PMU Test Platform

Nuno Canto Brum
† Instituto Superior Técnico, Av Aníbal Cavaco Silva, 2744-016 Porto Salvo, Portugal
Phone: +351-939529676, e-mail: nuno.brum@gmail.com

Abstract — In this paper is described the development of a Automated Test Platform (ATP) focused on power management prototypes. The types of measurement applicable to Power Management and their test methodologies are described. The architecture of the ATP is presented as well as the schematic solutions for the power driving, and loading circuits. The automation process and data manipulation are also discussed.

I. INTRODUCTION

The test of Power Management Units is nowadays a very labor intensive task taking several weeks before a full characterization of a Power Management unit is done. This project proposes to develop an Automatic Test Equipment devoted to speed-up the prototype characterization of DC power management units, minimizing the need of external equipment. Although this work was initially intended for the characterization of DC/DCs, its applicability can be extended to other DC Power Management IPs such as LDOs and Charge Pumps and also serve as a demonstration vehicle for Power Management IPs.

II. OBJECTIVES

A. Power Management Tests

From the key figures that characterize a PMU we divide them into three categories: (i) Static, i.e measurements that are not time dependent. (ii) Dynamic, which observability depends on time and (iii) Spectrum measurements, which depend on the frequency.

On Static measurements, there are included: the accuracy of \( V_{\text{OUT}} \); the dependency of \( V_{\text{OUT}} \) on the voltage input (line regulation); the dependency in load current \( i_{\text{OUT}} \) (load regulation), current limitation, current protection and the power consumption.

The dynamic measurements are included the: start-up/wake-up time and the control response times e.g. enable/disable time; other time dependent figures like output ripple and finally the line transients and load transients, where it is measured the output response correspondently to a step on the voltage input and a step on the output current.

The Spectrum measurements are essentially the output noise figure and the Power Supply Rejection Ratio (PSRR).

The objective of this platform is to

B. Real Test Situation

A typical case for a test of a DC to DC converter for example, is where 5 input voltages are considered, with 15 different load currents, with 15 Output voltages, 2 switching frequencies, in 2 modes of operation and 3 different temperatures (max.; min. and room) will yield roughly 13500 tests.

Each test involves 2 voltage and 2 current measurements in order to calculate the Power Converter Efficiency1. Moreover, this test has to be repeated over a reasonable number of samples (typ. 40) to account for the dispersion of the technology process in which the component was manufactured and to evaluate possible yield problems. If this test is to be done with off-the shelf instrumentation, it is bound to take a lot of time. So, one of the first priorities was to minimize the number of needed equipment for all the tests, with a special emphasis in reducing the test time no minimum.

II. ARCHITECTURE

The architecture of the test platform is depicted in Fig.2. The system is divided into Five major building blocks: Supplies; Loads; Measurement; Control and Device Under Test (DUT).

![Fig. 2 Simplified Architecture](image-url)

Since this project is intended to be a generic PMU Test Platform, the focus is in the solutions devised for Power Supplies; Output Loads and measurement blocks.

The Control block for this project was for convenient reasons the a PIC18F8722 from MicroChip Devices was

---

1Acknowledgments should appear at the bottom of the first page (8pt).
used. It provides the necessary communication channels that are needed to communicate with both DUT and Controller PC.

In Fig. 3 is illustrated the physical implementation of the ATP. The DUT is kept on a separate board, following the concept of loadboard in Industrial Automatic Test Equipment. Note that supply and load lines have sensing points, so that the IR drop on board traces is not taken into account.

C. Static Measurements

The control block sets the supply output and sets the load condition by means of DAC interfaces. The voltage measurements are taken from DUT input and output nodes through an high precision adc. The DUT input current also is measured and the output current is set by the load circuit. This gives all the information needed to perform all the static PMU measurements. Connectors A and B will allow calibration of the ATP and if needed to bypass the built-in supplies and load circuits.

D. Dynamic Measurements

In dynamic measurements, for line transients the supply are able to achieve at least 1V/us rise/fall times, and the output voltage must be monitored in B by an oscilloscope. For load transient tests, the loads can achieve 6mA/us.

E. Spectrum Measurements

The output noise measurement is straight forward, only requires a Spectrum Analyzer and a DC blocker circuit not to destroy the input stage of the instrument. A simple series capacitor can act as a DC blocker.

In Fig. 4 in illustrated the setup for the PSRR measurements. To measure the PSRR, a Network Analyzer is used to generate the stimuli and the board supply acts as a power buffer. In order to have a correct measurement, the frequency response of the Power Supply needs to be decoupled. The PSRR is the difference between the spectral power observed in C and D.

III. IMPLEMENTATION

F. Supply

As seen in Fig. 3 the supply block has one analog input reference which sets the voltage input for the DUT. The supply block is basically a Power Buffer Circuit. The supply for a modern IC should to supply up to 500mA, have a voltage range of 0.8 up to 5V; be able to drive an AC voltage up to 500kHz and a noise floor below -90dBm.

G. Load

For almost all PMU measurements a current sink like is illustrated in Fig. 7. The circuit implemented has
For current fold-back tests it requires that the load has a resistive behavior. Using an actual resistor for this test hinders the automation, so there was need to implement a Resistive Load.

In Fig. 8, it is the solution that was used for the resistive load.

**H. Measurement Circuit**

The ADC used for voltage acquisition is the built-in 10bit ADC using 0-5V as full scale. This means a reading resolution of about 5mV, which for test and demo purposes is a good starting point. Next version should aim to achieve higher resolution at the expense of adding an 12bit ADC to the board. As for accuracy, the circuit needs to be calibrated prior to use. Calibration procedures were created and are documented in the main document.

The Power Supply current measurement is done on a sense resistor at its output. An off-the-shelf instrumentation amplifier (INA141UAE4) is used to monitor the voltage drop in the sense resistor and amplify it to be read 10bit ADC. There are provisions on the board to scale the current to voltage gain so that we can read from about 5uA to 1A.

**I. Board Layout**

The layout for this ATP was done in 4 layer board taking into consideration design recommendations found in [17] to [25]. It uses top and bottom layers for signaling and the internal layers are reserved for ground and supplies.

The daughterboard layout followed the same layer stack-up as the ATP.

**IV. TEST EXECUTION**

**H. Test Automation**

The control of the board is made by a USB interface, from which the controlling application manages the events on the Test Platform. The Test scripts are made in Python Language.

Python was the preferred language because all the libraries needed to control GPIB and USB peripherals was readily available. Instrument drivers had to be developed for Multimeter, Source Meter, Oscilloscope and Spectrum Analyzer, in order to automate tests that could not be done with on-board instrumentation.

**Conclusions**

For reasons alien to the execution of this project, the board was never manufactured and we were not able to use the board with the automation scripts that were created. However, by using an handcrafted board and stand-alone equipment, a full characterization of a PMU was done. Despite the limitations imposed by the handcrafted board, the test results were compiled and reported in the main document.

**References**

[1] Robert W. Erickson, “DC-DC Power Converters” Department of Electrical and Computer Engineering University of Colorado
[4] Christophe Vaucourt, "Choose the best inductor, capacitor for DC/DC converters in portables” Texas Instruments
[14] Jeff Barrow, "Reducing Ground Bounce in DC-to-DC
Converters—Some Grounding Essentials”, Analog Dialogue 41-06, June 2007

15 Paul Brokaw and Jeff Barrow, “Grounding for Low and High Frequency Circuits”, Analog Devices Application Note AN-345


17 Henry W. Ott, “Partitioning and Layout of a Mixed-Signal PCB”, Printed Circuit Design June 2001

18 “Avoid noises in mixed signal design”, http://www.scienceprog.com


20 by the staff at Sanders RF Consulting, “Practical Electromagnetic Compliance Design Tips for Printed Circuit Board Layouts”


22 PCB Trace Impedance Calculator http://emclabinfo.com/emc_calc/emccalc.htm

23 Brian D. Butler, “Propagation Delay Measurements with TDR in the Manufacturing Environment” by Introbotics Corporation; Albuquerque, New Mexico

