

# MCP3905A/06A Energy Meter Reference Design

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**NOTES:**


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# Preface

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**Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.**

**For the most up-to-date information on development tools, see the MPLAB® IDE on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.**

## INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP3905A/06A Energy Meter Reference Design. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Customer Support
- Document Revision History

## DOCUMENT LAYOUT

This document describes how to use the MCP3905A/06A Energy Meter Reference Design as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP3905A/06A Energy Meter Reference Design.
- **Chapter 2. "Installation and Operation"** – Provides a detailed description of each block, as well as instructions on how to get started with this board.
- **Appendix A. "Schematics and Layouts"** – Shows the schematic and board layout diagrams for the MCP3905A/06A Energy Meter Reference Design.
- **Appendix B. "Bill Of Materials (BOM)"** – Lists the parts used to build the MCP3905A/06A Energy Meter Reference Design.

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## CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

**DOCUMENTATION CONVENTIONS**

| Description | Represents | Examples |
|---|---|---|
| **Arial font:** | | |
| Italic characters | Referenced books | *MPLAB® IDE User's Guide* |
| | Emphasized text | ...is the *only* compiler... |
| Initial caps | A window | the Output window |
| | A dialog | the Settings dialog |
| | A menu selection | select Enable Programmer |
| Quotes | A field name in a window or dialog | "Save project before build" |
| Underlined, italic text with right angle bracket | A menu path | *File>Save* |
| Bold characters | A dialog button | Click **OK** |
| | A tab | Click the **Power** tab |
| N'Rnnnn | A number in verilog format, where N is the total number of digits, R is the radix and n is a digit. | 4'b0010, 2'hF1 |
| Text in angle brackets < > | A key on the keyboard | Press <Enter>, <F1> |
| **Courier New font:** | | |
| Plain Courier New | Sample source code | `#define START` |
| | Filenames | `autoexec.bat` |
| | File paths | `c:\mcc18\h` |
| | Keywords | `_asm, _endasm, static` |
| | Command-line options | `-Opa+, -Opa-` |
| | Bit values | `0, 1` |
| | Constants | `0xFF, 'A'` |
| Italic Courier New | A variable argument | *`file`*`.o`, where *`file`* can be any valid filename |
| Square brackets [ ] | Optional arguments | `mcc18 [options]` *`file`* `[options]` |
| Curly brackets and pipe character: { \| } | Choice of mutually exclusive arguments; an OR selection | `errorlevel {0\|1}` |
| Ellipses... | Replaces repeated text | `var_name [, var_name...]` |
| | Represents code supplied by user | `void main (void) { ... }` |


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## RECOMMENDED READING

This user's guide describes how to use MCP3905A/06A Energy Meter Reference Design. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

- **MCP3905 Data Sheet, *"Energy Metering IC with Active Real Power Pulse Output"* (DS21948)**

This data sheet provides detailed information regarding the MCP3905A device.

- **AN994 Application Note *"IEC Compliant Active Energy Meter Design Using The MCP3905A/06A"* (DS00994)**

This application note documents the design decisions associated with this reference design.

## THE MICROCHIP WEB SITE

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

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- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

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Technical support is available through the web site at: http://support.microchip.com

## DOCUMENT REVISION HISTORY

### Revision B (August 2009)

- Update from MCP3905/06 to MCP3905A/06A devices

### Revision A (July 2005)

- Initial Release of this Document


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# Chapter 1. Product Overview

## 1.1 INTRODUCTION

This chapter provides an overview of the MCP3905A/06A Energy Meter Reference Design and covers the following topics:

- What is the MCP3905A/06A Energy Meter Reference Design?
- What the MCP3905A/06A Energy Meter Reference Design Kit includes

## 1.2 WHAT IS THE MCP3905A/06A ENERGY METER REFERENCE DESIGN

The MCP3905A/06A Energy Meter Reference Design device is an energy metering IC that supplies *average active power* information via a pulse output with direct drive for mechanical counters. It also includes a higher-frequency output that supplies instantanous power information for calibration. The device contains function blocks specific for IEC energy meter compliance, such as a no-load threshhold and startup current.

The MCP3905A/06A Energy Meter Reference Design Printed Circuit Board (PCB) is used as a reference design for single-phase, residential meters. The MCP3905A/06A Energy Meter Reference Design kit includes all necessary PCB circuits and layout tips for IEC62053 and prior 1036/61036/687 active-energy meter standards compliance. For more information regarding IEC compliance, refer to AN994, *"IEC Compliant Active Energy Meter Design Using The MCP3905A/06A Energy Meter Reference Design"* (DS00994).

## 1.3 WHAT THE MCP3905A/06A ENERGY METER REFERENCE DESIGN KIT INCLUDES:

This MCP3905A/06A Energy Meter Reference Design kit includes:

- MCP3905A/06A Energy Meter Reference Design, 102-00037
- Important Information Sheet

**NOTES:**


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# Chapter 2. Installation and Operation

## 2.1 INTRODUCTION

The MCP3905A/06A Energy Meter Reference Design is a stand-alone, single-phase residential meter design for active-energy meter designs. For advanced microcontroller-based meter products, this design also serves as the design of the Analog Front-End (AFE). This design includes a low-cost DC power supply circuit and the necessary protection for IEC62053 EMC compliance.

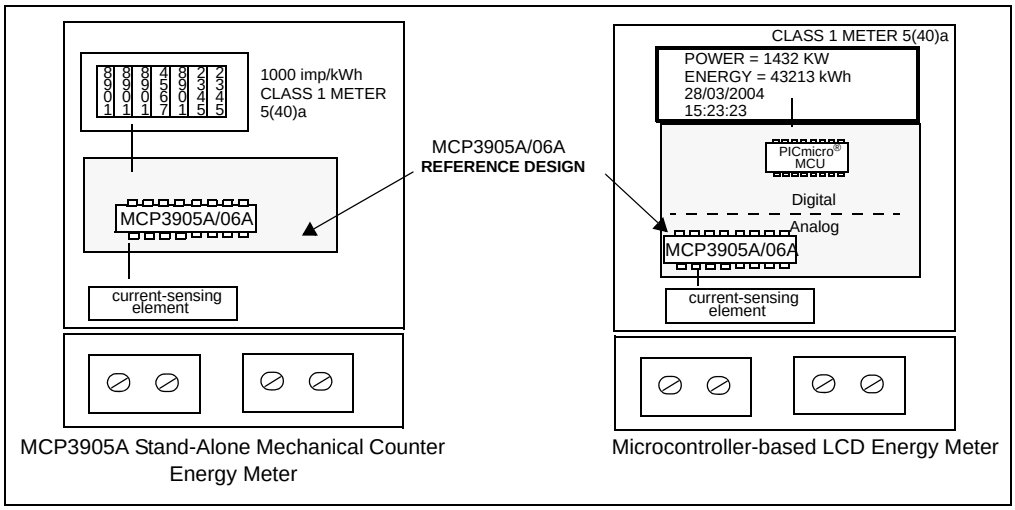



***FIGURE 2-1:*** *MCP3905A Stand-Alone Energy Meter and Microcontroller-Based Energy Meter Using MCP3905A AFE Design.*

For more detailed information regarding design decisions and an approach to IEC62053 compliance using the circuitry in this board, refer to AN994 *"IEC Compliant Active Energy Meter Design Using The MCP3905A/06A"* (DS00994).

## 2.2 FEATURES

The MCP3905A/06A Energy Meter Reference Design PCB has the following features:

- Protection for IEC62053 Energy Meter EMC Immunity Tests
- On-Board DC power supply
- Resistor divider circuit for single-point meter calibration
- Connections for current-sensing shunt or other current sensing element
- Connection for voltage-sensing and power supply biasing
- Connections for mechanical counter and calibration output
- Low-noise PCB layout for small-signal conversion and IEC62053 accuracy compliance for small shunt values
- Low-cost design

## 2.3 GETTING STARTED

This meter can be manufactured by performing the following two steps detailed in this document. For the external connections, the following terms are used: “phase” refers to the hot (or line) side of the power supply lines. “Neutral” refers to the return wire (or low-side) of the power supply lines.

### 2.3.1 External Connections

Connections are made to the phase and neutral wire for voltage-detection and AC/DC power supply. The MCP3905A/06A Energy Meter Reference Design is designed to be biased to the phase (or hot) side of a 2-wire power supply system.

1. Connect JP4 to the phase power supply line connection.
2. Connect JP3 to the neutral line.
3. Connect JP1 and JP2 across the shunt.
4. Connect JP5 and JP6 to the mechanical counter.

### 2.3.2 Calibration of the Frequency Output using the Voltage Divider Calibration Circuit

Each meter must be calibrated using the voltage divider circuit going into Channel 1 of the MCP3905A/06A. A known power is supplied to the meter (e.g., 1000W), and an expected output frequency is the goal (1000 imp/kWh). Start with the highest value resistor and short the resistor using it's respective shorting jumper. If the output frequency is too high, remove the shunt. Continue testing each resistor short until all jumpers are tested once. For more detailed information regarding meter calibration and the PCB design approach using the circuitry in this document, refer to AN994, *“IEC Compliant Active Energy Meter Design Using The MCP3905A/06A”* (DS00994).

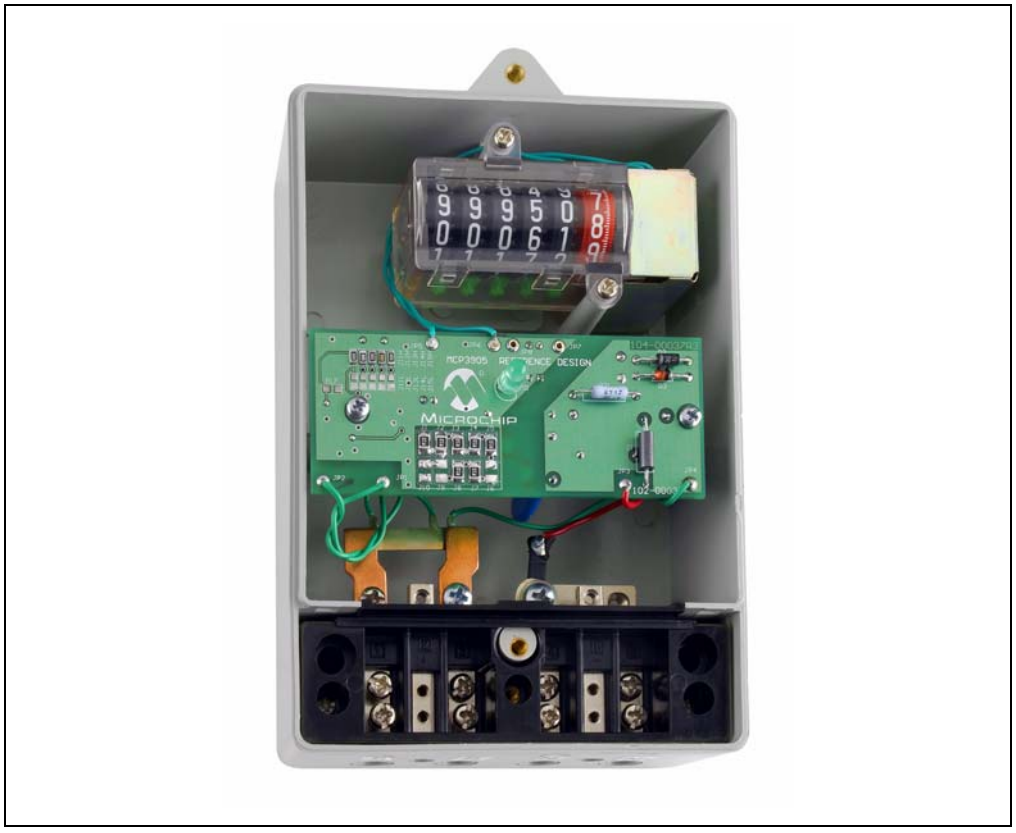


***FIGURE 2-2:*** *Photograph of Complete, Stand-Alone MCP3905A Energy Meter.*


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## 2.4 ENERGY METER REFERENCE DESIGN OVERVIEW

This reference design can be used as either a stand-alone mechanical counter energy meter, or as the analog front-end design in advanced microcontroller-based meter designs.

The AFE design limits the overall meter accuracy. A low noise, proven AFE circuit and layout is still required for a high-accuracy meter. For both meter types, the current sense input, voltage sense input, calibration scheme, jumper selection and power supply design blocks described here should apply.

This reference design keeps all of the major components on the back-side of the PCB. This minimizes any ill effects from the environment in the situation that a meter case experiences failure. Only the necessary components for calibration, jumper selection and external connections are placed on the front-side of the board. Keeping the larger DC power supply components on the back-side of the board is also necessary for installation in some meter cases with PCB standoffs.

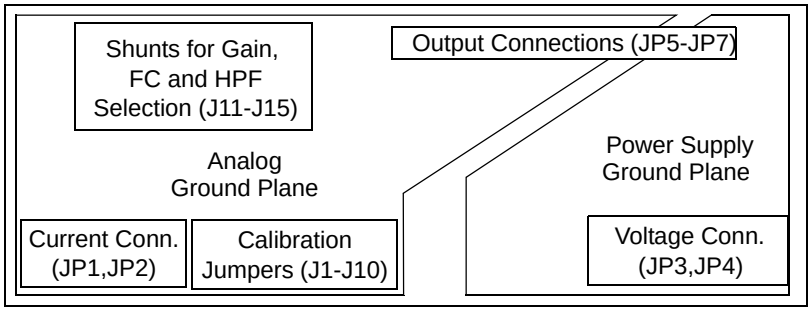
The major components on the front-side of the MCP3905A/06A Energy Meter Reference Design are listed here and described in **Section 2.5 “Front-Side Of PCB Detailed Description”**.

1. Shunts for Gain, FC and HPF selection (J11-J15).
2. Calibration jumpers (J1-J10).
3. Output connections for mechanical counter and calibration (JP5-JP7).
4. Input connection from the current-sensing element (JP1,JP2).
5. Input connection from voltage or phase line and ground reference point (JP3,JP4).
6. The analog ground plane, power supply ground plane, moat.

The major components on the back-side of the MCP3905A/06A Energy Meter Reference Design are listed here and described in **Section 2.6 “Back Side Of PCB Detailed Description”**.

1. MCP3905A (U1).
2. DC Power Supply (C17, C16, U2, C18, etc.).
3. Metal Oxide Varistor (MOV1).
4. Optical isolator for PIC® Microcontroller Unit (MCU) or calibration (U3).

These blocks, and their functionality, will be briefly described in the following two sections. For more detailed information regarding design decisions and approaches to IEC1036 compliance, refer to AN994, *“IEC Compliant Active Energy Meter Design Using The MCP3905A/06A”* (DS00994). For a more detailed circuit schematic, refer to **Appendix A. “Schematics and Layouts”** and **Appendix B. “Bill Of Materials (BOM)”**.



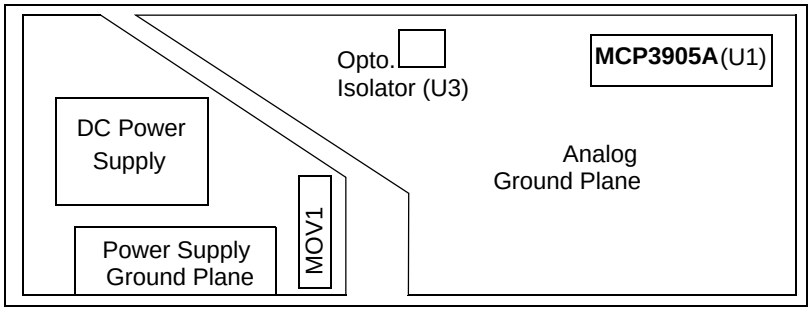




***FIGURE 2-3:*** *MCP3905A/06A Energy Meter Reference Design Block Diagram.*

## 2.5 FRONT-SIDE OF PCB DETAILED DESCRIPTION

### 2.5.1 Shunts for Gain and FC Selection (J11-J15)

Positions for both logic-high and logic-low are here for all gain and frequency constant selections. The logic-high positions are labeled “J1H” and the logic-low positions are labeled “J1L” (Jumper 1 used here as an example). Do not short both the high and the low positions for any one jumper.

### 2.5.2 Calibration Jumpers (J1-J10)

Calibration resistors for each of these jumper locations are located directly beneath the associated jumper. When a shorting resistor or jumper is in place, the associated calibration resistor is shorted and bypassed.

### 2.5.3 Output Connections for Mechanical Counter and Calibration (JP5-JP7)

JP5 and JP6 are the differential output drive for the mechanical counter.

JP7 is the calibration or microcontroller output that is connected to $HF_{OUT}$ on the MCP3905A/06A devices. A LED is supplied to assist in any optical calibration schemes.

### 2.5.4 Connection to Current-Sensing Element (JP1,JP2)

These two connections lead directly through LRC filtering into Channel 0 of the MCP3905A/06A. The schematic in Appendix A uses a low-cost shunt as the current-sensing element. The shunt resistance should be placed in parallel with these two connections, between JP1 and JP2.


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### 2.5.5 Connection to Voltage or Phase Line and Ground Reference Point (JP3,JP4)

These two connections feed the DC power supply circuitry described in **Section 2.6.3 "Metal Oxide Varistor (MOV1)"**. JP4 is connected to the ground of the PCB, and JP3 to the high-side of the DC power supply circuitry. JP3 is also connected to the resistor divider that feeds the analog input of Channel 1 of the MCP3905A/06A. This is the channel for measuring voltage and is connected to the differential input in a single-ended fashion. See **Appendix A. "Schematics and Layouts"** for further detail.

## 2.6 BACK SIDE OF PCB DETAILED DESCRIPTION

### 2.6.1 MCP3905A (U1)

From the back side of the board, the MCP3905A/06A is located on the right hand side where the analog ground plane exists. The MCP3905A/06A has appropriate bypass capacitors on $V_{DD}$ coming from the DC power supply circuitry. The MCP3905A/06A has its input logic pins connected to user-selectable jumpers, with the exception of the HPF pin. For this system, the HPF is turned on with this pin connected to $V_{DD}$; the device is in AC mode only. The NEG connection is not connected in this reference design; this pin should be left floating. The other three output pins ($F_{OUT0}$, $F_{OUT1}$, $HF_{OUT}$) are connected to nodes JP5, JP6 and JP7 described later in this section.

### 2.6.2 DC Power Supply (C17, C16, U2, C18, D2)

The DC power supply is created from a half-wave zener diode limited AC signal feeding a 7805 +5V regulator. C17 and C16 divide the AC signal coming directly from the line and designed in this document for 220V. The zener diode D2 limits the peak voltage to 15V.

### 2.6.3 Metal Oxide Varistor (MOV1)

A MOV is included to suppress any high voltage transients coming through the power lines.

### 2.6.4 Optical Isolator (U3)

An optical isolator is included in the reference design as an additional level of protection for other circuitry used in advanced meter designs (PICmicro® microcontroller, DSP or otherwise). It is connected to the $HF_{OUT}$ frequency output of the MCP3905A. Depending on the meter design, it may not be required. This design is a direct-connect meter that has the entire PCB referenced to the phase or line-side of the power supply. Therefore, any other circuitry would either need to be biased to the same point or isolated using this scheme. A pull-up resistor is required on the output of the optical isolator to allow the HF logic signal to appear.

### 2.6.5 The Analog Ground Plane, Power Supply Ground Plane, Moat.

The MCP3905A/06A Energy Meter Reference Design PCB is designed for low-noise performance and immunity to external influences, as required by IEC61036. The DC power supply and digital outputs are connected to the power supply ground plane (right-side of the board when looking at it from the front). The lower noise analog ground plane, including the MCP3905A/06A connections, is on the opposite side of the board, separated by a moat between the two ground planes. An inductive choke connects the two grounds.

**NOTES:**


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# Appendix A. Schematics and Layouts

## A.1 INTRODUCTION

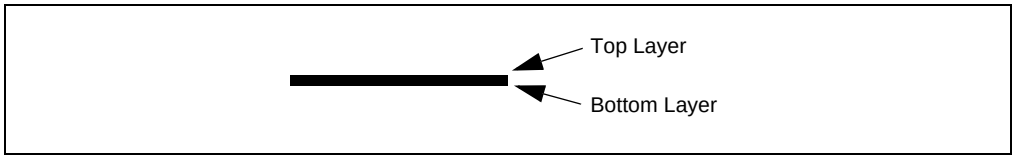
This appendix contains the following schematics and layouts for the MCP3905A/06A Energy Meter Reference Design:

- Board Schematic
- Board – Top Layer
- Board – Bottom Layer

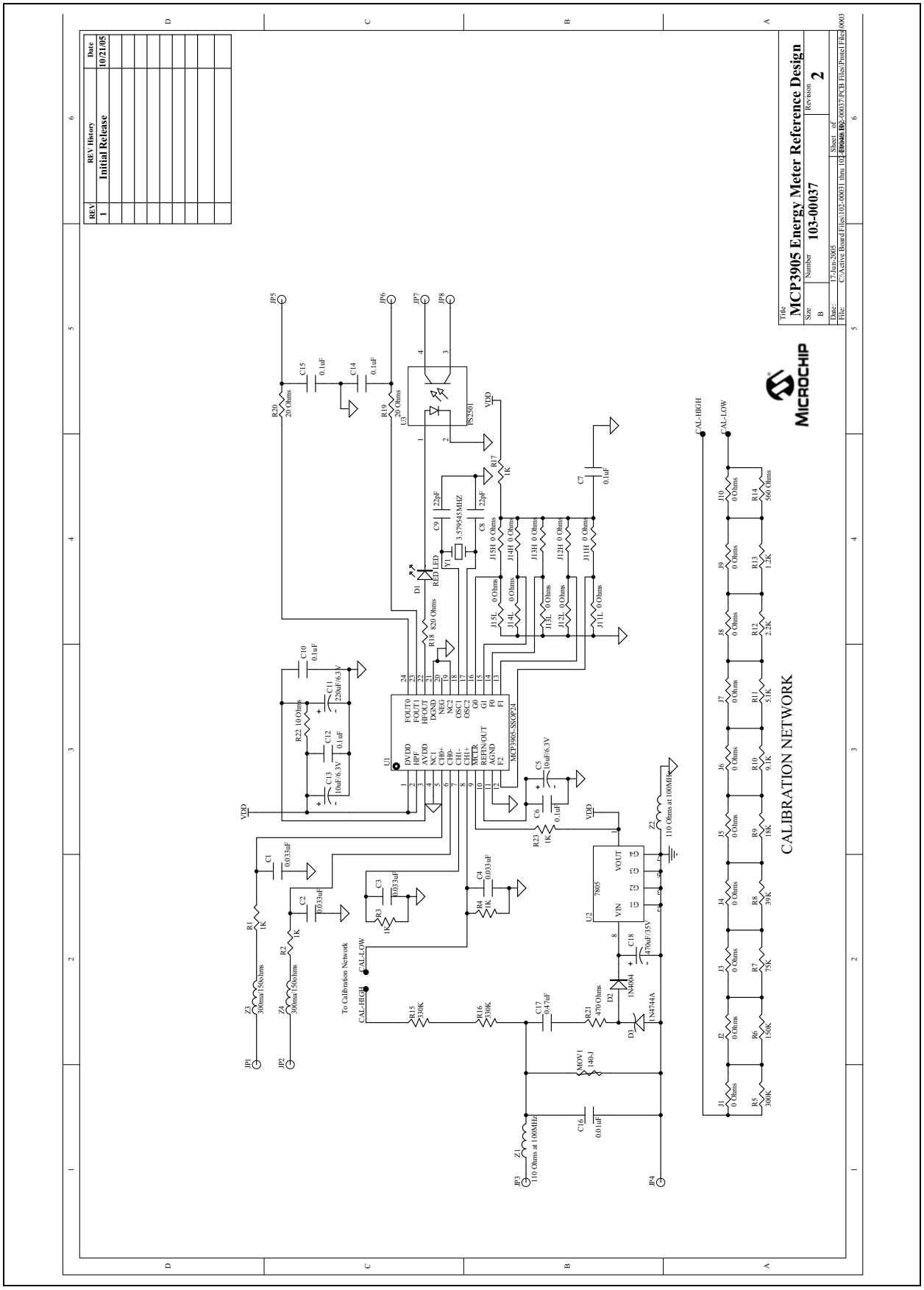
## A.2 SCHEMATICS AND PCB LAYOUT

The layer order is shown in Figure A-1.

**FIGURE A-1: LAYER ORDER**



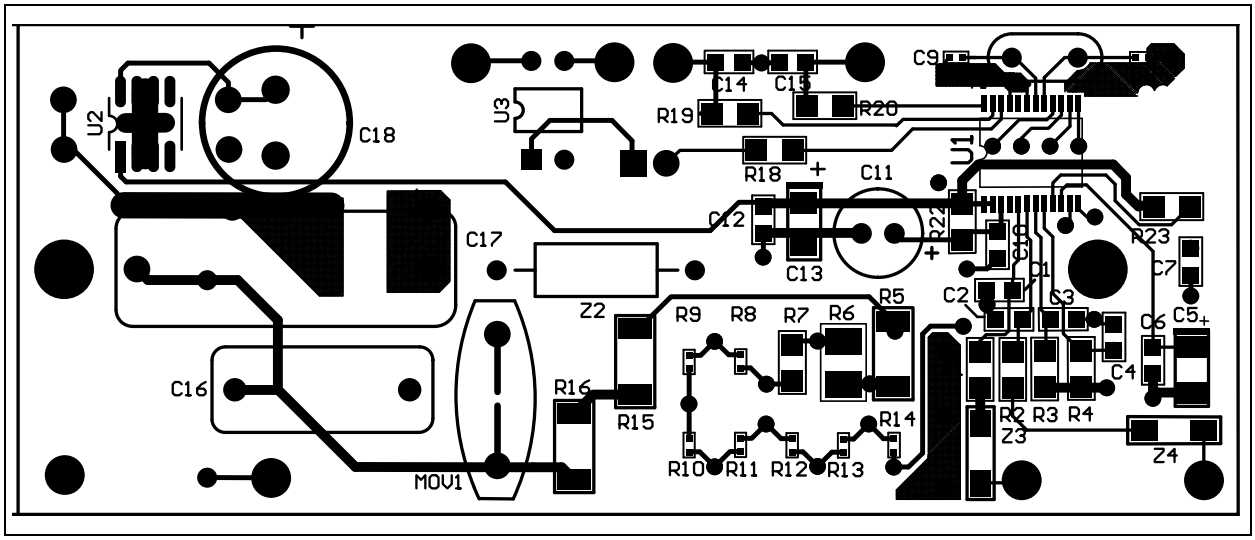
## A.3 BOARD SCHEMATIC



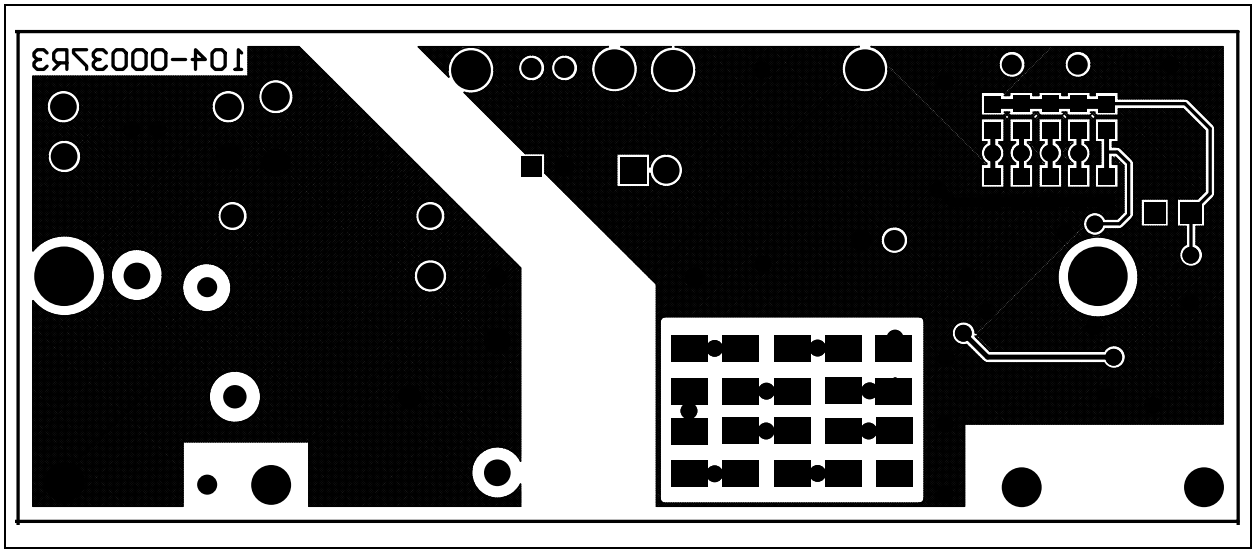


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## A.4 BOARD LAYOUT – TOP LAYER




## A.5 BOARD LAYOUT – BOTTOM LAYER



**NOTES:**


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# Appendix B. Bill Of Materials (BOM)

**TABLE B-1: BILL OF MATERIALS (BOM)**

| Qty | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 4 | C1, C2, C3, C4 | CAP 33000PF 50V CERM X7R 0805 | Panasonic® - ECG | ECJ-2VB1H333K |
| 2 | C5, C13 | CAPACITOR TANT 10UF 6.3V 20% SMD | Kemet® Electronics Corp. | T491A106M006AS |
| 6 | C6, C7, C10, C12, C14,C15 | CAP .1UF 16V CERAMIC X7R 0805 | Panasonic - ECG | ECJ-2VB1C104K |
| 2 | C8, C9 | CAP 22PF 50V CERAMIC 0402 SMD | Panasonic - ECG | ECJ-0EC1H220J |
| 1 | C11 | CAP 220UF 10V ELECT FC RADIAL | Panasonic - ECG | EEU-FC1A221S |
| 1 | C16 | 01UF INTERFERFENCE METAL CAP | Panasonic - ECG | ECQ-U2A103MN |
| 1 | C17 | 47UF/630VDC METAL POLY CAP | Panasonic - ECG | ECQ-E6474KF |
| 1 | C18 | CAP 470UF 35V ELECT FC RADIAL | Panasonic - ECG | EEU-FC1V471 |
| 1 | D1 | LED GREEN DIFFUSED ROUND LONG | Panasonic - SSG | LN31GPH |
| 1 | D2 | RECTIFIER GPP 400V 1A DO-41 | Diodes Inc. | 1N4004-T |
| 1 | D3 | DIODE ZENER 15V 1W 5% DO-41 | Diodes Inc. | 1N4744A-T |
| 10 | J1-J10 | RES .1 OHM 1/4W 5% 1210 SMD | Panasonic - ECG | ERJ-14RSJR10U |
| 5 | J11H, J12H, J13H, J14H, J15H | RES 0.0 OHM 1/8W 5% 0805 SMD | Panasonic - ECG | ERJ-6GEY0R00V |
| 5 | J11L, J12L, J13L, J14L, J15L | Do Not Populate | — | — |
| 8 | JP1--JP8 | PIN RECPT .032/.046 DIA 0328 SER | Mill-Max® Manufacturing Corp. | 0328-0-15-15-34-27-10-0 |
| 1 | MOV1 | Suppressors;Clamping Voltage Maximum:710V | EPCOS | SIOV-S20K275 |
| 1 | PCB | RoHS Compliant Bare PCB, MCP3905A/06A Energy Meter Reference Design | — | 104-00037 |
| 5 | R1-R4, R23 | RES 1.00K OHM 1/8W 1% 1206 SMD | Panasonic - ECG | ERJ-8ENF1001V |
| 1 | R5 | RES 300K OHM 1/2W 5% 2010 SMD | Panasonic - ECG | ERJ-12ZYJ304U |
| 1 | R6 | RES 150K OHM 1/4W 5% 1210 SMD | Panasonic - ECG | ERJ-14YJ154U |
| 1 | R7 | RES 75K OHM 1/4W 5% 1206 SMD | Panasonic - ECG | ERJ-8GEYJ753V |
| 1 | R8 | RES 39K OHM 1/16W 5% 0402 SMD | Panasonic - ECG | ERJ-2GEJ393X |
| 1 | R9 | RES 18K OHM 1/16W 5% 0402 SMD | Panasonic - ECG | ERJ-2GEJ183X |
| 1 | R10 | RES 9.1K OHM 1/16W 5% 0402 SMD | Panasonic - ECG | ERJ-2GEJ912X |
| 1 | R11 | RES 5.1K OHM 1/16W 5% 0402 SMD | Panasonic - ECG | ERJ-2GEJ512X |
| 1 | R12 | RES 2.2K OHM 1/16W 5% 0402 SMD | Panasonic - ECG | ERJ-2GEJ222X |
| 1 | R13 | RES 1.2K OHM 1/16W 5% 0402 SMD | Panasonic - ECG | ERJ-2GEJ122X |

**Note 1:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

**TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)**

| Qty | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | R14 | RES 560 OHM 1/16W 5% 0402 SMD | Panasonic - ECG | ERJ-2GEJ561X |
| 2 | R15, R16 | RES 330K OHM 1/2W 5% 2010 SMD | Panasonic - ECG | ERJ-12ZYJ334U |
| 1 | R18 | RES 820 OHM 1/4W 5% 1206 SMD | Panasonic - ECG | ERJ-8GEYJ821V |
| 2 | R19, R20 | RES 20 OHM 1/4W 5% 1206 SMD | Panasonic - ECG | ERJ-8GEYJ200V |
| 1 | R21 | RES 470 OHM 1W 5% METAL OXIDE | Panasonic - ECG | ERG-1SJ471 |
| 1 | R22 | RES 10 OHM 1/4W 5% 1206 SMD | Panasonic - ECG | ERJ-8GEYJ100V |
| 1 | U1 | Energy Metering Device | Microchip Technology Inc. | **MCP3905A-I/SS** |
| 1 | U2 | IC VOLT REG 5V 100MA 8-SOIC | National Semiconductor® | LM78L05ACM |
| 1 | U3 | 1 CHANNEL OPTO COUPLER TRANS DIP | NEC | PS2501-1 |
| 1 | Y1 | CRYSTAL 3.579545MHZ 17PF HC49/US | ECS Inc | ECS-35-17-4 |
| 2 | Z1, Z2 | BEAD CORE SINGLE 3.5X9MM AXIAL | Panasonic - ECG | EXC-ELSA39 |
| 2 | Z3, Z4 | FERRITE 300MA 150 OHM 1806 SMD | Steward® Inc. | LI1806C151R-10 |

**Note 1:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.


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**NOTES:**

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