Anti-tamper em Máquinas de Cartão

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Bacharelado em Ciência da Computação (2010).

Professor e Coordenador no Centro de Inovação Vincit (UNICIV).

Coordenador da pós graduação em Ethical hacking e Cybersecurity EAD.

Coordenador da pós graduação em Forense Computacional EAD.

Objetivo da Pesquisa

- Essa é uma pesquisa exploratória que almeja efetuar testes de segurança (hardware) em terminais POS (point of sale) especificamente máquinas de cartão.

- Devido ao tempo bem como a superfície de ataque do equipamento, nem todos os testes e hipóteses propostas pelo autor foram realizados.

Dúvida e Hipótese

Skimmers / Shimmers

Image 12

Staff should also be aware of the addition of overlays. An overlay can be a small sticker that forms to the device and covers the keyboard area.

Overlays may hide damage due to tampering or wires that can allow for keyboard logging. Overlays should not be used.

Image 3

Skimming devices hidden within the terminal will not be visible, and neither the merchant staff nor the cardholder will know that the card has been skimmed.

This picture shows a skimming device inserted in a terminal. This would have been hidden by the SIM card cover plate.

Image 15

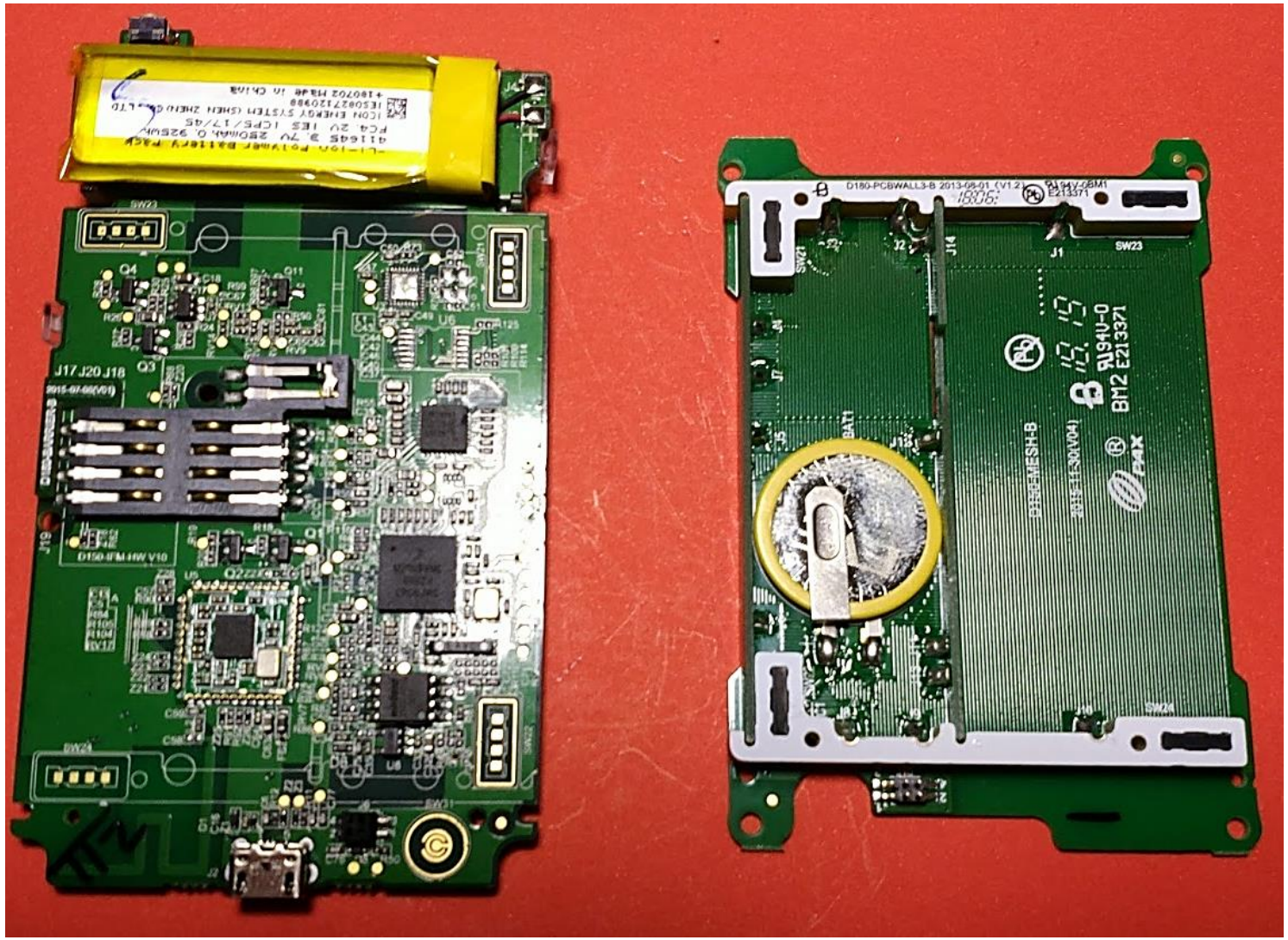
EMV or chip cards are not immune to skimming. Staff and consumers should be aware of modifications or wires to the smart-card slot. If anything appears different with the device, it should be reported immediately.

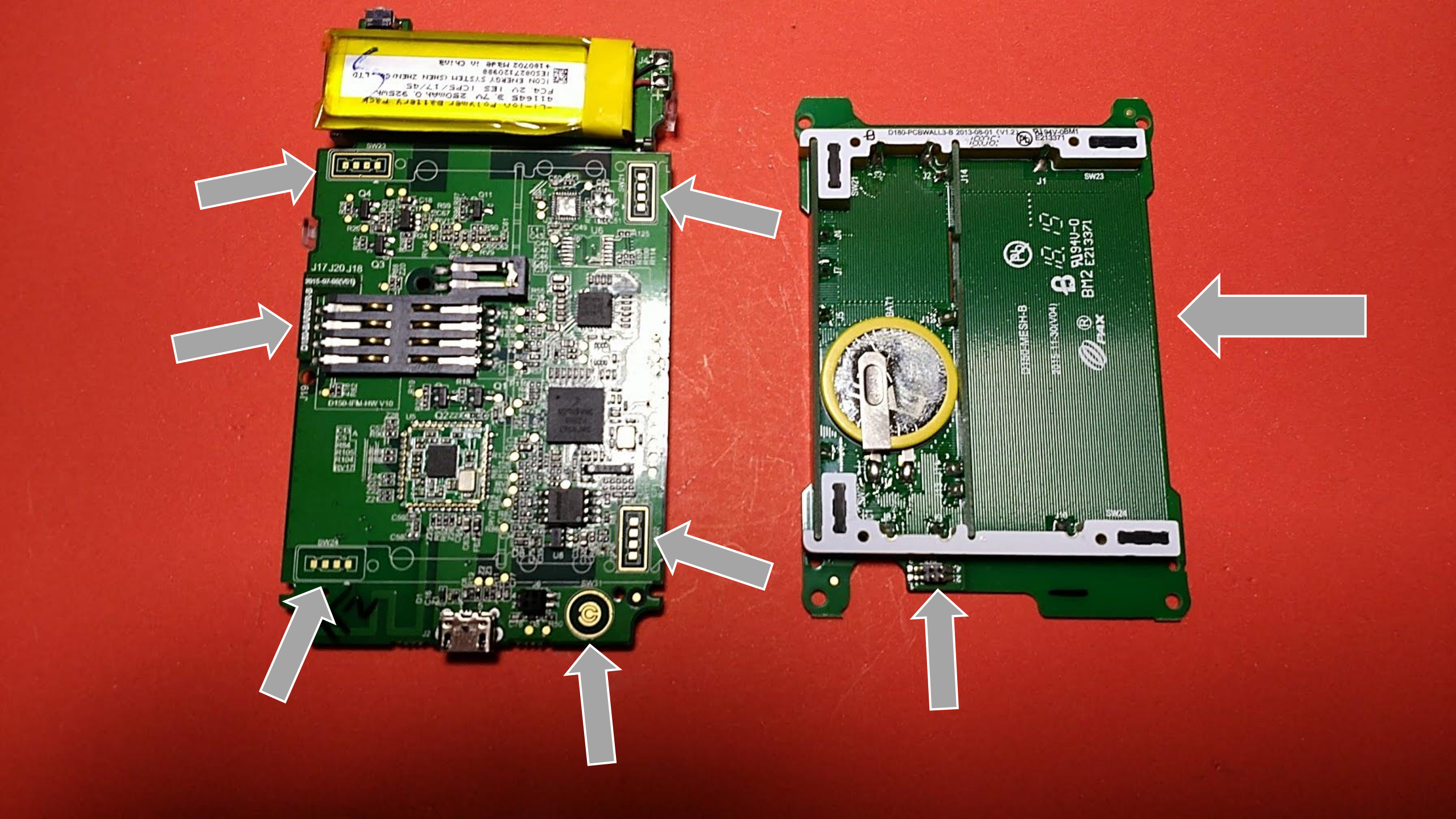
Graças à PCI PTS, Não é assim tão fácil hoje em dia...

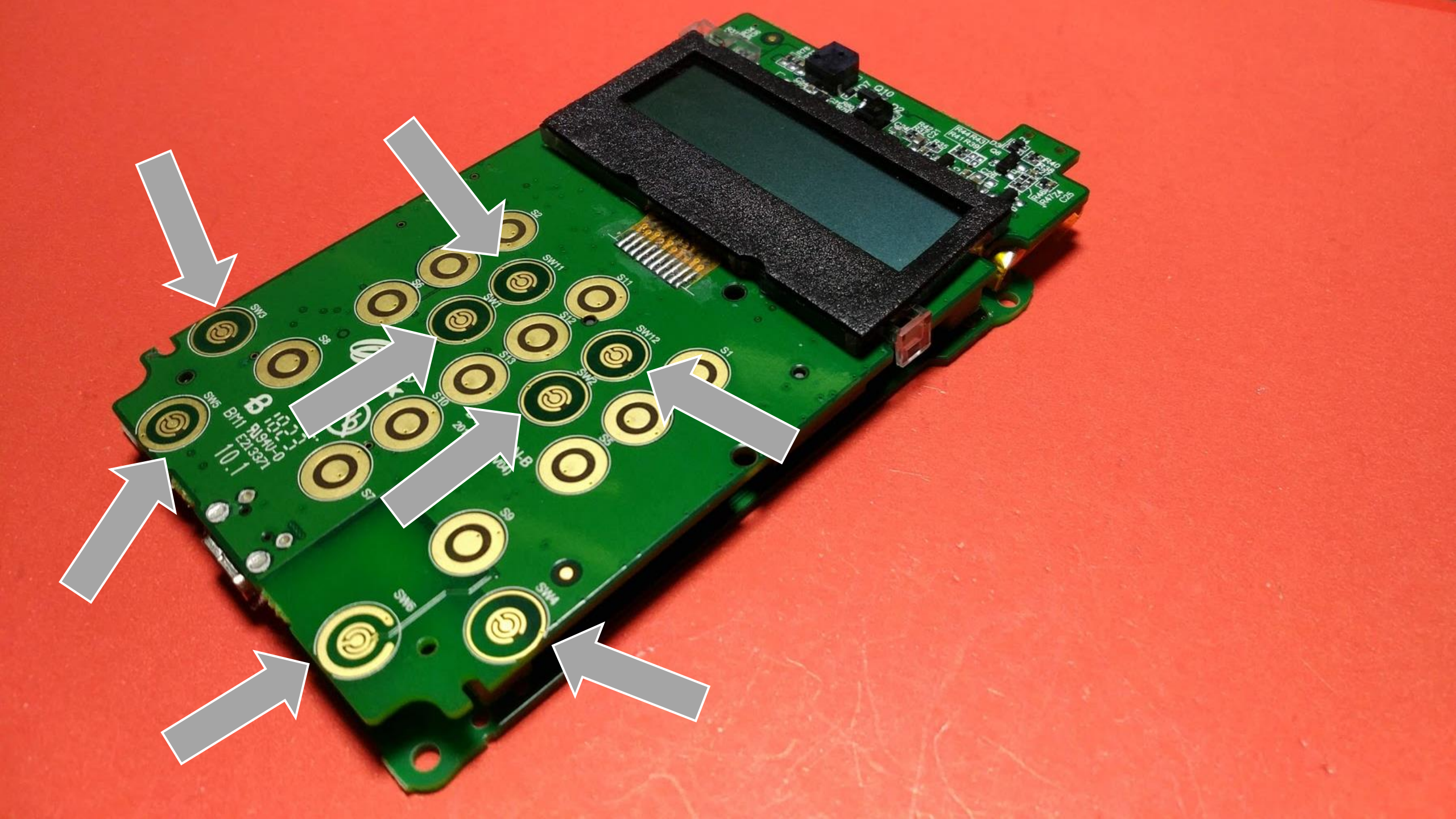
Algumas Máquinas Utilizadas [redacted]

Mecanismos Anti-Tamper

Anti-tamper ou tamper-resistant é um software e/ou hardware que dificulta a modificação por parte do atacante.




J17 J20 J18
D150-IFM-HW V10
D180-PCBWALL3-B 2013-08-01 (V1.2)
BM2 E213371
94V-0
BAT1

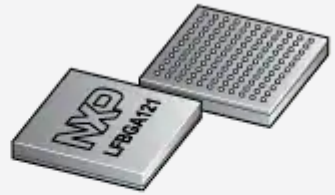

SW3
SW11
SW1
SW12
SW2
SW5
SW6
SW4
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
BM1
94V-0
E21337
10.1

MK21DN512VMC5 (End of Life)

Kinetis K21: 50MHz Cortex-M4 MCU, 512KB Flash, 64KB SRAM, Full-Speed USB, Anti-tamper, 121-MAPBGA

Data Sheet | Product Summary

Software & Tools | Documentation



Package:
LFBGA121
LFBGA121, plastic, low profile fine-pitch ball grid array; 121 bumps; 0.65 mm pitch; 8 mm x 8 mm x 1.3 mm body

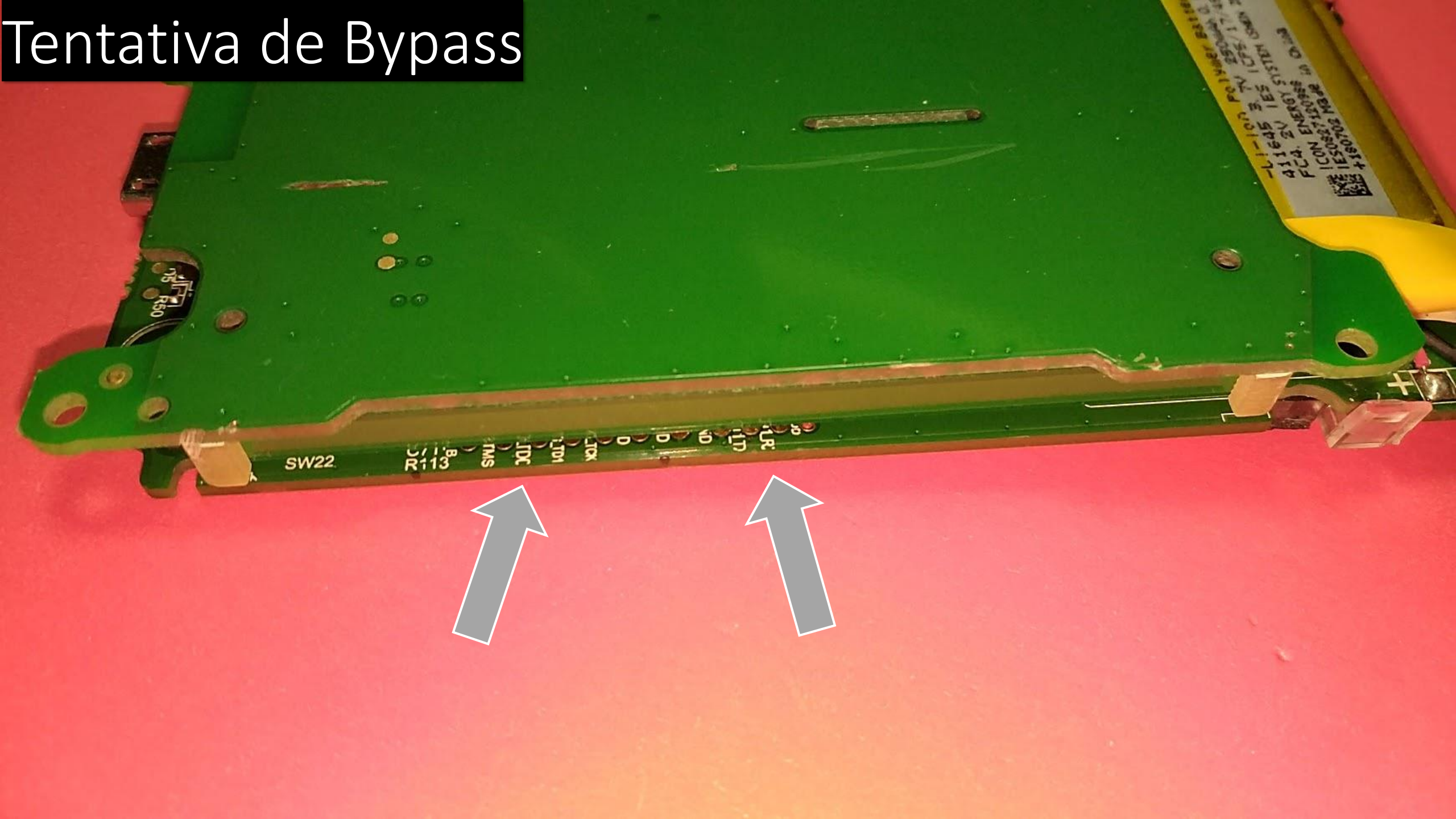
Operating Characteristics

Parameter	Value
Core Type	Arm Cortex-M4
Operating Frequency [Max (MHz)]	50
SRAM (kB)	64
Flash (kB)	512
GPIO	64

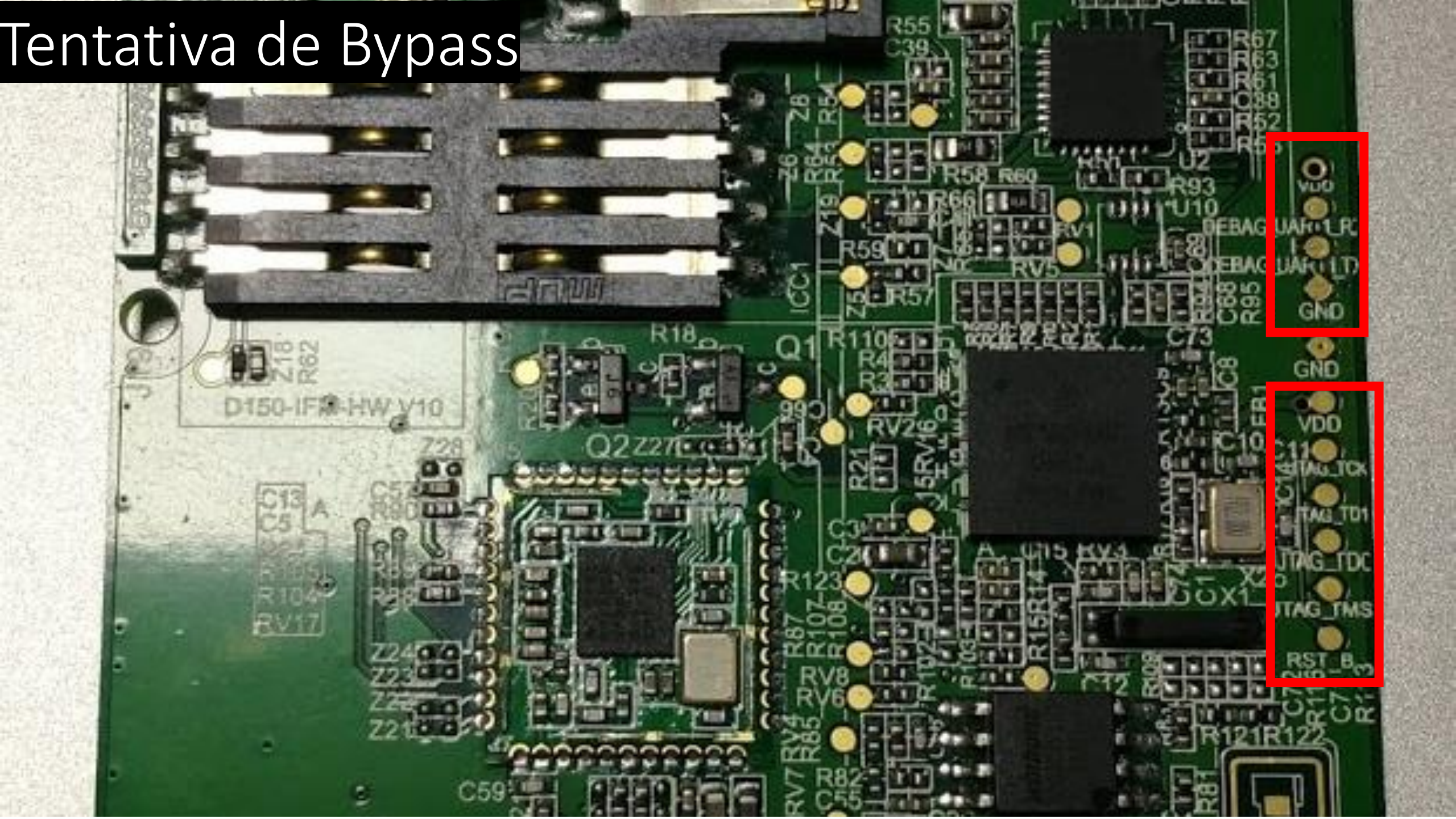
Parameter	Value
Security	CRC
Supply voltage [min] (V)	1.71
Supply voltage [max] (V)	3.6
Ambient Operating Temperature (Min to Max) (°C)	-40 to 105

- Memories and memory interfaces
  - Up to 512 KB of program flash for devices without FlexNVM.
  - Up to 256 KB program flash for devices with FlexNVM.
  - 64 KB FlexNVM on FlexMemory devices
  - 4 KB FlexRAM on FlexMemory devices
  - Up to 64 KB RAM
  - Serial programming interface (EzPort)
- Security and integrity modules
  - Hardware CRC module to support fast cyclic redundancy checks
  - Tamper detect and secure storage
  - Hardware random-number generator
  - Hardware encryption supporting DES, 3DES, AES, MD5, SHA-1, and SHA-256 algorithms
  - 128-bit unique identification (ID) number per chip
- Communication interfaces
  - USB full-/low-speed On-the-Go controller with on-chip transceiver
  - USB Device Charger detect
  - Two SPI modules
  - Two I2C modules
  - Four UART modules
  - I2S module

Tentativa de Bypass



Tentativa de Bypass

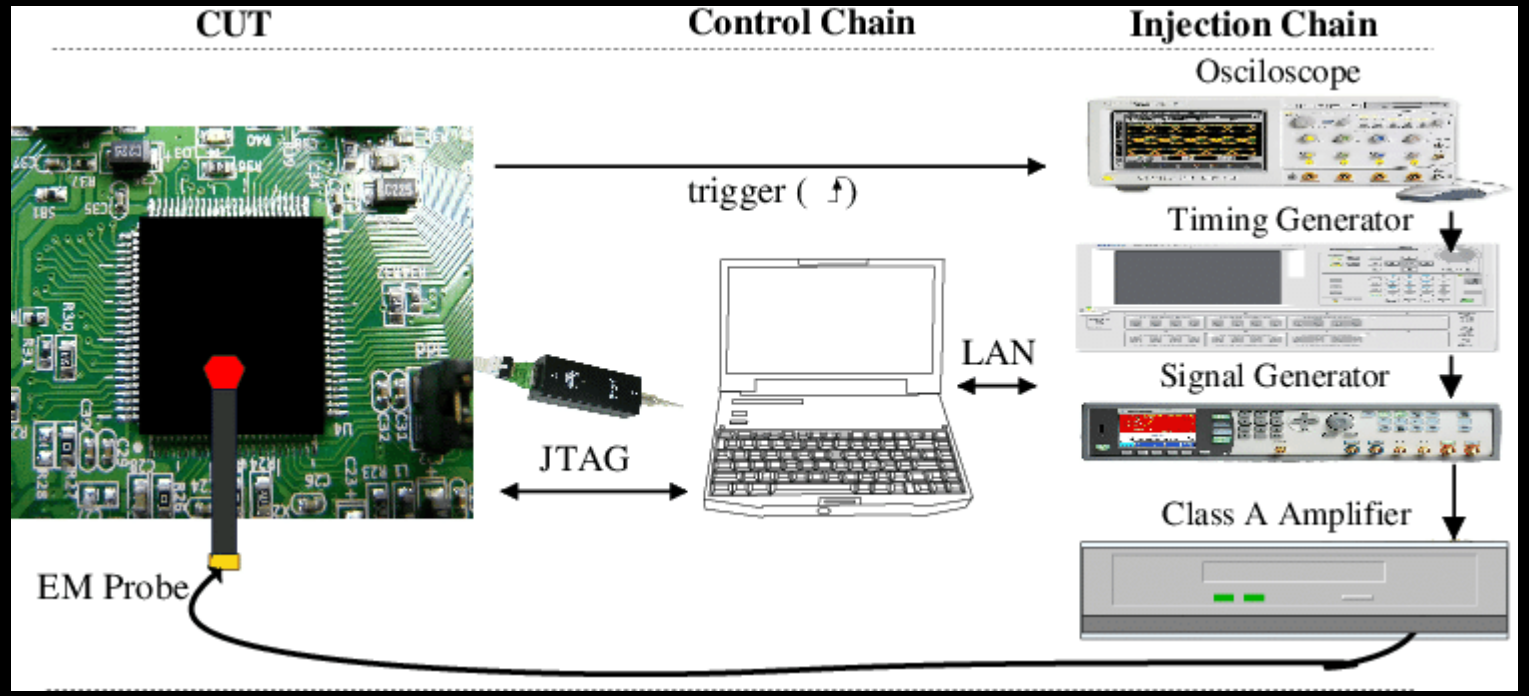


Tentativa de Bypass

Tentativa de Bypass

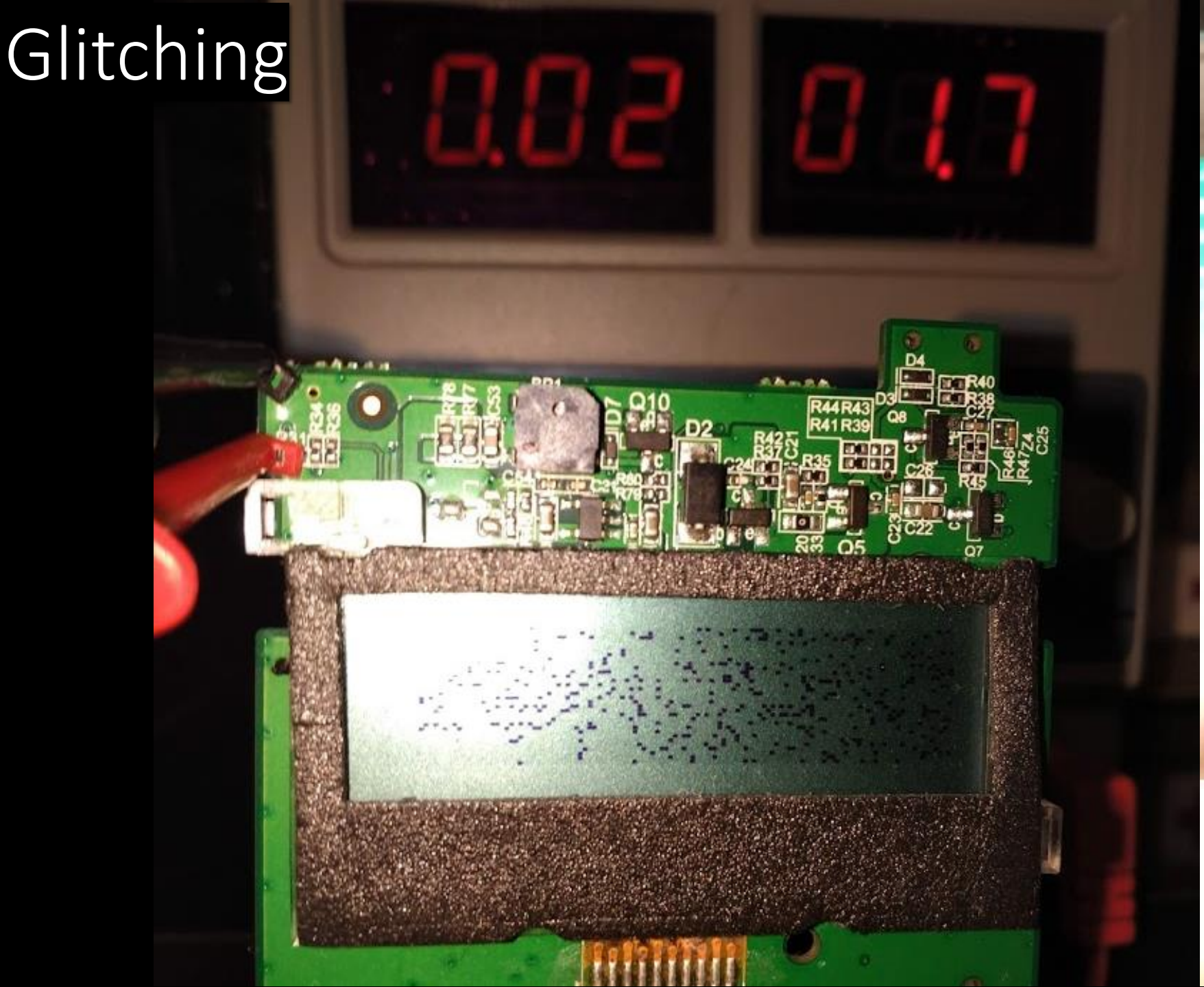
Insucessos no Caminho

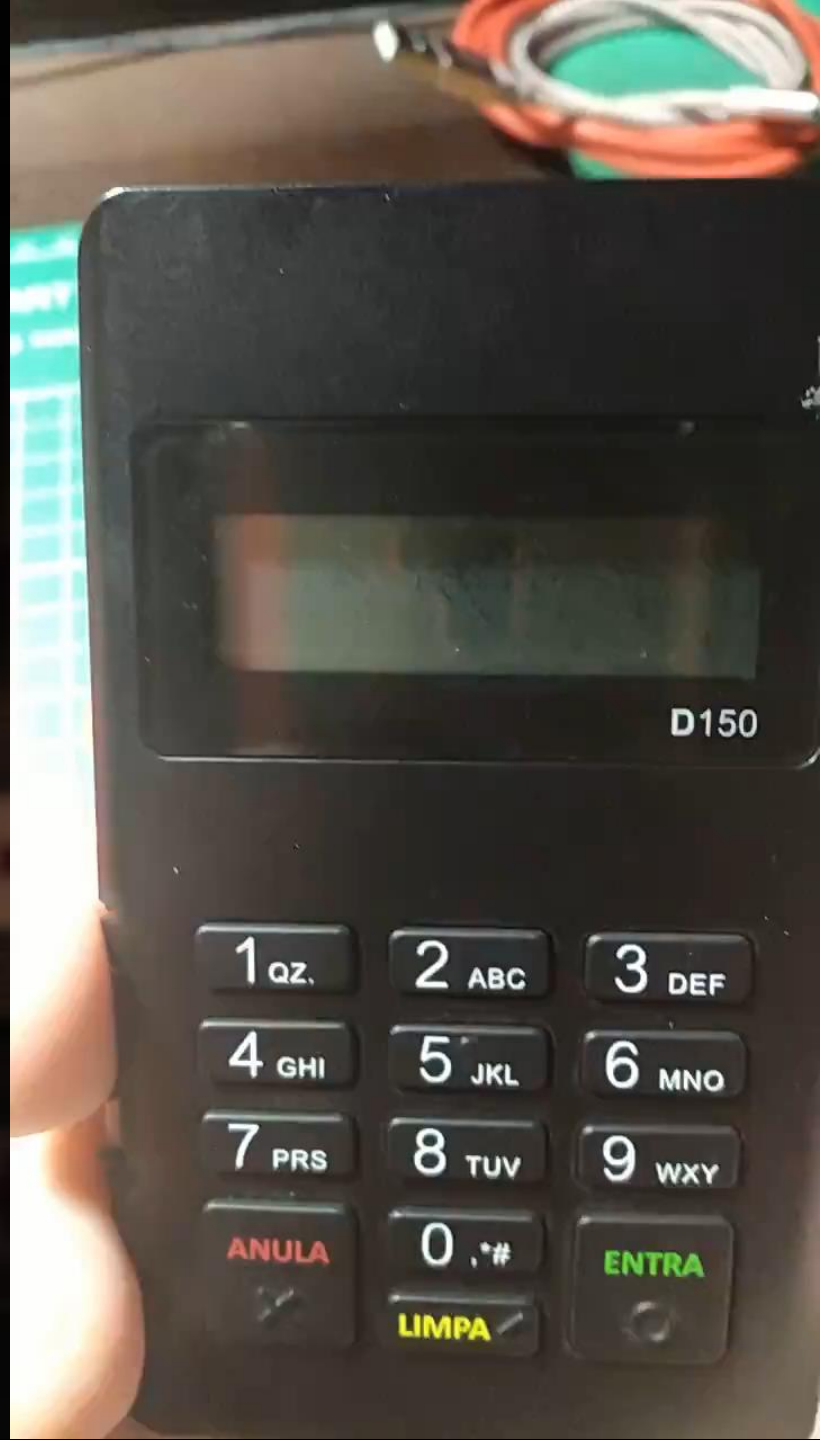
Glitching



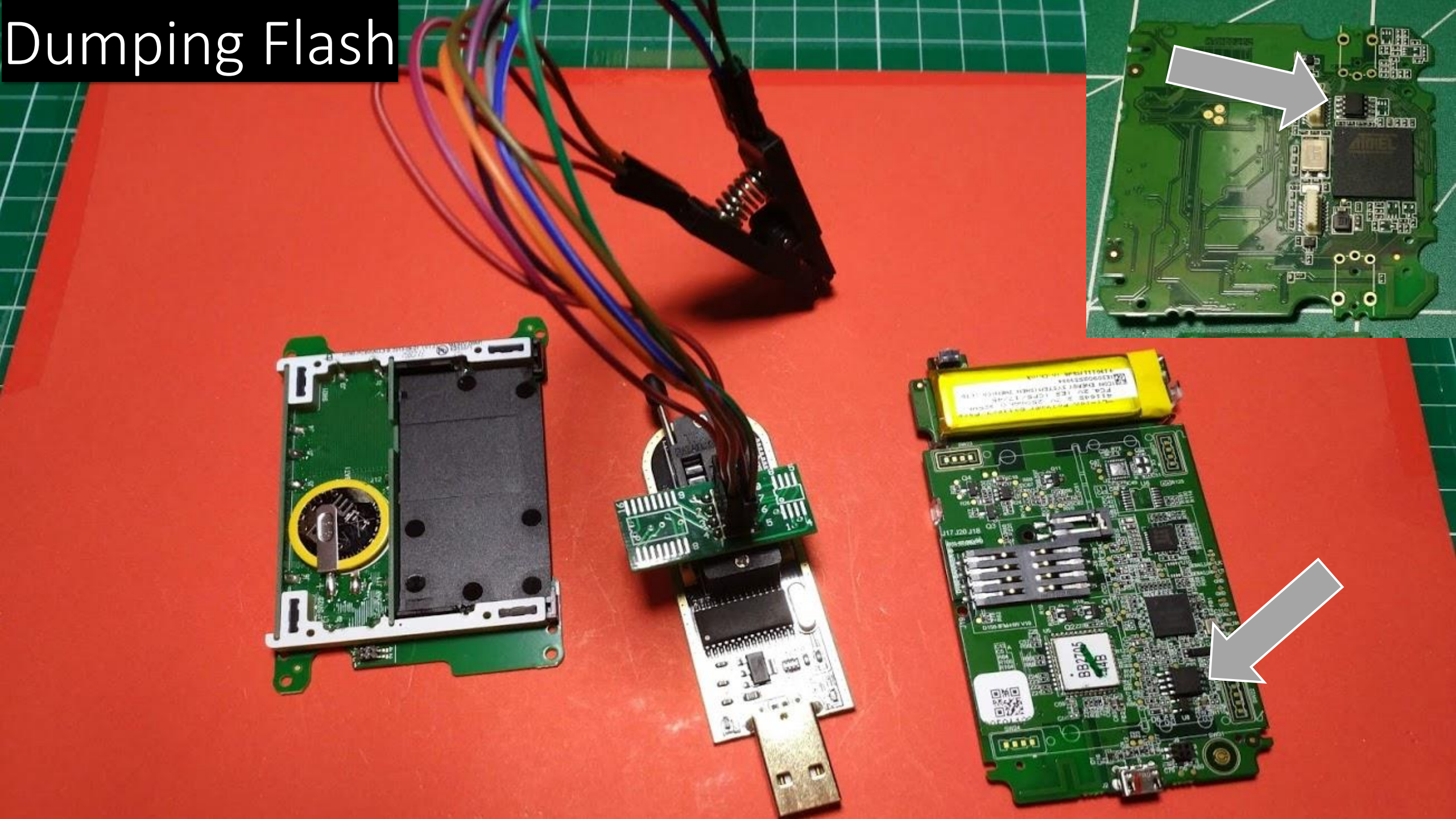
https://www.researchgate.net/publication/275582530_High_Precision_Fault_Injections_on_the_Instruction_Cache_of_ARMv7-M_Architectures

Glitching

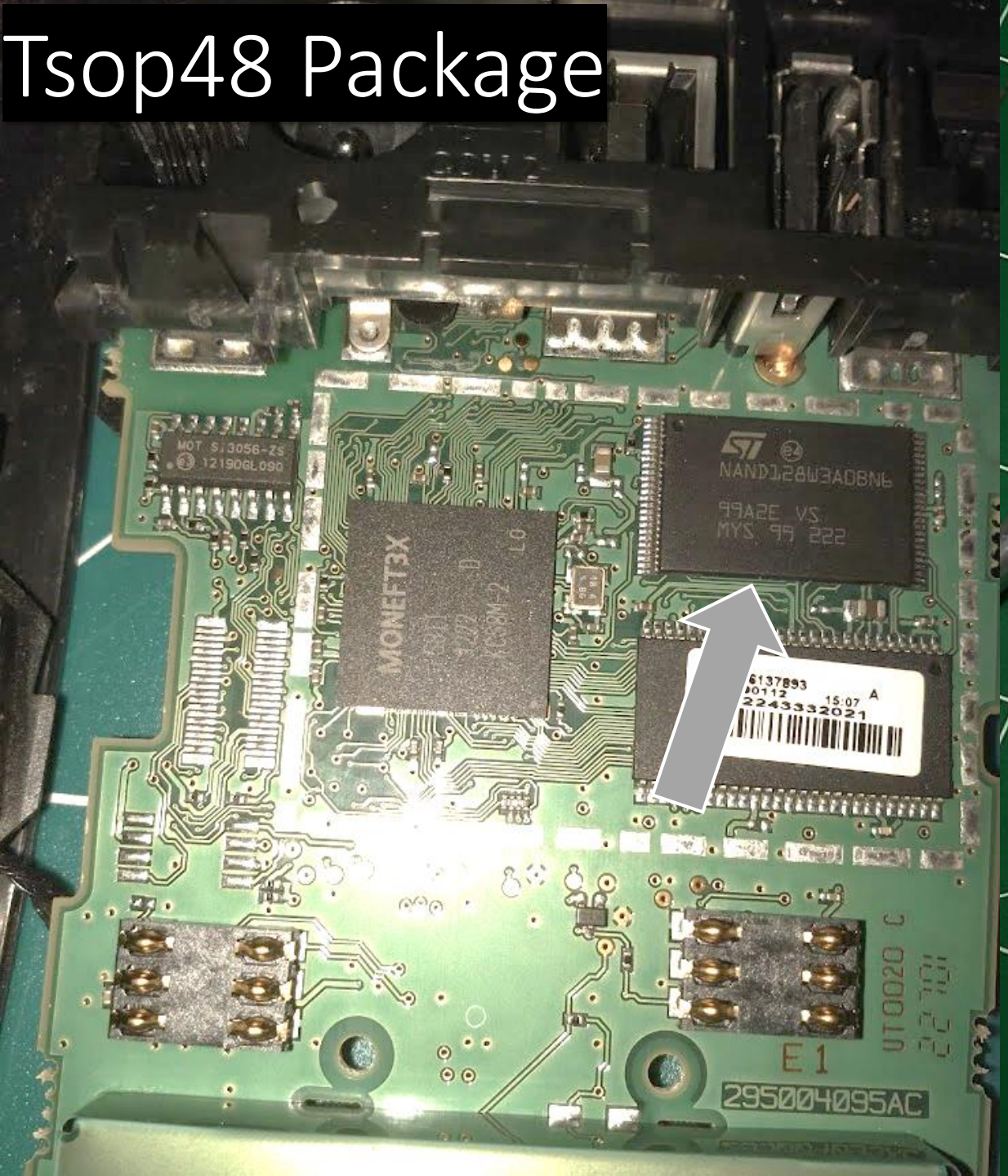

0.02
01.7


D150
1 QZ.
2 ABC
3 DEF
4 GHI
5 JKL
6 MNO
7 PRS
8 TUV
9 WXY
ANULA
0 .*#
ENTRA
LIMPA

Dumping Flash



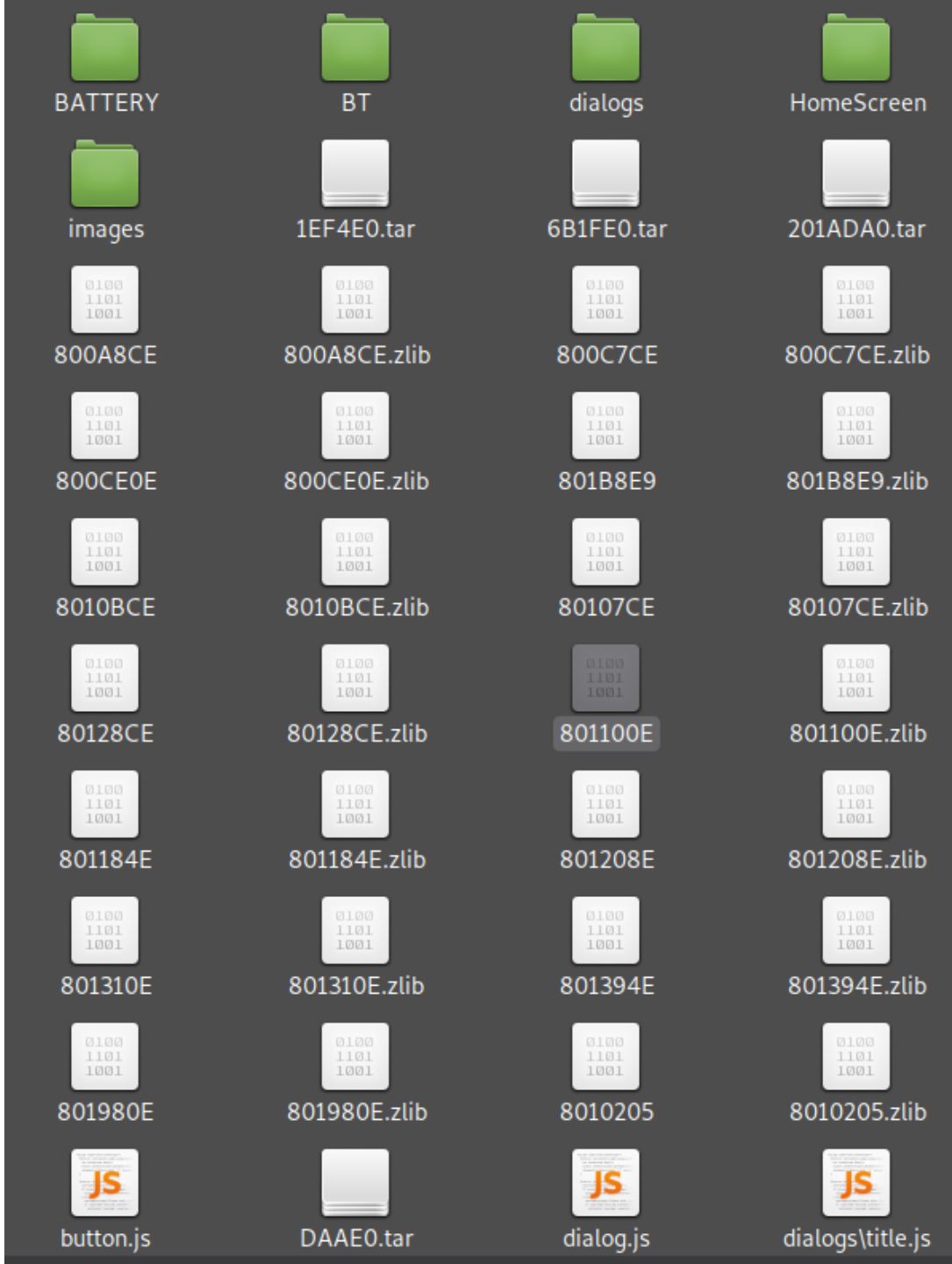
Tsop48 Package



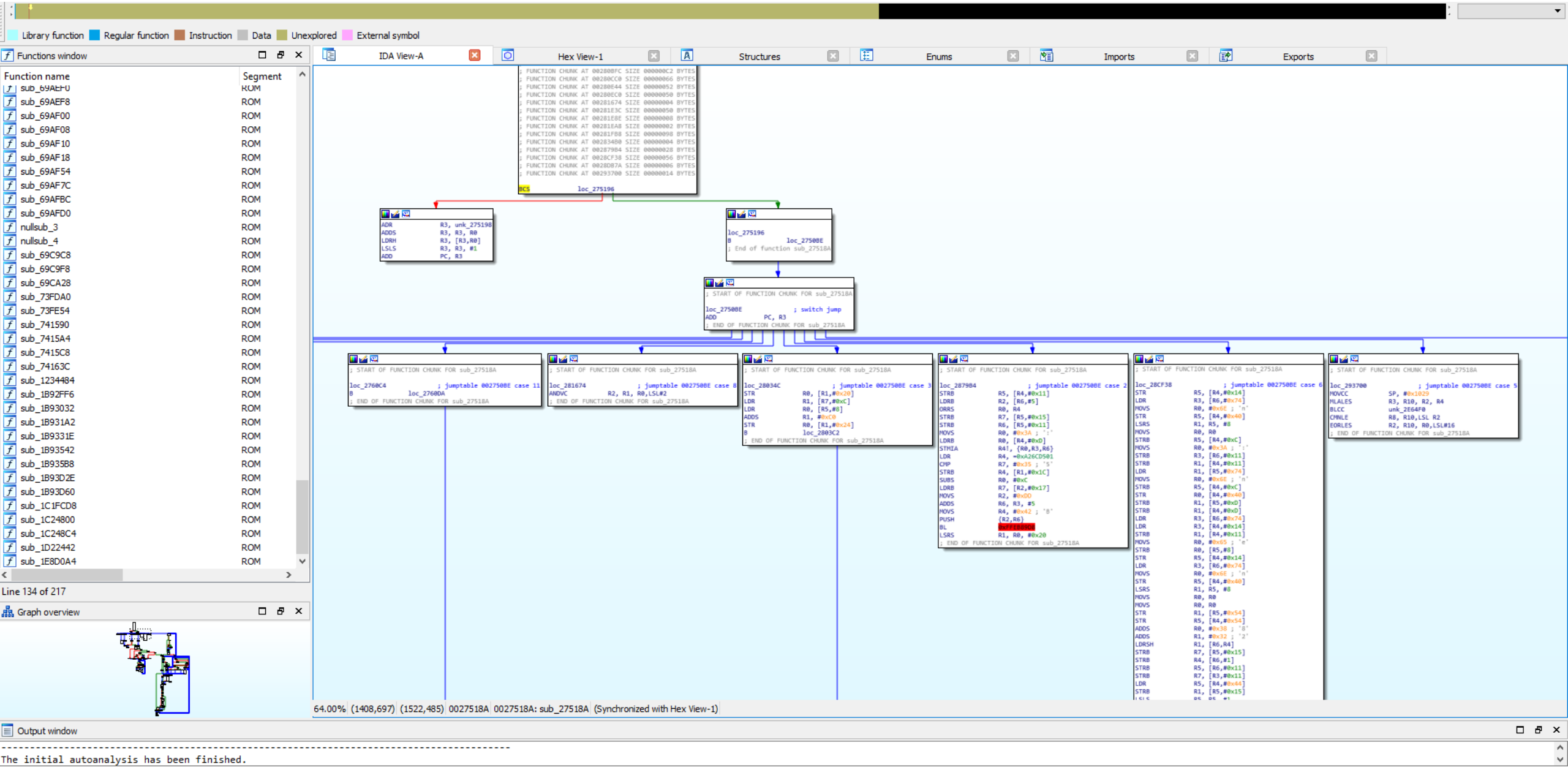
Analisando Dumps (POS 1)

```
root@kali:~/Desktop/DUMPS DE FLASH# binwalk -e ingenicoIWL280.BIN

DECIMAL       HEXADECIMAL     DESCRIPTION
--------------------------------------------------------------------------------
895712        0xDAAE0         POSIX tar archive (GNU), owner user name: "SECTEUR.wgu"
2028768       0x1EF4E0        POSIX tar archive (GNU), owner user name: "alidation.wgu"
4700576       0x47B9A0        CRC32 polynomial table, little endian
4701679       0x47BDEF        Copyright string: "Copyright 1995-2010 Jean-loup Gailly and Mark Adler "
4707091       0x47D313        Copyright string: "Copyright 1995-2010 Mark Adler "
5054234       0x4D1F1A        GIF image data, version "89a", 18176 x 17993
5054241       0x4D1F21        GIF image data, version "87a", 19968 x 21573
5090556       0x4DACFC        Copyright string: "Copyright (c) 1998-2010 Glenn Randers-Pehrson"
5090602       0x4DAD2A        Copyright string: "Copyright (c) 1996-1997 Andreas Dilger"
5090641       0x4DAD51        Copyright string: "Copyright (c) 1995-1996 Guy Eric Schalnat, Group 42, Inc."
5710712       0x572378        TROC filesystem, 537463119 file entries
5710739       0x572393        TROC filesystem, 622869071 file entries
5722996       0x575374        XML document, version: "1.0"
6656232       0x6590E8        SHA256 hash constants, little endian
7020512       0x6B1FE0        POSIX tar archive, owner user name: "s"
28840740      0x1B81324       SHA256 hash constants, little endian
30431540      0x1D05934       JPEG image data, JFIF standard 1.01
30482877      0x1D121BD       MySQL ISAM compressed data file Version 6
30482973      0x1D1221D       MySQL ISAM compressed data file Version 6
30483024      0x1D12250       MySQL ISAM compressed data file Version 6
30483072      0x1D12280       MySQL ISAM compressed data file Version 6
30483220      0x1D12314       MySQL ISAM compressed data file Version 6
30483549      0x1D1245D       MySQL ISAM compressed data file Version 6
30483651      0x1D124C3       MySQL ISAM compressed data file Version 6
30483756      0x1D1252C       MySQL ISAM compressed data file Version 6
30484130      0x1D126A2       MySQL ISAM compressed data file Version 6
30543164      0x1D20D3C       Copyright string: "Copyright 1998-2006 NexGen Software."
30561422      0x1D2548E       Copyright string: "Copyright (c) 1993-2001 ATI - Nucleus PLUS - Version ATMEL40807,
30627236      0x1D355A4       SHA256 hash constants, little endian
31806104      0x1E55298       JPEG image data, JFIF standard 1.01
31844297      0x1E5E7C9       JPEG image data, JFIF standard 1.01
31868485      0x1E64645       JPEG image data, JFIF standard 1.01
32325447      0x1ED3F47       MySQL ISAM compressed data file Version 6
33664416      0x201ADA0       POSIX tar archive (GNU)
```



Analisando Dumps (POS 1)



Analisando Dumps (POS 1)

```
/HOST
[SSA]
; CARD_NUMBER: Card number used to sign the schemes. Value in Hexadecimal
CARD_NUMBER = 100020FF
; VAR_ID: VarId from the certificate used to sign the schemes. Value in Hexadecimal
VAR_ID = 013F
; PIN_KEY_LOCATION: 0-Terminal 1-PINPad
PIN_KEY_LOCATION  = 0
; KEYBOARD_CHECK: Check if keyboard is open on PIN entry (0-Off 1-On)
KEYBOARD_CHECK = 0
; DES_3DES_PIN_SECRET_AREA_ID: MK/SK PIN secret area ID (for old applications only that do not use ssaCmd lib). Value in Hexadecimal
;DES_3DES_PIN_SECRET_AREA_ID =
; DES_3DES_DATA_SECRET_AREA_ID: MK/SK DATA secret area ID (for old applications only that do not use ssaCmd lib). Value in Hexadecimal
;DES_3DES_DATA_SECRET_AREA_ID =
; DUKPT_PIN_SECRET_AREA_ID: DUKPT PIN secret area ID (for old applications only that do not use ssaCmd lib). Value in Hexadecimal
;DUKPT_PIN_SECRET_AREA_ID =
; DUKPT_DATA_SECRET_AREA_ID: DUKPT DATA secret area ID (for old applications only that do not use ssaCmd lib). Value in Hexadecimal
;DUKPT_DATA_SECRET_AREA_ID =
; HIDE_MENU: HIDE SSA ON MANAGER MENU
HIDE_MENU = 0
; BOOSTER_CHECK_TIMER: Minimum time (* 10ms) between booster checks (default: 0 - always) | (-1: never)
BOOSTER_CHECK_TIMER = 200
SSA.INI
3[CONF_OPT01 = 01]
[CONF_OPT02 = 02]
GETNET
PARAM
/GETNET
GIF89a
   000@@@PPP```ppp
+#h^<
```

Analisando Dumps (POS 1)

```
14/03/19 16:53:34 UDP_SND: 10.248.63.219 0
14/03/19 22:36:44 TCP_CON: 201.87.163.104 29000
15/03/19 05:04:22 TCP_CON: 201.87.163.104 29000
15/03/19 14:24:39 TCP_CON: 201.87.163.100 27000
15/03/19 14:24:40 UDP_SND: 10.251.64.37 0
15/03/19 14:25:32 TCP_CON: 201.87.163.100 27000
15/03/19 14:25:34 UDP_SND: 10.251.64.37 0
15/03/19 15:13:23 TCP_CON: 201.87.163.104 29000
15/03/19 15:13:44 TCP_CON: 201.87.163.104 29000
15/03/19 20:57:14 TCP_CON: 201.87.163.104 29000
16/03/19 06:14:17 TCP_CON: 201.87.163.104 29000
16/03/19 15:01:16 TCP_CON: 201.87.163.104 29000
16/03/19 22:21:02 TCP_CON: 201.87.163.104 29000
17/03/19 07:25:03 TCP_CON: 201.87.163.104 29000
17/03/19 09:13:54 TCP_CON: 201.87.163.104 29000
17/03/19 23:10:43 TCP_CON: 201.87.163.104 29000
18/03/19 07:44:40 TCP_CON: 201.87.163.104 29000
18/03/19 08:05:19 TCP_CON: 201.87.163.100 27000
18/03/19 15:40:12 TCP_CON: 201.87.163.104 29000
18/03/19 22:55:56 TCP_CON: 201.87.163.104 29000
19/03/19 01:11:51 TCP_CON: 201.87.163.104 29000
19/03/19 15:40:45 TCP_CON: 201.87.163.104 29000
19/03/19 23:45:37 TCP_CON: 201.87.163.104 29000
20/03/19 02:24:38 TCP_CON: 201.87.163.104 29000
20/03/19 09:12:18 TCP_CON: 201.87.163.104 29000
20/03/19 21:35:58 TCP_CON: 201.87.163.104 29000
21/03/19 01:18:11 TCP_CON: 201.87.163.104 29000
21/03/19 10:41:16 TCP_CON: 201.87.163.104 29000
21/03/19 22:58:00 TCP_CON: 201.87.163.104 29000
22/03/19 06:17:45 TCP_CON: 201.u\
 UDP_RCV 0: 10.248.63.219 0
14/03/19 16:53:29 UDP_RCV 0: 10.248.63.219 0
```

```
/GETLAC
; Configura
o inicial da Aplica
o GetNet LAC
CONF_FONE = 08007221141
CONF_NII = 501
CONF_FONE_TC = 08006423133
CONF_GRPS_PIN = 1010
CONF_GPRS_IP = 201.087.163.100:27000
CONF_GPRS_IPTC = 201.007.198.017:06000
CONF_NII_CRYPTO = 511
CONF_RNPC_HOST = 13082009
CONF_RNPC_CRYPTO = 77774444
CONF_RNPC_NIU = 90143352
CONF_RNPC_SENHA = AAGGLL
CONF_OPT01 = 01
CONF_OPT02 = 02
CONF_NOME = 1;BANDEIRAS
CONF_NOME = 5;
CONF_NII_INIT = 502;
CONF_NII_INIT_RECARGA = 502;
CONF_NII_INIT_RECARGA_DISCADO = 503;
; Identifica
o da operadora pelo IMSI -> IMSI;Operadora
CONF_OPERS = 72402;03
CONF_OPERS = 72403;03
CONF_OPERS = 72404;03
CONF_OPERS = 72405;02
CONF_OPERS = 72406;01
CONF_OPERS = 72408;03
CONF_OPERS = 72410;01
CONF_OPERS = 72411;01
CONF_OPERS = 72415;04
CONF_OPERS = 72416;04
CONF_OPERS = 72423;01
CONF_OPERS = 72431;04
CONF_CSD_NII = 109
CONF_CSD_FONE = 08006484002
CONF_CSD_MODULACAO = 7
CONF_CSD_TO = 60
CONF_CSD_FLAG = 0
GETLAC
CONFLAC.INI
```

Analisando Dumps (POS 1)

```
*0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz-._$
exit        Return to main menu
help        Display this menu again
list        Disk & files info
open [name] Open a file
read        Read opened file
link [adr]  Display Flash linked blocks
dump [adr]  Dump Flash block
map         display flash mapping
free
      display free blocks table
obj         display object link table
bad         display bad blocks table
mp          mapping page
mo [Ident]  mapping object ident
blockdump [adr] [nb blocks] Dump blocks
linktable [Ident]  display link table
mt [typ]    mapping page type
diag        display Flash diag.
ver         Verify
Erase [adr] Erase Flash block
EraseAll    Erase All Flash block
Move  [adr] Move block
SetBad [adr] Move block and set bad
Write [adr] Write a 0 page
Erasable [adr] Set erasable page
rm [name]   erase file
ren [old] [new]  rename file
garb        Garbage
de          Dump Erased
data        FM datas
hf          Header File
nf          Find not free
diskcopy    copy files to host
NandId      Read nand id Area
scan        Scan Nand flash
Erase
EraseAll
SetBad
Write
linktable
Erasable
NandId
test2
```

```
          MMC Menu
exit          Return to main menu
help          Display this menu again
bread         Bloc read [adr]
bwrite        Bloc write [adr]
bm            Bloc modify [off] [data]
download      Download MMC
upload        Upload MMC
BlocErase     Erase bloc [adr]
bread
bwrite
upload
download
BlocErase
******* I2C menu  *****
exit           Return to main menu
help           Display this menu again
*** Configuration
*** > max9850 (iSC350): channel 1, 0x11
*** > usb2513 (iSC350): channel 0, 0x2c (smbus)
*** > mma7660fc (iWL2x0) : channel 0, 0x4c
*** > nau8401 (iWL250) :  channel 0, 0x1a (reg*2)
*** > nau8401 (iWL280) :  channel 1, 0x1a (reg*2)
open   [bus]   I2C_Open call
select [bus]   Select bus (0:default)
set    [addr]  Set slave address (in hexa) [A7..A1]
*** Operation on current bus
reset           Send a bus recovery sequence
rd1             Read 1 byte (sync)
rd    [n]       Read N bytes (async)
read1 [reg]     Read 1 byte (sync), reg is 1 (hex) byte
readN [reg] [n] Read N byte (sync), reg is 1 (hex) byte
read  [reg] [n] Read N bytes (async), reg is 1 (hex) byte
I2C >
reset
select
read1
readN
```

Analisando Dumps (POS 1)

```
BL2 Version  : 0x%08X
Bit Ruf2 : 0x%08X
Activated State  : 0x%08X  DMMC Flag : 0x%08X
   Tampering Detectors 6----[0x%04X]  (Switch)
   Tampering Detectors 5----[0x%04X]  (Membrane 2)
   Tampering Detectors 4----[0x%04X]  (Upper Wire Mesh)
   Tampering Detectors 3----[0x%04X]  (Internal Wire Mesh)
   Tampering Detectors 2----[0x%04X]  (Membrane 1)
   Tampering Detectors 1----[0x%04X]  (Menbrane 0)
   Tampering Vdd Io High----[0x%04X]  Vdd Io Low-----[0x%04X]
   Tampering Vdd Core High--[0x%04X]  Vdd Core Low---[0x%04X]
   Tampering Vdd BU High----[0x%04X]  Vdd BU Low-----[0x%04X]
   Tampering Temp High------[0x%04X]  Temp Low-------[0x%04X]
   Tampering MCK -----------[0x%04X]
   Tampering ERA-----------[0x%04X]
   Tampering JTGTCK---------[0x%04X]  JTGSEL---------[0x%04X]
   Tampering TST-----------[0x%04X]
   Tampering DBF-----------[0x%04X]
   Tampering SHL-----------[0x%04X]
Out Of Order State : 0x%02X
exception_spsr : 0x%08X
   Secu_PIOBUi [7..4]/[3..0] :
37s$B""(
e*Ywww
062ydI
   Tab Key  :
```

Analisando Dumps (POS 1)

```
PrePPP
pUNIX L8
0pFTP server error %d while starting.
,pStart FTP Task
Stop FTP Task
FTP server error %d while stoping.
FTP server error %d while resuming.
jij`C
FTP server resuming.
FTP server error %d while suspending.
FTP server suspending.
0psizeof(NGftps)     = %d
sizeof(NGftpsctl)  = %d
sizeof(NGftpsf)    = %d
sizeof(NGftpsconn) = %d
pPPP-CB[cb_ppp_conn_f]: Link connected, local=%I, dest=%I
0pPPP LAYER::cb_ppp_conn_f:NU_Set_Events (%d)
THH0!
```

```
260528003515Z0
000028003325908 60
{gtHc
4http://ingetrustcrl.ingenico.com/terminal_v3_fit.crl
Ingenico1)0'
 IngeTrust V3 Terminal CRL Issuer0
NRbcK
V`Ab    9b
p+DX_
t       @DM
Ingenico1#0!
IngeTrust V3 Terminal Root0
150928140150Z
350928140150Z0$1
Ingenico1
FIT0490
?SYSTEM
INGETRUST.CFG
/SYSTEM
BjR9i
=l'=}
ITc|#-
j?3p?b
FBjT>
4http://ingetrustcrl.ingenico.com/terminal_v3_fit.crl
Ingenico1)0'
 IngeTrust V3 Terminal CRL Issuer0
```

Analisando Dumps (POS 1)

```
[Via Estabelecimento          V006T.918A]6
[     PRATA FORMULA FARMACIA DE MANI]:
[ AVENIDA PRESIDENTE VARGAS 1118 LOJA 03]"
[NOVA PRATA - RS]2
[03.543.842/0001-88 CV:000002461];
[07/03/19 13:33:48  AUT:101203 DOC:001978];
[EC:000000001156877 TERM:03545141       D];
[VISA CREDITO            ***********1104]+
[                        ].
[            CREDITO A VISTA]'
[VALOR:        72,00 ]
[        ----------------------]'
[                ],
[               ASSINATURA]
[Via Cliente                  V006T.918A]6
[     PRATA FORMULA FARMACIA DE MANI]:
[ AVENIDA PRESIDENTE VARGAS 1118 LOJA 03]"
[NOVA PRATA - RS],
[03.543.842/0001-88 CV:000002461];
[07/03/19 13:33:48  AUT:101203 DOC:001978];
[EC:000000001156877 TERM:03545141       D];
[VISA CREDITO            ***********1104]+
[                        ].
[            CREDITO A VISTA],
[VALOR:        72,00 ]
[COM_iSendMsg] Enviando [928 bytes antes do crypto]E
[TELM_MOD_GET][POS_iModemTxBlk] LL_Send (antes) - Tam[978]V
[TELM_MOD_GET][POS_iModemTxBlk] LL_Send (depois) - Retorno [978]c
[TELM_MOD_GET][POS_iModemRxBlk] LL_Receive (antes) - Tam Buffer [4096] TOUT [3000]^
[TELM_MOD_GET][POS_iModemRxBlk] LL_Receive (depois) - Tam recebido [194]@
[COM_Disconnect_Confirmacao] Desconectando)
[COM_Disconnect] Desconectando&
[GTN_Main][pszShowError][0]7
[COM_Disconnect] Desconectando&
[GTN_Main][pszShowError][0]4
[POS_Main_GETNET] POSEVENT_KEYC
[GTN_COM] COM_iStartConnection PreDiscagem[0]I
[GTN_HW][GTNHW_fVerificaComunicacaoGerenciador] TAG DF56T
[GTN_HW][GTNHW_fVerificaComunicacaoGerenciador] iLen = [296] st size[148];
[GTN_HW][Debug_st_info_chip_CLOG] iStructVer [1]L
[GTN_HW][Debug_st_info_chip_CLOG] szAPN      [GETNET.VIVO.COM.BR]@
[GTN_HW][Debug_st_info_chip_CLOG] szUsrPPP   [GETNET]F
```

Analisando Dumps (POS 1)

Analisando Dumps (POS 2)

```
  %16.16s
Nivel de debug:
0 - Desativado
1 - Minimo
2 - Completo
Atual: %d
```

```
0\*, #:;+-=?$&%!~@^()|/_[]{}<>`'"
ANT_BOARD
syspassword
18C,140508
B c0
s2R"
b$C4
```

```
Wireless iAP
BCM20702B0 Generic UART Detuned Class 1 @ 20 MHz
BZ3C_
$0`g
```

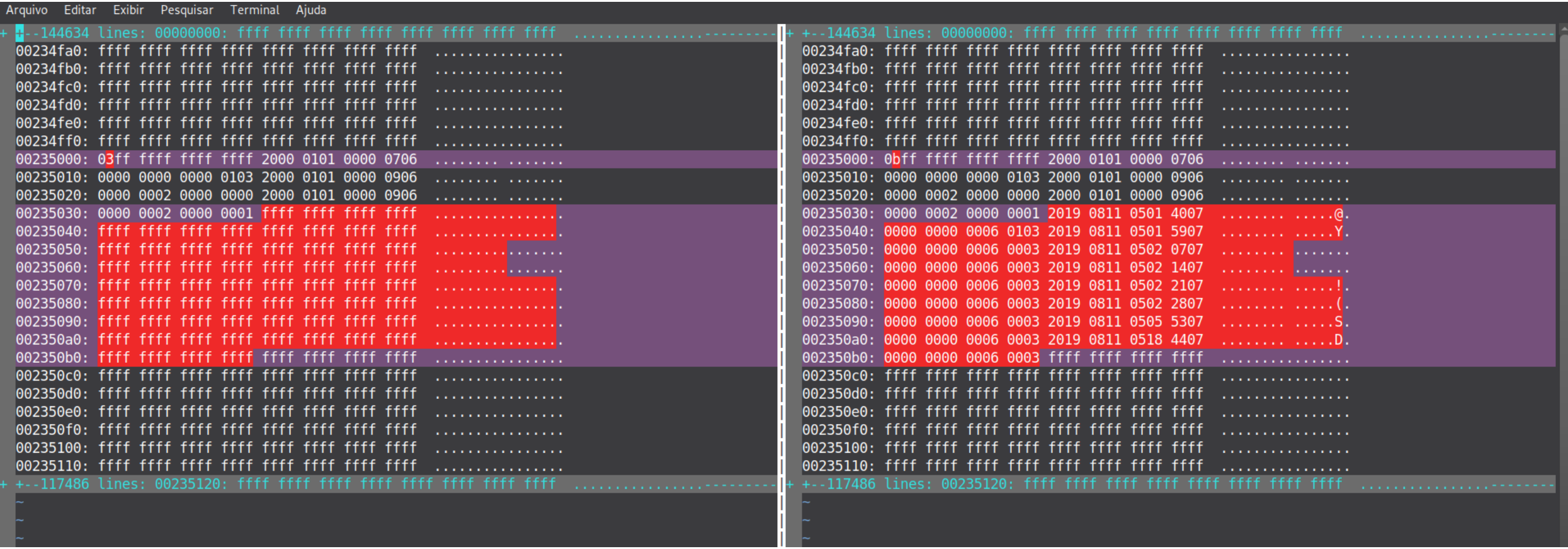
```
TFT_H24C117-00N
DUAL_SIM
TRUE
SL811HS
SD_READER
NULL
BLUE_TOOTH
WT12
BM57SPP
BM77SPP
NULL
BAR_CODE
MOTOROLA-SE955
MOTOROLA-SE655
WIFI_NET
CO2128
SIM4100D
WCDMA
EM701
MU509
GPRS
Q24C
Q24E
Q2687RD
GSM0306-70
BGS2
MG323-B
G620-A50
G610
CDMA
EM200
Q26Elite
MC509
MODEM
CX93011
ZA9L0
Si2457D
ETHERNET
DM9000
BCM5892
ON-CHIP
G_SENSOR
```

```
    WARNING!
ACCESS EXCEPTION
0x%08X
 %d:%d
TAMPER STATUS:%06X
Tamper Pin0
Tamper Pin1
Tamper Pin2
Temperature Tamper
Voltage Tamper
Clock Tamper
Test Mode Tamper
Security Tamper
Monotonic Overflow
Time Overflow Tamper
Tamper Acknowledge
DryIce Tamper
POS BE ATTACKED
ALL KEYS ARE CLEARED!
CLEAR ATTACK FAIL!
     REBOOT
```

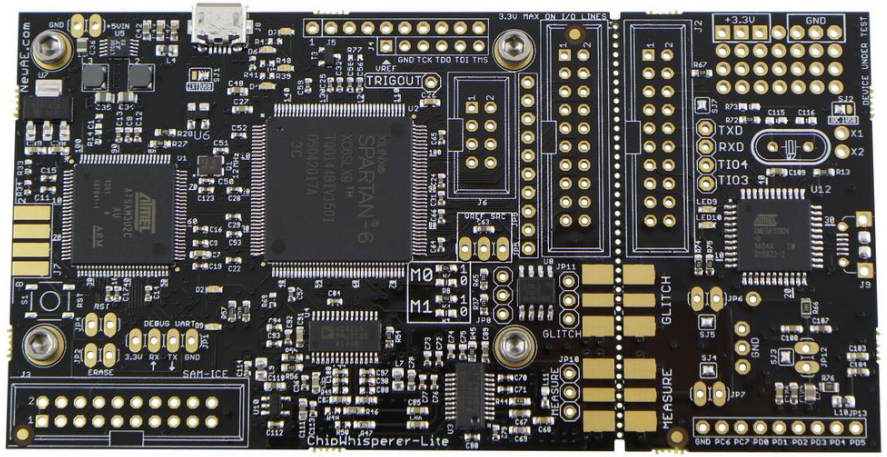
Analisando Dumps (POS 2)

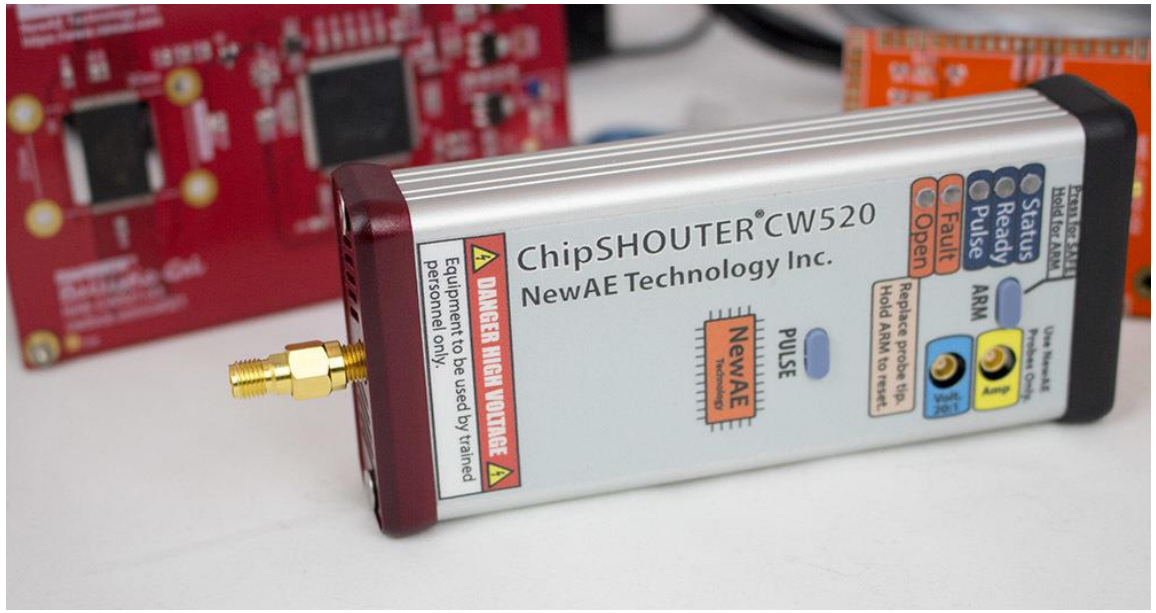
```
PAX-7F202701
353957
123456
000000
PAX-7F202701
350702
123456
000000
PAX-7F202701
I129M9
123456
000000
PAX-7F202701
687748
123456
000000
PAX-7F202701
5LA4EN
123456
000000
PAX-7F202701
DWLDTR
123456
000000
PAX-7F202701
463459
123456
000000
PAX-7F202701
463459
123456
133713
PAX-7F202701
463459
123456
133713
PAX-7F202701
N628IJ
123456
133713
PAX-7F202701
816962
123456
GCR0840800000000000100190810074644000600000211080108030804080708090811081308140815081608170
```

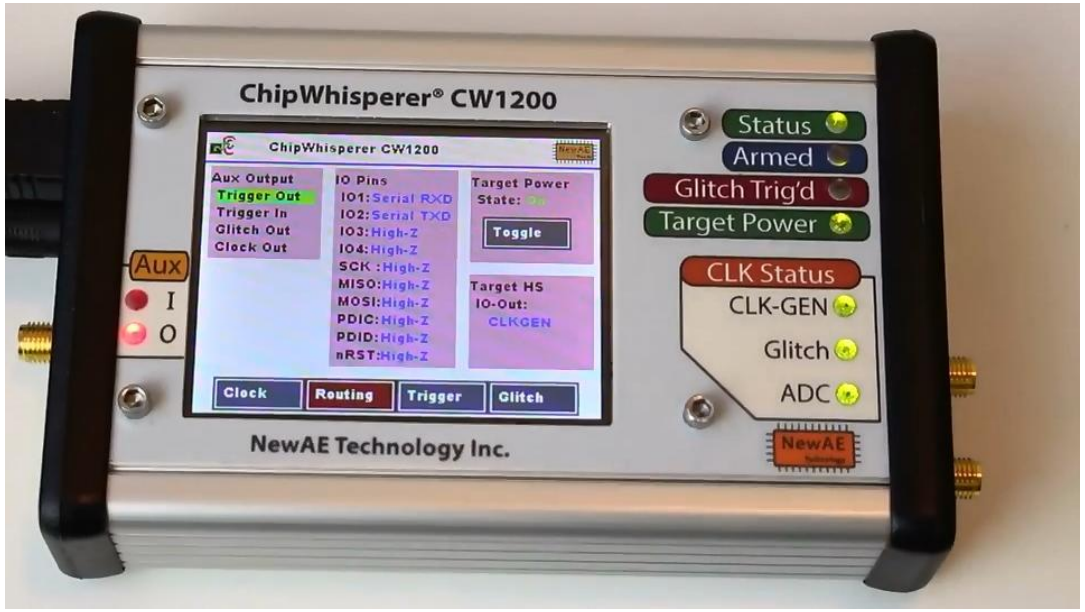
Analisando Dumps (POS 2)



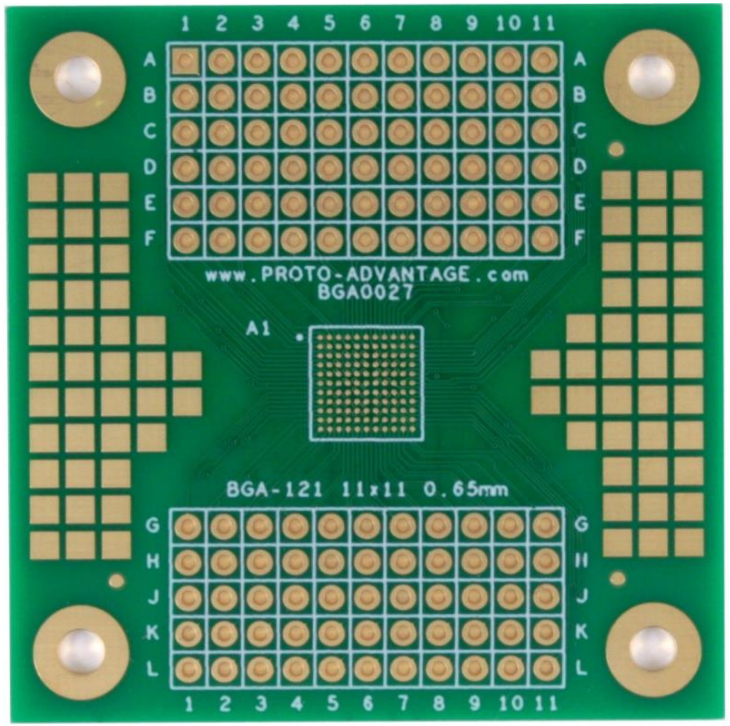
Pesquisas Futuras







Pesquisas Futuras



	1	2	3	4	5	6	7	8	9	10	11	
A	PTD7	PTD5	PTD4/ LLWU_P14	NC	NC	PTC13	PTC8	PTC4/ LLWU_P8	NC	PTE19	PTE18	A
B	NC	PTD6/ LLWU_P15	PTD3	NC	NC	PTC12	PTC7	PTC3/ LLWU_P7	PTC0	PTB16	PTB12	B
C	NC	NC	PTD2/ LLWU_P13	PTC17	PTC11/ LLWU_P11	PTC10	PTC6/ LLWU_P10	PTC2	PTB19	PTB11	PTB13	C
D	NC	NC	PTD1	PTD0/ LLWU_P12	PTC16	PTC9	PTC5/ LLWU_P9	PTC1/ LLWU_P6	PTB18	PTB10	NC	D
E	NC	PTE2/ LLWU_P1	PTE1/ LLWU_P0	PTE0	VDD	VDD	NC	NC	PTB17	NC	NC	E
F	USB0_DP	USB0_DM	NC	PTE3	VDDA	VSSA	NC	NC	NC	NC	NC	F
G	VOUT33	VREGIN	VSS	PTE5	VREFH	VREFL	VSS	PTB3	PTB2	PTB1	PTB0/ LLWU_P5	G
H	NC	NC	NC	PTE17	TAMPER1	NC	PTE4/ LLWU_P2	PTA1	PTA3	PTA17	NC	H
J	NC	NC	NC	NC	TAMPER2	PTA0	PTA2	PTA4/ LLWU_P3	NC	PTA16	RESET_b	J
K	ADC0_DP0	ADC0_DM0	PTE16	NC	DAC0_OUT/ CMP1_IN3/ ADC0_SE23	VBAT	PTA5	PTA12	PTA14	VSS	PTA19	K
L	ADC0_DP3	ADC0_DM3	VREF_OUT/ CMP1_IN5/ CMP0_IN5	XTAL32	EXTAL32	VSS	TAMPER0/ RTC_ WAKEUP_B	PTA13/ LLWU_P4	PTA15	VDD	PTA18	L
	1	2	3	4	5	6	7	8	9	10	11	

Figure 24. K21 121 MAPBGA Pinout Diagram

Testar conexões:
Uart0
Uart1
Uart2
Jtag
EZP
SWO

J6	JTAG_TCLK/ SWD_CLK/ EZP_CLK		PTA0	UART0_CTS_b/ UART0_COL_b	FTM0_CH5				JTAG_TCLK/ SWD_CLK	EZP_CLK
H8	JTAG_TDI/ EZP_DI		PTA1	UART0_RX	FTM0_CH6				JTAG_TDI	EZP_DI
J7	JTAG_TDO/ TRACE_SWO/ EZP_DO		PTA2	UART0_TX	FTM0_CH7				JTAG_TDO/ TRACE_SWO	EZP_DO
H9	JTAG_TMS/ SWD_DIO		PTA3	UART0_RTS_b	FTM0_CH0				JTAG_TMS/ SWD_DIO	
J8	NMI_b/ EZP_CS_b		PTA4/ LLWU_P3		FTM0_CH1				NMI_b	EZP_CS_b
K7	DISABLED		PTA5	USB_CLKIN	FTM0_CH2			I2S0_TX_BCLK	JTAG_TRST_b	

https://www.nxp.com/docs/en/data-sheet/K21P121M50SF4.pdf

http://www.utasker.com/docs/uTasker/uTaskerEzPortCloner.pdf

Pesquisas Futuras

NXP, Placas de Desenvolvimento

Freedom FRDM-K64F

REF: DRE10

Novidade aqui em nossa loja virtual para você que estava procurando por placas da NXP. Esta placa de desenvolvimento Freedom-K64F possui um microcontrolador MK64FN1M0VLL12 com core ARM© Cortex®-M4 32-bit e ainda possui uma pinagem compatível com Arduino Uno R3. Agora ficou fácil comprar a sua placa NXP por um ótimo preço e envio para todo o Brasil.

LISTA DE DESEJOS

Disponibilidade: em estoque

R$449,90

6X DE R$74,98 S/ JUROS

QUANTIDADE

1

Comprar

2.1 Verifying that the EzPort is not Disabled

Some Kinetis parts allow the EzPort to be disabled in their flash configuration. In order to be able to control an EzPort slave the slave must not have enabled this protection, otherwise it will not be possible to work with its EzPort.

Devices that have been fully erased will not have the EzPort disabled.

Devices that have software running on them *may* have their EzPorts disabled.