Protecting ADC with TVS Diode – Improved Solution

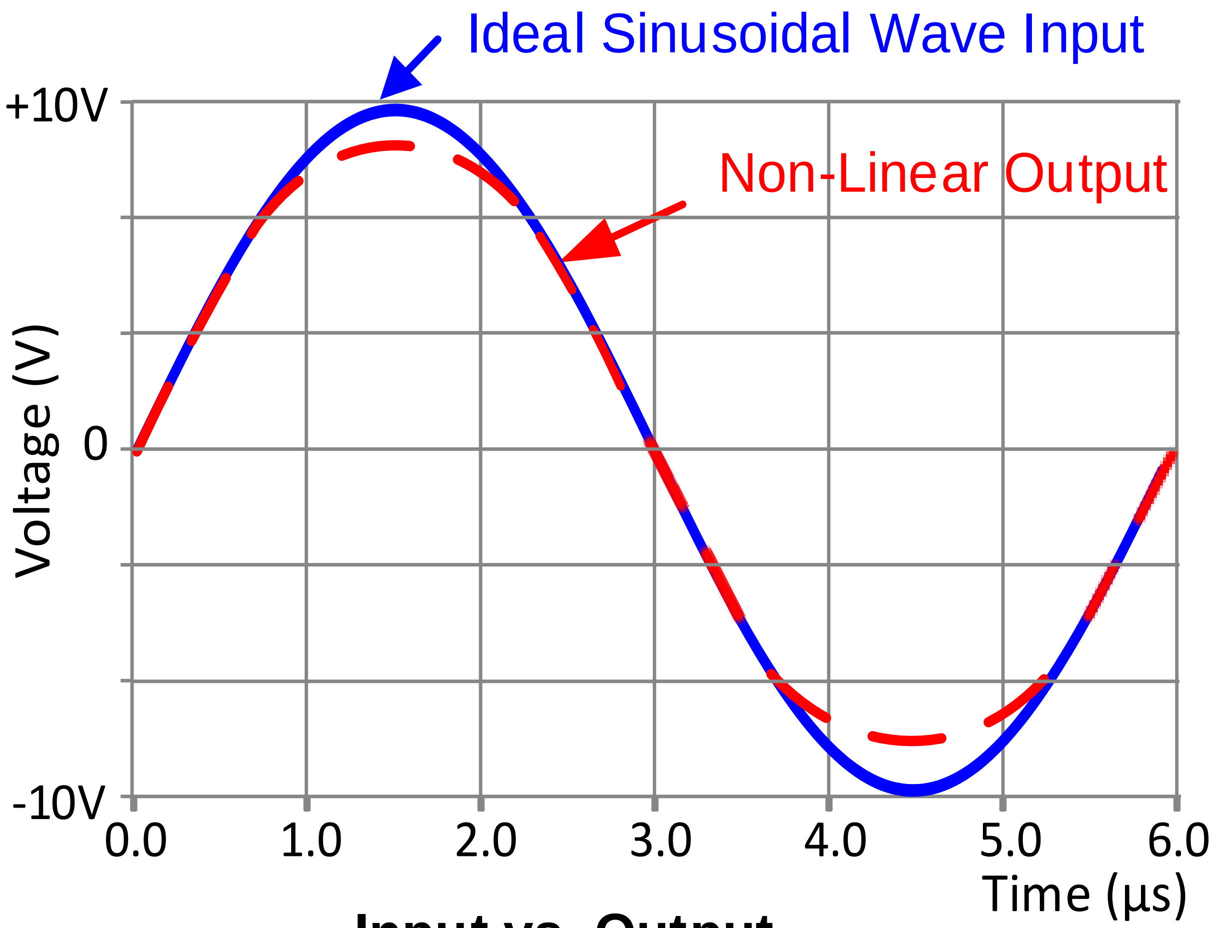
TI Precision Labs – ADCs

Presented by Alex Smith

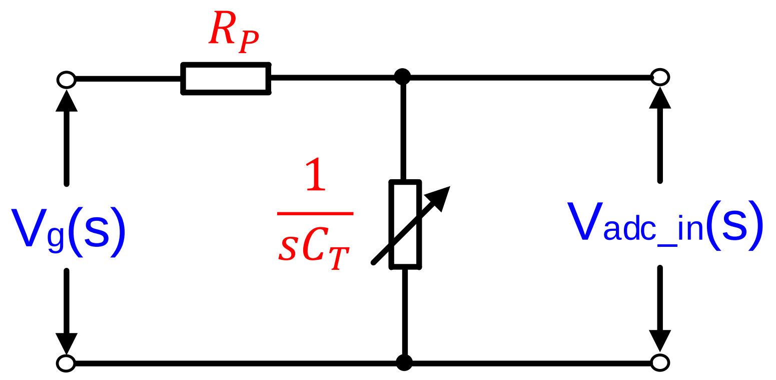
Prepared by Dale Li

Capacitance Variation Causes Worse THD

- The non-linear capacitance to voltage (resistance) can increase distortion.



Input vs. Output



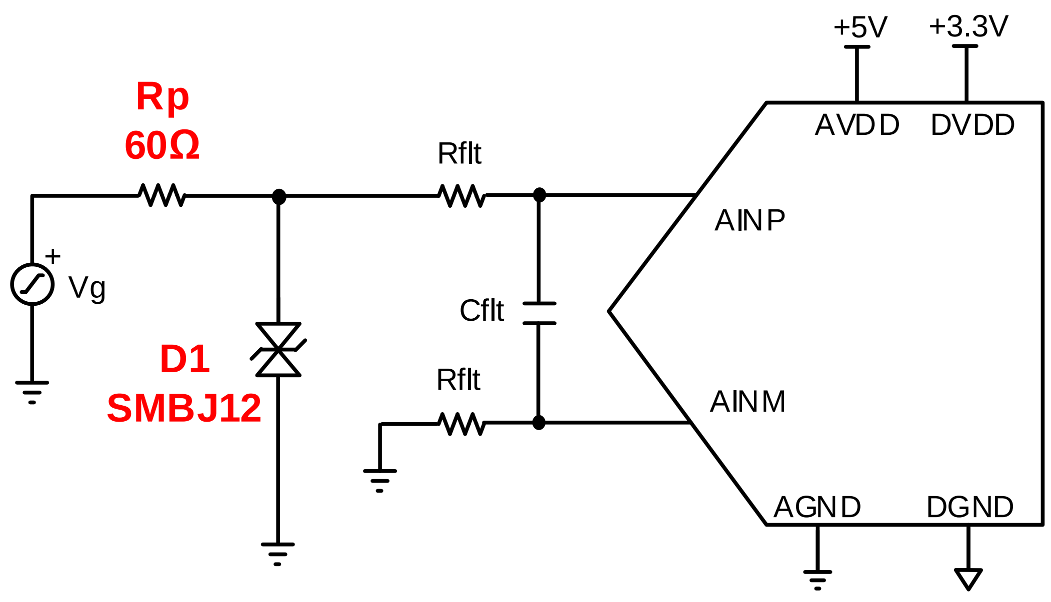
$$V_{adc\_in}(s) = V_g(s) \cdot \frac{\frac{1}{sC_T}}{R_P + \frac{1}{sC_T}} = V_g(s) \cdot \frac{1}{1 + sR_P C_T}$$

$$\frac{V_{adc\_in}(j\omega)}{V_g(j\omega)} = \frac{1}{1 + j\omega R_P C_T} = \frac{1}{1 + j2\pi f_{in} R_P C_T}$$

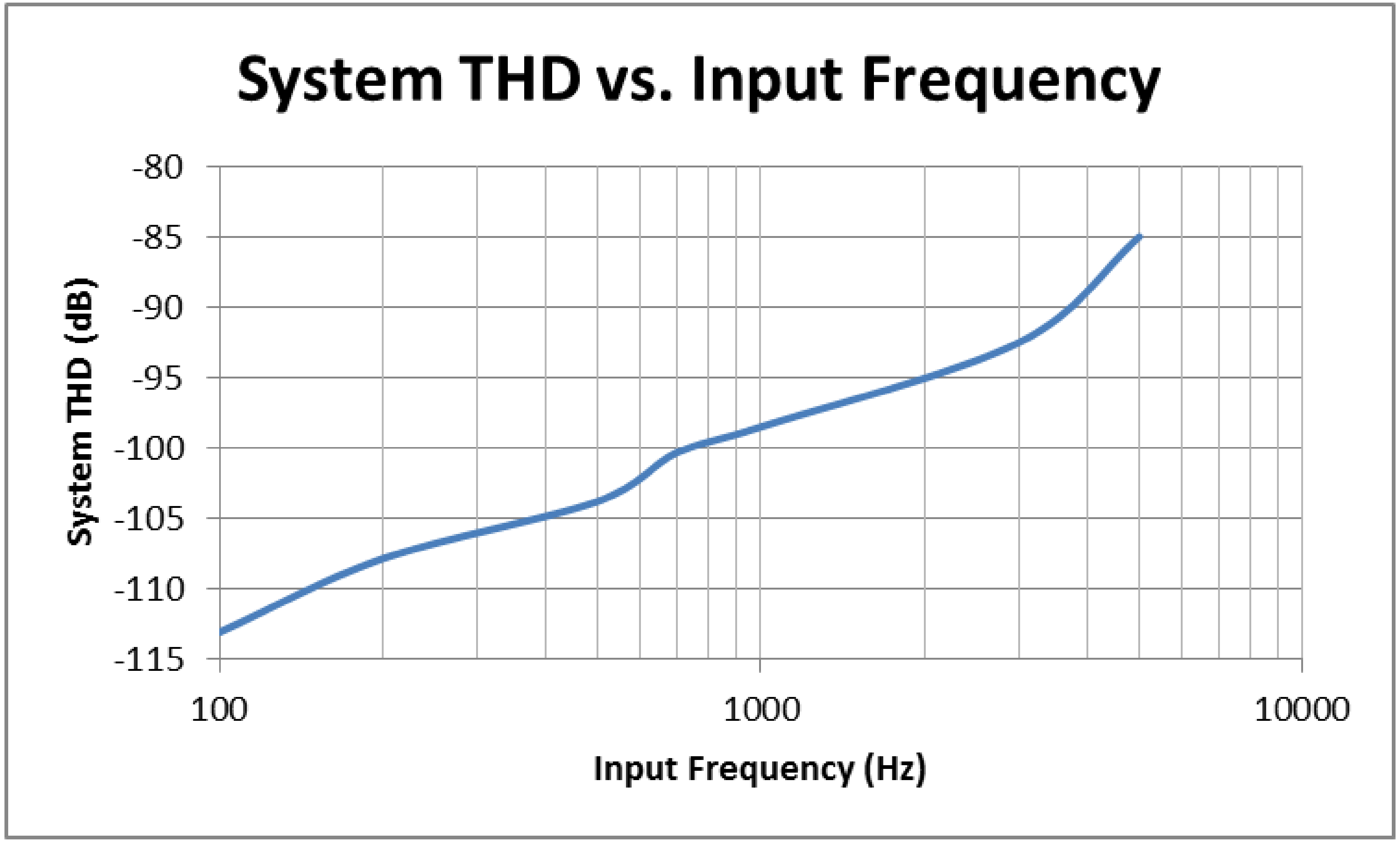
- Signal source's output resistance is not covered in the equation.

- Bidirectional TVS diode has low capacitance than unidirectional TVS because two P-N junctions in series, thus further reducing capacitance.

THD improves as input frequency decreases



Typ Spec THD = -114dB



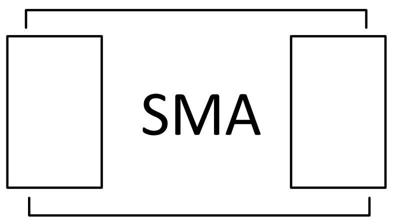
Consider the Power Dissipation of a TVS diode

The Capacitance on TVS is proportional to rated Peak Pulse Power Dissipation(P_{PP}):

Capacitance on 1500W TVS ≈ 3.75 * Capacitance on 400W TVS diode.

SMAJ series
- Bourns

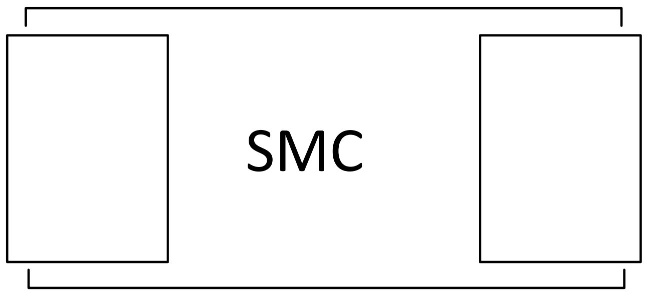
0.18inch



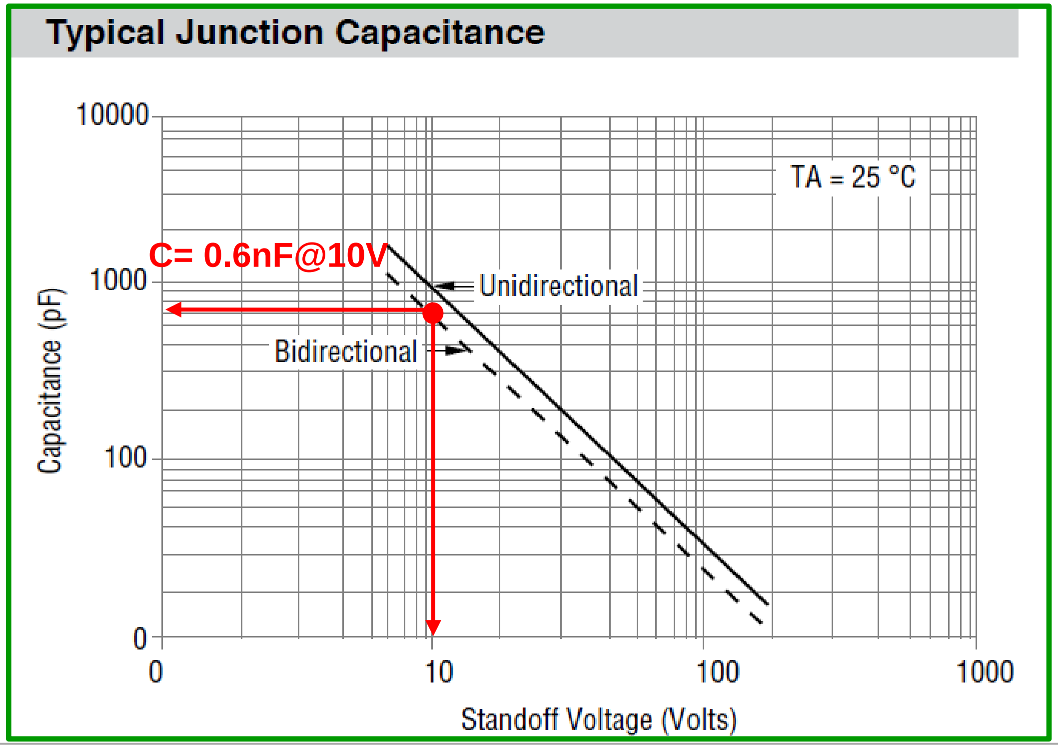
400W

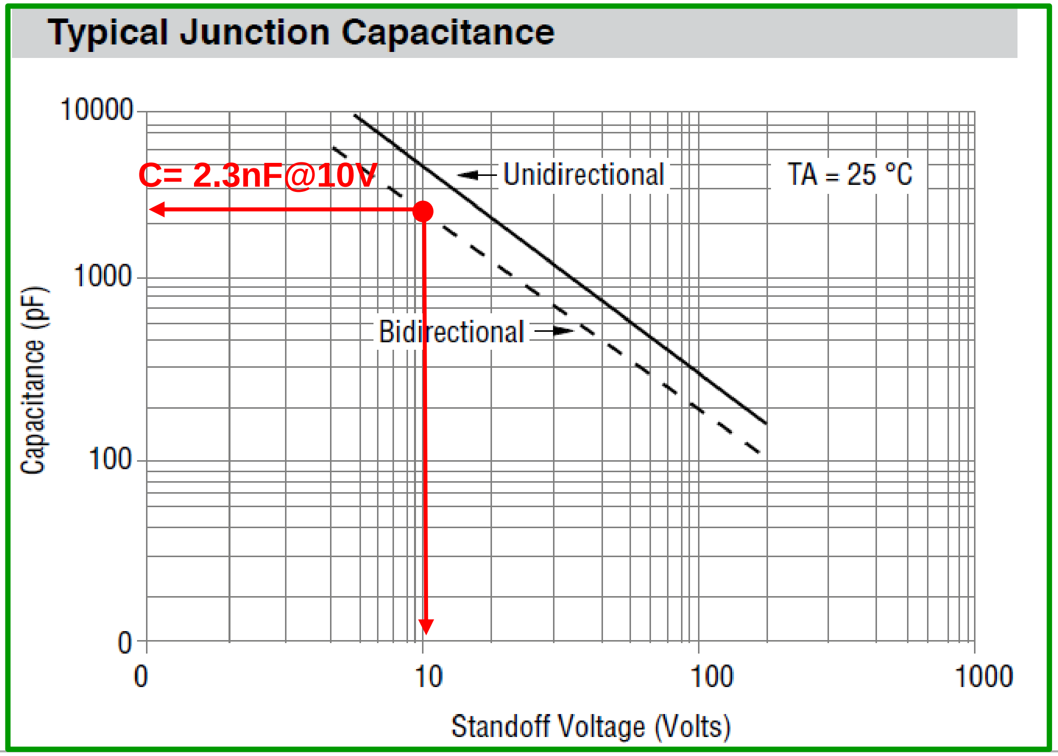
SMCJ series
- Bourns

0.28inch



1500W



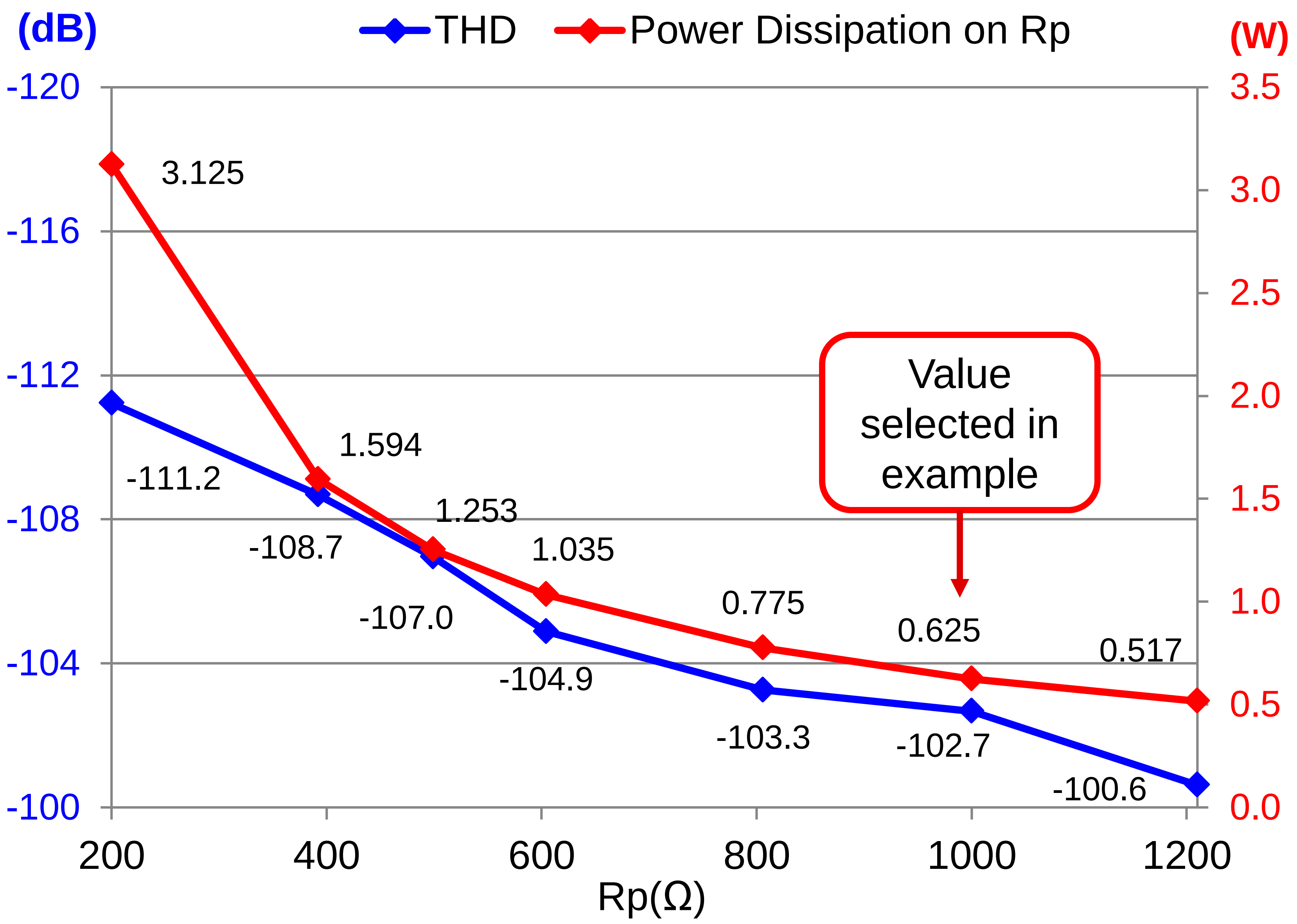


Low Capacitance TVS diode - Select R_P

Part Number	MFG	Reverse Standoff Voltage(V_R)	Breakdown Voltage Min (V_{BR})	Clamping Voltage Max (V_C) @I_C=1A	Reverse Leakage Max (I_R@V_R)	Typical Capacitanc e (0V,1MHz)	Breakdown Current (I_{BR}@V_{BR})	Peak pulse Current (I_{PP})	Peak Power Dissipation (P_{PP})
CDSOD323-T12C	Bourns	12V	13.3	19V	1uA	3pF	1mA	11A	350W

1	$R_P \geq \frac{(V_{in\_AbsMax} - V_{BRmin})^2}{P_{RPmax}} = \frac{(40V - 13.3V)^2}{1W} = 712\Omega$ $(\boldsymbol{choose\ 1k\Omega})$
2	$I_{max} = \frac{V_{in\_AbsMax} - V_{BRmin}}{R_P} = \frac{40V - 13.3V}{1k\Omega} = 26.7mA$
3	$P_{TVSmax} = I_{max} \cdot V_C = (26.7mA)(19V) = 507mW$

THD Measurement and Power Dissipation on R_P



The larger value resistor (Rp):

- Smaller current to TVS/ADC.
- Small package size and more choices in the market.
- Less risk for continuous EOS.

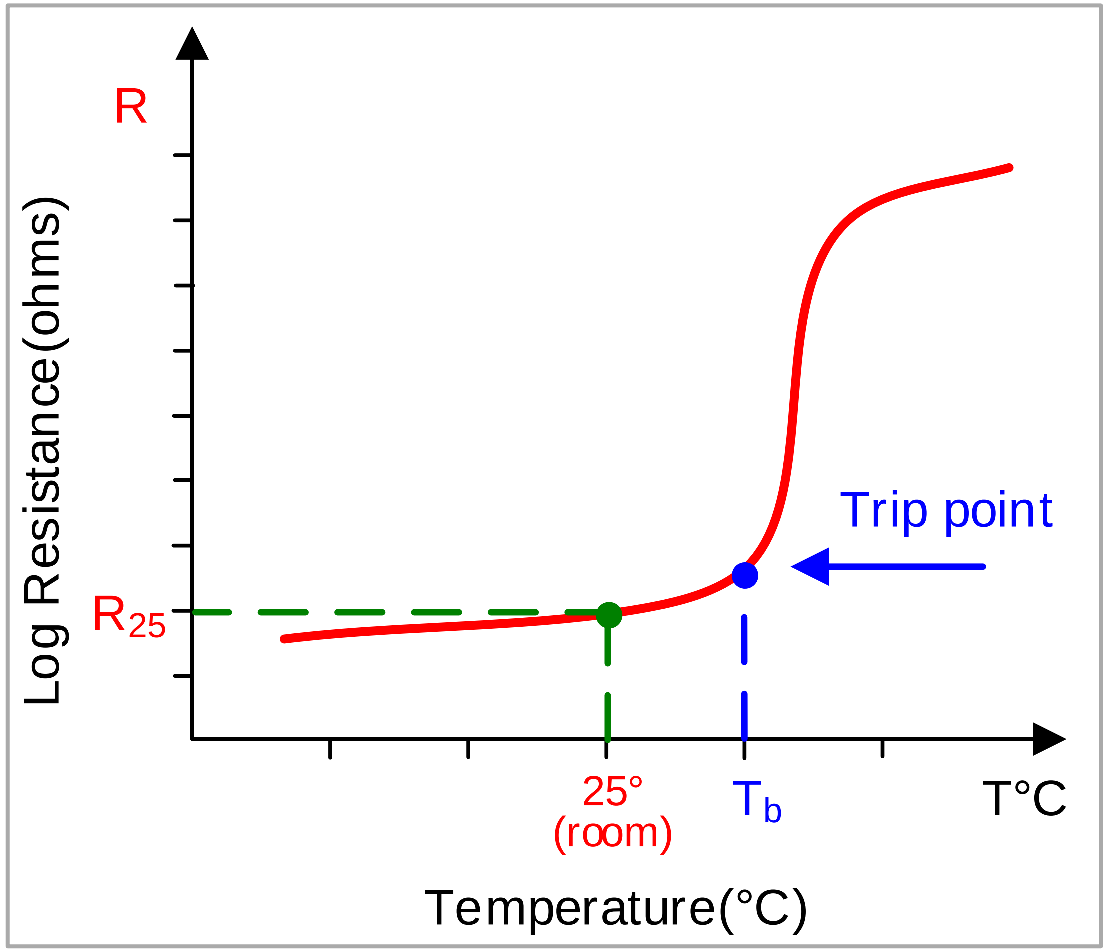
But:

- Worse THD.

- Test Data with CDSOD323-T12C and ADS8588SEVM.

PTC Fuse - Characteristics and Terminology

PTC (**P**ositive **T**emperature **C**oefficient) Fuse is placed in series with the circuit protects the circuit by changing from a low-resistance to a high resistance state in response to an overcurrent.



- **V_{max}**: Maximum continuous voltage the device can withstand without damage at rated current (I_{max}).
- **I_{max}**: Maximum fault current the device can withstand without damage at rated voltage (V_{max}).
- **I_{hold}**: Maximum current device will pass without tripping at T°C.
- **I_{trip}**: Minimum current that the device will trip and transition from low resistance to high resistance at T°C.
- **P_d**: Power dissipated from device when in tripped state at T°C.
- **R_i** : Minimum resistance of device in initial (un-soldered) state.
- **R_1**: Maximum resistance of the device when measured one hour post reflow at T°C.

* Note for T°C: certain temperature room temperature still air

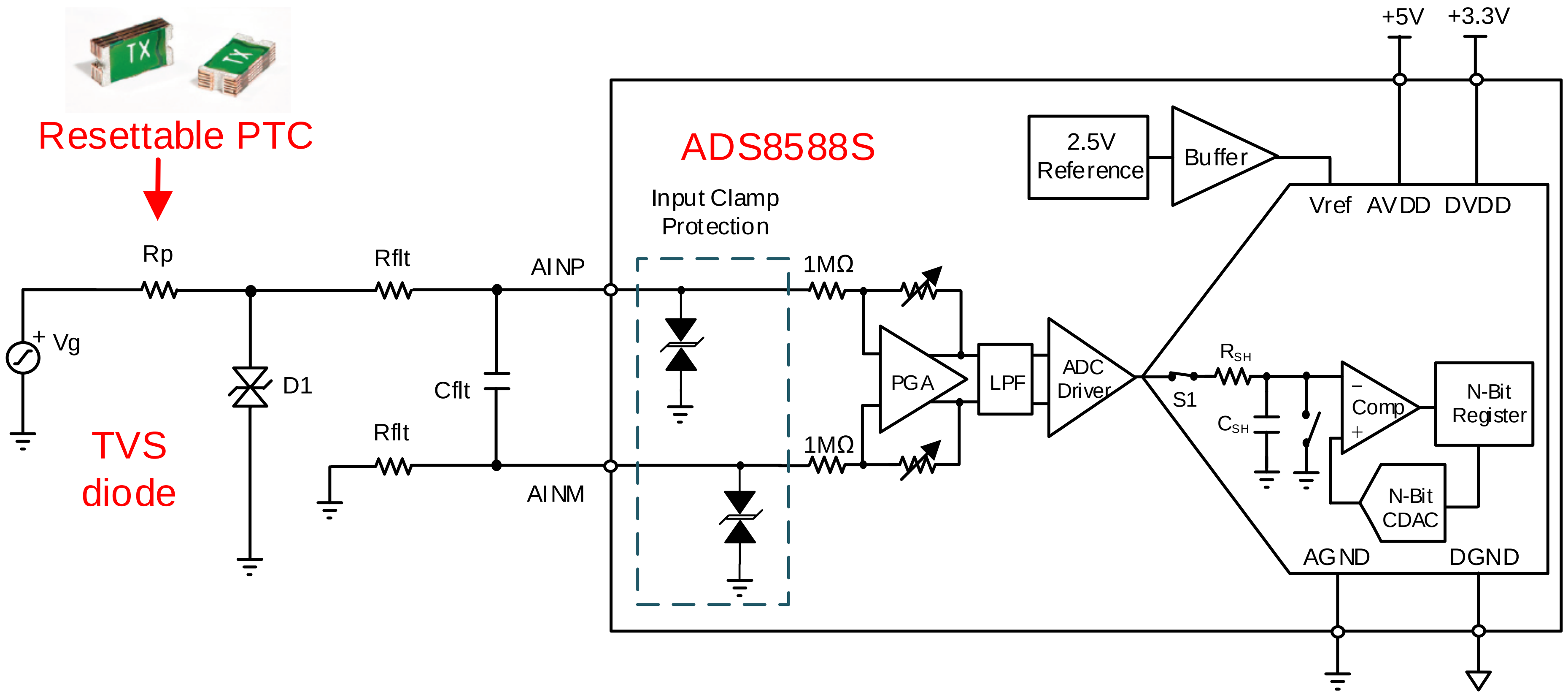
PTC Solution to Resolve the Challenges(THD vs Power Dissipation)

PTC selection for

SMCJ10CA 2.3nF to 10nF TVS Diode:

- V_{fault} (40V) ≤ V_{max} of PTC
- $I_{fault(min)}$ = 0.6A > I_{trip} of PTC
- $I_{fault(max)}$ = 8A < I_{max} of PTC

(see excel file for I_{fault} calculation)



Eaton:

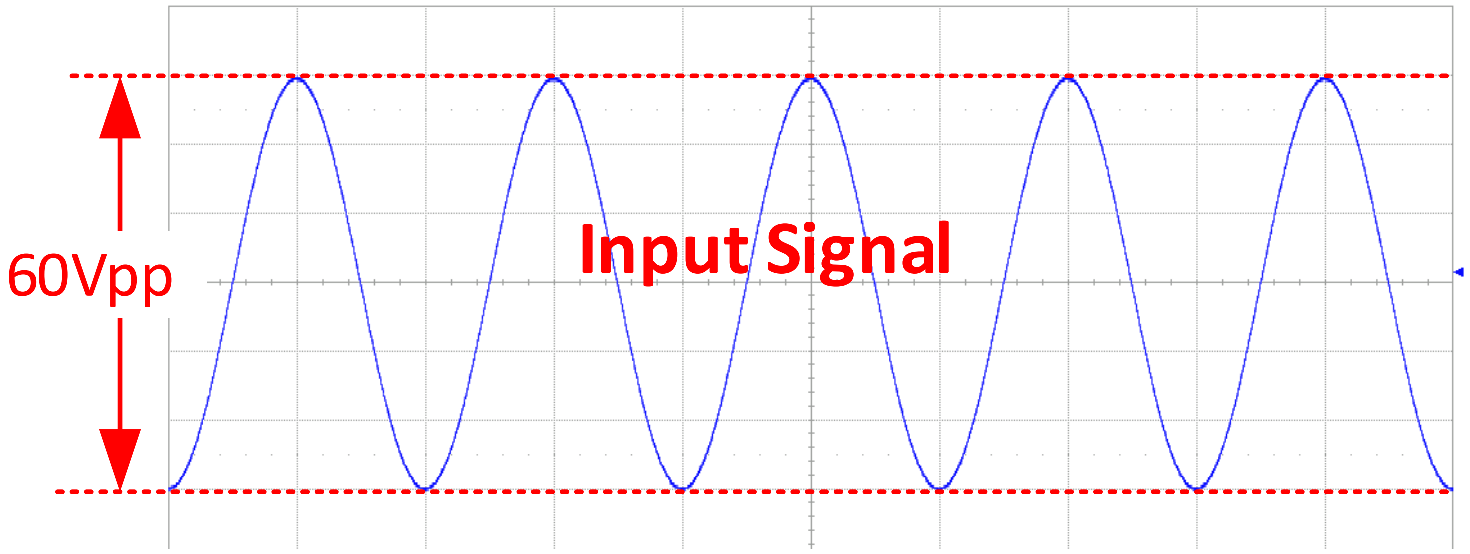
Part Number[7]	Vmax[1] (V_{DC})	Imax[2] (A)	Ihold[3] (A)	Itrip[4] (A)	Pd[5] typical (W)	Time to trip (maximum (A)	(Seconds)	Resistance[6] Initial (R_i) minimum (Ω)	Post trip (R_1) maximum (Ω)
PTS120660V005	60	100	0.05	0.15	0.4	0.25	1.5	3.6	50
PTS120660V010	60	100	0.10	0.25	0.4	0.5	1.0	1.6	15
PTS120630V012	30	100	0.12	0.29	0.5	1	0.2	1.4	6
PTS120630V016	30	100	0.16	0.37	0.5	1	0.3	1.1	4.5
PTS120624V020	24	100	0.20	0.42	0.6	8	0.1	0.65	2.6

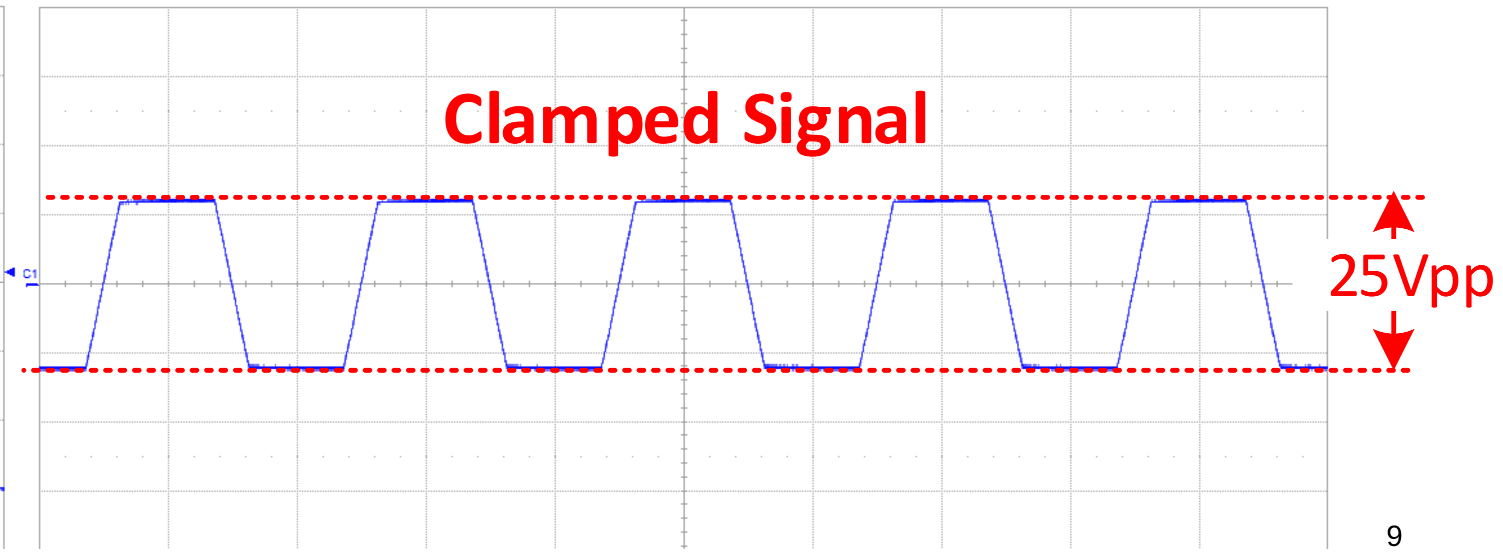
Microsoft Excel Worksheet

PTC with Regular TVS (SMCJ10CA) – Hardware Performance

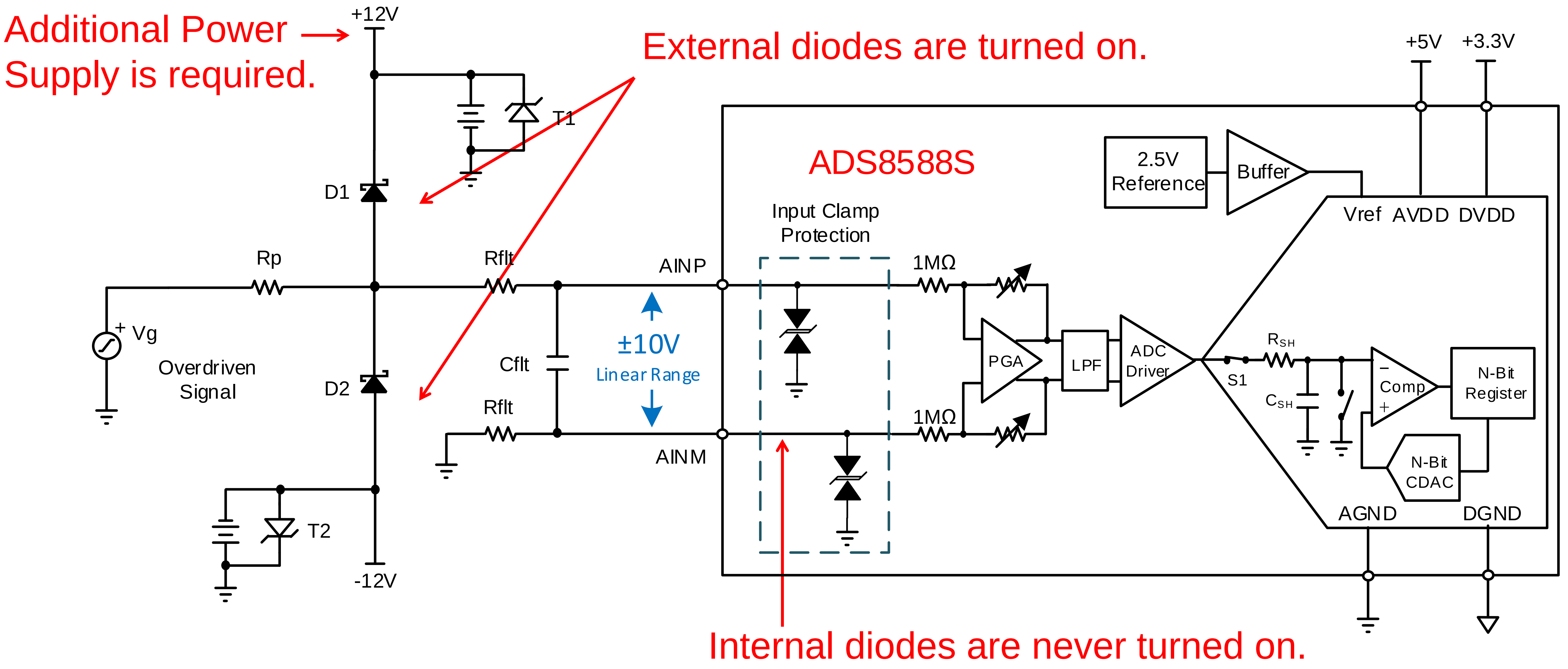
ADS8588S at 200ksps sampling rate:

TVS	R_p	Measured	Typ	Unit
ADS8588S Data Sheet Spec.		SNR	**92**	dB
		THD	**-110**	dB
SMCJ10CA	1kΩ Resistor	SNR	**92.3**	dB
		THD	**- 69.6**	dB
	PTS120660V005 (PTC Resettable Fuse)	SNR	**92.0**	dB
		THD	**- 96.8**	dB



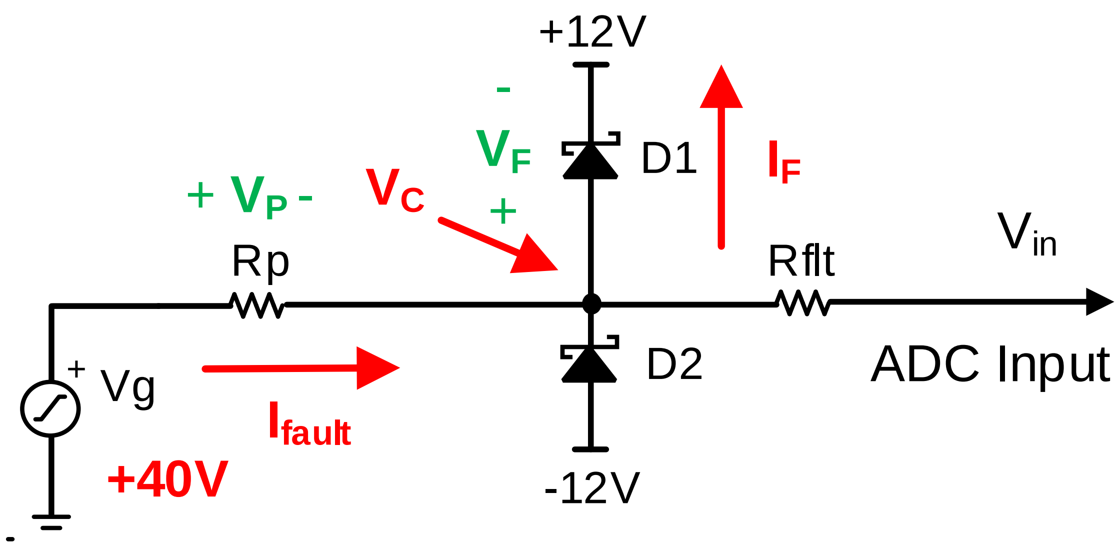


Solution 3: External Protection with Schottky diode



- This solution can be used for SCR-Based input ADC.

Selecting R_P for Abs Ratings to Prevent damage



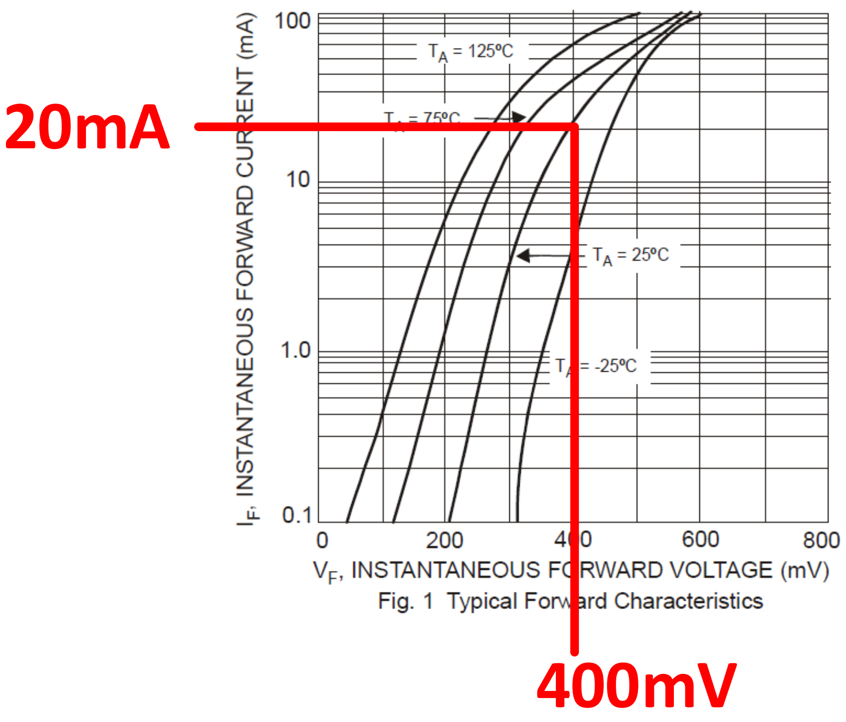


Fig. 1 Typical Forward Characteristics

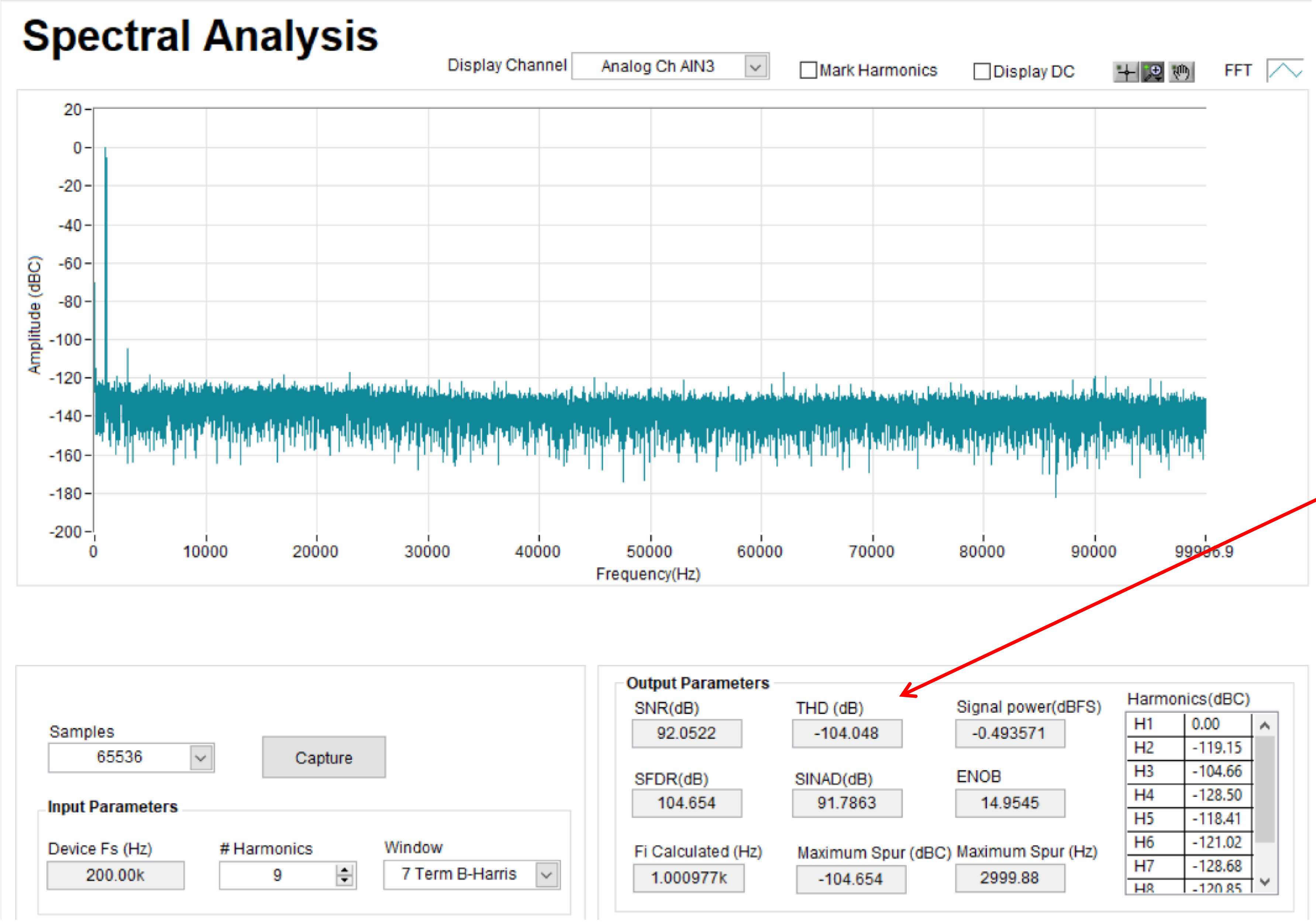
Absolute Ratings – Schottky Diode - Diodes			
Part Number	**Max Forward Continuous Current (I_F)**	**Power Dissipation (P_{tot})**	**Max Forward Voltage (V_F@ I_F=200mA)**
BAT42WS	**200mA**	**200mW**	**1V**

1	$I_{fault} \approx 0.1 \cdot I_F = 20mA$
2	$V_P = V_g - V_C = V_g - (V_F + 12V) = 40 - (0.4+12) =$ **27.6V**
3	$R_P \geq \frac{V_P}{I_{fault}} = \frac{27.6V}{20mA} =$ **1380Ω**
4	$R_P \geq \frac{{V_P}^2}{P_D} = \frac{(27.6)^2}{0.5w} =$ **1523.5Ω** (may use 1W with margin)
5	**Select R_P = 1.54kΩ**

* P_D is power dissipation of R_P.

External Schottky Diode (BAT42) – Hardware Performance

(Schottky – BAT42WS, Rp=**1.54kΩ**, Rflt=1kΩ, Cflt=1nF, ADS8588S at 200ksps sampling rate)



Performance without external diode Measured on ADS8588SEVM (200ksps):

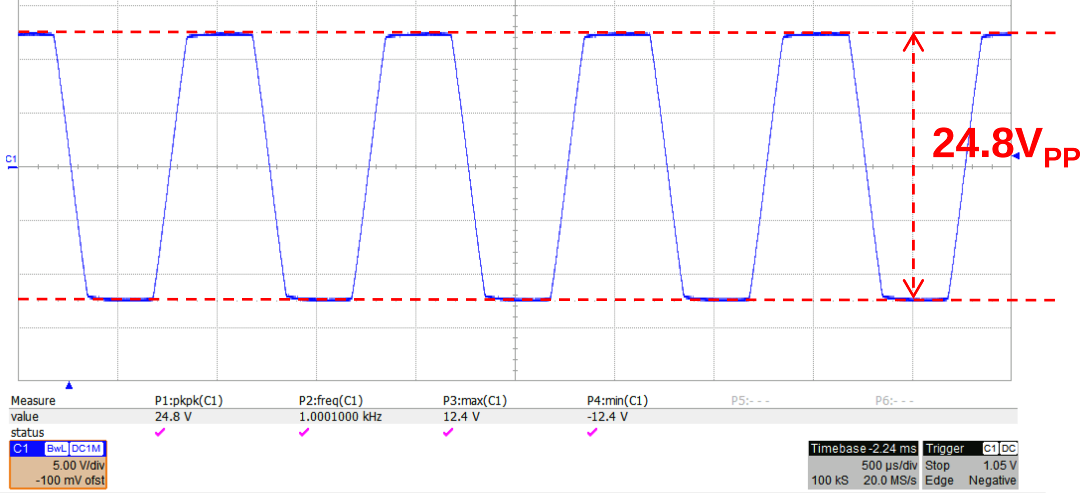
Parameter	Min	Typ	Max	Unit
SNR	91	92		dB
THD		-110	-95	dB

Measured with BAT42:

SNR = 92dB

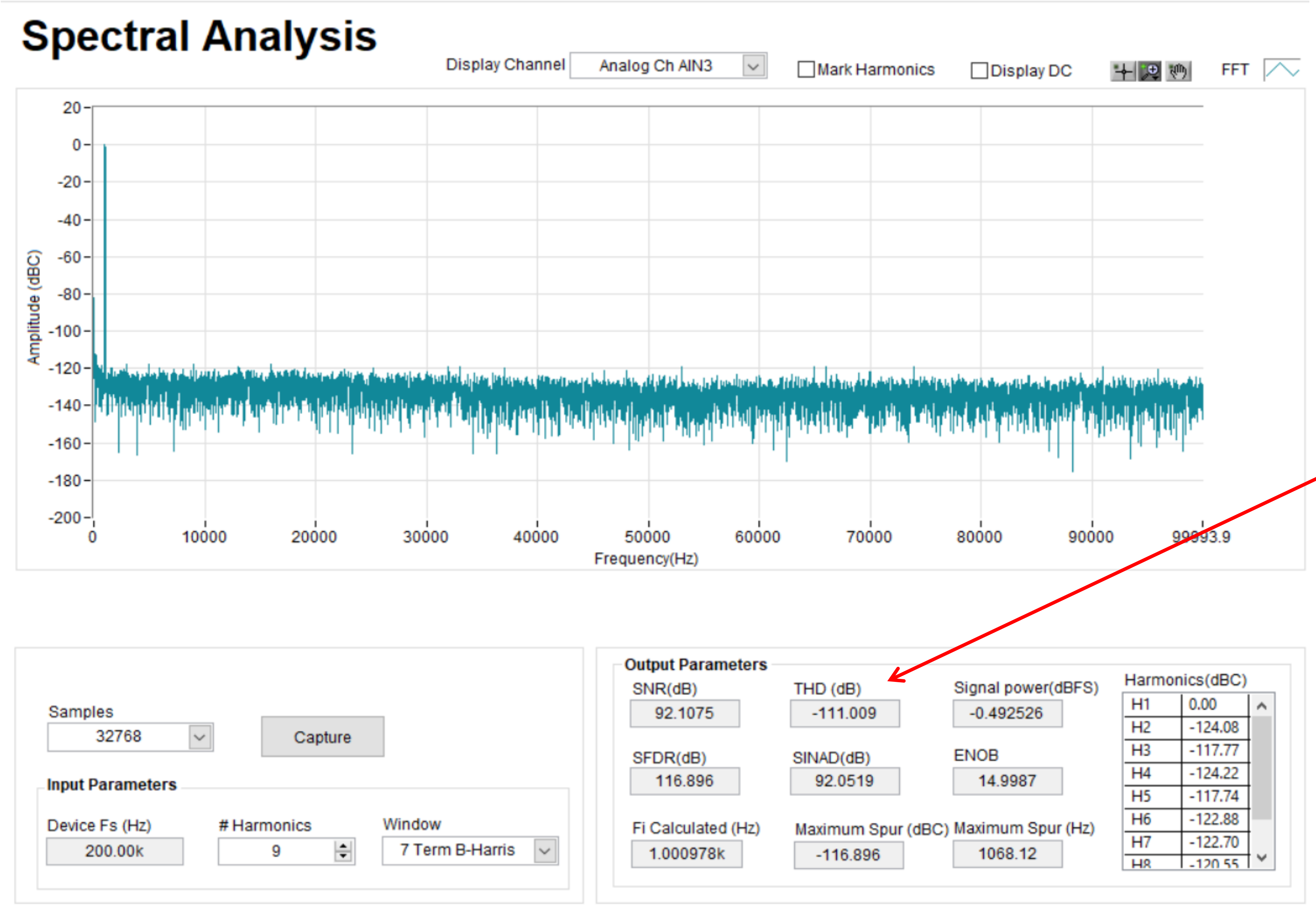
THD = - 104dB

Signal Clamping Check (±30V sinewave input):



PTC with Schottky Diode (BAT42) – Hardware Performance

(Schottky – BAT42WS, PTS120660V005, R_{flt}=1kΩ, C_{flt}=1nF, ADS8588S at 200ksps sampling rate)



Performance without external diode Measured on ADS8588SEVM (200ksps):

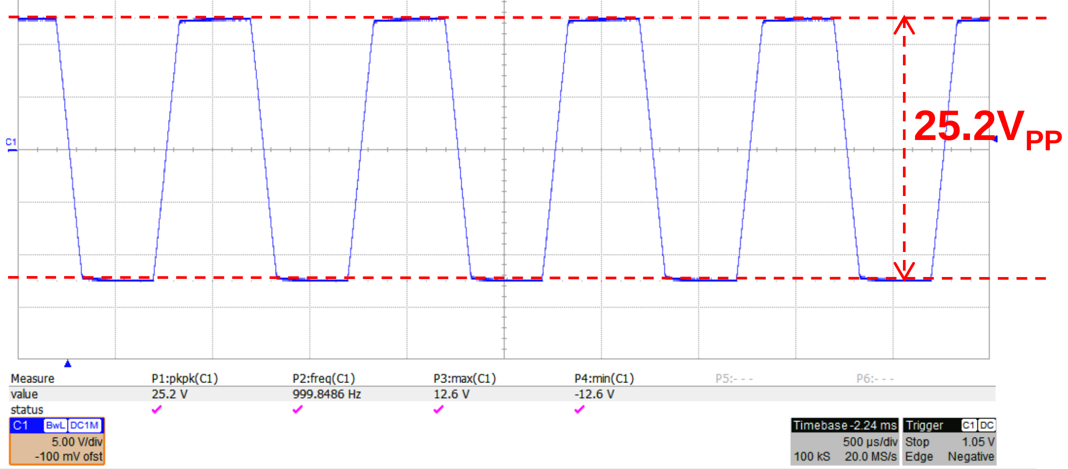
Parameter	Min	Typ	Max	Unit
SNR	91	92		dB
THD		-110	-95	dB

Measured with BAT42 and PTC:

SNR = 92.1dB

THD = - 111dB

Signal Clamping Check (±30V sinewave input):



Thanks for your time! Please try the quiz.

Questions: Protecting ADC with TVS Diode - Improved

1. What is a possible ***disadvantage*** of using a TVS with a higher power rating?
    a. It will not be able to protect for large transient inputs
    b. The voltage rating will not be as good as low power TVS diodes
    c. The leakage current will be higher
    d. The capacitance is higher

2. What is the ***advantage*** of a larger series resistor before the TVS diode?
    a. A lower power rating resistor can be used
    b. Lower distortion
    c. Lower noise
    d. Faster fault protection

Questions: Protecting ADC with TVS Diode - Improved

3. What is a possible ***advantage*** of using a PTC fuse with a TVS diode?
    a. The normal resistance of the PTC fuse is low which allows for lower distortion
    b. The power rating of the PTC doesn’t have to be as large because it’s resistance increases under fault conditions
    c. The gain accuracy of the solution will be better using the PTC
    d. The offset error of the system will be better using the PTC
    e. Answer a, and b
    f. Answer c, and d

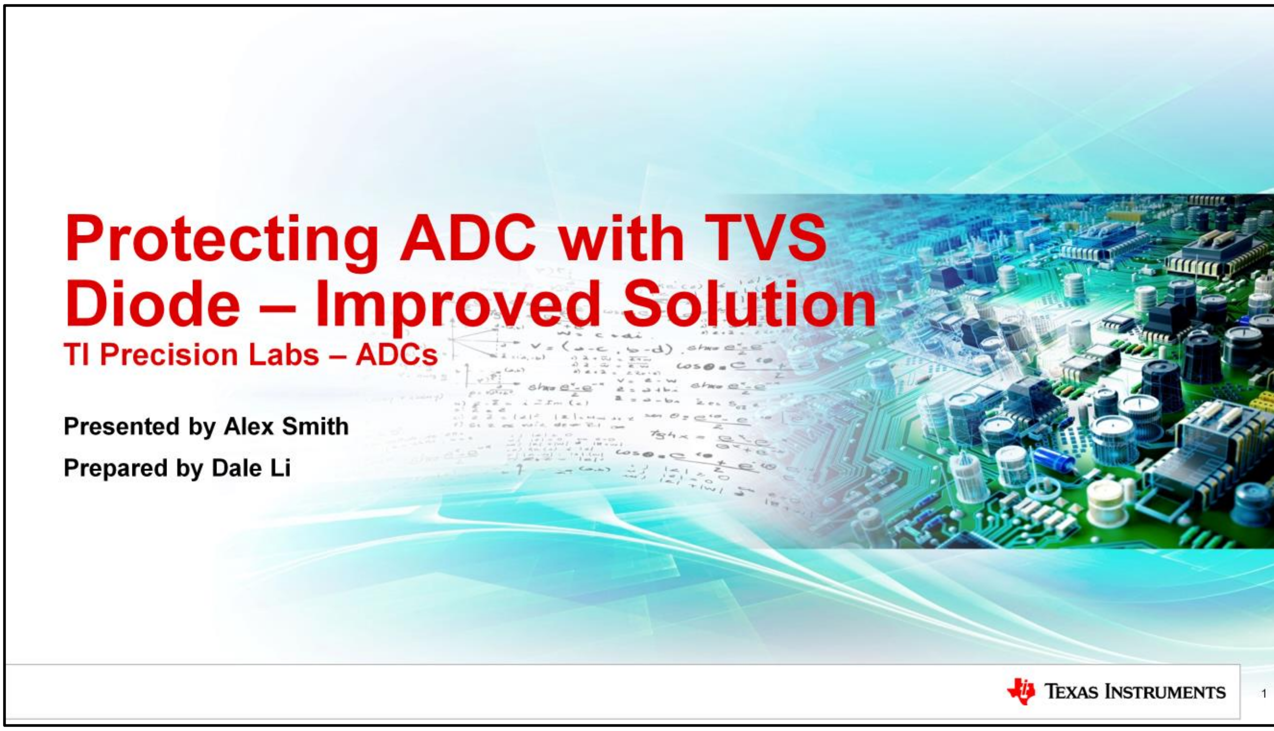
Questions: Protecting ADC with TVS Diode - Improved

4. A system has two power supply rails available: 3.3V, and 5V. The ADC has a 10V input range. Can the Schottky input circuit be used to protect the device?
   a. Yes
   b. No

Questions: Protecting ADC with TVS Diode - Improved

5. Assuming the protection circuit is causing distortion. How can the distortion be reduced?
    a. Increase the series resistance
    b. Increase the sampling rate.
    c. Increase the input signal frequency
    d. Decrease the input signal frequency

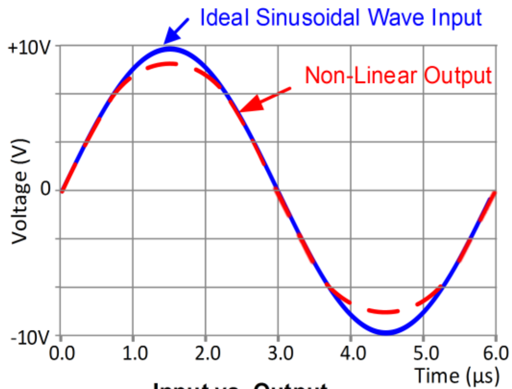
Thanks for your time!



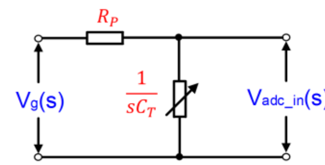
In the last presentation we saw that using TVS diodes and series current limiting resistors is an effective way of protecting data converts, but it can have a significant impact on performance. In this presentation we will consider some different approaches that can improve performance but still provide good protection.

Capacitance Variation Causes Worse THD

- The non-linear capacitance to voltage (resistance) can increase distortion.



Input vs. Output



$$V_{adc\_in}(s) = V_g(s) \cdot \frac{\frac{1}{sC_T}}{R_P + \frac{1}{sC_T}} = V_g(s) \cdot \frac{1}{1 + sR_PC_T}$$

$$\frac{V_{adc\_in}(j\omega)}{V_g(j\omega)} = \frac{1}{1 + j\omega R_P C_T} = \frac{1}{1 + j2\pi f_{in} R_P C_T}$$

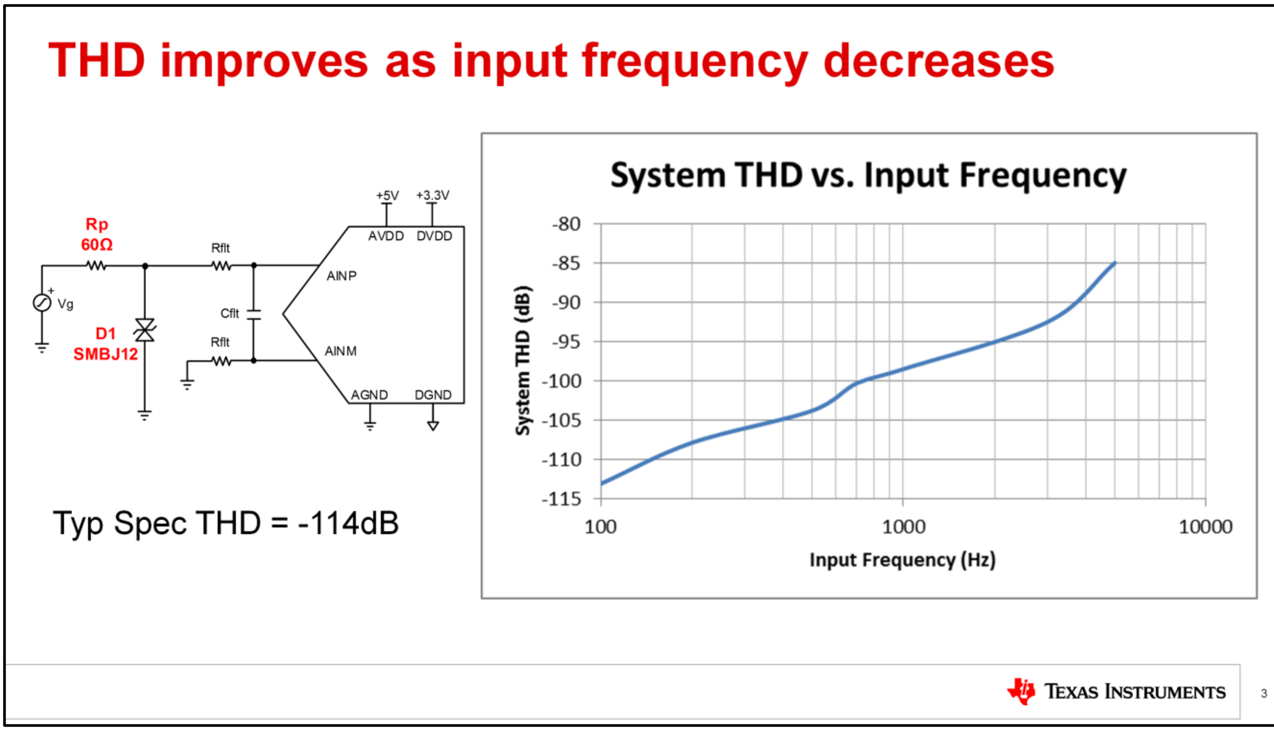
- Signal source's output resistance is not covered in the equation.

- Bidirectional TVS diode has low capacitance than unidirectional TVS because two P-N junctions in series, thus further reducing capacitance.

2

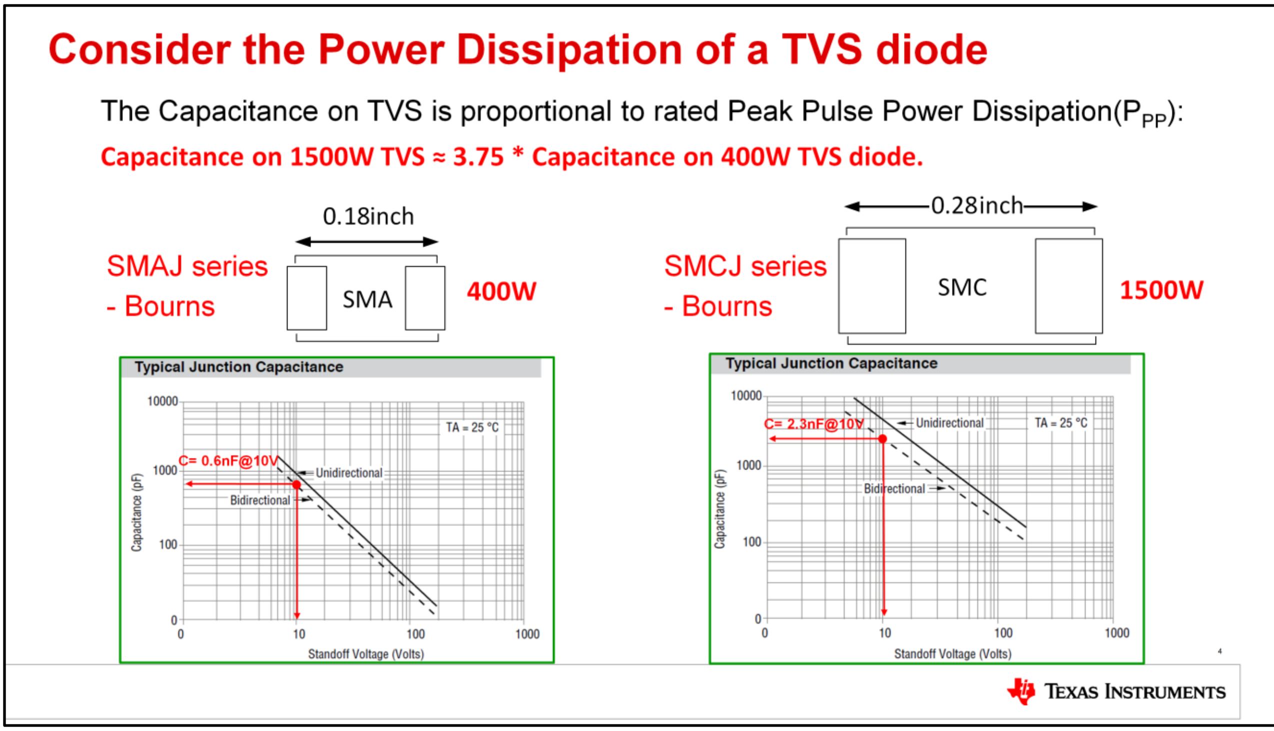
Texas Instruments

Recall from the last presentation that the capacitance of the TVS changes versus applied reverse voltage. So, for the input signal shown at the right, the capacitance changes as the voltage swings from 0V to 10V. The input resistor and TVS capacitance form a low pass filter. The cutoff frequency of this filter changes depending on the instantanous voltage of the input signal. So, for example, when the input signal is a 5V the filter will have a different cutoff frequency then it has when the input is at 10V. Thus the attenuation is dependent on the instantaneous voltage of the waveform. So, for example, the waveform will be attenuated differently for voltages from 0V to 5V than from 5V to 10V. This has the effect of distorting the shape of the waveform and introducing more THD. Notice in this example that the output signal tracks the input well for lower voltages, but for higher voltages no longer tracks because it attenuates. It may be difficult to realize by looking at the output waveform, but it is no longer a pure sine wave.



In the previous slide we learned that Rp and the capacitance of the diode D1 form a low pass filter. The capacitance of D1 changes with applied signal so the cutoff frequency changes with the instantaneous input signal level. The changes in cutoff frequency will introduce distortion as the signal is attenuated differently depending on the instantaneous voltage of the signal. However, if the frequency of the applied signal is far from the cutoff introduced by the diode capacitance, than the distortion will be minimized. This plot shows how distortion gets worse as the input signal frequency increases. In this example the THD near 100Hz is very close to the specified typical THD for this device. The important point here is that distortion introduced by nonlinear capacitances can often be minimized by reducing the input signal frequency.

In the next slide we will look at how the power rating of the TVS effects its capacitance. We will then continue on to do a reference design with a low capacitance TVS diode.



One thing to keep in mind on when using TVS diodes for input protection is the power rating. Choosing a higher power rating will increase the size of the device. Besides allowing for more power dissipation this larger device will also have more capacitance. For example the TVS diode with a 1500W peak pulse power rating has 3.75 times more capacitance than the 400W device. Since we are using a series current limiting resistor before the TVS device it will not need a very high power rating. Consequently, it is generally recommended for input protection to use a TVS with a lower power rating as the lower capacitance will have less impact on distortion.

Low Capacitance TVS diode - Select R_P

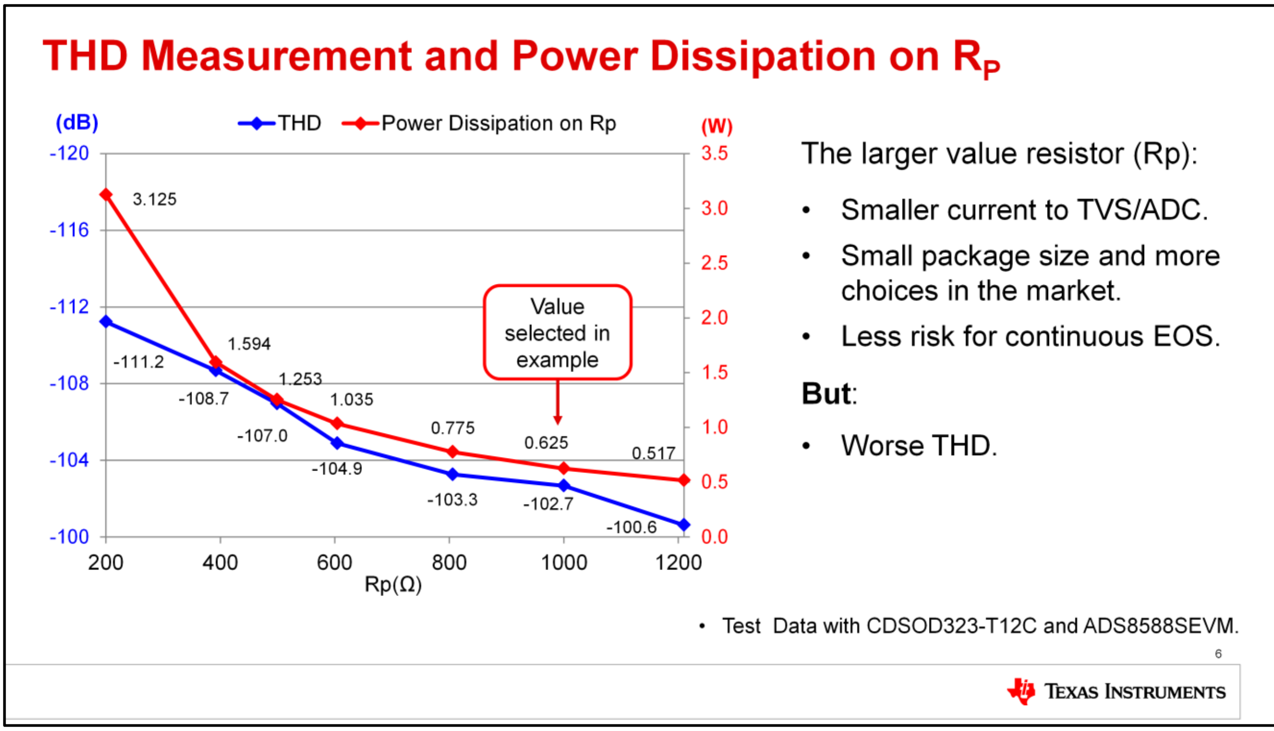
Part Number	MFG	Reverse Standoff Voltage(V_R)	Breakdown Voltage Min (V_{BR})	Clamping Voltage Max (V_C) @I_C=1A	Reverse Leakage Max (I_R@V_R)	Typical Capacitance (0V,1MHz)	Breakdown Current (I_{BR}@V_{BR})	Peak pulse Current (I_{PP})	Peak Power Dissipation (P_{PP})
CDSOD323-T12C	Bourns	12V	13.3	19V	1uA	3pF	1mA	11A	350W

1	$R_P \geq \frac{(V_{in\_AbsMax} - V_{BRmin})^2}{P_{RPmax}} = \frac{(40V - 13.3V)^2}{1W} = 712\Omega$ $(\textbf{\textit{choose 1k}}\boldsymbol{\Omega})$
2	$I_{max} = \frac{V_{in\_AbsMax} - V_{BRmin}}{R_P} = \frac{40V - 13.3V}{1k\Omega} = 26.7mA$
3	$P_{TVSmax} = I_{max} \cdot V_C = (26.7mA)(19V) = 507mW$

5

Texas Instruments

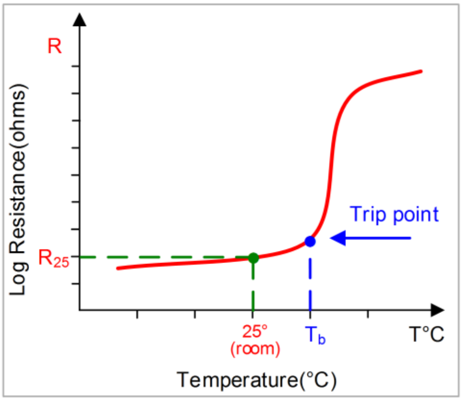
Here we do the same calculations to select the series protection resistor Rp that we did with the previous example. The results are slightly different since the breakdowns and clamp voltage is different in this example. Nevertheless, we use a 1kohm series resistor for both examples. Again, notice in this slide that the power dissipations during the fault condition can be very high. These can be minimized by choosing a larger value of Rp. Let's take a look at how changing Rp impacts performance.



This graph shows THD performance on the left and power dissipation on the right for the protection circuit with a wide range of Rp. Notice that the best performance is achieved with small resistors, but the power dissipation for the small resistors will be very high for a continuous fault event. This relationship can make it very difficult to create a compact, low cost, high performance circuit that is protected from large steady state fault conditions. In the next slide we will consider a device that can be used in place of the resistor to achieve good THD performance without using a large high power device.

PTC Fuse - Characteristics and Terminology

PTC (**P**ositive **T**emperature **C**oefficient) Fuse is placed in series with the circuit protects the circuit by changing from a low-resistance to a high resistance state in response to an overcurrent.



- **V_{max}**: Maximum continuous voltage the device can withstand without damage at rated current (I_{max}).
- **I_{max}**: Maximum fault current the device can withstand without damage at rated voltage (V_{max}).
- **I_{hold}**: Maximum current device will pass without tripping at T°C.
- **I_{trip}**: Minimum current that the device will trip and transition from low resistance to high resistance at T°C.
- **P_d**: Power dissipated from device when in tripped state at T°C.
- **R_i** : Minimum resistance of device in initial (un-soldered) state.
- **R_1**: Maximum resistance of the device when measured one hour post reflow at T°C.

* Note for T°C: certain temperature room temperature still air

7

Texas Instruments

The PTC fuse is a device that exhibits a low-resistance under normal conditions and exhibits a high resistance in response to an overcurrent. PTC stands for Positive Temperature Coefficient, so it's resistance will increase with temperature. Under a fault condition the self heating of the resistor will cause the resistance to pass a trip point and the resistance will dramatically increase. The large tripped resistance will effectively limit the current similar to an open mechanical fuse. Once the fault condition is removed the PTC will return to a low resistance state, however the device has some hysteresis and it will take time for the resistance to reach a low value.

This behavior is useful for our input protection circuit as the series resistance will be low in the normal un-tripped state keeping distortion relatively low, and high in the tripped state limiting the fault current and power dissipation.

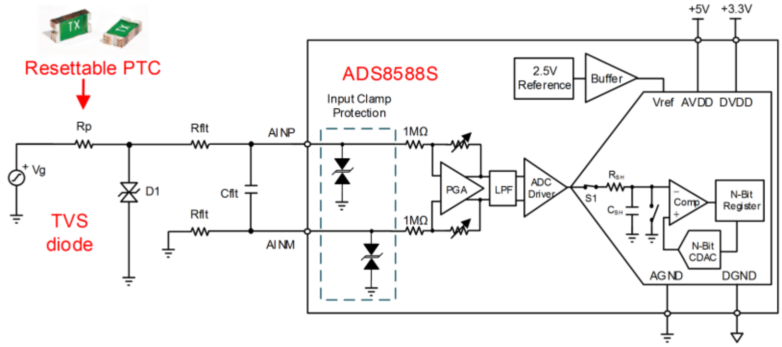
PTC Solution to Resolve the Challenges(THD vs Power Dissipation)

PTC selection for

SMCJ10CA 2.3nF to 10nF TVS Diode:

- V_{fault} (40V) ≤ V_{max} of PTC
- $I_{fault(min)}$ = 0.6A > I_{trip} of PTC
- $I_{fault(max)}$ = 8A < I_{max} of PTC

(see excel file for I_{fault} calculation)



Microsoft Excel Worksheet

Eaton:

Part Number[7]	Vmax[1] (V_{DC})	Imax[2] (A)	Ihold[3] (A)	Itrip[4] (A)	Pd[5] typical (W)	Time to trip (maximum (A)	Time to trip (Seconds)	Resistance[6] Initial (R_i) minimum (Ω)	Resistance[6] Post trip (R_1) maximum (Ω)
PTS120660V005	60	100	0.05	0.15	0.4	0.25	1.5	3.6	50
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PTS120630V016	30	100	0.16	0.37	0.5	1	0.3	1.1	4.5
PTS120624V020	24	100	0.20	0.42	0.6	8	0.1	0.65	2.6

TEXAS INSTRUMENTS 8

This slide shows a list of several different PTC fuses. We selected the device with a 60V rating and the lowest trip current. Also, notice that the post trip resistance and initial resistance is relatively low. In the next slide we will look at how the PTC impacts THD performance.

PTC with Regular TVS (SMCJ10CA) – Hardware Performance

ADS8588S at 200ksps sampling rate:

TVS	R_p	Measured	Typ	Unit
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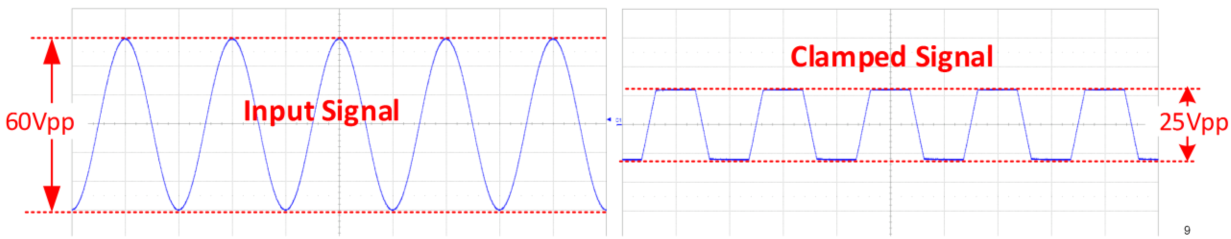
		THD	-110	dB
SMCJ10CA	1kΩ Resistor	SNR	92.3	dB
		THD	- 69.6	dB
	PTS120660V005 (PTC Resettable Fuse)	SNR	92.0	dB
		THD	- 96.8	dB



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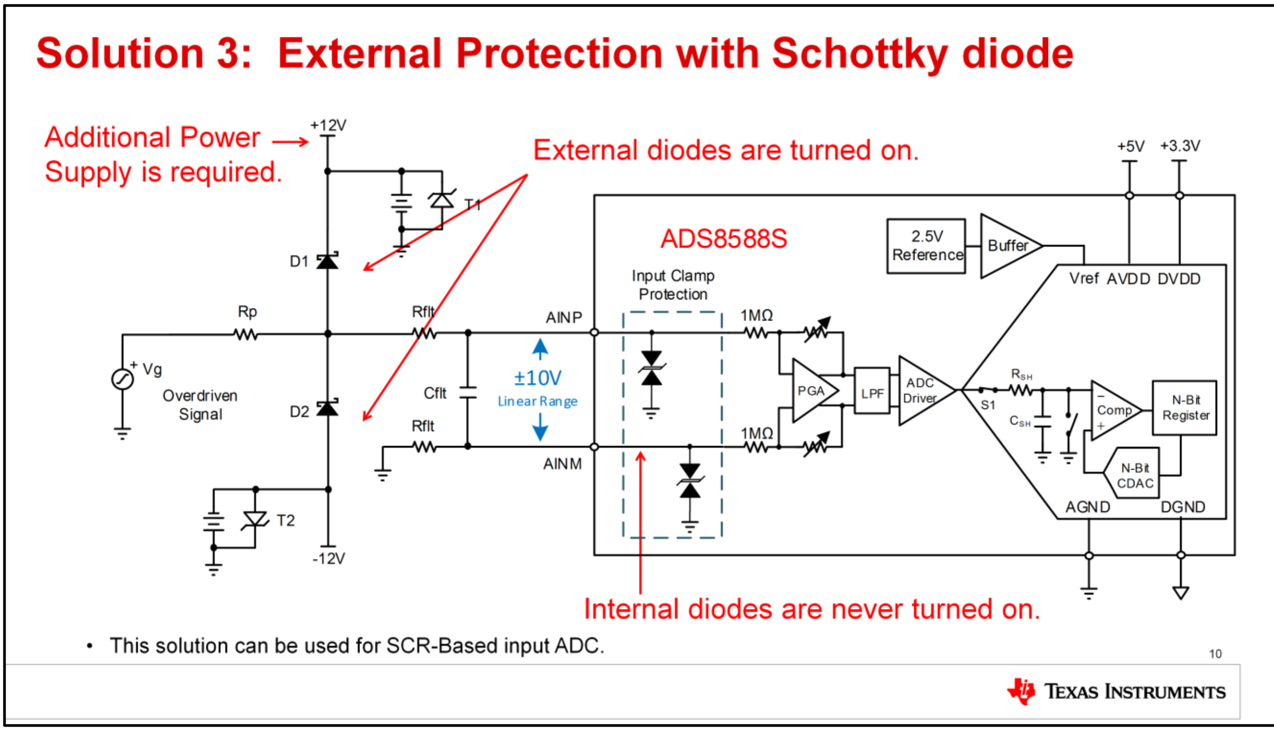
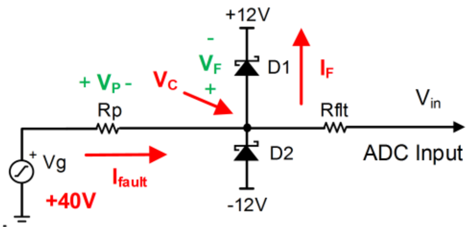
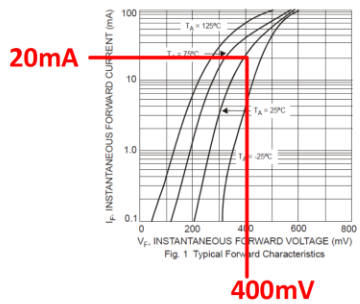
Earlier we looked at a SMAJ10CA TVS diode with a 1k current limiting resistor. Under a 40V fault condition the 1k resistor limited the current and power dissipation so that a 1W external resistor is required. This solution can be costly and uses a large area on a PCB. Furthermore, the AC performance of the device with the TVS+1k ohm resistor protection is significantly degraded compared to the data sheet specification. The THD specification is -110dB and the TVS+1k has THD performance of -69.6dB. Now, the same circuit using the PTC fuse has an improved THD of -96.8dB. So the low on resistance of the PTC fuse significantly improves the performance of the protection circuit but it still does not meet the data sheet specifications. Note that the solution size for the PTC fuse solution is much smaller than the 1W resistor solution. The waveforms at the bottom of the screen show the input signal and the signal clamped by the TVS diode.



In this section of precision labs we have been looking at data converters with integrated analog front ends. These devices use Zener clamp diodes and SCR ESD clamps. The input range of these data converters is typically ±10V, but the analog supply voltage is only 5V. Generally with this kind of system there is no higher voltage supplies. The external TVS diode protection solutions that we have looked at are connected to ground and do not require high voltage supplies. In cases where higher voltage supplies are available a Schottky diode clamp is a better solution. The Shottky solution is better because the voltage that the Schottky clamps at is generally more precise than the TVS breakdown voltage. Furthermore, Schottky diodes have lower capacitance than TVS diodes so the distortion issue is minimized. In this example we are clamping the input voltage of the ADS8588 to ±12V. Technically the actual clamp voltage will include the diode drop so it will be about ±12.3V when using Schottky diodes. Let’s take a look at component selection and performance for this solution.

Selecting R_P for Abs Ratings to Prevent damage





Absolute Ratings – Schottky Diode - Diodes			
Part Number	Max Forward Continuous Current (I_F)	Power Dissipation (P_{tot})	Max Forward Voltage (V_F@ I_F=200mA)
BAT42WS	200mA	200mW	1V

1	$I_{fault} \approx 0.1 \cdot I_F = 20mA$
2	$V_P = V_g - V_C = V_g - (V_F + 12V) = 40 - (0.4+12) = \mathbf{27.6V}$
3	$R_P \geq \frac{V_P}{I_{fault}} = \frac{27.6V}{20mA} = \mathbf{1380\Omega}$
4	$R_P \geq \frac{V_P{}^2}{P_D} = \frac{(27.6)^2}{0.5w} = \mathbf{1523.5\Omega}$ (may use 1W with margin)
5	**Select R_P = 1.54kΩ**

* P_D is power dissipation of R_P.

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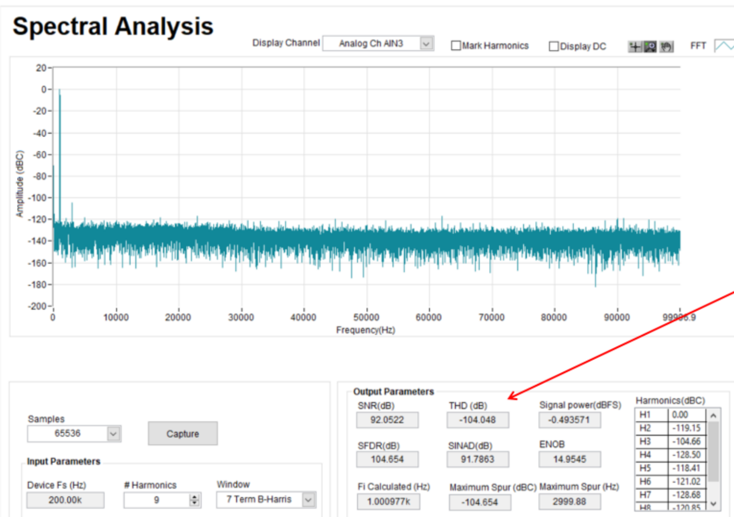
TEXAS INSTRUMENTS

This slide shows how to select the series current limiting resistor for when using the Schottky protection method discussed on the pervious slide. First we set the fault current limit to be equal to 10% of the maximum forward continuous current for the Schottky diode. For this example the BAT42 has a max forward current of 200mA, so we set the fault current to 20mA. Using the characteristic curve the diode forward voltage is 0.4V. Knowing this we can calculate the voltage across the protection resistor under a fault condition by subtracting the supply and diode drop from the fault voltage. Dividing the voltage across the protection resistor by the fault current gives the minimum value of protection resistance. The protection resistor value is also bounded by the power dissipation in it. It is calculated by dividing voltage squared over power. Finally, choose the largest value of Rp and round it up to a standard resistor value. Let's take a look at the measured performance for this circuit.

External Schottky Diode (BAT42) – Hardware Performance

(Schottky – BAT42WS, Rp=**1.54kΩ**, Rflt=1kΩ, Cflt=1nF, ADS8588S at 200ksps sampling rate)



Performance without external diode Measured on ADS8588SEVM (200ksps):

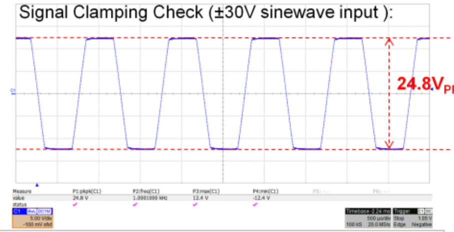
Parameter	Min	Typ	Max	Unit
SNR	91	92		dB
THD		-110	-95	dB

Measured with BAT42:

SNR = 92dB

THD = - 104dB

Signal Clamping Check (±30V sinewave input):



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Here is the measured performance for the ADS8688S with the Schottky diode protection circuit we just designed. Looking at the FFT you can see minimal distortion components. The measured SNR and THD for this case are very close to the data sheet specification. In general, this circuit will have better performance than the TVS protection as the Schottky reverse capacitance is lower than the TVS. The figure in the lower right corner shows the circuit output under fault condition.

PTC with Schottky Diode (BAT42) – Hardware Performance

(Schottky – BAT42WS, PTS120660V005, R_{flt}=1kΩ, C_{flt}=1nF, ADS8588S at 200ksps sampling rate)

Performance without external diode Measured on ADS8588SEVM (200ksps):

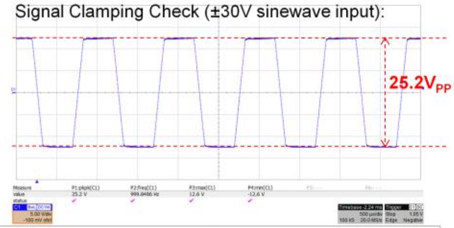
Parameter	Min	Typ	Max	Unit
SNR	91	92		dB
THD		-110	-95	dB

Measured with BAT42 and PTC:

SNR = 92.1dB

THD = - 111dB

Signal Clamping Check (±30V sinewave input):



TEXAS INSTRUMENTS

This slide shows the same Schottky protection circuit with the 1.52k ohm limiting resistor replaced with a PTC fuse. In this example the lower resistance of the PTC helps to reduce the distortion so that the performance matches the data sheet specifications for the ADC. The ADS8588S data sheet specification is typically 92dB and -110dB for SNR and THD, and the measured performance for the circuit with the protection circuit 92.1 and -111dB for SNR and THD. The time domain graph in the lower right hand corner shows the clamped overstress signal.

Thanks for your time!
Please try the quiz.

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That concludes this video – thank you for watching! Please try the quiz to check your understanding of this video's content.

Questions: Protecting ADC with TVS Diode - Improved

1. What is a possible ***disadvantage*** of using a TVS with a higher power rating?
   a. It will not be able to protect for large transient inputs
   b. The voltage rating will not be as good as low power TVS diodes
   c. The leakage current will be higher
   d. The capacitance is higher

2. What is the ***advantage*** of a larger series resistor before the TVS diode?
   a. A lower power rating resistor can be used
   b. Lower distortion
   c. Lower noise
   d. Faster fault protection

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The correct answer is “d. The capacitance is higher”. This is an important reason to consider a lower power TVS diode.

The correct answer is “a. A lower power rating resistor can be used”. In most cases a very low series resistor will give the best THD performance, but unfortunately, the power dissipation under fault conditions may be too high.

Questions: Protecting ADC with TVS Diode - Improved

3. What is a possible ***advantage*** of using a PTC fuse with a TVS diode?
   a. The normal resistance of the PTC fuse is low which allows for lower distortion
   b. The power rating of the PTC doesn't have to be as large because it's resistance increases under fault conditions
   c. The gain accuracy of the solution will be better using the PTC
   d. The offset error of the system will be better using the PTC
   e. Answer a, and b
   f. Answer c, and d

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The correct answer is "e. Answer a and b". Remember, distortion is caused by an interaction of the series resistance with the nonlinear capacitance of the TVS diode. So a small resistance PTC fuse will minimize the distortion. Also the PTC's resistance increases under a fault condition, so that a lower power rating and smaller physical device can be used.

Questions: Protecting ADC with TVS Diode - Improved

4. A system has two power supply rails available: 3.3V, and 5V. The ADC has a 10V input range. Can the Schottky input circuit be used to protect the device?
   a. Yes
   b. No

The correct answer is “b. No”. The reason is that we need a 10V supply to protect a 10V input range for a Shottky type input protection. If that supply is not available than the best alternative is to use a TVS type protection.

Questions: Protecting ADC with TVS Diode - Improved

5. Assuming the protection circuit is causing distortion. How can the distortion be reduced?
   a. Increase the series resistance
   b. Increase the sampling rate.
   c. Increase the input signal frequency
   d. Decrease the input signal frequency

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The correct answer is “d. Decrease the input signal frequency”. Decreasing the signal frequency moves further away from the cutoff of the nonlinear low pass filter from the TVS diode.

Thanks for your time!