Reference Implementation for AMB-4001 Series Datacast Chip

This document explains the use of the Ambient reference implementation for its AMB series datacast chips. The datacast modules simply the prototyping process of incorporating AMB-4001 series datacast chips into products.

Author: Benjamin Resner, VP Technology
Document version 1.04
November 2, 2005

Table of Contents

1 Introduction

When paired with the appropriate pager radio, the AMB-4001 series datacast chips receive realtime web-enabled user-customizable content over a nationwide wireless network. The datacast chips decode and parse the signal, storing content on the chip. This content can be queried by an external device for display on a variety of product forms.

These developer kits contain a complete reference implementation for the AMB-4001 series datacast chipsets, as well as tools to make embedding Ambient into target products as straightforward as possible.

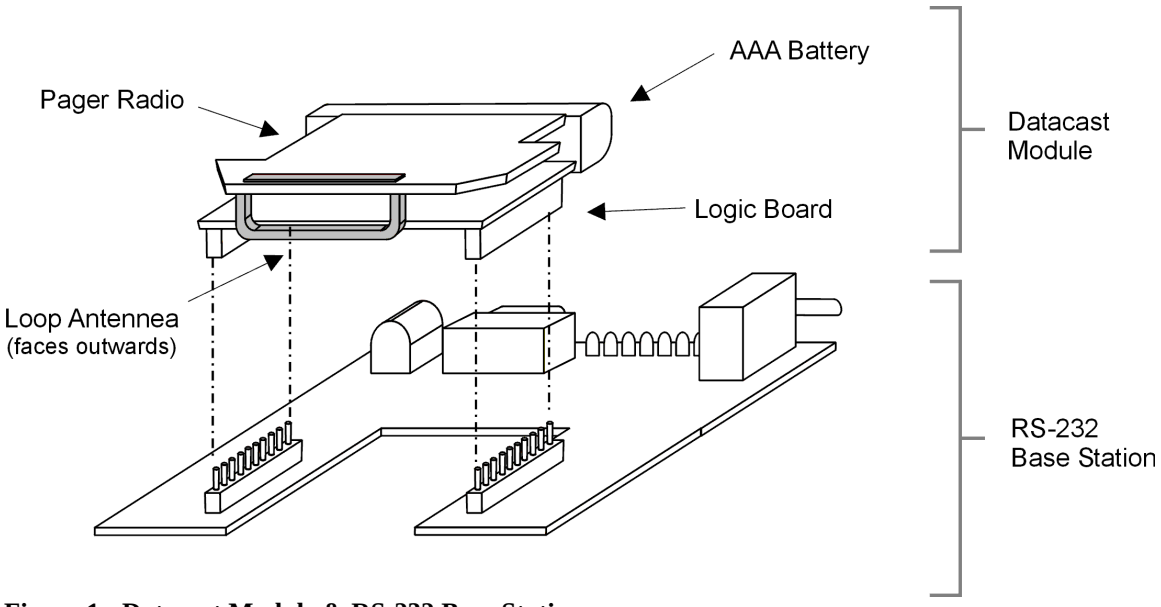


Figure 1: Datacast Module & RS-232 Base Station

The developer kit contains the following three components, described below

1) Datacast Module
    a. Pager Radio
    b. Logic Board
2) RS-232 Base Station
3) Breadboard Adaptor

1.1 Datacast module:

A complete implementation for wirelessly decoding and caching realtime customizable web-enabled content. The datacast module consists of two PC boards and a battery.

1.1.1 Pager Radio

4-Level superheterodyne FSK receiver detecting offsets of +/- 1600 Hz and +/- 4500 Hz.

1.1.2 Logic Board

- 14-pin connector for pager PCB
- TPS61014 single-cell DC-DC voltage booster
- AMB series datacast chip and associated crystals
- RESET click button
- red, green, yellow LEDs
- AAA battery holder
- 6401 FET for reverse polarity protection

1.2 RS-232 Base Station:

The datacast module optionally plugs into the RS-232 base station for interfacing from a PC computer. Sample Java code running on a PC computer demonstrates the functionality of the AMB chipset, and how to interface with this chip via the serial port.

The RS-232 Base Station contains the following subsystems:

- MAX232 line level converter
- 7805 5-volt regulator to power datacast module logic circuitry
- LM317 regulator to provide 1.5 volts to the datacast module pager radio
- RESET click button

1.3 Breadboard Adaptor:

The datacast module can also plug into the breadboard adaptor, simplifying the prototyping process for embedding either the complete datacast module or the AMB chips into target products.

Figure 2: Breadboard Adaptor

Figure 3: Breadoard Adaptor with Datacast Module

2 Pinouts

Note that all inputs on the AMB-4001 series chip are attached to pullup resistors to prevent floating inputs. Therefore, these inputs can be left unconnected. Also, for maximum battery life, the external controller should avoid drawing current through these pullup resistors.

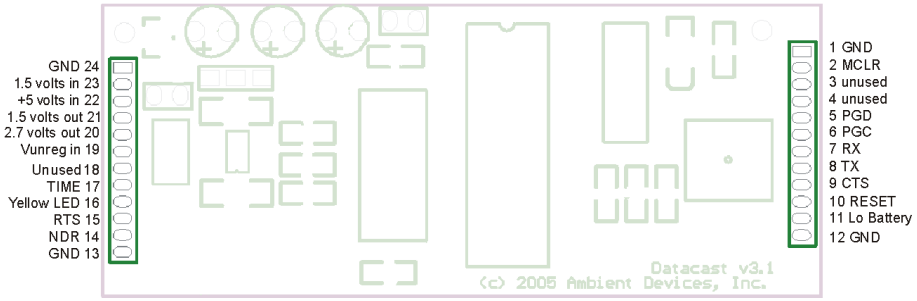


Figure 4: Top View of Datacast Logic Board

Pin #	Name	Description
1	GND	Electrical ground
2	MCLR	MCLR on AMB Datacast Chip. Leave unconnected.
3	unused	
4	unused	
5	PGD	PGD on AMB Datacast Chip. Leave unconnected.
6	PGC	PGC on AMB Datacast Chip. Leave unconnected.
7	RX	RX on AMB Datacast Chip
8	TX	TX on AMB Datacast Chip
9	CTS	CTS on AMB Datacast Chip
10	RESET	RESET on AMB Datacast Chip
11	LoBattery	LoBatt on AMB Datacast Chip
12	GND	Electrical ground
13	GND	Electrical ground
14	New Data Ready	NDR on AMB Datacast Chip
15	RTS	RTS on AMB Datacast Chip
16	Yellow LED	Yellow LED on AMB Datacast Chip
17	TIME	TIME on AMB Datacast Chip
18	Unused	
19	Vunreg in	currently unused
20	2.7 volts out	When jumpers are configured for battery operation, this is the output from the DC-DC step-up converter. External devices can use up to 80ma of power from this pin.

21	1.5 volts out	Reverse-polarity protected 1.5 volt power
22	+5 volts in	External power supply ranging from 2.7 volts to 5.5 volts. This voltage is not required when on-board DC-DC step-up converter is engaged. Jumpers selectively isolate or connect this voltage source.
23	1.5 volts in	1.5 volt input directly from single battery or equivalent. This is not reverse-polarity protected.
24	GND	Electrical ground

3 Powering the Datacast Module

The entire datacast module can be powered by a single AAA battery, or by attaching to the RS-232 Base Station. Internally, the datacast module requires separate power supplies for the radio and digital logic:

Pager Radio: This MUST be powered by a 1.5 volt source applied to pin 23. The pager radio is designed to be directly powered by a single battery without any power loss from a DC-DC converter. (Note: The pager board can be powered up to 2.5 volts, but sensitivity is tuned at 1.5 volts)

If using AC power, 1.5 volts can be generated either by using a 3-terminal supply such as a LM317, or by using a voltage drop incorporating two or three small signal diodes and a resistor. See appendix 1 for more information.

Digital Logic Board: The logic board requires a source from 2.7 – 5.5 volts. Depending on jumpers J4 and J7, this can either be generated from the on-board TPS61014 DC-DC converter supplied from the same 1.5 volt input to the pager radio, OR from externally generated 2.7 – 5.5 volts applied to pin 22.

3.1 Single-Cell Battery Operation

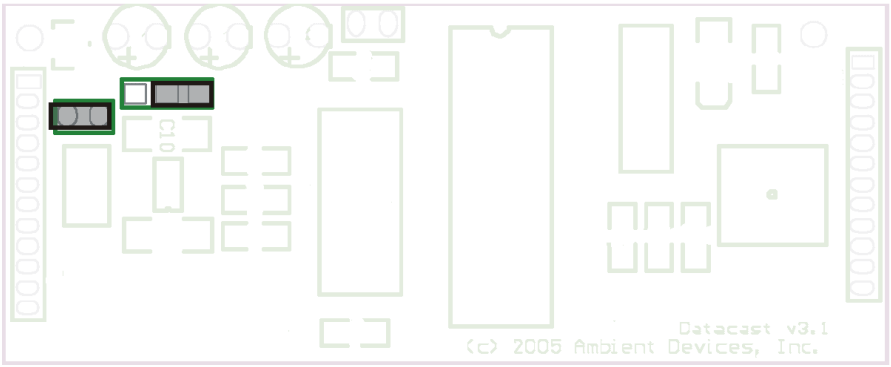


Figure 5: Jumper Settings for Single-Cell Battery operation when not attached to the RS-232 Base Station

Use this configuration when powering the entire datacast module from a single 1.5 volt power source. This jumper configuration enables the TPS61014 DC-DC converter to step up the 1.5 volt battery to 2.7 volts required by the AMB datacast chip.

This stepped up 2.7 volt output voltage is available on pin 20 of the datacast module. External devices can draw up to 80ma from this pin. However, battery life is significantly reduced at this load.

When the datacast module is attached to the RS-232 base station in this jumper configuration, the output voltage levels from the AMB datacast chip may not be

sufficient for the MAX233 RS-232 line-level converter to register as a logic high. Therefore, the datacast module may appear to be broken.

3.2 5 volt AC Powered Operation

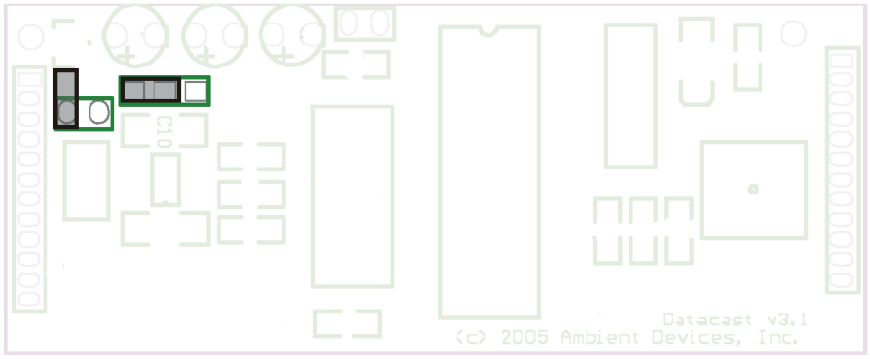


Figure 6: Jumper settings for operation in RS-232 Base Station. Note the left jumper can be entirely removed.

Use this configuration when operating the datacast module in the RS-232 base station, or when interfacing with any other devices that operates at a 5-volt logic level. Note that at 5-volt operation, current consumption is increased by a factor of five.

This configuration isolates the battery and the TPS61014 DC-DC converter from the circuit and powers the AMB datacast chipset directly from the voltage at pin 22. Note that if battery is installed, no current will be drawn in this jumper configuration. Therefore, the battery WILL NOT power the RS-232 base station.

Keep in mind that even though the AMB-4001 datacast chip is running at 5 volts, the pager radio still requires a 1.5-volt supply, which is supplied by the RS-232 Base Station

3.3 Battery Life

When powered by a single AAA (triple-A) battery, battery life is about 2 months. Using 2 AAA batteries doubles this amount to 4 months, and using 2 AA (double-A) batteries doubles this again to 8 months.

The AMB-DATA reference implementation uses a TPS61014 voltage step up converter to boost the battery voltage from 1.5 volts to 2.7 volts. With the components selected, this chip operates at about 75% efficiency. With theoretically perfect efficiency, battery life is improved another – almost a year with 2 AA batteries.

Please see Appendix 1 for more information on battery life.

4 RF Considerations

The Datacast Modules contain a sensitive wireless receiver. Therefore it is important to follow some basic guidelines to ensure the radio performance is optimal.

4.1 Metal Enclosures

Enclosing the datacast module in metal, or the use of metallic accents can adversely affect reception. This includes foil stickers and metallic paint.

In practice, the effect of metal is difficult to predict. In areas of strong coverage, even well sealed metallic enclosures do not interfere with reception. In weaker reception areas, even metal accents have the potential to lower the sensitivity of the pager radio.

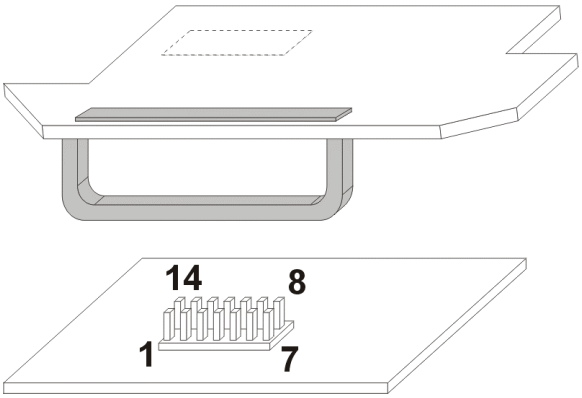
4.2 FCC Approval

The datacast modules are based on the 5-Day Weather Forecaster hardware, which is FCC approved. However, the Datacast modules have not been approved. It is the responsibility of the client to obtain FCC and any other regulatory approval.

4.3 Grounding and Noise

It is recommended that any target board attaching to the datacast modules incorporate 10pf ceramic bypass capacitors and judicious use of groundhole vias to reduce RF noise. Depending on board density, one should consider the use of a 4-layer board.

Appendix 1 – Pager Radio Pinouts



PIN	I/O	Function
1	Out	Lo battery. Open collector output, normally low. Goes high when battery drops below ~1.1 volts.
2	Out	FSK1 open collector output
3	Out	FSK2 open collector output
4	In	Sleep High – normal operation Low – sleep
5	In	Charge
6	In	Internally attached to 100k pullup resistor to FSK1/FSK2. Connect to Vcc of datacast chip
7	In	1.5 volts for pager.
8	---	Unused – leave unconnected
9	---	Unused – leave unconnected
10	---	Unused – leave unconnected
11	---	Unused – leave unconnected
12	---	Unused – leave unconnected
13	In	Filter
14	In	Ground

Appendix 2 – Current and Power Readings

The reference implementation uses a Texas Instruments TPS61014 DC-DC single cell voltage booster. This voltage booster uses a 10uF inductor as well as two 10uF ceramic filtering capacitors. In this configuration, efficiency of the TPS61014 is about 75%. The TPS61014 datasheet claims efficiency above 95%. In such a configuration, the reference implemenation would gain another 2 weeks of battery life.

Figure 7 shows current consumption at various points in the example circuit. The values given are typical. Because Ambient Devices does not supply the underlying hardware, we make no guarantees for minimum and maximum performance. More details about electrical characteristics can be found in the Microchip datasheets, as well as datasheets from the appropriate pager radio manufacturing company.

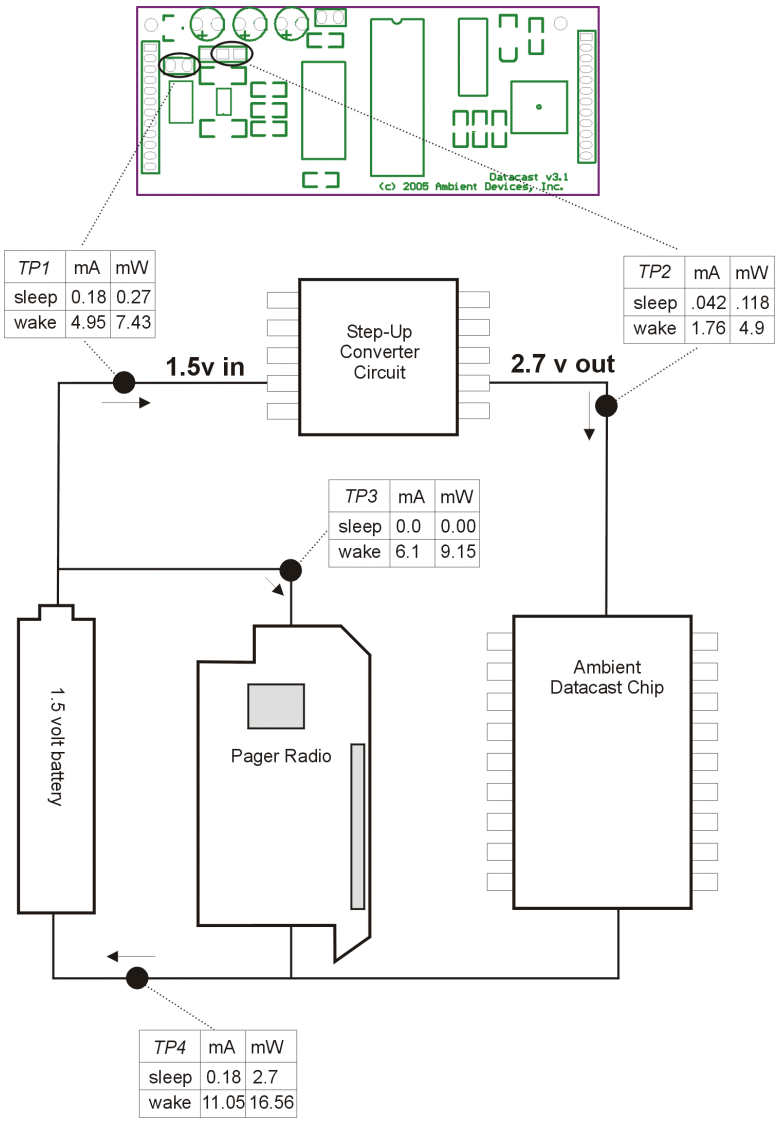


Figure 7: Power Consumption for reference implementation

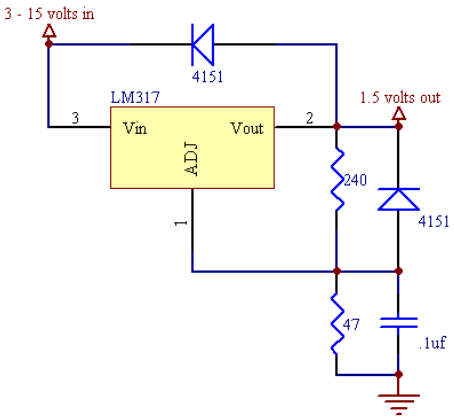
	Constants			
1	battery voltage	1.5	volts	
2	TPS61014output voltage	2.8	volts	
3	Wake Duty Cycle	4.50%		
4	AAA capacity	1000	ma-Hours	
5	AAA capacity	1500	mW-Hours	
6				
7	**Measured**	**sleep**	**wake**	**units**
8	TPS61014 (TP1)	0.27	7.43	mW
9	Datacast Chip (TP2)	0.118	4.9	mW
10	Pager Radio (TP3)	0	9.15	mW
11				
12	**Calculated**			
13	Total draw from battery (TP1 + TP3)	0.27	16.58	mW
14	Average battery draw (wake * dutyCycle) + (sleep * (1-dutyCycle))		1.004	mW
15	Battery Life Hours (AAA capacity mW-hours/average draw)		1494.10	hours
16	Battery Life Months (Hours / 24 / 30)		2.08	months
17	Average power consumption: (TP2sleep)*(1-dutyCycle) + (TP2wake + TP3 wake) * dutyCycle		0.74	mW
17	Total Efficiency (average battery draw / average power consumption)		74.20%	percent

Table 1: Power Consumption Calculations for Reference Implementation

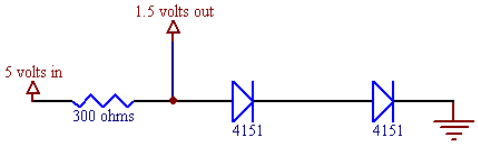
Note: Battery capacity (line 3, 4) are from http://www.duracell.com/oem/Pdf/others/ATB-full.pdf Note these figures assume a discharge to 0.8 volts. The pager radio performance degrades below 1.1 volts, so not all battery capacity is available. Therefore a lower value for ma-hours is used.

Appendix 3 – External Pager Power Supplies

The datacast module require 1.5 volts for the pager radio, regardless of how the AMB-4001 datacast chip is powered. Below are two suggestions for generating 1.5 volts from higher fixed voltages.



Note the two diodes and capacitor are optional, but improve performance.



The diodes and resistors form a voltage divider. Each diode has a voltage drop of about .7 volts, for a total drop of 1.4 volts.

Note this circuit draws current even when the pager is asleep. Therefore, it is not recommended for battery power.