Implementing the Remote Sense and Adjust Functions

Certain models of single and dual output hybrid power converters have Remote Sense pins and/or Voltage Adjust pins available to use when voltage drop or output adjustment is required. **Table 5** defines the models with these features.

The Remote Sense feature (see **Figure 12**) allows the user to compensate for line drops that are inherent in power distribution. This feature is not as useful for lower power or higher output voltage converters because the line drops tend to be small in these applications, therefore remote sense compensation is only available in certain units. The converters are generally designed to allow up to 0.25 V total line drop and still meet performance. It should be noted that as the line drop compensation increases, the low line voltage operating point increases slightly. In other words, the unit may only regulate down to 17 VDC (for 28 V units) rather than 16 VDC. The higher input voltage units have additional margin to give full performance with the .25 V line drop. Also, if the output voltage increases due to line drop compensation, the output current drawn should be proportionally reduced to maintain rated power output.

If the Remote Sense feature is not needed, the +RS terminal should be connected to the positive output terminal at the converter and the -RS terminal should be connected to the negative output terminal at the converter. If the remote sense terminals are left open, the unit will regulate at approximately 50 mV to 100 mV higher than the nominal set point and the load regulation may be degraded. However, no damage to the hybrid will be experienced.

When the Remote Sense feature is used, there is a chance of instability depending on the length of the output cable. The pole introduced by the cable inductance and the load resistance can cause the voltage loop to go unstable. The length of the allowable cabling (both positive and negative added together) has been calculated for various output voltages at several output currents. A minimum frequency of 50 kHz was used for these calculations. This allows minimal phase shift at the crossover frequency of the hybrid power converter. **Table 6** lists the maximum load resistance/cable length for the various voltages and currents.

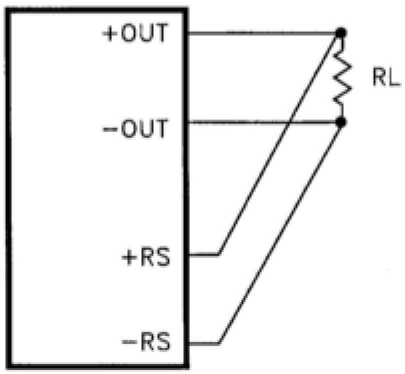


Figure 12
Typical Remote
Sense Connection

Table 5: Hybrid Converter Models With Remote Sense and Adjust Functions

MDI Model Number	Nominal Input VDC	Output Power	Remote Sense	Vref	R 2	R 3
2680 {**} SXX [**]	28	30W	Y	2.5	998	10K
2690 {**} SXX [**]	28	6.5W	N	2.5	998	10K
3000 {**} SXX [**]	270	30W	Y	2.5	998	10K
3001 {**} SXX [**]	28	30W	Y	2.5	998	10K
3011 {**} SXX [**]	28	20W	N	2.5	998	10K
3020 {**} SXX [**]	270	6.5W	N	2.5	998	10K
3031 {**} SXX [**]	28	80W	Y	2.5	998	10K
3041 {**} SXX [**]	270	80W	Y	2.5	998	10K
3051 {**} SXX [**]	120	80W	Y	2.5	998	10K
3060 {**} SXX [**]	120	30W	Y	2.5	998	10K
3061 {**} SXX [**]	8 - 40	5W	N	2.5	998	10K
3062 {**} SXX [**]	8 - 40	6.5W	N	2.5	998	10K
3070 {**} SXX [**]	120	6.5W	N	2.5	998	10K
3080 {**} SXX [**]	28	5W	N	2.5	998	10K
3107 {**} SXX [**]	28	20W	N	2.5	998	10K
3108 {**} SXX [**]	120	20W	N	2.5	998	10K
3109 {**} SXX [**]	270	20W	N	2.5	998	10K
3113 {**} SXX [**]	8 - 40	20W	N	2.5	998	10K
3114 {**} SXX [**]	8 - 40	40W	Y	2.5	998	10K
3193 {**} SXX [**]	28	40W	Y	2.5	998	10K
3326 {**} SXX [**]	120	40W	Y	2.5	998	10K
3327 {**} SXX [**]	270	40W	Y	2.5	998	10K
3378 {**} SXX [**]	8 - 40	30W	Y	2.5	998	10K
5031 {**} S02-05 [**]	28	80W	Y	1.5	9.53K	15K
5031 {**} S12-15 [**]	28	80W	Y	1.5	4.02K	15K
5031 {**} D02-05.2 [**]	28	80W	Y	1.5	9.53K	15K
5031 {**} D12-15 [**]	28	80W	Y	1.5	4.02K	15K
5107 {**} SXX [**]	28	20W	N	1.5	9.53K/4.02K(*)	15K
5107 {**} SXX [**]	28	20W	N	1.5	9.53K/4.02K(*)	15K
5193 {**} SXX [**]	28	40W	Y	1.5	9.53K/4.02K(*)	1K
5193 {**} SXX [**]	28	40W	Y	1.5	9.53K/4.02K(*)	1K
5193 {**} DXX [**]	28	40W	Y	1.5	9.53K/4.02K(*)	15K
5193 {**} DXX [**]	28	40W	Y	1.5	9.53K/4.02K(*)	15K

MDI Model Number	Nominal Input VDC	Output Power	Remote Sense	Vref	R 2	R 3
5680 {**} SXX [**]	28	30W	Y	1.5	9.53K/4.02K(*)	15K
5680 {**} SXX [**]	28	30W	Y	1.5	9.53K/4.02K(*)	15K
5680 {**} DXX [**]	28	30W	Y	1.5	9.53K/4.02K(*)	15K
5680 {**} DXX [**]	28	6.5W	N	1.5	9.53K/4.02K(*)	15K
6031 {**} SXX [**]	28	80W	Y	2.5	998	10K
6107 {**} SXX [**]	28	20W	N	2.5	998	10K
6193 {**} SXX [**]	28	40W	Y	2.5	998	10K
6680 {**} SXX [**]	28	30W	Y	2.5	998	10K
6690 {**} SXX [**]	28	6.5W	N	2.5	998	10K
7031 {**} SXX [**]	50	80W	Y	1.5	9.53K/4.02K(*)	15K
7031 {**} DXX [**]	50	80W	Y	1.5	9.53K/4.02K(*)	15K
7107 {**} SXX [**]	50	20W	N	1.5	9.53K/4.02K(*)	15K
7193 {**} SXX [**]	50	40W	Y	1.5	9.53K/4.02K(*)	1K
7193 {**} DXX [**]	50	40W	Y	1.5	9.53K/4.02K(*)	15K
7680 {**} SXX [**]	50	30W	Y	1.5	9.53K/4.02K(*)	15K
7680 {**} DXX [**]	50	30W	Y	1.5	9.53K/4.02K(*)	15K
7690 {**} SXX [**]	50	6.5W	N	1.5	9.53K/4.02K(*)	15K
8031 {**} SXX [**]	70	80W	Y	1.5	9.53K/4.02K(*)	15K
8031 {**} SXX [**]	70	80W	Y	1.5	9.53K/4.02K(*)	15K
8107 {**} SXX [**]	70	20W	N	1.5	9.53K/4.02K(*)	15K
8193 {**} SXX [**]	70	40W	Y	1.5	9.53K/4.02K(*)	1K
8193 {**} DXX [**]	70	40W	Y	1.5	9.53K/4.02K(*)	15K
8680 {**} SXX [**]	70	30W	Y	1.5	9.53K/4.02K(*)	15K
8680 {**} DXX [**]	70	30W	Y	1.5	9.53K/4.02K(*)	15K
8690 {**} SXX [**]	70	6.5W	N	1.5	9.53K/4.02K(*)	15K
9031 {**} SXX [**]	100	80W	Y	1.5	9.53K/4.02K(*)	15K
9031 {**} DXX [**]	100	80W	Y	1.5	9.53K/4.02K(*)	15K
9107 {**} SXX [**]	100	20W	N	1.5	9.53K/4.02K(*)	15K
9193 {**} SXX [**]	100	40W	Y	1.5	9.53K/4.02K(*)	1K
9193 {**} DXX [**]	100	40W	Y	1.5	9.53K/4.02K(*)	15K
9680 {**} SXX [**]	100	30W	Y	1.5	9.53K/4.02K(*)	15K
9680 {**} DXX [**]	100	30W	Y	1.5	9.53K/4.02K(*)	15K
9690 {**} SXX [**]	100	6.5W	N	1.5	9.53K/4.02K(*)	15K

Notes to Table 5:
{**} indicates grade level
XX indicates an output voltage in the range of 3.3 to 23 VDC
[**]indicates case style
(*) 9.53K for units less than 12 VDC / 4.02K for units 12 VDC and above.
For the 5000, 7000,8000 and 9000 series converters, the value of R2 depends on the nominal output voltage, according to table 5.

Table 6: Maximum Load Resistance vs. Cable Length

V out	3.3V	5 V	12 V	15 V	23 V
I out	RL/FT*	RL/FT*	RL/FT*	RL/FT*	RL/FT*
1 A	3.3/52'	5/79'	12/191'	15/239'	23/366'
2 A	1.6/26'	2.5/40'	6/95'	7.5/119'	11.5/183'
4 A	0.83/13'	1.3/20'	3/48'	3.8/59'	N/A
6 A	0.55/8.7'	0.83/13'	2/32'	N/A	N/A
10 A	0.33/5.3'	0.5/8'	N/A	N/A	N/A
15 A	0.22/3.5'	0.33/5.3'	N/A	N/A	N/A

* Total Feet In Both High And Low Line

The Adjust Pin allows the user to externally adjust the output voltage to approximately 10% above or below the nominal value. When the adjust pin is connected to the *output return* through an external series resistor, the output will regulate at a level higher than the nominal output. Conversely, when the adjust pin is connected to the output through an external series resistor, the output will regulate at a level lower than the nominal output.

The adjust pin allows the converter's feedback voltage divider to be modified by the external resistor. Also, the adjust pin is connected to an internal series resistor whose purpose is to prevent damage to the internal circuit and to reduce noise pickup.

The Adjust Pin should be connected at the hybrid as connecting the pin at the load will cause a degeneration of the load regulation performance. *If the Adjust feature is not used, the adjust pin should be left unconnected.* It should be noted that for 28 VDC input units, as the output rises, the low line operating point increases slightly. In other words, the unit may only regulate down to 17 VDC (for 28 volt inputs) rather than the normal 16 VDC at full load. The higher input voltage units have sufficient margin so as not to be affected by any adjusted output voltage.

The following equations describe how to determine the external resistance value needed to program the converter voltage up or down:

Vadj is the desired output voltage

Vo is the converter's nominal output voltage, prior to adjust

Vref is the converter's internal reference voltage, according to table 5.

R1 is the internal resistor between the output and the feedback node, according to table 5.

R2 is the internal resistor between the feedback node and the output return, according to table 5.

R3 is the internal resistor between the feedback node and the adjust pin, according to table 5.

R4 is the sum of R3 and the external adjust resistor.

To determine the external trim resistor, first compute the value of R1 from the table 5 values and the converter's nominal output voltage, using equation #1. If an upward adjustment is desired, use equation #2 to solve for R4. For an upward adjustment, R4 is connected to the output return. If an downward adjustment is desired, use equation #3 to solve for R4. For an downward adjustment, R4 is connected to the output terminal.

Finally, since R4 is the sum of the internal resistor R3 and the external adjust resistor, use the value of R3 from table 5 to find the value of the external adjust resistor, using equation #4

Equation 1

$$R_1 = \frac{R_2\left(V_o - V_{Ref}\right)}{V_{Ref}}$$

Equation 2

$$V_{Adj} = V_{Ref}\left[1 + \frac{\left(R_1 R_2\right) + \left(R_1 R_4\right)}{R_2 R_4}\right]$$

Equation 3

$$V_{Adj} = V_{Ref}\left[1 + \frac{R_1 R_4}{R_2\left(R_1 + R_4\right)}\right]$$

Equation 4

$$R_4 = R_3 + R_{Adj}$$

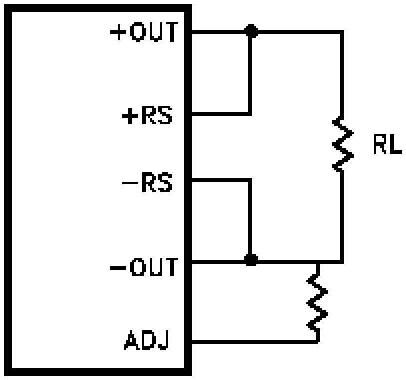
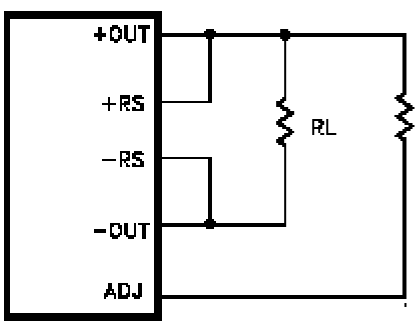


Figure 13
Typical Adjust Pin
Connection for increased
Output voltage with local sense



(If Required)

Figure 13A
Typical Adjust Pin
Connection for decreased
Output voltage with local sense

The preceding examples have shown either the singular Remote Sense or the Adjust features being used singularly. However, both features can be used in tandem.

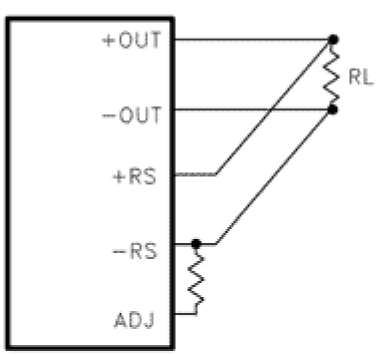


Figure 14
Adjust and Remote Sense
Functions Used In Combination

Within 10%, external adjustment causes no problems internal to the hybrid power converter. Be aware that an adjustment of more than 10% may can cause internal damage to the hybrid converter. Please consult MDI applications engineering if an adjustment range greater than 10% is required.

The Remote Sense and Adjust functions integral to MDI's full featured power converters enable them to excel in a variety of situations under a range of circumstances. The reader is encouraged to contact Hybrid Engineering at MDI to discuss these features as well as any aspects of these devices.

Figure 15
Internal Interconnections of Remote Sense and Adjust Pins