1. General Information

1.1 Features

- Fast satellite acquisition with twelve parallel tracking channels
- Enhanced Time To First Fix (TTFF) from battery back-up to power-on condition
- NMEA (National Marine Electronics Association)-0183 data protocol support
- Standard Positioning Service (SPS) accuracy
- Operational flexibility, configured through user commands via the host serial port
- Accepts user supplied initialization data via the host serial port
- User selectable satellites and satellite mask angles
- Three dimensional (3D) and two dimensional (2D) navigation modes supported
- Automatic altitude hold lets the receiver use an altitude determined in 3D navigation mode to calculate a fix in 2D navigation mode
- Automatic cold-start acquisition process
- Meets rigid vibration and shock requirements
- One pulse per second (PPS) output available
- Right angle MCX type, snap-on coaxial radio frequency (RF) jack
- Standard 2 x 5 pin input/output connector
- Operation over an extended temperature range: -40° C to +85° C
- Very small footprint: 66 x 40 x 4.5 mm

1.2 Description

The IBM Global Positioning Satellite (GPS) Receiver, IBM43GAENGP0002, is a single-board, twelve parallel-channel engine designed for OEM use. The GPS Receiver works with a wide variety of end products including hand-held, marine, and in-vehicle automotive devices.

The GPS Receiver processes signals from all the visible GPS satellites broadcasting radio frequency (RF) navigation information. “All-in-view” satellite tracking produces highly accurate, smoothed navigation data. The data is relatively immune to the position jumps that occur when fewer satellites are monitored. Designed to withstand harsh industrial environments, the GPS Receiver performs robustly in situations (such as dense urban areas) where extreme vehicle movement or high signal blockage are concerns.

When fewer than four satellites are available or when operating conditions require, the GPS Receiver supports 2D navigation. To calculate a fix while in 2D navigation mode, the receiver uses either the last altitude determined while in 3D navigation mode or data supplied by the user.

Satellite acquisition can be obtained under most initialization situations, as long as the receiver can ‘see’ the satellites. Rapid Time To First Fix (TTFF) is a feature of the twelve parallel-channel architecture of the IBM GPS Receiver. The flexible satellite acquisition system takes advantage of all available information to provide rapid TTFF even without user initiation. To minimize TTFF when primary power is removed from the receiver, a DC supply voltage maintains the Real Time Clock (RTC). This allows the GPS Receiver to use the prior position data and satellite information stored in the GPS Receiver’s flash memory.

The receiver has an independent, asynchronous serial input/output port that outputs navigation data and accepts commands in NMEA-0183 or IBM Binary message formats.

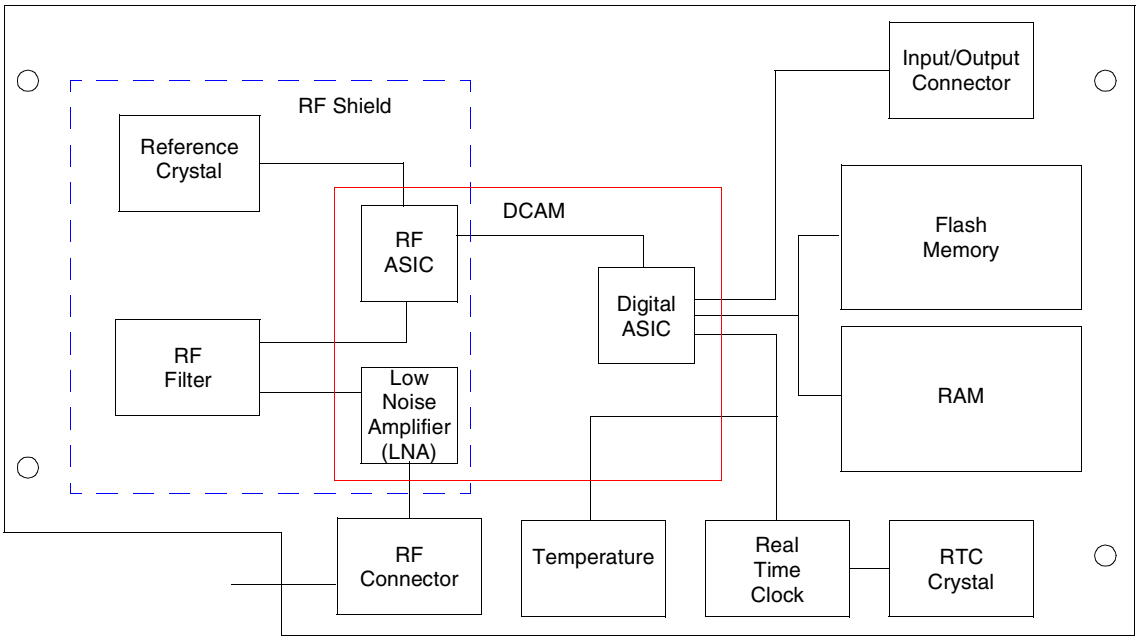
1.3 Ordering Information

Part Number	Product Name
IBM43GAENGP0002	IBM Global Positioning Satellite Receiver

1.4 Receiver Architecture

The functional architecture of the IBM GPS Receiver is shown in the block diagram below. The IBM GPS Receiver chip set includes all the radio frequency (RF) direct sampling and amplification circuitry. These circuits present both the sign (±) and magnitude of sampled data to the Digital ASIC. The Digital ASIC contains an integral microprocessor (401 PowerPC®) and all GPS signal processing hardware. Memory and other supporting components are needed to make a complete navigation system.

Figure 1: GPS Engine Block Diagram



1.5 Receiver Operation

The receiver requires 3.3 V DC primary input power.

The receiver's antenna must have visibility of the sky in order to acquire enough satellites to produce a navigation solution. While this is usually not a problem outdoors, operation indoors or in a vehicle may require that the antenna be located with an unobstructed view of the sky. If the satellites are blocked from the receiver's antenna, the receiver will take longer to acquire a position. If fewer than three satellites are available, the receiver may not be able to determine a valid position solution.

1.5.1 Signal Acquisition Modes

The IBM GPS Receiver supports the following three signal acquisition modes, depending on the availability of critical data:

Cold Start — In this mode, the receiver has valid almanac and frequency standard parameters available in memory. The receiver enters this mode on start-up when battery back-up power is not maintained.

Warm Start — In this mode, the receiver has the following valid data either available in memory or provided by the user at initialization: position, velocity, time, almanac, and frequency standard parameters. The receiver enters this mode on start-up when battery back-up power is maintained.

Hot Start — In this mode, the receiver has the following valid data available in memory: position, velocity, time, ephemeris, almanac, and frequency standard parameters. The receiver enters this mode following a software reset.

Table 1 below indicates the Time To First Fix (TTFF) when operating in each of the signal acquisition modes.

Table 1: Signal Acquisition Mode Performance

Acquisition Mode	Time to First Fix[1, 2] (seconds)	Initial Position Tolerance (3 Sigma)			Maximum Almanac Age (weeks)	Maximum Ephemeris Age (hours)
		Position (km)	Velocity (m/sec.)	Time (minutes)		
Cold Start	120	N/A[3]	N/A[3]	N/A[3]	1	N/A[3]
Warm Start	45	100	75	5	1	N/A[3]
Hot Start	15	100	75	5	1	4

1. 95% probability.
2. Times given are valid at 25° C with no signal blockage.
3. Not available in real time to the receiver.

1.5.2 Navigation Modes

The GPS Receiver supports two navigation modes: three-dimensional (3D) and two-dimensional (2D).

When four or more satellites are available with good geometry, the receiver will use the 3D navigation mode. See *Table 2: Standard Positioning Service (SPS) Navigational Accuracy* on page 4 for the 3D navigation mode accuracy.

When fewer than four GPS satellites are available, or when a fixed altitude can be used to produce an acceptable result, the GPS Receiver enters the 2D navigation mode. To calculate a fix in 2D navigation mode, the receiver uses either the last altitude determined in 3D navigation mode or data supplied by the user. In 2D navigation, navigational accuracy is primarily determined by the relationship of the fixed value of altitude to the true altitude of the antenna.

Table 2: Standard Positioning Service (SPS) Navigational Accuracy

Position (meters)			
Horizontal		3D	Vertical
Circular Error Probability (CEP)	Two Dimensional Root Mean Square (2D RMS)		
42	100 (95%)[1]	187 (95%)[1]	156 (95%)[1]

1. Percentage of time this accuracy is attained.

Full Horizontal position accuracy for C/A is 20 m CEP.

1.5.3 Power Modes

The IBM GPS Receiver has the following three power modes:

Off Mode The receiver is completely de-energized at all DC supplies, input signals, and control signals.

Operate Mode The receiver operates normally when energized by +3.3 ±.3 V DC. The RESET control signal must be at a CMOS logic “high” level.

Battery Backup Mode The receiver enters battery backup mode when the primary input power voltage is removed, provided an external DC supply is connected to the Real Time Clock (RTC) terminal. If the receiver is powered up in this mode, it uses the current time from the RTC and critical satellite data stored in flash memory to achieve rapid TTFF.

Caution:
During off and battery backup modes, de-energize the RESET pin and the serial port. Do not drive to a logic “high” level.

1.5.4 Power-up Sequence

Power-up works the same way from either the off mode or the battery backup mode. The host system supplies power as specified in *Table 3* below to the PWR pin of the GPS Receiver connector. If the RESET pin is at logic “high” when DC power is applied, the receiver begins normal operation in approximately 200 milliseconds.

Table 3: External Power Requirements

Power Parameter	Requirement by Mode	
	Operate Mode	Battery Backup Mode
Voltage	3.3 V DC ± 10%	1.0 to 3.0 V DC
Power Consumption (Typical)	250 mA	4 µA
Power Consumption (Maximum)	300 mA	10 µA
Ripple Peak-to-Peak (P-P)	100 mV	N/A

1.6 Technical Specifications

1.6.1 Signal Acquisition Performance

For more information, refer to *Table 1: Signal Acquisition Mode Performance* on page 3. Values are based on unobstructed satellite signals.

Accuracy	Accuracy is a function of the entire GPS system, including the geometry of the satellites at the time of measurement. Individual GPS receivers have very little influence over position accuracy. Navigational accuracies based on the Standard Positioning Service (SPS) are provided in *Table 2: Standard Positioning Service (SPS) Navigational Accuracy* on page 4. These figures are based on a geographic dilution of precision (GDOP) of 6.0.
Solution Update Rate	Once per second
Re-acquisition	Less than one second typical with a ten second blockage
Time Mark	Once per second (± 500 ns)
Serial Data Output Protocol	IBM Binary or NMEA-0183

1.6.2 Antenna Requirements

Frequency	1575 MHz ± 2 MHz
Antenna Gain	75 dBic typical at zenith
VSWR	1.2:1 typical 1.5:1 maximum (active)
Temperature	-40^{o} C to +95^{o} C
Filtering	-27.0 dB typical at ± 50 MHz
Noise Figure	1.5 dB maximum
Gain	33 dBic ± 2 dB (Cable loss of approximately .42 dB per foot is not included)
Voltage Protection	Zener diode limited

1.6.3 Power Requirements

The regulated power requirements are described in *Table 3: External Power Requirements* on page 4. When the GPS Receiver is operated with an active GPS antenna, the antenna's maximum pre-amp, pass-through current on V_ANT is 100 mA at voltages up to +12 V DC. Pass-through current must be limited outside the receiver.

1.6.4 RF Signal Environment

RF Input	1575.42 MHz (L1 band) at a level between -100 dBm and -133 dBm
RF Connector	50 Ω standard right-angle MCX snap-on coaxial RF jack

1.6.5 Physical Characteristics

Dimensions	66 mm x 40 mm x 4.5 mm with an MCX right-angle coaxial RF jack and a standard 2 x 5 pin-field input/output connector
Weight	18 grams

1.6.6 Environmental Requirements

Cooling (operating/storage)	Free air convection
Temperature (operating/storage)	-40° C to +85° C
Humidity	Relative humidity up to 95% non-condensing or a wet-bulb temperature of +35° C, whichever is less
Altitude	-1000 feet to +60,000 feet
Maximum Vehicle Dynamic	515 meters per second (acquisition and navigation)
Vibration and Shock	per MIL-STD-167
Jerk	5 m/s^3
Acceleration	4 G

1.6.7 Input/Output Signals

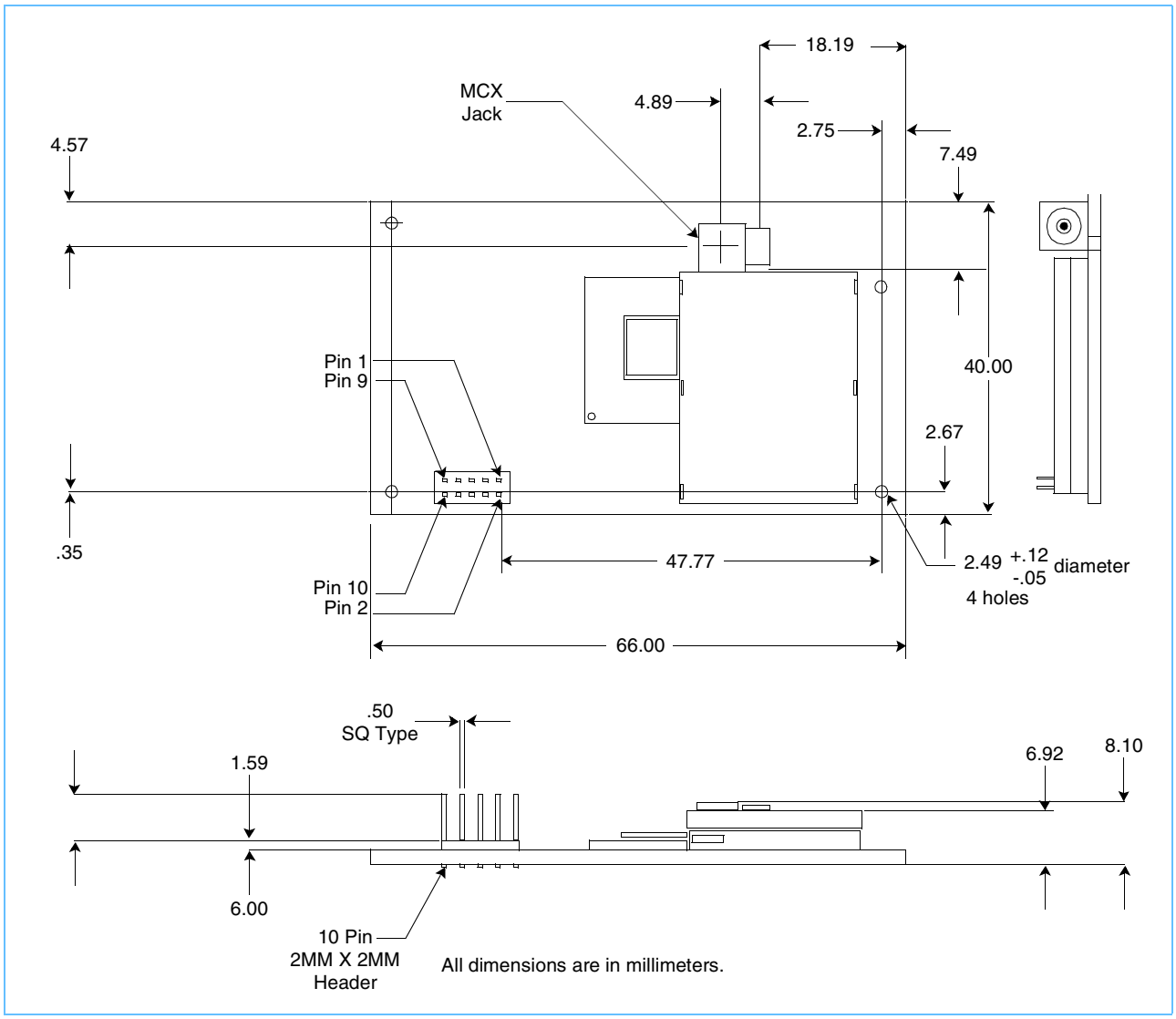
Refer to *Table 4*, below.

Table 4: Input/Output Connections

Pin Number	Signal Name	Description
1	PWR	Main power input to the receiver. Input power requirements are defined in *Table 3: External Power Requirements* on page 4.
2	GND	DC ground for the receiver.
3	TX1	Primary asynchronous full-duplex serial data port transmit (TX) line. IBM Binary and NMEA message protocols are supported. The default settings are: Message format IBM Binary Baud 19200 bps Parity None Data Bits 8 Stop Bit 1 For additional information, see the IBM GPS Receiver Evaluation Kit User Manual.
4	RX1	Primary asynchronous full-duplex serial data port receive (RX) line. IBM Binary and NMEA message protocols are supported. The default settings are: Message format IBM Binary Baud 19200 bps Parity None Data Bits 8 Stop Bit 1 For additional information, see the IBM GPS Receiver Evaluation Kit User Manual.
5	GPIO1	No connection. Reserved for general purpose input/output.
6	RX2	Auxiliary asynchronous serial data port receive (RX) line.
7	RESET	Pull low (GND) to generate a system reset. Must be held low for a minimum of 100 ns.
8	V_ANT	Provides a power connection to the pre-amp of the active antenna.
9	V_RTC	Provides a back-up power connection for the receiver's Real Time Clock. 1.0 to 3.0 V DC.
10	TMARK	UTC time-mark pulse, one pulse per second. An IBM Binary message contains the UTC time associated with the time-mark pulse.

1.6.8 Mechanical Layout

Figure 2: GPS Receiver Dimensions



1.7 Message Definitions

Table 5: IBM Binary Output Messages

Binary Message	Description	Default On
ONVD	Navigation Solution Data	Yes
OSAT	Visible Satellites	Yes
OCHS	Channel Status	Yes
ONOC	Navigation Operational Configuration	Once at Power-Up/Reset
ONVC	Navigation Validity Configuration	Once at Power-Up/Reset
ONPC	Navigation Platform Configuration	No
OCSC	Cold Start Configuration	Once at Power-Up/Reset
OEMA	Elevation Mask Angle Configuration	Once at Power-Up/Reset
ODTM	Map Datum Select	No
ODTU	User Datum Definition	No
OTMP	UTC Time Mark Pulse	Yes
OALD	Download Almanac Data	No
OEPD	Download Ephemeris Data	No
OUTD	Download UTC/IONO Data	No
OSHM	Satellite Health Masking Configuration	No
OSID	Receiver Software ID	Once at Power-Up/Reset
OBIT	Built-In-Test Results	No
OFSH	Command Flash Upload (ACK)	No
OFMS	Flash Memory Status	No

Table 6: IBM Binary Input Messages

Binary Message	Description
INIT	Navigation Initialization
INOC	Navigation Operational Configuration
INVC	Navigation Validity Configuration
INPC	Navigation Platform Configuration
ICSC	Cold Start Configuration
IEMA	Elevation Mask Angle Configuration
IDTM	Map Datum Select
IDTU	User Datum Definition
IALD	Command Almanac Upload
IEPD	Command Ephemeris Upload
IUTD	Command UTC/IONO Upload
ISHM	Satellite Health Masking Configuration
IRST	Command Reset

Table 6: IBM Binary Input Messages (Continued)

Binary Message	Description
IFSH	Command Flash Upload
ILOG	Message Log Control
IIOC	Input/Output Port Configuration
IMPC	Message Protocol Configuration
IBIT	Command Built-In-Test

Table 7: NMEA Output Messages

NMEA Message	Description	Default On
SID	Software Version (IBM Proprietary)	Once at Power-Up/Reset
GGA	GPS Fix Data	Yes
GLL	Geographic Position: Latitude/Longitude	No
GSA	GPS DOP and Active Satellites	Yes
GSV	GPS Satellites in View	Yes
RMC	Recommended Minimum Specific GPS/Transit Data	Yes
VTG	Track Made Good and Ground Speed	No
ZDA	Time and Date	No

Table 8: IBM Proprietary NMEA Input Messages

NMEA Message	Description
INT	Receiver Initialization
LOG	Message Log Control
IOC	Input/Output Port Configuration
MPC	Message Protocol Configuration
RST	Command Reset

Revision Log

Revision Date	Contents of Modification
October 1999	Initial release.
October 29, 1999	First Revision (01) Corrections to *Table 7: NMEA Output Messages* on page 10.
August 11, 2000	Second Revision (02). Revised section *1.1 Features* on page 1. - Added and deleted features. - Reorganized. Revised section *1.2 Description* on page 1. Rewritten. Replaced *Figure 1: GPS Engine Block Diagram* on page 2. Revised section *1.5 Receiver Operation* on page 2. - Renamed. - Defined Signal Acquisition Modes. Added section *1.6.2 Antenna Requirements* on page 5. Revised section *1.6.6 Environmental Requirements* on page 6. Revised *Table 4: Input/Output Connections* on page 7. Redrew *Figure 2: GPS Receiver Dimensions* on page 8. Replaced section *1.7 Message Definitions* on page 9. Made minor improvements to wording throughout.

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