KAM/TCG/105

Time-code generator with GPS/IRIG input and battery backup

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Key Features

- Synchronizes with IRIG-B or GPS
- 1 µs time resolution
- Less than three parts per million drift when acting as a generator
- Time is maintained on an internal battery during power-off
- GPS navigation information is available
- Secondary time source input

Applications

- System synchronization
- Parameter time tagging
- Global positioning

Overview

The KAM/TCG/105 can accept time from an IRIG-B time source, from its onboard GPS receiver (external antenna required), or from an external GPS receiver outputting NMEA messages and a one PPS signal. The received time is written to an internal timer and to a Real-Time Clock (RTC) that maintains time during power-down. The time can be used for synchronization of a distributed Acra KAM-500 data acquisition system. The module generates IRIG-B outputs to allow external devices to synchronize with the Acra KAM-500 system.

The module comprises a GPS reader and an IRIG reader which decode incoming signals. The IRIG reader extracts control functions and straight binary seconds as well as time. The GPS reader parses NMEA messages as they are generated by the receiver. Extracted navigation data such as position, altitude, velocity, and heading are available as individual parameters. The module can also be synchronized via NMEA messages being sent over RS-232 from a third party GPS or PC with granularity of one second.

The timer block is a 4 x 16-bit Binary Coded Decimal (BCD) counter with microsecond resolution. For example, at 1 µs before midnight on January 1, the timer would read 0001 23:59 59.99 9999.

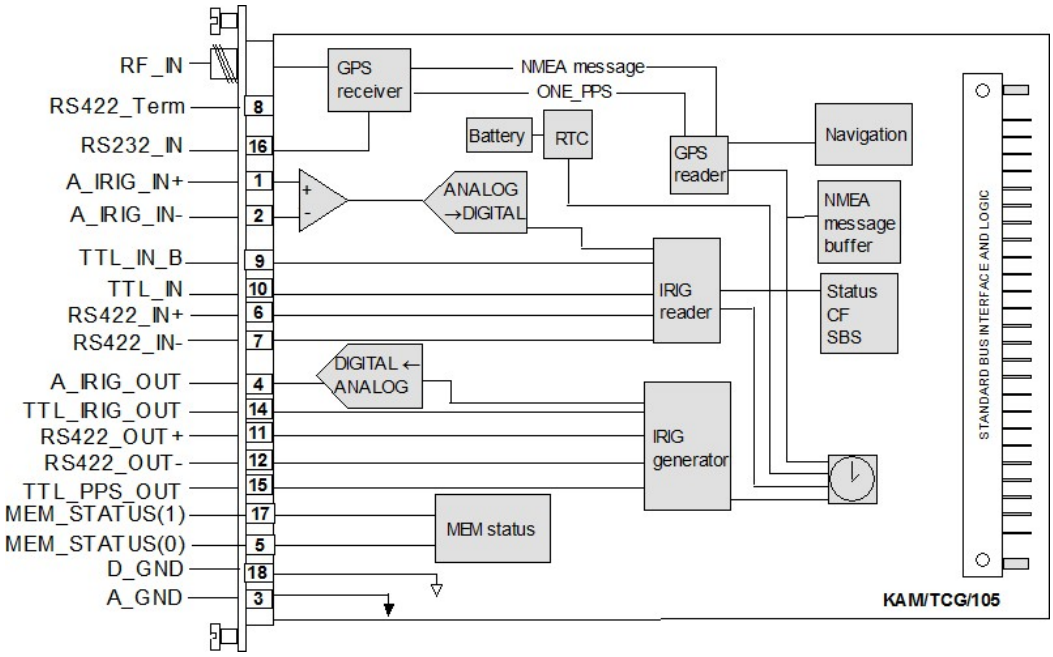

Figure 1: Inputs and outputs on the KAM/TCG/105

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	–	Can be placed in any user-slot in any combination.
Mass					
	–	90	–	g	
	–	3.17	–	oz	Design metric is grams.
Height above chassis					For recommended clearance requirements see the *CON/KAD/003/CP* data sheet.
bare connector	–	–	11	mm	
bare connector	–	–	0.43	inch	Design metric is millimeters.
Access rate	–	–	2	Msps	Maximum combined access rate for read and write.
Power consumption					
+5V	–	–	230	mA	
±7V	–	–	0	mA	
+12V	–	–	63	mA	When driving the recommended antenna RFE/AEG/001.
+12V	–	–	32	mA	With no antenna connected.
-12V	–	–	28	mA	
total power	–	–	2.24	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	
Battery duration	–	–	4	years	To replace the battery, the unit must be returned to Curtiss-Wright. Contact Curtiss-Wright support (acra-support@curtisswright.com) for details.

TABLE 2	Active antenna inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	1	–	
Bias voltage	5.15	–	5.35	V	
Bias current	–	–	50	mA	
Signal strength	-138	–	–	dBm	
Antenna gain	10	26	50	dB	See "GPS antenna" on page 15.
Antenna noise	–	–	1.5	dB	See "GPS antenna" on page 15.
ESD protection	–	2	–	kV	Human body model

TABLE 3	Onboard GPS receiver				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	1	–	
Time accuracy	–	–	1	µs	Relative to GPS time. See “GPS time” on page 15.
Position accuracy					See “Navigation data accuracy” on page 16.
2D fix	2.5	–	22	m	Circular Error Probable (CEP).
3D fix	2.5	–	22	m	Spherical Error Probable (SEP).
Satellite acquisition time					See “Acquisition” on page 15.
reacquisition	3.5	5	–	s	
warm power-up	–	40	–	s	
cold power-up	–	60	–	s	Test carried out with a minimum of four satellites in use.
GPS update rate	–	1	1	Hz	
Time format	–	–	–	–	Coordinated Universal Time (UTC).
Navigation datum	–	–	–	–	World Geodetic System-84 (WGS-84). See “Datum” on page 15.
Restrictions					Coordinating Committee for Multilateral Export Controls restrictions apply.
velocity	–	–	1,854	kph	
velocity	–	–	1,000	knots	
altitude	–	–	18,000	m	
altitude	–	–	60,000	ft	

TABLE 4	Analog IRIG time inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	1	–	
Sampling rate					
A_IRIG_IN	–	–	2	Msps	Operating as analog IRIG-B input, the following time codes are supported: IRIG-B 120, 121, 122, 123.
Input voltage					
voltage range	0.1	–	10	V_{p-p}	
overvoltage protection	-7	–	12	V	Voltages outside of this range can damage input.
Time error					
offset	–	–	4	µs	
Input resistance					
between inputs	–	1.1	–	MΩ	Module powered off.
between inputs	52	–	–	kΩ	Module powered on.
each input to GND	–	75	–	kΩ	Module powered off.
each input to GND	390	–	–	kΩ	Module powered on.

TABLE 5	BTTL inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	2	–	
Signalling rate					
TTL_IN	–	–	1	bps	Operating as ONE_PPS input.
TTL_IN	–	–	100	bps	Operating as IRIG-B input, the following time codes are supported: IRIG-B 000, 001, 002, 003.
Input voltage					
operating range	0	–	5.25	V	
logic 0	0	–	0.7	V	
logic 1	2	–	5.25	V	
overvoltage protection	-0.3	–	6	V	Voltage in excess of these values can damage input.
Signalling currents					
logic 0	–	-0.2	-0.5	mA	
logic 1	–	2	5	mA	
Input resistance					
each input to GND	–	27	–	MΩ	Module powered on.
each input to GND	–	53	–	kΩ	Module powered off.
Time error					
offset	–	–	2	µs	Over full operating temperature range. When configured as primary (TTL_IRIG) input range.

TABLE 6	RS-232 inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	1	–	
Baud rate					
RS232_IN	4,800	–	115,200	bps	The following baud rates are supported: 4800, 9600, 19200, 115200.
Input voltage					
operating range	-25	–	25	V	Do not exceed operating range.
logic 0	–	–	0.6	V	V_{IN+} - V_{IN-}.
logic 1	2.4	–	–	V	V_{IN+} - V_{IN-}.
overvoltage protection	-25	–	25	V	Voltage in excess of these values can damage input.
ESD protection	-15	–	15	kV	Human Body Model.
Input resistance					
each input to GND	–	4.8	–	MΩ	Module powered on.
each input to GND	–	4.7	–	kΩ	Module powered off.

TABLE 7	RS-422 inputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Inputs	–	–	2	–	
Signalling rate					
RS422_IN	–	–	100	bps	Operating as IRIG-B input, the following time codes are supported: IRIG-B 000, 001, 002, 003.
RS422_IN	4,800	–	115,200	bps	Operating as NMEA data input, the following baud rates are supported: 4800, 9600, 19200, 115200.
Input voltage					
operating range	-7	–	12	V	Do not exceed operating range.
logic 0	–	–	-0.7	V	V_{IN+} - V_{IN-}.
logic 1	0.7	–	–	V	V_{IN+} - V_{IN-}.
overvoltage protection	-7	–	12	V	Voltage in excess of these values can damage input.
ESD protection	–	–	15	kV	Human Body Model.
Input resistance					
between inputs	–	117	–	MΩ	Module powered on.
between inputs	–	117	–	kΩ	Module powered off.
between inputs	–	121	–	Ω	Module powered on and inputs terminated.
between inputs	–	121	–	Ω	Module powered off and inputs terminated.
each input to GND	–	4.2	–	MΩ	Module powered on.
each input to GND	–	59	–	kΩ	Module powered off.

TABLE 8	Analog IRIG time outputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Outputs	–	–	1	–	
Signaling rate					
A_IRIG_OUT	–	–	1	kHz	Operating as analog IRIG-B 123 output with a 1 kHz carrier frequency.
Output voltage					
mark amplitude	4	–	20	V_{p-p}	Range: 4, 8, 12, 16, 20.
mark to space ratio	–	3	–	–	Space amplitude = mark amplitude/3.
short circuit current	3	10	–	mA	
short circuit duration	∞	–	–	s	To GND.
Output resistance	–	0.2	–	Ω	Load impedance must not be less than 3.3 kΩ.

TABLE 9	BTTL outputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Outputs	–	–	2	–	
Signaling rate					Outputs are updated at the start of the acquisition cycle.
MEM_STATUS(0)	–	–	100	kbps	
MEM_STATUS(1)	–	–	100	kbps	
Output voltage					
logic 0	–	–	0.44	V	Sinking 24 mA.
logic 1	4.4	–	–	V	Sourcing 24 mA.
short circuit current	–	–	50	mA	
short circuit duration	∞	–	–	s	To GND.
Output resistance	–	120	–	Ω	120Ω resistor in series with a TTL output.

TABLE 10	BTTL outputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Outputs	–	–	2	–	
Signaling rate					
TTL_IRIG_OUT	–	–	100	bps	Operating as IRIG-B 003 digital output.
TTL_PPS_OUT	1	–	10	Hz	Operating as a selectable one or 10-PPS output. Rising edge of TTL_PPS_OUT indicates the start of a second.
Output voltage					
logic 0	–	–	0.2	V	Sinking 0.1 mA through 100Ω output resistance.
logic 1	4.8	–	–	V	Sourcing 0. 1mA through 100Ω output resistance.
short circuit current	–	–	50	mA	
short circuit duration	∞	–	–	s	To GND.
Output resistance	–	200	–	Ω	

TABLE 11	RS-422 outputs				
PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITION/DETAILS
Outputs	–	–	1	–	
Signaling rate					
RS422_OUT	100	–	–	bps	When providing IRIG-B.
RS422_OUT	–	–	1	Mbps	When providing X-SYNC.
Output voltage					
operating voltage	-7	–	12	V	Absolute voltage of the operating signal must stay within this range.
logic 0	–	–	-2	V	V_{0+} - V_{0-} ; R_{LOAD} = 100Ω.
logic 1	2	–	–	V	V_{0+} - V_{0-} ; R_{LOAD} = 100Ω.
overvoltage protection	-7	–	12	V	
short circuit current	–	–	250	mA	
short circuit duration	∞	–	–	s	Only one output may be shorted at a time.
ESD protection	-15	–	15	kV	Human Body Model.
Output resistance	–	25	–	Ω	

Setting up the KAM/TCG/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	KAM/TCG/105	KAM/TCG/105	The instrument part reference.
SerialNumber	AB1234	AB1234	Unique name for each module.
Settings	-	-	-
Time Server	Master FreeRunning Slave	Master	When Master, time is seeded from the KAM/TCG/105 into other slave modules. When Slave, time is seeded from a master module into the KAM/TCG/105. When FreeRunning, no time seeding takes place.
Primary Input	IRIG-B GPS RTC	IRIG-B	Specifies which input takes priority; when selecting RTC, seeded time is loaded from the RTC.
Allow Secondary	True False	True	When set to True allows the module to switch to either the primary or secondary time source (which-ever is in lock).
Control Function Source	IRIG-B Zeros Year	Zeros	Selects which bit-pattern is loaded on the Control Function field of the outgoing IRIG-B stream.
Settings *IRIG-B-In*	-	-	Settings on the IRIG-B input.
Current Year	2011 to 2098	2015	Indicates the current year.
IRIG Source	Analog RS-422 TTL_A	TTL_A	Selects the physical interface used for decoding the IRIG-B time code stream.
IRIG-B revision	IRIG-B-200-9x IRIG-B-200-04	IRIG-B-200-9x	When selected, module decodes the year from the CF bits (IRIG-B-200-04).
Processes	-	-	-
MemoryFilter	-	-	A parameter placed in this register is used to gener-ate the output of the MEM_STATUS (80% full and logging).
Parser(14:0)	-	-	One of 15 NMEA parser slots.
Catchall-Parser	-	-	Any NMEA message that is not parsed goes to this final parser slot.
Channels	-	-	-
GPS-In *GPS-In Input*	-	-	Time and navigation parameters are taken from the KAM/TCG/105's onboard GPS receiver.
Settings	-	-	-
GPS Source	OnBoardGPS RS-422 RS-232	OnBoardGPS	-
PPS Source	TTL_A RS-422	None	-
Maximum Dilution Of Precision	1 to 15	5	Specifies the maximum Dilution of Precision (DOP) allowed. DOP is an expression of the quality of the GPS solution; the lower the value, the more accurate it is.

SETUP DATA	CHOICE	DEFAULT	NOTES
Baud Rate	4800 9600 19200 38400 57600 115200	19200	Specifies the number of symbols received per second.
Settings *On Board GPS*	-	-	These settings are only applied to the onboard GPS receiver.
Dynamic	Stationary Pedestrian Automotive Sea Airborne with <1g Acceleration Airborne with <2g Acceleration Airborne with <4g Acceleration	Airborne with <2g Acceleration	Dynamic profile of onboard GPS receiver.
Leap Seconds	0 to 255	15	The number of seconds difference between UTC and GPS time; only applied to onboard GPS receiver.
PPS-Out *TTL Output*	-	-	One or ten Pulse Per Second output.
Settings	-	-	-
PPS Rate	1 10	1	-
RS-422-Out *RS-422 Output*	-	-	Outputting IRIG-B, NMEA or X-SYNC
Settings	-	-	-
Mode	IRIG-B X-SYNC NMEA	IRIG-B	Switches amongst outputting digital IRIG-B, X-SYNC out (which synchronizes legacy data acquisition systems) or NMEA (NMEA being the electrical copy of the NMEA source). If GPS onboard is used, the baud rate set internally for output NMEA messages is 115200 bps.
TTL-Out *TTL Output*	-	-	Outputting IRIG-B.
MEM_STATUS(1:0) *Digital Output*	-	-	MEM_STATUS(1:0) showing 80% full and logging function of the memory card.
Analog-IRIG-BOut *Analog Output*	-	-	Outputting an analog IRIG-B stream (1kHz amplitude modulated sine wave).
Settings	-	-	-
Amplitude	2 to 10	4	-
RS-422-In *RS-422 Input*	-	-	-
Settings	-	-	-
TTL-In *TTL Input*	-	-	-
Analog-IRIG-BIn *Analog Input*	-	-	-
Settings	-	-	-

SETUP DATA	CHOICE	DEFAULT	NOTES
PPS Source	TTL_A TTL_B RS-422 None	None	-
RS-232-In *RS-232 Input*	-	-	-

Parameter definitions

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
Global Parameters				
StatusIn IRIG-B and timer status register.	BitVector	BitVector	16	R[15:0] R(15) IRIG-BLock - When 1, the IRIG-B decoder is locked to a valid IRIG-B stream. R(14) StraightBinarySeconds(16) - Bit 16 (MSB) of the Straight Binary Seconds decoded from the IRIG-B stream (see StraightBinarySeconds for bits 15 to 0). R[13:3] Reserved R(2) SourcePrimary - When 1, the timer is locked to the primary timer source. R(1) TimerLock - When 1, the timer's PLL is in lock with the input TIME ONE_PPS source. R(0) Reserved
ControlFunction Control Function (CF) bits received from the IRIG-B input.	BitVector	BitVector	32	R[31:0] R[31:5] ControlFunction R[4:0] Reserved
StraightBinarySeconds Sixteen LSBs of the seventeen Straight Binary Seconds received in the IRIG-B stream.	Second	OffsetBinary	16	R[15:0]
IrigTime48 48-bit wide IRIG time word.	BitVector	BitVector	48	R[47:0]
TimeHi Time in hours and minutes at the start of the acquisition cycle.	BitVector	BitVector	16	R[47:32] R[15:13] Reserved - Reserved for future use R[12:7] Hours - BCD Hours 0 to 23. R[6:0] Minutes - BCD Minutes 0 to 59.
TimeLo Time in seconds and centiseconds at the start of the acquisition cycle.	BitVector	BitVector	16	R[31:16] R(15) Reserved - Reserved for future use R[14:8] Seconds - Seconds 0 to 59. R[7:0] Centiseconds - Centiseconds 0 to 99.
TimeMicro Time in microseconds at the start of the acquisition cycle.	Second	BCD	16	R[15:0] R[15:0] Microseconds - Microseconds 0 to 9999.
DayOfYear The day of the year from 1 to 366 at the start of the acquisition cycle.	BitVector	BitVector	16	R[15:0] R[15:10] Reserved R[9:0] DayOfYear
MemoryFilter Parameters				

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
MemoryReportRegister Use the MEM module report register as input. This drives the MEM_STATUS(1:0) outputs.	BitVector	BitVector	16	R[15:0]
Parser(14:0) Parameters				
MessageInfo Indicates status of message (stale/skipped/empty)	BitVector	BitVector	16	R[15:0] R(15) Empty - This slot is empty. R(14) Stale - Contents of this slot have already been read. R(13) Skipped - Contents of this slot have been overwritten. R[12:0] Reserved - Reserved for future use.
Catchall-Parser Parameters				
MessageData(40:0) The 2x8 bits of a particular byte in serial NMEA messages (word aligned, 41 words maximum)	BitVector	BitVector	16	R[15:0]
MessageInfo Indicates status of message (stale/skipped/empty)	BitVector	BitVector	16	R[15:0] R(15) Empty - This slot is empty. R(14) Stale - Contents of this slot have already been read. R(13) Skipped - Contents of this slot have been overwritten. R[12:0] Reserved - Reserved for future use.
GPS-In Parameters				
Latitude Latitude received in the NMEA stream.	BitVector	BitVector	48	R[47:0]
LatitudeHi Degrees and minutes of latitude.	Unitless	BCD	16	R[47:32] R[15:8] Degrees - Degrees of latitude 0 to 89. R[7:0] Minutes - Minutes of latitude 0 to 59.
LatitudeLo Decimal minutes of latitude.	Unitless	BCD	16	R[31:16] R[31:16] DecimalMinutes - Decimal places of minutes of latitude 0.0000 to 0.9999.
LatitudeMicroMinutes Fifth decimal place of minutes of latitude.	BitVector	BitVector	16	R[15:0] R[15:4] Reserved R[3:0] DecimalMinutes - Fifth decimal place of minutes of latitude 0.00000 to 0.00009.
Longitude Longitude received in the NMEA stream.	BitVector	BitVector	48	R[47:0]
LongitudeHi Degrees of Longitude.	BitVector	BitVector	16	R[47:32] R[47:44] Reserved R[43:32] Degrees - Degrees of longitude 0 to 179.
LongitudeLo Minutes and decimal minutes of longitude.	Unitless	BCD	16	R[31:16] R[31:24] Minutes - Minutes of longitude 0 to 59. R[23:16] DecimalMinutes - Decimal places of minutes of longitude 0.00 to 0.99.

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
LongitudeMicroMinutes Decimal minutes of longitude.	BitVector	BitVector	16	R[15:0] R[27:12] Reserved R[11:0] DecimalMinutes - Last three decimal places of minutes of longitude 0.00000 to 0.00999.
Altitude Altitude expressed as height above Mean Sea Level (MSL).	BitVector	BitVector	32	R[31:0]
AltitudeHi Tens of thousands of meters.	BitVector	BitVector	16	R[31:16] R(31) AltitudeIsNegative - When 1, the altitude is below mean sea level. R[30:20] Reserved R[19:16] Altitude - Tens of thousands of meters 0 to 9.
AltitudeLo Thousands of meters.	Meter	BCD	16	R[15:0] R[15:0] Altitude - Meters 0 to 9999.
VelocityInKph Velocity in kilometers per hour.	MetersPerSecond	BCD	16	R[15:0] R[15:0] VelocityInKph - KM 0 to 9999.
VelocityInKn Velocity in nautical miles per hour.	Unitless	BCD	16	R[15:0] R[15:0] VelocityInKn - KN 0 to 9999.
Heading True course over ground.	BitVector	BitVector	32	R[31:0]
HeadingHi Degrees of true course over ground.	Unitless	BCD	16	R[31:16] R[31:26] Reserved R[25:16] Degrees - Degrees 0 to 359.
HeadingLo Decimal degrees of true course over ground	Unitless	BCD	16	R[15:0] R[15:8] Reserved R[7:0] DecimalDegrees - Decimal degrees of true course over ground.
DilutionOfPrecision Dilution of precision. See “Dilution of Precision (DOP)” section.	BitVector	BitVector	16	R[15:0] R[15:12] Reserved R[11:8] PDOP - Positional DOP; if DOP > 15 then 15 is returned. R[7:4] HDOP - Horizontal DOP; if DOP > 15 then 15 is returned. R[3:0] VDOP - Vertical DOP; if DOP > 15 then 15 is returned.

NAME/DESCRIPTION	BASE UNIT	DATA FORMAT	BITS	REGISTER DEFINITION
StatusGPS GPS status register.	BitVector	BitVector	16	R[15:0] R(15) GPSLock - When 1, the GPS decoder is locked to a valid NMEA stream. R(14) FixError - When 1, indicates that the Fix Flag was not set R(15)=0. R(13) CheckSumError - When 1, indicates that a checksum error was detected R(15)=0. R(12) TooFewSatellites - When 1, indicates that less than the minimum configured number of satellites are used, which can affect the quality of the received data. R(11) DOPTooHigh - When 1, indicates that one of the DOP (Dilution of Precision) figures is outside a specified range. R(10) North/South - When 0, the latitude read is in the northern hemisphere; when 1, the latitude read is in the southern hemisphere. R(9) East/West - When 0, the longitude read is east of the Greenwich Meridian; when 1, the longitude read is west of the Greenwich Meridian. R(8) LocationValid - This bit will be set when Latitude/Longitude information has been successfully parsed from the NMEA stream. R[7:4] SatellitesInView - Number of satellites in view. R[3:0] SatellitesInUse - Number of satellites used to calculate GPS solution.

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 KAM/TCG/105

The KAM/TCG/105 is a combined GPS and IRIG-B input module. It can accept inputs from a number of sources.

SMA torque setting

The recommended torque setting for the SMA connector is 0.45 Nm (0.33 foot pound-force).

PPS pulse input

There are three PPS inputs: TTL_IN_A, TTL_IN_B, and RS-422 (when selected).

TTL_IN_B is a dedicated PPS input. TTL_IN_A and RS-422 can also be used to take in IRIG-B digital or NMEA messages.

When used for PPS inputs, these can be used to synchronize to an external 1 PPS pulse.

NOTE: TTL_IN_B can only be used with analog IRIG-B.

Time seeding

On power-up of the Acra KAM-500, the KAM/TCG/105's timer is seeded with time from the RTC. The RTC receives time once the source (GPS or IRIG) is locked. Once powered down, the battery maintains time on the RTC. Then on subsequent power-ups, time is loaded from the RTC.

NOTE: Typically, it can take 2 seconds from power up for the module to get its time from the RTC, during which time it will free run.

Once a time source is locked, it updates the internal RTC time. If the module is in slave mode, the RTC time is updated with time from the master module.

Alternatively, the initial time can be set from the PC using either Time Seeder or kTimeseed.

It is not recommended to power on the module at less than -30°C if no external timing source is applied, as the RTC may not seed the correct time and the internal clock will indicate time since power on.

Primary and secondary inputs

The KAM/TCG/105 accepts time from either an IRIG-B stream or a GPS receiver via NMEA messages.

It is possible to use one time source as the primary input and optionally enable the other time source as the secondary input. If the primary time source becomes unavailable (missing or has errors), then after 10 seconds the KAM/TCG/105 switches to the secondary source. Later, if the primary source becomes available again then the KAM/TCG/105 switches back to the primary time source after 10 seconds.

This allows for synchronization with a secondary IRIG source when an aircraft is in the hangar where GPS is not available; then for GPS to be used when the aircraft is on the runway or in flight, without reprogramming the Acra KAM-500.

If the primary source is GPS then the secondary source must be IRIG and vice versa. For instance, you cannot use an external GPS receiver as the primary time input and use the onboard GPS receiver as the secondary time input. Also, because the digital pins are used for more than one function, there must be no pin clash between the primary and secondary input pins.

The following table shows available combinations of primary and secondary time inputs.

		IRIG		
		Analog	TTL_IN	RS422_IN
GPS	On Board	Y	Y	Y
	RS422_IN TTL_PPS	Y	N	N
	RS232_IN TTL_PPS	Y	N	Y

Control Function Source

The KAM/TCG/105 can set the control function bits of the outgoing IRIG-B stream as shown in the following table.

SETTING	DESCRIPTION
IRIG-B	CF bits are copied from the incoming IRIG-B stream
Zeros	CF bits are set to Zero
Year	CF bits are used to encode the current year as per IRIG Standard 200-04.

Clock synchronization

The KAM/TCG/105's timer uses a digital Phase Locked Loop (PLL) to synchronize its own clock with an external time source. Frequency and phase error are corrected every second. If the error is greater than 500 µs, the PLL jumps to the correct time immediately. After that it tracks the external time source. When the PLL is locked to the external time source, R(1) of the IRIG_STATUS register is set to one.

The timer in a KAD/BCU/101 can be seeded with time from

the KAM/TCG/105 at the start of the acquisition cycle, but over the course of the acquisition cycle, it can drift by up to 4 µs per second. This can be eliminated by physically connecting the KAM/TCG/105's X-SYNC OUT signal to the KAD/BCU/101 X-SYNC signal.

GPS antenna

The recommended antenna, RFE/AEG/001, has an antenna gain of 26 dB with an antenna noise figure of 2.5 dB. A minimum antenna gain of 10dB is recommended to compensate for losses in the cable connecting the antenna to the KAM/TCG/105. A maximum antenna gain of 50 dB and a maximum antenna noise figure of 1.5 dB are required by the GPS receiver.

The GPS receiver calculates the carrier-to-noise ratio for the antenna at power-up. It is therefore important that the GPS antenna is connected to the module before it is powered up.

GPS receiver

The KAM/TCG/105 uses a civilian-band (L1) GPS receiver. The United States Department of Defense (DoD) can turn on Selective Availability (SA) at any time without warning. This degrades the accuracy of the GPS data.

The KAM/TCG/105 can extract time and navigation information from an NMEA data stream. It is fitted with an onboard GPS receiver but can be interfaced to an external L1 or L2 GPS receiver via the 19-way connector.

The NMEA messages, GGA, GSV, ZDA, GSA, and GLL, are the minimum required for KAM/TCG/105 time synchronization. The VTG message is required to get velocity and true heading. If it is not provided then registers VELOCITY_KPH, VELOCITY_KN, HEADING are forced to an illegal state of all 1s.

NOTE: GPS is a broad subject and beyond the scope of this data sheet. There are many online guides and GPS dictionaries such as those found at the following links:
www.gps.oma.be/gb/dic_gb_ok_css.htm
www.colorado.edu/geography/gcraft/notes/gps/gps_f.html

Altitude representation

The GGA NMEA message contains altitude fields above mean sea level. When the altitude is 25 meters above sea level, it gives a reading of 00025; when the altitude is 25 meters below sea level, it gives a reading of 00D25. The D indicates that the reading is negative.

GPS time

The KAM/TCG/105 derives time from data received from a constellation of satellites. These satellites are in continuous moving orbit which affects the behavior of the KAM/TCG/105 as described in “Acquisition” on page 15 and “Reacquisition” on page 15.

The KAM/TCG/105 measures GPS time; the accuracy of the time is not absolute but relative to the GPS time. If an external GPS receiver is used, the KAM/TCG/105 locks to within ±1 µs without considering the external GPS receiver accuracy.

Acquisition

Along with time and navigation data, GPS satellites transmit GPS ephemeris data and GPS almanac data.

Ephemeris data tells the GPS receiver where each GPS satellite is at any time throughout the day. Each satellite transmits ephemeris data showing the orbital information for that satellite and for every other satellite in the system.

Almanac data is constantly transmitted by each satellite. It contains information about the status of the satellite, current date and time.

Cold power-up

When the GPS receiver is powered up for the first time or has no backup battery connected, the GPS receiver has no knowledge of its last position or approximate time, and has no ephemeris or almanac data. The GPS receiver starts to search for signals blindly. This is normal behavior. Cold power-up for GPS receivers can take several minutes.

Warm power-up

If the GPS receiver was connected to a backup battery before powering down, the GPS receiver knows its last position, approximate time and almanac. The ephemeris data is cleared. Because the almanac data is retained it can acquire satellites and get a position fix faster than in cold start mode.

Reacquisition

If the GPS receiver was off for less than two hours with battery backup, the almanac and ephemeris data are used to acquire satellites. Because the ephemeris data is retained it can acquire satellites and get a position fix faster than in other modes.

Navigational data

The KAM/TCG/105 may be used to record navigation information. The information provided by the KAM/TCG/105 is referenced to a specific datum.

Datum

The onboard GPS receiver uses WGS-84, which is a geographic model obtained by referencing the earth's sea

level surface area and applying theoretical mathematical calculations. The chart datum is usually defined in the legend of the chart.

Navigation data accuracy

Unlike GPS time the position information is subject to a number of inaccuracies, due to the inherent behavior of the GPS system.

GPS status register

GPS lock is set to one when the KAM/TCG/105 receives a valid NMEA stream and accompanying PPS signal from either the onboard GPS receiver or an external GPS receiver connected to the KAM/TCG/105. It is cleared only on arrival of a PPS signal if the NMEA stream is not valid (for example the fix flag not set), or after two seconds without a PPS signal.

Any error in the GPS stream is indicated by the fix error bit which is set as soon as an error is received and can lead to the clearing of the GPS lock bit by up to two seconds, if the GPS receiver stops outputting a PPS pulse.

Dilution Of Precision (DOP)

DOP is a function expressing the mathematical uncertainty in a position fix, based on the relative positions of the satellites used to obtain that position fix. In standard GPS applications there are three types of DOP information available.

PDOP: Position (three coordinates)

HDOP: Horizontal (two horizontal coordinates)

VDOP: Vertical (height only)

DOP has a best case value of 1; higher numbers indicating a greater uncertainty in the precision of the position fix. A low DOP value (2) is considered good, a high number (>7) is considered poor.

Circular Error Probable (CEP)

CEP is the radius of a circle within which there is a 50% probability of the antenna being located.

Spherical Error Probable (SEP)

SEP is the three-dimensional analog of CEP, it is the radius of a sphere within which there is a 50% probability of being located.

Grounding the IRIG source

It is important to ground (GND) the source of the IRIG-B stream. If the time source is a single-ended analog signal, the GND must be connected to the negative IRIG-B input A_IRIG_IN- (see Figure 5 on page 17).

RS-422 output - X-SYNC operation

The KAM/TCG/105 can output an X-SYNC stream on pins 11 and 12 (for synchronization of backplane controller modules) instead of IRIG time on RS422_OUT. This allows the KAM/TCG/105 to be used to synchronize the acquisition cycle to the start of a second. When X-SYNC is in use, some restrictions must be placed on the acquisition cycle frequency; that is, only the following frequencies are supported: 0.5, 1, 2, 4, 5, 8 10, 16, 20, 25, 32, 40, 50, 64, 80, 100 Hz.

RS-422 output - NMEA messages

The KAM/TCG/105 can output NMEA messages on pins 11 and 12 (RS422_OUT).

When the NMEA option is enabled, the KAM/TCG/105 generates NMEA messages continuously, which are an electrical copy of the NMEA source. If GPS onboard is used, the baud rate set internally for output NMEA messages is 115200 bps.

Before GPS lock is achieved, the KAM/TCG/105 does not have sufficient information to populate the NMEA messages, and as a result, the message fields are set to null or default values.

Once the GPS lock has been achieved, the various NMEA output message fields are filled in correctly.

Looking into a GPSGGA message, before GPS lock has occurred, the location information is populated entirely with null and default values. The output message for this example would look like this:

$GPGGA,094902.00,,,,,0,00,99.99,,,,,,*60

Once GPS lock has been achieved, the location information is populated correctly and the GPSGGA message for this example now looks like this:

$GPGGA,094903.00,5318.75900,N,00614.26146,W,1,09,1.01, 35.6,M,52.9,M,,*7E

Battery drift when module powered off

When the Acra KAM-500 is switched off, the battery back-up time continues. This can drift, however only up to 3.5 ppm.

TTL status outputs

The KAM/TCG/105 monitors the performance of a KAM/MEM/003, KAM/MEM/103, or KAD/MEM/004 module in the same chassis and provides two status outputs showing whether the MEM is logging or not, and whether the memory is more than 80% full.

Possible configurations

The following diagrams illustrate the different configurations possible with the KAM/TCG/105. In each case the time input source is illustrated in the top half of the diagram, while the available outputs are shown in the bottom half.

NMEA format

All NMEA inputs/outputs on the KAM/TCG/105 use the NMEA 0183 standard.

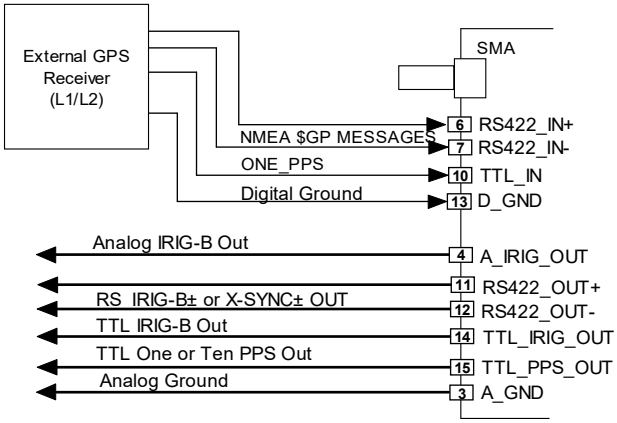

Figure 2: Connected to external GPS receiver using RS-422 and TTL

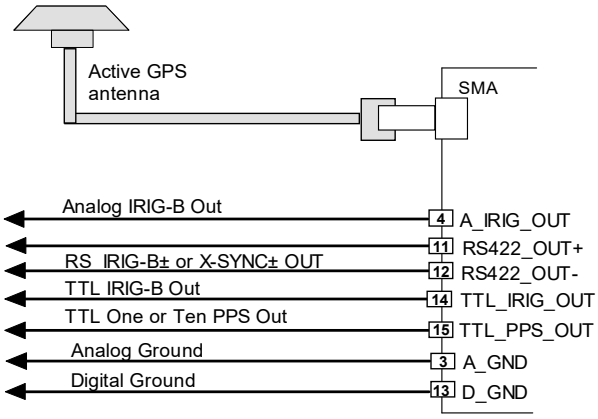

Figure 3: Connected to active GPS antenna

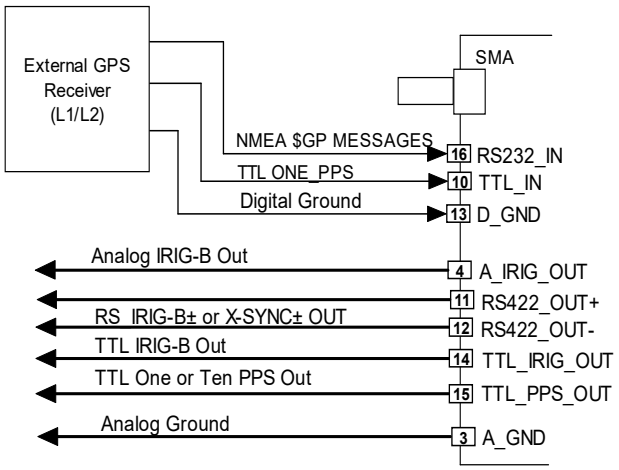

Figure 4: Connected to external GPS receiver using RS-232 and TTL

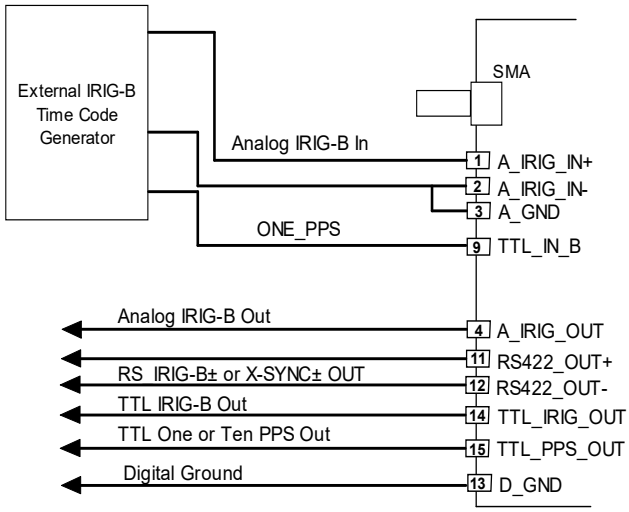

Figure 5: Receiving analog IRIG Time

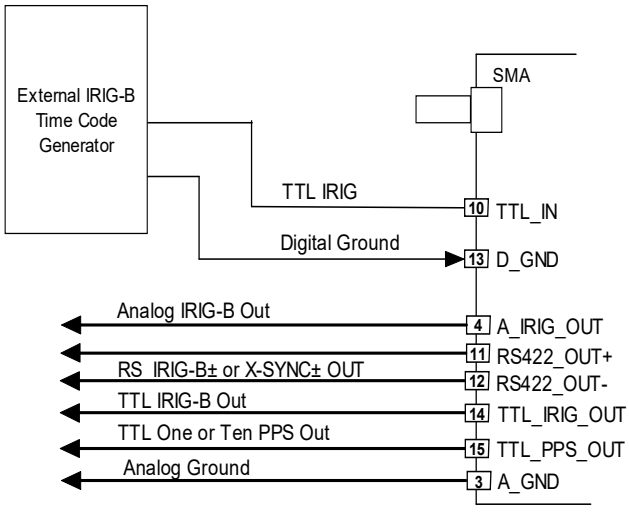

Figure 6: Connected to external IRIG source using TTL

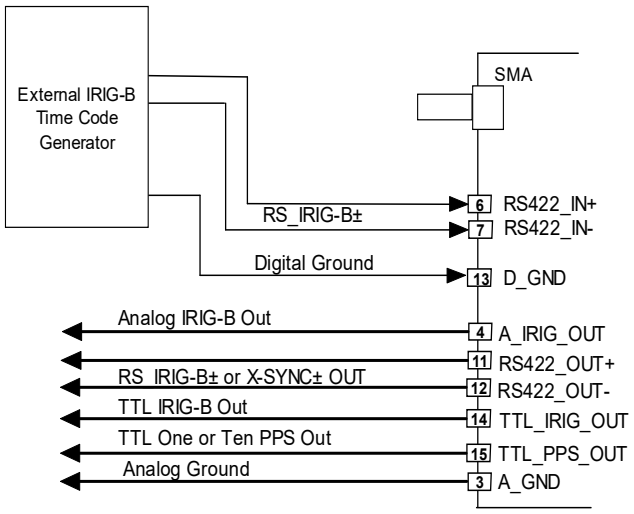

Figure 7: Connected to external IRIG Time source using RS422

Connector pinout of the KAM/TCG/105

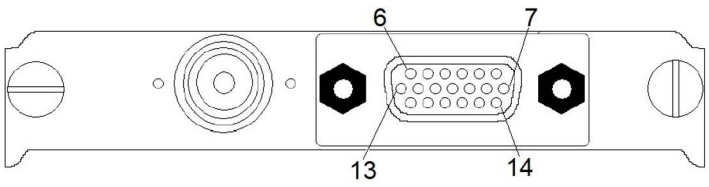

Figure 8: 19-way DD-type connector plus SMA connector

19-way Double-Density (DD) type connector

PIN	NAME	SEE SPECIFICATIONS TABLE	COMMENT
1	A_IRIG_IN+	Analog IRIG time inputs	Analog IRIG-B time in (AM/PWM); 1kHz carrier
2	A_IRIG_IN-	Analog IRIG time inputs	Analog IRIG-B time in (AM/PWM); 1kHz carrier
3	A_GND	Analog ground	
4	A_IRIG_OUT	Analog IRIG time outputs	Analog IRIG-B time out (AM/PWM); 1kHz carrier
5	MEM_STATUS(0)	BTTL outputs	Asserted when memory card is logging
6	RS422_IN+	RS-422 inputs	Either IRIG-B time (PWM) or NMEA data
7	RS422_IN-	RS-422 inputs	Either IRIG-B time (PWM) or NMEA data
8	RS_IRIG_TERM	Termination pin for RS-422	Connect to RS422_IN+ if needed
9	TTL_IN_B	BTTL inputs	
10	TTL_IN_A	BTTL inputs	Additional PPS input for use with analog IRIG-B input only. Either IRIG-B or ONE_PPS in from external GPS source
11	RS422_OUT+	RS-422 outputs	Either IRIG-B, X-SYNC, or NMEA out
12	RS422_OUT-	RS-422 outputs	Either IRIG-B, X-SYNC, or NMEA out
13	D_GND	Digital ground	
14	TTL_IRIG_OUT	BTTL outputs	IRIG-B time out (PWM)
15	TTL_PPS_OUT	BTTL outputs	One or ten pulses per second
16	RS232_IN	RS-232 inputs	NMEA stream in from external GPS receiver
17	MEM_STATUS(1)	BTTL outputs	Asserted when memory card is 80% (or more) full
18	D_GND	Digital ground	
19	CHASSIS	Chassis	Chassis connection

SMA connector[1]

PIN	NAME	SEE SPECIFICATIONS TABLE	COMMENT
Center	RF_IN	Active antenna inputs	Excitation output to active antenna and RF input to module (50Ω impedance)
Outer shell	RF_GND	Active antenna inputs	RF ground reference; isolated from chassis

1. For details of cables that connect to this interface, see the Related products table in this data sheet.

Ordering information

PART NUMBER	DESCRIPTION
KAM/TCG/105	Time-code generator with GPS/IRIG input and battery backup

By default, the standard mating connector CON/KAD/003/CP, and an ACD/BAC/004/B backshell, are included with each module in the shipment. Its part number 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
KAM/TCG/105	First release	Recommended for new programs

Supporting software

SOFTWARE	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
RFE/AEG/001	Airborne active GPS antenna, with TNC female connector
ACC/GPS/001/05M	GPS antenna interface cable (5m long) terminated with Threaded Neill-Concelman (TNC) male (shield isolated)

Related documentation

DOCUMENT	DETAILS
DOC/DBK/001	Acra KAM-500 Databook
DOC/MAN/018	KSM-500 Databook
DOC/HBK/002	Environmental Qualification Handbook
DOC/MAN/030	DAS Studio 3 User Manual
XidML wall chart	Overview of key concepts and components in XidML