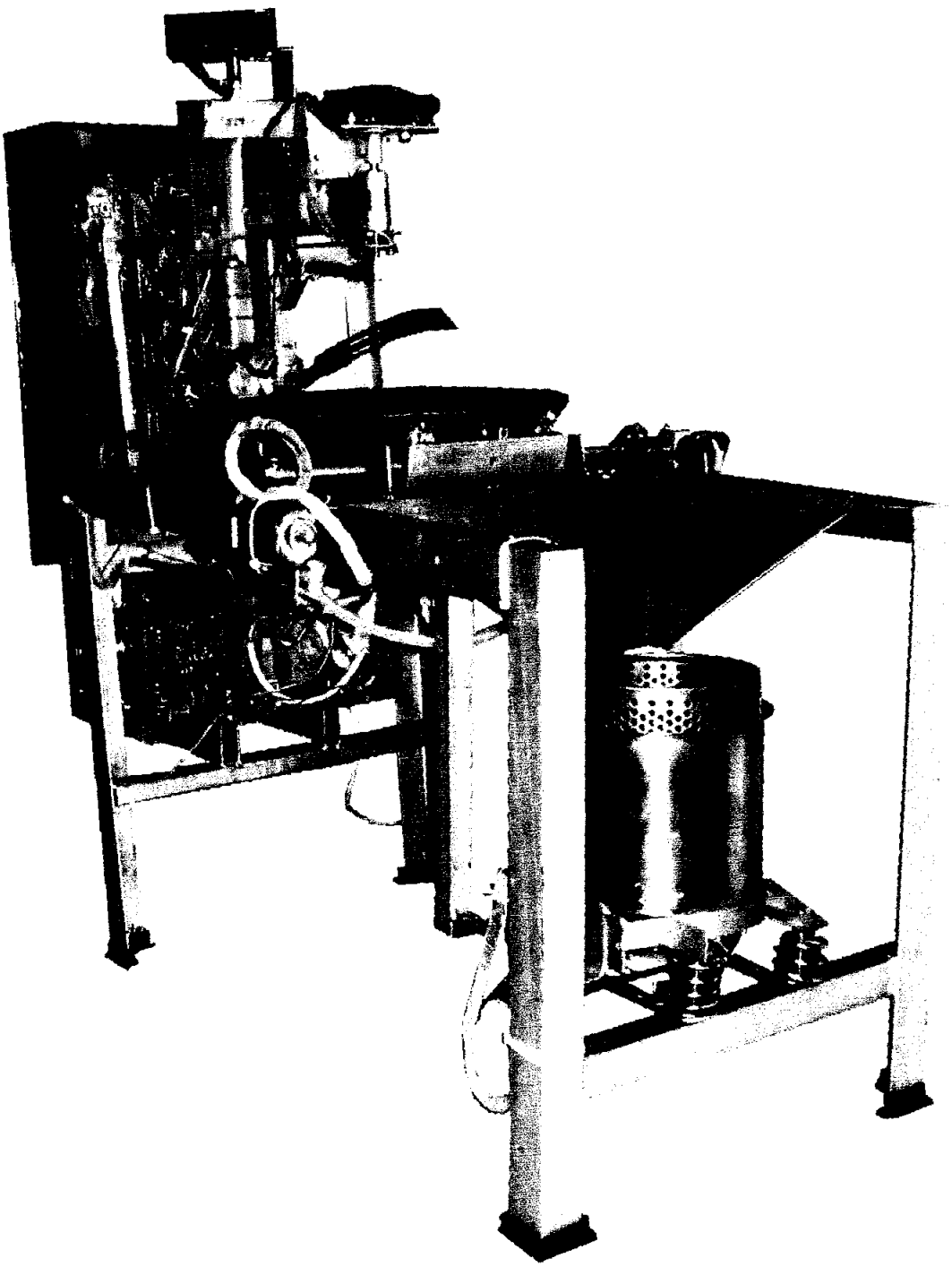
LAMPIRAN

LAMPIRAN A

Gambar Alat



LAMPIRAN C

LISTING MIKROKONTROLLER

```
#include<stdio.h>
#include<regx51.h>
sbit DQ  =  P0_4;
sfr ldata = 0x90;
sbit rs = P3_0;
sbit en = P3_1;
unsigned int suhu;
char a;
int b,c,d,e,f;

void delay(int useconds)
{
int s;
for (s=0; s<useconds;s++);
}
unsigned char ow_reset(void)
{
unsigned char presence;
DQ = 0; //pull DQ line low
delay(29); // leave it low for 480ìs
DQ = 1; // allow line to return high
delay(3); // wait for presence
presence = DQ; // get presence signal
delay(25); // wait for end of timeslot
return(presence); // presence signal returned
} // 0=presence, 1 = no part
unsigned char read_bit(void)
{
unsigned char i;
DQ = 0; // pull DQ low to start timeslot
DQ = 1; // then return high
for (i=0; i<3; i++); // delay 15ìs from start of timeslot
return(DQ); // return value of DQ line
}
void write_bit(char bitval)
{
DQ = 0; // pull DQ low to start timeslot
if(bitval==1) DQ =1; // return DQ high if write 1
delay(5); // hold value for remainder of timeslot
DQ = 1;
}
unsigned char read_byte(void)
{
unsigned char i;
unsigned char value = 0;
for (i=0;i<8;i++)
{
if(read_bit()) value|=0x01<<i; // reads byte in, one bit at a time and then
// shifts it left
delay(6); // wait for rest of timeslot
}
return(value);
}
void write_byte(char val)
{
unsigned char i;
unsigned char temp;
for (i=0; i<8; i++) // writes byte, one bit at a time
{
temp = val>>i; // shifts val right 'i' spaces
temp &= 0x01; // copy that bit to temp
write_bit(temp); // write bit in temp into
}
```

```
delay(5);
}
void MSDelay(unsigned int itime)
{
 unsigned int i, j;
 for(i=0;i<itime;i++)
   for(j=0;j<1275;j++);
}
void lcddata(unsigned char value)
{ldata = value;
rs = 1;
en = 1;
MSDelay(20);
en = 0;
return;
}

void tampilkan_ke_lcd(char *tulisan)
{
char hitung_tulisan;
while (hitung_tulisan=*tulisan++)
        {
        lcddata(hitung_tulisan);
        };
}

unsigned char Read_Current (void)
{
int lsb, msb, temp, nilai;
float Current; //This value may be declared globally
if(ow_reset()==0) //If a presence is detected, continue to read
{
write_byte(0xCC); // Skip Net Address Command
write_byte(0x69); // Read Registers Command
write_byte(0x0E); //Current Register Address
msb = read_byte(); // Read msb
lsb = read_byte() & 0xF8; // Read lsb and mask off lower 3 bits

suhu = 256*msb + lsb;
suhu = 65535 - suhu;
suhu = suhu/4;
nilai = suhu*(-0.2215)+3698.8;
if (nilai >100 & nilai < 200)
{nilai=nilai-20;}
if (nilai < 100)
{nilai=nilai-40;}

lcddata(nilai/100  %10 + 0x30);
lcddata(nilai/10   %10 + 0x30);
lcddata(nilai      %10 + 0x30);
lcddata(0xDF);
lcddata('C');

return(0); //Return 0 if no error
}
return(1); //Return 1 if no presence detected
}
void motor_putar()
{P3_7 = 1;
}
void motor_aduk()
{P2_4 = 1;
P2_5 = 1;
}
void motor_wajan()
{P2_2 = 1;// on
P2_3 = 1;//balik
}
void pemanas1()
{P2_6 = 1;
```

```
P2_7 = 1;
}
void pemanas2()
{P2_6 = 0;
P2_7 = 0;
}
void posisi()//akuuuu
{satu:
if (P0_5 == 0)
P2_4 = 0;
else
goto satu;
dua:
MSDelay(1000);
if (P0_6 == 0)
P2_5 = 0;
else
goto dua;
}
void lcdcmd(unsigned char value)
{
ldata = value;
rs = 0;
en = 1;
MSDelay(20);
en = 0;
return;
}
void wajan_naik()
{lcdcmd(0x01);
tampilkan_ke_lcd("penirisan");
MSDelay(1000);
P2_1 = 1;    ////////motor atas
MSDelay(100);
P2_1 = 0;
MSDelay(200);
P2_1 = 1;
MSDelay(1000);
P2_1 = 0;
MSDelay(1000);
/////motor wajan
P2_3 = 1;
while(P0_3 != 0);
P2_2 = 1;
MSDelay(50);
P2 = 0x00;
}
void wajan_turun()
{P2 = 0x0C;
MSDelay(100);
P2 = 0x00;
MSDelay(2000);///////motor wajan
P2_1 = 1;
P2_0 = 1;
MSDelay(100);
P2 = 0x00;
MSDelay(100);
P2 = 0x03;
MSDelay(200);//motor atas
P2 = 0x00;
}

void init_lcd()
{lcdcmd(0x038);
MSDelay(20);
lcdcmd(0x0C);
MSDelay(20);
lcdcmd(0x06);
MSDelay(20);
lcdcmd(0x01);
```

```
MSDelay(20);
}
void mulai()
{
pemanas1();
a = 0;
while(P0_3 != 0)
{P3_2 = 0;
if (P0_3 !=0)
MSDelay(500);
P3_2 = 1;
if (P0_3 !=0)
{MSDelay(500);}
a++;
if (a>10)
break;
}

if (a>=10)
{P3_2 = 0;
 while (P0_3 != 0)
 {
  if (P0_3 !=0)
  MSDelay(1000);
 if (suhu < 15597)
    pemanas2();
 else
 pemanas1();
 }
}
lcdcmd(0x01);
pemanas1();
P3_2 = 1;
lcdcmd(0x01);
tampilkan_ke_lcd("tunggu suhu");
lcdcmd(0xC4);
read_current();
while(suhu > 14687)
{lcdcmd(0xC4);
read_current();
MSDelay(1000);
}
}
void daging()
{
lcdcmd(0x01);
tampilkan_ke_lcd("masukkan");
lcdcmd(0xC0);
tampilkan_ke_lcd("daging + bumbu");
a = 0;
while(P0_3 != 0)
{P3_2 = 0;
if (P0_3 !=0)
MSDelay(500);
P3_2 = 1;
if (P0_3 !=0)
MSDelay(1000);
a++;
if (a>10)
break;
}
if (a>=10)
{P3_2 = 0;
 while (P0_3 != 0);
}
P3_2 = 1;
lcdcmd(0x01);
}
void daging_bumbu()
{
```

```
lcdcmd(0x01);
tampilkan_ke_lcd("masukkan");
lcdcmd(0xC0);
tampilkan_ke_lcd("daging berbumbu");
MSDelay(1000);
a = 0;
while(P0_3 != 0)
{P3_2 = 0;
if (P0_3 !=0)
MSDelay(500);
P3_2 = 1;
if (P0_3 !=0)
MSDelay(1000);
a++;
if (a>10)
break;
}
if (a>=10)
{P3_2 = 0;
 while (P0_3 != 0);
}
P3_2 = 1;
lcdcmd(0x01);
}
void waktu()
{
c = 0;
tampilkan_ke_lcd("sisa ");
 if (b != f)
motor_aduk();
while (b != 0)
{if (b == d)
 posisi();
 if (b == e)
 motor_aduk();
lcdcmd(0x85);
lcddata(b/10   %10 + 0x30);
lcddata(b      %10 + 0x30);
tampilkan_ke_lcd(" menit");
c = 0;
while (c <= 173)
{lcdcmd(0xc4);
 read_current();
 MSDelay(10);
 c++;
}
b--;
}
}
void waktu_kering()
{c = 0;
while (b != 0)
{c = 0;
while (c <= 233)
{MSDelay(100);
 c++;
}
b--;
}
}
void main(void)
{P3 = 0x04;
P1 = 0x00;
P2 = 0x00;
P0 = 0xff;
init_lcd();
lcdcmd(0x01);
lcdcmd(0x84);
tampilkan_ke_lcd("wibisono");
lcdcmd(0xc3);
```

```
tampilkan_ke_lcd("5103003007");
while(P0_3 != 0);
lcdcmd(0x01);
tampilkan_ke_lcd("tombol 1 = 100g");
lcdcmd(0xc0);
tampilkan_ke_lcd("tombol 2 = 250g");
while(1)
{ if (P0_0 == 0)
{lcdcmd(0x01);
tampilkan_ke_lcd("masukkan minyak");
lcdcmd(0xc0);
tampilkan_ke_lcd("2 sendok makan");
mulai();
daging();
b=10;
d=5;
e=25;
f=25;
waktu();
pemanas2();
wajan_naik();
MSDelay(500);
wajan_turun();
motor_putar();
b=3;
waktu_kering();
P3_7 = 0;//goreng
pemanas1();
lcdcmd(0x01);
tampilkan_ke_lcd("masukkan minyak");
lcdcmd(0xc0);
tampilkan_ke_lcd("200 ml");
mulai();
daging_bumbu();
b=20;
d=5;
e=15;
f=20;
waktu();
pemanas2();
wajan_naik();
MSDelay(500);
wajan_turun();
motor_putar();
b=3;
waktu_kering();
P3_7 = 0;
lcdcmd(0x01);
tampilkan_ke_lcd("selesai!!!!!");
while(P0_3 != 0)
{P3_2 = 0;
if (P0_3 !=0)
MSDelay(500);
P3_2 = 1;
if (P0_3 !=0)
MSDelay(1000);
}
lcdcmd(0x01);
lcdcmd(0x80);
tampilkan_ke_lcd("tombol 1 = 100g");
lcdcmd(0xc0);
tampilkan_ke_lcd("tombol 2 = 250g");
}
else
if (P0_1 == 0)
{lcdcmd(0x01);
tampilkan_ke_lcd("masukkan minyak");
lcdcmd(0xc0);
tampilkan_ke_lcd("2 sendok makan");
mulai();
```

```
daging();
b=10;
d=5;
e=25;
f=15;
waktu();
pemanas2();
wajan_naik();
MSDelay(500);
wajan_turun();
motor_putar();
b=3;
waktu_kering();
P3_7 = 0;//goreng
pemanas1();
lcdcmd(0x01);
tampilkan_ke_lcd("masukkan minyak");
lcdcmd(0xc0);
tampilkan_ke_lcd("300 ml");
mulai();
daging_bumbu();
b=30;
d=10;
e=20;
f=30;
waktu();
pemanas2();
wajan_naik();
MSDelay(500);
wajan_turun();
motor_putar();
b=3;
waktu_kering();
P3_7 = 0;
lcdcmd(0x01);
tampilkan_ke_lcd("selesai!!!!!");
while(P0_3 != 0)
{P3_2 = 0;
if (P0_3 !=0)
MSDelay(500);
P3_2 = 1;
if (P0_3 !=0)
MSDelay(1000);
}
lcdcmd(0x01);
lcdcmd(0x80);
tampilkan_ke_lcd("tombol 1 = 100g");
lcdcmd(0xc0);
tampilkan_ke_lcd("tombol 2 = 250g");
}
//motor_aduk();
}
}
```

LAMPIRAN D

DATA PENGAMBILAN SAMPEL

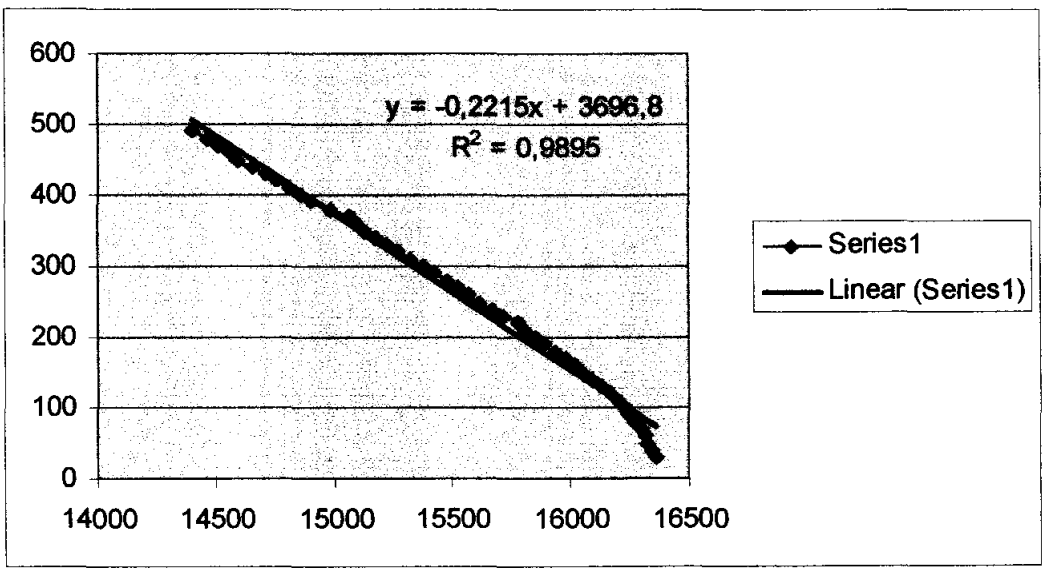
Tabel Sampel

DS2760	Multimeter UNI-T Type UT720B	Hasil dari persamaan Y	Selisih
16365	30	71,9525	41,9525
16347	40	75,9395	35,9395
16331	50	79,4835	29,4835
16313	60	83,4705	23,4705
16295	70	87,4575	17,4575
16273	80	92,3305	12,3305
16249	90	97,6465	7,6465
16225	100	102,9625	2,9625
16195	110	109,6075	-0,3925
16159	120	117,5815	-2,4185
16129	130	124,2265	-5,7735
16091	140	132,6435	-7,3565
16051	150	141,5035	-8,4965
16013	160	149,9205	-10,0795
15979	170	157,4515	-12,5485
15933	180	167,6405	-12,3595
15891	190	176,9435	-13,0565
15849	200	186,2465	-13,7535
15803	210	196,4355	-13,5645
15775	220	202,6375	-17,3625
15715	230	215,9275	-14,0725
15667	240	226,5595	-13,4405
15613	250	238,5205	-11,4795
15567	260	248,7095	-11,2905
15523	270	258,4555	-11,5445
15475	280	269,0875	-10,9125
15423	290	280,6055	-9,3945
15377	300	290,7945	-9,2055
15327	310	301,8695	-8,1305
15265	320	315,6025	-4,3975
15225	330	324,4625	-5,5375
15181	340	334,2085	-5,7915
15129	350	345,7265	-4,2735
15091	360	354,1435	-5,8565
15065	370	359,9025	-10,0975
14981	380	378,5085	-1,4915
14901	390	396,2285	6,2285
14861	400	405,0885	5,0885
14811	410	416,1635	6,1635
14761	420	427,2385	7,2385

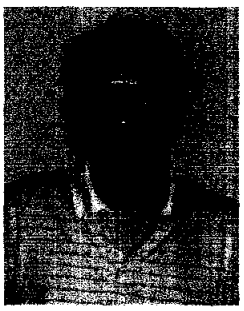
Tabel Sampel (lanjutan)

DS2760	Multimeter UNI-T Type UT720B	Hasil dari persamaan Y	Selisih
14711	430	438,3135	8,3135
14657	440	450,2745	10,2745
14597	450	463,5645	13,5645
14561	460	471,5385	11,5385
14509	470	483,0565	13,0565
14461	480	493,6885	13,6885
14403	490	506,5355	16,5355

Grafik dari pengambilan sampel



BIODATA



Nama	: Wibisono
NRP	: 5103003007
Tempat/ Tgl. Lahir	: Surabaya / 1 April 1982
Agama	: Katholik
Alamat Rumah	: Jl. Tarmidi 52
	Samarinda – Kalimantan Timur

Riwayat Pendidikan :

- Tahun 1988, Lulus TK Kristus Radja Surabaya.
- Tahun 1996, Lulus SD Swasta Megawati Surabaya.
- Tahun 1999, Lulus SLTP Katholik Santa Agnes Surabaya.
- Tahun 2003, Lulus SMK Katholik St. Louis Surabaya.
- Tahun 2003 hingga buku ini ditulis, tercatat sebagai mahasiswa di Jurusan Teknik Elektro, Fakultas Teknik, Universitas Katolik Widya Mandala, Surabaya.

)ALLAS MICONDUCTOR MAXIM

DS2760

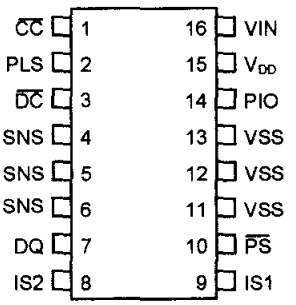
High-Precision Li+ Battery Monitor

.maxim-ic.com

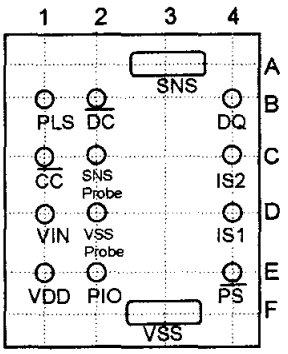
TURES

+ safety circuit
Overvoltage protection
Overcurrent/short circuit protection
Undervoltage protection
ero Volt Battery Recovery Charge
vailable in two configurations:
Internal 25mΩ sense resistor
External user-selectable sense resistor
urrent measurement
12-bit bidirectional measurement
Internal sense resistor configuration:
0.625mA LSB and ±1.9A dynamic range
External sense resistor configuration:
15.625µV LSB and ±64mV dynamic range
urrent accumulation
Internal sense resistor: 0.25mAhr LSB
External sense resistor: 6.25µVhr LSB
oltage measurement with 4.88mV resolution
emperature measurement using integrated
ensor with 0.125°C resolution
ystem power management and control feature
ipport
2 bytes of lockable EEPROM
6 bytes of general purpose SRAM
allas 1-Wire® interface with unique 64-bit
evice address
ow power consumption:
Active current: 90µA max
Sleep current: 2µA max

PIN ASSIGNMENT



DS2760
16-Pin TSSOP Package



DS2760
Flip-Chip Packaging
Top View

PIN DESCRIPTION

$\overline{CC}$ - Charge control output
$\overline{DC}$ - Discharge control output
DQ - Data input/output
PIO - Programmable I/O pin
PLS - Battery pack positive terminal input
$\overline{PS}$ - Power switch sense input
VIN - Voltage sense input
V_{DD} - Power supply input (2.5V to 5.5V)
VSS - Device ground
SNS - Sense resistor connection
IS1 - Current sense input
IS2 - Current sense input
SNS Probe - Do not connect
VSS Probe - Do not connect

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ERING INFORMATION

Part	Marking	Description
60AE+	DS2760A	TSSOP, External Sense Resistor, 4.275V Vov, Lead-Free
60BE+	DS2760B	TSSOP, External Sense Resistor, 4.35V Vov, Lead-Free
60AE+T&R	DS2760A	DS2760AE+ on Tape & Reel, Lead-Free
60 BE+T&R	DS2760B	DS2760BE+ on Tape & Reel, Lead-Free
60AE+025	2760A25	TSSOP, 25mΩ Sense Resistor, 4.275V Vov, Lead-Free
60BE+025	2760B25	TSSOP, 25mΩ Sense Resistor, 4.35V Vov, Lead-Free
60AE+025/T&R	2760A25	DS2760AE+025 in Tape & Reel, Lead-Free
60BE+025/T&R	2760B25	DS2760BE+025 in Tape & Reel, Lead-Free
60AX	DS2760A	Flipchip, External Sense Resistor, Tape & Reel, 4.275V Vov
60BX	DS2760B	Flipchip, External Sense Resistor, Tape & Reel, 4.35V Vov
60AX-025	DS2760AR	Flipchip, 25mΩ Sense Resistor, Tape & Reel, 4.275V Vov
60BX-025	DS2760BR	Flipchip, 25mΩ Sense Resistor, Tape & Reel, 4.35V Vov
60AE	DS2760A	TSSOP, External Sense Resistor, 4.275V Vov
60BE	DS2760B	TSSOP, External Sense Resistor, 4.35V Vov
60AE/T&R	DS2760A	DS2760AE on Tape & Reel
60 BE/T&R	DS2760B	DS2760BE on Tape & Reel
60AE-025	2760A25	TSSOP, 25mΩ Sense Resistor, 4.275V Vov
60BE-025	2760B25	TSSOP, 25mΩ Sense Resistor, 4.35V Vov
60AE-025/T&R	2760A25	DS2760AE-025 in Tape & Reel
60BE-025/T&R	2760B25	DS2760BE-025 in Tape & Reel

CRIPTION

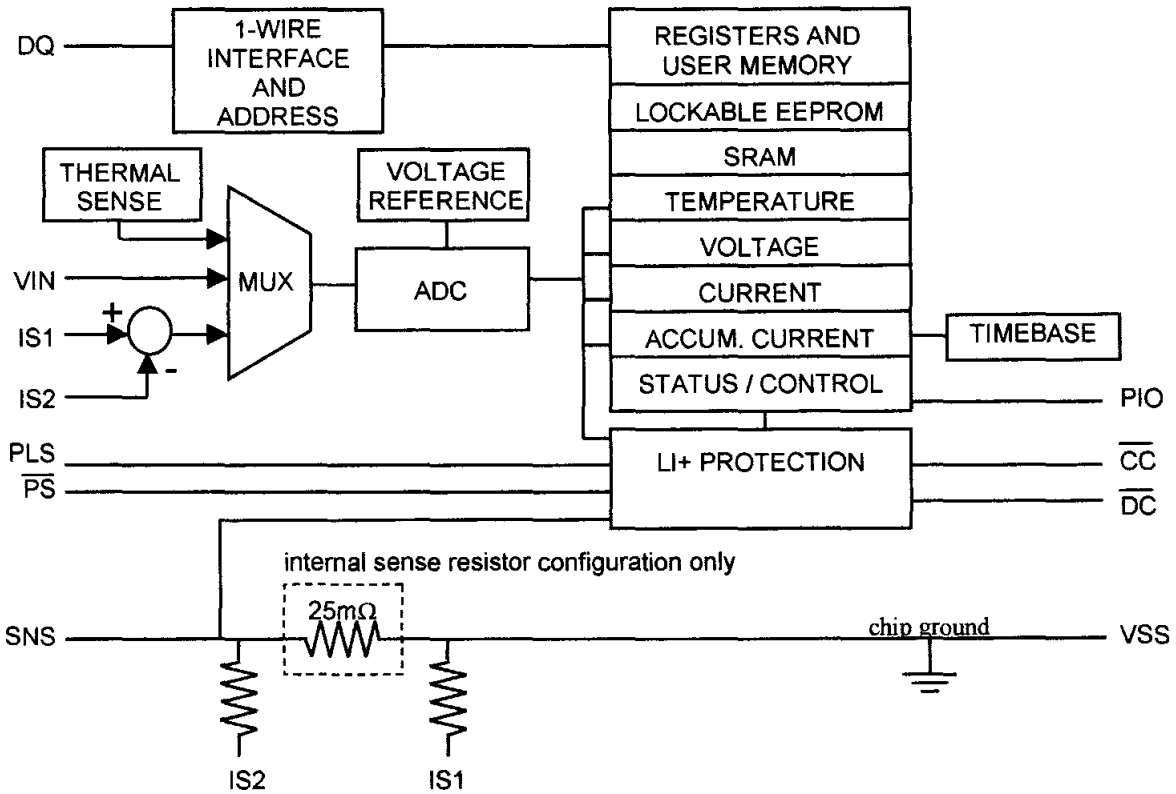
DS2760 High-Precision Li+ Battery Monitor is a data acquisition, information storage, and safety ction device tailored for cost-sensitive battery pack applications. This low-power device integrates se temperature, voltage, and current measurement, nonvolatile data storage, and Li+ protection into mall footprint of either a TSSOP package or flip chip. The DS2760 is a key component in cations including remaining capacity estimation, safety monitoring, and battery-specific data storage.

Its 1-Wire interface, the DS2760 gives the host system read/write access to status and control ters, instrumentation registers, and general purpose data storage. Each device has a unique factory- rammed 64-bit net address which allows it to be individually addressed by the host system, orting multi-battery operation.

DS2760 is capable of performing temperature, voltage and current measurement to a resolution cient to support process monitoring applications such as battery charge control, remaining capacity ation, and safety monitoring. Temperature is measured using an on-chip sensor, eliminating the need separate thermistor. Bidirectional current measurement and accumulation are accomplished using r an internal 25mΩ sense resistor or an external device. The DS2760 also features a programmable in that allows the host system to sense and control other electronics in the pack, including switches, tion motors, speakers and LEDs.

e types of memory are provided on the DS2760 for battery information storage: EEPROM, lockable ROM and SRAM. EEPROM memory saves important battery data in true nonvolatile memory that affected by severe battery depletion, accidental shorts or ESD events. Lockable EEPROM becomes I when locked to provide additional security for unchanging battery data. SRAM provides pensive storage for temporary data.

CK DIAGRAM Figure 1

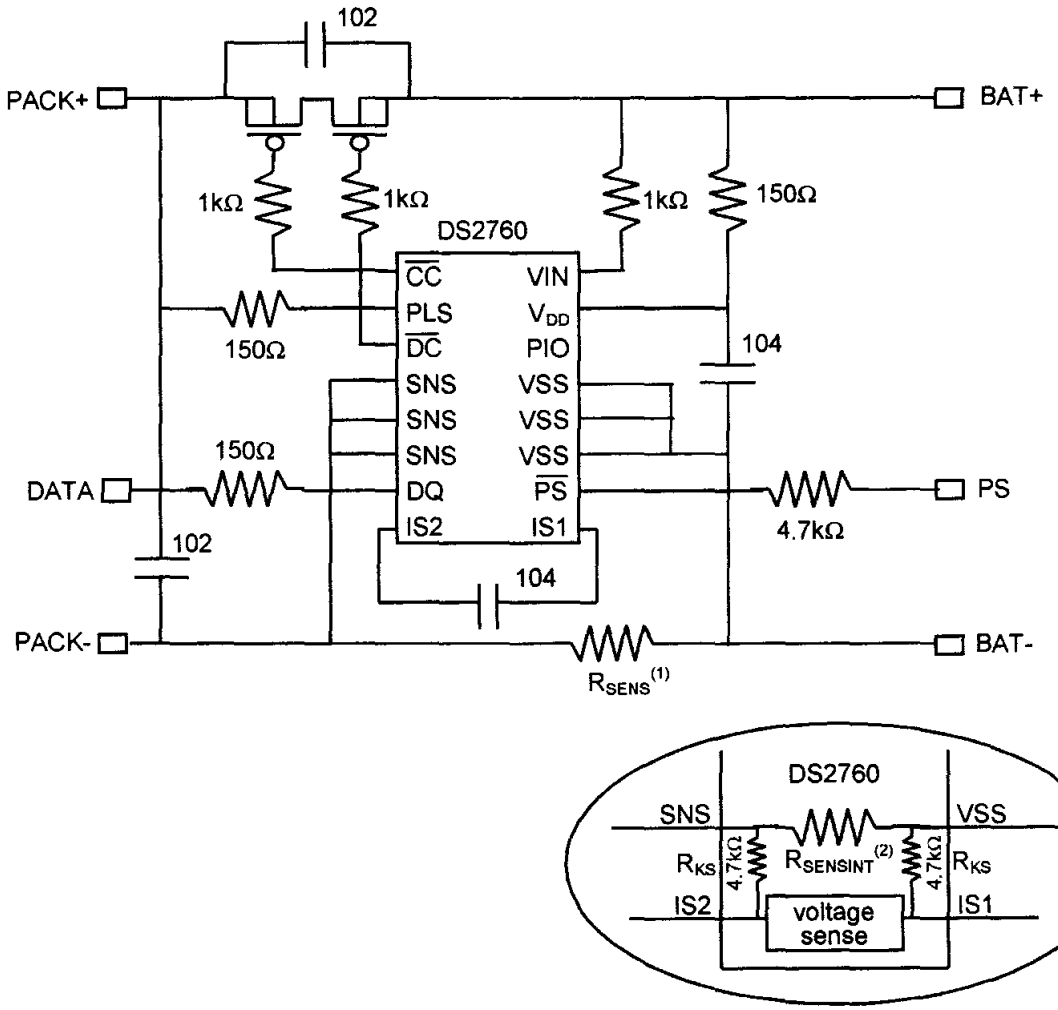


AILED PIN DESCRIPTION Table 1

IBOL	TSSOP*	FLIP CHIP*	DESCRIPTION
$\overline{C}$	1	C1	**Charge Protection Control Output.** Controls an external p-channel high-side charge protection FET.
$\overline{C}$	3	B2	**Discharge Protection Control Output.** Controls an external p-channel high-side discharge protection FET.
Q	7	B4	**Data Input/Out.** 1-Wire data line. Open-drain output driver. Connect this pin to the DATA terminal of the battery pack. Pin has an internal 1µA pull-down for sensing disconnection.
IO	14	E2	**Programmable I/O Pin.** Used to control and monitor user-defined external circuitry. Open drain to VSS.
LS	2	B1	**Battery Pack Positive Terminal Input.** The device monitors the state of the battery pack's positive terminal through this pin in order to detect events such as the attachment of a charger or the removal of a short circuit. Additionally, a charge path to recover a deeply depleted cell is provided from PLS to VDD.
$\overline{S}$	10	E4	**Power Switch Sense Input.** The device wakes up from Sleep Mode when it senses the closure of a switch to VSS on this pin. Pin has an internal 1µA pull-up to V_{DD}.
IN	16	D1	**Voltage Sense Input.** The voltage of the Li+ cell is monitored via this input pin. This pin has a weak pullup to V_{DD}.
DD	15	E1	**Power Supply Input.** Connect to the positive terminal of the Li+ cell through a decoupling network.
SS	11,12,13	F3	**Device Ground.** Connect directly to the negative terminal of the Li+ cell. For the external sense resistor configuration, connect the sense resistor between VSS and SNS.
NS	4,5,6	A3	**Sense Resistor Connection.** Connect to the negative terminal of the battery pack. In the internal sense resistor configuration, the sense resistor is connected between VSS and SNS.
S1	9	D4	**Current Sense Input.** This pin is internally connected to VSS through a 4.7kΩ resistor. Connect a 0.1µF capacitor between IS1 and IS2 to complete a low-pass input filter.
S2	8	C4	**Current Sense Input.** This pin is internally connected to SNS through a 4.7kΩ resistor.
NS robe	N/A	C2	**Do Not Connect.**
SS robe	N/A	D2	**Do Not Connect.**

chanical drawing for the 16-pin TSSOP and DS2760 flip-chip package can be found at:
/pdfserv.maxim-ic.com/arpdf/Packages/16tssop.pdf
/pdfserv.maxim-ic.com/arpdf/Packages/chips/2760x.pdf

_ICATION EXAMPLE Figure 2



SENS is present for external sense resistor configurations only
SENSINT is present for internal sense resistor configurations only

ER MODES

S2760 has two power modes: Active and Sleep. While in Active Mode, the DS2760 continually res current, voltage and temperature to provide data to the host system and to support current ulation and Li+ safety monitoring. In Sleep Mode, the DS2760 ceases these activities. The 0 enters Sleep Mode when any of the following conditions occurs:

- PMOD bit in the Status Register has been set to 1 and the DQ line is low for longer than econds (pack disconnection)
- voltage on VIN drops below undervoltage threshold V_{UV} for t_{UVD} (cell depletion)
- pack is disabled through the issuance of a SWAP command (SWEN bit =1)

S2760 returns to Active Mode when any of the following occurs:

- PMOD bit has been set to 1 and the SWEN bit is set to 0 and the DQ line is pulled high ick connection)
- $\overline{PS}$ pin is pulled low (power switch)
- voltage on PLS becomes greater than the voltage on VIN (charger connection) with the SWEN bit to 0
- pack is enabled through the issuance of a SWAP command (SWEN bit =1)

S2760 defaults to Sleep Mode when power is first applied.

ROTECTION CIRCUITRY

g Active Mode, the DS2760 constantly monitors cell voltage and current to protect the battery from harge (overvoltage), overdischarge (undervoltage) and excessive charge and discharge currents current, short circuit). Conditions and DS2760 responses are described in the sections below and arized in Table 2 and Figure 3.

ROTECTION CONDITIONS AND DS2760 RESPONSES Table 2

dition	Activation			Release
e	Threshold	Delay	Response	Threshold
voltage	VIN > V_{OV}	t_{OVD}	$\overline{CC}$ high	VIN < V_{CE}
ervoltage	VIN < V_{UV}	t_{UVD}	$\overline{CC}$, $\overline{DC}$ high, Sleep Mode	V_{PLS} > V_{DD} (1) (charger connected)
current, Charge	V_{IS} > V_{OC} (2)	t_{OCD}	$\overline{CC}$, $\overline{DC}$ high	V_{PLS} < V_{DD} – V_{TP} (3)
current, Discharge	V_{IS} < -V_{OC} (2)	t_{OCD}	$\overline{DC}$ high	V_{PLS} > V_{DD} – V_{TP} (4)
t Circuit	V_{SNS} > V_{SC}	t_{SCD}	$\overline{DC}$ high	V_{PLS} > V_{DD} – V_{TP} (4)

$V_{IS1} – V_{IS2}$. Logic high = V_{PLS} for $\overline{CC}$ and V_{DD} for $\overline{DC}$. All voltages are with respect to VSS. I_{SNS} nces current delivered from pin SNS.

V_{DD} <2.2V, release is delayed until the recovery charge current (I_{RC}) passed from PLS to V_{DD} harges the battery and allows V_{DD} to exceed 2.2V.

r the internal sense resistor configuration, the overcurrent thresholds are expressed in terms of rrent: I_{SNS} > I_{OC} for charge direction and I_{SNS} < -I_{OC} for discharge direction

ith test current I_{TST} current flowing from PLS to VSS (pull-down on PLS)

ith test current I_{TST} current flowing from V_{DD} to PLS (pull-up on PLS)

voltage. If the voltage of the cell exceeds overvoltage threshold V_{OV} for a period longer than oltage delay t_{OVD}, the DS2760 shuts off the external charge FET and sets the OV flag in the ction Register. When the cell voltage falls below charge enable threshold V_{CE}, the DS2760 turns the

FET back on (unless another protection condition prevents it). Discharging remains enabled overvoltage.

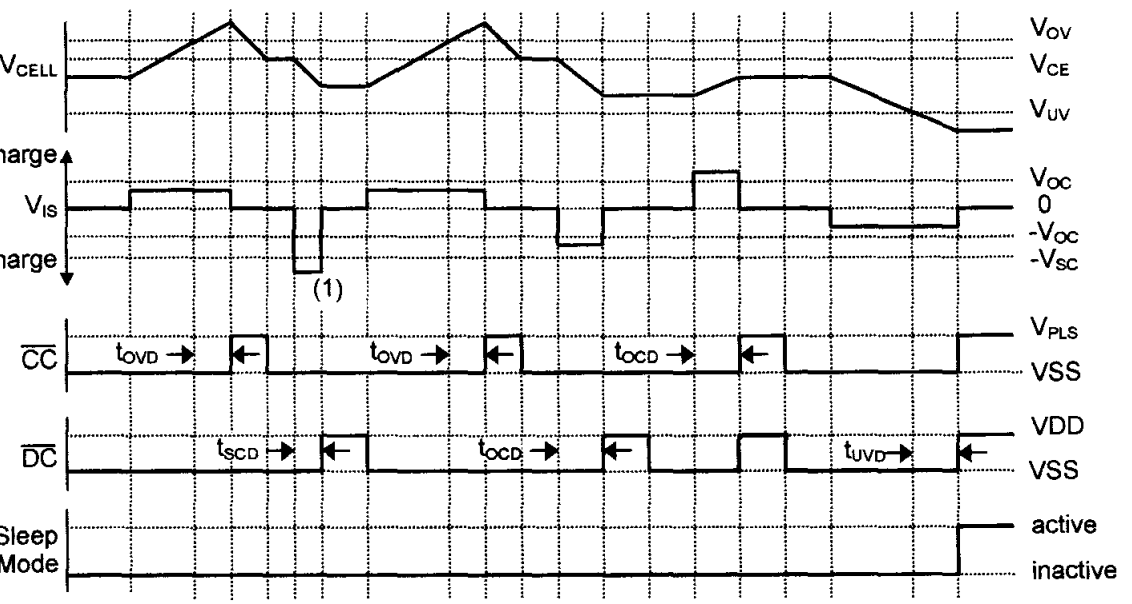
voltage. If the voltage of the cell drops below undervoltage threshold V_{UV} for a period longer than oltage delay t_{UVD}, the DS2760 shuts off the charge and discharge FETs, sets the UV flag in the tion Register, and enters Sleep Mode. The DS2760 provides a current-limited (I_{RC}) recovery path from PLS to VDD to gently charge severely depleted cells. The recovery path is enabled $0 \le VDD < 3V(typ)$. Once VDD reaches 3V(typ), the DS2760 will return to normal operation, ıg connection of a charger to turn on the charge FET and pull out of Sleep Mode.

urrent, Charge Direction. The voltage difference between the IS1 pin and the IS2 pin ($V_{IS} = V_{IS1}$) is the filtered voltage drop across the current sense resistor. If V_{IS} exceeds overcurrent threshold ır a period longer than overcurrent delay t_{OCD}, the DS2760 shuts off both external FETs and sets the lag in the Protection Register. The charge current path is not re-established until the voltage on the in drops below $V_{DD} - V_{TP}$. The DS2760 provides a test current of value I_{TST} from PLS to VSS to LS down in order to detect the removal of the offending charge current source.

urrent, Discharge Direction. If V_{IS} is less than $-V_{OC}$ for a period longer than t_{OCD}, the DS2760 off the external discharge FET and sets the DOC flag in the Protection Register. The discharge t path is not re-established until the voltage on PLS rises above $V_{DD} - V_{TP}$. The DS2760 provides a ırrent of value I_{TST} from V_{DD} to PLS to pull PLS up in order to detect the removal of the offending npedance load.

Circuit. If the voltage on the SNS pin with respect to VSS exceeds short circuit threshold V_{SC} for od longer than short circuit delay t_{SCD}, the DS2760 shuts off the external discharge FET and sets the flag in the Protection Register. The discharge current path is not re-established until the voltage on ises above $V_{DD} - V_{TP}$. The DS2760 provides a test current of value I_{TST} from V_{DD} to PLS to pull p in order to detect the removal of the short circuit.

IIUM-ION PROTECTION CIRCUITRY EXAMPLE WAVEFORMS Figure 3



(1) To allow the device to react quickly to short circuits, detection is actually done on the SNS pin rather than on the filtered IS1 and IS2 pins. The actual short circuit detect condition is $V_{SNS} > V_{SC}$.

ıary. All of the protection conditions described above are OR'ed together to affect the $\overline{CC}$ and $\overline{DC}$ s.

$\overline{DC}$ = (Undervoltage) or (Overcurrent, EITHER Direction) or (Short Circuit) or (Protection Register bit DE = 0) or (Sleep Mode)

$\overline{CC}$ = (Overvoltage) or (Undervoltage) or (Overcurrent, Charge Direction) or (Protection Register bit CE = 0) or (Sleep Mode)

RENT MEASUREMENT

Active Mode of operation, the DS2760 continually measures the current flow into and out of the y by measuring the voltage drop across a current sense resistor. The DS2760 is available in two ;urations: (1) internal 25mΩ current sense resistor, and (2) external user-selectable sense resistor. In configuration, the DS2760 considers the voltage difference between pins IS1 and IS2 ($V_{IS} = V_{IS1} -$ to be the filtered voltage drop across the sense resistor. A positive V_{IS} value indicates current is ıg into the battery (charging), while a negative V_{IS} value indicates current is flowing out of the y (discharging).

measured with a signed resolution of 12-bits. The current register is updated in two's complement t every 88ms (128/fsample) with an average of 128 readings. Currents outside the range of the er are reported at the limit of the range. The format of the Current Register is shown in Figure 4.

ıe internal sense resistor configuration, the DS2760 maintains the Current Register in units of Amps, ı resolution of 0.625mA and full scale range of no less than ±1.9A (see Note 7 on I_{FS} spec for more s). The DS2760 automatically compensates for internal sense resistor process variations and ɛrature effects when reporting current.

ıe external sense resistor configuration, the DS2760 writes the measured V_{IS} voltage to the Current ter, with a resolution of 15.625µV and a full scale range of ±64mV.

RRENT REGISTER FORMAT Figure 4

MSB—Address 0E

S	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5

MSb LSb

LSb—Address 0F

2^4	2^3	2^2	2^1	2^0	X	X	X

MSb LSb

Units: 0.625 mA for internal sense resistor
15.625 µV for external sense resistor

RRENT ACCUMULATOR

Current Accumulator facilitates remaining capacity estimation by tracking the net current flow into ut of the battery. Current flow into the battery increments the Current Accumulator while current out of the battery decrements it. Data is maintained in the Current Accumulator in two's-lement format. The format of the Current Accumulator is shown in Figure 5.

ı the internal sense resistor is used, the DS2760 maintains the Current Accumulator in units of Amp-, with a resolution of 0.25mAhrs and full scale range of ±8.2Ahrs. When using an external sense

ır, the DS2760 maintains the Current Accumulator in units of Volt-hours, with a resolution of .Vhrs and a full scale range of ±205 mVhrs.

urrent Accumulator is a read/write register that can be altered by the host system as needed.

.RENT ACCUMULATOR FORMAT Figure 5

MSB—Address 10

S	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}
MSb							LSb

LSb—Address 11

2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}
MSb							LSb

Units: 0.25 mAhrs for internal sense resistor
6.25 µVhrs for external sense resistor

;RENT OFFSET COMPENSATION

nt measurement and the current accumulation are both internally compensated for offset on a ıual basis minimizing error resulting from variations in device temperature and voltage. ionally a constant bias may be utilized to alter any other sources of offset. This bias resides in :OM address 33h in two's-complement format and is subtracted from each current measurement. :urrent offset bias is applied to both the internal and external sense resistor configurations. The 'y default for the current offset compensation is a value of 0.

;RENT OFFSET BIAS Figure 6

Address 33

S	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}
MSb							LSb

Units: 0.625 mA for internal sense resistor
15.625 µV for external sense resistor

.TAGE MEASUREMENT

)S2760 continually measures the voltage between pins VIN and VSS over a range of 0 to 4.75V. resulting data is placed in the Voltage Register in two's-complement format with a resolution of ıV. Voltages above the maximum register value are reported as the maximum value. The Voltage ;ter format is shown in Figure 7.

.TAGE REGISTER FORMAT Figure 7

MSB—Address 0C

S	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}
MSb							LSb

LSb—Address 0D

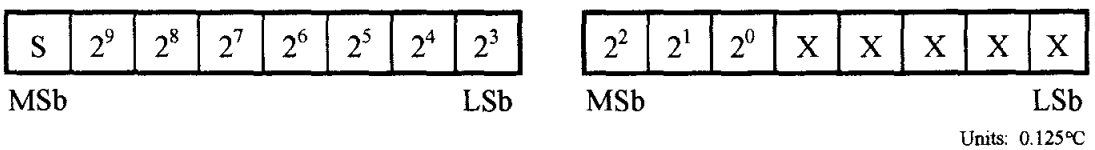
2^{2}	2^{1}	2^{0}	X	X	X	X	X
MSb							LSb

Units: 4.88 mV

PERATURE MEASUREMENT

)S2760 uses an integrated temperature sensor to continually measure battery temperature. :rature measurements are placed in the Temperature Register in two's-complement format with a ion of 0.125°C over a range of ±127°C. The Temperature Register format is shown in Figure 8.

PERATURE REGISTER FORMAT Figure 8



GRAMMABLE I/O

e the PIO pin as an output, write the desired output value to the PIO bit in the Special Feature :er. Writing a 0 to the PIO bit enables the PIO output driver, pulling the PIO pin to VSS. Writing a ıe PIO bit disables the output driver, allowing the PIO pin to be pulled high or used as an input. To the value on the PIO pin, read the PIO bit. The DS2760 turns off the PIO output driver and sets the igh when it enters Sleep Mode or when DQ is low for more than 2 seconds, regardless of the state PMOD bit.

VER SWITCH INPUT

)S2760 provides a power control function that uses the discharge protection FET to gate battery r to the system. The $\overline{PS}$ pin, internally pulled to V_{DD} through a 1µA current source, is continuously ored for a low-impedance connection to VSS. If the DS2760 is in Sleep Mode, the detection of a n $\overline{PS}$ causes the device to transition into Active Mode, turning on the discharge FET. If the DS2760 eady in Active Mode, activity on $\overline{PS}$ has no effect other than the mirroring of its logic level in the t in the Special Feature Register. The reading of a 0 in the $\overline{PS}$ bit should be immediately followed iting a 1 to the $\overline{PS}$ bit to ensure proper operation.

MORY

)S2760 has a 256-byte linear address space with registers for instrumentation, status and control in wer 32 bytes, with lockable EEPROM and SRAM memory occupying portions of the remaining ss space. All EEPROM and SRAM memory is general-purpose except addresses 30h, 31h, and 33h, ı should be written with the default values for the Protection Register, Status Register, and Current t Register, respectively. When the MSB of any 2-byte register is read, both the MSB and LSB are ed and held for the duration of the Read Data command to prevent updates during the read and e synchronization between the two register bytes. For consistent results, always read the MSB and SB of a two-byte register during the same Read Data command sequence.

ROM memory is shadowed by RAM to eliminate programming delays between writes and to allow ata to be verified by the host system before being copied to EEPROM. All reads and writes to/from ROM memory actually access the shadow RAM. In unlocked EEPROM blocks, the Write Data nand updates shadow RAM. In locked EEPROM blocks, the Write Data command is ignored. The Data command copies the contents of shadow RAM to EEPROM in an unlocked block of ROM but has no effect on locked blocks. The Recall Data command copies the contents of a block of ROM to shadow RAM regardless of whether the block is locked or not.

ORY MAP Table 3

ldress (Hex)	Description	Read/Write
00	Protection Register	R/W
01	Status Register	R
02-06	Reserved	
07	EEPROM Register	R/W
08	Special Feature Register	R/W
09-0B	Reserved	
0C	Voltage Register MSb	R
0D	Voltage Register LSb	R
0E	Current Register MSB	R
0F	Current Register LSb	R
10	Accumulated Current Register MSB	R/W
11	Accumulated Current Register LSb	R/W
12-17	Reserved	
18	Temperature Register MSB	R
19	Temperature Register LSb	R
1A-1F	Reserved	
20-2F	EEPROM, block 0	R/W*
30-3F	EEPROM, block 1	R/W*
40-7F	Reserved	
80-8F	SRAM	R/W
90-FF	Reserved	

EEPROM block is read/write until locked by the LOCK command, after which it is read-only.

OTECTION REGISTER

Protection Register consists of flags that indicate protection circuit status and switches that give tional control over the charging and discharging paths. Bits OV, UV, COC and DOC are set when sponding protection conditions occur and remain set until cleared by the host system. The default s of the CE and DE bits of the Protection Register are stored in lockable EEPROM in the sponding bits in address 30h. A Recall Data command for EEPROM block 1 recalls the default s of 1 into CE and DE. The format of the Protection Register is shown in Figure 9. The function of bit is described in detail in the following paragraphs.

OTECTION REGISTER FORMAT Figure 9

Address 00

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
OV	UV	COC	DOC	$\overline{CC}$	$\overline{DC}$	CE	DE

- Overvoltage Flag. When set to 1, this bit indicates the battery pack has experienced an overvoltage tion. This bit must be reset by the host system.

– Undervoltage Flag. When set to 1, this bit indicates the battery pack has experienced an rvoltage condition. This bit must be reset by the host system.

- Charge Overcurrent Flag. When set to 1, this bit indicates the battery pack has experienced a -direction overcurrent condition. This bit must be reset by the host system.

- Discharge Overcurrent Flag. When set to 1, this bit indicates the battery pack has experienced a rge-direction overcurrent condition. This bit must be reset by the host system.

$\overline{CC}$ Pin Mirror. This read-only bit mirrors the state of the $\overline{CC}$ output pin.

$\overline{DC}$ Pin Mirror. This read-only bit mirrors the state of the $\overline{DC}$ output pin.

Charge Enable. Writing a 0 to this bit disables charging ($\overline{CC}$ output high, external charge FET off) lless of cell or pack conditions. Writing a 1 to this bit enables charging, subject to override by the ıce of any protection conditions. The DS2760 automatically sets this bit to 1 when it transitions Sleep Mode to Active Mode.

Discharge Enable. Writing a 0 to this bit disables discharging ($\overline{DC}$ output high, external discharge ɔff) regardless of cell or pack conditions. Writing a 1 to this bit enables discharging, subject to de by the presence of any protection conditions. The DS2760 automatically sets this bit to 1 when sitions from Sleep Mode to Active Mode.

TUS REGISTER

lefault values for the Status Register bits are stored in lockable EEPROM in the corresponding bits dress 31h. A Recall Data command for EEPROM block 1 recalls the default values into the Status ter bits. The format of the Status Register is shown in Figure 10. The function of each bit is ibed in detail in the following paragraphs.

TUS REGISTER FORMAT Figure 10

Address 01

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
X	X	PMOD	RNAOP	SWEN	X	X	X

D – Sleep Mode Enable. A value of 1 in this bit enables the DS2760 to enter Sleep Mode when the ine goes low for greater than 2 seconds and leave Sleep Mode when the DQ line goes high. A value disables DQ-related transitions into and out of Sleep Mode. This bit is read-only. The desired lt value should be set in bit 5 of address 31h. The factory default is 0.

OP – Read Net Address Opcode. A value of 0 in this bit sets the opcode for the Read Net Address nand to 33h, while a 1 sets the opcode to 39h. This bit is read-only. The desired default value should t in bit 4 of address 31h. The factory default is 0.

N - SWAP Command Enable. A value of 1 in this bit location enables the recognition of a SWAP nand. If set to 0, SWAP commands are ignored. The desired default value should be set in bit 3 of ss 31h. This bit is read-only. The factory default is 0.

Reserved bits.

ROM REGISTER

ormat of the EEPROM Register is shown in Figure 11. The function of each bit is described in in the following paragraphs.

ROM REGISTER FORMAT Figure 11

Address 07

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
EEC	LOCK	X	X	X	X	BL1	BL0

– EEPROM Copy Flag. A 1 in this read-only bit indicates that a Copy Data command is in ess. While this bit is high, writes to EEPROM addresses are ignored. A 0 in this bit indicates that nay be written to unlocked EEPROM blocks.

K – EEPROM Lock Enable. When this bit is 0, the Lock command is ignored. Writing a 1 to this ables the Lock command. After the Lock command is executed, the LOCK bit is reset to 0. The y default is 0.

– EEPROM Block 1 Lock Flag. A 1 in this read-only bit indicates that EEPROM Block 1 esses 30-3F) is locked (read-only) while a 0 indicates Block 1 is unlocked (read/write).

– EEPROM Block 0 Lock Flag. A 1 in this read-only bit indicates that EEPROM Block 0 esses 20-2F) is locked (read-only) while a 0 indicates Block 0 is unlocked (read/write).

Reserved bits.

ECIAL FEATURE REGISTER

ormat of the Special Feature Register is shown in Figure 12. The function of each bit is described in in the following paragraphs.

ECIAL FEATURE REGISTER FORMAT Figure 12

Address 08

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
$\overline{PS}$	PIO	MSTR	X	X	X	X	X

- $\overline{PS}$ Pin Mirror. This read-only bit mirrors the state of the PS pin. The reading of a 0 in this bit d be immediately followed by writing a 1 to this location to insure proper operation.

– PIO Pin Sense and Control. See the *Programmable I/O* section for details on this read/write bit.

R - SWAP Master Status Bit. This bit indicates whether a device has been selected through the P command. Selection of this device through the SWAP command and the appropriate Net Address esult in setting this bit, indicating that this device is the master. A 0 signifies that this device is not aster.

Reserved bits.

RE BUS SYSTEM

·Wire bus is a system which has a single bus master and one or more slaves. A multidrop bus is a ɜ bus with multiple slaves. A single-drop bus has only one slave device. In all instances, the ɔ0 is a slave device. The bus master is typically a microprocessor in the host system. The sion of this bus system consists of four topics: 64-Bit Net Address, Hardware Configuration, ıction Sequence, and 1-Wire Signaling.

IT NET ADDRESS

DS2760 has a unique, factory-programmed 1-Wire net address which is 64 bits in length. The first are the 1-Wire family code (30h for DS2760). The next 48 bits are a unique serial number. The bits are a CRC of the first 56 bits (see Figure 13). The 64-bit net address and the 1-Wire I/O try built into the device enable the DS2760 to communicate via the 1-Wire protocol detailed in the *e Bus System* section of this data sheet.

IRE NET ADDRESS FORMAT Figure 13

8-bit CRC	48-bit Serial Number	8-Bit Family Code 30h)
MSb		LSb

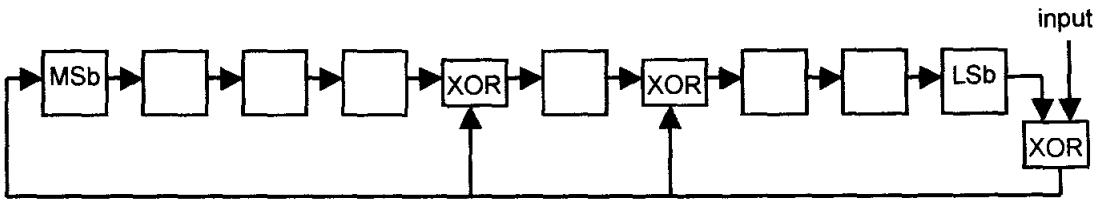
; GENERATION

)S2760 has an 8-bit CRC stored in the most significant byte of its 1-Wire net address. To ensure ·free transmission of the address, the host system can compute a CRC value from the first 56 bits of ldress and compare it to the CRC from the DS2760. The host system is responsible for verifying the value and taking action as a result. The DS2760 does not compare CRC values and does not ent a command sequence from proceeding as a result of a CRC mismatch. Proper use of the CRC esult in a communication channel with a very high level of integrity.

CRC can be generated by the host using a circuit consisting of a shift register and XOR gates as n in Figure 10, or it can be generated in software. Additional information about the Dallas 1-Wire ic Redundancy Check is available in Application Note 27 entitled "*Understanding and Using Cyclic ndancy Checks with Dallas Semiconductor Touch Memory Products*". (This application note can be l on the Maxim/Dallas Semiconductor website at www.maxim-ic.com).

e circuit in Figure 14, the shift register bits are initialized to 0. Then, starting with the least ficant bit of the family code, one bit at a time is shifted in. After the 8th bit of the family code has entered, then the serial number is entered. After the 48th bit of the serial number has been entered, ıift register contains the CRC value.

RE CRC GENERATION BLOCK DIAGRAM Figure 14

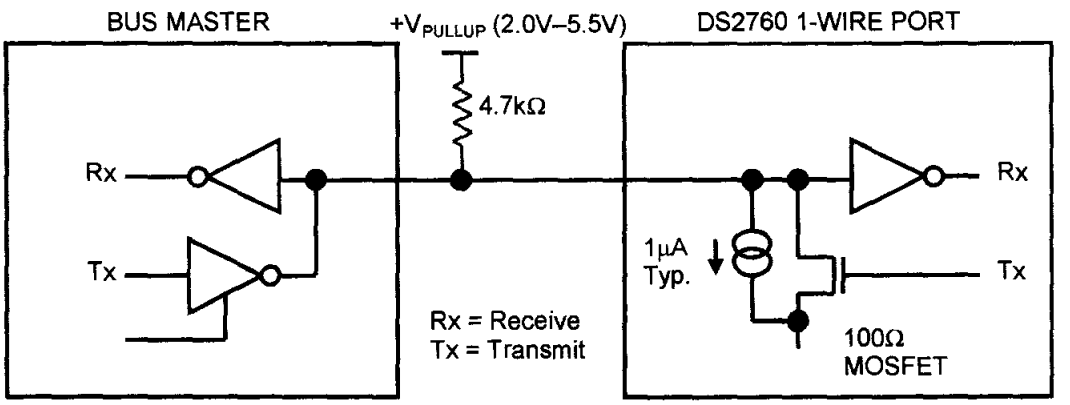


DWARE CONFIGURATION

ıse the 1-Wire bus has only a single line, it is important that each device on the bus be able to drive ıe appropriate time. To facilitate this, each device attached to the 1-Wire bus must connect to the ith open-drain or tri-state output drivers. The DS2760 used an open-drain output driver as part of directional interface circuitry shown in Figure 15. If a bidirectional pin is not available on the bus r, separate output and input pins can be tied together.

-Wire bus must have a pull-up resistor at the bus-master end of the bus. For short line lengths, the of this resistor should be approximately 5kΩ. The idle state for the 1-Wire bus is high. If, for any n, a bus transaction must be suspended, the bus MUST be left in the idle state in order to properly ıe the transaction later. If the bus is left low for more than 120µs, slave devices on the bus begin to ›ret the low period as a Reset Pulse, effectively terminating the transaction.

IRE BUS INTERFACE CIRCUITRY Figure 15



ANSACTION SEQUENCE

›rotocol for accessing the DS2760 via the 1-Wire port is as follows:

ıitialization
Jet Address Command
unction Command
Transaction/Data

sections that follow describe each of these steps in detail.

insactions of the 1-Wire bus begin with an initialization sequence consisting of a Reset Pulse itted by the bus master followed by a presence pulse simultaneously transmitted by the DS2760 y other slaves on the bus. The presence pulse tells the bus master that one or more devices are on s and ready to operate. For more details, see the *1-Wire Signaling* section.

ADDRESS COMMANDS

the bus master has detected the presence of one or more slaves, it can issue one of the Net Address ands described in the following paragraphs. The name of each ROM Command is followed by the pcode for that command in square brackets. Figure 16 presents a transaction flowchart of the Net ss Commands.

Net Address [33h or 39h]. This command allows the bus master to read the DS2760's 1-Wire net ss. This command can only be used if there is a single slave on the bus. If more than one slave is it, a data collision occurs when all slaves try to transmit at the same time (open-drain produces a -AND result). The RNAOP bit in the Status Register selects the opcode for this command, with OP=0 indicating 33h and RNAOP=1 indicating 39h.

h Net Address [55h]. This command allows the bus master to specifically address one DS2760 on Wire bus. Only the addressed DS2760 responds to any subsequent Function Command. All other devices ignore the Function Command and wait for a reset pulse. This command can be used with r more slave devices on the bus.

Net Address [CCh]. This command saves time when there is only one DS2760 on the bus by ing the bus master to issue a Function Command without specifying the address of the slave. If than one slave device is present on the bus, a subsequent Function Command can cause a data ion when all slaves transmit data at the same time.

ch Net Address [F0h]. This command allows the bus master to use a process of elimination to ify the 1-Wire net addresses of all slave devices on the bus. The search process involves the ition of a simple three-step routine: read a bit, read the complement of the bit, then write the desired e of that bit. The bus master performs this simple three-step routine on each bit location of the net ss. After one complete pass through all 64 bits, the bus master knows the address of one device. emaining devices can then be identified on additional iterations of the process. See Chapter 5 of the *of DS19xx iButton® Standards* for a comprehensive discussion of a net address search, including an l example. (This publication can be found on the Maxim/Dallas Semiconductor website at .maxim-ic.com).

AP [AAh]. SWAP is a Net Address level command specifically intended to aid in distributed plexing applications and is described specifically with regards to power control using the 27xx series oducts. The term power control refers to the ability of the DS2760 to control the flow of power into t the battery pack using control pins $\overline{DC}$ and $\overline{CC}$. The SWAP command is issued followed by the Address. The effect is to cause the addressed device to enable power to or from the system while ltaneously (break-before-make) deselecting and powering down (SLEEP) all other packs. This hing sequence is controlled by a timing pulse issued on the DQ line following the net address. The g edge of the pulse is used to disable power with the rising edge enabling power flow by the selected ce. The DS2760 will recognize a SWAP command, device address, and timing pulse if and only if WEN bit is set.

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CTION COMMANDS

successfully completing one of the Net Address Commands, the bus master can access the features DS2760 with any of the Function Commands described in the following paragraphs. The name of nction is followed by the 8-bit opcode for that command in square brackets.

Data [69h, XX]. This command reads data from the DS2760 starting at memory address XX. The f the data in address XX is available to be read immediately after the MSb of the address has been d. Because the address is automatically incremented after the MSb of each byte is received, the f the data at address XX+1 is available to be read immediately after the MSb of the data at address If the bus master continues to read beyond address FFh, the DS2760 outputs logic 1 until a Reset occurs. Addresses labeled "Reserved" in the Memory Map contain undefined data. The Read Data and may be terminated by the bus master with a Reset Pulse at any bit boundary.

Data [6 Ch, XX]. This command writes data to the DS2760 starting at memory address XX. The f the data to be stored at address XX can be written immediately after the MSb of address has been d. Because the address is automatically incremented after the MSb of each byte is written, the LSb stored at address XX+1 can be written immediately after the MSb to be stored at address XX. If the aster continues to write beyond address FFh, the DS2760 ignores the data. Writes to read-only sses, reserved addresses and locked EEPROM blocks are ignored. Incomplete bytes are not written. s to unlocked EEPROM blocks are to shadow RAM rather than EEPROM. See the *Memory* section ore details.

Data [48h, XX]. This command copies the contents of shadow RAM to EEPROM for the 16-byte OM block containing address XX. Copy Data commands that address locked blocks are ignored. the Copy Data command is executing, the EEC bit in the EEPROM Register is set to 1 and writes PROM addresses are ignored. Reads and writes to non-EEPROM addresses can still occur while py is in progress. The Copy Data command takes t_{EEC} time to execute, starting on the next falling after the address is transmitted.

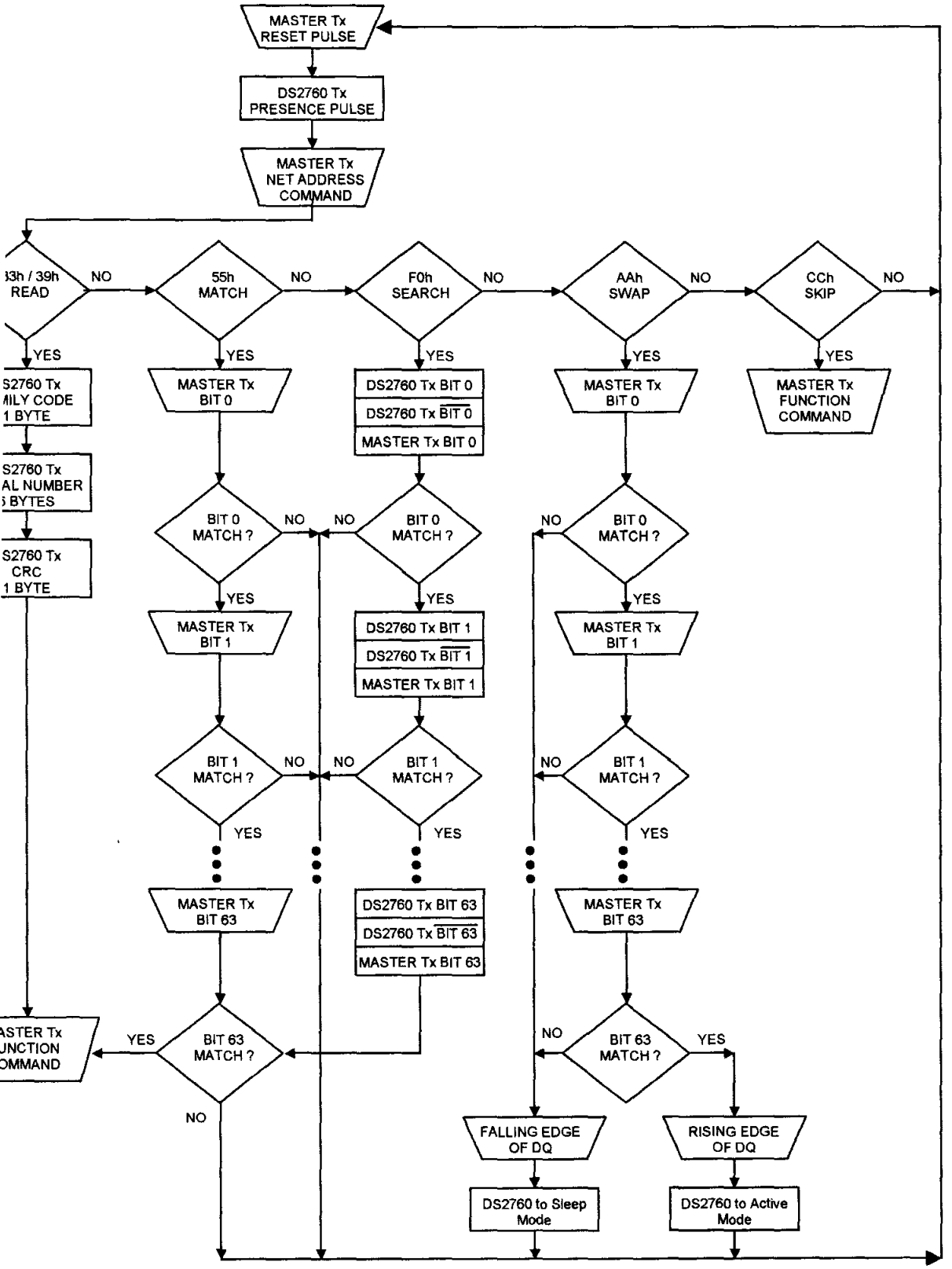
l Data [B8h, XX]. This command recalls the contents of the 16-byte EEPROM block containing ss XX to shadow RAM.

[6 Ah, XX]. This command locks (write-protects) the 16-byte block of EEPROM memory ining memory address XX. The LOCK bit in the EEPROM Register must be set to 1 before the command is executed. If the LOCK bit is 0, the Lock command has no effect. The Lock command manent; a locked block can never be written again.

NCTION COMMANDS Table 4

mmand	Description	Command Protocol	Bus State After Command Protocol	Bus Data
ıd Data	Reads data from memory starting at address XX	69h, XX	Master Rx	up to 256 bytes of data
ite Data	Writes data to memory starting at address XX	6Ch, XX	Master Tx	up to 256 bytes of data
ɔy Data	Copies shadow RAM data to EEPROM block containing address XX	48h, XX	Bus Idle	none
ːall Data	Recalls EEPROM block containing address XX to shadow RAM	B8h, XX	Bus Idle	none
ːk	Permanently locks the block of EEPROM containing address XX	6Ah, XX	Bus Idle	none

ADDRESS COMMAND FLOW CHART Figure 16

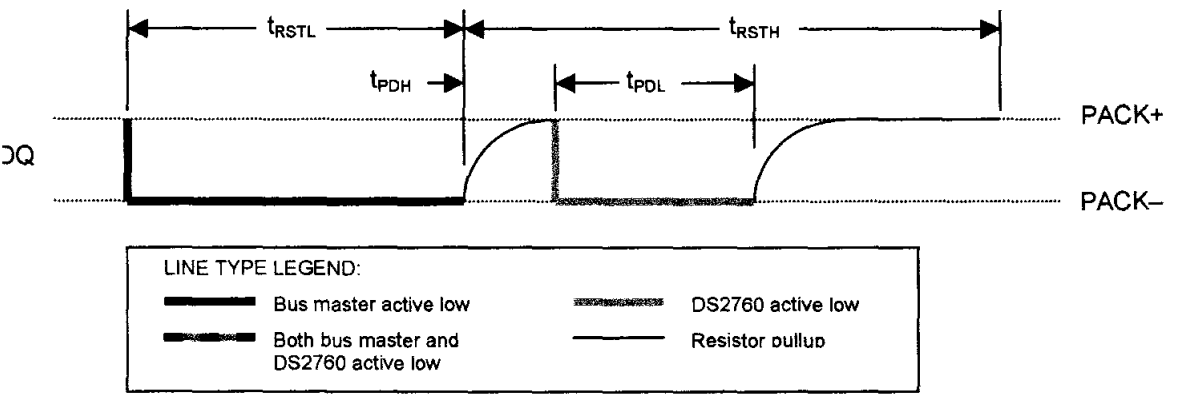


IGNALING

-Wire bus requires strict signaling protocols to insure data integrity. The four protocols used by the 50 are: the initialization sequence (Reset Pulse followed by Presence Pulse), Write 0, Write 1, and Data. All of these types of signaling except the Presence Pulse are initiated by the bus master.

itialization sequence required to begin any communication with the DS2760 is shown in Figure 17. sence Pulse following a Reset Pulse indicates the DS2760 is read to accept a Net Address and. The bus master transmits (Tx) a Reset Pulse for t_{RSTL}. The bus master then releases the line es into receive mode (Rx). The 1-Wire bus line is then pulled high by the pull-up resistor. After ing the rising edge on the DQ pin, the DS2760 waits for t_{PDH} and then transmits the Presence Pulse L.

RE INITIALIZATION SEQUENCE Figure 17



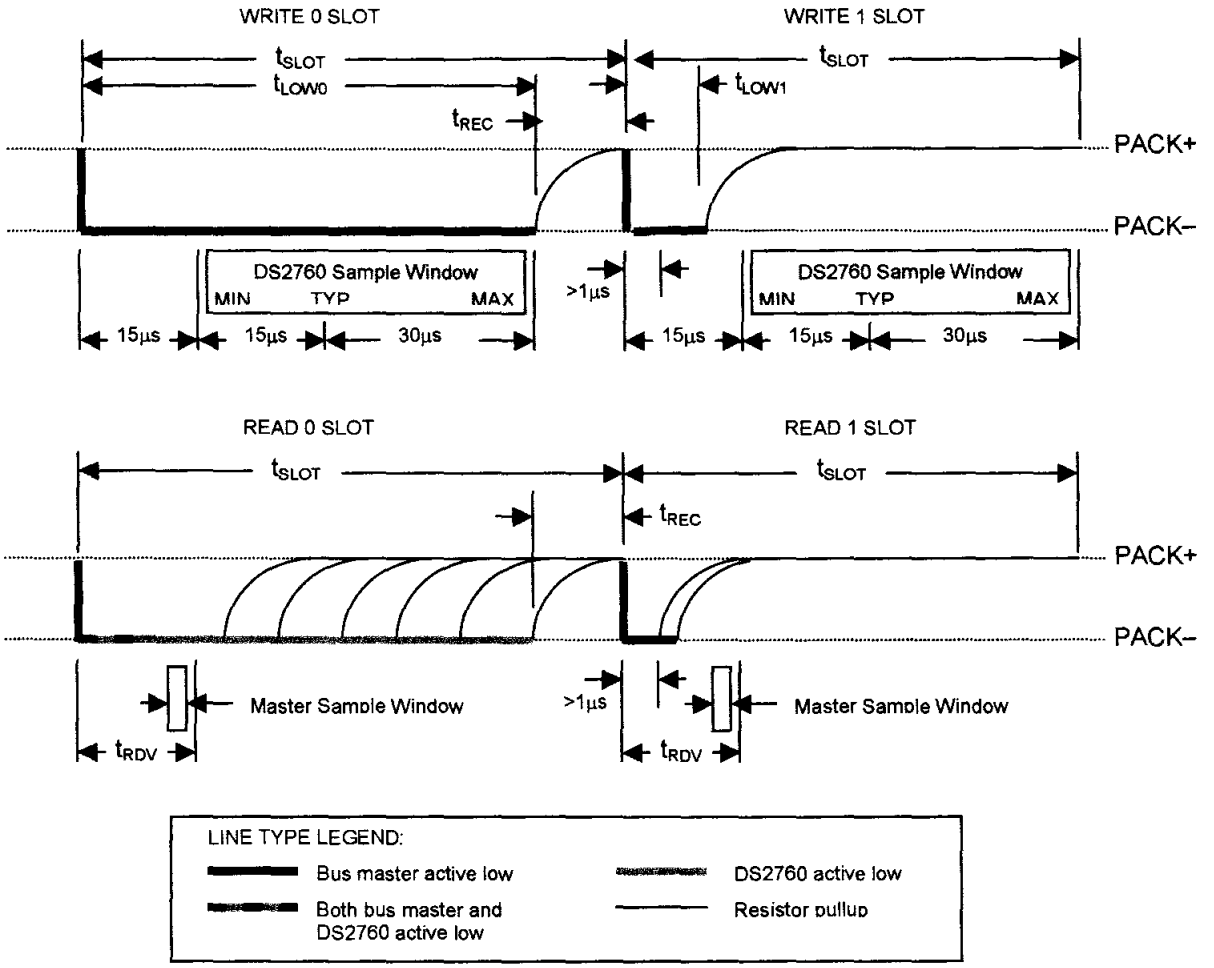
TE TIME SLOTS

te time slot is initiated when the bus master pulls the 1-Wire bus from a logic high (inactive) level to c low level. There are two types of write time slots: Write 1 and Write 0. All write time slots must t_{SLOT} (60µs to 120µs) in duration with a 1µs minimum recovery time, t_{REC}, between cycles. The 60 samples the 1-Wire bus line between 15µs and 60µs after the line falls. If the line is high when led, a Write 1 occurs. If the line is low when sampled, a Write 0 occurs (see Figure 18). For the bus r to generate a Write 1 time slot, the bus line must be pulled low and then released, allowing the line pulled high within 15µs after the start of the write time slot. For the host to generate a Write 0 time he bus line must be pulled low and held low for the duration of the write time slot.

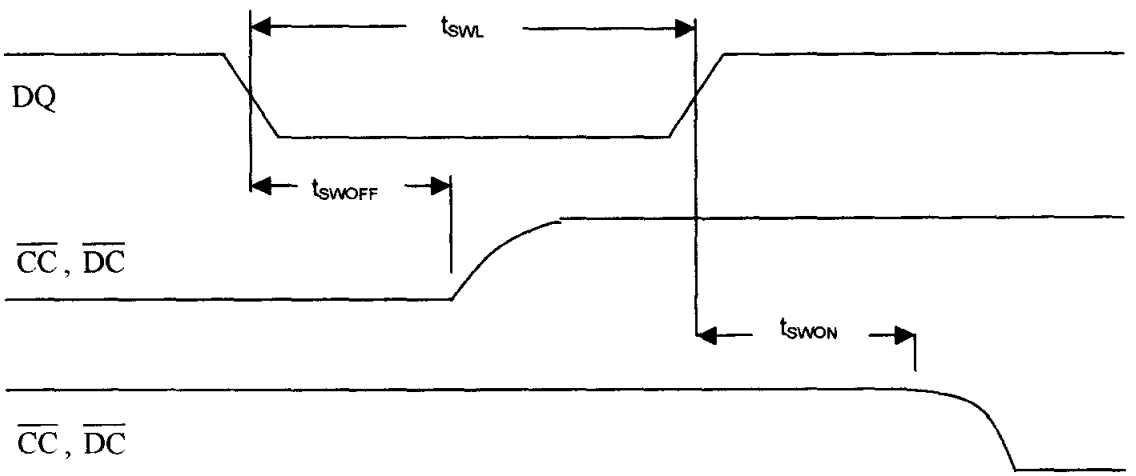
AD TIME SLOTS

d time slot is initiated when the bus master pulls the 1-Wire bus line from a logic high level to a low level. The bus master must keep the bus line low for at least 1µs and then release it to allow the 60 to present valid data. The bus master can then sample the data t_{RDV} (15µs) from the start of the time slot. By the end of the read time slot, the DS2760 releases the bus line and allows it to be d high by the external pull-up resistor. All read time slots must be t_{SLOT} (60µs to 120µs) in duration a 1µs minimum recovery time, t_{REC}, between cycles. See Figure 18 for more information.

RE WRITE AND READ TIME SLOTS Figure 18



AP COMMAND TIMING Figure 19



OLUTE MAXIMUM RATINGS*

ge on PLS and $\overline{CC}$ pin, Relative to VSS	-0.3V to +18V
ge on PIO pin, Relative to VSS	-0.3V to +12V
ge on VIN and $\overline{PS}$, Relative to VSS	-0.3V to V_{DD} + 0.3
ge on any other pin, Relative to VSS	-0.3V to +6V
uous Internal Sense Resistor Current	±2.5A
l Internal Sense Resistor Current	±50A for <100µs/sec, <1000 pulses
ting Temperature Range	-40°C to +85°C
ge Temperature Range	-55°C to +125°C
ring Temperature	See IPC/JEDEC J-STD-020A Specification

is a stress rating only and functional operation of the device at these or any other conditions above e indicated in the operation sections of this specification is not implied. Exposure to absolute imum rating conditions for extended periods of time may affect reliability.

OMMENDED DC RATING CONDITIONS

(-20°C to +70°C, 2.5V ≤ V_{DD} ≤ 5.5V)

AMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNITS	NOTES
ly Voltage	V_{DD}		2.5		5.5	V	1
Pin	DQ		-0.3		5.5	V	1

ELECTRICAL CHARACTERISTICS

(-20°C to +70°C; 2.5V ≤ V_{DD} ≤ 5.5V)

AMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNITS	NOTES
ve Current	I_{ACTIVE}	DQ = V_{DD}, norm. operation		60	90	µA	
p Mode Current	I_{SLEEP}	DQ = 0V, no activity, $\overline{PS}$ floating		1	2	µA	
t Logic High: PIO	V_{IH}		1.5			V	1
t Logic High: $\overline{PS}$	V_{IH}		V_{DD} - 0.2V			V	1
t Logic Low: PIO	V_{IL}				0.4	V	1
t Logic Low: $\overline{PS}$	V_{IL}				0.2	V	1
ut Logic High: $\overline{CC}$	V_{OH}	I_{OH} = -0.1mA	V_{PLS} - 0.4V			V	1
ut Logic High: $\overline{DC}$	V_{OH}	I_{OH} = -0.1mA	V_{DD} - 0.4V			V	1
ut Logic Low: , $\overline{DC}$	V_{OL}	I_{OL} = 0.1mA			0.4	V	1
ut Logic Low: PIO	V_{OL}	I_{OL} = 4mA			0.4	V	1
Pulldown Current	I_{PD}			1		µA	
t Resistance: VIN	R_{IN}		5			MΩ	
nal Current Sense stor	R_{SNS}	+25°C	20	25	30	mΩ	
Low to Sleep time	t_{SLEEP}		2.1			sec	

CTRICAL CHARACTERISTICS:
TECTION CIRCUITRY

(0°C to +50°C; 2.5V ≤ V_{DD} ≤ 5.5V)

AMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
voltage Detect	V_{OV}	4.325 4.250	4.350 4.275	4.375 4.300	V	1, 2
ge Enable	V_{CE}	4.10	4.15	4.20	V	1
rvoltage Detect	V_{UV}	2.5	2.6	2.7	V	1
current Detect	I_{OC}	1.8	1.9	2.0	A	3
current Detect	V_{OC}	45	47.5	50	mV	1, 4
t Circuit Detect	I_{SC}	5.0	8.0	11	A	3
t Circuit Detect	V_{SC}	150	200	250	mV	1
voltage Delay	t_{OVD}	0.8	1	1.2	sec	
rvoltage Delay	t_{UVD}	90	100	110	ms	
current Delay	t_{OCD}	5	10	20	ms	
t Circuit Delay	t_{SCD}	80	100	120	µs	
Threshold	V_{TP}	0.5	1.0	1.5	V	
Current	I_{TST}	10	20	40	µA	
very Charge Current	I_{RC}	0.5	1	2	mA	13

CTRICAL CHARACTERISTICS:
PERATURE, VOLTAGE, CURRENT (0°C to +50°C; 2.5V ≤ V_{DD} ≤ 5.5V)

AMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
perature Resolution	T_{LSB}		0.125		°C	
perature Full Scale nitude	T_{FS}	127			°C	
perature Error	T_{ERR}			±3	°C	5
age Resolution	V_{LSB}		4.88		mV	
age Full Scale nitude	V_{FS}	4.75			V	
age Offset Error	V_{OERR}			1	LSB	6
age Gain Error	V_{GERR}			5	%V reading	
ent Resolution	I_{LSB}		0.625 15.625		mA µV	3 4
ent Full Scale nitude	I_{FS}	1.9	2.56 64		A mV	3, 7 4
ent Offset Error	I_{OERR}			1	LSB	8
ent Gain Error	I_{GERR}			3 1	%I reading	3, 9, 14 4
umulated Current olution	q_{CA}		0.25 6.25		mAhr µVhr	3 4
ent Sampling quency	f_{SAMP}		1456		Hz	
rnal Timebase Accuracy	t_{ERR}		±1	±3	%	10

CTRICAL CHARACTERISTICS:

RE INTERFACE (-20°C to +70°C; 2.5V ≤ V_{DD} ≤ 5.5V)

AMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
Slot	t_{SLOT}	60		120	µs	
very Time	t_{REC}	1			µs	
0 Low Time	t_{LOW0}	60		120	µs	
1 Low Time	t_{LOW1}	1		15	µs	
Data Valid	t_{RDV}			15	µs	
t Time High	t_{RSTH}	480			µs	
t Time Low	t_{RSTL}	480		960	µs	
nce Detect High	t_{PDH}	15		60	µs	
nce Detect Low	t_{PDL}	60		240	µs	
P timing pulse width	t_{SWL}	0.2		120	µs	
P timing pulse g edge to $\overline{DC}$ release	t_{SWOFF}	0		1	µs	12
P timing pulse rising to $\overline{DC}$ engage	t_{SWON}	0		1	µs	12
Capacitance	C_{DQ}			60	pF	

ROM RELIABILITY SPECIFICATION (-20°C to +70°C; 2.5V ≤ V_{DD} ≤ 5.5V)

AMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
y to EEPROM Time	t_{EEC}		2	10	ms	
ROM Copy Endurance	N_{EEC}	25000			cycles	11

TES

ll voltages are referenced to VSS.

ee "Ordering Information" section of datasheet to determine corresponding part number for each V_{OV} value.

ternal current sense resistor configuration.

xternal current sense resistor configuration.

elf heating due to output pin loading and sense resistor power dissipation can alter the reading from ambient conditions.

oltage offset measurement is with respect to V_{OV} at +25°C.

he current register supports measurement magnitudes up to 2.56A using the internal sense resistor option and 64mV with e external resistor option. Compensation of the internal sense resistor value for process and temperature variation can educe the maximum reportable magnitude to 1.9A.

urrent offset error null to ±1LSB typically requires 3.5s in-system calibration by user.

urrent gain error specification applies to gain error in converting the voltage difference at IS1 and IS2, and excludes any rror remaining after the DS2760 compensates for the internal sense resistor's temperature coefficient of 3700ppm/°C to accuracy of ±500ppm/°C. The DS2760 does not compensate for external sense resistor characteristics, and any error rms arising from the use of an external sense resistor should be taken into account when calculating total current easurement error.

ypical value for t_{ERR} is at 3.6V and +25°C.

-year data retention at +70°C.

ypical load capacitance on $\overline{DC}$ and $\overline{CC}$ is 1000pF.

est conditions are PLS = 4.1V, V_{DD} = 2.5V. Maximum current for conditions of PLS = 15V, V_{DD} =0V is 10mA.

rror at time of shipment from Dallas Semiconductor is 3% max. Board mounting processes may cause the current gain rror to widen to as much as 10% for devices with the internal sense resistor option. Contact factory for on-board calibration procedure for devices with the internal sense resistor option to improve accuracy.

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DS2760 Thermocouple Kit (#28022)

1-Wire® Thermocouple Interface

Introduction

Thermocouples provide a low-cost, reliable means of measuring temperature over a wide range. The challenge when using a thermocouple is accurately measuring the very low Seebeck output voltage (fractional to low millivolts) from the element, and providing for cold junction temperature compensation.

The Dallas/Maxim DS2760 High Precision Li+ Battery Monitor is very easily configured into an effective thermocouple interface. The Parallax DS2760 Thermocouple Module capitalizes on this application and provides a complete connection between the BASIC Stamp and a standard thermocouple element.

Features

- 1-Wire® interface allows multiple devices with just one Stamp IO pin
- Cold Junction measurement: 0°C to +127°C (0.125°C resolution)
- Low power consumption:
  - -- Active current: 90 µA max
  - -- Sleep current: 2 µA max

Packing List

Verify that your DS2760 kit is complete in accordance with the list below:

- DS2760 Thermocouple Module #550-28022
- (3) Thermocouple elements:
  - -- (1) K-type (Chromel / Alumel) #800-00011
  - -- (1) J-type (Iron / Constantan) #800-00012
  - -- (1) T-type (Copper / Constantan) #800-00010
- This documentation

Note: DS2760 demonstration software may be downloaded from www.parallax.com.

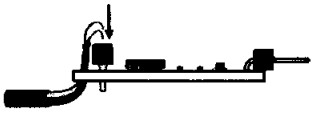
Connections

Before connecting the DS2760 Thermocouple Module to the BASIC Stamp you will need to prepare a thermocouple element, and then connect it to the cold junction port of the module. Start by carefully removing about one inch (250 mm) of the outer sleeve from each end of the element. From each lead on the temperature measurement end, remove about ½ inch (125 mm) of insulation and then carefully twist together (using pliers if necessary) and trim as shown in Figure 1.

Figure 1: Thermocouple Junction

On the cold junction (DS2760 module) end of the element, remove only ¼ inch (60 mm) of insulation from each lead. Route these leads through the bottom of the thermocouple module PCB and insert snuggly into the pin sockets as shown in Figure 2.

Figure 2: Cold Junction Connection to DS2760 PCB

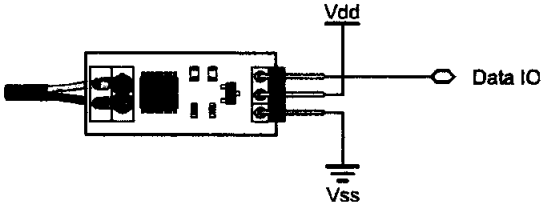


Use this table to ensure that you make the proper thermocouple connections to the module. If the leads are reversed, the measured temperature will be incorrect.

Type	Materials	SNS	Vss
K	Chromel / Alumel	Red	Yellow
J	Iron / Constantan	Red	White
T	Copper / Constantan	Red	Blue

Finally, the DS2760 Thermocouple Module is connected to the BASIC Stamp as shown in Figure 3 below (Note that the module includes a 4.7 KΩ pull-up on the 1-Wire® data line).

Figure 3: DS2760 Connections to BASIC Stamp



BASIC Stamp Application

The following BASIC Stamp application will run on either the BS2p or BS2pe and demonstrates how easy measuring wide-range temperatures can be when using the DS2760 Thermocouple Module. Other Stamps will require a Serial-to-1-Wire protocol converter, as well as code to manage the large tables across program slots, and are not covered in this document.

A little background: When two dissimilar metal wires are joined, a voltage will be developed across the open end that is proportional to the temperature difference between the joined and open ends. This effect was discovered by Thomas Seebeck in 1821. Through empirical testing, voltage tables have been established that correspond to the thermocouple junction temperature. These tables, however, use a cold junction (voltage measurement point) reference of zero degrees Celsius, forcing electronic devices to employ cold junction compensation.

Using the DS2760 we can measure the Seebeck voltage from the thermocouple with a resolution of 15.625 microvolts, then measure the cold junction temperature with a resolution of 0.125 degrees Celsius. A simple table look-up using the cold junction temperature will give us the cold junction compensation voltage. This is combined with the Seebeck voltage and, using a modified binary search algorithm, we can determine the compensated temperature from the thermocouple data table.

```
' ================================================================================
'
'   File..... DS2760TC_Demo.BPE
'   Purpose... Thermocouple temperature measurement using the DS2760
'   Author.... Parallax, Inc.  (Copyright 2004, All Rights Reserved)
'   E-mail.... support@parallax.com
'   Started...
'   Updated... 19 JAN 2004
'
'   {$STAMP BS2pe, KTablePos.BPE, JTablePos.BPE, TTablePos.BPE}
'   {$PBASIC 2.5}
'
' ================================================================================


' -----[ Program Description ]---------------------------------------------
'
' This program lets a BS2p or BS2pe read the temperature from the Parallax
' DS2760 thermocouple module.  User input of thermocouple type (K, J, or T)
' and temperature display is via the DEBUG window.


' -----[ Revision History ]------------------------------------------------


' -----[ I/O Definitions ]-------------------------------------------------

OW              PIN     8                       ' 1-Wire buss pin
```

```
' -----[ Constants ]-------------------------------------------------------

ReadNet         CON     $33                     ' read OW net address
SkipNet         CON     $CC                     ' skip OW net address
RdReg           CON     $69                     ' read register


' -----[ Variables ]-------------------------------------------------------

idx             VAR     Nib                     ' loop counter
type            VAR     Nib                     ' device type
char            VAR     Byte                    ' display byte/char

vIn             VAR     Word                    ' in millivolts
tmpCJ           VAR     Word                    ' device temp in C
tCuV            VAR     Word                    ' thermocouple millivolts
sign            VAR     Word                    ' TC sign bit

cjComp          VAR     Word                    ' temp compensation
tempC           VAR     Word                    ' temp in Celsius
tempF           VAR     Word                    ' temp in Fahrenheit

tblLo           VAR     Word                    ' table pointers
tblHi           VAR     Word
eePntr          VAR     Word
testVal         VAR     Word                    ' test value from table
error           VAR     Bit                     ' 1 = out of range


' -----[ EEPROM Data ]-----------------------------------------------------


' -----[ Initialization ]---------------------------------------------------

Stamp_Check:
  #IF ($stamp < BS2P) #THEN
    #ERROR "This program requires BS2p or BS2pe"
  #ENDIF

Check_Device:
  OWOUT OW, %0001, [ReadNet]                    ' get serial number
  OWIN  OW, %0010, [SPSTR 8]                    ' store in SPRAM
  GET idx, char                                 ' read device type
  IF (char <> $30) THEN                         ' if not $30, wrong device
    DEBUG "No DS2760 found."
    STOP                                        ' stop program
  ENDIF
```

```
Menu:
  DEBUG CLS,
        "==============================", CR,
        " DS2760 Thermocouple Interface ", CR,
        "==============================", CR,
        CR,
        "Select TC Type (1 - 3)", CR,
        CR,
        "(1) K - Chromel/Alumel", CR,
        "(2) J - Iron/Constantan", CR,
        "(3) T - Copper/Constantan", CR,
        CR,
        ">>> "

  DEBUGIN DEC1 type                                 ' get selection
  IF (type < 1) OR (type > 3) THEN Menu             ' validate selection
  DEBUG CRSRXY, 0, 3, CLRDN                         ' remove selections
  STORE type                                        ' point READ to table

Show_SN:
  DEBUG CRSRXY, 0, 4, "Device SN... "
  FOR idx = 0 TO 7
    GET idx, char
    DEBUG HEX2 char
  NEXT

Show_Type:
  DEBUG CRSRXY, 0, 6, "TC Type..... "
  LOOKUP (type - 1), ["KJT"], char
  DEBUG char


' -----[ Program Code ]----------------------------------------------------

Main:
  DO
    GOSUB Read_TC_Volts                             ' read Seebeck voltage
    GOSUB Read_CJ_Temp                              ' read cold junction temp
    READ (tmpCJ * 2), Word cjComp                   ' get compensation voltage

    ' combine cjComp and tCuV
    '
    IF sign THEN
      ' TC below cold junction
      IF (tCuV < cjComp) THEN
        cjComp = cjComp - tCuV
      ELSE
        cjComp = 0                                  ' limit to 0C
      ENDIF
```

```
    ELSE
      ' TC above cold junction
      cjComp = cjComp + tCuV
    ENDIF

    LOOKUP type, [1023, 1023, 400], tblHi       ' set high end of search
    GOSUB TC_Lookup                             ' reverse lookup of table
    tempF = tempC * 9 / 5 + 32                  ' x 1.8 + 32

    IF (error = 0) THEN
      DEBUG CRSRXY, 0, 7,
            "Temp °C..... ", SDEC tempC, CLREOL
      DEBUG CRSRXY, 0, 8,
            "Temp °F..... ", SDEC tempF, CLREOL
    ELSE
      DEBUG CRSRXY, 0, 7,
            "Temp °C..... Out of Range", CLREOL
      DEBUG CRSRXY, 0, 8,
            "Temp °F..... Out of Range", CLREOL
    ENDIF

    PAUSE 1000
  LOOP
  END


' -----[ Subroutines ]-------------------------------------------------------

' Reads device input voltage (Vin pin)
' -- mV in millivolts (max reading is 4.75 volts)

Read_Vin:
  OWOUT OW, %0001, [SkipNet, RdReg, $0C]
  OWIN  OW, %0010, [vIn.BYTE1, vIn.BYTE0]
  IF (vIn.BIT15) THEN                           ' check sign
    vIn = 0                                     ' disallow negative
  ELSE
    vIn = vIn >> 5 */ $4E1                      ' x 4.88 millivolts
  ENDIF
  RETURN


' Reads current register to get TC voltage
' -- each raw bit = 15.625 uV
' -- tCuV in microvolts

Read_TC_Volts:
  OWOUT OW, %0001, [SkipNet, RdReg, $0E]        ' read current register
  OWIN  OW, %0010, [tCuV.BYTE1, tCuV.BYTE0]
```

```
  sign = tCuV.BIT15                                 ' save sign bit
  tCuV = tCuV >> 3                                  ' correct alignment
  IF sign THEN
    tCuV = tCuV | $F000                             ' pad 2's-compliment bits
  ENDIF
  tCuV = ABS tCuV */ 4000                           ' x 15.625 uV
  RETURN


' Reads cold junction (device) temperature
' -- each raw bit = 0.125 degrees C
' -- returns tmpCJ in whole degrees C

Read_CJ_Temp:
  OWOUT OW, %0001, [SkipNet, RdReg, $18]
  OWIN  OW, %0010, [tmpCJ.BYTE1, tmpCJ.BYTE0]
  IF (tmpCJ.BIT15) THEN                             ' check sign
    tmpCJ = 0                                       ' disallow negative
  ELSE
    tmpCJ = tmpCJ.HIGHBYTE                          ' >> 5 x 0.125 (>> 3)
  ENDIF
  RETURN


' Search currently selected TC table for nearest entry
' -- uses modified binary algorithm to find cjComp
' -- high end of search set before calling (tblHi)
' -- successful search sets tempC

TC_Lookup:
  tblLo = 0                                         ' low entry of table
  tempC = 22                                        ' default to room temp

  READ (tblHi * 2), Word testVal                    ' check max temp
  IF (cjComp > testVal) THEN
    error = 1                                       ' out of range
  ELSE
    DO
      eePntr = (tblLo + tblHi) / 2                  ' midpoint of search span
      READ (eePntr * 2), Word testVal               ' read value from midpoint

      IF (cjComp = testVal) THEN
        EXIT                                        ' found it!
      ELSEIF (cjComp < testVal) THEN
        tblHi = eePntr                              ' search lower half
      ELSE
        tblLo = eePntr                              ' search upper half
      ENDIF
```

```
    IF ((tblHi - tblLo) < 2) THEN              ' span at minimum
      eePntr = tblLo
      EXIT
    ENDIF
  LOOP
  tempC = eePntr
ENDIF
RETURN
```

Additional Resources

- Advanced thermocouple interface software (download from Parallax)
- Web Links:
  -- www.maxim-ic.com/quick_view2.cfm/qv_pk/2931
  -- www.capgo.com/Resources/Sensors/Temperature/Thermocouple/Thermocouple.html
  -- instserv.com/rmocoupl.htm
  -- instrumentation-central.com/pages/thermocouple_reference_table.htm

DS2760 Module Schematic