ARINC Protocol Summary

Part Number: 10011-00000-A1
Cage Code: 4RK27 • NAICS: 334119

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Document Information:

Rev A1 – Release Date: 7 April 2010

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Chapter 1 – Introduction

ARINC (Aeronautical Radio Inc.) maintains specifications for many avionics data bus protocols. The current versions of the ARINC specification documents can be purchased from ARINC:

https://www.arinc.com/cf/store/category.cfm?prod_group_id=1

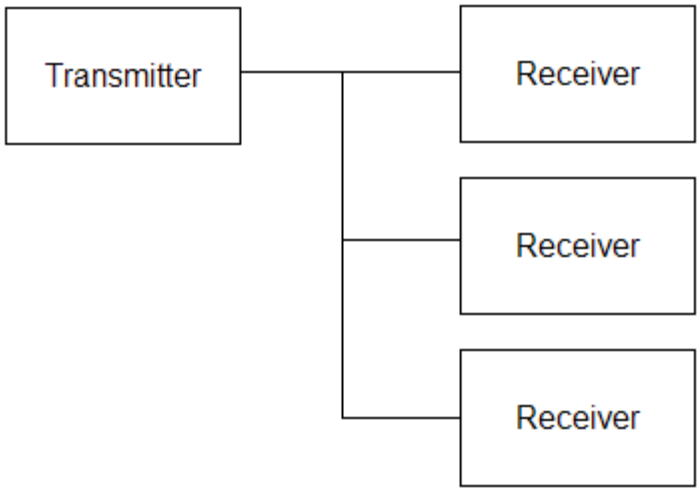
This document will provide a summary of some of the commonly used ARINC protocols. This is intended only as a brief overview and should not be used in place of the ARINC specification documents.

Chapter 2 – ARINC 429

ARINC 429, formally known as the Mark 33 Digital Information Transfer System (DITS), is a specification for the transfer of digital information between avionics system elements.

Network Topology

In its simplest form, an ARINC 429 network consists of a single transmitter (source) connected to a single receiver (sink). Up to 20 receivers can be connected to a single transmitter. ARINC 429 systems can include many of these connections to share data between the elements of the avionics system.



Bit Rates

ARINC 429 typically uses either “low speed” (12 to 14.5 kbps +/- 1%) or “high speed” (100 kbps +/- 1%) bit rates.

Electrical Signals

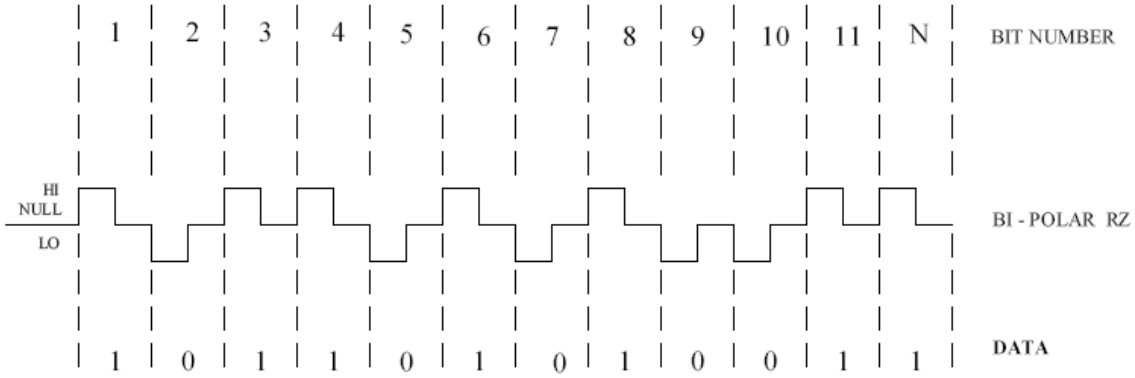
ARINC 429 uses shielded twisted-pair wiring. When a transmitter connection is an open-circuit, the differential voltage is as follows:

	HI (V)	NULL (V)	LO (V)
Line A to Line B	+10 ±1.0	0 ±0.5	-10 ±1.0
Line A to Ground	+5 ±0.5	0 ±0.25	-5 ±0.5
Line B to Ground	-5 ±0.5	0 ±0.25	+5 ±0.5

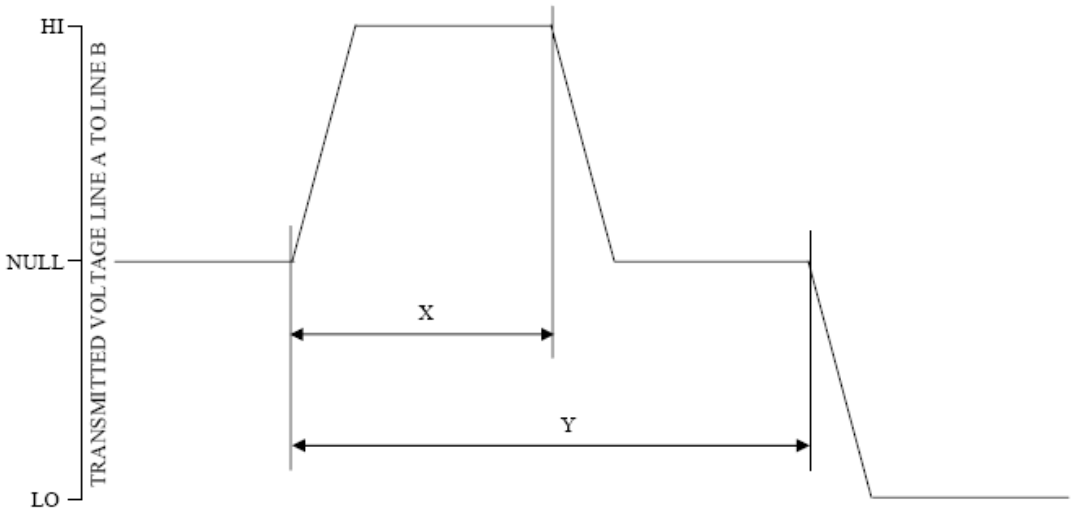
The differential voltage at the receiver input will be dependent on factors like line length, configuration, and number of receivers connected. Receivers should define the “HI”, “LO”, and “NULL” states using the following voltage ranges:

HI	+6.5V to +13V
NULL	-2.5V to +2.5V
LO	-6.5V to -13V

ARINC 429 bit encoding uses RZ bipolar modulation as shown below:



The ARINC 429 output signal timing tolerances are shown below:

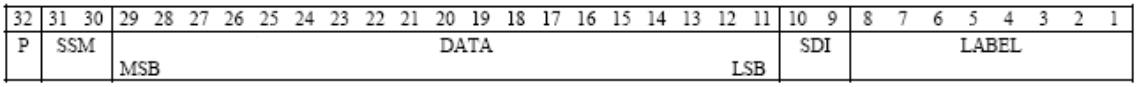


PARAMETER	HIGH SPEED OPERATION	LOW SPEED OPERATION
Bit Rate	100k bps ± 1%	12 – 14.5kbps
Time Y	10 µsec ± 2.5%	Z* µsec ± 2.5%
Time X	5 µsec ± 5%	Y/2 ± 5%
Pulse Rise Time**	1.5 ± 0.5 µsec	10 ± 5 µsec
Pulse Fall Time**	1.5 ± 0.5 µsec	10 ± 5 µsec

* Z = 1 where R = bit rate selected from 12 – 14.5kbps range
** Pulse rise and fall times are measured between the 10% and 90% voltage amplitude points on the leading and trailing edges of the pulse and include permitted time skew between the transmitter output voltages A-to-ground and B-to-ground.

Word Format

ARINC 429 uses 32-bit words. There must be a minimum gap of at least 4 bit-times between each word transmitted.



ARINC 429 words contain five basic fields – Label, SDI (Source/Destination Identifier, Data, SSM (Sign/Status Matrix), and a Parity bit. The Label is transmitted first and the Parity bit is transmitted last.

Label

The 8-bit Label identifies the type of information contained in the word. The Label is represented as a 3-digit octal number, where the bits are reversed from transmission order. For example, octal label 012 typically represents Ground Speed in knots. The 8-bit binary equivalent of octal 012 is 00 001 010. This is transmitted in reverse order, or 010 100 00. Therefore bits 1-8 in the word format diagram above would be 01010000.

SDI

The SDI, or Source/Destination Identifier, can be used in addition to the label to identify where the data came from or where it is supposed to go. For example, when multiple receivers are connected to a transmitter, the SDI could be used to indicate which receiver the data is intended for. Note that the SDI bits could be used as part of the Data field when more data bits are needed.

Data

The Data field contains the meaningful information in the word. The specific interpretation of this information is determined by the Label field (as defined by the Equipment ID assigned for the channel). ARINC 429 data types include BNR (Binary), BCD (Binary Coded Decimal), DSC (Discrete), maintenance data, and ISO Alphabet Number 5 character data.

SSM

The SSM, or Sign/Status Matrix, can be used to provide information associated with the data like positive, negative, north, south, east, west, failure warning, functional test, no computed data, normal operation, etc. The usage of this field is determined by the Label field.

Parity

The Parity bit is used to detect bit-encoding errors. ARINC 429 typically uses odd parity.

Standard EQID/Label Definitions

The ARINC 429 specification includes extensive lists of “industry standard” label definitions organized by “equipment ID” (or EQID). The EQID is a 3-digit hexadecimal number (000 to FFF), allowing for 4096 possible equipment IDs. Each EQID contains a set of defined labels. Note that the same label number could be defined differently for different EQID values.

Labels can be represented by six characters, where the first three characters contain the Label number (three octal digits) and the last three characters contain the EQID number (three hexadecimal digits).

Attachment 2 of the ARINC 429 Specification provides lists of standard label definitions by label number and EQID number:

Label	Eqpt ID (Hex)	Parameter Name	Units	Range (Scale)	Sig Bits	Pos Sense	Reso-lution	Min Transit Interval (msec) 2	Max Transit Interval (msec) 2	Max Trans-port Delay (msec) 3	Notes & Cross Ref. to Tables and Attachments
0 0 1	0 0 2	Distance to Go	N.M.	±3999.9	5		0.1	100	200		6-25
	0 5 6	Distance to Go	N.M.	±3999.9	5		0.1	100	200		
	0 6 0	Distance to Go	N.M.	±3999.9	5		0.1	100	200		
0 0 2	0 0 2	Time to Go	Min	0-399.9	4		0.1	100	200		6-25
	0 5 6	Time to Go	Min	0-399.9	4		0.1	100	200		
	0 6 0	Time to Go	Min	0-399.9	4		0.1	100	200		
	1 1 5	Time to Station	Min	0-399.9	4		0.1	50	50		
0 0 3	0 0 2	Cross Track Distance	N.M.	0-399.9	4		0.1	100	200		6-25
0 0 4	0 0 1	Runway Distance to Go	Feet	0-79900	3		100.0	100	200		
0 1 0	0 0 2	Present Position - Latitude	Deg:Min	180N-180S	6	N	0.1	250	500		Section 2.1.2
	0 0 4	Present Position - Latitude	Deg:Min	180N-180S	6	N	0.1	250	500		Section 2.1.2
	0 3 8	Present Position - Latitude	Deg:Min	180N-180S	6	N	0.1	250	500		
0 1 1	0 0 2	Present Position - Longitude	Deg:Min	180E-180W	6	E	0.1	250	500		
	0 0 4	Present Position - Longitude	Deg:Min	180E-180W	6	E	0.1	250	500		
	0 3 8	Present Position - Longitude	Deg:Min	180E-180W	6	E	0.1	250	500		

Attachment 6 of the ARINC 429 Specification provides general word formats and encoding examples. A few of these are shown below:

TABLE 6-1

32	31 30	29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11	10 9	8 7 6 5 4 3 2 1
P	SSM	DATA → ← PAD ← DISCRETES	SDI	LABEL
[5]	[4]	MSB [3] [2] LSB	[1]	

Generalized BCD Word Format

TABLE 6-1-1

P	SSM	BCD CH #2	BCD CH #2	BCD CH #3	BCD CH #4	BCD CH #5	SDI	8 7 6 5 4 3 2 1
		4 2 1	8 4 2 1	8 4 2 1	8 4 2 1	8 4 2 1		
0	0 0	0 1 0	0 1 0 1	0 1 1 1	1 0 0 0	0 1 1 0	0 0	1 0 0 0 0 0 0 1
Example		2	5	7	8	6		DME DISTANCE (201)

BCD Word Format Example (No Discretes)

TABLE 6-2

32	31 30	29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11	10 9	8 7 6 5 4 3 2 1
P	SSM	DATA → ← PAD ← DISCRETES	SDI	LABEL
[5]	[4]	MSB [3] [2] LSB	[1]	

Generalized BNR Word Format

TABLE 6-2-1

P	31 30 SSM	29 PAD 11	SDI	8 7 6 5 4 3 2 1 LABEL
		1/2 1/4 1/8 1/16 1/32 1/64 1/128 etc		
0	1 0	0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0	0 1 1 0 1 1 1 1
Example:		512 Knots (i.e., 1/8 x 4096 where 4096 is entry in range column of Table 2, Att. 2)		N-S VELOCITY (366)

BNR Word Format Example (No Discretes)

Chapter 3 – ARINC 708

ARINC 708 is a characteristic for airborne pulse Doppler weather radar systems. Refer to the ARINC 708 characteristic document for details.

ARINC 708 data is transmitted over the display data bus from the **Transmitter-Receiver unit (T-R)** to the **Control/Display Unit (CDU)**.

Electrical Signals

ARINC 708 uses a transformer-coupled Manchester encoded signal with a 1 MHz bit-rate (same as the MIL-STD-1553 protocol).

Word Format

Data frames (words) are 1600 bits long containing header information and data information. Each frame starts with a 3us sync pattern (1.5us high, 1.5us low) and ends with another 3us sync pattern (1.5us low, 1.5us high). Therefore a complete frame takes 1606us on the bus.

Header

The header portion consists of a 64-bit status word. The table below shows what this contains:

Bits	Function	Description
1-8	Label	Always octal 055 (binary 10110100)
9-10	Control Accept	See below
11	Slave	0=Master (normal), 1=Slave
12-13	Spare	
14-18	Mode Annunciation	See below
19-25	Faults	See below
26	Stabilization	0=OFF, 1=ON
27-29	Operating Mode	See below
30-36	Tilt	See below
37-42	Gain	See below
43-48	Range	See below
49	Spare	
50-51	Data Accept	See below
52-63	Scan Angle	See below
64	Spare	

Control Accept (bits 9-10):

Bit 10	Bit 9	Control Accept
0	0	Do not accept control
0	1	IND1 accept control
1	0	IND2 accept control
1	1	All INDs accept control

Mode Annunciation (bits 14-18):

Bits 14-18 are treated as discrete bits where 0 indicates normal condition and 1 indicates the conditions listed below:

Bit	Mode Annunciation
14	Automatic sensing of a **turbulence alert** has occurred
15	Automatic sensing of a reflectivity **weather alert** has occurred
16	**Clutter elimination** circuitry is in operation
17	Reduced **sector scan** is in operation
18	Aircraft attitude and/or tilt exceeds the system's design limits

Faults (bits 19-25):

Bits 19-25 are treated as discrete bits where 0 indicates normal condition and 1 indicates the faults listed below:

Bit	Fault
19	Cooling fault
20	Display fault
21	Calibration fault (T-R)
22	Altitude input fault
23	Control fault
24	Antenna fault
25	Transmitter-receiver fault

Operating Mode (bits 27-29):

Bit 29	Bit 28	Bit 27	Operating Mode
0	0	0	Standby
0	0	1	Weather (only)
0	1	0	Map
0	1	1	Contour
1	0	0	Test
1	0	1	Turbulence (only)
1	1	0	Weather and Turbulence
1	1	1	Reserved (calibration annunciation)

Tilt (bits 30-36):

Bits 30-36 represent a 2's complement value for tilt:

Bit	Tilt in Degrees
36	-16
35	+8
34	+4
33	+2
32	+1
31	+0.5
30	+0.25

Gain (bits 37-42):

Bit 42	Bit 41	Bit 40	Bit 39	Bit 38	Bit 37	Gain
1	1	1	1	1	1	Cal
0	0	0	0	0	0	Max
0	0	0	1	0	1	-5
0	0	1	0	1	1	-11
1	1	1	1	1	0	-62

Range (bits 43-48):

Bit 48	Bit 47	Bit 46	Bit 45	Bit 44	Bit 43	Range in NM
0	0	0	0	0	1	5
0	0	0	0	1	0	10
0	0	0	1	0	0	20
0	0	1	0	0	0	40
0	1	0	0	0	0	80
1	0	0	0	0	0	160
1	1	1	1	1	1	315
0	0	0	0	0	0	320

Data Accept (bits 50-51):

Bit 51	Bit 50	Data Accept
0	0	Do not accept data
0	1	Accept data 1
1	0	Accept data 2
1	1	Accept any data

Scan Angle (bits 52-63):

Bits 52-63 represent the Scan Angle in degrees as a numerical value. Bit 63 is the MSB with a value of 180 degrees. Bit 52 is the LSB with a value of 0.087890625 degrees.

Data

The data portion is organized into 512 range-bins per scan angle value. Each range-bin contains a 3-bit color value to indicate the intensity at that position.

Bit 2	Bit 1	Bit 0	Weather Condition/Reflectivity	Color Example
0	0	0	No precipitation (< Z2)	Black
0	0	1	Light precipitation (Z2 to Z3)	Green
0	1	0	Moderate precipitation (Z3 to Z4)	Yellow
0	1	1	Heavy precipitation (Z4 to Z5)	Red
1	0	0	Very heavy precipitation (> Z5)	Magenta
1	0	1	Reserved (out of calibration indication)	
1	1	0	Medium turbulence	
1	1	1	Heavy turbulence	

Each data frame represents a single radius line emanating from the center of a circle. The color values in the range-bins are displayed on this radius line to show the weather conditions in the surrounding area.

Chapter 4 – ARINC 717

ARINC 717 is a characteristic for flight data acquisition and recording systems. Refer to the ARINC 717 characteristic document for details.

ARINC 717 replaces the older ARINC 573 characteristic.

Digital Flight Recorder output signals include the following:

1. Primary Output – ARINC 717 Harvard bi-phase encoding
2. Auxiliary Output – ARINC 429 (DITS) bi-polar encoding

This chapter discusses the ARINC 717 primary output signal.

Bit Rates

ARINC 717 data is sent at a nominal rate of 768 bits per second (64 12-bit words per second). Provisions should also be made to accommodate output rates of two, four, and eight times the nominal rate (128, 256, and 512 12-bit words per second).

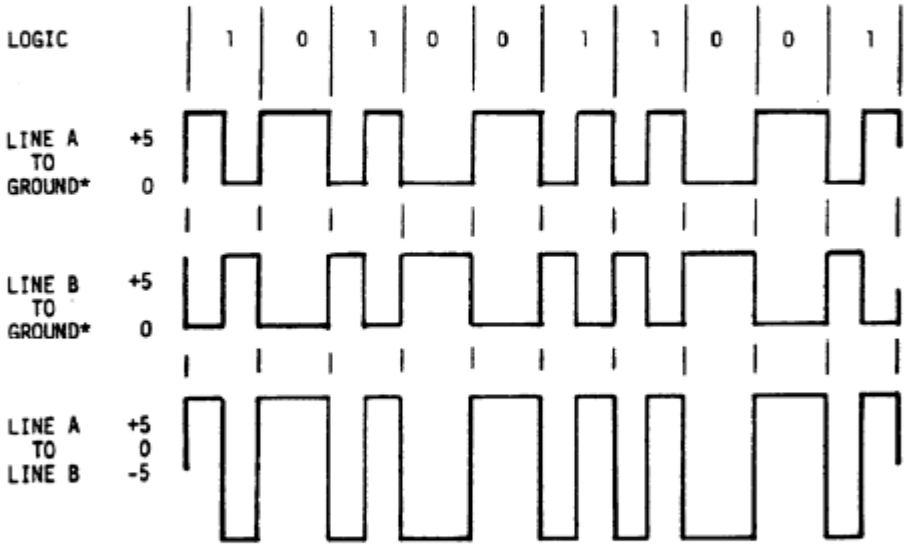
Electrical Signals

Attachment 9.4 of the ARINC 717 characteristic illustrates Harvard bi-phase encoding, as shown below:

Tabulated Voltages and Tolerances

Circuit	Transmitted Voltages HI NOM	HI TOL	LO NOM	LO TOL	Received Voltage HI NOM	HI TOL	LO NOM	LO TOL
LINE A TO LINE B	+5	±1.0	-5	±1.0	+5	±3.0	-5	±3.0
LINE A TO GROUND*	+5	±0.5	0	±0.5	+5	±1.5	0	±1.5
LINE B TO GROUND*	0	±0.5	+5	±0.5	0	±1.5	+5	±1.5

OUTPUT LINE WAVEFORMS



NOTE 1: "*" Indicates DFDAU"Digital Signal Ground"

NOTE 2: The "A" and "B" sides of each digital circuit (data and word sync) should use twisted and shielded cable with an insulating jacket.

NOTE 3: Above voltages and Tolerances are for loads in the range of 3,000 to 12,000 ohms and do not apply where direct head drive is used in DFDR.

Word and Frame Formats

Refer to section 5.3 of the ARINC 717 characteristic for information on word and frame structure. Words consist of 12-bits sent at a nominal rate of 768 bits per second (64 words per second). Data words are formatted into four sub-frames of 64 words each. Provisions should also be made to use faster bit rates to send 128, 256, or 512 words per second.

The complete "frame" repeats every four seconds and consists of four sub-frames (one sub-frame per second).

The first word in each sub-frame provides a synchronization pattern. There is a unique synchronization pattern for each sub-frame as shown below:

Sub-Frame	Synchronization Pattern (octal)
1	1107
2	2670
3	5107
4	6670

Specific data is identified by means of frame position or "time-slot" addresses. The assignment of data parameters to words in the frame is application-specific and is determined by the system designer. As stated in section 5.1.2 of the ARINC 717 characteristic, the DFDAU ROM will assign all word slots to data, providing the parameter choice and the sampling rate and sequence needed for the application.

Attachment 4 of the ARINC 717 characteristic describes the data frame in detail:

1. One frame of data contains four sub-frames each with 64 words, each with 12 bits.
2. The frame is repeated every four seconds with a bit rate of 768 Hz.
3. There is one sub-frame per second. The timing tolerance is 0.1 %.
4. The sub-frames are numbered one to four from the beginning of each sub-frame.
5. The bits are numbered from one to twelve from the beginning of each word.
6. Bit number one is the least significant bit (LSB) and transmitted first.
7. Bit number twelve is the most significant bit (MSB) and transmitted last.
8. Word number one of each sub-frame is the synch word. The synch words are specified by this Characteristic.
   Sub-frame One Synch word - MSB 001 001 000 111 LSB; Octal 1107
   Sub-frame Two Synch word - MSB 010 110 111 000 LSB; Octal 2670

Sub-frame Three Synch word - MSB 101 001 000 111 LSB; Octal 5107
Sub-frame Four Synch word - MSB 110 110 111 000 LSB; Octal 6670

9. Words two through 64 contain data as assigned by the ROM described in Section 5.1.2.
10. Words may be identified as, for example
    ALL/33 – word 33 of all four sub-frames
    1/3 – Sub-frame one, word 3
    1,3/16 – Sub-frame one, and three, word 16
    All/18,50 – Words 18 and 50 of all sub-frames.
11. Bits may be identified as, for example
    All/6/1 – Bit 1 (LSB) of word six in all sub-frames.
    1/14/4-6 – Bits four to six of sub-frame one, word 14.