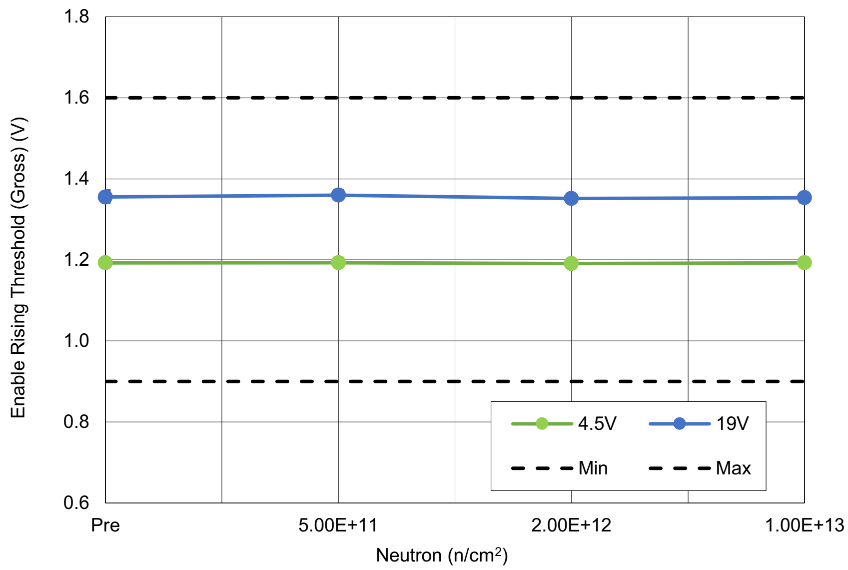

Figure 48. Enable rising threshold (Gross) ($V_{IH-EN-G}$) with V_{DD} = 4.5V and 19V; FS = V_{CC}, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.9V minimum and 1.6V maximum.

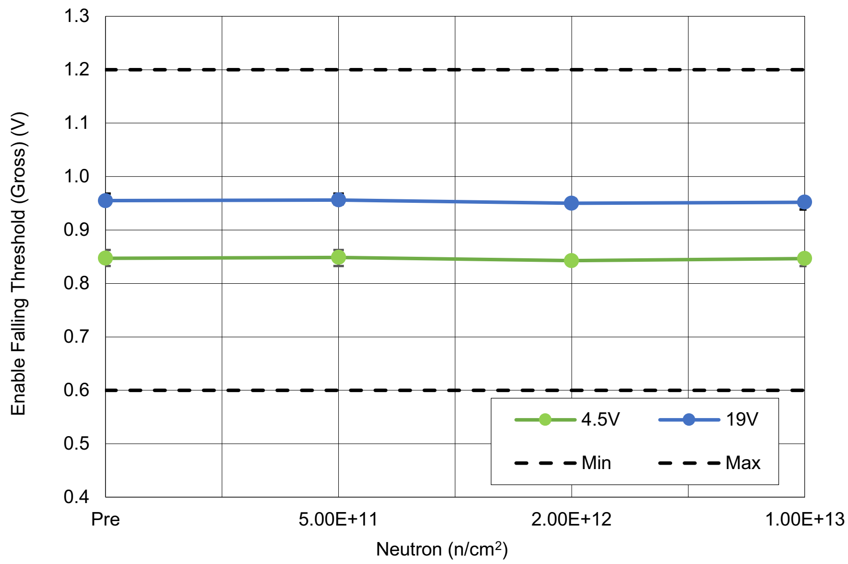

Figure 49. Enable falling threshold (Gross) ($V_{IL\text{-}EN\text{-}G}$) with V_{DD} = 4.5V and 19V; FS = V_{CC}, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 0.6V minimum and 1.2V maximum.

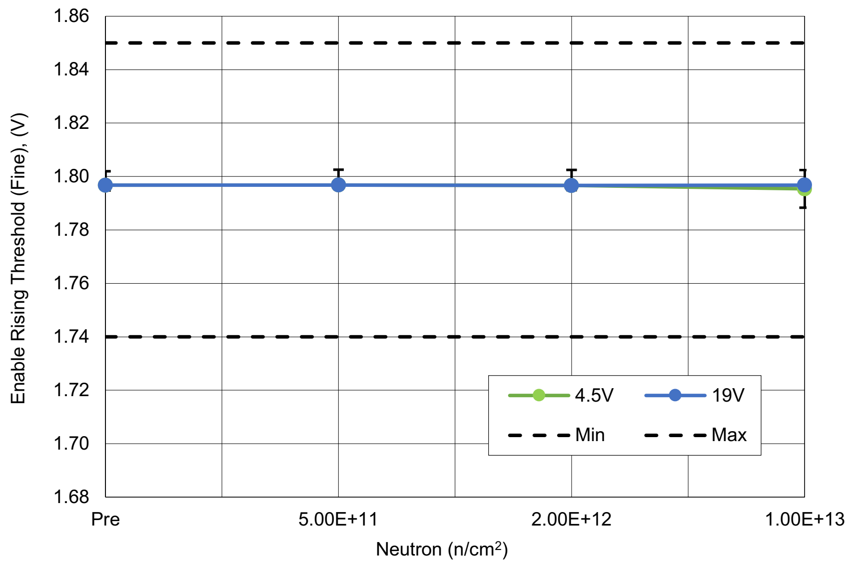

Figure 50. Enable rising threshold (Fine) ($V_{IH\text{-}EN\text{-}F}$) with V_{DD} = 4.5V and 19V; FS = V_{CC}, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 1.74V minimum and 1.85V maximum.

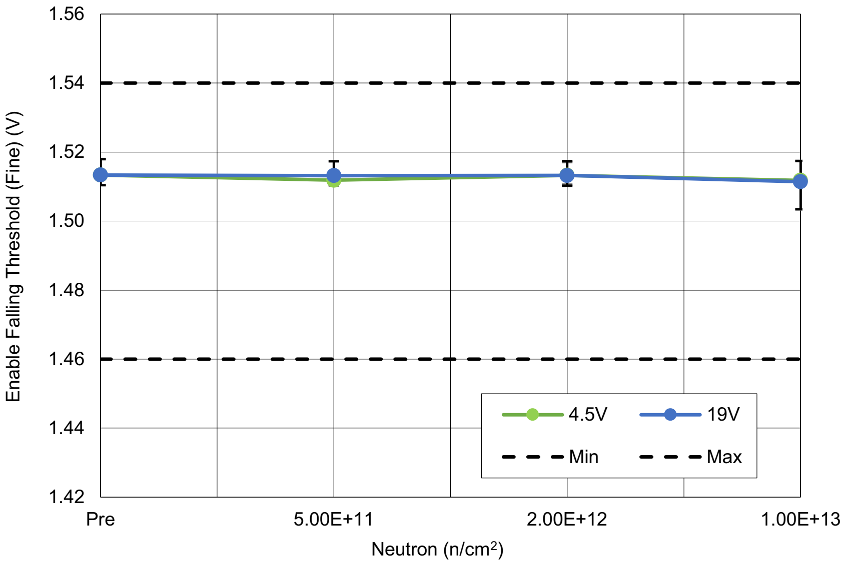

Figure 51. Enable falling threshold (Fine) ($V_{IL-EN-F}$) with V_{DD} = 4.5V and 19V; FS = V_{CC}, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 1.46V minimum and 1.54V maximum.

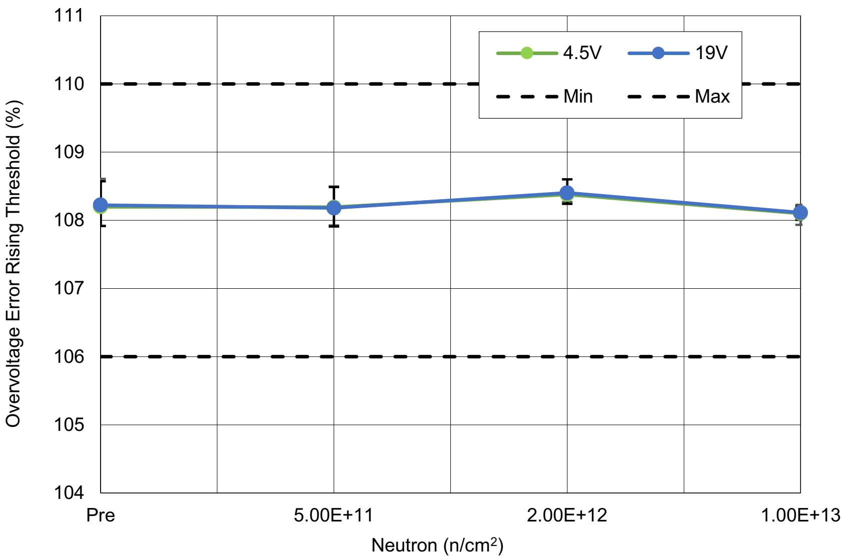

Figure 52. Overvoltage error threshold rising (V_{OVH}) with V_{DD} = 4.5V and 19V; EN = 3.3V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 106% minimum and 110% maximum.

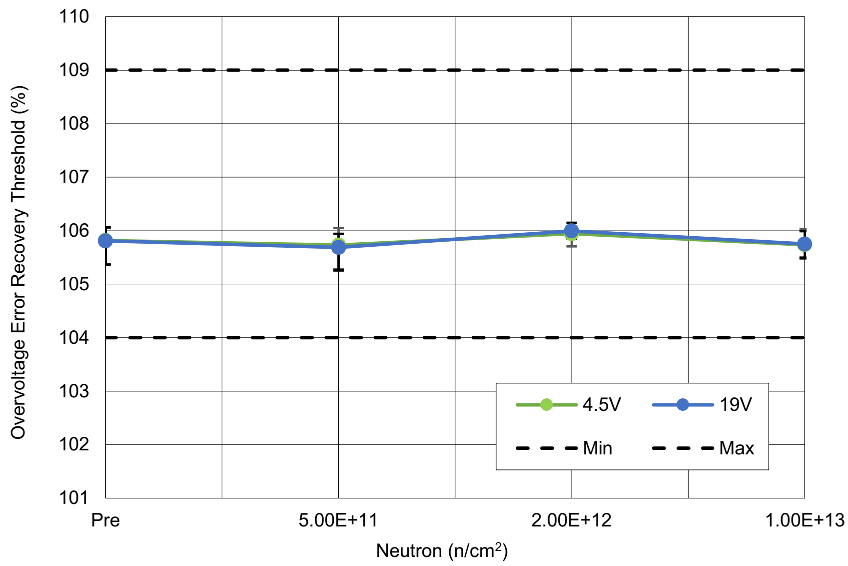

Figure 53. Overvoltage error threshold recovery (V_{OVL}) with V_{DD} = 4.5V and 19V; EN = 3.3V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 104% minimum and 109% maximum.

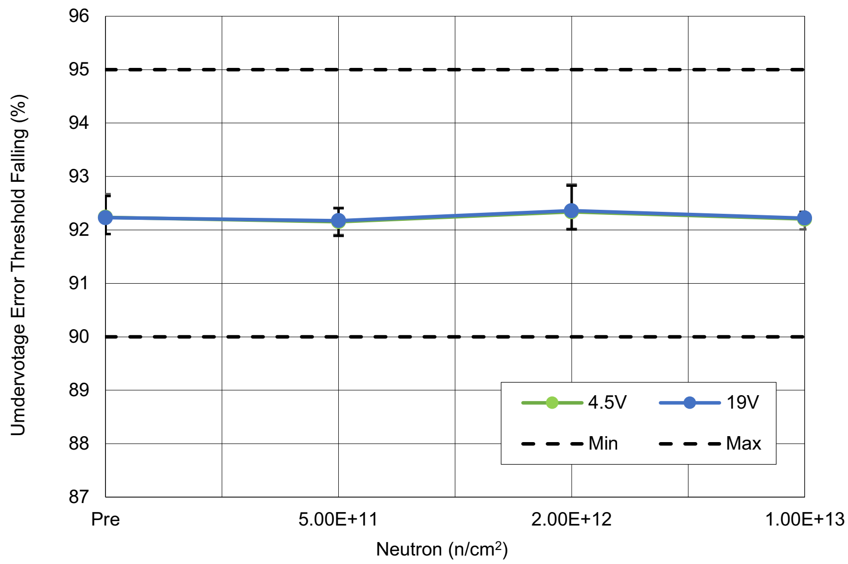

Figure 54. Undervoltage error threshold (V_{UVL}) with V_{DD} = 4.5V and 19V; EN = 3.3V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 90% minimum and 95% maximum.

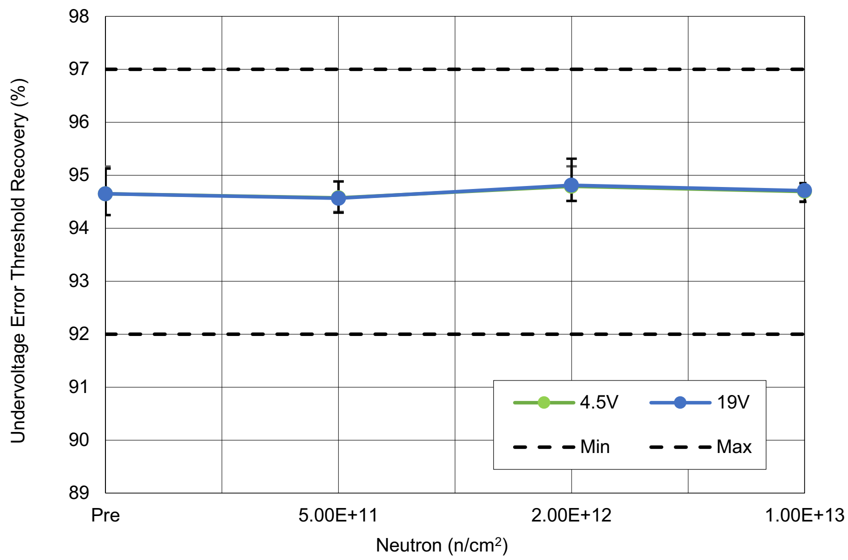

Figure 55. Undervoltage error threshold recovery (V_{UVH}) with V_{DD} = 4.5V and 19V; EN = 3.3V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 92% minimum and 97% maximum.

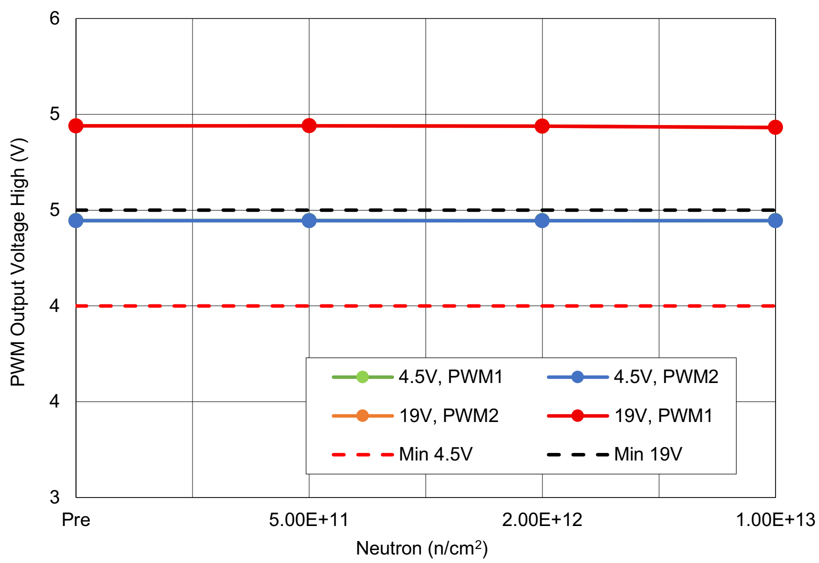

Figure 56. PWM output voltage high (V_{OH}) with V_{DD} = 4.5V and 19V; I_{PWM} = -500µA as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 4.2V minimum for V_{DD} = 4.5V and 4.6V minimum for V_{DD} = 19V.

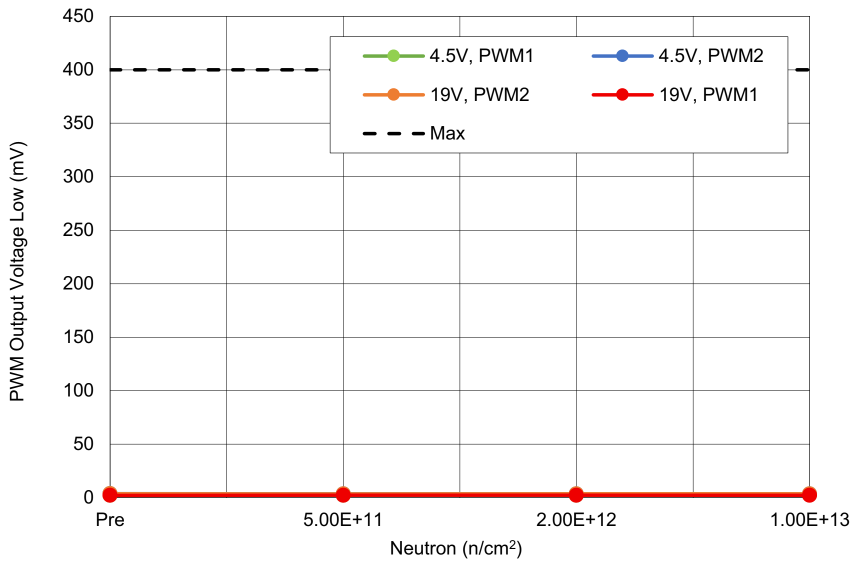

Figure 57. PWM output voltage low (V_{OL}) with V_{DD} = 4.5V and 19V; I_{PWM} = +500µA as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limit is 400mV maximum.

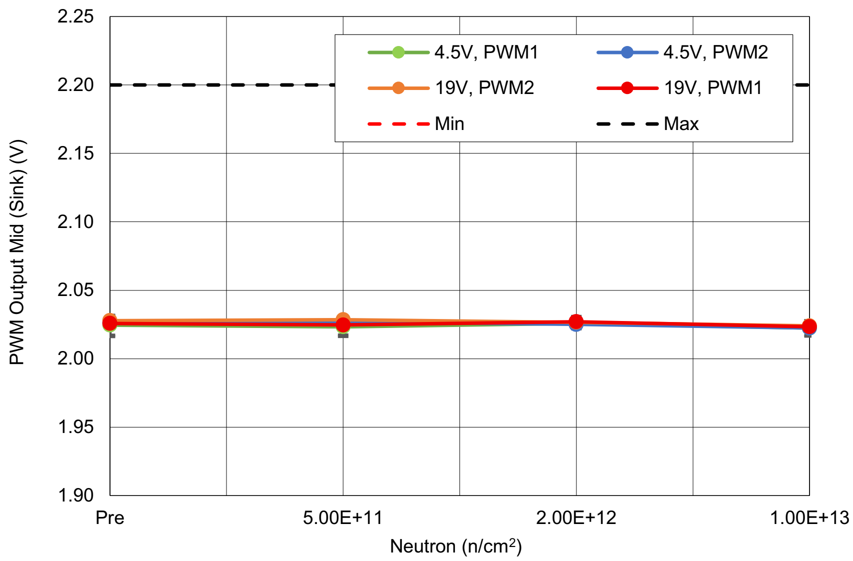

Figure 58. PWM output voltage mid sink (V_{OZ}) with V_{DD} = 4.5V and 19V; I_{PWM} = -100µA, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limit is 2.20V maximum.

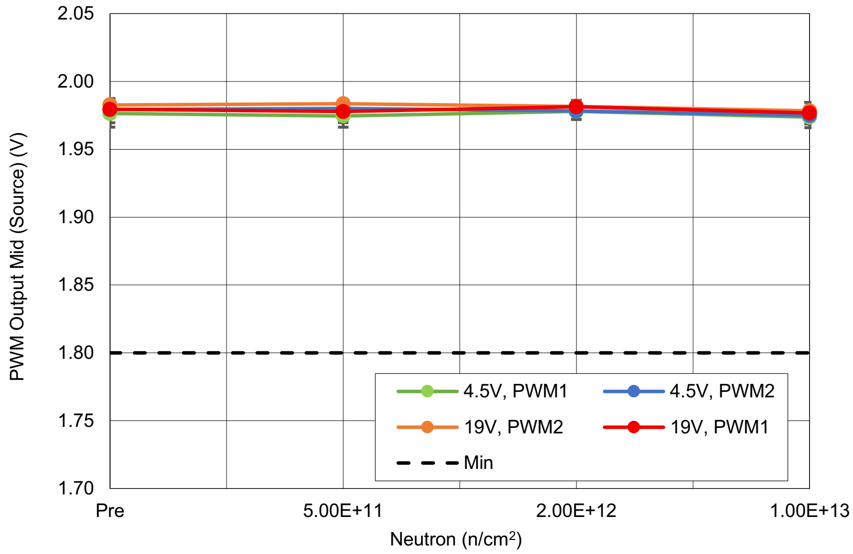

Figure 59. PWM output voltage mid source (V_{OZ}) with V_{DD} = 4.5V and 19V; I_{PWM} = +100µA, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limit is 1.80V minimum.

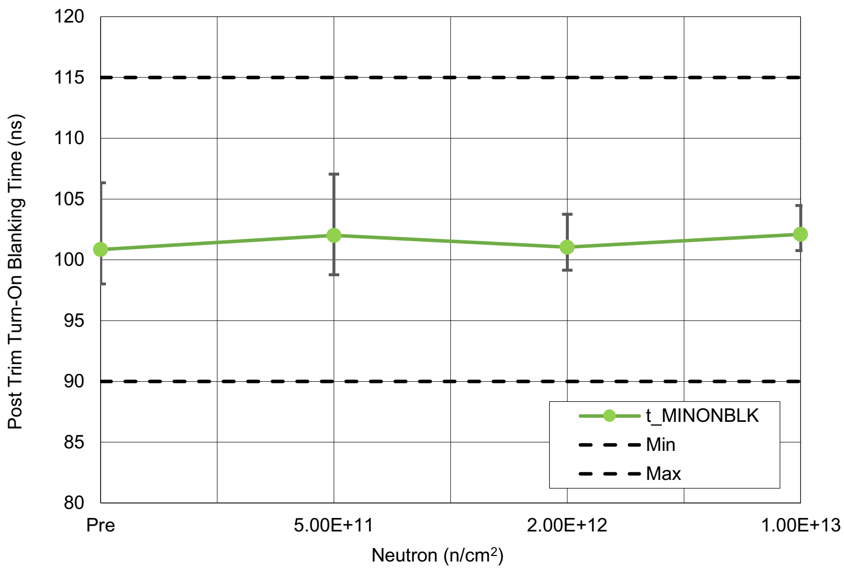

Figure 60. Turn-on blanking time ($t_{MINONBLK}$) as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 90ns minimum and 115ns maximum.

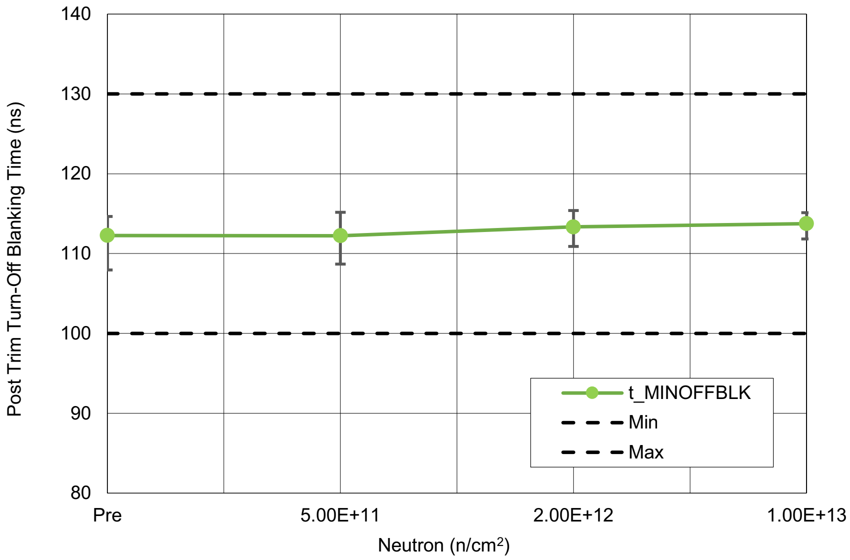

Figure 61. Turn-off blanking time ($t_{MINOFFBLK}$) as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 100ns minimum and 130ns maximum.

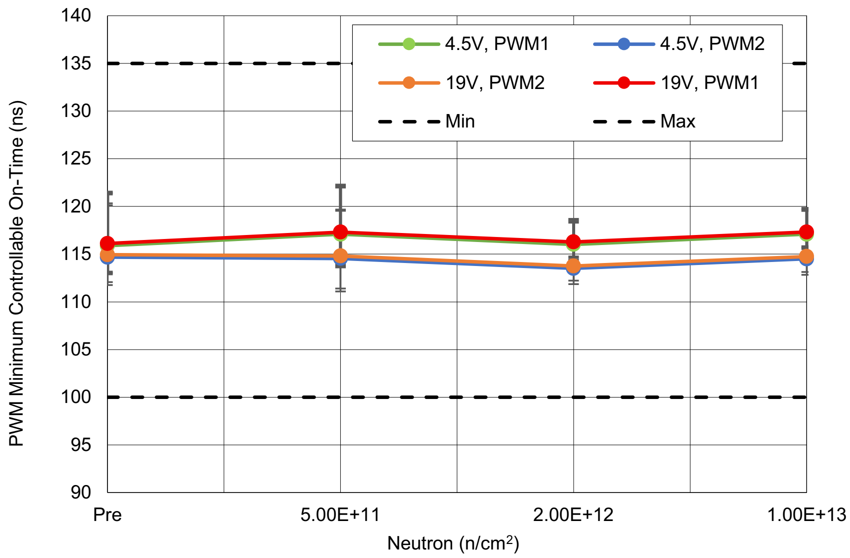

Figure 62. PWM minimum controllable ON time ($t_{MINCTRLON}$) with V_{DD} = 4.5V and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 100ns minimum and 135ns maximum.

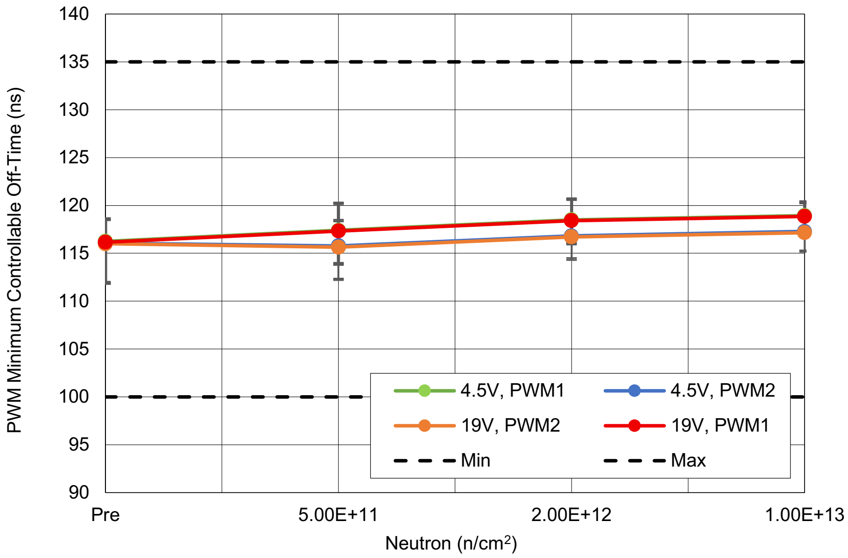

Figure 63. PWM minimum controllable Off time ($t_{MINCTRLOFF}$) with V_{DD} = 4.5V and 19V, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 100ns minimum and 135ns maximum.

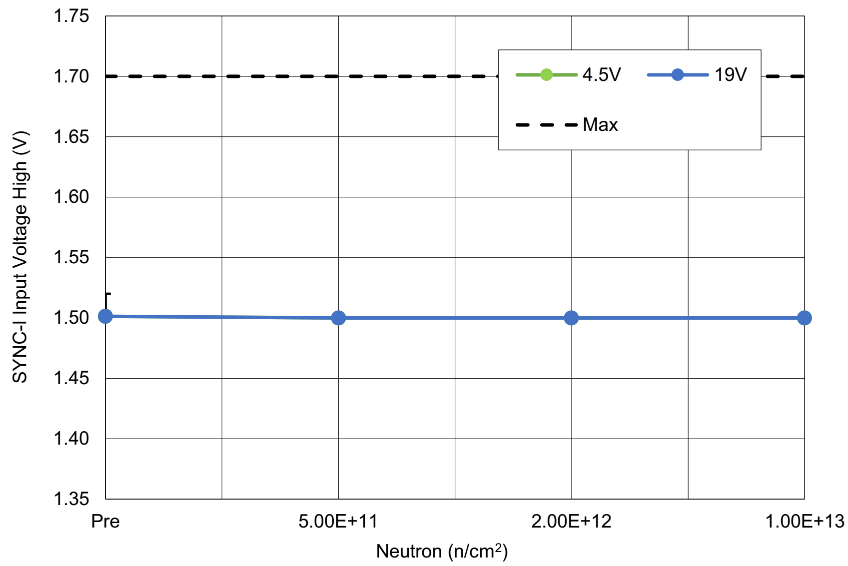

Figure 64. SYNC-I input voltage high (V_{SYNCH}) with V_{DD} = 4.5V and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limit is 1.7V maximum.

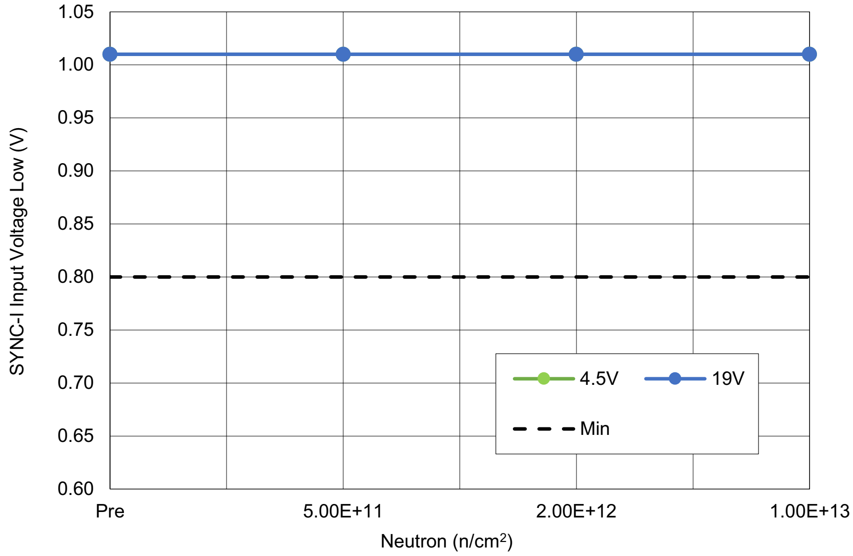

Figure 65. SYNC-I input voltage low (V_{SYNCL}) with V_{DD} = 4.5V and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limit is 0.8V minimum.

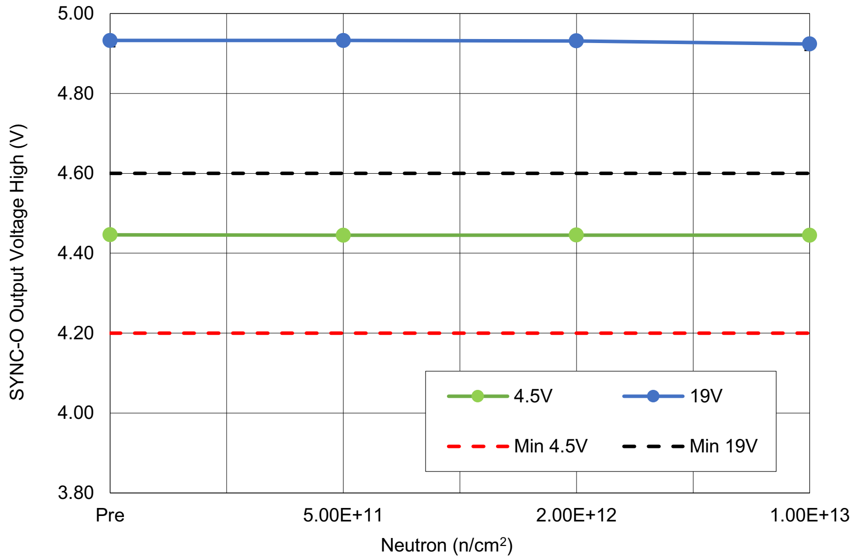

Figure 66. SYNC-O output voltage high ($V_{SYNC\text{-}OH}$) with V_{DD} = 4.5V and 19V; $I_{SYNC\text{-}O}$ = -500µA, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 4.2V minimum for V_{DD} = 4.5V and 4.6V minimum for V_{DD} = 19V.

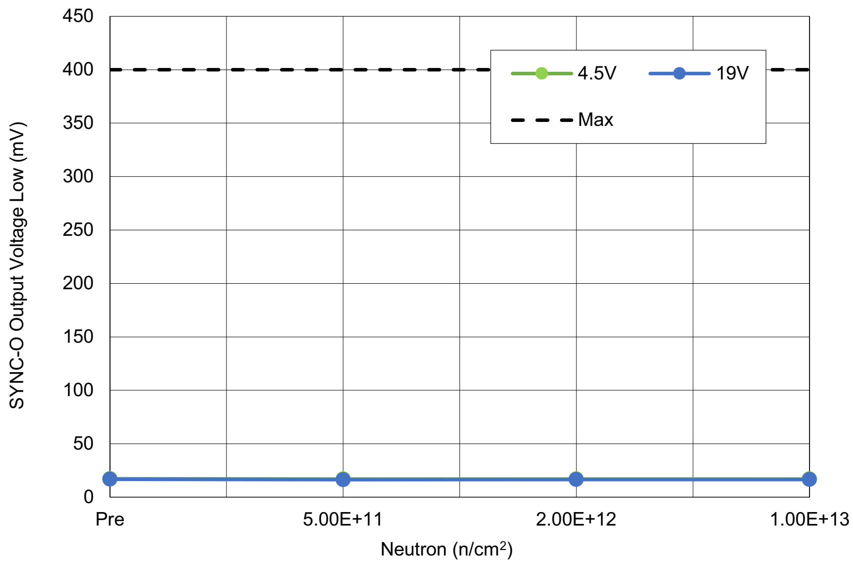

Figure 67. SYNC-O output voltage low ($V_{SYNC\text{-}OL}$) with V_{DD} = 4.5V and 19V; $I_{SYNC\text{-}O}$ = +500µA, as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limit is 400mV maximum.

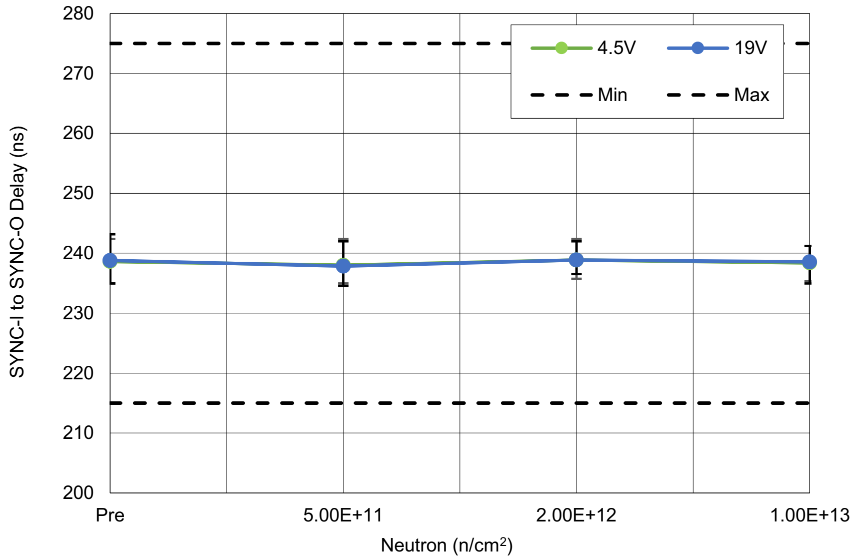

Figure 68. SYNC-I to SYNC-O delay ($t_{SYNC\text{-}DLY}$) with V_{DD} = 4.5V and 19V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The post-irradiation datasheet limits are 215ns minimum and 275ns maximum.

3. Discussion and Conclusion

The results of 1MeV equivalent neutron testing of the ISL73847xxx radiation-tolerant low dropout linear regulator were reported. Parts were tested at actual fluences of 6.12×10^{11}n/cm^2, 2.38×10^{12}n/cm^2, and 1.19×10^{13}n/cm^2. The results of key parameters before and after irradiation to each level are plotted in Figure 2 through Figure 68. The plots show the mean of each parameter as a function of neutron irradiation, with error bars that represent the minimum and maximum measured values. Each marker represents a different set of five samples. The line connecting them is for trend visualization only. The figures also show the applicable electrical limits taken from the datasheet.

4. Revision History

Revision	Date	Description
1.00	Sep 8, 2025	Initial release.

A. Reported Parameters

Table 4 lists the datasheet parameters that are considered indicative of part performance. These parameters are plotted in Figure 2 through Figure 68. All limits are taken from the *ISL73847SLH Datasheet*, which has more details on the test conditions.

Table 4. Datasheet Post-Irradiation Parameters (T_A = 25°C)

Figure	Parameter	Symbol	Conditions	Low Limit	High Limit	Unit
2	Operating Supply Current	I_{DDO}	V_{DD} = 4.5V, 12V, 19V, EN = 3.3V, f_{SW} = 500kHz, C_L = 100pF	9	16	mA
3	Shutdown Supply Current	I_{DDSD}	V_{DD} = 4.5V, EN = GND	-	0.80	µA
			V_{DD} = 12V, EN = GND	-	17	µA
			V_{DD} = 19V, EN = GND	-	35	µA
4	Output Voltage Range	VCC	V_{DD} = 6V, 19V, I_{OUT} = 0mA, 20mA	4.7	5.3	V
5	Dropout Voltage	VCC_{DO}	V_{DD} = 4.5V, I_{OUT} = 50mA	85	250	mV
6	VCC Foldback Current	I_{CC-SC}	V_{DD} = 5.5V, 19V, V_{CC} = 0V, EN = 1.6V	40	90	mA
7	VCC Overcurrent Limit	-	V_{DD} = 5.5V, 19V, V_{CC} = 4.5V, EN = 1.6V	75	130	mA
8	Voltage Set Point	V_{FB+}	V_{REF} = V_{DROOP}, V_{SEN1} = V_{SEN2} = 0mV	0.592	0.605	V
9			V_{REF} = V_{DROOP}, V_{SEN1} = V_{SEN2} = 50mV			
10	Soft-Start Sourcing Current	$I_{SOFTSTART}$	V_{DD} = 19V	9.2	10.5	µA
11	Peak Positive Current Limit (Channel 1)	V_{PCL}	V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, 19V	67.5	82.5	mV
12			V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, 19V			
13	Peak Positive Current Limit (Channel 2)	V_{PCL}	V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, 19V	67.5	82.5	mV
14			V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, 19V			
15	Peak Positive Overcurrent (Channel 1)	V_{POC}	V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, 19V	90	110	mV
16			V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, 19V			
17	Peak Positive Overcurrent (Channel 2)	V_{POC}	V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, 19V	90	110	mV
18			V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, 19V			
19	Peak Negative Overcurrent (Channel 1)	V_{NOC}	V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, 19V	-84	-62	mV
20			V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, 19V			
21	Peak Negative Overcurrent (Channel 2)	V_{NOC}	V_{DD} = 4.5V; V_{CM} = 0.6V, 5.0V, 19V	-84	-62	mV
22			V_{DD} = 19V; V_{CM} = 0.6V, 5.0V, 19V			
23	Overvoltage Threshold	$V_{(FB, OV)}$	V_{DD} = 4.5V, 19V	112	118	%

Table 4. Datasheet Post-Irradiation Parameters (T_A = 25°C)

Figure	Parameter	Symbol	Conditions	Low Limit	High Limit	Unit
24	Undervoltage Threshold	$V_{(FB, UV)}$	V_{DD} = 4.5V, 19V	82	88	%
25	Error Amplifier Transconductance	$g_{m\text{-}EA}$	V_{DD} = 4.5V, 19V	3	4	mA/V
26	Droop Transconductance (CSA1)	$g_{m(CSA, DRP)}$	V_{DD} = 4.5V; $V(I_{SEN+} - I_{SEN-})$ = 10mV, 50mV, V_{CM} = 0.6V, 5.0V, 19V	0.38	0.42	µA/mV
27			V_{DD} = 19V; $V(I_{SEN+} - I_{SEN-})$ = 10mV, 50mV, V_{CM} = 0.6V, 5.0V, 19V			
28	Droop Transconductance (CSA2)	$g_{m(CSA, DRP)}$	V_{DD} = 4.5V; $V(I_{SEN+} - I_{SEN-})$ = 10mV, 50mV, V_{CM} = 0.6V, 5.0V, 19V	0.38	0.42	µA/mV
29			V_{DD} = 19V; $V(I_{SEN+} - I_{SEN-})$ = 10mV, 50mV, V_{CM} = 0.6V, 5.0V, 19V			
30	IMON Transconductance (CSA1, 1V)	$g_{m(CSA, IMON)}$	V_{DD} = 4.5V; $V(I_{SEN+} - I_{SEN-})$ = 10mV, 50mV, V_{CM} = 0.6V, 5.0V, 19V	0.36	0.47	µA/mV
31	IMON Transconductance (CSA1, 2V)					
32	IMON Transconductance (CSA2, 1V)					
33	IMON Transconductance (CSA2, 2V)					
34	IMON Transconductance (CSA1, 1V)	$g_{m(CSA, IMON)}$	V_{DD} = 19V; $V(I_{SEN+} - I_{SEN-})$ = 10mV, 50mV, V_{CM} = 0.6V, 5.0V, 19V	0.36	0.47	µA/mV
35	IMON Transconductance (CSA1, 2V)					
36	IMON Transconductance (CSA2, 1V)					
37	IMON Transconductance (CSA2, 2V)					
38	CSA Offset Voltage (Low Side)	$V_{OS(CSA)}$	V_{DD} = 4.5V, $V(I_{SEN+} - I_{SEN-})$ = 0mV, V_{CM} = 0.6V	-5	5	V
39			V_{DD} = 19V, $V(I_{SEN+} - I_{SEN-})$ = 0mV, V_{CM} = 0.6V			
40	CSA Offset Voltage (High Side)	$V_{OS(CSA)}$	V_{DD} = 4.5V, $V(I_{SEN+} - I_{SEN-})$ = 0mV, V_{CM} = 5V	-5	5	V
41			V_{DD} = 19V, $V(I_{SEN+} - I_{SEN-})$ = 0mV, V_{CM} = 5V			
42			V_{DD} = 4.5V, $V(I_{SEN+} - I_{SEN-})$ = 0mV, V_{CM} = 19V			
43			V_{DD} = 19V, $V(I_{SEN+} - I_{SEN-})$ = 0mV, V_{CM} = 19V			
44	HS CSA Supply Current per Phase (Current into ISENx- pin)	I_{CSA}	V_{DD} = 19V; EN = 3.3V; V_{CM} = 2.7V		3	µA
45	Oscillator Frequency Range	$f_{OSC\text{-}0.5M}$	V_{DD} = 4.5V, 19V, R_{FS} = 205kΩ, EN = 3.3V, $R_{SYNC\text{-}O}$ = 100kΩ to GND	0.45	0.55	MHz
46		$f_{OSC\text{-}3M}$	V_{DD} = 4.5V, 19V, R_{FS} = 16.7kΩ, EN = 3.3V, $R_{SYNC\text{-}O}$ =100kΩ to GND	2.70	3.30	MHz
47	Ramp Slope	$V_{RAMP\text{-}SLOPE}$	V_{DD} = 4.5V, 19V, f_{SW} = 500kHz, V_{SLOPE} = 0.4V	0.06	0.15	V/µs
48	Rising Enable Threshold (Gross)	$V_{IH\text{-}EN\text{-}G}$	V_{DD} = 4.5V, 19V, FS = V_{CC}	0.9	1.6	V
49	Falling Enable Threshold (Gross)	$V_{IL\text{-}EN\text{-}G}$	V_{DD} = 4.5V, 19V, FS = V_{CC}	0.6	1.2	V
50	Rising Enable Threshold (Fine)	$V_{IH\text{-}EN\text{-}F}$	V_{DD} = 4.5V, 19V, FS = V_{CC}	1.74	1.85	V
51	Falling Enable Threshold (Fine)	$V_{IL\text{-}EN\text{-}F}$	V_{DD} = 4.5V, 19V, FS = V_{CC}	1.46	1.54	V
52	Overvoltage Error Threshold	V_{OVH}	V_{DD} = 4.5V, 19V, EN = 3.3V	106	110	%

Table 4. Datasheet Post-Irradiation Parameters (T_A = 25°C)

Figure	Parameter	Symbol	Conditions	Low Limit	High Limit	Unit
53	Overvoltage Error Threshold Recovery	V_{OVL}	V_{DD} = 4.5V, 19V, EN = 3.3V	104	109	%
54	Undervoltage Error Threshold	V_{UVL}	V_{DD} = 4.5V, 19V, EN = 3.3V	90	95	%
55	Undervoltage Error Threshold Recovery	V_{UVH}	V_{DD} = 4.5V, 19V, EN = 3.3V	92	97	%
56	PWM Output High	V_{OH}	V_{DD} = 4.5V, I_{PWM} = -500µA	4.2	-	V
			V_{DD} = 19V, I_{PWM} = -500µA	4.6	-	V
57	PWM Output Low	V_{OL}	V_{DD} = 4.5V, 19V, and I_{PWM} = +500µA	-	0.4	V
58	PWM Output Mid (Sink)	V_{OZ}	V_{DD} = 4.5V, 19V, and I_{PWM} = -100µA	-	2.20	V
59	PWM Output Mid (Source)	-	V_{DD} = 4.5V, 19V, and I_{PWM} = +100µA	1.8	-	V
60	Turn-On Blanking Time	$t_{MINONBLK}$	-	90	115	ns
61	Turn-Off Blanking Time	$t_{MINOFFBLK}$	-	100	130	ns
62	Minimum Controllable ON-Time	$t_{MINCTRLON}$	V_{DD} = 4.5V, 19V	100	135	ns
63	Minimum Controllable OFF-Time	$t_{MINCTRLOFF}$	V_{DD} = 4.5V, 19V	100	135	ns
64	SYNC-I Input Voltage High	V_{SYNCH}	V_{DD} = 4.5V, 19V	-	1.7	V
65	SYNC-I Input Voltage Low	V_{SYNCL}	V_{DD} = 4.5V, 19V	0.8	-	V
66	SYNC-O Output Voltage High	$V_{SYNC-OH}$	V_{DD} = 4.5V, 19V, I_{SYNC-O} = -500µA	4.2	-	V
67	SYNC-O Output Voltage Low	$V_{SYNC-OL}$	ISYNC-O = +500µA	-	400	mV
68	SYNC-I to SYNC-O Delay	$t_{SYNC-DLY}$	50% of SYNC-I to 50% of SYNC-O	215	275	ns

IMPORTANT NOTICE AND DISCLAIMER

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit www.renesas.com/contact-us/.