KAD/BCU/105

Ethernet backplane controller - IENA compatible

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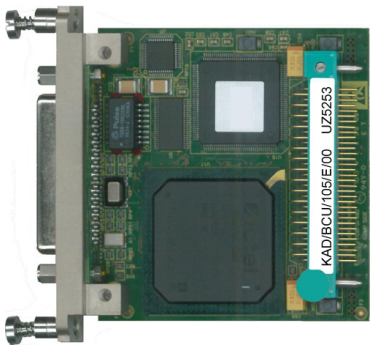

Key Features

- Single 100BaseTx Ethernet channels
- Fixed user-assigned IP address
- Responds to ARP and PING messages
- Programs and verifies Acra KAM-500 hardware
- Synchronization with PTPv1 Grandmaster
- Jumbo packet support, up to 64Kbyte

Applications

- Ethernet based data acquisition systems

Overview

The KAD/BCU/105 is a full-duplex 100BaseTX Ethernet Acra KAM-500 backplane controller, programmer, and IPv4 packet generator. Its Ethernet interface supports auto sensing with a link speed of 100BaseTX. The IPv4 packet generator has IP fragmentation support.

In acquisition mode some or all acquired data is transferred from the backplane to the onboard CVT. Onboard, it is packetized into a user-defined structure. Once full, the packet is transmitted via UDP.

Any number of user-defined IENA packet structures can be handled simultaneously. Different packet identifiers, packet sizes and destination IP addresses can be individually programmed for each packet type. Destination IP addresses can be unicast, multicast, or broadcast.

Upon reception of a programming packet, the module immediately exits acquisition mode and switches to program/verify mode. In program/verify mode it can read or write data blocks to or from any module within an Acra KAM-500 chassis.

The Acra KAM-500 backplane controller supports chassis programming via Ethernet. Synchronization is achieved using an external IEEE 1588-2004 Precision Time Protocol version 1 (PTPv1) source.

The KAD/BCU/105 supports IPv4 networks with fixed IP address allocation, including user-assignment of the module's IP address. The module is factory-programmed with a unique Ethernet MAC address.

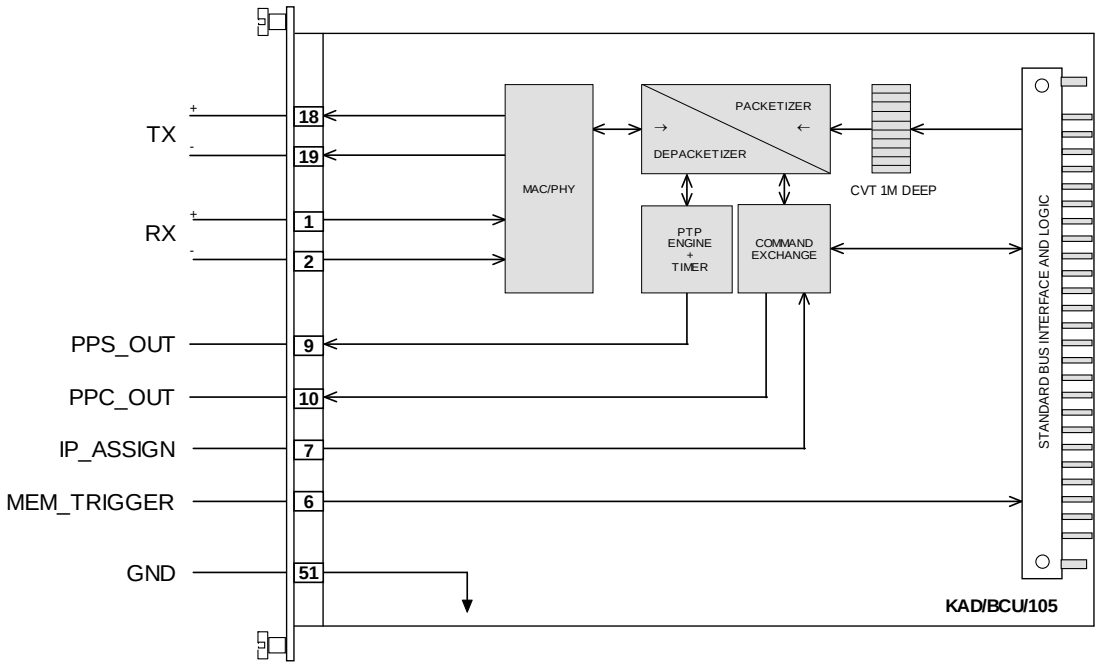

Figure 1: Ethernet interface, PPS and PPC outputs, MEM Trigger and IP Assign inputs of the KAD/BCU/105

Specifications

All values provided in the following specification tables are valid within the operating temperature range specified under "Environmental ratings" in the "General specifications" table.

TABLE 1	General specifications				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Slots	–	–	1	–	Use in controller slot only (J2).
Mass					
	–	75	–	g	
	–	2.65	–	oz	Design metric is grams.
Height above chassis					For recommended clearance requirements see the *CON/KAD/002/CP* data sheet.
bare connector	–	–	11	mm	
bare connector	–	–	0.43	in.	Design metric is millimeters.
Access rate	–	–	2	Msps	Maximum combined access rate over the backplane for read and write.
Power consumption					
+5V	311	–	414	mA	
±7V	0	–	0	mA	
±12V	0	–	0	mA	
total power	1.55	–	2.07	W	Particular combinations of chassis and Acra KAM-500 modules may have power or current limitations. For details, see *TEC/NOT/016 - Power dissipation, TEC/NOT/049 - Power estimation*, and the relevant chassis data sheet.
Environmental ratings					See *Environmental Qualification Handbook*.
operating temperature	-40	–	85	°C	Chassis base/side plate temperature.
storage temperature	-55	–	105	°C	

TABLE 2	Synchronization specification				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Time accuracy					Measured over the full operating temperature range with temperature changing at up to 1°C per minute.
mean error	–	200	350	ns	Mean of PPS errors calculated over +/-60 seconds from any reading.
error within 500ns	99.5	100	100	%	
instantaneous error	–	0.1	1.5	µs	After synchronization is achieved, with no loss of connection to Grandmaster.
Time to synchronize					Measured from a power-up of the test chassis, using a Meinberg M600 IEEE 1588 Grandmaster, supplying PTPv1 messages to the KAD/BCU/105 via OnTime T208 switch, configured in IEEE 1588 transparent mode.
1µs	–	39	–	s	
250ns	–	52	–	s	

TABLE 3	BTTL inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	2	–	
Input voltage					
operating range	0	–	5.5	V	
logic 0	–	–	0.8	V	
logic 1	2	–	5.5	V	
overvoltage protection	-40	–	40	V	Voltages outside of this range can damage input.
Input resistance					
each input to GND	–	41	–	kΩ	Module powered on.
each input to GND	–	41	–	kΩ	Module powered off.

TABLE 4	BTTL outputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Outputs	–	–	2	–	
Signaling rate					
PPS_OUT	–	–	1	Hz	
Output voltage					
logic 0	–	–	0.44	V	Sinking 24mA.
logic 1	3.76	–	–	V	Sourcing 24mA.
short circuit current	–	–	50	mA	
short circuit duration	∞	–	–	s	To GND.
Output resistance	–	121	–	Ω	

TABLE 5	BVDD outputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Outputs	–	–	1	–	
Range	4.8	5	5.1	V	
Current output					
compliance[1]	–	–	12	mA	
short circuit current	–	–	23	mA	
short circuit duration	∞	–	–	s	To GND.
Output resistance	–	211	–	Ω	

1. Currents in excess of the maximum value shown will result in output voltages below the minimum voltage required to be detected as a logic 1 for a standard BTTL input.

TABLE 6	Ethernet interface				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs/outputs	–	–	1	–	IEEE 802.3 compatible -100BaesTX operation only.

Setting up the KAD/BCU/105

All module setup can be defined in XML using XidML® schemas (see http://www.xidml.org).

Instrument settings

SETUP DATA	CHOICE	DEFAULT	NOTES
Manufacturer	-	-	-
Name	ACRA CONTROL	ACRA CONTROL	Name of manufacturer.
PartReference	KAD/BCU/105/E	KAD/BCU/105/E	The instrument part reference.
SerialNumber	AB1234	AB1234	Unique name for each module.
Settings	-	-	-
Is Leap Year	False True	False	Specifies if the current year is a leap year.
Channels	-	-	-
Ethernet Ethernet Output	-	-	Represents a typical Ethernet channel on a networked device
Settings	-	-	-
IP Address	0.0.0.0 to 255.255.255.255	192.168.2.1	Specifies the IP Address of the instrument
PPSOut TTL Output	-	-	Pulse per second.

Parameter definitions

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
Global Parameters				
DayOfYear Day of Year, 1-365 in normal years, 1-366 in leap years	BitVector	BitVector	16	R[15:0] R[15:10] Reserved R[9:0] DayOfYear - Day of Year 1 to 366.
IrigTime48 48-bit wide IRIG time word.	BitVector	BitVector	48	R[47:0]
TimeHi Hours and minutes at the start of the acquisition cycle.	BitVector	BitVector	16	R[47:32] R[15:13] Reserved R[12:7] Hours - BCD Hours 0 to 23. R[6:0] Minutes - BCD Minutes 0 to 59.
TimeLo Seconds and centiseconds at the start of the acquisition cycle.	Second	BCD	16	R[31:16] R(15) Reserved R[14:8] Seconds - Seconds 0 to 59. R[7:0] Centiseconds - Centiseconds 0 to 99.
TimeMicro Microseconds at the start of the acquisition cycle.	Second	BCD	16	R[15:0] R[15:0] Microseconds - Microseconds 0 to 9999.

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
Report Report status of module.	BitVector	BitVector	16	R[15:0] R(15) Event - Event occurred since last read R(14) Programming - Module in Programming mode R(13) IP Configuration - Module in IP Configuration mode R(12) BIST - Module in BIST mode R[11:10] Reserved - Reserved for future use R(9) EEPROM failure - Configuration reading failure. This indicates a hardware error detected on the module. R(8) Invalid configuration - Invalid configuration. The module has been programmed with an EEPROM image that cannot produce a valid acquisition cycle. R(7) Rx Error - Unexpected Ethernet frame received. An Ethernet frame was received that was invalid in some way. R(6) Rx Overflow - Ethernet receive buffer overflow. The module is receiving packets faster than they can be processed. Packets which can cause this include those addressed to the broadcast MAC address, the module's own MAC address, or the PTP multicast MAC address. R(5) BIST failed - BIST failed. A '1' here indicates that the built-in self-test has detected an error in the module's RAM. R(4) Watchdog timeout - Watchdog timeout. A '1' here indicates that the module has failed, and has been reset by the internal watchdog timer. This also interrupts the acquisition cycle. R(3) RAM error - Internal memory access error. R(2) Memory overflow - Memory overflow. The module was delayed in sending an Ethernet frame, with the result that there was insufficient memory for acquired data. R(1) Time Source Lost - Missed more than five consecutive PTP packets R(0) Out Of Synch - On the last update PTP error was greater than 500 ns
Status Reports status of memory trigger pin	BitVector	BitVector	16	R[15:0] R[14:0] Reserved - Reserved for future use R(15) MemTrigger - MEM_TRIGGER pin status

NOTE: It is recommended that names are less than 20 characters, have no white space or contain any of the following five characters "/><\.

Getting the most from the KAD/BCU/105

The Ethernet cabling standard (EIA/TIA-568-B) recommends the use of Category 5 cable.

Achieving a full-duplex link

Ethernet connection between two link partners can be established via auto-negotiation or by forcing them into fixed speeds.

NOTE: During auto-negotiation, both the speed and the duplex capability can be successfully detected and the link can be configured to full-duplex operation. If either of the partners is in forced link speed, then the link is established using the parallel detection algorithm, which does not recognize the difference between full and half-duplex. In this scenario, the link defaults to half-duplex mode. This scenario applies to both 10BaseT and 100BaseT.

NOTE: In a half-duplex link, where simultaneous transmitting and receiving is taking place, packet drops occur. Therefore, to achieve a full-duplex link, it is important to ensure the partner connected to a fixed speed module such as the KAD/BCU/105/E, is also configured to be in the corresponding fixed mode speed.

User-assignment of IP address

Unlike the KAD/ETH/101, the KAD/BCU/105 does not have a 32-bit top-block pin-out, which enables the module's IP address to be hard-wired. Instead, the KSM-500 software is used to configure the module with a user-assigned IP address. The mechanism works as follows:

A top-block pin (pin#7 = IP_ASSIGN) is connected to BVDD to put the module into IP Assign mode. When in this mode, the module will assume a default hard-wired IP address. The IP address 239.0.0.0 is used, as it is an administratively scoped IP multicast address (defined by IETF RFC2365), within the local network control block of addresses. It can be used to transmit packets to a network element using a multicast Ethernet MAC address (01-00-5E-00-00-00), and is limited to the local network, such that it will not be forwarded by a router.

An IP address configuration packet is sent to the module for the purpose of configuring the module with a user-assigned IP address. The user-assigned IP address is stored in EEPROM on the module for subsequent reference.

The KAD/BCU/105 module is then released from IP address configuration mode by removing BVDD from top-block pin#7.

NOTE: Only one module on the network should be set to IP Assign mode at any time. This prevents other KAD/BCU/105 modules from simultaneously processing the configuration packets and thus mistakenly acquiring the same user-assigned IP address.

Once an IP address has been configured, the KAD/BCU/105 responds to ARP requests searching for the MAC address of that IP address.

NOTE: The KAD/BCU/105 does not respond to Unicast-ARP Requests. That is, Broadcast-ARP must be used.

Internet Group Management Protocol

The KAD/BCU/105 uses Internet Group Management Protocol version 2 (IGMPv2) to inform switches that it wishes to receive PTP messages. If a switch between the KAD/BCU/105 and the PTP Grandmaster uses IGMP to control multicast traffic, the KAD/BCU/105 will not start synchronizing to the PTP Grandmaster until after it receives, and responds to, an IGMP query from the switch. To minimize this delay, the KAD/BCU/105 will periodically send unsolicited IGMP join requests if it does not receive any PTP messages.

Packet fragmentation

Ethernet packet sizes range between 64 bytes and 1518 bytes. Ideally, application data packets are designed to fit, with their headers, in 1518-byte Ethernet packets. Packets larger than this can be transmitted over Ethernet by high level protocols such as IP, but they get fragmented (split into smaller pieces). Fragmented packets must then be reassembled by the receiving device to recreate the original IP packet. Packet fragmentation is undesirable for the following reasons:

- Fragments may arrive out of order and complicate reassembly of the data.
- Fragments may be lost, rendering all other fragments of the frame useless.
- The process of fragmenting and reassembling the data is time-consuming.

NOTE: Switches and routers which support IEEE 802.1Q VLAN tagging support Ethernet packets of up to 1522 bytes, including the 4-byte IEEE 802.1Q VLAN tag.

Networked Acra KAM-500 system and acquisition cycles

In a networked data acquisition system, all chassis with KAD/BCU/105 controllers are able to acquire data synchronously by synchronizing their acquisition cycles using

PTPv1. A requirement is that the length of acquisition cycle is an integer divisor of two seconds and the maximal length of acquisition cycle is two seconds. If the KAD/BCU/105 has to adjust it's clock by more than 500µs, data acquisition ceases until the next two-second boundary. This happens once after power-up and once when the module synchronizes with a time master. If a memory module, such as the KAM/MEM/103, in the Acra KAM-500 chassis is configured to Always Log, it records this adjustment as an event.

The following table lists all possible acquisition cycle frequencies.

0.5	2.5	12.5	62.5	312.5	1562.5
1	5	25	125	625	3125
2	10	50	250	1250	6250
4	20	100	500	2500	
8	40	200	1000	5000	
16	80	400	2000	10000	
32	160	800	4000		
64	320	1600	8000		
128	640	3200			
256	1280	6400			
512	2560				

To get the most from networked Acra KAM-500 data acquisition systems, it is essential that PTPv1 Ethernet switches are used. For a list of suitable switches, contact Curtiss-Wright support (acra-support@curtisswright.com).

PTP restrictions

By default, a PTP Grandmaster sends sync messages at two-second intervals. Although the protocol allows for sync message intervals of between one and 64 seconds, intervals should not be above two seconds. The KAD/BCU/105 has been designed based on sync messages arriving at two-second intervals. If it was to accept a Grandmaster with a longer sync interval, clock drift between sync messages would degrade the clock accuracy of the KAD/BCU/105. When time on a KAD/BCU/105 changes by more than 500µs, the KAD/BCU/105's acquisition cycle is halted for up to two seconds. This means, for example, when a Grandmaster switches between GPS/IRIG time sources or entering/exiting free running mode, synchronization is lost, and the KAD/BCU/105 stops sending packets for up to two seconds whilst it resynchronizes. The sequence number of the first packet transmitted after resynchronization is reset to zero.

The KAD/BCU/105 ignores a PTP Grandmaster if it sends messages more than four seconds apart.

Mid-year leap seconds and IENA time

PTP time is based on the time recorded by atomic clocks, such as the time signal from GPS satellites. This is more accurate than Coordinated Universal Time (UTC), on which terrestrial clocks are based, because the rotation of the earth varies slightly. For this reason, UTC is occasionally adjusted by lengthening or shortening the last minute of a month by one second. Of the 24 leap seconds that were added from 1972 to 2008, most were conveniently applied at the end of the last minute of the year. However, nine occurred on the 31st of June in various years.

The PTP Grandmaster reports the number of seconds by which UTC currently differs from PTP time, but not whether any of them has happened since this year began.

A problem arises when the KAD/BCU/105 is started after a leap second has occurred during the current year. IENA time is based on the start of the current year in UTC. This means the KAD/BCU/105 must calculate when the current year began.

If the KAD/BCU/105 starts to synchronize with a Grandmaster in the second half of a year, it does not know whether a leap second was applied in June of the current year. For this reason, the KAD/BCU/105 always calculates the start of the current year by assuming every hour since the start of the year has had 3,600 seconds.

Connector pinout of the KAD/BCU/105

PIN	NAME	SEE SPECIFICATIONS TABLE	COMMENT
1	RX+	Ethernet interface	Ethernet interface
2	RX-	Ethernet interface	Ethernet interface
3	GND	Internal ground	
4	BVDD	BVDD outputs	5V; internally buffered with 220Ω resistor
5	CHASSIS	Chassis	
6	MEM_TRIGGER	BTTL inputs	Trigger for memory recording; internally pulled to 0
7	IP_ASSIGN	BTTL inputs	IP Assign mode; internally pulled to 0
8	DNC		Do not connect
9	PPS_OUT	BTTL outputs	One pulse per second
10	PPC_OUT	BTTL outputs	One pulse per acquisition cycle
11	DNC		Do not connect
12	DNC		Do not connect
13	DNC		Do not connect
14	DNC		Do not connect
15	GND	Internal ground	
16	DNC		Do not connect
17	DNC		Do not connect
18	TX+	Ethernet interface	Ethernet interface
19	TX-	Ethernet interface	Ethernet interface
20	CHASSIS	Chassis	
21	DNC		Do not connect
22	DNC		Do not connect
23	DNC		Do not connect
24	DNC		Do not connect
25	DNC		Do not connect
26	DNC		Do not connect
27	DNC		Do not connect
28	DNC		Do not connect
29	DNC		Do not connect
30	DNC		Do not connect
31	DNC		Do not connect
32	DNC		Do not connect
33	DNC		Do not connect
34	DNC		Do not connect
35	DNC		Do not connect
36	DNC		Do not connect
37	DNC		Do not connect
38	DNC		Do not connect
39	DNC		Do not connect
40	DNC		Do not connect
41	DNC		Do not connect
42	DNC		Do not connect
43	DNC		Do not connect
44	DNC		Do not connect
45	DNC		Do not connect
46	DNC		Do not connect
47	DNC		Do not connect
48	DNC		Do not connect
49	DNC		Do not connect
50	DNC		Do not connect
51	GND	Internal ground	
52	CHASSIS	Chassis	

Ordering information

PART NUMBER	DESCRIPTION
KAD/BCU/105/E	Ethernet backplane controller - IENA compatible

By default, one ACC/ASY/023/C cable is included with each order, while a standard mating connector, CON/KAD/002/CP, is included with each module in the order. Their part numbers will be added to the Confirmation of Order unless an alternative option is specified (see the *Cables* data sheet). Additional items must be ordered separately; refer to Related Products for options.

Revision history

REVISION	DIFFERENCES	STATUS
KAD/BCU/105/E	Improved IRIG time sync after power-up	Recommended for new programs
KAD/BCU/105/D	Improved PTPv1 synchronization with third party boundary clocks	Not recommended for new programs
KAD/BCU/105/C	Improved synchronization at varying temperatures; improved randomization of PTP messages to avoid flooding switches	Not recommended for new programs
KAD/BCU/105/B	First release	Not recommended for new programs

Supporting software

MODULE	DETAILS
DAS Studio 3	User interface for setup and management of data acquisition, network switches, recorders and ground stations in an integrated environment
KSM-500	This module is supported by the KSM-500 suite of software tools

Related products

MODULE	DETAILS
NET/CON/002	1.5m female micro-miniature, circular connector to KAD Ethernet cable

Related documentation

DOCUMENT	DETAILS
DOC/DBK/001	Acra KAM-500 Databook
DOC/HBK/002	Environmental Qualification Handbook
DOC/MAN/018	KSM-500 Databook
DOC/MAN/030	DAS Studio 3 User Manual
TEC/NOT/016	Power dissipation
TEC/NOT/032	Using Ethernet for data acquisition
TEC/NOT/049	Power estimation
TEC/NOT/053	Using the KAD/BCU/105

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