HOLT INC. INTEGRATED CIRCUITS

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White Paper – Autonomous Transmission of Analog Sensor Data on an ARINC 429 bus without an MCU

Introduction

In today's complex aircraft, sensors are everywhere. Gathering data is critical. Figure 1 shows a block diagram of a typical implementation. A sensor measures an analog value that is converted to a binary value using an analog to digital converter (ADC). This value is read by a microcontroller and sent to an ARINC 429 Protocol IC (such as the HI-3593), where it is buffered, combined with the appropriate ARINC 429 constructs, and transmitted over the ARINC 429 bus by an integrated line driver that translates to the required ARINC 429 voltage levels. This all happens under the supervision of the microcontroller which periodically executes this function at regular intervals.

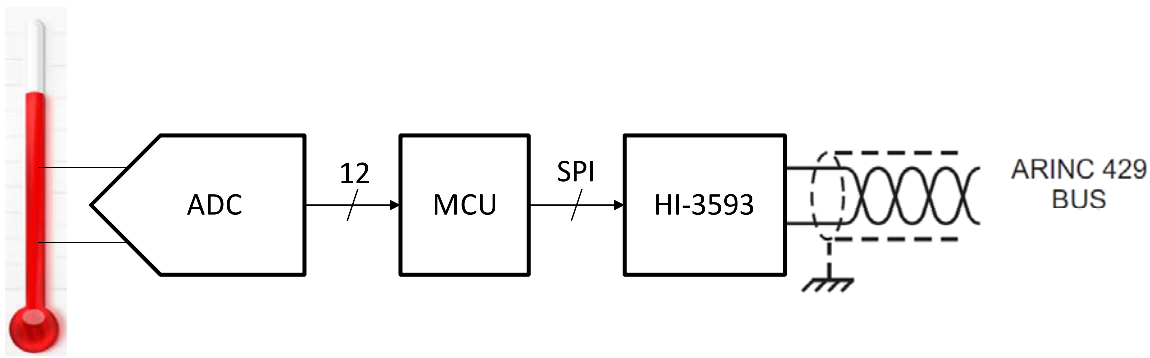

Figure 1 Monitoring and Transmitting Data over the ARINC 429 Bus

Unfortunately, the design can be costly, in both time and money, as each line of source code is scrutinized during the DO-178 qualification process.

But what if the microcontroller could be eliminated? What if the application could be implemented without software?

That is the goal of the HI-8470, a simple commercial off the shelf (COTS), 16-channel discrete-to-digital converter with built-in ARINC 429 transmitter. The HI-8470 implementation (See Figure 2) can periodically read the output of the ADC, construct a value and transmit it over the ARINC 429 bus, all without a microcontroller. No microcontroller means no software programming. No software results in faster development time, simplified qualification, and a reduction in time and costs.

The HI-8470 is a 16 channel discrete-to-digital sensor with an integrated ARINC 429 transmitter. All sense input configuration and ARINC 429 transmission control are programmed via logic level input pins, eliminating the need for a microprocessor or software interface. A block diagram is shown in Figure 3. The IC consists of an ARINC 429 word assembler, transmitter (basically a serializer), a scheduler and a line driver. Details can be found in the HI-8470 datasheet.

This paper will focus on interfacing the HI-8470 with an analog to digital converter.

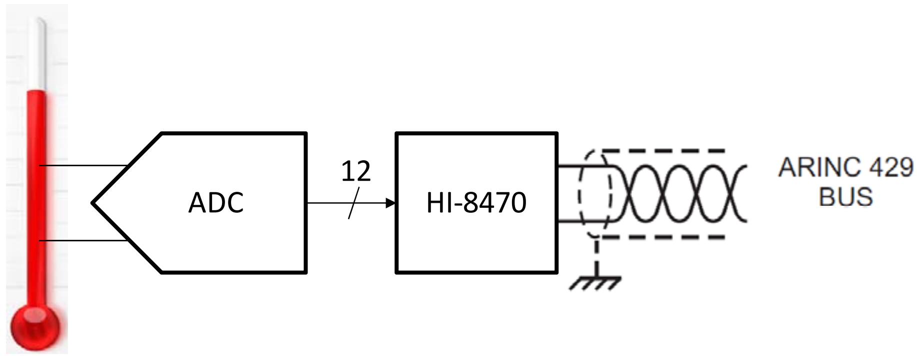

Figure 2 Monitoring without Microcontroller Supervision or Software Programming

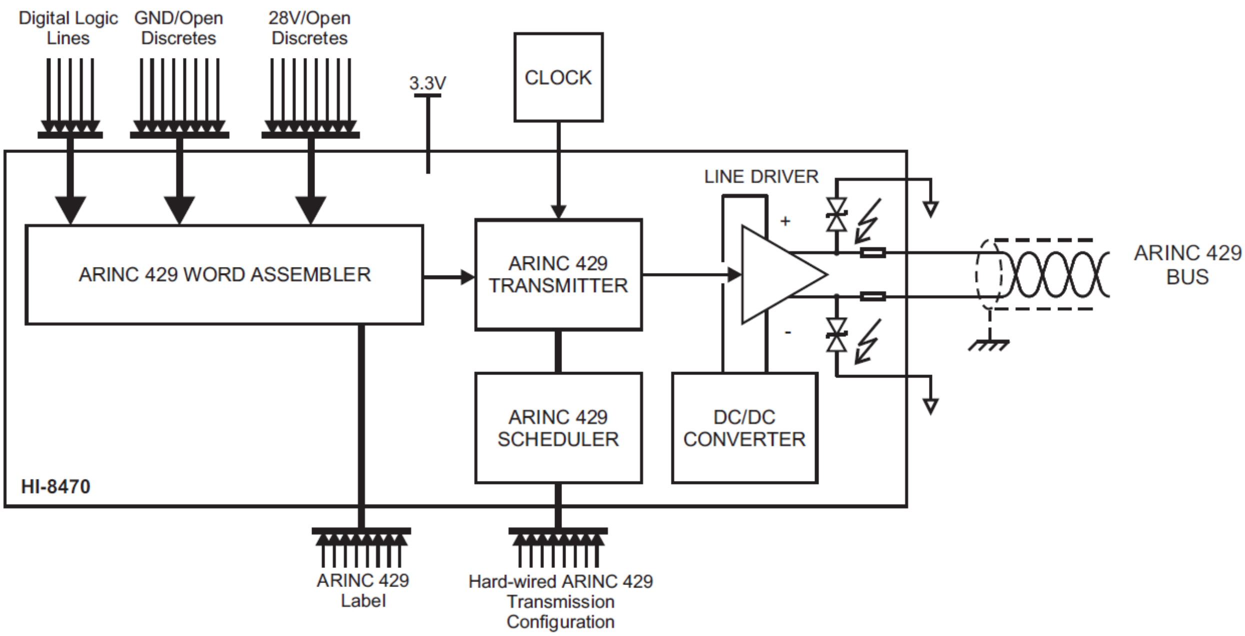

Figure 3 Block Diagram of the HI-8470

Configuring the HI-8470 Input

To interface to an ADC, the HI-8470 should be configured to take a digital input instead of a discrete input. Set the sense channels to GND/OPEN detection by grounding the SELx pins. To set the sense inputs to CMOS logic levels, use the internal thresholds by grounding the EXTTHSVO and EXTTHSOG pins. Leave the unused external thresholds pins floating. Note that the HI-8470 inverts so a logic inverter may be required between the ADC output and the sense input. A 12-bit ADC is shown in Figure 2 but the HI-8470 has 16 sense inputs. Any unused sense pins can be left floating.

The TEST0 and TEST1 pins can be used to functionally verify the HI-8470 converter. Pulling TEST0 HIGH while TEST1 is LOW pulls all 16 sense inputs to GND. Pulling Test1 HIGH while TEST0 is LOW pulls the sense inputs HIGH. Pulling both TEST0 and TEST1 HIGH creates a 0101 pattern on the sense inputs. For normal operation, tie both TEST0 and TEST1 to GND. For more details, refer to the HI-8470 datasheet.

Configuring the ARINC 429 Transmitter

The ARINC 429 Transmitter consists of a word assembler, a scheduler, a serializer, and a line driver. The transmitter is completely configured using input pins.

The ARINC 429 word assembler takes the 16 bit sense input values and combines them with 16 other inputs to create an ARINC 429 word, whose format is shown in Figure 4. The first eight bits transmitted are the ARINC 429 label byte. The label value reflects the state of input pins LBL7 through LBL0 immediately prior to transmission. ARINC 429 SD bits reflect the state of the BIT9 and BIT10 pins. Bits 11 through 26 reflect the state of discrete sense pins SI0 through SI15 respectively, and bits 28 and 29 reflect the state of the BIT28 and BIT29 pins. The ARINC 429 SSM bits, bit 30 and 31 are set by input pins BIT30 and BIT31. The last transmitted ARINC 429 bit is an odd parity bit, which is automatically calculated by the HI-8470.

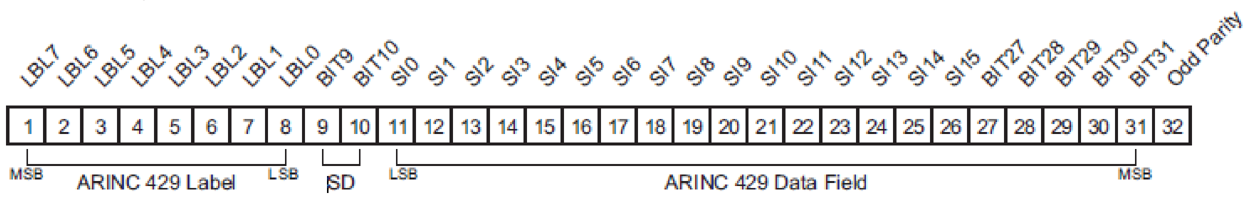

Figure 4 ARINC 429 Word Format

The scheduler autonomously handles periodic transmission of data. It requires a 1 MHz ±1% reference clock and is configured through input pins.

The data rate is selected via the SPEED pin. HIGH selects 100kbps while LOW selects 12.5kbps. This setting will also adjust the slope of the ARINC 429 waveform accordingly.

The frequency of transmission is set by the TMRx pins where 0x00 specifies the shortest transmission interval and 0xFF specifies the longest transmission interval. A list of possible repetition intervals are shown in Table 1. For more details, please see the HI-8470 datasheet.

The active low Master Reset ($\overline{\mathrm{MR}}$) initializes the integrated ARINC 429 transmitter. On power up, an internal power-on reset circuit automatically resets the part. For normal operation, leave the $\overline{\mathrm{MR}}$ pin floating.

The ARINC 429 Transmitter shown in Figure 3 is a essentially a shift register that serializes the ARINC 429 word and encodes it for the line driver. The TXADIG and TXBDIG pins are the output of the serializer which goes into the line driver. These digital outputs may be used for an external line driver, but may be useful as test points.

SPEED	TMR7:0	BIT RATE	SLOPE	REPETITION INTERVAL	WORDS/ SECOND
0	0x00	12.5 Kb/s	10 us	2.88 ms	347.2
1	0x00	100 Kb/s	1.5 us	360 us	2,777
X	0x01	X	X	10 ms	100
X	0x05	X	X	50 ms	20
X	0x0A	X	X	100 ms	10
X	0x14	X	X	200 ms	5
X	0x32	X	X	500 ms	2
X	0x64	X	X	1 s	1
X	0xC8	X	X	2 s	0.5
X	0xFF	X	X	2.55 s	0.392
X = Don't Care					

Table 1 Example Transmission Schedule Rates

Finally, the transmit enable pin or TXENB must be set HIGH to enable transmission. If TXENB is LOW, the ARINC 429 output will be in the NULL state. TXENB may also be pulsed to send a single ARINC word. For more details, please see the HI-8470 datasheet.

Conclusion

The HI-8470 with an ADC is an elegant solution for periodically transmitting analog data over an ARINC 429 bus without microprocessor supervision. All configurations are set using external pins. No software programming is required, simplifying development, qualification and manufacturing, ultimately saving time and money.

Holt Integrated Circuits has released the ADK-8470ADC, the HI-8470 with ADC evaluation board (Figure 5). Measuring 2" x 2.25", this board includes the HI-8470, a 12-bit ADC and all the switches and jumpers required to get a prototype up and running and transmitting ARINC 429 data in minutes. To order, visit our website at www.holtic.com.

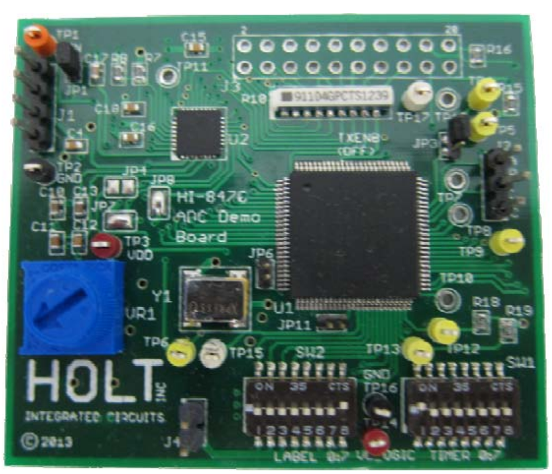

Figure 5 ADK-8470ADC, the HI-8470 Evaluation Board with 12-bit ADC