THE POWER LINE COMMUNICATION MODEM SOLUTION

Overview

The SM2101 contains a complete packet data modem with the network protocol of ANSI/IEC 709.1/2 standards allowing the development of popular narrow band PLC networks. SM2101 is the modem only version of the SM6401 Power Line Communication (PLC) transceiver which utilizes the ultra reliable and versatile power line transceiver components of the SM6401, while eliminating the embedded Flash and application microcontroller (MCU) to provide a more cost effective solution for high volume PLC applications on low or medium voltage power line networks for uses such as smart metering and home automation. Combined with an external MCU (with a serial peripheral interface (SPI) connection and an interrupt request output), the SM2101 provides a cost-effective solution for data links and networks.

Benefits

- User selectable between BPSK modulation for noise immunity and compatibility to ANSI/EIA 709.1 and ANSI/EIA 709.2 devices and FSK modulation to allow high immunity to the phase distortion
- Approximates the amount of noise on a frequency by direct measurement and the signal strength of received packets
- No embedded user MCU allows for low cost PLC and user’s own MCU

Features

- Combines an ANSI/EIA 709.1 compliant core with an ANSI/EIA 709.2 compliant power line transceiver into a single chip
- Support CENELEC A, B and C band operation
- Medium metrics estimation
- Dual carrier frequencies from a choice of 8 programmable communication frequencies dynamically selectable with programmable bit rate from 5.4kbps to 1kbps
- Triple DES encryption / decryption
- Selectable BPSK and FSK modulation
- Forward Error Correction
- Very high tonal and impulse noise immunity
- A 32-bit EISC processor for ANSI/EIA 709.1 protocol firmware processing
- Receiver sensitivity of -80dBV
- SPI to user specified MCU
- Phase detection and mains zero crossing detection
- 3.3V supply
- 48-bit unique ID number in each chip

Communicates to existing ANSI/EIA 709.1 and ANSI/EIA 709.2 devices

Avoids interference on the power line by having a choice of two communication frequencies on which to transmit and receive data from a list of 8 factory preset frequencies

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Applications

These are a number of applications that the SM2101 is ideally suited for:

- Advanced Metering Infrastructure (AMR)
- Automated Meter Reading (AMI)
- Smart metering and smart grid
- Street lighting control
- Smart energy home area networking
- Home automation (HA)
- Building automation (BA)
- SCADA (Supervisory Control And Data Acquisition)

As can be seen in the diagram above SPI is used to interface the SM2101 to a host MCU in order to add communications connectivity to existing or new products. The advantage of the SM2101 is that communications will leverage the existing power line infrastructure for the communications channel. This leads to a cost reduction for a system implementation of one of the above examples compared to other communication solutions.

With the SM2101 not containing an embedded MCU for applications there is a reduction in the cost of adding power line communications to products and devices that already have a
**Power Line Transceiver**

**Carrier Frequencies**

The SM2101 programmable carrier frequencies are extremely flexible giving the user control of the communications channel without needing to change oscillator frequencies. Not only can the user choose between eight different carrier frequencies but they also can be controlled dynamically through software, even on a packet-by-packet basis.

This paves the way for dynamic frequency allocation according to the communications medium conditions. The eight frequencies are located within the CENELEC bands. The following table outlines the available carrier frequencies and the corresponding data rates.

<table>
<thead>
<tr>
<th>Carrier</th>
<th>Frequency</th>
<th>Bit Rate</th>
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<tbody>
<tr>
<td>F0</td>
<td>131.578 kHz</td>
<td>5482 bps</td>
</tr>
<tr>
<td>F1</td>
<td>113.636 kHz</td>
<td>4735 bps</td>
</tr>
<tr>
<td>F2</td>
<td>104.166 kHz</td>
<td>4340 bps</td>
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<tr>
<td>F3</td>
<td>94.339 kHz</td>
<td>3931 bps</td>
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<tr>
<td>F4</td>
<td>86.206 kHz</td>
<td>3592 bps</td>
</tr>
<tr>
<td>F5</td>
<td>79.365 kHz</td>
<td>3307 bps</td>
</tr>
<tr>
<td>F6</td>
<td>73.529 kHz</td>
<td>3063 bps</td>
</tr>
<tr>
<td>F7</td>
<td>67.567 kHz</td>
<td>2815 bps</td>
</tr>
</tbody>
</table>

Along with the communications medium metric estimation networks can dynamically determine the optimum communications frequencies to use for a particular installation. SM2101 nodes can communicate with other ANSI/EIA 709.1/2 based systems when either the F0 or F4 carriers are selected and all other relevant features are correctly configured. Please see ANSI/EIA 709.1/2 compatibility section for details.

**Selectable Modulation**

The SM2101 system allows the user to change modulation techniques between FSK and BPSK. This functionality is provided on the secondary channel and can be used as an extra level of redundancy. Abrupt impedance variation can make BPSK demodulation virtually impossible due to the fact that all of the information is encoded into the phase. The phase variation can look like valid data when demodulated. FSK is chosen due to its relatively high immunity to the phase distortion as well as its suitability for use on the power.
line. FSK and BPSK therefore complement each other by largely overcoming each other's weaknesses by configuring the primary channel to use BPSK and the secondary channel to use FSK. This configuration allows the SM2101 to automatically switch to the alternative modulation scheme on a packet by packet basis.

**Dual Receiver Transmitter Mode**

The SM2101 can operate on two different carrier frequencies simultaneously. These two transmission frequencies can be used for a variety of applications. In the case of other ANSI/EIA 709.2 based systems the secondary channel is superfluous and only used when communications on the primary are no longer possible. This could be due to particular devices on the power line jamming communications at the primary carrier frequency. With the dual channel mode enabled the last two retries of acknowledged service messages are sent using the secondary carrier frequency. This enables automatic enabling of the redundant carrier frequency. This enables automatic enabling of the redundant carrier frequency in an attempt to finish the data transmission transaction. All SM2101 nodes that wish to communicate in this fashion have to be configured for the same carrier frequencies in order to make communications possible. A minimum of two retries must be used in this mode so that the first packet sent will be tried on the primary channel and then the secondary channel will be used. Dual channel mode can also be used in applications where common channel repeating is needed. Parts of a network can be segregated into different frequencies in order to effectively isolate the communication channels. SM2101 nodes can then be configured to repeat packets across the different carrier frequencies. The two carrier frequencies can be configured as any of the eight frequencies outlined in the carrier frequencies section.

**Communication Medium Metric Estimation**

Each SM2101 has the ability to estimate two communications medium metrics. The first metric is an estimate of in-band noise level. Whilst idle a SM2101 node can acquire a 16-bit value, which approximates the amount of noise that is presented to the node within the transmission frequency. This in band noise metric is the received idle noise level averaged over a period of time. It is recommended that multiple readings are taken and averaged once again due to the large fluctuations of noise commonly seen on power lines. Generally the less noise (e.g. the lower the acquired in band noise metric) the more reliable communications will be. The second metric is an estimate of received signal strength. Each packet received can be interrogated for its estimated signal strength. This is very useful to determine the signal to noise ratio of different nodes on the network. It may be that the noise in a particular band is low but the signal is also attenuated significantly making data transmission unreliable. Network management systems can also interrogate each node for signal to noise ratios to create a database of all transmission path conditions. This produces a deterministic way of finding where repeaters are needed in a difficult environment even if they are dynamic.

**ANSI/EIA / CENELEC Medium Access Protocol**

The SM2101 has selectable medium access protocols to keep it in line with local regulatory bodies. SM2101 can be configured to use either the CENELEC or ANSI/EIA 709.1/2 access protocols. When CENELEC mode is selected it is compliant with the Access protocol outlined in the EN 50065-1:2001 standard, sub-clause 5. Maximum theoretical throughput is reduced whilst in this mode.

CENELEC outlines that every power line communications device must monitor the band from 131.5kHz to 133.5kHz and be able to detect the presence of a signal that is asserted for at least 4ms and of at least 86dBµVrms amplitude. A power line signalling device is permitted to transmit if the band-in-use (BIU) shows that the medium has been inactive for at least 85 milliseconds. Each device must then choose a random interval for transmission, and at least seven evenly distributed intervals must be available for random selection.

**Error Correction Mode**

Devastating noise on the power lines comes in many forms. Noise that is bursting or impulsive in nature can typically have the effect of destroying a whole byte of data. Most power line communication systems are unable to recover from such noise. If the noise is also repetitive in nature then communications may
never normally be possible. When error correction mode is enabled a SM2101 node has the ability to correct for multiple errors that would normally be unrecoverable in most other systems. When in this mode the data throughput rate is lowered by approximately 20%. Error correction can be enabled and disabled through software.

**Encryption Mode**

SM2101 possesses integrated Triple DES encryption/decryption hardware acceleration. Due to the power line being an open medium any individual has the ability to read transmitted packets. There is even the possibility of intercepting packets, then manipulating data to falsify information. SM2101’s strong encryption overcomes the problems of packet sniffing and manipulating data. Although the ANSI/EIA 709.1/2 protocol claims to have encryption it is not the case. The original message is transmitted “in the clear” when using ANSI/EIA 709.1/2 Authentication. SM2101’s encryption keys are field updateable to allow key rotation once significant amounts of data have been transferred.

**Variable BIU Threshold**

The CENELEC EN50065-1: 2001 standard, sub-clause 5 specifies that the Band-In-Use threshold level is set at an amplitude of 86dBµVrms. This level may not always be practical in many installations. Many environments contain noise levels that are in excess of this threshold level making reliable medium access impossible. It is for this reason that SM2101 offers a variable Band-In-Use threshold to accommodate the ambient noise levels of a wide range of installations, with programmable hysteresis.

**Mains Synchronization**

When the ACSYNC pin is connected in the correct manner a SM2101 node is able to synchronise to the phase of the AC power. Mains synchronisation can help in overcoming particular sources of noise on the power lines by transmitting at a user defined point of the AC power cycle.

**Phase Detection**

SM2101 has the ability to detect if two nodes are connected to the same phase. The SM2101 is able to provide the relative phase angle difference between the two nodes. The ACSYNC pin must be connected as described in the mains synchronisation configuration setting. The node must send a phase detection packet addressed to a remote node, the remote node will respond with the relative phase. This can be used in the field, as often in installations we are unable to ascertain if two power lines are on the same phase. Inter-phase communications are often difficult due to the large amounts of attenuation across phase couplings. During installation it is almost always best to communicate on the same phase.

**ANSI/EIA 709.1/2 Interoperability**

In their basic mode of operation, SM2101 nodes are compatible with other ANSI/EIA 709.1/2 based systems. Advanced features such as error correction and encryption must be turned off in order to enable communications with other ANSI/EIA 709.1/2 based systems.

To ensure interoperability with ANSI/EIA 709.1/2 devices SM2101 must be configured to use BPSK modulation and 132kHz (C-band). For compatibility with some other ANSI/EIA 709.1/2 derivative devices a carrier frequency of 86kHz (A-band) is also possible.

As SM2101 incorporates a dual channel transceiver it is possible to configure the primary channel as 132kHz and the secondary channel as 86kHz, or vice versa.
Contact Information

For more information regarding the SM2101 chips including technical data sheets, application notes, sample enquiries, demonstration modules, pricing and ordering please contact:

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Revision (110)

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