Monitoring Components Evaluation

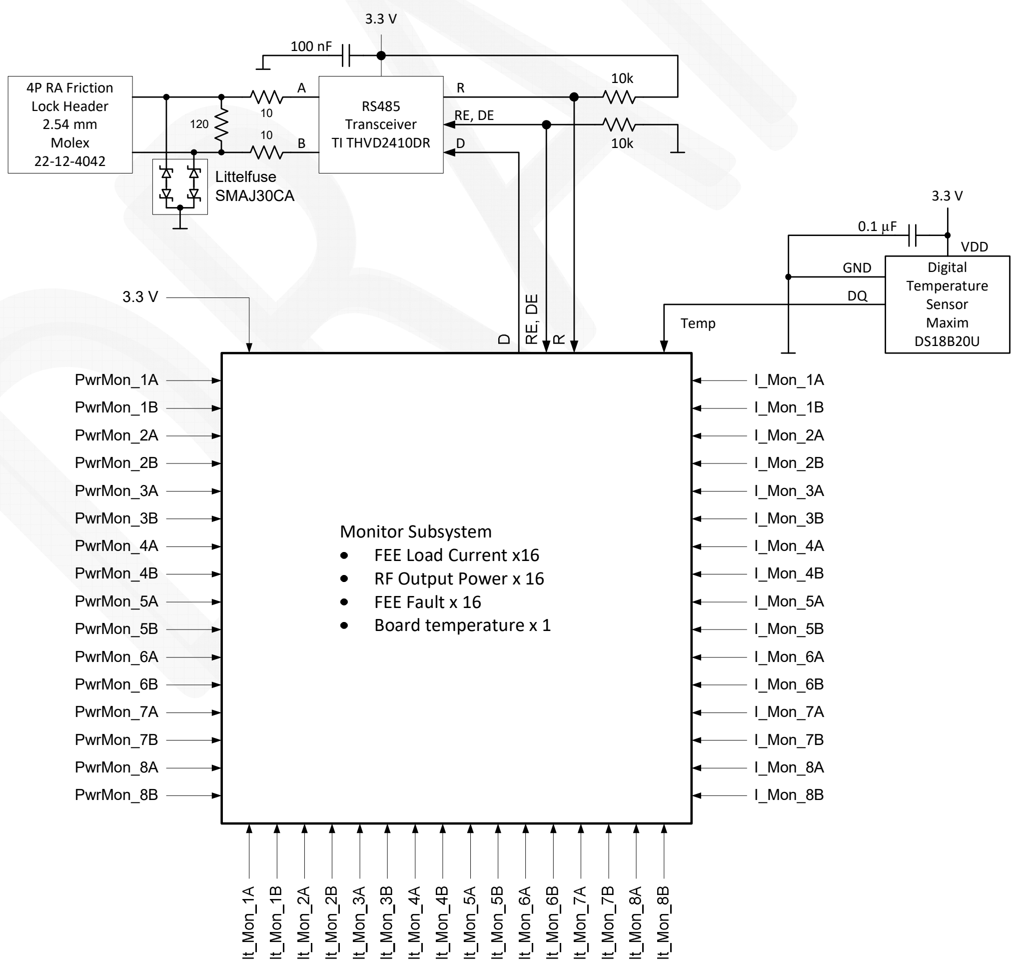
This document provides analyses of the monitoring components used in the existing Rev. G and H ARX and proposed for use in the Rev. I ARX. Refer to the Rev. I ARX block diagram for reference (see Reports folder).

Monitor Subsystem:

Monitoring components: The Rev. G ARX has no specific monitors or diagnostics, whereas the Rev. H ARX has a microprocessor controlled FEE load current monitor and RF output power detector and used the EIA-485 interface for communications.

The Rev. I ARX borrows the basic monitor concepts from the Rev. H ARX but uses the Serial Peripheral Interface (SPI) for communications; this SPI is separate from the SPI used to control the ARX. The Rev. I monitor subsystem provides microprocessor controlled monitoring of at least 49 signals (see basic monitor subsystem block diagram below):

- ✓ FEE load current (signal from the TI TPS16412 eFuse): 16 analog monitor points;
- ✓ FEE fault (signal from the TI TPS16412 eFuse): 16 digital monitor points;
- ✓ RF output power (signal from the ADI AD8361 detector IC): 16 analog monitor points;
- ✓ Board temperature: At least 1 analog monitor point.



To minimize the possibility of self-generated radio frequency interference (RFI), the microprocessor is activated only for diagnostic purposes and powered down at all other times. The monitor subsystem including microprocessor, FEE fault indication, temperature and associated analog signals (FEE load current and RF output power) is operated through a separate TIA-485 control interface. All analog signals are single-ended.

The Rev. H ARX uses the PIC16F15386-E_PT microcontroller, and it is proposed to use the same PIC in the Rev. I ARX for compatibility with existing control system hardware and software.

TIA-485 Interface:

The TIA-485 (commonly called RS-485) interface is used to communicate with the Monitor Subsystem. The Rev. H ARX uses the half-duplex, 500 kbps Texas Instruments THVD1500DR transceiver IC, but it only works with a 5 V power supply. The Rev. I uses the TI THVD2410DR IC, which operates from 3 to 5.5 V and otherwise has similar performance.

TI recommends the component values shown in the schematic below. The 120 ohm resistor across A and B terminates the transmission line. The two 10 ohm resistors in series with A and B limit short-circuit current. The Littelfuse SMAJ30CA TVS connected from A and B to ground has a 30 V working voltage.

Temperature Monitor:

At least one temperature sensor will be placed on the Rev. I ARX PCB. Additional details including its location on the PCB will be provided in this section as they are developed.

The Rev. H ARX uses the Maxim DS18B20U digital temperature sensor. It is assumed that precise temperature is not needed for diagnostics.

ARX FEE Current and Fault Monitor:

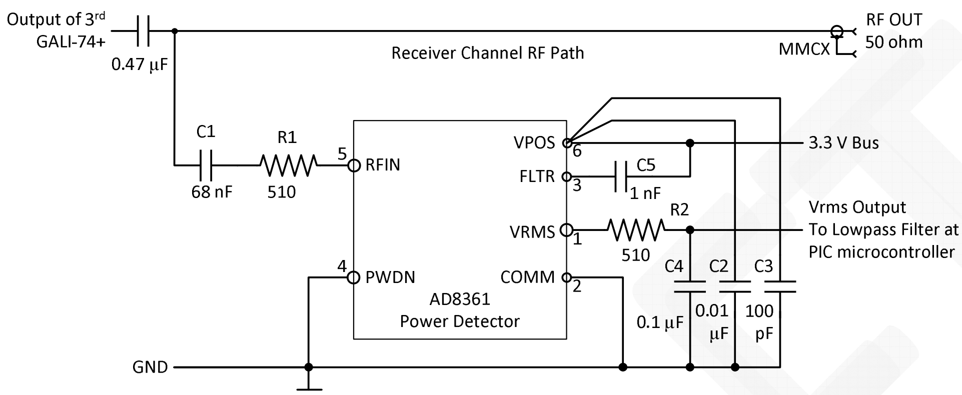
The Rev. I ARX uses a TPS16412 eFuse to control power to each FEE. The eFuse produces an output voltage to the monitor subsystem that is proportional to the load current. It also produces an overcurrent fault indication that drives a low-current LED on the PCB and an output to the monitor subsystem. Refer to ***Evaluation of the TI TPS16412 eFuse for Use in the Rev. I ARX*** for additional information about the eFuse. Additional details concerning the eFuse connections to the monitor subsystem will be provided in this section as they are developed.

ARX RF Output Power Detector:

<u>Device type</u>: The Rev. H ARX uses the SOT-23 version of the AD8361 power detector IC. The same basic design is incorporated in the Rev. I ARX with only a change in the input capacitor as described below. The device RF input is the total power in the passband spectrum, which depends on the ARX filter settings but in the worst-case will be on the order of 100 MHz wide. The power detector has an internal squaring functions and filter that produces a dc voltage output that is proportional to the square root of the average, or rms, value of input voltage.

The dynamic range of the AD8361 is specified in the datasheet only for CW signals and is given as 26 to 30 dB depending on the error. An error of a few dB can be expected at low levels of around 20 mVrms, or -21 dBm; the error rapidly increases at lower input signal levels. The actual ARX signals generally are noise-like, but the dynamic range of the power detector in the ARX application probably is not much different since the device responds to the rms voltage on its input.

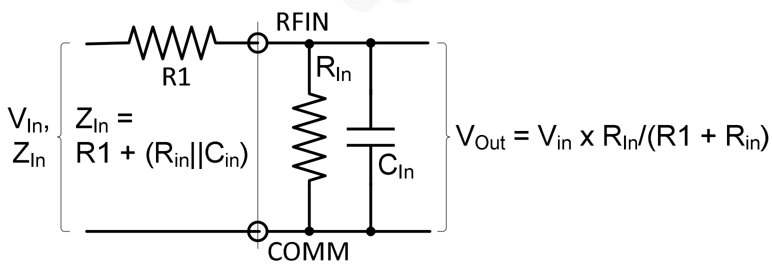
AD8361 Application Schematic:



Device connections: The datasheet mentions in several places that two power supply decoupling capacitors, C2 and C3 in the schematic, are used. The datasheet also provides guidance on controlling the input interface impedance for a 50 ohm system but, in the ARX application, the AD8361 is connected to the RF path through a relatively high-impedance bridging connection and appears as shunt load across the 50 ohm RF path.

The RF power detector output is a dc voltage but is curiously named Vrms in the datasheet. It is connected to an ADC channel in a Monitor Subsystem (see previous section) through lowpass filters. The RF input and dc output are further discussed below.

RF Input: Refer to the full schematic above. C1 is required to isolate the RF path from the dc voltage on the device's RFIN pin. Its capacitance is large enough to provide negligible impedance to the RF signal. C1 = 2 nF in the Rev. H design. C1 = 68 nF in the Rev. I design for commonality with other isolation capacitors in the receiver channel. The impedance of 68 nF is –j0.78 ohms at 3 MHz. R1 forms a voltage divider with the device input impedance of 225 ohms in parallel with 0.9 pF capacitance (see equivalent circuit below). The value of R1 is a tradeoff between providing a high input signal voltage (low resistance) and a high bridging impedance (high resistance).



The capacitive reactance of Cin at 100 MHz is –j1768 ohms, and the impedance magnitude of the parallel combination of RIN and Cin is 223 ohms. Thus, the impedance seen by the RF path to which this circuit is bridged is approximately R1 + 223 ohms.

In the Rev. H ARX, R1 = 510 ohms, so the shunt impedance on the RF path is R1 + RIN, or about 733 ohms. The impedance seen by the RF path at its junction with the bridging circuit is the parallel combination of 50 ohms and 733 ohms, or 46.8 ohms. This is an impedance change of –6.4%, and the return loss seen by the 50 ohm RF path is 29.6 dB. The voltage drop factor with R1 = 510 ohms and RIN = 223 ohm input impedance is approximately 0.30, or –10.3 dB. Therefore, for R1 = 510 ohms, the AD8361 sensitivity is reduced by 10.3 dB. For reference, the series resistance R1 for any desired input attenuation can expressed as
$R1 = RIN\,(1 - 10^{ATTN/20})/(10^{ATTN/20})$

where *RIN* is the device input impedance (223 ohms) and *ATTN* is the desired attenuation in dB.

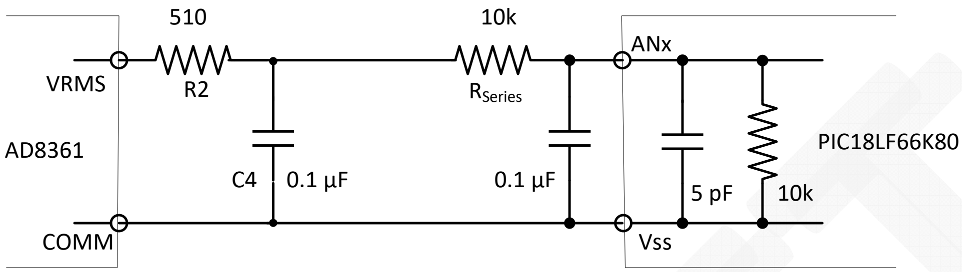
If it is desired to introduce no more than 2% impedance change at the junction, the value of R1 would have to be about 2500 ohms. If R1 = 2500 ohms, the equivalent return loss is 39.9 dB, and improvement of 10.3 dB compared to R1 = 510 ohms. The volage drop factor when R1 = 2500 ohms is approximately 0.08, or –21.7 dB. Thus, while R1 = 2500 ohms improves the impedance mismatch of the bridging connection, it decreases the voltage available at the output of the power detector, and thus the device sensitivity, by 10.4 dB compared to R1 = 510 ohms.

The AD8361 loses accuracy at low input signal levels so, depending on the normal signal levels being monitored, a decrease of 10.4 dB compared to the Rev. H ARX may be a significant reduction of the power detector performance. There have been no reports of unsatisfactory operation of the power detector with R1 = 510 ohms. Therefore, no changes are made to the input series resistor in Rev. I compared to the Rev. H design.

<u>Signal input range</u>: The SOT-23 version of the AD8361 operates in the ground-reference mode in which its output is referenced to 0 V. The upper input limit for a linear response when operated from a 3.3 V power supply typically is 390 mVrms. In a 50 ohm system, this voltage is equivalent to +4.8 dBm at the device's signal input interface. However, the device input impedance is 225 ohms in parallel with a 0.9 pF capacitor at the frequencies of interest (< 100 MHz) and, as discussed above, a 510 ohm resistor is placed in series with the input, which increases the overall input impedance at the RF path measurement point to about 733 ohms. Therefore, with the voltage divider used in the ARX application, the input voltage limit of 390 mVrms at the RFIN pin corresponds to 1.28 Vrms at the RF path connection. This is equivalent to a power level in the 50 ohm RF path of +15 dBm.

<u>External Filter Capacitor</u>: The power detector has an internal lowpass filter for reducing ripple on its output. It consists of 27 pF || 2 kohms for small input signals. As the input signal increases, the resistive component decreases. For large input signals, the filter is equivalent to 27 pF || 500 ohms. The associated RC corner frequencies for small and large input signals are 3 and 12 MHz, respectively. Connecting an external capacitor between the FLTR pin and VPOS reduces the corner frequency. The Rev. H ARX uses a 1 nF external filter capacitor with corresponding small and large signal corner frequencies of 77 and 310 kHz, respectively. This capacitor value appears to be adequate and is proposed for the Rev. I ARX.

Output Termination and Filtering: The Rev. H ARX has an RC lowpass filter consisting of a series 510 ohm resistor and 0.1 µF shunt capacitor connected closely to the AD8361 output. The corner frequency of this combination is 31 kHz. This filter is then connected to RSeries = 10 kohms series resistor and 0.1 µF capacitor close to the PIC ADC input, and its corner frequency is 159 kHz. The PIC18LF66K80 datasheet recommends a source impedance of 10 kohms, which is satisfied by RSeries shown below. The purpose of the first filter (R2, C4) is not known, but it is not changed in the Rev. I ARX.



Document Information

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