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White Paper
Constructing an ARINC 429 Repeater

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Introduction

Below is a diagram of a typical ARINC 429 network. An ARINC 429 network consists of one transmitter and one or more receivers. Only two receivers are shown below, but the ARINC 429 specification allows up to 20 receivers or a minimum of 400Ω load impedance to be used with one driver. The length and performance of the cable and/or load capacitance also limits what can be driven by the transmitter, exceeding the loading results in reduced amplitude and distorted signal. This degradation of the signal reduces margin and is likely to result in bit errors.

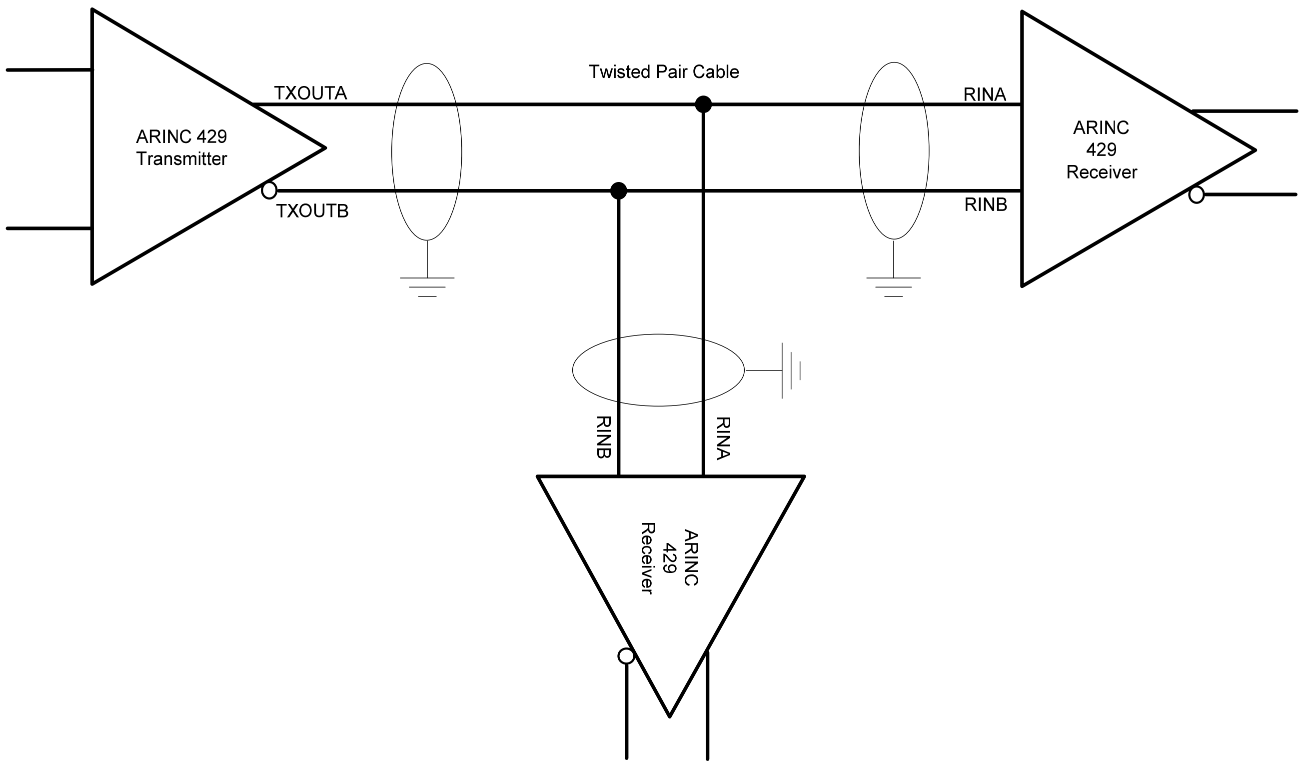
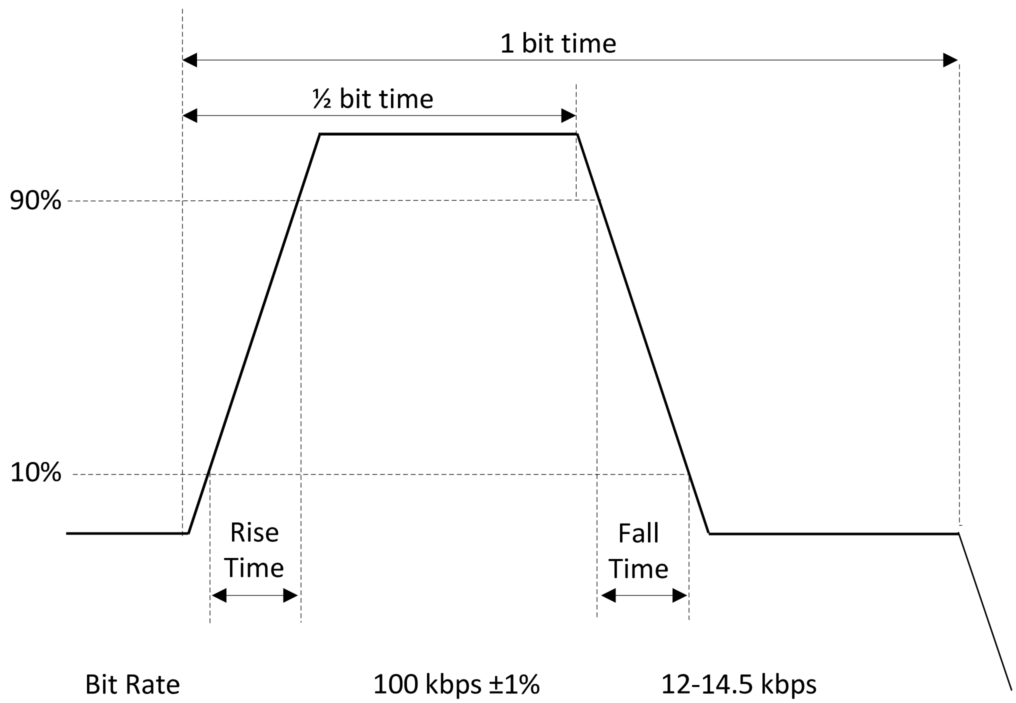


Fig 1 – ARINC system connections

One solution to resolve this is to insert a repeater that will regenerate the signal. A well designed repeater will regenerate the ARINC signal to a quality level that is as good as the original transmitted waveform. The repeater output should have full amplitude and timing parameters that are well within the ARINC 429 specification, as shown in Fig 2.



Bit Rate	100 kbps ±1%	12-14.5 kbps
1 bit time	10µsec ±2.5%	1/bit rate ±2.5%
½ bit time	5µsec ±2.5%	1 bit time/2 ±5%
Rise Time	1.5 ±0.5 µsec	10 ±5 µsec
Fall Time	1.5 ±0.5 µsec	10 ±5 µsec

Fig 2 – The ARINC 429 Output Specification

Simple Repeater

A common misconception is that an ARINC repeater can be made by connecting an ARINC 429 line receiver to an ARINC 429 line driver, as shown in the example below in Fig 3.

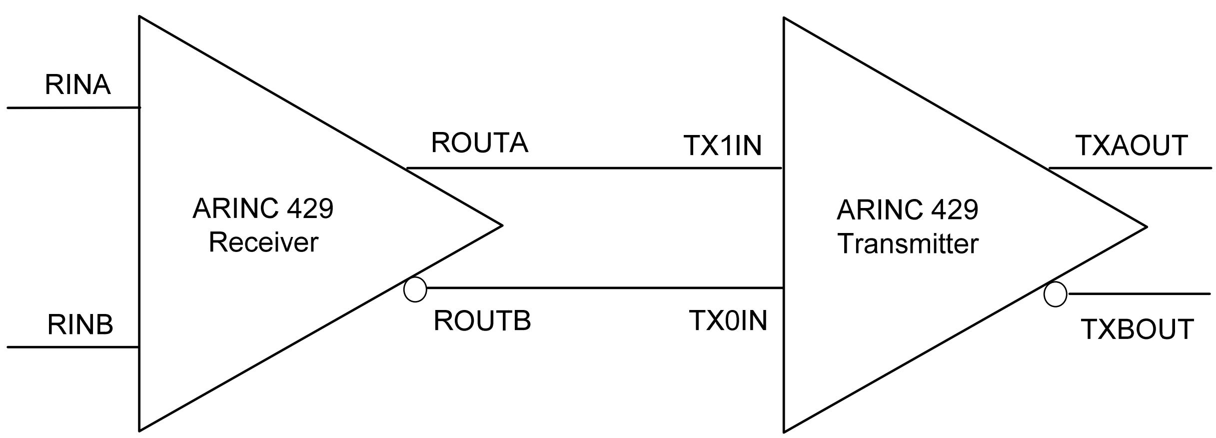


Fig 3 – A simple ARINC repeater

The benefit of this circuit is that it is very easy to build and will function after a fashion; however it has serious draw backs and performance problems which may not be immediately apparent. As can be seen in Fig 2, the ARINC-429 output waveform is engineered with a trapezoidal shape; this has benefits in that it reduces EMI emissions compared with a typical vertical edge waveform.

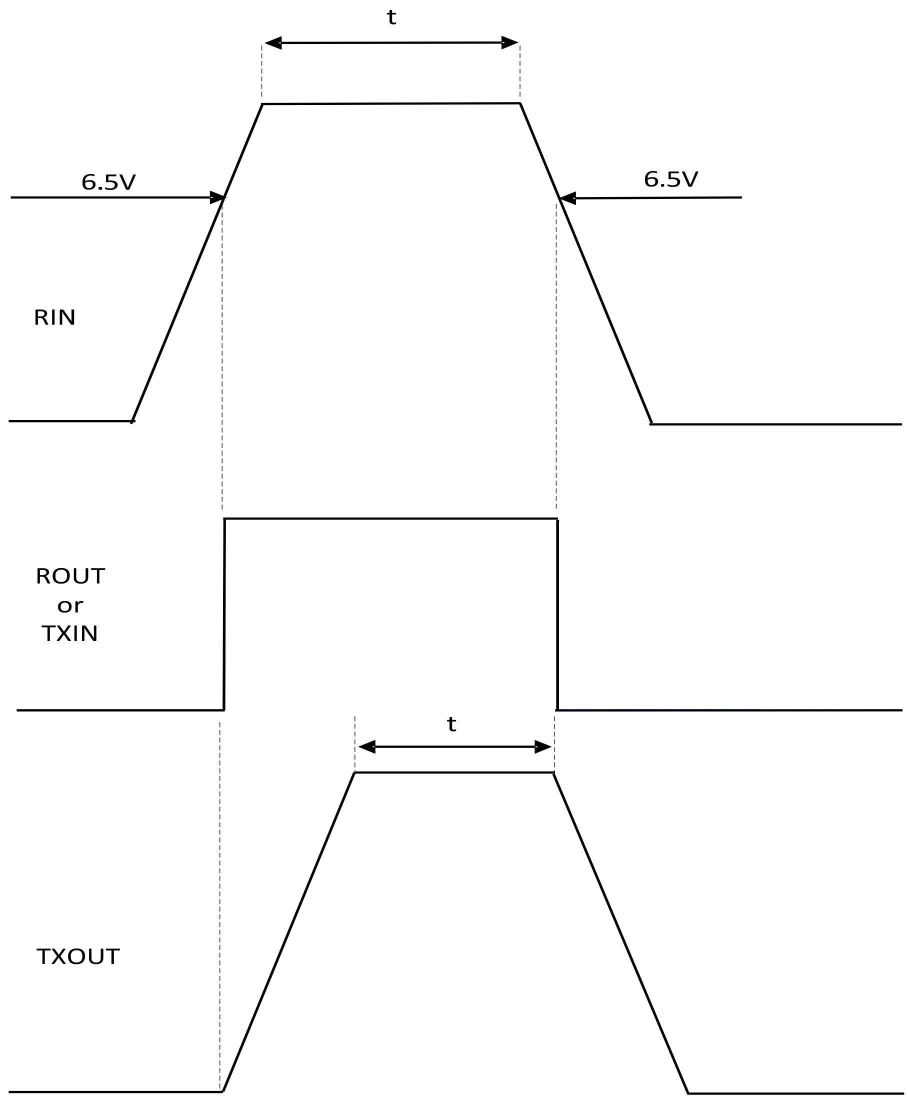


Fig 4 – ARINC Output Pulse Shortening

The slow edge however causes a problem for a simple repeater, as shown in fig 4. In the simple repeater circuit, the zero crossover point timing is altered at the receiver. A 'one' will be detected when the input has reached the minimum one receive threshold (+6.5V), similarly a 'zero' cannot be detected until the input has reached the minimum zero receive threshold (-6.5V). Pulse shortening distortion occurs at the ROUT (TXIN) pins as a result and this distortion is transferred directly to the output driver. As can be seen in fig 4 by comparing the parameter "t" at RIN and TXOUT.

Fig 5 below is a real life example of this distortion. The top yellow trace is the input to the ARINC receiver, at the minimum ARINC 429 level of ±6.5V, the lower magenta trace is the output from the ARINC line driver. Note the flat sections of the peaks on the output waveform have been shortened due to the effect mentioned earlier.

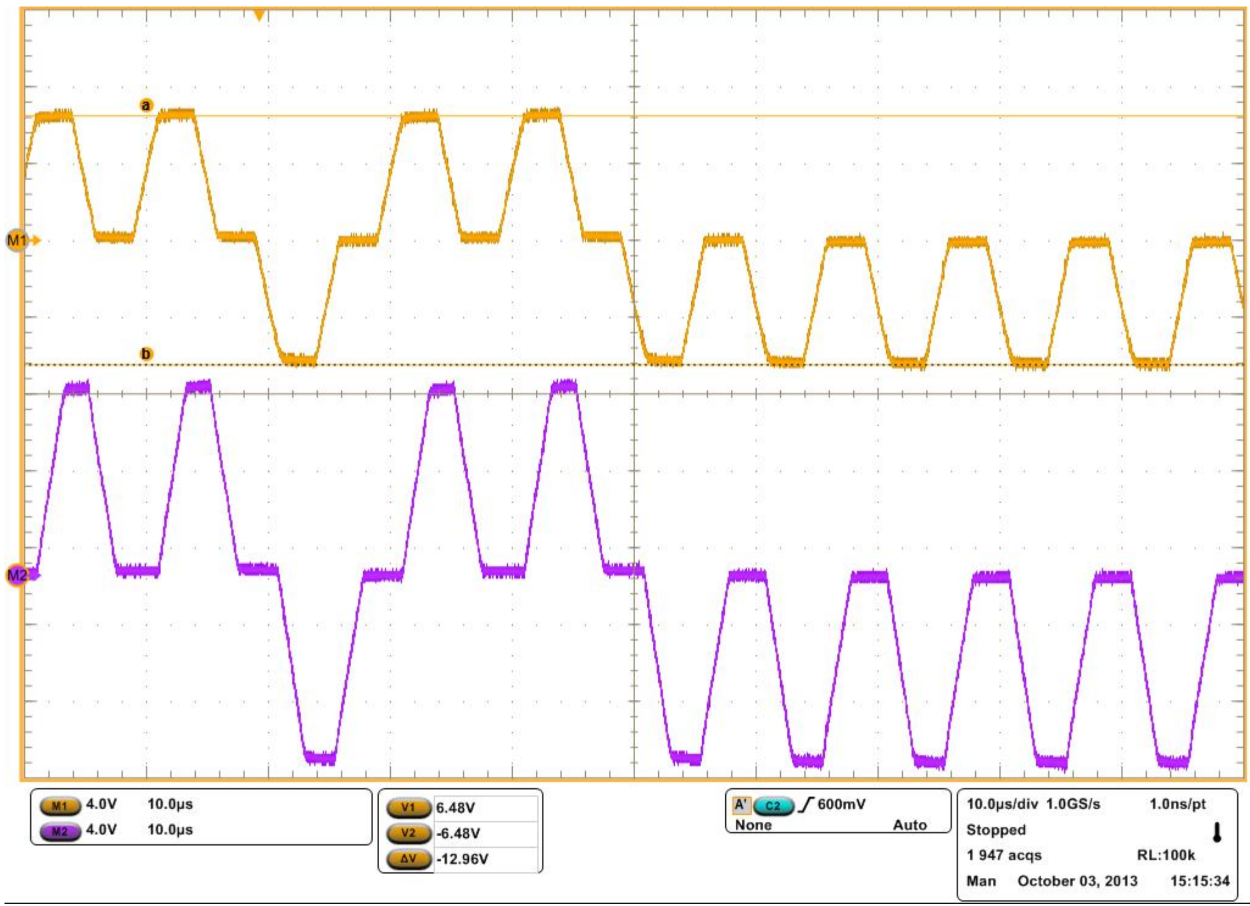


Fig 5 - Minimum input level of ±6.5V (top), showing distortion at output (bottom)

Fig 6/7 show close ups of the waveforms, it can be seen in Fig 6 the input waveform has pulse timing that meets the ARINC specification of 5µs ±5% or 5µs ±0.25µs, however in Fig 7, the ARINC output pulse width measures 4.3µs, a 0.7µs error and 0.45µs outside the ARINC 429 specification. Clearly for an ARINC compliant system; this circuit is not adequate.

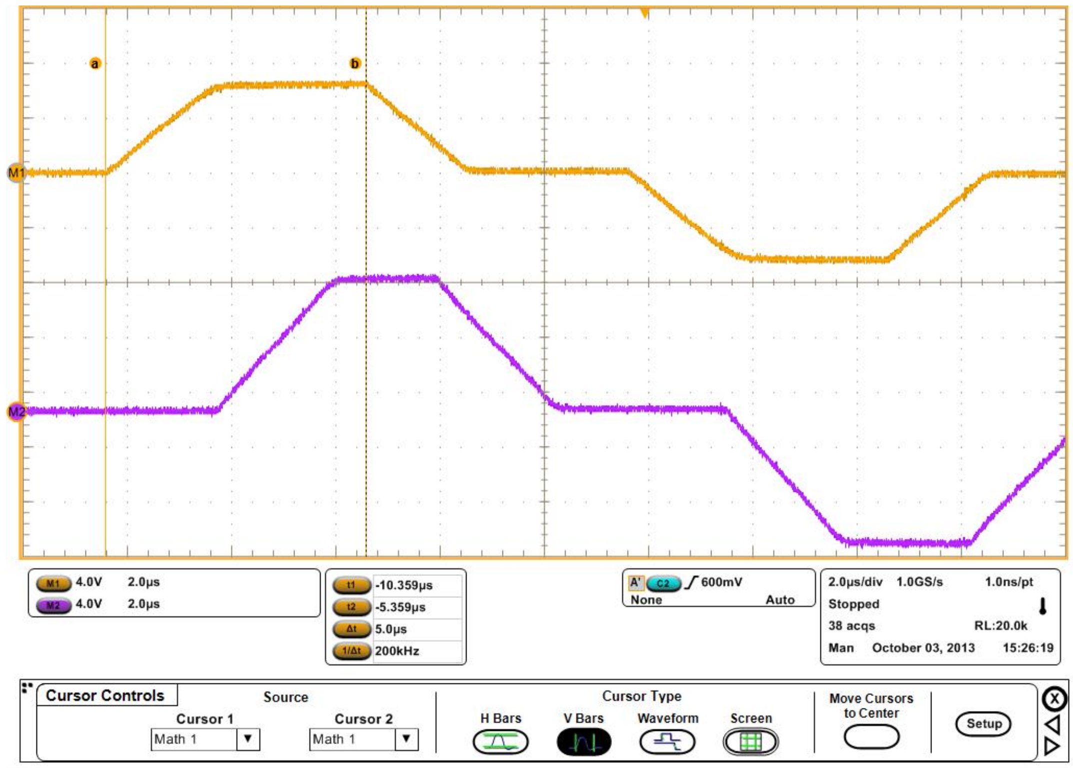


Fig 6 - ARINC 429 input meets the specification of 5µs ±0.25µs for pulse width

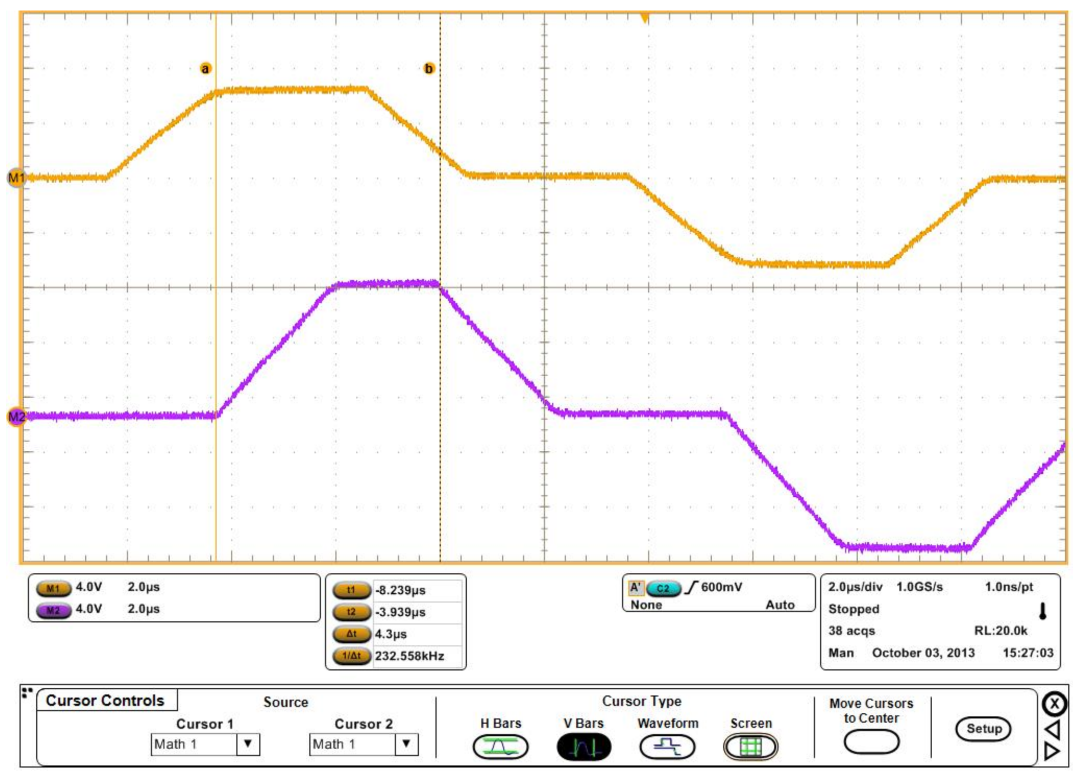


Fig 7 – Output pulse measures 4.3µs, not meeting the ARINC 429 specification of 5µs ±0.25µs

A Better ARINC Repeater Solution

A better way of constructing the repeater is to use a device that reformats the waveform to the ARINC 429 specification for both voltage and timing parameters. Most devices that perform this function require software to program and operate the device. This requires a separate microprocessor, software code writing and software validation and approval. Holt Integrated Circuits has produced a pair of devices (the HI-8470 and HI-8476) that solves these problems, without the use of any software; these devices are hardware pin programmable. When the HI-8476 ARINC receiver is married to the HI-8470 ARINC transmitter it will make an excellent repeater. Fig 8 shows a block diagram of how they are coupled together to produce a repeater. The HI-8476 converts the ARINC input serial stream into 32 bit parallel data, these bits are then passed to the parallel inputs of the HI-8470.

Both the HI-8470 and HI-8476 are retimed from the same 1MHz clock. This clock is used to re-construct the waveform into a correctly retimed and proportioned ARINC 429 serial data stream, which meets all the ARINC 429 timing specifications and is practically jitter free.

The block diagram below shows the structure of the HI-8476/HI-8470 repeater. The ARINC 429 signal is fed directly into the HI-8476 differential receiver pins. If required, label and SD bit filtering may be applied so that only certain label numbers are re-transmitted. This feature also allows the repeater to be used in data splitters; in this case two or more repeaters would be required.

Separate speed selection for each device is used. Thus the repeater can also be used as a rate converter; e.g. receive at low speed and re-transmit at high speed or vice versa.

Once a valid ARINC 429 word is received, this data is presented on the HI-8476 parallel data outputs and the UPDATE flag then goes high. The UPDATE signal clocks the 74HCT74 flip flop; this circuit produces a 1µs pulse into the TXENB (Transmit Enable) input of the HI-8470. This pulse initiates a single 32 bit word transmission at the HI-8470 ARINC outputs; this transmission uses the 32 bits from the parallel data inputs.

The HI-8476 has parity checking capability. If this is enabled on the repeater board and the word is received with odd parity, then the bit32 output is set to '0'. If parity is even, then the HI-8476 will set bit32 output to a '1' and the received parallel data will still be presented at the outputs even though the parity is incorrect. If parity checking is enabled, then output bit32N is used to set the 74HCT74 output to '0' and no ARINC word is transmitted from the HI-8470. If parity checking is disabled bits 1-31 will be transmitted 'as-is', but ODD parity will assigned to bit32 by HI-8470.

The HI- 8470 has 16 inputs for sensor applications; these use ARINC bits [26:11] for transmission. Because they are normally used as sensor inputs, they have inverted logic; a logic '1' input is transmitted as logic '0'. To correct this; HI-8470 sensor inputs are connected to the HI-8476 inverted outputs (BITN [26:12]); all the other inputs use positive logic.

These sensor inputs have externally adjustable thresholds or internally set thresholds. In this application the internal thresholds are used; a logic 0 = 0.8V and logic 1 = 2.5V, this is compatible with most popular logic levels.

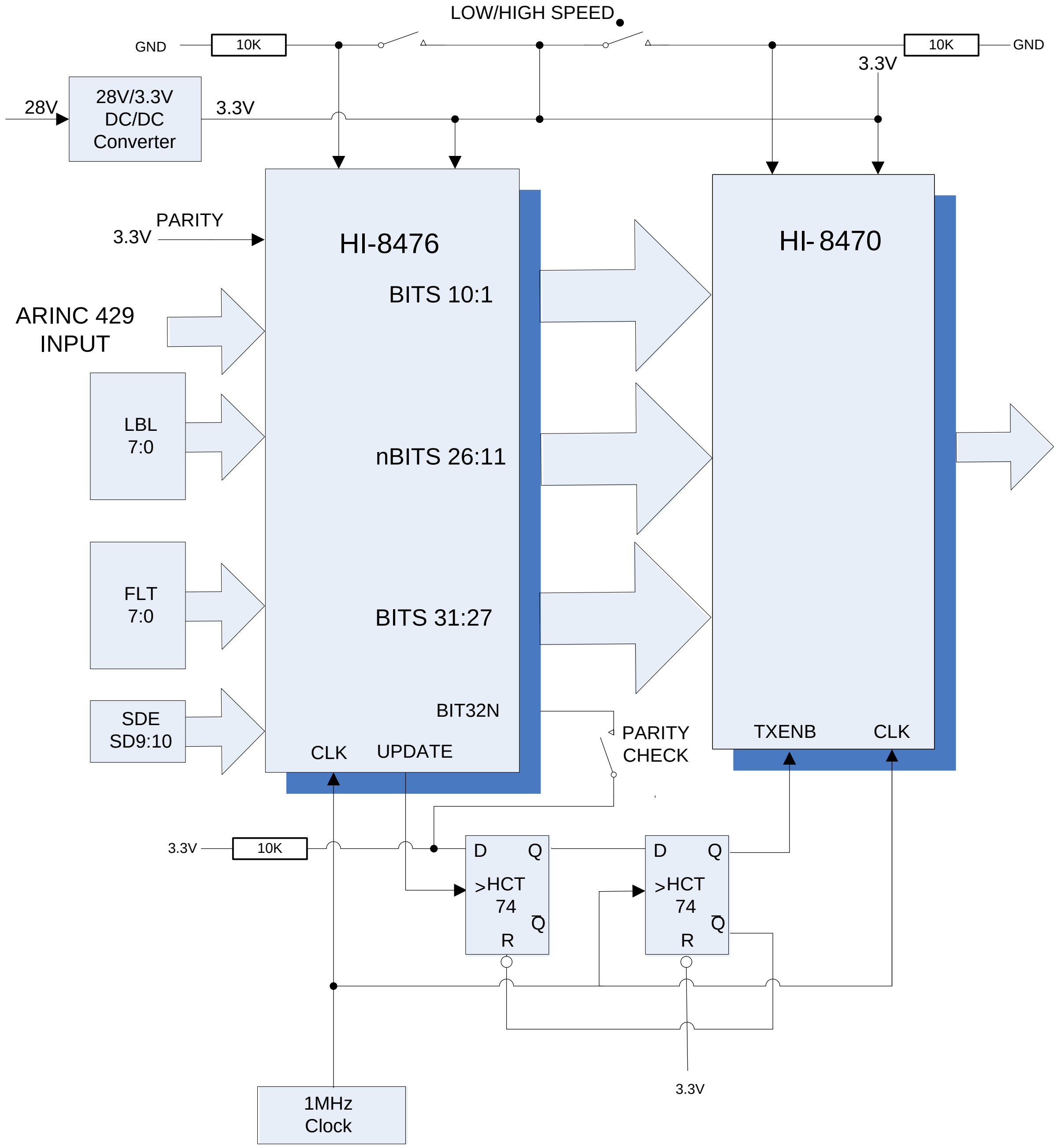


Fig 8 – Block Diagram of HI-8476/HI-8470 Repeater

Power Supply

In an avionics environment, the repeater will likely need to be powered from an aircraft 28V supply, so the Holt repeater board includes a DC-DC converter that operates from a 7 to 36V power input and provides a regulated 3.3V output.

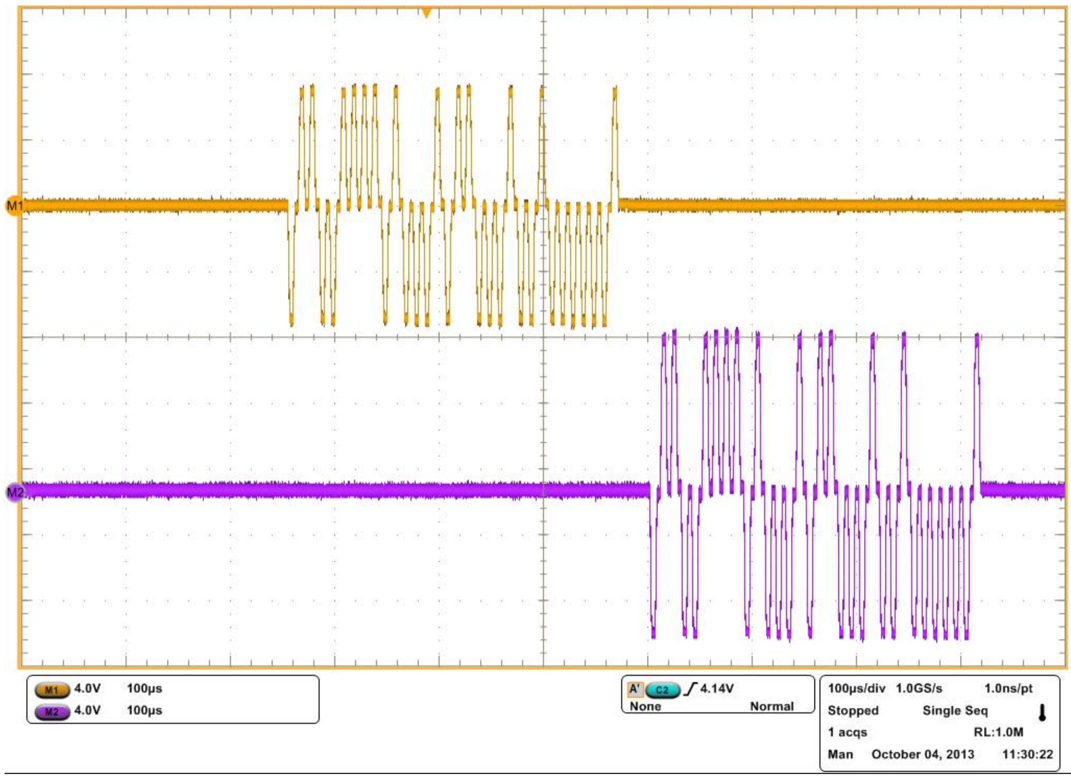


Fig 9 – Input (top) and Output (bottom) words for HI-8476/8470 repeater (min input level)

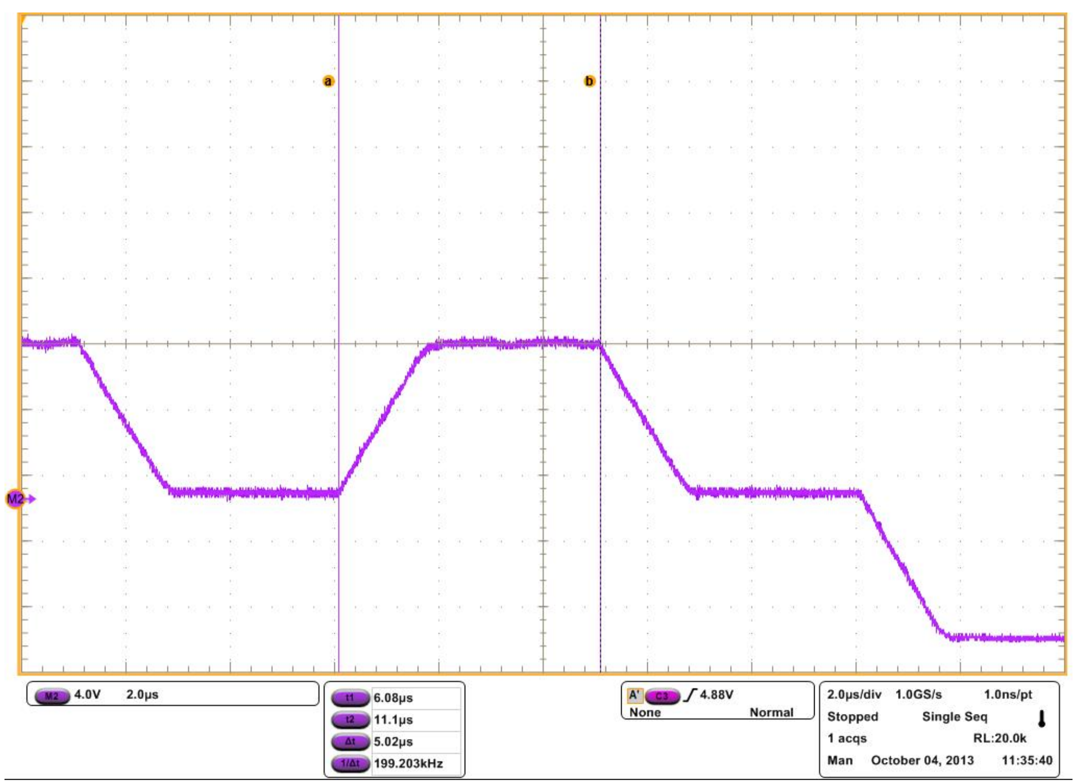


Fig 10 – Output timing of HI-8476/8470 repeater (min input level) - pulse width is accurate.

Extended Cable Length

Furthers tests were done transmitting over a typical application cable length of 125ft. Unlike the simple receiver (Fig 11), the HI-8470/8476 (Fig 12) repeater showed no deterioration in output quality.

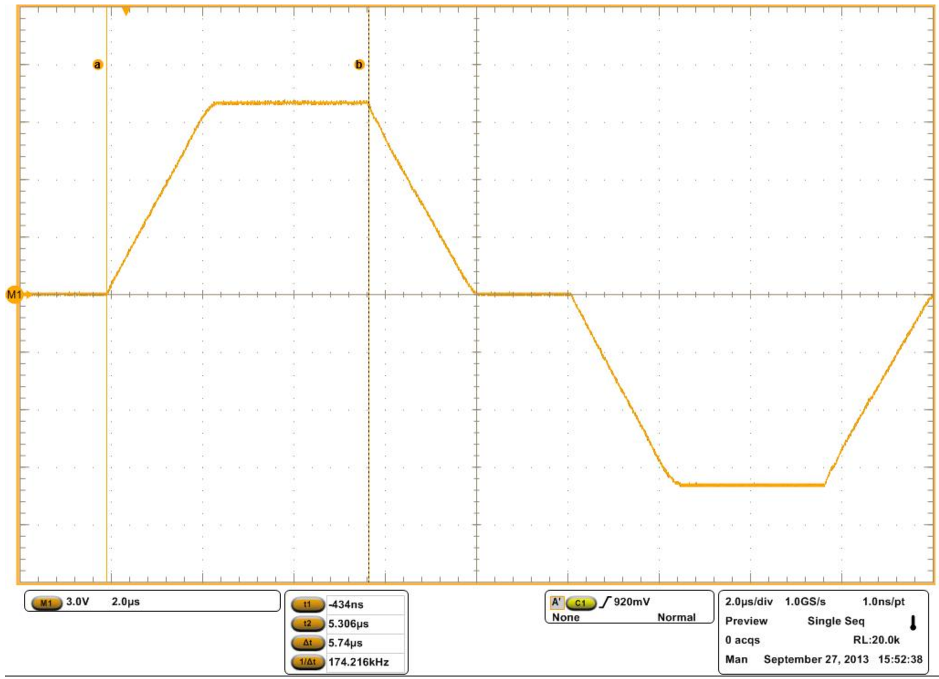


Fig11 – Output of simple ARINC Repeater with 125ft of cable, pulse width parameter is 5.74μs

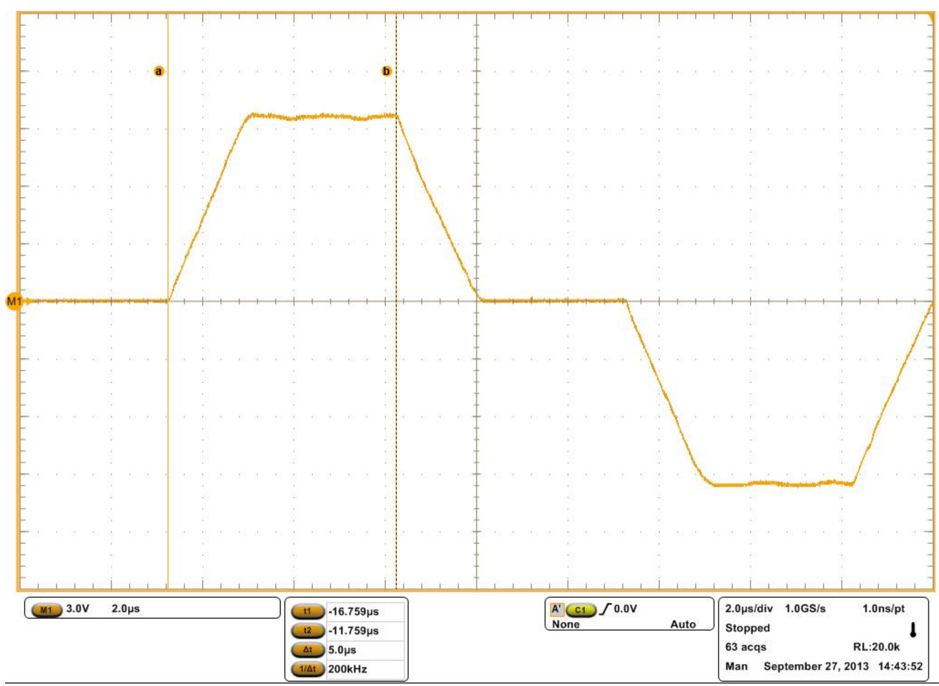


Fig 12 - HI-8476/70 ARINC Repeater with 125ft of cable, the output pulse width timing is accurate at 5.00μs

REVISION HISTORY

Revision	Date	Description of Change
AN-8476, Rev. New	12/11/13	Initial Release
AN-8476-Repeater, Rev. New	01/20/14	Change document name from AN-8476_New to AN-8476-Repeater_New