INTRODUCTION

This paper discusses the EMI results of the PIC16C54A. These measurements were taken by an independent consulting firm that specializes in electromagnetic testing. These results are for a specific system design, each design will have its own results.

DEVICES USED

These tests were done on a randomly selected PIC16C54A device, and should be considered as typical results. Initial testing was done on three boards/devices. The device frequency of the boards were, respectively, 32 kHz, 4 MHz, and 20 MHz. As would be expected there was a substantial difference in EMI levels (decrease) at the low frequency as compared to the higher frequencies. The difference between the 4 MHz operation and the 20 MHz operation was marginal. The final testing of the device was done at 4 MHz, and was according to the FCC measurement procedure MP-4.

SYSTEM USED

The PIC16C54A device was tested in the Microchip OHMMETER board. This board is a three layer board, with a ground plane. Power and ground planes greatly help in the compliance of designs to the FCC part 15 subpart B testing. This board had minimal external components, so that the electromagnetic measurements could mostly be attributed to the device and design of the system. To reduce the noise that comes from a power supply, a 10 nF bypass capacitor was attached to the power / ground of the input jack.

EMI TESTING

The testing of electromagnetic noise (EMI) on a system has two types of commonly used testing environments, internal and external. The internal test is performed in a screen room to reduce the amount of stray EMI. The indoor test is useful in determining the source of EMI radiation. The external test is performed outdoors. This places the equipment under test in an environment to measure radiated emissions (EMI). The FCC only requires the outdoor testing of devices. The Equipment Under Test (EUT) was positioned to maximize the emissions.

INTERNAL TESTS

The Equipment Under Test (EUT) was placed on a wooden test bench, inside a screen room, 0.8 meters above the earth ground plane (Figure 1). The EUT was powered through the Line Impedance Stabilization Network (LISN) bonded to the ground plane. The LISN power was filtered and the filter was bonded to the ground plane. The EUT was positioned on the table with the minimum distance from any conductive surface, as specified in MP-4. The excess power cord was wrapped in a figure-8 pattern to form a bundle approximately 8 cm in length. The EUT configuration was set for the highest emission frequency, and data was collected under the program control of the host computer. The spectrum analyzer collected the maximum peak readings over each spectrum. The six highest emission levels and corresponding frequencies were sorted and are listed in Table 1.

### TABLE 1: CONDUCTED EMISSIONS RESULTS

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Emission Level dBBμV</th>
<th>Emission Level μV</th>
<th>Specification Limit μV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5345</td>
<td>33.2</td>
<td>46</td>
<td>250</td>
</tr>
<tr>
<td>7.085</td>
<td>33.1</td>
<td>45</td>
<td>250</td>
</tr>
<tr>
<td>10.08</td>
<td>33.1</td>
<td>45</td>
<td>250</td>
</tr>
<tr>
<td>10.42</td>
<td>33.3</td>
<td>46</td>
<td>250</td>
</tr>
<tr>
<td>11.62</td>
<td>33.4</td>
<td>47</td>
<td>250</td>
</tr>
<tr>
<td>13.41</td>
<td>33.8</td>
<td>49</td>
<td>250</td>
</tr>
</tbody>
</table>
While in the screen room additional analyses on the device were done. First a local probe was used to test the emission levels around the board and device. There were no measurable emissions at the I/O pins or their corresponding trace lines. Emissions were measured at the jack to the power supply. The power supply and cord were the greatest source of emissions for the EUT. This is due to the power cord being an antenna which emitted the noise from the power supply. Designers should attempt to minimize antennas which emit EMI. Antennas could be the power supply cord, as well as traces on the system board.

Second the PIC16C54A was monitored for susceptibility, following the IEC 801-3 specification. This test was measured from 27 MHz to 500 MHz in 10 kHz steps. The device did not display any signs of susceptibility (Table 2).

**EXTERNAL TESTS**

The open field site used for radiated emission testing was set up according to FCC bulletin OST 55.

Figure 2 shows the layout of the open field test site. The EUT was mounted on a turntable. The position of the turntable was remotely controlled to determine the highest emission levels. Initial testing was done with a broad band mounted on the antenna mast at a distance of 3 meters. Further investigation was done to determine the EUT positions that produced the maximum level of emissions. The receiving antenna was mounted on the antenna mast. The antenna height was varied to find the highest level of radiated emissions at each frequency. The six highest emission levels and corresponding frequencies were sorted and are listed in Table 3. Figure A-1 and Figure A-2 show the dBμV vs. MHz graphs.

**TABLE 2: RADIATED SUSCEPTIBILITY**

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>SPEC V/M</th>
<th>Threshold V/M</th>
<th>Modulation</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.0 - 500.0(1)</td>
<td>3.0</td>
<td>&gt; 3.0</td>
<td>80%</td>
<td>No Susceptibility</td>
</tr>
</tbody>
</table>

† Frequency incremented in 10 kHz steps

**TABLE 3: RADIATED EMISSIONS RESULTS**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Meter Reading (dBμV)</th>
<th>Antenna Factor dB</th>
<th>Effective Gain dB</th>
<th>Distribution Factor dB</th>
<th>Corr. Rdg. dBμV/m</th>
<th>Corr. Rdg. μV/m</th>
<th>Spec Limit μV/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>36.01</td>
<td>53.1</td>
<td>11.8</td>
<td>34.0</td>
<td>0</td>
<td>30.9</td>
<td>35</td>
<td>100</td>
</tr>
<tr>
<td>40.04</td>
<td>53.0</td>
<td>11.3</td>
<td>34.2</td>
<td>0</td>
<td>30.1</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>44.04</td>
<td>56.1</td>
<td>11.1</td>
<td>34.0</td>
<td>0</td>
<td>33.2</td>
<td>46</td>
<td>100</td>
</tr>
<tr>
<td>48.04</td>
<td>55.1</td>
<td>11.0</td>
<td>33.7</td>
<td>0</td>
<td>32.4</td>
<td>42</td>
<td>100</td>
</tr>
<tr>
<td>64.05</td>
<td>55.2</td>
<td>9.0</td>
<td>33.9</td>
<td>0</td>
<td>30.3</td>
<td>33</td>
<td>100</td>
</tr>
<tr>
<td>112.05</td>
<td>56.0</td>
<td>10.6</td>
<td>33.4</td>
<td>0</td>
<td>33.2</td>
<td>46</td>
<td>150</td>
</tr>
</tbody>
</table>
FIGURE 1:

EMISSION (dBµV/m) | PEAK  | 30 Sep 1993 03:43:20
---|---|---
90 | RADIATED EMISSIONS 30-250 MHz
70 | MICROCHIP W/0.1 µF CAP +5 - GND
50 | ANT. 130 cm HIGH
30 | DIS. 1M ANT. HORIZONTAL
10 | FCC CLASS B

FIGURE 2:

EMISSION (dBµV/m) | PEAK  | 30 Sep 1993 05:31:35
---|---|---
90 | RADIATED EMISSIONS 250-1000 MHz
70 | MICROCHIP W/0.1 µF CAP +5 - GND
50 | ANT. 130 cm HIGH
30 | DIS. 1M ANT. HORIZONTAL
10 | FCC CLASS B

FREQUENCY (MHz)

30 Sep 1993 03:43:20 PEAK EMISSION (dBµV/m)
30 Sep 1993 05:31:35 PEAK EMISSION (dBµV/m)
CONCLUSION

The PIC16C54A device can be implemented into system designs that are required to be certified to the FCC Class B specification limits as defined by the FCC Title 47, Part 15 Subpart B and IEC 801-3 susceptibility.

APPENDIX A: TEST SETUPS

FIGURE A-1: CONDUCTED EMISSIONS TEST SETUP FOR SITE “A”

EUT 80 cm away from the LISNs. Rear of table 40 cm from wall.

Wooden Test Bench (1 x 1.5m)

To Spectrum Analyzer
FIGURE A-2: RADIATED EMISSIONS TEST SETUP FOR SITE “B”

Test Equipment

Test Facility Building

X = Copper rods used for grounding
D = Test Distance

*Non-Conductive Equipment Cover

Open Land

Conductive Ground Plane Boundary

Open Area Required by OST-55

EUT

Antenna Mast

\[ d = \sqrt{3}D \]
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- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the PICmicro microcontroller in a manner outside the operating specifications contained in the data sheet. The person doing so may be engaged in theft of intellectual property.
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