Chapter 5

The System

5.1.System description

5.1.1. General.

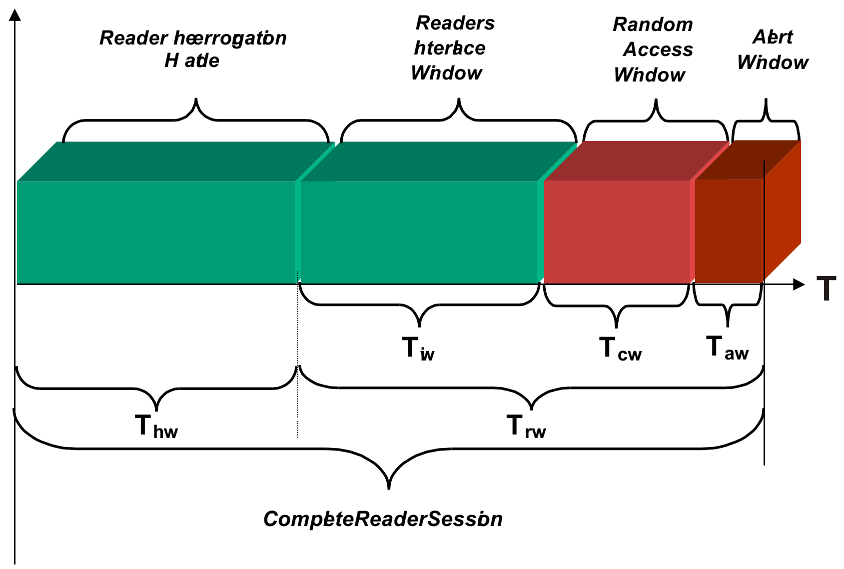
Hi-G-Tek DataSeals operate in sleep mode to conserve power. A pre-determined periodically awakens them from sleep mode. This allows them to monitor the surrounding airwaves for a Reader's wake up signal.

Tw is the notation used throughout this manual for the wakeup cycle time of the seal.

When the Reader initiates a session, it transmits a stream of data bits of programmable length. The notation of the data stream length is ***Thw***.

The seals use the SLOTTED ALOHA concept to communicate back to a Reader. The length of an ALOHA time slot is notated as ***Ts. (Ts*** is also notated as a window). This time slot is usually of fixed duration. For the ***Verify***, ***Addressed Verify*** and ***Tamper*** commands, ***Ts*** should be defined externally in the command (see paragraph 5.6.3.2.).

Fig. 5.1 - RF Communication Channels



Ts can have one of the following values: 21, 41, 63, 81 msec.
The System has four communication channels

- ***Reader Interrogation Header*** with time duration of ***Thw***. Within this time frame the Reader sends a data stream to the seals.
- ***Readers Interlace Window*** with time duration of ***Tiw***. This window is to allow other Readers to transmit and to share one ***Random Access Window***.
- ***Random Access Window*** with time duration of ***Tcw***. During this period seals responds in random access mode. Because the access is random, collisions between seal messages are to be expected.
- ***Alert Window*** with time duration of ***Taw***. The last channel is an emergency channel allowing seals with high priority alert messages to transmit the message to the Reader.

Trw is the notation used for the seals transmitting (Reader is receiving) time frame.

A complete communication ***Reader Session*** is ***Thw + Trw***.
To overcome collisions, the seals should retransmit their message several times within the ***Random Access Window***. The number of retransmissions should be defined externally in the command and is called ***Rr***.

The seal may also retransmit in the ***Alert Window.*** This is notated as ***Rt***.

Both Thw and Tw can be programmed.
The relationship between Thw and Tw should be kept constant.

Thw=Tw+ 135 msec

See paragraph 5.2.3. for information on how to calculate ***Thw*** and ***Tw***

When there are a certain number of seals in the Reader's receiving zone, probability calculations show that more than one ***Seal Transmission*** is required to obtain a complete result.

The following table demonstrates the number of retransmissions required for different situations.

Table 5.1 Number of retries within the Random Access Window

Max # of Seals	Min # of Reader Sessions	# Of seal slots (Ts)																						
		30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250
2	1	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2
	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	-	9	6	5	5	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3
	2	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	1	-	-	-	-	10	6	6	6	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4
	2	-	4	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	1	-	-	-	-	-	-	-	8	7	7	6	6	6	6	5	5	5	5	5	4	4	4	4
	2	-	-	5	4	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	1	-	-	-	-	-	-	-	-	-	10	8	8	8	6	6	6	6	6	5	5	5	5	5
	2	-	-	-	5	4	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2
7	1	-	-	-	-	-	-	-	-	-	-	-	-	9	8	8	7	6	6	6	6	6	6	5
	2	-	-	-	-	6	5	4	4	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2
8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	8	8	7	7	6	6	6
	2	-	-	-	-	-	-	5	5	4	3	3	3	3	3	3	3	3	3	3	2	2	2	2
9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	9	9	8	8
	2	-	-	-	-	-	-	-	6	5	4	4	4	3	3	3	3	3	3	3	3	3	3	3
10	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	9	9
	2	-	-	-	-	-	-	-	-	7	5	5	5	4	4	4	4	3	3	3	3	3	3	3
12	2	-	-	-	-	-	-	-	-	-	-	7	6	5	5	4	4	4	4	4	3	3	3	3
	3	-	-	-	-	-	-	4	4	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2
14	2	-	-	-	-	-	-	-	-	-	-	-	-	-	9	7	5	5	4	4	4	4	4	4
	3	-	-	-	-	-	-	-	-	5	4	3	3	3	3	3	2	2	2	2	2	2	2	2
16	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	5	5	5	4	4	4
	3	-	-	-	-	-	-	-	-	-	-	4	4	3	3	3	3	3	3	3	2	2	2	2
18	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	7	6	5
	3	-	-	-	-	-	-	-	-	-	-	-	6	4	4	4	3	3	3	3	3	3	2	2
20	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	6
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	5	4	4	4	3	3	3	3	3	2
25	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	4	3	3	3	3
	4	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	3	3	2	2	2	2	2	2
30	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	3	3	3	3	2
35	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	3
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	2	2	2	2	2

Table 5.2. Minimum Requirements

Maximum # Seals	Minimum # Sessions	Minimum # Windows	Optimum # Retries
2	1	16	6
3	1	40	9
4	1	67	10
5	1	94	9
6	1	122	9
7	1	147	10
8	1	175	9
9	1	207	8
10	1	229	10
11	2	118	8
12	2	129	7
13	2	141	9
14	2	154	9
15	2	169	9
16	2	182	9
17	2	197	9
18	2	211	7
19	2	221	8
20	2	239	8
22	2	255	9
24	3	193	5
26	3	217	6
28	3	226	6
30	3	243	6
35	4	228	4

Table 5.3. below shows some examples of the ***Verify*** command using different retransmissions and ***Reader Sessions***. In this example, ***Thw=3 sec***; Ts=21 msec; Taw=105 msec.

Table 5.3.

Number of Seals	Random Access Window Number of Windows	Random Access Window *Tcw* sec	Number of Seal Retransmissions *Rr*	Number of Reader Sessions	Total Verify duration sec
1	3	0.21	3	1	3.35
2	40	0.84	3	1	3.95
3	50	1.05	6	1	4.15
4	70	1.47	10	1	4.60
5	100	2.10	8	1	5.20
10	230	4.83	10	1	7.94
20	240	5.04	7	2	16.30

Reducing the ***Reader Interrogation Header*** - ***Thw*** increases the speed of the ***Verify*** session. Increasing the speed of the process is in conflict with the battery lifetime of the seal. (Higher speed = lower battery lifetime). When designing an application, careful attention should be paid to optimizing the correct tradeoffs between system response time, battery lifetime and number of seals.
Taw is calculated for 5 slots of ***Ts***.

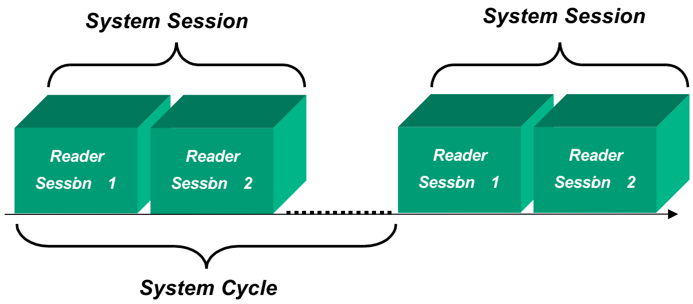
Table 5.4 demonstrates the impact of Thw on response time and battery life. The scenario for the results in the table is a GATE concept, whereby a seal is exposed to a reader for 6 minutes per 24 hours and: ***Ts=21 msec***; ***Taw=105 msec***.

Table 5.4.

Number of Seals	Thw	Reader Session time *sec*	Number of Retransmis-sions *Rr*	Number of Reader Sessions	Battery Life Years	Total Verify duration Sec
1	0.5	0.67	2	1	2.2	0.67
2	0.5	1.45	3	1	2.2	1.45
3	0.5	1.70	6	1	2.1	1.70
4	0.5	2.10	6	1	2.1	2.10
5	0.5	2.70	8	1	2.1	2.70
10	0.5	5.50	10	1	2.2	5.50
20	0.5	5.64	7	2	2.3	11.3
1	1	1.17	2	1	3.8	1.17
2	1	1.95	3	1	3.8	1.95
3	1	2.20	6	1	3.6	2.20
4	1	2.60	6	1	3.7	2.60
5	1	3.20	8	1	3.6	3.20
10	1	6.00	10	1	3.8	6.00
20	1	6.15	7	2	3.9	12.3
1	3	3.20	2	1	5.0	3.20
2	3	3.95	3	1	5.0	3.95
3	3	4.16	6	1	5.0	4.16
4	3	4.68	6	1	5.0	4.68
5	3	5.20	8	1	5.0	5.20
10	3	7.94	10	1	5.0	7.94
20	3	8.15	7	2	5.0	16.3

Table 5.5. demonstrates the impact of Thw on response time and battery life for a YARD Management concept, where a seal is constantly exposed to a reader 24 hours a day.

As mentioned previously, the reader in some cases should carry out a number of ***Reader Sessions*** to achieve the required performance. A group of ***Reader Sessions*** is a ***System Session***. The frequency in which the system performs ***System Sessions*** is a ***System Cycle***



The following table uses: ***System Cycle = 15 min***; ***Ts=21 msec; Taw=105 msec***

Table 5.5

Number of Seals	Thw	Reader Session time sec	Number of Retransmissions *Rr*	Number of Windows	Number of Reader Sessions	Battery Life Years	Total Verify duration sec
1	1	1.15	2	2	1	3.78	1.15
2	1	1.95	3	40	1	3.63	1.95
3	1	2.16	6	50	1	3.23	2.16
4	1	2.79	6	80	1	3.23	2.79
5	1	3.21	8	100	1	3.0	3.21
10	1	5.94	10	230	1	2.82	5.94
20	1	6.15	7	240	2	2.47	12.29
1	2	2.15	2	2	1	5.0	2.15
2	2	2.95	3	40	1	5.0	2.95
3	2	3.16	6	50	1	4.54	3.16
4	2	3.79	6	80	1	4.54	3.79
5	2	4.21	8	100	1	4.11	4.21
10	2	6.94	10	230	1	3.77	6.94
20	2	7.15	7	240	2	3.16	14.29
1	3	3.15	2	2	1	5.0	3.15
2	3	3.95	3	40	1	5.0	3.95
3	3	4.16	6	50	1	5.0	4.16
4	3	4.79	6	80	1	5.0	4.79
5	3	5.21	8	100	1	4.7	5.21
10	3	7.94	10	230	1	4.24	7.94
20	3	8.15	7	240	2	3.48	16.29

5.2. System Parameters.

5.2.1. Seal Parameters.

Table 5.6. describes the seal parameters. These parameters are accessible via either the Low Frequency or the High Frequency channels using the READ and WRITE PARAMETERS commands.

Table 5.6: Seal Parameters

#	Parameter Name	Parameter Code	Parameter Syntax	Read/Write Access	Verify command bit Access order	Parameter Length
1	Tag/Seal Status (Short Status)	00hex	TS	R	15*	1 Byte
2	Date & Time	01 hex	D&T	R	14*	5 Bytes
3	Seal Stamp	17 hex	STMP	R	5*	2 Bytes
4	# of Events	03 hex	#EV	R	12*	1 Byte
5	Version of firmware	06 hex	VER	R	9*	2 Byte
6	Long Status	07 hex	LTS	R	8	4 Bytes
7	T_w	31 hex	TW	R/W	n.a	2 Bytes
8	Tp	32 hex	Tp	R/W	n.a	2 bytes
9	ADI	13 hex	ADI	R/W	n.a	4 Bytes
10	Department	16 hex	DEP	R/W	6	1 Byte
11	Tbrs	34 hex	Tbrs	R/W	n.a	2 Bytes
12	User Data Size	42 hex	UDS	R	n.a	2 Bytes
13	Alert Bursts Counter - Cbrs.	76 hex	Cbrs	R/W	n.a	1 Byte
14	Alert Repetition Rate for Deep Sleep mode -Tds	77 hex	Tds	R/W	n.a	1 Byte
15	Alert Bursts Counter for Deep Sleep mode - Cds	78 hex	Cds	R/W	n.a	1 Byte

* The above parameters are visible for Global=1 (See paragraph 5.8.3)

Table 5.7

Parameter Name	Description
Tag/Seal Short Status	Status is a bit oriented register that indicates seal's (or Tag's) status. Table 5.6 describes each bit with its system meaning. This register is one byte.
Date & Time	This parameter provides the date & time value that the seal retains.
Seal Stamp	Seal Stamp is a stamp that is uniquely generated for each new trip when executing any type of SET command. This stamp is modified when a tamper event is detected. Tamper events are described in paragraph 5.8.2
# Of Events	New events that the seal detects will be logged in the seal's memory. # Of Events is the counter that counts the number of events in the seal's EVENT MEMORY .
Version of firmware	Version number of the firmware in the seal.
Long Status	Long Status is a wider status description of the seal's status. Table 5.6 describes each bit with its system meaning. This is a bit oriented register. This register is composed from bytes 1 to 4, and includes the Tag/Seal status.
T_W	Wakeup time interval of the seal for normal modes of operation. This parameter should match Thw.
Tp	Wakeup time interval of the seal for sleep mode of operation. This parameter should match Thp.
ADI	Allows the grouping of seals in a specific group. See paragraph 5.3.3. for details.
Department	Allows separation of departments within an organization. See paragraph 5.3.2. for details.
Tbrs	Determines the repetition rate of alert bursts. See paragraph 5.4.3 for details.
User Data Size	Allows the reading of the size of USER DATA memory
Alert Bursts Counter - Cbrs	Defines the number of burst cycles a seal will execute before it stops sending bursts. Acknowledgement should be received prior to cessation of activity. If value is set to 0, the seal will not stop bursting until an acknowledgement has been received. Attention should be paid to battery consumption.
Alert Repetition Rate for Deep Sleep mode -Tds	Burst repetition rate in Deep Sleep mode of operation.
Alert Bursts Counter for Deep Sleep mode -Cds	Defines the number of burst cycles a seal will execute before it stops sending bursts while in Deep Sleep mode. Acknowledgement should be received prior to cessation of activity. Value 0 is not supported.

Table 5.8a - Short Status

Bit #	Status	Note	
7	SET/TAMP (1)(2)	This bit is set to 1 by the SET command and reset to 0 when a tamper event is detected.	S/T
6	LB warning (2)	When low voltage battery is detected this bit is set to 1. This is a warning. There is enough time to replace the seal.	LBW
5	Open/Close (1)(2)	Indication whether the seal wire loop is open or closed.	O/C
4	Suspended SET	Indication flag of suspended sleep mode of operation.	SS
3	Seal Wire changed (1)(2)	Indication whether the seal wire loop electrical characteristics were changed relative to SET.	WRC
2	Sleep (3)	Indication of deep sleep mode of operation.	SL
1	General error (2)(4)(5)	This flag is a logical OR of errors in the following bytes.	GE
0	Spare		SPR

NOTES:

(1) These events are defined as TAMPER events.
(2) These flags will cause an alert, synchronized and unsynchronized.
(3) Sleep will generate an unsynchronized burst only if this mode is activated.
(4) This flag may be reset by an external RESET STATUS RF command of the flags that caused the error.
(5) This flag is set once one of the flags marked with * in the LONG STATUS is set. This flag will be reset if the appropriate originator flag is reset.

Table 5.8b - Long Status

Byte	Bit #	Status	Note	
1	7	SET/TAMP (1)(2)	This bit is set to 1 at SET command and reset to 0 when a tamper event is detected.	S/T
	6	LB warning (2)(4)	When low voltage battery is detected this bit is set to 1. This is a warning. There is enough time to replace the seal.	LBW
	5	Open/Close (1)(2)	Indication whether the seal wire loop is open or closed.	O/C
	4	Suspended SET	Suspended set mode of operation indication flag.	SS
	3	Seal Wire changed (1)(2)	Indication whether the seal wire loop electrical characteristics where changed relative to SET.	WRC
	2	Sleep (3)	Deep sleep mode of operation indication flag.	SL
	1	General error (2) (5)	This flag is a logical OR of errors in the following bytes.	GE
	0	Spare		SPR
Byte	**Bit #**	**Status**	**Note**	
2	7*	Life Counter 0	Flag indicating that the seal has ended its lifetime.	LCO
	6*	RTC error	Flag indicating that a problem with the Date & Time generator has occurred.	RTC
	5*	LB error	This bit is set to 1 when severe low voltage battery is detected. The seal is about to stop working and should be replaced immediately.	LBE
	4*	DB corrupted & restored (4)	Database is protected; when an error is detected and restored this bit will be set to 1.	DBE
	3*	DB corrupted	When the database cannot be restored after corruption, this bit will be set to 1.	DBC
	2	Lock (6)	For production use.	LCK
	1	New Battery (4)	In use for devices with replaceable batteries only.	NB
	0*	Hardware error	Indication of a hardware error detected.	HRE

Byte	Bit #	Status	Note	
3	7*	Illegal ORG_ID (4)	Indication of an attempt to contact the seal using unauthorized equipment.	OID
	6*	Command Failed	Seal's failure to execute a command will set this flag to 1.	CMF
	5*	Unrecognized command	Seal's failure to recognize a command will set this flag to 1.	UNC
	4	Spare		SPR
	3	Unsync Burst Mode	Indication of Unsync Burst Mode of operation.	BMU
	2	Spare		SPR
	1	Spare		SPR
	0	Spare		SPR
Byte	**Bit #**	**Status**	**Note**	
4	7	Buffer full	In the commands: Read/Write Data or Reader/Write Parameters or Read Events. If the message is too long this flag will be set to 1.	BF
	6	Scroll	When events in the seal's memory reach the upper portion, this flag is set to 1	SRL
	5	H.F Disable	Enables or disables the high frequency channel using the Reset Status command.	HFD
	4	ORG_ID in Burst Mode.	This flag can enable or disable the ORG_ID field in a seal's message in Burst Mode. Set and Reset is done by an appropriate RF Command (see paragraph 5.6.3.2.15)	ORGB
	3	Spare		SPR
	2	Spare		SPR
	1	Spare		SPR
	0	Spare		SPR

NOTES:

(1) These events are defined as TAMPER events.

(2) These events will cause an alert, synchronized and unsynchronized.

(3) Sleep will generate an UNSYNCHRONIZED burst only if this mode is activated.

(4) These flags may be reset by an external RESET STATUS RF command.

(5) This flag is set once one of the flags marked with * in the LONG STATUS is set. This flag will be reset only if the appropriate originator flag is reset.
(6) For production use only.

* These flags will set the General Error flag.

Table 5. 9: Seal Parameters: Defaults and Extreme Values.

#	Parameter Name	Default value	Minimum Value	Maximum Value	Unit	Parameter Length
1	Tag/Seal Status	-	-	-		1 Byte
2	Date & Time	-	-	-		5 Bytes
3	Seal Stamp	-	-	-		2 Byte
4	# Of Events	-	-	-		1 Byte
5	Version of firmware	-	-	-		2 Byte
6	Long Status	-	-	-		4 bytes
8	T_w	3000	400	10000	0.977 ms	2 Bytes
9	ADI	00000000	-	-		4 Bytes
10	Department	00	-	-		1 Byte
11	Tp	10000	400	10000	0.977 ms	2 bytes
12	Tbrs	4096	1024	10240	0.977 ms	2 bytes
13	Alert Bursts Counter-Cbrs.	10	0	50		1 byte
14	Alert Repetition Rate for Deep Sleep mode-Tds	32	3	40	250 ms	1 byte
15	Alert Bursts Counter for Deep Sleep mode-Cds	5	1	50		1 byte

5.2.2. Reader Parameters.

Table 5.10 describes the Reader parameters. These parameters are accessible via the serial communication port.

Table 5.10. Reader Parameters

#	Parameter Name	Parameter Code	Parameter Syntax	Read/Write Access	Parameter Length
1	Version of MCU_firmware	01 hex	MVER	R	2 Bytes
2	Version of S2_firmware	40 hex	SVER2	R	2 Bytes
3	RSSI2	47 hex	RSSI2	R	1 Byte
4	Reader ID	02 hex	RID	R	4 Bytes
5	ADI ch2	41 hex	ADI2	R/W	4 Bytes
6	Department ch2	42 hex	DEP2	R/W	1 Byte
7	Thw ch2	45 hex	Thw2	R/W	2 Bytes
8	Reader Address	03 hex	RADD	R/W	2 Bytes
9	Transmitter Power ch2	48 hex	TRPOR2	R/W	1 Byte
10	System ch2	43 hex	SYS2	R/W	1 Byte
11	Mode ch2	44 hex	MODE2	R/W	1 Byte
12	Thp ch2	46 hex	T_{HP2}	R/W	2 Bytess

NOTE: The Reader supports two channels. The RF Modem's default position is channel 2. The channel must be specified in the commands.

Channel 1 is intended for future use.

Table 5.11. Description of Reader Parameters

#	Parameter Name	Description
1	Version of MCU_firmware	Provides the MCU's firmware version number.
2	Version of S2_firmware	Provide Slave's firmware version number in channel 2.
3	RSSI ch2	Provide RSSI level in channel 2.
4	Reader ID	This is the Reader's ID.
5	ADI ch2	See table 5
6	Department ch2	See table 5
7	Thw ch2	Length of the ***Reader Interrogation Header*** This parameter should match Tw.
8	Reader Address	The address of the reader on the RS-485 pary line
9	Transmitter Power ch2	Sets output transmission power.
10	System ch2	The MSB of the SYSTEM defines whether the FOOTPRINT is ON or OFF, see paragraph 5.2.6
11	Mode ch2	Bits 6&7 define the Reader's mode of operation. See paragraph 5.5.
12	Thp ch2	Length of the ***Reader Interrogation Header*** for the Hard Wakeup command. This parameter should match Tp of the Seal.

MCU is the main board of the DataReader.
S2 is the slave daughterboard in channel two in the DataReader.

Table 5.12.: Reader Parameters: Default Value and Extreme Values.

#	Parameter Name	Default value [unit]	Minimum Value	Maximum Value	Unit	Parameter length
1	Version of MCU_firmware	-	-	-		2 Byte
2	Version of S1_firmware	-	-	-		2 Byte
3	RSSI ch2	-	-	-		1 Byte
4	Reader ID	-	-	-		4 Byte
5	ADI ch2	00000000	-	-		4 Byte
6	Department ch2	00	-	-		1 Byte
7	Thw ch2	997	390	9766	3.072ms	2 Byte
8	Reader Address	0000	-	-		2 Byte
9	Transmitter Power ch2	65	0	100		1 Byte
10	System ch2	00	-	-		1 Byte
11	Mode ch2	00	-	-		1 Byte
12	Hard Wakeup	3256	390	9766	3.072ms	2 Byte

5.2.3. Calculating ***Thw***.

Thw is one of the system's most important parameters. It determines both: system response time and the seal's battery lifetime..

The default value of ***Thw*** is 997 decimal where the units are 3.072 msec.

The meaning in terms of time is: 997 X 3.072 = 3067 msec.

Increasing ***Thw*** increases the seal battery's lifetime. On the other hand, larger ***Thw*** values increase the system's response time. This is illustrated in table 5.4

Example: Calculation of ***Thw*** for approximately 2 sec.
2000/3.072=651.042.
We will select 652 as the integer.
The final value of ***Thw*** is: 652 x 3.072=2003 msec.

5.2.4 Calculating ***Tw***.

The difference between ***Thw*** and ***Tw*** should be a minimum of 135 msec, where ***Thw*** > ***Tw***. A greater difference will shorten the seal battery's lifetime

As ***Tw*** gets smaller the battery consumption gets higher.

A ***Tw*** unit is 0.997 msec.
The default value of ***Tw*** is 3000 decimal.
The meaning in terms of time is: 3000 X 0.997 = 2929 msec.
The difference between ***Thw*** and ***Tw*** for the default values is:
3067 - 2929 = 138 msec.
As can be seen, it is higher than the minimum 135 msec required.

Example:
Calculate the appropriate ***Tw*** for a ***Thw***=2003 msec.

1. Calculation of the approximate value for ***Tw***: 2003 135=1868 msec
2. Calculation of the decimal value for ***Tw***: 1868/0.997=1873.62
3. Find the integer value for ***Tw***: The integer value is 1873, lower than 1873.62 calculated in step 2, but not too small.
4. Verify the calculations.

Thw - Tw = 2003 - (1873 X 0.997)=135.6 msec>135 msec!

Readers Interlace Window is the window that other Readers can use in order to transmit a message during interlace mode of operation. By using this mode, all the Readers share a common set of ***Random Access*** and ***Alert*** windows***.*** This mode is useful if system analysis shows that system response time will be improved.

Since the Readers share the same response windows, the ***Reader Interrogation Header*** and the ***Thw*** of each Reader **must** be identical, as should be the ***Thw*** of each Reader.

For k Readers, the ***Tiw*** will be:

Tiwj=TiwX(k-j)	where j=1,,,k

5.2.5 Calculating ***Thp***.

Calculating ***Thp*** is identical to calculating ***Thw***. To calculate ***Thp*** refer to the appropriate ***Tp***.

5.3. Parameter's Format.

Most of the parameters have a simple binary value.
Some of them have a specific format.

5.3.1. Date & Time

The date and time are represented in Greenwich Mean Time (GMT).

Bits and Bytes assignment:

<table>
<tr><td>Byte# / Bit#</td><td colspan="3">7 6 5 4</td><td>3 2 1 0</td></tr>
<tr><td>0</td><td>0</td><td colspan="2">Minutes / 10</td><td>Minutes % 10</td></tr>
<tr><td>1</td><td colspan="2">Month %4</td><td>Hours/10</td><td>Hours % 10</td></tr>
<tr><td>2</td><td colspan="2">Month / 4</td><td>Days/10</td><td>Days % 10</td></tr>
<tr><td>3</td><td colspan="3">Years / 10</td><td>Years % 10</td></tr>
<tr><td>4</td><td colspan="2">0</td><td>Seconds / 10</td><td>Seconds % 10</td></tr>
</table>

Minutes range is: 0 - 59.
Hours range is: 0 - 23.
Day range is: 1 - 31.
Month's range is: 1 - 12.
Year's range is: 00 - 99.
Seconds range is: 0 - 59. The seconds field is relevant only for read & write parameters.

NOTE: The character "%" denotes the operation of getting the remainder.

5.3.2. Seal Serial Number (or TF & ID).

The Seal Number is composed of 4 alpha characters and 8 decimal digits. For example: QWER85723456

7 … 3	2 … 0 7 6	5 … 1	0 7 … 4	3 … 0 7 … 0 7 … 0 7 … 0
Char1	Char2	Char3	Char4	Series Number - 8 decimal digits

Byte 6 (MSB)	Byte 5	Byte 4	Byte 3	Byte 2	Byte 1
7 … 0	7 … 0	7 … 0	7 … 0	7 … 0	7 … 0

The ID is converted from two seperate fields. The Decimal conversion is from 28 binary value into an 8 digit value.
The alpha characters are converted by using the following conversion table. Each character is 5 bits:

	Binary	Text
1	**00001**	**A**
2	**00010**	**B**
3	**00011**	**C**
4	**00100**	**D**
5	**00101**	**E**
6	**00110**	**F**
7	**00111**	**G**
8	**01000**	**H**
9	**01001**	**I**
10	**01010**	**J**
11	**01011**	**K**
12	**01100**	**L**
13	**01101**	**M**
14	**01110**	**N**
15	**01111**	**O**
16	**10000**	**P**
17	**10001**	**Q**
18	**10010**	**R**
19	**10011**	**S**
20	**10100**	**T**
21	**10101**	**U**
22	**10110**	**V**
23	**10111**	**W**
24	**11000**	**X**
25	**11001**	**Y**
26	**11010**	**Z**

* All other values are illegal.

The Seal Number is composed from the TF & ID fields in the communication protocol. See Commands for further details.

5.3.3. **ORG_ID** & **DEPARTMENT**.

ORG_ID is a 3-byte value.
DEPARTMENT is the least significant byte of the ORG_ID parameter.
DEPARTMENT values range from zero to 255 (or 0xFF).
ORG_ID* is composed of the 2 most significant bytes of the ***ORG_ID*** parameter.

ORG_ID		
ORG_ID*		***DEPARTMENT***
MSbyte		LSbyte

5.3.4 **SYSTEM**

SYSTEM is a parameter that defines the system characteristics.
Only bit 7 is in use.
Default value of bit 7 is 0.
When bit 7 is set to the value of 1, the ***FOOTPRINT*** option comes into use. This option allows some of the commands to leave the RD_ID as a footprint in the seal's memory for later tractability (see paragraph 5.4.4).

5.3.5 **MODE**.

7	6	5	4	3	2	1	0
CRNC	UNSYNC	ABMSG	N.A	N.A	N.A	N.A	N.A

CRNC Carrier Sense: In some applications carrier sense should be used before bursting into the air. The Reader uses this flag to decide whether it is required or not.
CRNC=0 determines the regular mode: no carrier sense.
CRNC=1 determines the Reader's ability to sense the carrier.
The Reader executes the RF command only after determining that the air is free.

UNSYNC In unsynchronized commands such as Unsynchronized Alert, the Reader's receiver must be ON all the time looking for incoming messages from the seals.
The Reader will set the required mode depending on the flag's value.
UNSYNC=0 Synchronized mode only.
UNSYNC=1 Unsynchronized mode in use, receiver should be set to on.

ABMSG Burst Messages. This flag indicates whether the alert messages will be sent following a GET Burst Message or if the Reader will burst independently with Alert Messages.
BRMSG=0 determines the independent messages burst mode.
BRMSG=1 indicates the GET Burst Message mode.

5.4 Seal Modes of Operation.

The seal can function in several modes of operation, in accordance with the application.

5.4.1. Normal Mode.

In the normal mode of operation, the seal is in standby mode most of the time. When a **DataTerminal** starts communication, the transmitted message wakes the seal up.

As explained previously, the method used to establish communication with the **DataReader** is different than that used for the **DataTerminal**. Using a pre-determined cycle, the seal wakes and performs a channel monitoring process, searching for the presence of a **DataReader.** The frequency of this cycle is notated as ***Tw***. In Normal mode, any event detected by the seal will be logged in the ***EVENT Memory***.

5.4.2. Sleep Mode.

It is recommended to use the Sleep mode when a seal is not in use in order to conserve energy. In this mode, the seal enters an extreme power-saving mode. To exit this mode, interrogate the seal using the **DataTerminal** or use the Hard Wakeup via the **DataReader**.

When the seal is in Sleep mode no EVENTS will be recorded until a new SET is performed.

As opposed to the Normal mode, Sleep mode is not an operative mode.

5.4.3. Alert Burst Mode.

The seal should report any detected TAMPER event. The report can be in the STATUS register of a VERIFY cycle. This approach is good as long as the system's VERIFY cycle time meets the required system response time. In applications in which the ***System Cycle*** is very long and the TAMPER event is reported with a long delay, it is possible to use the ***Unsynchronized Alert Burst*** mode. This mode allows the seal to transmit a burst with a tamper message without waiting for a ***Reader Session***.

5.4.4. Events Footprint Mode.

A command issued by a Reader may be registered as an event in the ***Events Memory*** by the seal.

This mode should be configured at the Reader before issuing the command. This mode is useful for tractability purposes. It is possible to track a specific Reader that performed the command by registering the Reader ID in the seal's Event Memory with each command.

5.5. Reader Modes of Operation.

The Reader can work in several modes of operation. This is defined by the ***MODE*** parameter***,*** which is a bit oriented parameter.

5.5.1 Carrier Sense Collision.

If set to 1, the Reader will be activated by the MSB's Carrier Sense Collision Avoidance ability. This mode of operation is useful if the Reader is activated individually, without synchronization with other Readers in the same area.

5.5.2 Unsynchronized Mode.

When seals are operating in Unsynchronized Alert Burst mode, the Reader's receiver must be ON at all times. This is done by setting bit 6 of the MODE parameter.

5.6. System Commands.

The following paragraph is a general description of the system commands.

For a deeper insight see the following:

- For low-level RS-485/232 users, see chapter 6.
- For high-level DLL users refer to the DLL help file.

5.6.1. LSC and Reader Messages.

Table 5.12: LSC Commands and Acknowledge Table:

#	Commands Set	Command Code	***Comments***
1	Wakeup	E0 h	Wakes the Readers if they are in sleep mode.
2	Execute RF cmnd	20 h	Generates an appropriate command from the Reader to the tags.
3	Get Results	15 h	Allows the LSC to retrieve the results received by the Reader from the tags in the event of a tag-reader session.
4	Get Status	16 h	In the event of a self-contained command, the Reader will return to its current status.
5	Get Burst Message	1C h	This command should be used to retrieve the alert messages received from the seals when using the alert burst mode. Alert messages originating from burst mode are not available through the regular Get Results command.
6	Reset Reader	14 h	Resets a Reader.
7	Write Parameters	06 h	ModifiesReader PARAMETERS. Not all parameters are accessible after the execution of a LOCK command.
8	Read Parameters	07 h	Reads Reader PARAMETERS.
9	BIT	09 h	Built-in Execute test
10	Sleep	08 h	Places the Reader in Sleep mode of operation to save power.
11	Unsync Ack	0A h	Reserved for unsynchronized responses, see table 5.2
12	Get Reader's baud rate	FF h	Allows the LSC to get the Reader's baud rate.
13	Set Reader baud rate	FE h	Allows the LSC to set the Reader's baud rate.
14	Set Reader's Address	12 h	Sets Reader's address for RS-485 usage
15	Acknowledge OK	92 h	Acknowledgment of a message coming from a Reader and to get the next packet.
16	Acknowledge Failed	94 h	Acknowledgment of an improper message coming from a Reader.
17	Save Command	0F h	Saves one of the above commands for later execution. This command is used to synchronize readers.

18	Execute Saved command	17 h	Executes a command saved in the Reader. When it is used in broadcast mode, all the Readers execute the saved command simultaneously.
19	Read Channel Definitions	11 h	Allows the Reader to read channel definitions.
20	Write Channel Definitions	10 h	Allows the Reader to write channel definitions.

Table 5.13: Reader Message Table

#	Message	Message Code	Comments
1	Wakeup response	-	No response for WAKEUP string
2	Execute RF cmnd response	20 h	
3	Get Results response	15 h	
4	Get Status response	16 h	
5	Get Burst Message	1C h	
6	Reset Reader response	14 h	
7	Write Parameters response	06 h	
8	Read Parameters response	07 h	
9	BIT response	09 h	
10	Sleep response	08 h	
11	Unsync Message	0A h	When a Reader is in unsync mode the Reader may send an unsynchronized message. Such a message results from an alert message coming from a seal.
12	Get Reader's baud rate response	FF h	
13	Set Reader baud rate response	FE h	

14	Set Reader's Address response	12 h	
15	Save Command response	0F h	Saves one of the above commands for later execution. This command is used to synchronize readers.
16	Execute Saved command response	_	This is a broadcast command. There is no response to this command.
17	Read Channel Definitions response	11 h	Allows the Reader to read the definitions of a channel.
18	Write Channel Definitions response	10 h	Allows the Reader to write the definitions of a channel.

5.6.2. Error Codes.

Errors	**Error Code**
Unrecognized Command	01 h
MCU Error	02 h
HF Modem Error	03 h
Result is not ready	05 h
HF Modem is not responding	06 h
MCU I/O Error	07 h
HF Modem BIT Error	08 h
Parameter is locked	09 h
Illegal Parameter Code	0A h

5.6.3. Detailed Commands.

5.6.3.1. Wakeup.

5.6.3.1.1. Command Transmission.

Only a very short string needs to be sent by the LSC to wake a sleeping Reader. The string is detected by the hardware and wakes the Reader. This is a hardware-oriented command, therefore the format is different than all the other commands.

5.6.3.2. Execute RF Command.

5.6.3.2.1. Command Transmission.

This command enables communication sessions with seals. In the data field the LSC inserts the relevant information allowing the reader to easily compile the final command string.

LSC > Reader

CMND (0320h)	channel	Data	
2	1	m	*# of bytes*

Where the CMND is the “execute RF command” opcode. Channel field is one of the following:

Channel	Code
Channel 1	01h
Channel 2	02h

Data contains the details of the RF command together with the **RF command opcode**.

5.6.3.2.2. Verify.

This command verifies the status of seals that are in the Reader's receiving zone. This is the most basic and the commonly used command in the DataSeal system. When executing the Verify command, the specific parameters for this command must be defined.

The data field in the Execute RF Command will be:

Data

Cmnd*(10h)	T_{cm}	T_{iw}	t_s	N_a	N_r	N_t	R_r	R_t	ASID	Parameters mask	
1	1	2	1	1	1	1	1	1	1	2	*# of bytes*

Where:

Cnmd*	The RF command's opcode.
Tcm	Duration of the calibration message window. Resolution is in units of 1024 msec.
Tiw	The duration of the readers interlace window. Resolution is in units of 1024 msec.
Ts	Duration of a slot for receiving responses from a tag or a seal. Resolution is in units of 1024 msec.
Na	Number of slots in the Fixed Assignment Receiving Window.
Nr	Number of slots in the Random Access Receiving Window.
Nt	Number of slots in the Alert Receiving Window.
Rr	Number of random retransmissions from a tag in the Random Access Receiving Window.
Rt	Number of random retransmissions from a tag in the Alert Receiving Window
ASID	A unique and random ID, assigned by the system to a specific assignment.
Parameters Mask	The seal's parameters bit mask which the tags and seals respond with.

.

Nr+Nt should be lower or equal to 255

The Bit Mask should comply with table 5.14 on the following page.

Table 5.14: Parameter Mask

#	Parameter Name	Parameter Code	Parameter Syntax	Read/Write Access	Bit Mask Access order	Parameter Length
1	Seal Status	00hex	TS	R	15	1 Byte
2	Date & Time	01 hex	D&T	R/W	14	4 Bytes
3	# of Events	03 hex	#EV	R	12	1 Byte
4	Life Counter	04 hex	LFC	R	11	2 Bytes
5	Version of firmware	06 hex	VER	R	9	2 Byte
6	Long Status	07 hex	LTS	R	8	4 bytes
7	RSSI	08 hex	RSSI	R	7	1 Byte
8	Seal Stamp	17 hex	STMP	R	5	2 Byte

* The length of Date & Time in Read and Write parameters is 4 bytes. See paragraph 5.3.1.

5.6.3.2.3. TAMPER.

Tamper is a command intended solely for interrogation of tampered Seals.

The command is identical to the Verify command except for the opcode, which is 11h.

Only the Seals that have detected tamper status respond. The aim of this command is to provide high priority to tampered Seals in a crowded Seal environment.

5.6.3.2.4. SET.

Ð

Cmnd* (98h)	P#/PK	TF	TID	CRC	TF	TID	CRC		...	TF	TID	CRC	
1	1	2	4	2	2	4	2		...	2	4	2	*# of bytes*

SET is the first command used prior to consigning a secured cargo shipment. A SET command initiates the seal process. The SET command initiates the seal process, and must be performed when applying the seal to the cargo, prior to shipment.

The Set command can be used on a number of or seals. The maximum number of seals it can be used on is 8.

Where:

P# The high 4 bits of the first byte in the packet serial number.

PK The low 4 bits of the first byte in the packet serial of packets in the BMM string.

At present the packet option is not in use. The value should be 0x11.

5.6.3.2.5. Suspended SET.

The Suspended Set command functions in the same way as the SET command. The only difference is that the SET command is executed immediately, while the Seal will execute the Suspended SET automatically only after the Seal wire has been plugged into the Seal. The opcode for this command is 99h. The response is the same response as the SET response but with 19h as the message type.

5.6.3.2.6. Soft SET.

This command has the same structure as the SET command. The difference is at the Seal level. In this command the seal marks the command as an event, but doesn't reset the events memory. The opcode for this command is 9Ah. The response is the same response as the SET response but with 1Ah as the message type.

5.6.3.2.7. Deep Sleep.

The Deep Sleep command allows battery power to be conserved when seals are in storage and not in use.

Data

Cmnd* (B0h)	TF	TID	CRC	TF	TID	CRC	TF	TID	CRC	
1	2	4	2	2	4	2	2	4	2	*# of bytes*

5.6.3.2.8. Hard Wakeup.

Hard Wakeup is the command that should be used to wake the seal from deep sleep mode.

Data

Cmnd* (B1h)	TF	TID	CRC	TF	TID	CRC	TF	TID	CRC	
1	2	4	2	2	4	2	2	4	2	*# of bytes*

5.6.3.2.9. Start Alert Burst Mode.

Seals usually operate in synchronized mode. In this mode, the Seals respond to messages from the Reader. In applications where the frequency of Reader sessions is low, the system's response time is slow. This has a positive effect on power conservation and other system considerations.
The seal can be programmed to send an independent asynchronous alert. In this case, the response time to an alert situation will be short.
Start Alert Burst Mode command can be initiated in two separate modes: Broadcast mode or Addressed mode.

Data

Cmnd* (38h)	
1	*# of bytes*

Starting specific tags:

Data

Cmnd* (B8h)	TF	TID	CRC	TF	TID	CRC	...	TF	TID	CRC	
1	2	4	2	2	4	2	...	2	4	2	*# of bytes*

5.6.3.2.10. Stop Alert Burst Mode.

The Start Alert Burst mode operation can be stopped by the Stop Alert command. The command can be initiated in two separate modes: Broadcast mode or Individual Seal mode

Stopping all tags:

Data

Cmnd* (39h)	
1	*# of bytes*

Stopping specific tags:

Data

Cmnd* (B9h)	TF	TID	CRC	TF	TID	CRC	...	TF	TID	CRC	
1	2	4	2	2	4	2	...	2	4	2	*# of bytes*

5.6.3.2.11. Ack Alert Burst Mode.

Data

Cmnd* (BBh)	TF	TID	CRC	TF	TID	CRC	...	TF	TID	CRC	
1	2	4	2	2	4	2	...	2	4	2	*# of bytes*

This is to acknowledge receipt of the alert message from specific seals. The seals will stop bursting until a new alert is detected.

5.6.3.2.12. Read Data.

Data

Cmnd* (63h)	TF	TID	BA Base address	BL Block length	
1	2	4	2	2	*# of bytes*

Where:

This is the base address in the memory of the block of BA data.
This is the data block length.BL

5.6.3.2.13. Write Data

Data

Cmnd* (68h)	TF	TID	PK/P#	BA Base address	Data	
1	2	4	1	2	m	*# of bytes*

PK/P# = 11h. At present the packets are fixed.

5.6.3.2.14. Reset Data.

Data

Cmnd* (AAh)	TF	TID	CRC_1		TF_8	TID_8	CRC_8	
1	2	4	2	- - - - - -	2	4	2	*# of bytes*

Seal #1 (TF, TID, CRC_1) Seal #8 (TF_8, TID_8, CRC_8)

Up to 8 seals can be reset in one cycle.

5.6.3.2.15. Set/Reset Status.

Data

Cmnd* (6Bh)	TF	TID	Bit mask	Bit value	
1	2	4	4	4	*# of bytes*

Only some of the flags can be set and reset.

Bit mask marks the status bits to be reset.
When the value is set to “0”, this means: “don't modify”.
When the value is set to “1”, this means: “reset value to zero”.
Each bit corresponds to the appropriate bit in the LTS.

5.6.3.2.16. Write Parameters

Data

Cmnd* (69h)	TF	TID	PK/P#	Par Code	value	Par Code	value	---	Par Code	value	
1	2	4	1	1	i	1	j		1	k	*# of bytes*

TF&TID=00 is for a broadcast command.
PK/P# = 11h. At present the packets are fixed.

5.6.3.2.17. Read Parameters.

Data

Cmnd* (64h)	TF	TID	Par Code	Par Code	----	Par Code	
1	2	4	1	2		j	*# of bytes*

5.6.3.2.18. Addressed Verify.

Data

Cmnd* (50h)	TF	TID	T_{cm}	T_{iw}	t_s	N_a	N_r	N_t	R_r	R_t	ASID	Parameters mask	
1	2	4	1	2	1	1	1	1	1	1	1	2	*# of bytes*

The following parameters are not applicable to this command:
Na, Nt, Rt.

5.6.3.2.19. Read Events.

Data

Cmnd* (61h)	TF	TID	EV#	# EV	
1	2	4	1	1	*# of bytes*

Where
is the start event sequential number.EV#
is the number of events to be read from memory.#EV

5.6.3.3. Get Results.

After transmission of a request to execute a command, the system should wait for a response. The Get Results command allows the retrieval of the response from the Reader. This command is carried out at the RS-485 level.
Using the DLL eliminates the need for the use of this command, as the DLL takes care of the response. For details see the STAR CORE DLL help file.

5.6.3.4. Get Status.

5.6.3.4.1. Command transmission.

This command is used to retrieve the status of the READER.

LSC > Reader

CMND(0016h)	
2	*# of bytes*

5.6.3.4.2. Get Status Command Response.

The following string is the general response.

Reader > LSC

MSGT(8016h)	R_status	
2	4	*# of bytes*

R_STATUS field is 4 bytes.

Byte A	Byte B	Byte C	Byte D

Byte A represents the status of the main motherboard MCU.
The other bytes represent the RF modem status.
In a general Reader response, the R-Status reply contains bytes A&B only. In command GET Status the reply contains all the R-Status bytes.

Byte A:

7	6	5	4	3	2	1	0
UNLOCK	485	PCR	PER	VCCERR	VBERR	PMC	EDC

Where:

UNLOCK — if 0 reader's parameters are locked.
If 1 parameters are unlocked.

485 — If 0 reader is using the RS-232 mode for communication.
If 1 reader is using the RS-485 mode for communication.

PCR — If 0 parameters in the MCU's E^2ROM are OK.
If 1 parameters were corrupted and successfully restored.

PER — If 0 parameters in the MCU's E^2ROM are OK.
If 1 parameters are corrupted.

VCCERR — if 0 internal power is OK.
If 1 internal power is not OK.

VBERR — if 0 internal battery is OK.
If 1 internal battery is not OK.

PMC — If 0 program memory in the MCU is OK.
If 1 program memory is corrupted.

EDC — a flag indicating that a delayed command was triggered and is in process.

Byte B:

7	6	5	4	3	2	1	0
Ch1	Ch2	Ch3	Ch4	Ch1err	Ch2err	Ch3err	Ch4err

Where:

Ch1 — If 0 channel1 is not in use.
If 1 channel1 is in use.

Ch2 — If 0 channel2 is not in use.
If 1 channel2 is in use.

Ch3 If 0 channel 3 is not in use.
If 1 channel 3 is in use.

Ch4 If 0 channel 4 is not in use.
If 1 channel 4 is in use.

Ch1err If 0, channel is OK.
If 1, channel is defective. Details are in byte C. If byte C flags are OK, there is a communication failure with this channel.

Ch2err If 0, channel2 is OK.
If 1, channel2 is defective. Details are in byte C. If byte C flags are OK, there is a communication failure with this channel.

Ch3err If 0, channel3 is OK.
If 1, channel3 is defective. Details are in byte D. If byte D flags are OK, there is a communication failure with this channel.

Ch4err If 0, channel4 is OK.
If 1, channel4 is defective. Details are in byte D. If byte D flags are OK, there is a communication failure with this channel.

Bytes C&D:

7	6	5	4	3	2	1	0
VCCERR	PMC	EMC	EME	VCCERR	PMC	EMC	EME

For ch 1& ch3 (bits 7–4) For ch2 & ch4 (bits 3–0)

VCCERR	if 0 power is OK. If 1, power is not OK.
PMC	if 0 program memory in the module is OK. If 1 program memory is corrupted.
EMC	if 0 E^2ROM is OK. If 1 E^2ROM was corrupted and restored.
EME	if 0 E^2ROM is OK. If 1 E^2ROM was corrupted.

5.6.3.5. Get Burst Message Command

5.6.3.5.1. Command transmission.

This command is used to retrieve the alert messages transmitted asynchronously by seals that are in alert burst mode.

LSC > Reader

STX	#B	R#	CMND(001Ch)	Channel	CRC	ETX	
1	2	2	2	1	2	1	*# of bytes*

Channel indicates the source channel for the results. The value is according to the table in paragraph 5.5.2.1.

5.6.3.5.2. Get Burst Message Command Response.

The following string is the general response.

Reader > LSC

STX	#B	R#	MSGT (xx1Ch)	R_status	DATA	CRC	ETX	
1	2	2	2	2	n	2	*1*	*# of bytes*

DATA:

channel	PK	P#	Data*	
1	1	1	m	*# of bytes*

Where:

MSGT high byte of MSGT is according the scenario in use. The lower byte is 1C h.

DATA If the result is not ready the value of this field is 05 hex error code see Paragraph 5.4. If the result is ready the following applies.

PK Total number of packets.

P# Packet number sequence number.

Data* This string contains the Seal's records. This field should first be retrieved from all packets before being analyzed.

Seals Records:

Data*1			Data*2		- - - - - - - - - - - - - - -				Data*PK-1		Data*PK
Seal record		Seal record		Seal record		Seal record		Seal record		Seal record	
#B	Data**	#B	Data**	#B	Data**	#B	Data**	#B	Data**	#B	Data**
1	r		r		r		r		r		r

Where:

Data**				
TF	TID	Message Type	Resultant Data	
2	4	1		# of bytes

#B is the number of bytes for a seal record (including the #B field).
Data** is the data received after executing the RF command led by TF, TID and Message Type.

If no seal detected:

Data*1
Seal record
#B=0
1

5.6.3.6. Reset Reader.

5.6.3.6.1. Command transmission

This command is used to performa software reset to a readerReader.

LSC > Reader

CMND(0014h)	
2	*# of bytes*

5.6.3.6.2. Reset Reader Command Response.

The following string is the response.

Reader > LSC

MSGT(xx14h)	R_status	
2	2	*# of bytes*

5.6.3.7. Write Parameters.

5.6.3.7.1. Command transmission.

This command enables modification of a parameter's value in the Reader. It should be clear that not all the parameters are available for modification. Table 5.2 specifies which parameters may be modified.

LSC > Reader

CMND(0006h)	Data	
2	n	*# of bytes*

PAR1code	value	PAR2 code	value	...	PARmcode	value	
1	i	1	k	...	1	l	*# of bytes*

5.6.3.7.2. Write Parameters Command Response.

The following string is the response:

Reader > LSC

MSGT(xx06h)	R_status	
2	2	*# of bytes*

5.6.3.8. Read Parameters.

5.6.3.8.1. Command transmission.

This command is to enables the reading of a parameter's value from the Reader.

LSC > Reader

CMND(0007h)	Data	
2	n	*# of bytes*

PAR1 code	PAR2 code	----	PARm code	
1	1		1	*# of bytes*

5.6.3.8.2. Read Parameters Command Response.

The following string is the response.

Reader > LSC

MSGT(xx07h)	R_status	Data	
2	2	N	*# of bytes*

value	Value		value	
i	K	-------	m	*# of bytes*

5.6.3.9. BIT

5.6.3.9.1. Command Transmission

This command generates a set of built-in test procedures.

LSC > Reader

CMND(0009h)	
2	*# of bytes*

5.6.3.9.2. BIT Command Response.

The following string is the response.

Reader > LSC

MSGT(xx09 h)	R_status	
2	4	*# of bytes*

5.6.3.10. Sleep.

5.6.3.10.1. Command Transmission.

This command places the Reader in sleep mode to conserve energy. The command is useful when the Reader is operating on battery power. The Reader will wake when it receives a Wakeup command.

LSC > Reader

CMND(0008h)	
2	*# of bytes*

5.6.3.10.2. Sleep Command Response

The following string is the response:

Reader > LSC

MSGT(xx08h)	R_status	
2	4	*# of bytes*

5.6.3.11. Unsynchronized Reader Message.

5.6.3.11.1. Message Transmission.

If the Reader is in Alert Burst mode, a Burst Alert message may be transmitted. The following string will be received for each seal.

Reader > LSC

MSGT(800Ah)	R_status	Data	
2	2	n	*# of bytes*

Data:

TF	TID	Command code	Short status	ORG_ID	
2	4	1	1	3	*# of bytes*

ORG_ID is an option in the response, depending on the seal's configuration.

5.6.3.11.2. Message Command Ack.

This is an ack issued by the host computer to the Reader is a RS-232 application.

5.6.3.12. Get Reader's baud rate.

5.6.3.12.1. Command transmission

This command forces the Reader to report its baud rate.

LSC > Reader

R# (0000)	CMND (00ff h)	R_ID	
2	2	4	*# of bytes*

5.6.3.12.2. Get Reader's Baud Rate Response.

The following string is the response.

Reader > LSC

MSGT(80ff h)	R_ID	baudrate	
2	4	4	*# of bytes*

Baud rate: 2400, 4800, 9600, 19200, 38400

5.6.3.13. Set Reader's Baud Rate.

The baud rate is interpreted as a decimal number translated into a 32 bit binary number or vise-versa.

5.6.3.13.1. Command transmission.

This command forces a new value for the Reader's baud rate. The actual baud rate update is done after the completion of this command and receipt of the response.

LSC > Reader

CMND (00fe h)	R_ID	baudrate	
2	4	4	*# of bytes*

5.6.3.13.2. Set Reader's Baud Rate Response.

The following string is the response.

Reader > LSC

MSGT(80feh)	R_ID	baudrate	
2	4	4	*# of bytes*

5.6.3.14. Set Reader's Address.

5.6.3.14.1. Command Transmission.

This command requests the Reader to set its address on the RS-485 party line. Reader ID is used to distinguish between Readers sharing the same communication lines.

LSC > Reader

CMND(0012h)	R_ID	New add	
2	4	2	*# of bytes*

5.6.3.14.2. Set Reader's Address Response.

The following string is the response.

Reader > LSC

R#	MSGT(xx12h)	R_status	
2	2	2	*# of bytes*

The R# is with the new address.

.5.6.3.15. Acknowledge OK.

This string is a one-way LSC string to acknowledge a positive message coming from the READER. In case of packets, this will acknowledge the last packet received.

LSC > Reader

CMND(0092h)	
2	*# of bytes*

5.6.3.16. Acknowledge Failed.

This string is a one-way string to acknowledge a message indicating a problem originating from the READER.

LSC > Reader

CMND (0094h)	
2	*# of bytes*

5.6.3.17. Save Command.

5.6.3.17.1. Command Transmission.

In an application where a delayed command execution is required, the command must first be defined. This is done by saving the command in the Reader.

LSC > Reader

CMND(0008h 0Fh)	data	
2		*# of bytes*

phase	CMND*	Data*	
2	2		*# of bytes*

Where:

Phase	is the duration from the end of the "Execute saved command" and the time required to execute the saved command. The phase is in units of 1.024 msec.
CMND*	is the command code of the saved command for delayed execution.
Data*	is the relevant data field for the CMND*

Data set to 0 clears the saved command.

5.6.3.17.2. Save Command Response.

The following string is the response.

Reader > LSC

MSGT(XX08h XX0Fh)	R_status	
2	2	*# of bytes*

5.6.3.18. Execute Saved Command.

5.6.3.18.1. Command Transmission.

This is a broadcast command sent to all Readers.
There will be no response from any Reader to this command.

LSC > Reader

CMND(0017h)	data	
2	4*k	*# of bytes*

Reader ID [1]	Reader ID [2]	. . . .	Reader ID [k]	
4	4		4	*# of bytes*

The data field details the Readers by their IDs

5.6.3.18.2. Execute Saved Command Response.

The following string is the response. There is no response for this command.

Reader > LSC

STX	#B	R#	MSGT(XX08h)	R_status	CRC	ETX	
1	2	2	2	2	2	*1*	*# of bytes*

5.6.3.19. Read Channel Definitions Command.

5.6.3.19.1. Command Transmission.

This command allows reading the definitions of a device.

LSC > Reader

CMND(0011h)	channel	
2	1	*# of bytes*

Where:

is the channel number that the device is Channel connected to. Channel can be 0 to indicate the MCU, or 1,2 etc for the other channels.

5.6.2.19.2. Read Channel Definitions Response.

The following string is the response.

Reader > LSC

MSGT(XX11h)	R_status file	
2	82	*# of bytes*

Where:

File is the data file that defines the device.

File structure is:

	Name	Size [bytes]
1	Part number	16
2	Serial number	16
3	Hardware version	4
4	Production date	10
5	Production batch number	4
5	Description	32
6	Reserved	45

The file is in ASCII format.

5.7. System Planning.

When planning an application, attention should be paid to both system operation and topology. Application requirements and electromagnetic environment characteristics should also be taken into account.

The system has 2 basic applications: Fixed Reader applications and Mobile Reader applications.

The Fixed Reader applications are applications where the Readers are mounted in a fixed site. The Mobile applications are situations where the Reader is mounted on a vehicle for monitoring seals in transit.

5.7.1. Electromagnetic Environment.

Radio frequency communications is the basic technology used by the system. While this is a very robust method for communicating with remote devices, several issues should be considered when planning a site:

- Metal walls should not be used to shield the remote devices.
- Communication distance between remote devices is not a constant.
- Communication distance may vary according to one or more of the following:

  - Line of sight between devices - existence and clearance.
  - Proximity to metal objects.
  - Indoor or Outdoor environment.
  - Antenna orientation between the devices.

It is recommended to map the site with actual devices for proper coverage. When planning the site layout, safe margins should be taken into account to ensure proper operation at all times. Possible environmental changes should also be considered. System utilities should be used to test and verify proper and reliable operation.

5.7.2. System Layout.

Two aspects should be considered when dealing with system layout:

1. Radio Frequency Communication Layout.
2. Line Communication RS-485 or RS-232 Layout.

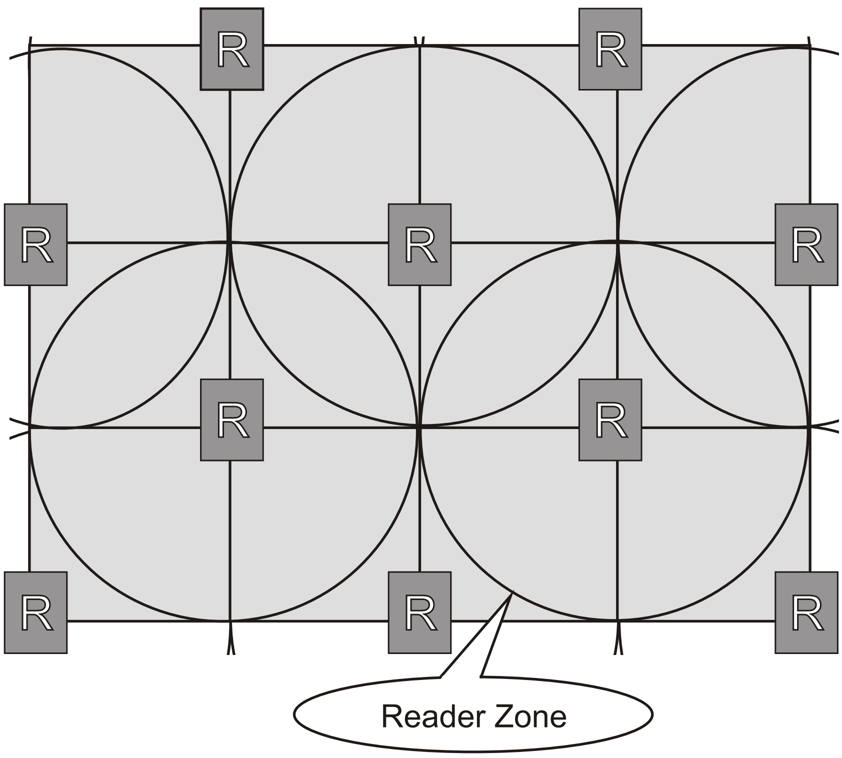
5.7.2.1 Radio Frequency Communication Layout.

When only one Reader is in use, the previously mentioned environmental considerations are all that need be taken into account.

When more then one reader is in use, it should be understood that in the same area **only one** Reader can communicate with the seals at the same time. Interference will be caused by more than one Reader trying to communicate with the seals in the same period in time. **The Readers should be synchronized using the application software.** Several Readers may operate simultaneously provided that it has previously been confirmed that they will not interfere with each other.

5.7.2.2. Cellular Layout.

Cellular topology should be used to ensure efficient coverage of a large area. The following drawing illustrates the concept.



Readers must be properly placed to ensure there are no dead zones within the defined area. Overlaps should be as shown in the above drawing.

Reader Zone is the term used to describe the area of reliable communication covered by a Reader. The Reader Zone is a CELL. As the drawing illustrates, it is extremely important that the application software controls and synchronizes the Reader's operation in order to avoid air collisions.

5.7.2.3. Reader Session Retransmissions.

Probability calculations were used to estimate Reader Session retransmissions when creating System Sessions. However, it is advisable that suitable retransmissions be on hand at the application level to overcome unpredictable radio interference.

The actual number of retransmissions can be either fixed or dynamic. These should be set in accordance with the application requirements and the empirically evaluated on-site electromagnetic characteristics.

5.7.2.4. Line Communication RS-485 Layout

The connection of many Readers to a Local Site Controller (LSC) is done via the RS-485 protocol. Up to 32 Readers may be connected to one COMM Port, depending on the type of RS-485 to RS-232 converter used.

Two topologies can be used:

- A long daisy chain connection, where all the readers are connected in one long line.
- A star-type connection, where the readers are split into groups and each group is connected directly to the converter.

It is recommended that the second alternative be used wherever possible. A star-type connection provides redundancy in terms of connections. This alternative is also preferable from the power supply point of view, as only one power supply for the Readers is necessary. The power supply should be located near the converter. When the line is divided into segments, the voltage drop along the segments is smaller.

5.8. System Segregation.

When operating the system, several security and operational considerations should be taken into account:

- Ensure that no similar equipment belonging to another company can operate your system.
- Limit unauthorized access between different departments of the same company.
- Allow a Service Provider to supply common services to several companies.
- Allow access to seal subgroups within a company.

5.8.1 Company Segregation by *ORG_ID*.

ORG_ID is a unique value assigned in production to each customer. Every device supplied to that company is programmed with the ***ORG_ID***. All communication sessions are based on a positive verification of the ***ORG_ID*** for complete match between the devices. There is no way to modify the value of the ***ORG_ID*** and only devices that comply with this request will get full service.

In the event a Reader tries to communicate with a seal without appropriate ***ORG_ID*** and ***GLOBAL*** settings, the ***Illegal ORG_ID*** flag in the ***LONG STATUS*** will be set. (For information regarding the ***GLOBAL*** setting, see paragraph 5.7.3.).

5.8.2. Department Isolation.

The inter-department relationship works on a similar concept to that described in section 5.7.1. It is possible to isolate equipment between departments by using the ***DEPARTMENT*** parameter.

The default value of ***DEPARTMENT*** is zero. When set to default settings, all the devices can communicate without any limitations.

If a value has been inserted, only devices with the same ***DEPARTMENT*** value will establish communication and will get service. Different departments will have different ***DEPARTMENT*** values. Only a device with ***DEPARTMENT*** set to zero will get full access to all devices. Devices with ***DEPARTMENT*** value zero are considered supervisors. ***DEPARTMENT*** values are not factory pre-sets, and can be set by the customer.

5.8.3. Common Services To Several Companies By A Service Provider.

The ***ORG_ID*** setting may comprise a barrier preventing access to all devices by a Service Provider. The ***GLOBAL*** parameter is designed to allow a Service Provider to service several customers.

If programmed accordingly, the ***GLOBAL*** parameter will release the ***VERIFY*** command only to a Service Provider. When the ***GLOBAL*** parameter is in use, the seal will ignore the ***VERIFY*** command except for the parameters marked with * in table 5.2.1. The ***GLOBAL*** parameter is programmed during production. It should be defined and requested in advance.

5.8.4. How To Use Subgroups Of Seals In A Company.

It may be convenient to the User to subgroup devices into small groups and then access them by group. The ADI parameter is used for this operation. The default value of ADI is zero. When set to default values, the ADI parameter is not in use and full access is available between all the devices. When ***ADI*** is programmed to a different value, only devices with the same ***ADI*** will communicate. ***The customer can program ADI on the fly***.

5.8.5: ***ORG_ID, DEPARTMENT, GLOBAL and ADI:*** Impact on seal's response

The following logical statements can summarize seal response:

1. Complete unmatched ORG_ID and GLOBAL is on: Seal will respond with limited VERIFY command only.
2. Complete unmatched ORG_ID and GLOBAL is off: Seal will not respond.
3. Complete match of ORG_ID and complete match of DEPARTMENT and complete match of ADI: Seal will respond without limitations.
4. Complete match of ORG_ID and unmatched ADI: Seal will not respond.

5.9. Seal Memory.

Seal memory is divided into 2 sections: ***EVENTS MEMORY*** and ***USER DATA***.

5.9.1 Events Memory.

This memory stores the events detected by a seal during normal operation. Memory size is 55 events.
The memory has a FIFO type structure with 2 segments.
The first segment can store 45 Events and is a simple FIFO buffer with the SET event at the beginning of the buffer.
The second segment can store 10 Events and is a cyclic buffer with the last events detected.
When this cyclic buffer is overrun, the ***SCROLL*** flag in the ***LONG STATUS*** is set.

First segment: 45 Events	SET
Second segment: 10 Events	

With the passing of time, the seal detects events that have been added to the seal. These additional events may be a result of an internal procedure or an external intervention.

The following table summarizes Events handled by the seal:

Table 5.15.

Events	**Event code**
Set	01h
Seal Tampered/ Wire changed (1)	02h
Low battery warning	03h
Seal open or cut (1)	04h
Seal close (1)	05h
Soft Set	07h
RTC Stopped	08h
Database corrupted	09h
Read	0Ah
Time Changed	0Bh
Suspended SET	0Ch

(1) These events are considered TAMPER Events.

5.9.2. User Data

USER DATA is the memory segment where free data for electronic manifests can be written and read. To use the USER DATA memory, the Write and Read Data commands should be used. Memory size is 2K.

Special attention should be taken at the lower portion of the memory. The DataTerminal supports the lower portion of the USER DATA memory. The following instructions should be maintained to ensure full compatibility between the DataReader channel and the DataTerminal channel:

Memory map of the lower portion.

Address	**1 Byte width**	
Address 0	UDT	Version
Address 1	Time & Date	
Address 2	Time & Date	
Address 3	Time & Date	
Address 4	Time & Date	
Address 5	Data	
. . . . . .	. . . . . .	
Address 52	Data	

The value **Version** is the lower nibble of the address 0 and is the version of the ***USERDATA*** format.

The value **UDT** is the upper nibble of the address 0 and is a number assigned the data base configuration by the User.

Using this **UDT**, the system can perform an integrity check of the ***USERDATA*** in the system.

Time & Date is the last time and date when the data was written.
Time and Date occupies 4 bytes and the format is:
Date and Time parameter is a counter of 4 bytes with a resolution of 1 minute.
The zero value starts from the date and time: 00:00:00 01.01.2000
The date and time is set to Greenwich Mean Time (GMT) in production and is stored under unlock mode.

Bits and Bytes assignment:

Address	7 6 5 4		3 2 1 0
1	0	Minutes / 10	Minutes % 10
2	Month %4	Hours/10	Hours % 10
3	Month / 4	Days/10	Days % 10
4	Years / 10		Years % 10

Minutes range is: 0-59.
Hours range is: 0- 23.
Day range is: 1-31.
Month's range is: 1-12.
Year's range is: 00-99.
Seconds range is: 0-59. Seconds field is relevant only for read & write parameters.
From address 5 to 52 the data is according to the application design.

5.10. Calculating Reader Session Duration

The total duration of a Reader Session can be calculated by using the following formula:

Reader Duration=(Thw * 3 + Tbmm + 57) * 1.024 + Trw

Tbmm and Trw are command dependent.

5.10.1. Calculating Tbmm:

a) Verify & Tamper Command

Tbmm = 10 msec

b) Addressed Verify Command

Tbmm = 13 msec

c) SET, Suspended SET, Soft SET, Deep Sleep, Reset Data, Start Burst Mode, Stop Burst Mode and Acknowledge Burst Mode Commands.

Tbmm = 4.5 + 4 * N msec
Where N is the number of seals

d) Read Data Command

Tbmm = 9 msec

e) Write Command

Tbmm = (17 + Data Size)/2 msec

5.10.2. Calculating Trw:

a) SET, SOFT SET and RESET DATA Commands

Trw = T_s * N * 1.024 msec

Where T_s is slot duration and N is the number of seals in a list.

b) READ PARAMETERS, WRITE PARAMETERS, READ DATA and WRITE DATA Commands.

Trw = 42 msec

c) VERIFY, TAMPER and ADDRESSED VERIFY Commands.

$Trw = (T_{iw} + T_s * (N_a + N_r + N_t)) * 1.024$ msec

Where T_{iw}, T_s, N_a, N_r, N_t are corresponding parameters of the command.

d) READ EVENTS Command:

$Trw = ((N_{max} + 1)/3) * 50$ msec

Where N_{max} is the maximal number of events.

e) START BURST MODE FOR ALL SEALS, STOP BURST

Trw = 0