IXAN0071
The SMPD Package and its Mounting Instructions

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Introduction:

IXYS has expanded its ISOPLUS package portfolio by offering a new package called the SMPD package. An illustration of the package shown in Figure 1 shows an isolated base (Copper) from the semiconductor chip. The electrical isolation between the semiconductor chip and the base copper is achieved by the Direct-Copper-Bonded (DCB) structure. The structure has three layers (Copper, Alumina Substrate, Copper) in which the Alumina substrate is a ceramic layer situated between the two copper layers and provides the necessary voltage isolation. The rated isolation voltage for this package is 2500V. The DCB is a well known technique for isolation and suitable for high current-carrying capability, excellent thermal conductivity and high reliability in the application.

In summary, the SMPD package has the following advantages:
- High voltage electrical isolation (~2500V)
- Lower thermal resistance compared to other standard packages (TO-247, TO-264 etc)
- Higher component density (H-bridge circuit)
- Higher current carrying capability
- The expansion coefficient of the DCB is close to that of the silicon, which results in high temperature cycle reliability
- If this package is compared with the standard package, the current loop is reduced and the parasitic capacitance is also reduced. Both result in better EMI behavior of the application.
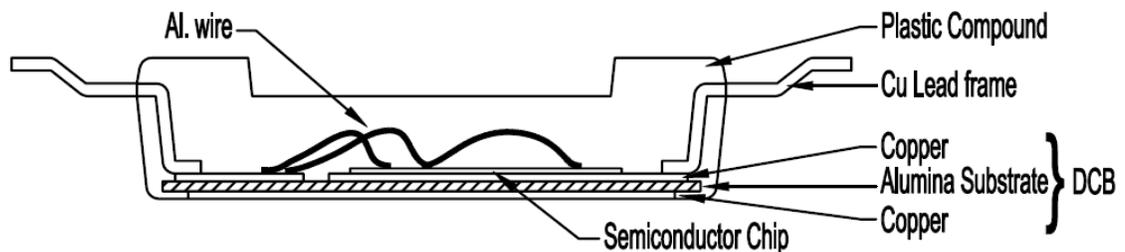
SMPD PACKAGE ILLUSTRATION

Figure 1: The SMPD Package Diagram

Mounting Instructions:

The SMPD package houses both discrete and module devices. To get the most effective heat dissipation, it's required to follow some basic mounting guideline when installing the device to a heat sink. By following this guideline, it's possible to enlarge the contact area, which minimizes the contact thermal resistance.

Use of Thermal Compound/Grease

The use of thermal compound provides a very good contact between the device's base and the heat sink surface. It ensures a very low value of contact thermal resistance (case-to-heat sink thermal resistance). The recommendation is to use either Dow Corning 340 (DC340) or silicone free HTCP equivalent thermal compound. Since the devices feature an internal isolation (DCB), it is not recommended to use an interface material with isolation (thermal pad) as these materials exhibit a higher thermal resistance compared to the materials mentioned above.

- Thermal compound should be applied evenly to the device base plate and the heat sink surface.
- Thermal compound layer thickness should be in the range of about 60 to 80 μm.

Heat Sink Surface

In order to ensure a very low value of contact thermal resistance, the contact surface of the heat sink must be flat and clean and fulfill the following mechanical specifications:
Unevenness: < 50μm over a distance of 100mm
Roughness: < 10μm

When installing the device to a heat sink, excessive uneven fastening force might apply stress to inside chips, which can lead to damage or degradation of the device. An example of heat sink assembly is shown in Figure 2.

Mounting Screw

The recommended mounting screw is M3.5 or 6-32 screw with flat and spring washers. Both flat and spring washers that fit the screw must be used for spreading the pressure evenly on the heat sink (or the PCB). The minimum length of the screw is 5/8" or 3/4".

Mounting Force/Torque

The recommended mounting force for the SMPD package is given in the datasheet as 50…200N/11…45lb. To convert it into a mounting torque, we can use the following formula:

$$F = \frac{2\pi.M}{P} \qquad (1)$$

Here F is the contact force in N, P is the pitch in m of used screw and M is the torque applied to the screw in N.m. The above relation states that the contact force is inversely proportional to the pitch of used screw.

Specifications of International Thread Standards

UNC Thread ANSI B1.1

UNC – Unified Coarse Thread. The old definition NC is comparable with the metric thread. The new term UNC is comparable with the ISO metric thread. NC and UNC threads are interchangeable, in an analogous manner like the metric and the ISO metric thread.

Nominal Diameter	Major Diameter Inch	Major Diameter mm	Tapping Drill Size mm	TPI	Pitch mm
N 1 - 64 UNC	0,073	1,854	1,50	64	0,397
N 2 - 56 UNC	0,086	2,184	1,78	56	0,453
N 3 - 48 UNC	0,099	2,515	2,05	48	0,529
N 4 - 40 UNC	0,112	2,845	2,27	40	0,635
N 5 - 40 UNC	0,125	3,175	2,59	40	0,635
N 6 - 32 UNC	0,138	3,505	2,77	32	0,794
N 8 - 32 UNC	0,164	4,166	3,42	32	0,794

http://www.gewinde-normen.de/en/unified-coarse-thread.html

For 6-32 screw from international thread standard
Pitch=0.794mm=0.000794m
Therefore,

F=50N, $M = \dfrac{50 x 0.000794}{2\pi} = 0.0063$N.m

F=100N, $M = \dfrac{100 x 0.000794}{2\pi} = 0.0126$N.m

F=200N, $M = \dfrac{200 x 0.000794}{2\pi} = 0.0253$N.m

In order to convert in the British unit ~lb.inch, the following relations can be used.
One Pound inch to Newton meter, → 1 lb.in=0.113N.m;
One Pound force to Newton, → 1 lb.f.=4.45N; One inch to meter, → 1 inch=0.0254m;

The following Table 1 provides the summary of the mounting requirements for the SMPD package.

Table 1: SMPD Mounting Torque and Heat Sink Flat Specifications

Parameters	Conditions	Limits			Unit
		Min	Typ.	Max.	
SMPD Device Flatness		--	--	100	μm
Heat Sink Flatness	Unevenness	--	--	50	μm
	Roughness	--	--	10	μm
Mounting Force	Screw	50	--	200	N
	6-32	11		45	lb

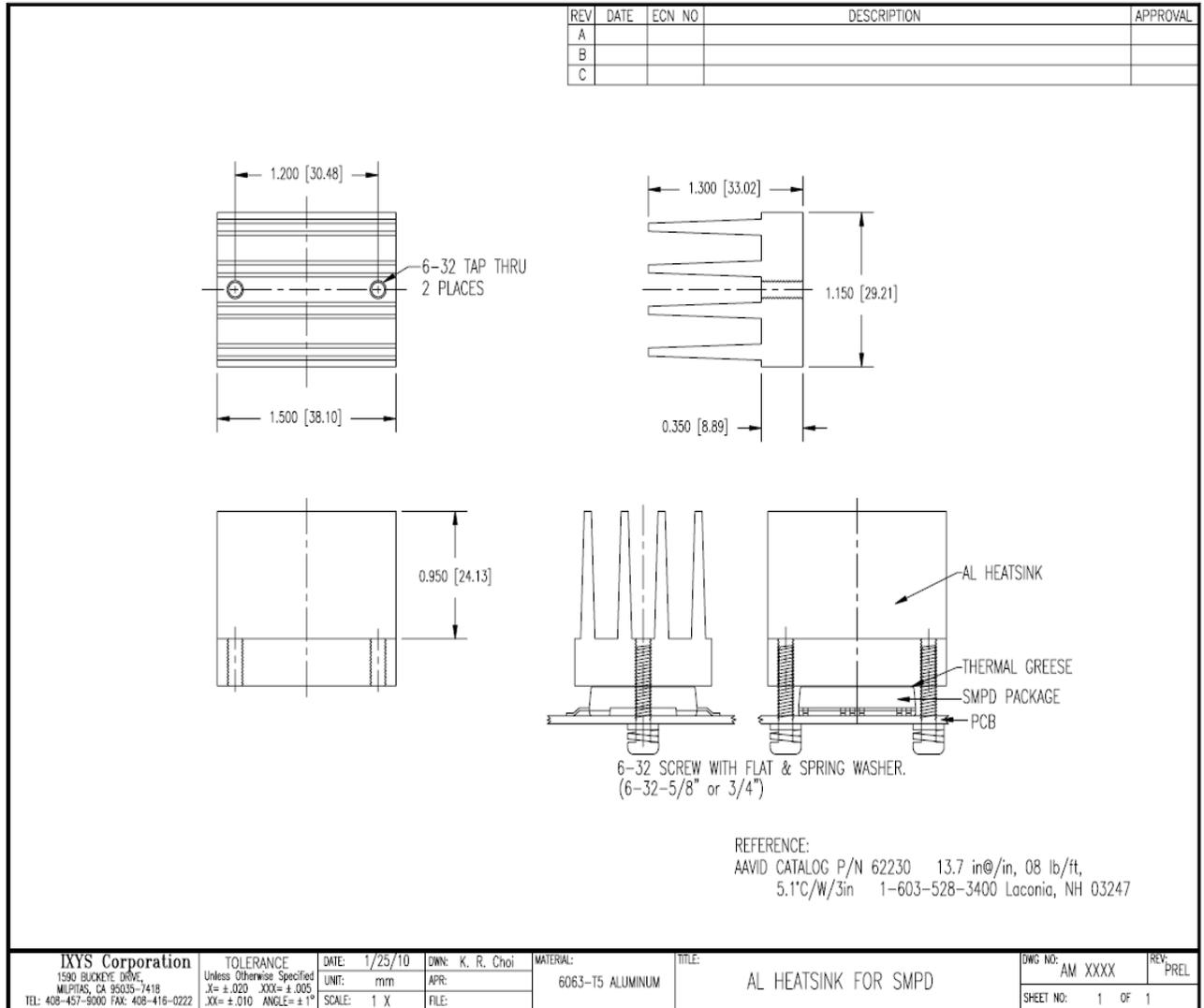|		60		80	μm
Thickness of thermal compound		60		80	μm
Weight		--	8	--	gram

Figure 2: Illustration of a heat sink assembly

Soldering of Terminals:

If the electrical connection is made by soldering, great care must be taken to avoid the overheating the device. In this case, the following requirements are recommended:

Table 2: Soldering Requirements

Soldering Temperature	Distance from case	Maximum soldering time
<260 ^{o}C	<3mm	3s

4

<260 °C	>3mm	5s

Mounting to a Heat Sink:

Mounting instructions would be a little different for different heat sinks. In Figure 3, we use AAVID Thermalloy P/N: 62230. For this heat sink, the dimension and the mounting process are illustrated in the previous figure 2.

	Part Number	Thermal Resistance °C/W at 3in length*	Width in	Height in	Surface Area in²/in	Weight lb/ft	Part Class
	62230	5.26	1.15	1.30	13.3	0.90	A

*Based on a 75°C rise in natural convection
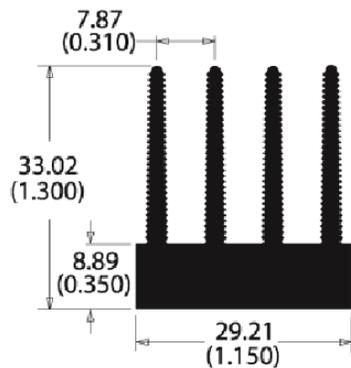
7.87 (0.310)

33.02 (1.300)

8.89 (0.350)

29.21 (1.150)

Figure 3: AAVID THERMALLOY Heat Sink P/N: 62230

The size of heat sink is chosen as LxWxH ~ 1.5in (38.1mm) x 1.15in (29.21mm) x1.3in (33.02mm). The following procedure can be followed to mount the device:

i)   When a PCB is used as shown in Figure 4 then the device should be soldered on the PCB first. It's required that the SMPD base and heat sink surfaces are parallel to each other.
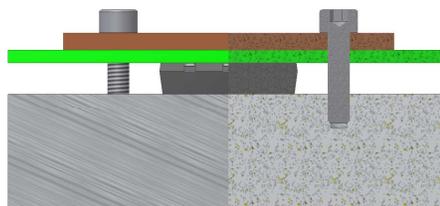

Figure 4: An example for PCB and heat sink assembly

ii)   Create two holes (30.48mm apart) on the surface of the heat sink. For mounting with screw and nut, the mounting hole should not exceed 0.140inch (screw 6-32). The recommended depth of thread in aluminum (Al) heat sink is 12mm and in copper (Cu) heat sink is 10 mm depending on the thickness of the heat sink base. Here, the maximum thickness of the heat sink base is 8.89mm therefore, 5 to 6 mm depth would be sufficient.

iii) Heat sink contact surfaces must be flat, clean and free of scratches. It should have the following specifications:
Unevenness: < 50μm over a distance of 100mm
Roughness: < 10μm

iv) Place a thin layer of thermal compound on the heat sink surface and on the device's base plate just sufficient to cover the entire DCB base to the heat sink. Best results are achieved when the thermal compound thickness is between 60 um to 80 um. Thicker layer of thermal compound may increase the risk of damage to the DCB base plate and internal chip.

v) The recommended mounting screw is M3.5 or 6-32 UNC with flat and spring washers. Both flat and spring washers fitting the screw have to be used between the screw and the heat sink (or the PCB) surface.

vi) First tighten the screw clockwise then use a torque wrench to apply the tightening force. The tightening force should not be exceeded the mounting force given in the datasheet.

vii) To prevent mechanical stress to leads of the device or on the connections between the device and the PCB, additional support from the heat sink to the PCB might be necessary.

Heat Sink Size Estimation:

In order to have higher power dissipation capability, the SMPD package should be mounted on a heat sink. To determine the heat sink size, it's important to estimate the maximum power dissipation of the device. The datasheet provides the useful parameters to determine the power dissipation. The maximum operating switching frequency of the device can be estimated as,

$$fs\ (max) = (P_D - P_C)/E_{SW} \qquad\qquad (2)$$

Where P_D is the maximum device power dissipation, P_C is the conduction power loss, fs (max) are the maximum switching frequency and E_{SW} is the switching energy loss.

The maximum power dissipation by a packaged device is determined by the maximum junction operating temperature rating, the ambient temperature, and the junction-to-ambient thermal resistance.

$$P_D = \frac{T_{J(Max)} - T_A}{R_{thJA}} = P_{C,Total} + P_{SW,Total} \qquad\qquad (3)$$

Where P_C is the conduction loss and P_{SW} is the switching loss. IXYS datasheet provides an absolute maximum junction temperature rating called T_{JM} of 150C. Operating in this temperature can severely impact the device's reliability. For this reason one important consideration in equation (3) is that the designer must select a maximum junction operating temperature, $T_{J(Max)}$, which should be lower than T_{JM}. IXYS recommends a value of the maximum operating junction temperature $T_{J(Max)}$ of between 100 and 125C.

Here are the generic formulas for determining the total power loss in a single Power MOSFET or IGBT.

Power MOSFET:

The Conduction loss is
$$P_C = I_{RMS}^2 * R_{DS(on)} \qquad\qquad (4)$$
Where the duty cycle is included in the rms value of the current
The switching power loss can be defined as
$$P_{SW} = E_{SW} * f_{S(max)} \qquad\qquad (5)$$

E_{SW} = Turn ON Energy Losses + Turn OFF Energy Losses + Gate Control Energy Loss+ Output Capacitance loss+ Diode Reverse Recovery loss
$$= E_{SW-ON} + E_{SW-OFF} + E_{SW-Gate} + E_{SW-OutputCAP} + E_{SW-DiodeRR} \qquad (6)$$
$$E_{SW-ON} = 0.5 * I_O * V_{OFF} * Q_{SW} I_G \qquad\qquad (7)$$
$$E_{SW-OFF} = 0.5 * I_O * V_{OFF} * Q_{SW}/I_G \qquad\qquad (8)$$
$$E_{SW-Gate} = Q_G * V_G \qquad\qquad (9)$$
$$E_{SW-OutputCAP} = 0.5 * C_P * V_{OFF}^2 + O.5 * Q_{OSS} * V_{off} \qquad (10)$$
$$E_{SW-DiodeRR} = V_{OFF} * Q_{RR} \qquad (11)$$
Where, I_O = Output current
V_{SW}= Switching gate voltage
V_G = Gate voltage

Q_G = Total gate charge
I_G = the gate driver current
Q_{OSS} = Output charge (if available)
C_P = Circuit parasitic capacitance (if available)
V_{OFF}= Off State drain voltage
Q_{RR}= Internal diode's reverse recovery charge
$f_{SW(max)}$= Maximum switching frequency
Similarly for IGBT application,

IGBT:
The Conduction loss is defined by,

$$P_C = I_C * V_{CE(sat)} \qquad (12)$$

Where the duty cycle is included in the rms value of the current, I_C
The switching power loss can be defined as

$$P_{SW} = E_{SW} * f_{S(max)} \qquad (13)$$

E_{SW} = Turn ON Energy Losses + Turn OFF Energy Losses + Gate Energy Loss

$$= E_{SW-ON} + E_{SW-OFF} + E_{SW-Gate} \qquad (14)$$

$$E_{SW-ON} \text{ or } E_{ON} \text{ is given in the device datasheet} \qquad (15)$$

$$E_{SW-OFF} \text{ or } E_{OFF} \text{ is given in the device datasheet} \qquad (16)$$

$$E_{SW-Gate} = Q_G * V_G \qquad (17)$$

Where,
V_G = Applied gate voltage
Q_G = Total gate charge
Here P_C and P_{SW} defined in equations (4), (5), (12) and (13) are for each device. To obtain $P_{C, Total}$ and $P_{SW, Total}$, you need to multiply the number of devices used per application. Now, equation (3) can be used to determine the total power dissipation in the application, P_D.

After determining the maximum power loss/dissipation, P_D in watt, we now can estimate the maximum junction to ambient thermal resistance, R_{thJA}, using equation (3):
R_{thJA} can also be written as,

$$R_{thJA} = R_{thJC} + R_{thC-SH} + R_{thSH-A} \qquad (18)$$

R_{thJA} is the thermal resistance of the entire assembly that has three components: the thermal resistance of the device, R_{thJC}, the thermal resistance of the interface material between the device and the heat sink, R_{thC-SH}, and the thermal resistance of the heat sink, R_{thSH-A}. The data for R_{thJC} and sometimes R_{thC-SH} or R_{thCS} are provided by the device datasheet. Otherwise, if the thermal compound is used between the heat sink and the base of the device then we can add a maximum thermal resistance between the case and heat sink, R_{thC-SH} as 0.2K/W (typical value). After obtaining the values for R_{thJC} and R_{thC-SH}, we can calculate the value for R_{thSH-A} which is the heat sink thermal resistance.

After obtaining the heat sink thermal resistance value, the next step is to select a heat sink based on the known thermal resistance and available dimensions that fit the size of the package.

New generation of IXYS Power MOSFETs and IGBTs in the SMPD package are given in Table 1 & 2.

Table 1: Latest SMPD Packaged Power MOSFET (www.ixyspower.com)

Power MOSFET	$V_{DS(max)}$ V	$I_{D25}(Cont.)$ Tc=25C A	$R_{DS(on)}$ type Tc=25C mΩ	$Q_{G(on)}$ type Tc=25C nC	t_{rr} type (ns)
MMIX1T600N04T2	40V	600A	1.30	590	100
MMIX1F520N075T2	75V	500A	1.60	545	150

Table 2: Latest SMPD Packaged IGBT

IGBT	$V_{DS(max)}$ V	$I_{D25}(Cont.)$ Tc=25C A	$I_{D110}(Cont.)$ Tc=110C A	$V_{CE(Sat)}$ type Tc=25C V	Q_G nC	R_{thJC} $^oC/W$
MM1X1G320N60B3	600V	400A	180A	1.5V	585	0.125

21-pin and 9-pin SMPD package illustration:

Isolated Tab
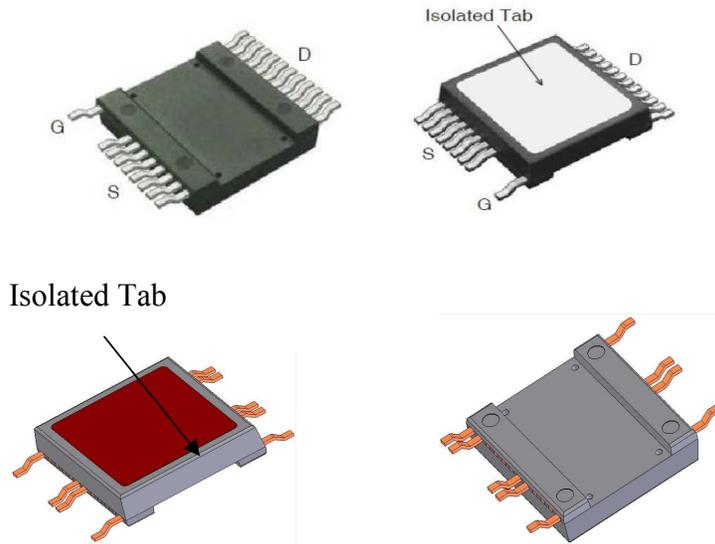
Figure 5: The SMPD Package Illustration
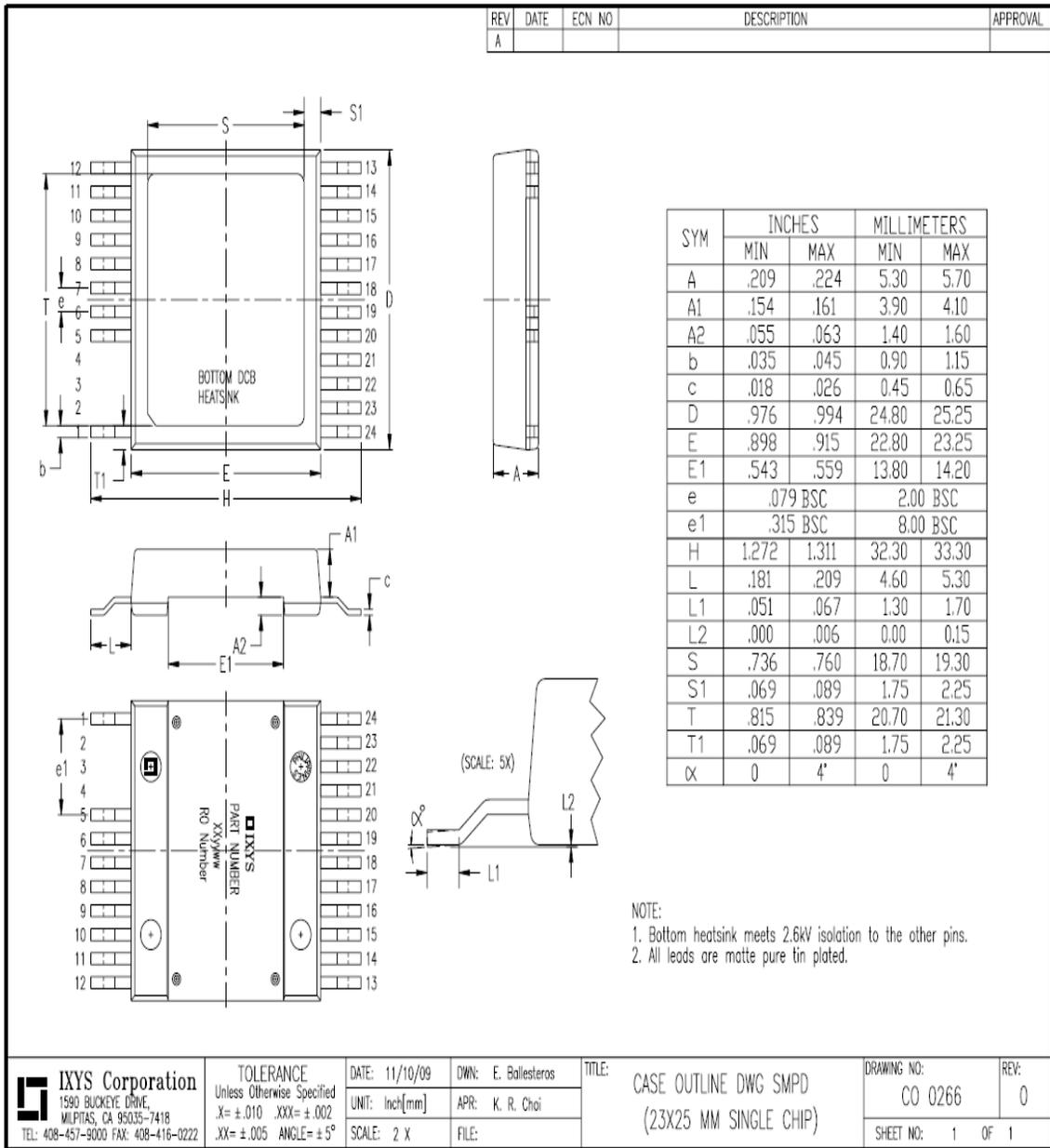
Figure 6: The SMPD Package: 21-pin mechanical outline

SYM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	.209	.224	5.30	5.70
A1	.154	.161	3.90	4.10
A2	.055	.063	1.40	1.60
b	.035	.045	0.90	1.15
c	.018	.026	0.45	0.65
D	.976	.994	24.80	25.25
E	.898	.915	22.80	23.25
E1	.543	.559	13.80	14.20
e	.079 BSC		2.00 BSC	
e1	.394 BSC		10.00 BSC	
e2	.315 BSC		8.00 BSC	
H	1.272	1.311	32.30	33.30
L	.181	.209	4.60	5.30
L1	.051	.067	1.30	1.70
L2	.000	.006	0.00	0.15
S	.736	.760	18.70	19.30
S1	.069	.089	1.75	2.25
T	.815	.839	20.70	21.30
T1	.069	.089	1.75	2.25
∝	0	4°	0	4°

NOTE:
1. Bottom heatsink meets 2.6kV isolation to the other pins.
2. All leads are matte pure tin plated.

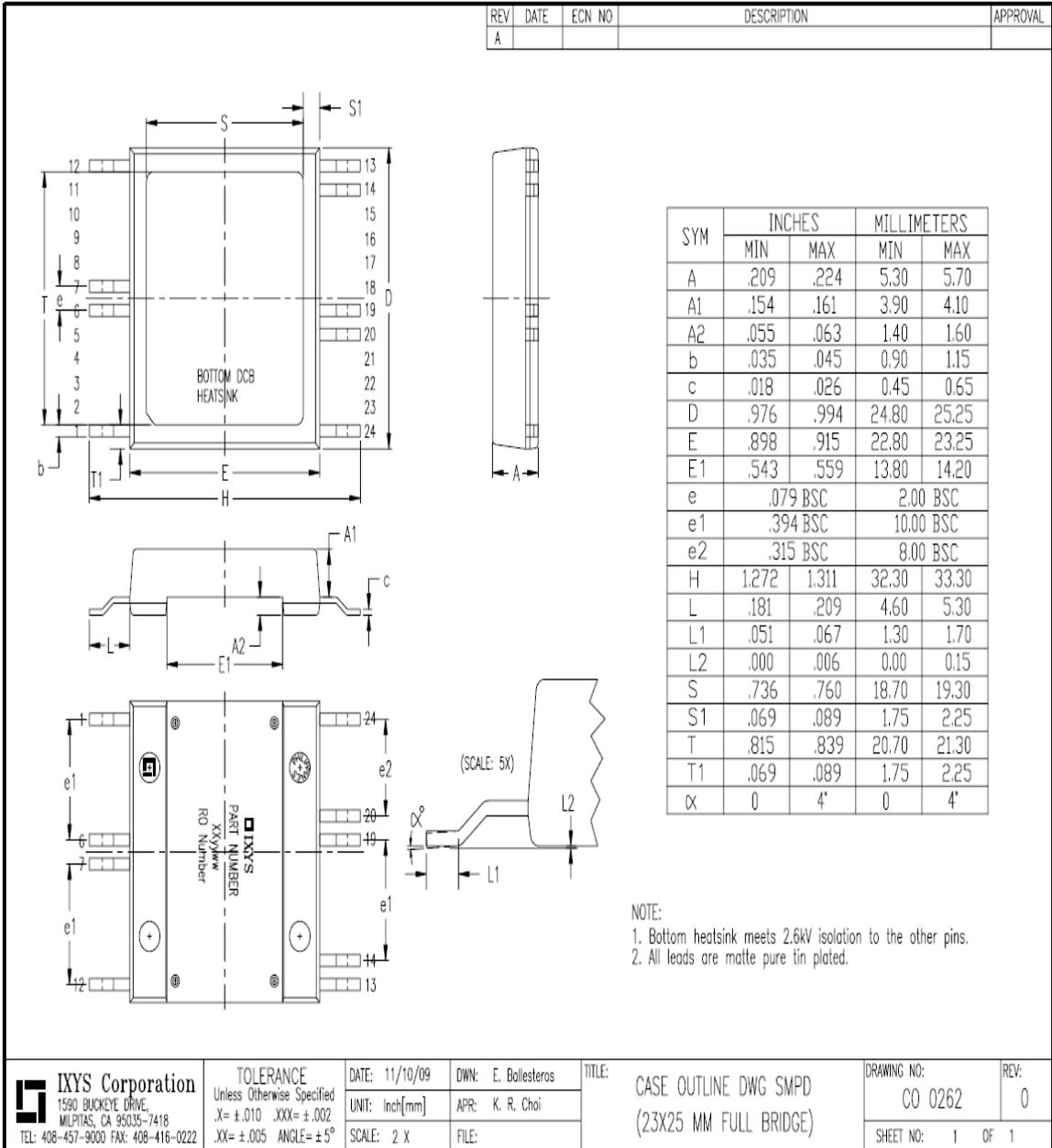(SCALE: 5X)

BOTTOM DCB HEATSINK

PART NUMBER
XXyyww
R0 Number

Figure 7: The SMPD Package: 9-pin mechanical outline