晶瀚科技
Chip Advanced Tech

CAT7104

3A Step-Down DC/DC Regulator

FEATURES

- Guaranteed 3A output current
- 3.3V, 5V, and adjustable versions
- Wide input voltage range, up to 22V
- Internal oscillator of 150KHz fixed frequency
- Wide adjustable version output voltage range, from 1.23V to 18V ±4% max over line and load condition
- Low standby current, typ. 80μA, at shutdown mode
- Requires only 4 external components
- Thermal shutdown and current limit protection
- Requires only 4 external components
- Excellent line and load regulation specifications
- TTL shutdown capability

APPLICATIONS

- LCD Monitors
- ADD-ON Cards Switching Regulators
- High Efficiency Step-Down Regulators
- Efficient Pre-regulator for Linear Regulators

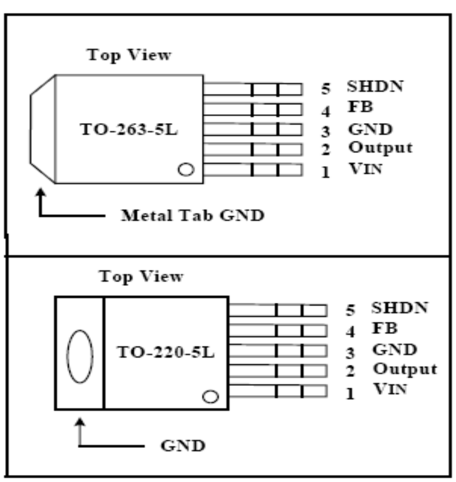
GENERAL DESCRIPTION

The CAT7104 series are step-down switching regulators with all required active functions. It is capable of driving 3A load with excellent line and load regulations. These devices are available in fixed output voltages of 3.3V, 5V and an adjustable output version.

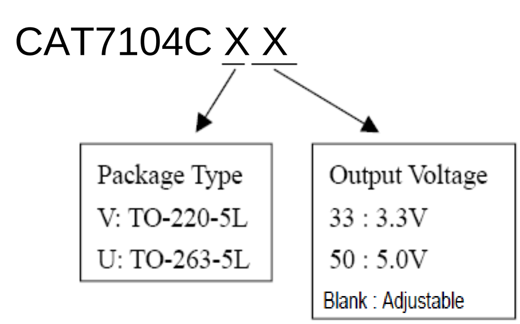
The CAT7104 series offers a high-efficiency replacement for popular three-terminal linear regulators. Also it requires a minimum number of external components. It substantially not only reduces the area of board size but also the size of the heat sink, and in some cases no heat sink is required.

Other features include we can guaranteed the ±4% tolerance on output voltage within specified input voltages and output load conditions is guaranteed. Also, the oscillator frequency accuracy is within ±15%. External shutdown is included, featuring 70μA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

PIN CONFIGURATION



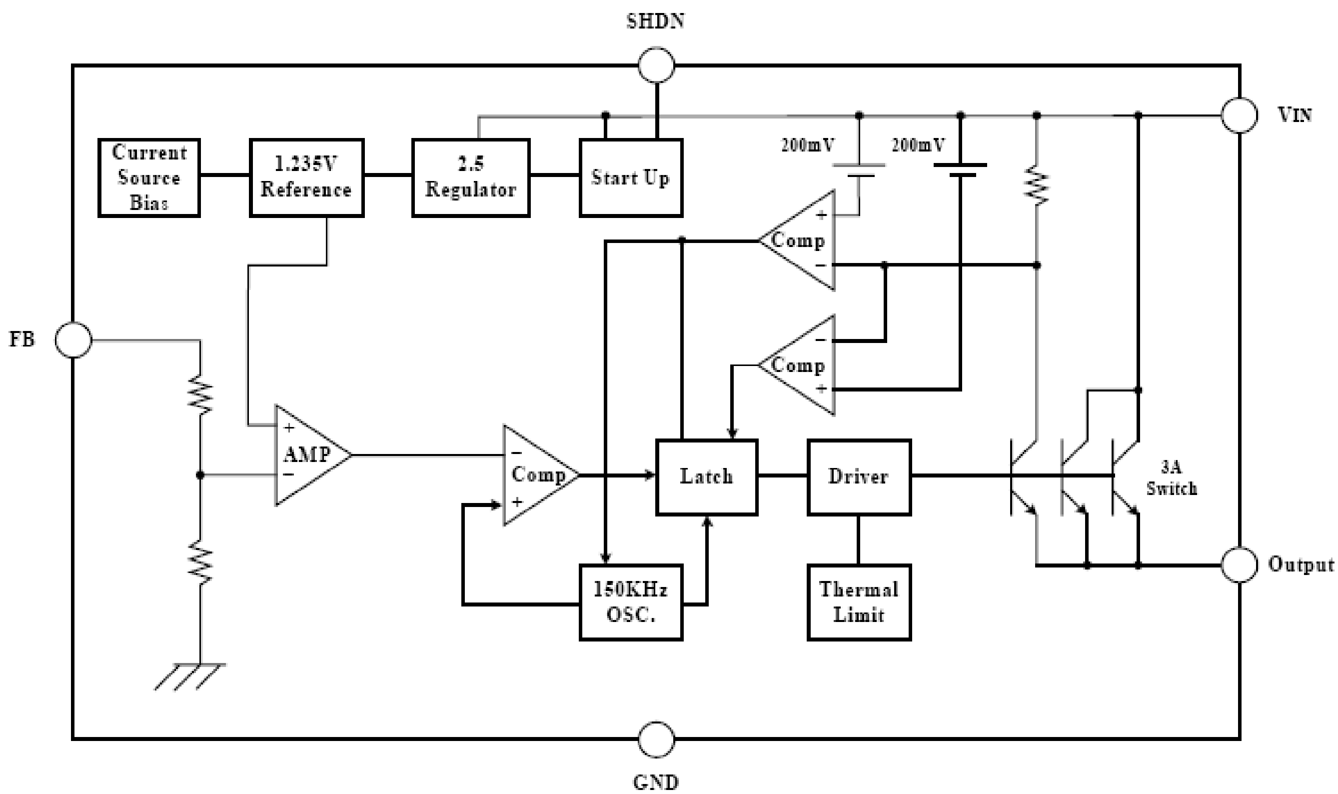
ORDERING INFORMATION



PIN DESCRIPTION

Name	Description
V_{IN}	Operating voltage input
Output	Switching output
GND	Ground
FB	Output voltage feedback control
SD	$\overline{ON}$/OFF Shutdown

BLOCK DIAGRAM



APPLICATION CIRCUIT

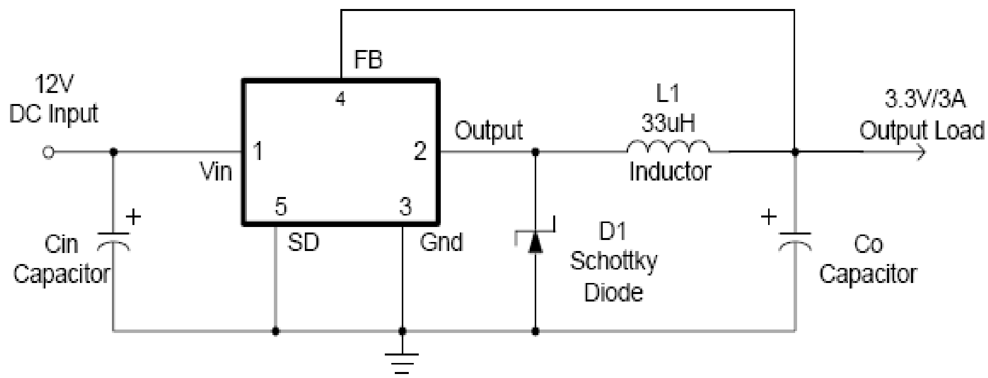


Figure1. Fixed Output Voltage Versions

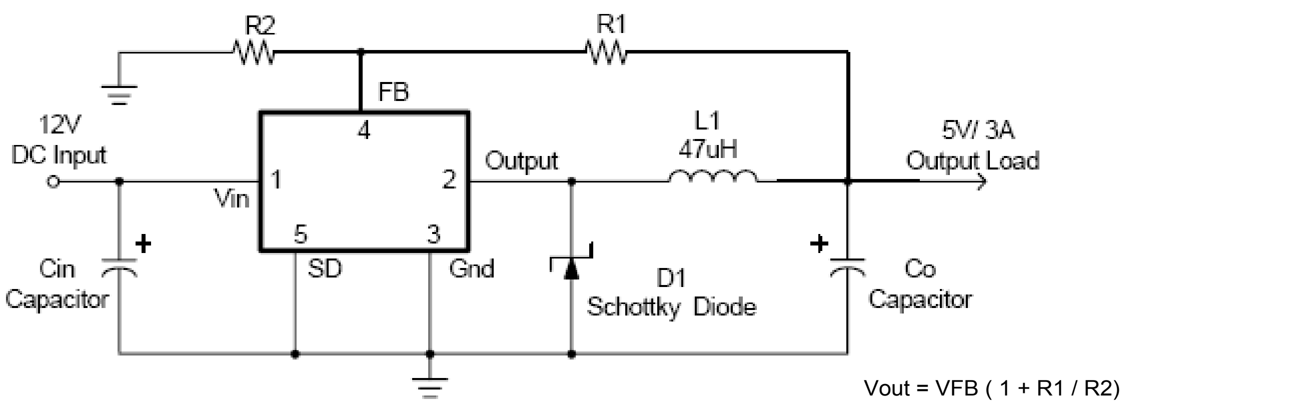


Figure2. Adjustable Output Voltage Versions

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
DC Supply Voltage	VIN	+24	V
SHDN Pin Input Voltage	VSHDN	-0.3 to +25	V
FB Pin Voltage	VFB	-0.3 to +25	V
Output Voltage to Ground	VOUT	-1	V
Power Dissipation	PD	Internal Limited	W
Operating Voltage	VOP	+4.5 ~ +22	V
Operating Temperature	TJ (Max)	-40 ~ +125	℃
Storage Temperature	TS	-65 ~ +150	℃

ELECTRCAL CHARACTERISTICS

(TA=25℃, VIN=12V for 3.3V,5V,Adjustable version and VIN=18V for the 12V version, ILOAD = 0.5A, unless otherwise specified)

Parameter	Conditions		Min.	Typ.	Max.	Unit
Feedback bias Current	V_{FB} = 1.3V (Adjustable Only)			40	60	nA
					100	
Oscillator Frequency			127	150	173	KHz
			110		173	
Saturation Voltage	I_{OUT} = 3A, No outside circuit and V_{FB} = 0V force driver on			1.5	1.6	V
					1.7	
Max. Duty Cycle (ON)	V_{FB} = 0V force driver on			100		%
Min. Duty Cycle (OFF)	V_{FB} = 12V force driver off			0		%
Current Limit	Peak current, No outside circuit and V_{FB} = 0V force driver on		3.6	4	5.5	A
					6.5	
Output Leakage Current	Output = 0V, No outside circuit and V_{FB} = 12V force driver off				200	μA
	Output = - 0.8V, V_{IN} = 20V			10	30	mA
Quiescent Current	V_{FB} = 12V force driver off			5	10	mA
Standby Quiescent Current	SHDN Pin = 5V, V_{IN} = 20V			150	250	μA
					300	
SHDN Pin Logic Input Threshold Voltage	Low (Regulator ON)			1.3	0.6	V
	High (Regulator OFF)		2.0			
SHDN Pin Logic Input Current	V_{LOGIC} = 2.5V (OFF)			15	25	μA
	V_{LOGIC} = 0.5V (ON)			0.02	5	
Thermal Resistance, Θ_{JC}	TO-220-5L	Junction to case		2.5		℃/W
	TO-263-5L			3.5		
Thermal Resistance with Copper area of approximately 3 in^2	TO-220-5L	Junction to ambient		28		℃/W
	TO-263-5L			23		

ELECTRCAL CHARACTERISTICS (Continued)

CAT7104-ADJ

Symbol	Parameter	Conditions	Typ.	Limit	Unit
VFB	Output Feedback	5V ≤ VIN ≤ 20V, 0.2A ≤ ILOAD ≤ 3A, VOUT programmed for 3V	1.23	1.193/1.18 1.267/1.28	V VMIN VMAX
η	Efficiency	VIN = 12V, ILOAD = 3A	72		%

CAT7104-3.3V

Symbol	Parameter	Conditions	Typ.	Limit	Unit
VFB	Output Feedback	5.5V ≤ VIN ≤ 20V, 0.2A ≤ ILOAD ≤ 3A,	3.3	3.168/3.135 13.432/3.465	V VMIN VMAX
η	Efficiency	VIN = 12V, ILOAD = 3A	71		%

CAT7104-5.0V

Symbol	Parameter	Conditions	Typ.	Limit	Unit
VFB	Output Feedback	8V ≤ VIN ≤ 20V, 0.2A ≤ ILOAD ≤ 3A, VOUT programmed for 3V	5	4.8/4.75 5.2/5.25	V VMIN VMAX
η	Efficiency	VIN = 12V, ILOAD = 3A	78		%

CAT7104-12V

Symbol	Parameter	Conditions	Typ.	Limit	Unit
VFB	Output Feedback	15V ≤ VIN ≤ 20V, 0.2A ≤ ILOAD ≤ 3A, VOUT programmed for 3V	12	11.52/11.4 12.48/12.6	V VMIN VMAX
η	Efficiency	VIN = 16V, ILOAD = 3A	88		%

APPLICATION INFORMATION

External component selector

Input Capacitors (Cin)

It is required that VIN must be bypassed with at least a 100uF electrolytic capacitor for stability. Also, it is strongly recommended the capacitor's leads must be short, wide and located near the regulator as possible. The important parameters for the capacitor are the voltage rating and the RMS current rating. For a maximum ambient temperature of 40℃, a general guideline would be to select a capacitor with a ripple current rating of approximately 50% of the DC load current. The capacitor voltage rating must be at least 1.25 times greater than the maximum input voltage.

For low operating temperature range, for example, below -25℃, the input capacitor value may need to be larger. This is due to the reason that the capacitance value of electrolytic capacitors decreases and the ESR increases with lower temperatures and age. Paralleling a ceramic or solid tantalum capacitor will increase the regulator stability at cold temperatures.

Output Capacitors (C_{OUT})

An output capacitor is also required to filter the output voltage and is needed for loop stability. The capacitor should be located near the CAT7104 using short PC board traces. Low ESR types capacitors are recommended for low output ripple voltage and good stability. Generally, low value or low voltage (less than 12V) electrolytic capacitors usually have higher ESR numbers. For example, the lower capacitor values (220uF – 1000uF) will yield typically 50mV to 150mV of output ripple voltage, while larger-value capacitors will reduce the ripple to approximately 20mV to 50mV.

The amount of output ripple voltage is primarily a function of the ESR (Equivalent Series Resistance) of the output capacitor and the amplitude of the inductor ripple current ($\triangle I_{IND}$).

Output Ripple Voltage = ($\triangle I_{IND}$) x (ESR of C_{OUT})

Some capacitors called “high-frequency”, “low-inductance”, or “low-ESR” are recommended to use to further reduce the output ripple voltage to 10mV or 20mV. However, very low ESR capacitors, such as Tantalum capacitors, should be carefully evaluated.

Catch Diode

This diode is required to provide a return path for the inductor current when the switch is off. It should be located close to the CAT7104 using short leads and short printed circuit traces as possible.

To satisfy the need of fast switching speed and low forward voltage drop, Schottky diodes are widely used to provide the best efficiency, especially in low output voltage switching regulators (less than 5V). Besides, fast-Recovery, high-efficiency, or ultra-fast recovery diodes are also suitable. But some types with an abrupt turn-off characteristic may cause instability and EMI problems. A fast-recovery diode with soft recovery characteristics is better choice.

Output Voltage Ripple and Transients

The output ripple voltage is due mainly to the inductor sawtooth ripple current multiplied by the ESR of the output capacitor. The output ripple voltage of a switching power supply will contain a sawtooth ripple voltages at the switcher frequency, typically about 1% of the output voltages, and may also contain short voltage spikes of the sawtooth waveform.

Due to the fast switching action, and the parasitic inductance of the output filter capacitor, there is voltage spikes presenting at the peaks of the sawtooth waveform. Cautions must be taken for stray capacitance, wiring inductance, and even the scope probes used for transients evaluation. To minimize these voltage spikes, shortening the lead length and PCB traces is always the first thought. Further more, an additional small LC filter (30uH & 100uF) (as shown in Figure 3) will possibly provide a 10X reduction in output ripple voltage and transients.

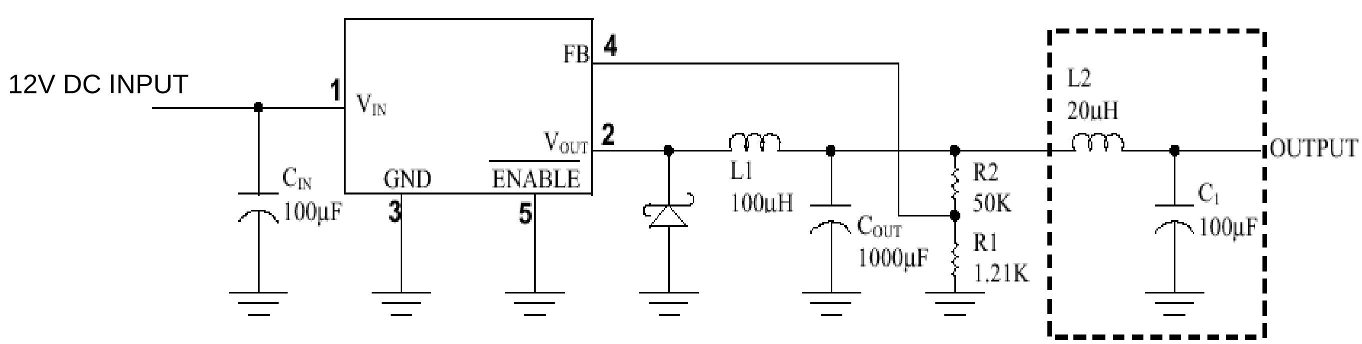


Figure 3. LC Filter for Low Output Ripple

Inductor Selection

The CAT7104 can be used for either continuous or discontinuous modes of operation. Each mode has distinctively different operating characteristics, which can affect the regulator performance and requirements.

With relatively heavy load currents, the circuit operates in the continuous mode (inductor current always flowing), but under light load conditions, the circuit will be forced to the discontinuous mode (inductor current falls to zero for a period of time). For light loads (less than approximately 300mA) it may be desirable to operate the regulator in the discontinuous mode, primarily because of the lower inductor values required for the discontinuous mode.

Inductors are available in different styles such as pot core, toriod, E-frame, bobbin core, et., as well as different core materials, such as ferrites and powdered iron. The least expensive, the bobbin core type, consists of wire wrapped on a ferrite rod core. This type of construction makes for an inexpensive inductor, but since the magnetic flux is not completely contained within the core, it generates more electromagnetic interference (EMI). This EMI can cause problems in sensitive circuits, or can give incorrect scope readings because of induced voltages in the scope probe.
An inductor should not be operated beyond its maximum rated current because it may saturate. When an inductor begins to saturate, the inductance decreases rapidly and the inductor begins to look mainly resistive (the DC resistance of the winding). This will cause the switch current to rise very rapidly. Different inductor types have different saturation characteristics, and this should be well considered when selecting as inductor.

Feedback Connection

For fixed output voltage version, the FB (feedback) pin must be connected to V_{OUT}. For the adjustable version, it is important to place the output voltage ratio resistors near CAT7104 as possible in order to minimize the noise introduction.

$\overline{\text{Enable}}$

It is required that the $\overline{\text{ENABLE}}$ must not be left open. For normal operation, connect this pin to a “LOW” voltage (typically, below 1.6V). On the other hand, for standby mode, connect this pin with a “HIGH” voltage. This pin can be safely pulled up to $+V_{IN}$ without a resistor in series with it.

Grounding

To maintain output voltage stability, the power ground connections must be low-impedance. For the 5-lead TO-220 and TO-263 style package, both the tab and pin 3 are ground and either connection may be used.

Heatsink and Thermal Consideration

Although the CAT7104 requires only a small heatsink for most cases, the following thermal consideration is important for all operation. With the package thermal resistances θJA and θJC, total power dissipation can be estimated as follows:
$P_D = (V_{IN} \times I_Q) + (V_{OUT} / V_{IN})(I_{LOAD} \times V_{SAT})$;

When no heatsink is used, the junction temperature rise can be determined by the following:

$\Delta T_J = P_D \times \theta_{JA}$;

With the ambient temerpature, the actual junction temperature will be:

$T_J = \Delta T_J + T_A$;

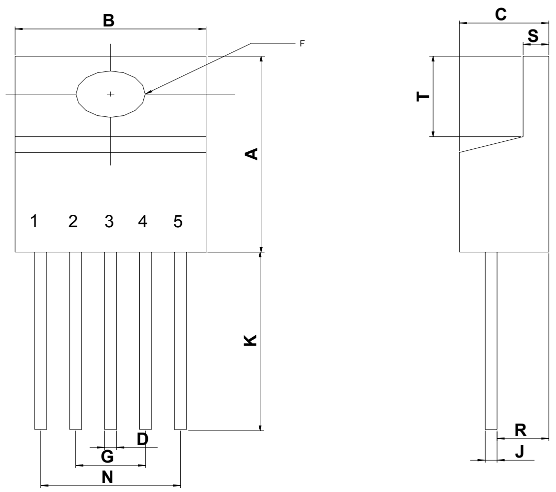
If the actual operating junction temperature is out of the safe operating junction temperature (typically 125℃), then a heatsink is required. When using a heatsink, the junction temperature rise will be reduced by the following:

$\Delta T_J = P_D \times (\theta_{JC} + \theta_{interface} + \theta_{Heatsink})$;

Also one can see from the above, it is important to choose an heatsink with adequate size and thermal resistance, such that to maintain the regulator’s junction temperature below the maximum operating temperature.

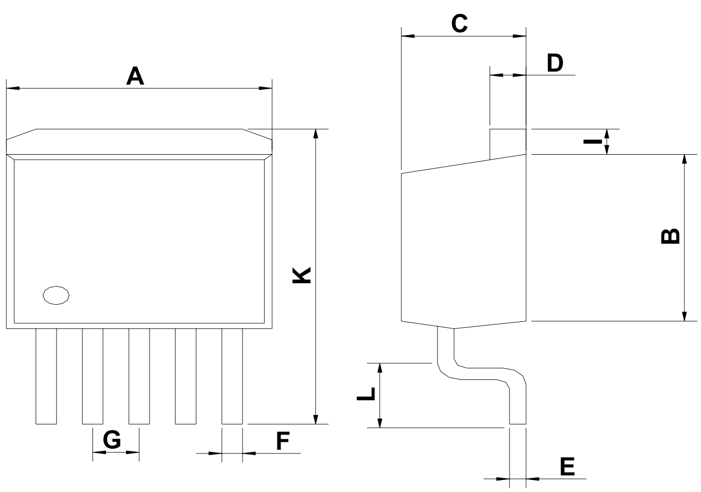
PACKAGE DIMENSION

TO-220 (N220)



SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	14.23	---	16.51	0.560	---	0.650
B	9.66	---	10.66	0.380	---	0.420
C	3.56	---	4.82	0.140	---	0.190
D	0.46	---	0.89	0.018	---	0.035
F	3.56	---	4.06	0.140	---	0.160
G	3.40	---	---	0.134	---	---
J	0.31	---	1.14	0.012	---	0.045
K	12.70	---	14.70	0.500	---	0.580
N	---	6.80	---	---	0.268	---
R	2.04	---	2.92	0.080	---	0.115
S	1.14	---	1.39	0.045	---	0.055
T	5.85	---	6.85	0.230	---	0.270

TO-263 (N263)



SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	10.03	---	10.67	0.395	---	0.420
B	8.25	---	9.17	0.325	---	0.361
C	4.34	---	4.59	0.171	---	0.181
D	1.14	---	1.40	0.045	---	0.055
E	0.33	---	0.432	0.013	---	0.017
F	0.737	---	0.889	0.029	---	0.035
G	1.57	---	1.83	0.062	---	0.072
I	---	---	1.65	---	---	0.065
K	14.60	---	16.13	0.575	---	0.635
L	2.29	---	2.79	0.090	---	0.110
V	1.14	---	1.40	0.045	---	0.055

TO-263 (N263)
Lead Position Overlay