

**AUTO-ID CENTER**

**STANDARDS FOR  
HF EPC TAGS**

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## OBJECTIVES OF STANDARD

- Operation at 13.56 MHz
- Ultra low cost read only labels
- Extensible to higher class labels
- Rapid multiple label reading
- Robust signalling
- Provision for user programming
- Supportive of a range of manufacturing technologies
- Provision for label destruction
- Industry will want to make it
- We specify necessary signalling and protocols
- Encourage industry to describe manufacturing



## EPC BASIC CONCEPTS

The EPC code structure is  
version-domain manager-object class-serial number

|   |    |    |    |         |
|---|----|----|----|---------|
| 8 | 28 | 24 | 36 | 96 bits |
|---|----|----|----|---------|

|   |    |    |    |                |
|---|----|----|----|----------------|
| 2 | 21 | 17 | 24 | 64 bits type I |
|---|----|----|----|----------------|

|   |    |    |    |                 |
|---|----|----|----|-----------------|
| 2 | 15 | 13 | 34 | 64 bits type II |
|---|----|----|----|-----------------|

|   |    |    |    |                  |
|---|----|----|----|------------------|
| 2 | 26 | 13 | 23 | 64 bits type III |
|---|----|----|----|------------------|

Longer codes will be defined



## LABEL MEMORY CONTENT

96 bit codes

|    |    |    |
|----|----|----|
| 96 | 16 | 24 |
|----|----|----|

$$96+16+24=136 \text{ bits}$$

64 bit codes

|    |    |    |
|----|----|----|
| 64 | 16 | 24 |
|----|----|----|

$$64+16+24=104 \text{ bits}$$

We see a 16 bit CRC and a 24 bit destruct password have been added



## MULTIPLE READ PROTOCOLS

- Context is EPC labels
- Tree walking is used at UHF
- Interrogator signalling is severely restricted at HF
- Change balance between interrogator and tag signalling
- Slotted terminating adaptive round adopted
- High label throughput
- Suited to dynamic label populations
- Robust collision detection provided



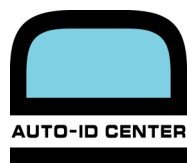
## STAR PROTOCOL FEATURES

- Signalling is EMC compliance driven
- Tag selection by section of EPC
- Reply is truncated for efficiency
- Tags reply randomly in slots
- Empty slots are closed early
- Slots are arranged in rounds
- Termination after reading occurs
- Return to round occurs on the conditions

Detection of collision

Detection of insecure communication

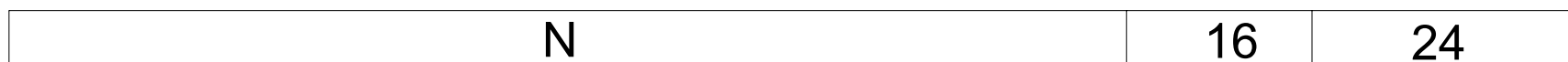
Detection of decoding error



## TRUNCATED LABEL REPLY

For time efficiency, replies are truncated to omit the section of the EPC used in the selection

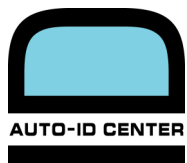
Selection and reply with N bit EPC and S bit selection



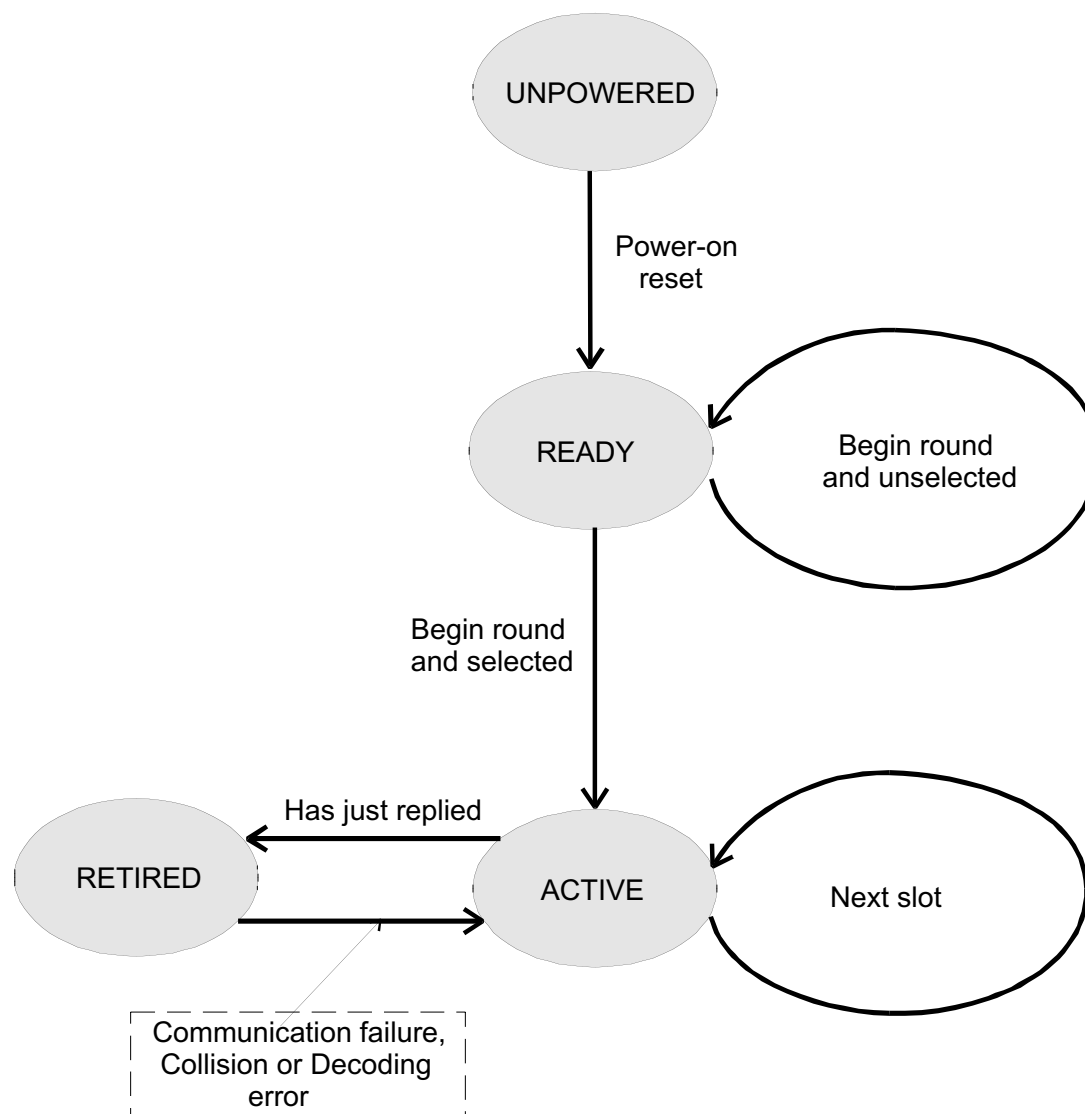
Extent of selection  
S bits

Extent of reply  
 $N+16-S$  bits

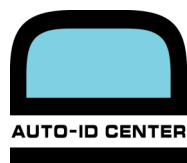
Destruct code does not participate



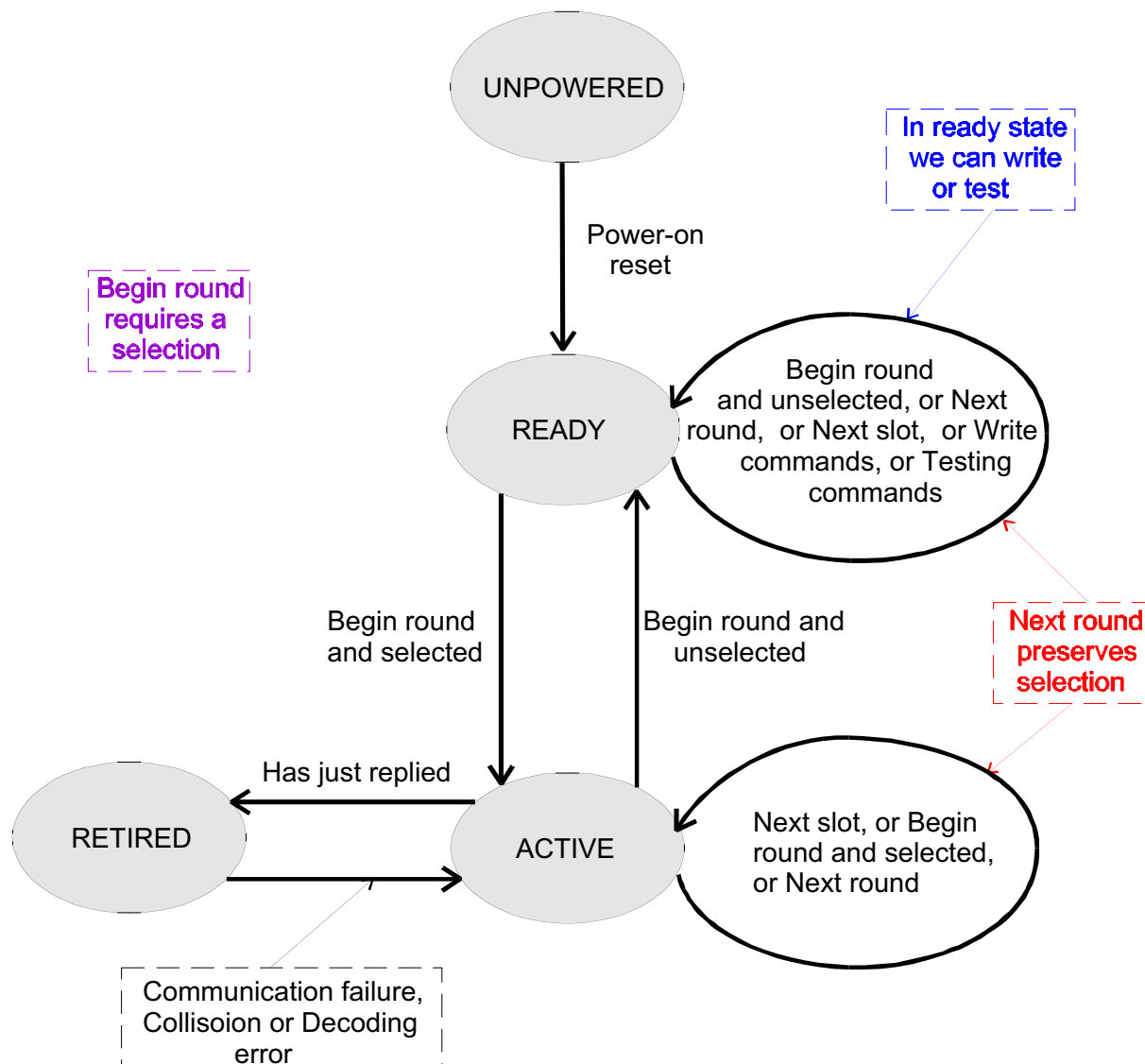
# STAR PROTOCOL SIMPLIFIED STATE DIAGRAM

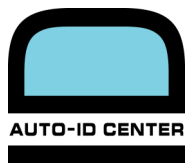




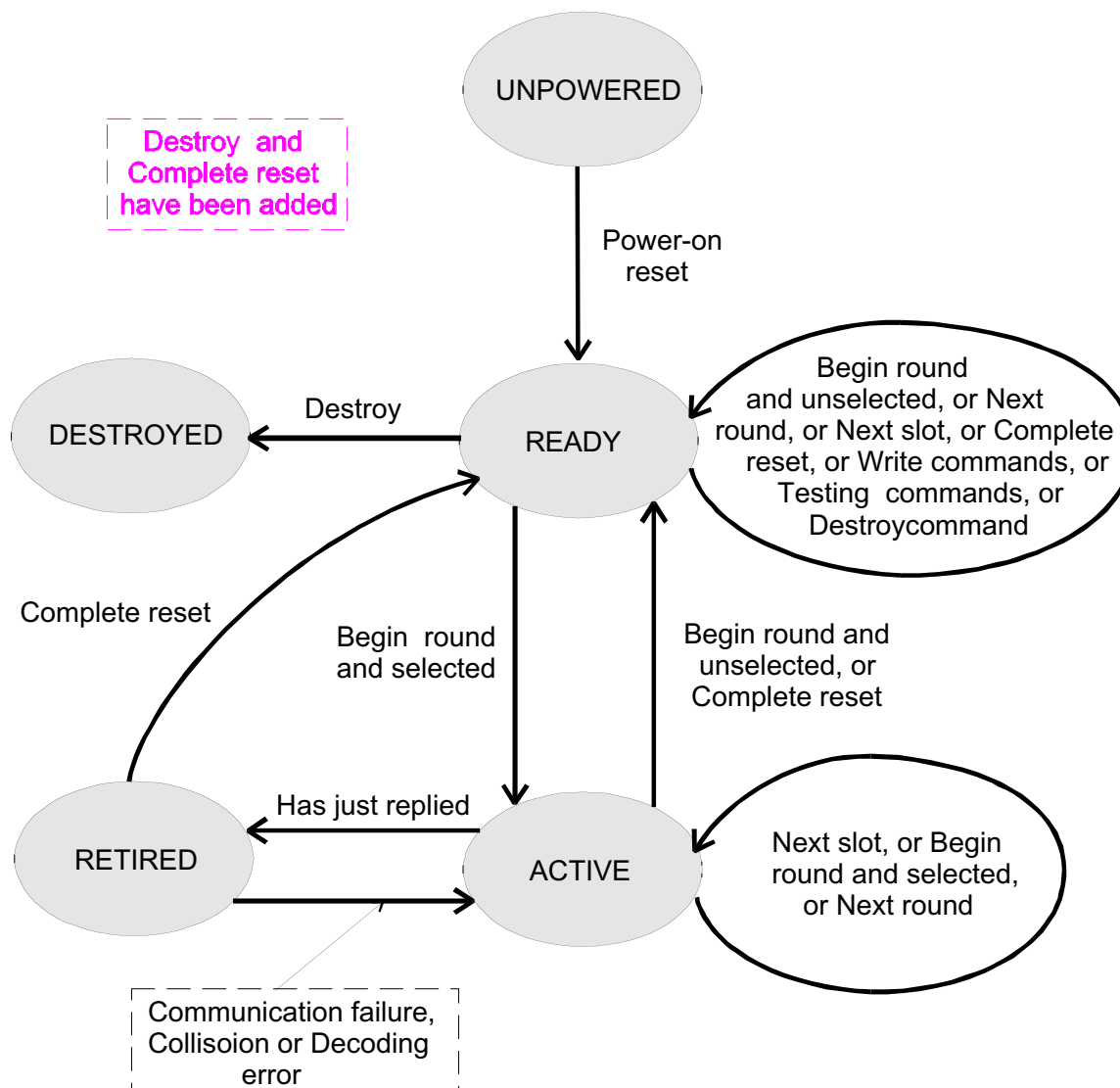


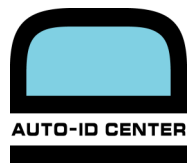
# STAR PROTOCOL AUGMENTED STATE DIAGRAM





# STAR PROTOCOL FULL STATE DIAGRAM





## **COLLISION DETECTION**

- Collision detection depends on label signalling
- It will be therefore be explained after label signalling



# LABEL PROGRAMMING

- Byte at a time
- Eventually the data is locked
- Different memory technologies provided for
- Some commands optional with technology
- Commands

Block write

Lock block (optional)

Lock whole memory (optional)

Destroy

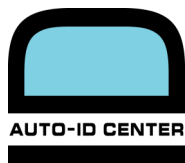
Chip test commands

Reserved commands



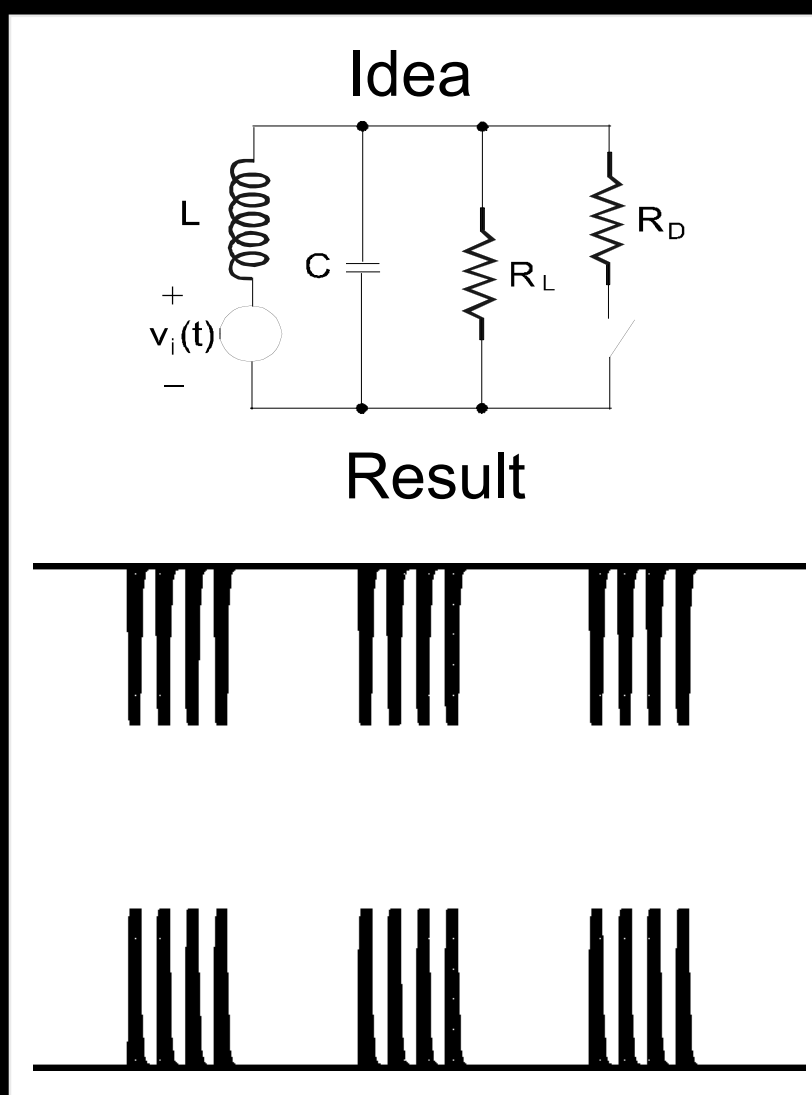
## DESTRUCTION

- Requires password
- Password length 24 bits
- Purpose is to frustrate unauthorised attempts
- Avoids precision on chip timing
- Long range destruction not needed



## TAG TO INTERROGATOR SIGNALLING

- Sub carrier of 424 kHz is synchronously generated
- Sub carrier modulates the interrogation signal
- Sub carrier is modulated with data
- Binary one is 4 sub carrier cycles followed by equal period of no sub carrier
- Binary zero is 4 sub carrier cycles preceded by equal period of no sub carrier
- This data structure supports collision detection





## INTERROGATOR AND LABEL SIGNALLING

- **Interrogator to labels**

Shallow dips 1 in 4 am

Symbols 1, 0, SOF and EOF

Data rate 26.4 kbit/s

8 bit CRC

Designed for compliant long streams

- **Labels to interrogator**

Sub-carrier based

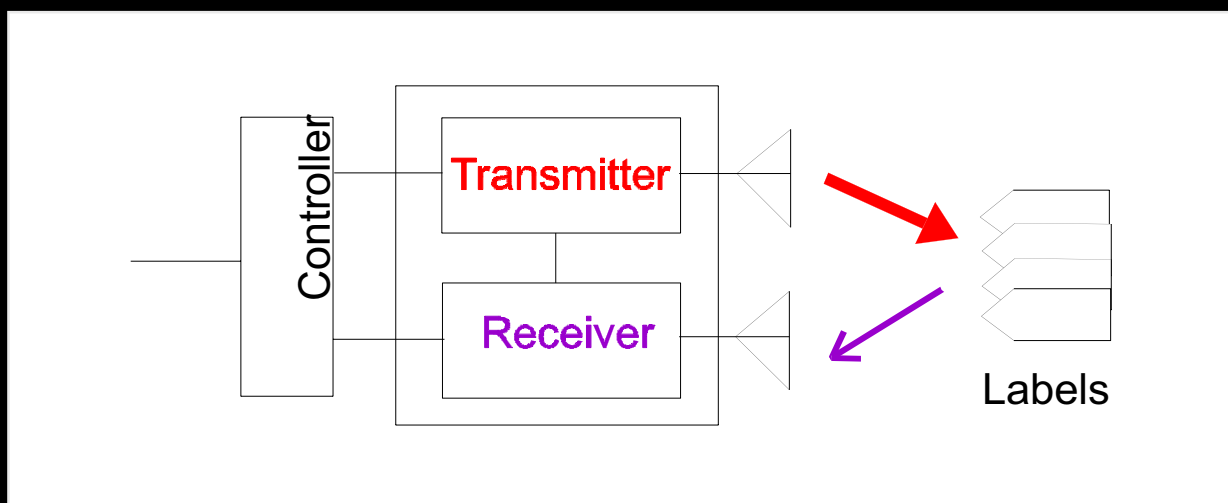
Sub-carrier am for

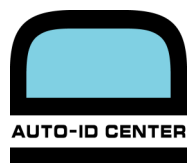
collision detection

Separate SOF and EOF

Data rate 53 kbit/s

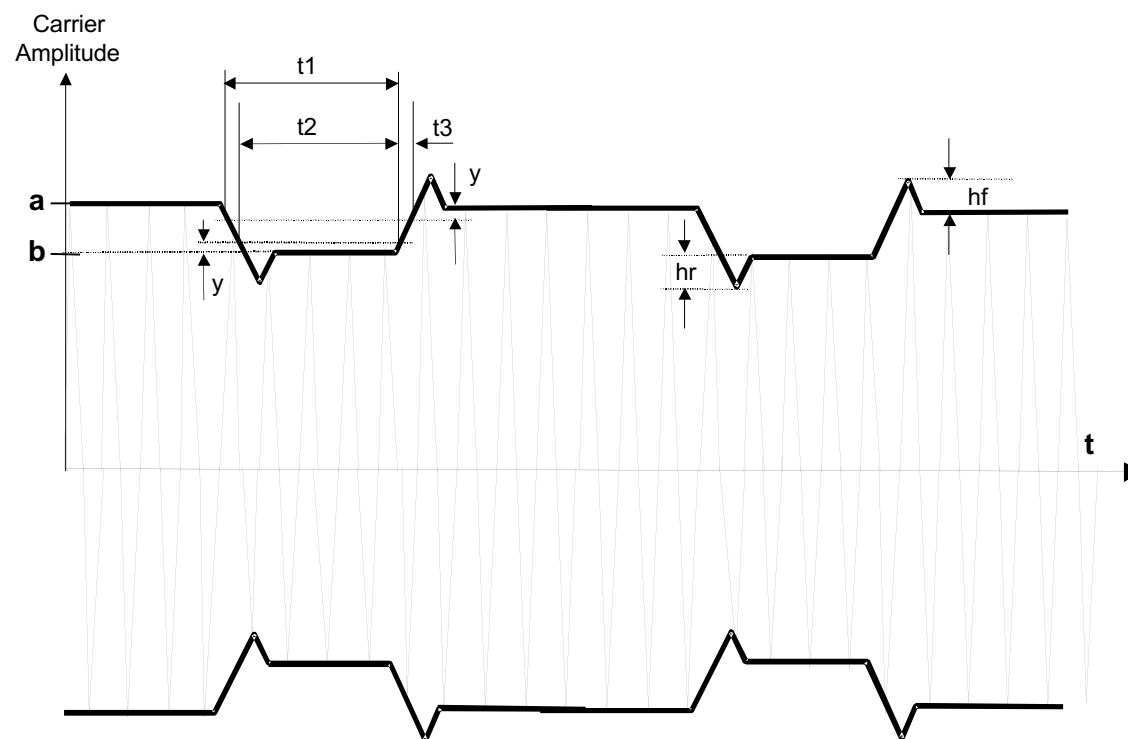
16 bit CRC





# BASIC INTERROGATOR TO TAG SIGNALLING PULSE

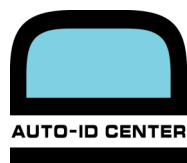
Two pulses are shown at the minimum separation



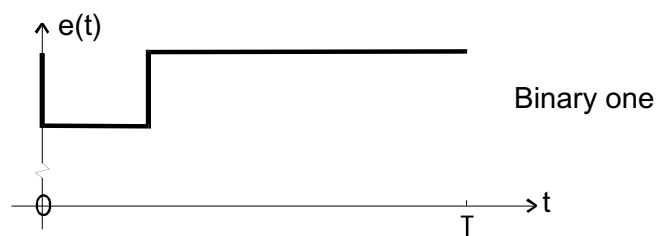
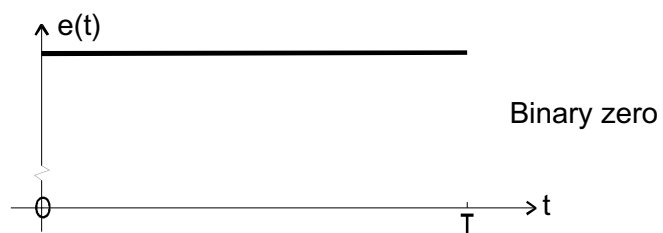
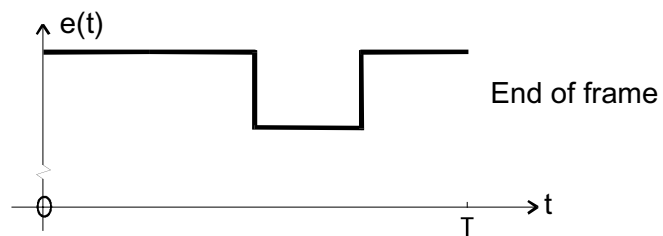
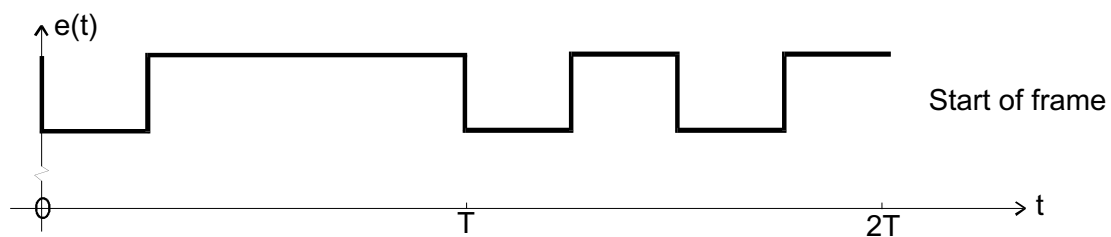
|                  | Min         | Max          |
|------------------|-------------|--------------|
| t1               | 6,0 $\mu$ s | 9,44 $\mu$ s |
| t2               | 3,0 $\mu$ s | t1           |
| t3               | 0           | 4,5 $\mu$ s  |
| Modulation Index | 10%         | 30%          |

|        |               |
|--------|---------------|
| y      | 0,05 (a-b)    |
| hf, hr | 0,1 (a-b) max |





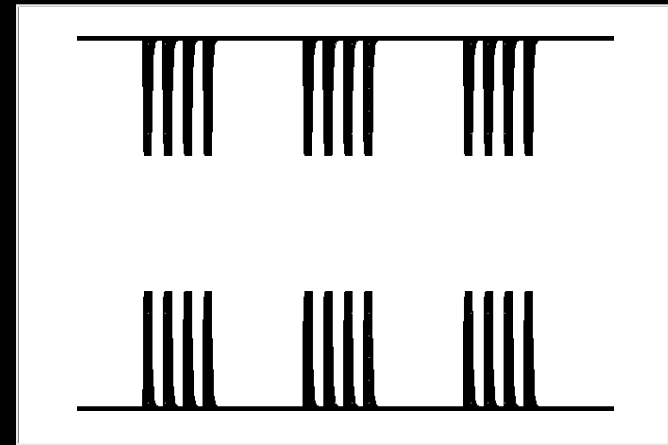
## INTERROGATOR TO TAG SYMBOLS



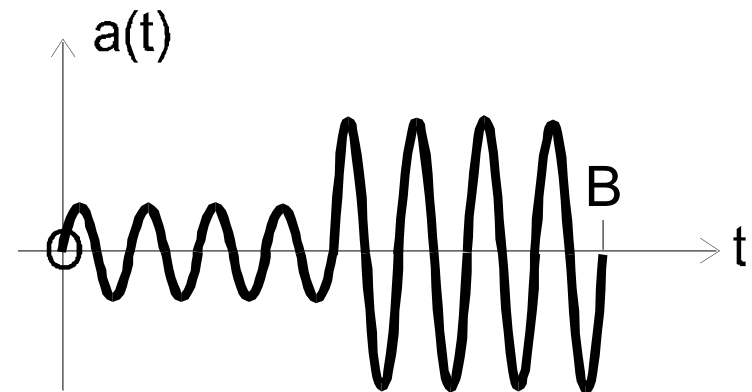
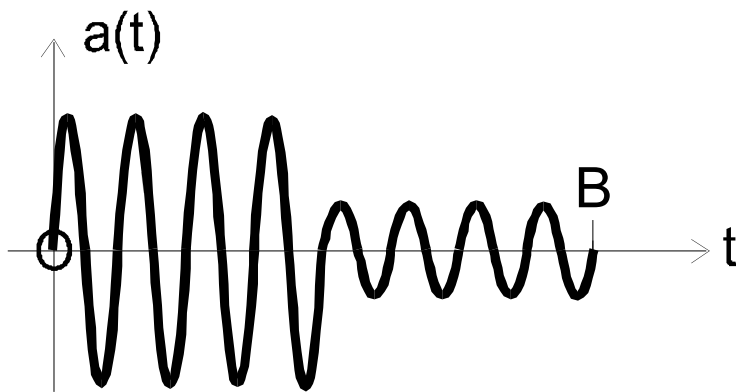


## COLLISION DETECTION

- All label contents are different
- Even after reply truncation
- Works by detection of oscillation in quiet period



Each of the diagrams presents a collision as two forms of data are present in a bit period B





## OPTIONAL LABEL OR INTERROGATOR FEATURES

- Kernel to retain been-read or not-been-read state  
Can be used to efficiently re-align interrogation field
- Mixed modulation in interrogator signals  
Allows deeper modulation depth  
Will not be perceived by label  
Keeps regulators happy



## FURTHER WORKING GROUP DEBATES

- Signalling protection by Hamming distance
- Licensing considerations
- Test specifications
- Manufacturing descriptions



## **STATUS EPC CHIP IMPLEMENTATION**

**CHRISTOPH KAUER**  
**GENERAL MANAGER**  
**BL TAGS & LABELS, BU**  
**IDENTIFICATION**  
**PHILIPS SEMICONDUCTORS**  
**GRATKORN**



## FEATURE SET OF PHILIPS EPC IC ACCORDING TO MIT HF CHEAP TAG SPEC

- Memory type OTP (in field)
- Identification rate 100 - 150/sec
- Max. # of labels 500
- Group Select Yes
- Destruct command Yes (password protected)
- Runs on ISO 18000-3 Mode1 infrastructure with dedicated EPC software
- Compliance with FCC47 part 15, EN 300-330, ETSI 300-683



## **SCHEDULE OF PHILIPS EPC PROJECT**

- **DESIGN ALMOST FINISHED**
  - **START OF SAMPLE PRODUCTION IN WEEK 24**
  - **FIRST SAMPLES AVAILABLE IN SEPT 2002**
  - **PARTICIPATION AT FIELD TRIAL IN OCT 2002 ?**
  - **HIGH VOLUME PRODUCTION RAMP UP**
- FIRST HALF OF 2003 (DEPENDING ON TEST RESULTS)**



## ACKNOWLEDGEMENTS

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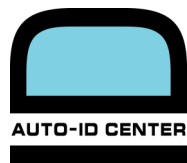
Matt Reynolds

Leigh Turner

Roger Stewart

Alfio Grasso

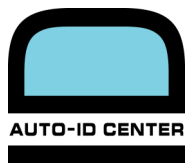




# AUTO-ID CENTER

**THE END**

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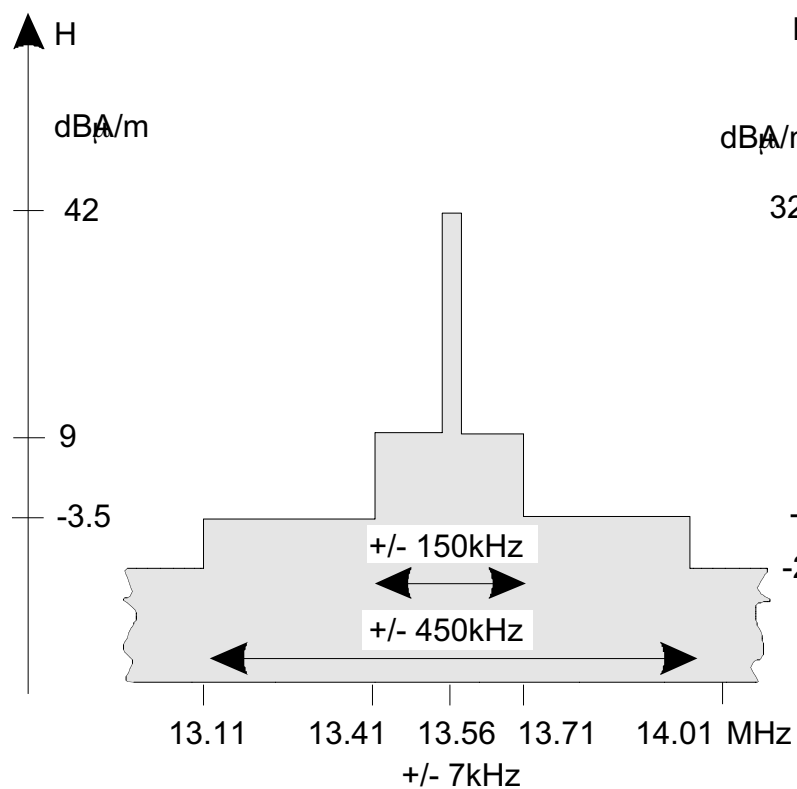


## EMC REGULATIONS AT HF

### EUROPEAN REGULATIONS

#### FIELD STRENGTH

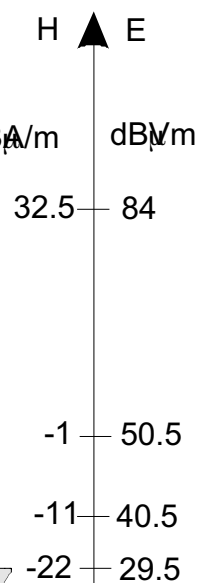
@ D = 10 m



### REVISED FCC PETITION

#### FIELD STRENGTH

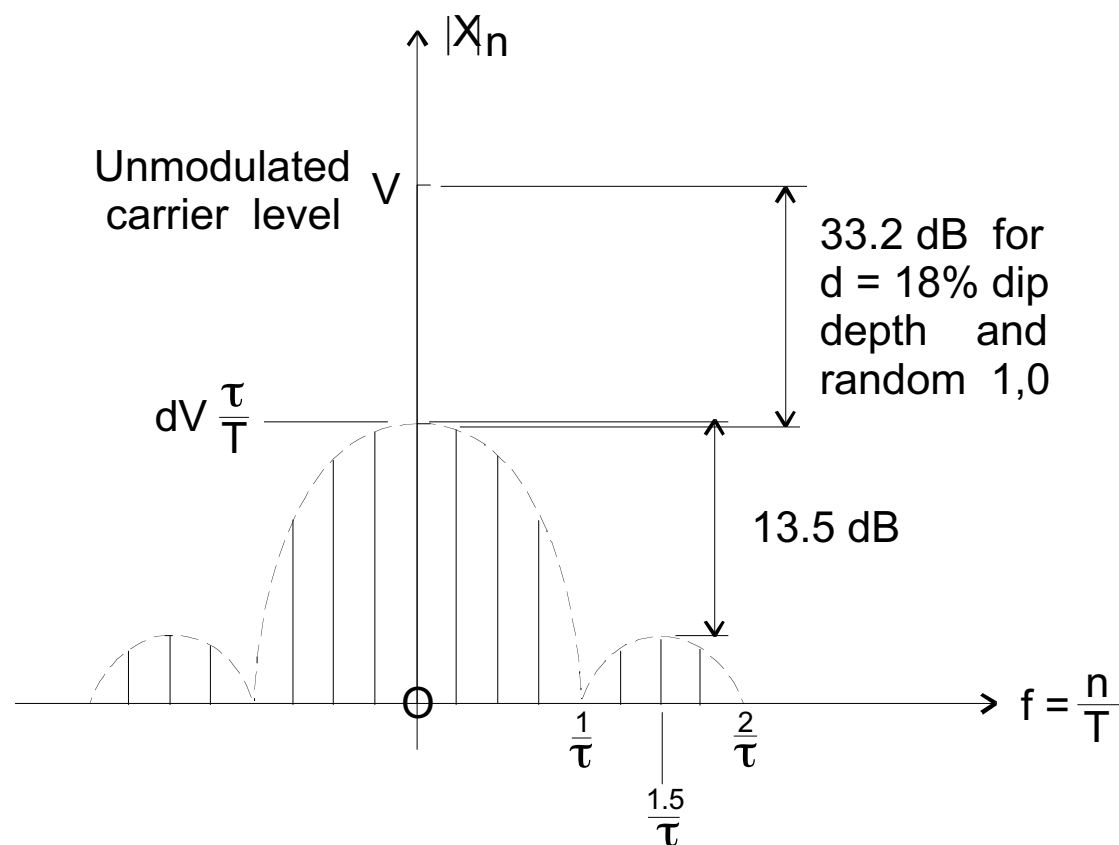
@ D = 30 m



ETSI and FCC spectral masks



## INTERROGATOR SIGNALLING SPECTRUM



Spectrum of a long interrogator signalling stream