HCS410 Evaluation Kit
User's Guide

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HCS410 Evaluation Kit User's Guide

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Chapter 1. Setup

Evaluation Kit Overview

The HCS410 Evaluation kit allows the user to program HCS410s and look at how the HCS410 is used in a system. The kit is made up of 4 principal items.

The software, the base station, a batteryless transponder and a battery powered transponder / RF transmitter.

The base station has the ability to program transponders inductively and act as a stand alone decoder. When in stand alone mode the base station can learn transponders and do inductive IFF validation.

The batteryless transponder is powered through the magnetic field provided by the base station.

The transponder / transmitter allows the user to combine the convenience of a RF transmitter with the security of a transponder. Typically the RF transmitter will be used as a convenience item unlocking the car as the user approaches the car. Once in the car a coil around the ignition electronically validates the key disarming the immobilizer. This is completely transparent to the user. Even if the battery in the key goes flat the HCS410 will still be able to get power from the field generated by the car's coil.

Software Installation

Place the software into a disk drive. From Program Manager choose File|Run

Type in a:install.exe

Follow the installation instructions from there on.

The first time you run the software please select the serial port you will be using for communicating to the base station from the Options|Serial port menu.

Hardware Setup

When the user wants to program either the base station or a transponder, the base station needs to be connected to a free serial port on the driving PC using the serial cable provided. After this the base station should be powered up using the 12V power supply provided in the evaluation kit.

When programming a transponder inductively make sure the transponder is in the field when hitting the program button.

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Chapter 2. Base Station

Base Station Overview

Warning: High Voltage

First and foremost. THERE ARE HIGH VOLTAGE AREAS on the base station board. The voltage on the coil can reach over 400 VPP and has a peak current of 1A. The high voltage areas on the board are marked clearly. Don't touch anything within those areas.

Warning: Strong Magnetic Field

The base stations generates a strong magnetic field. Avoid close proximity with devices influenced by magnetic fields, such as CRTs, pacemakers, computer disks, audio and video tapes, and magnetic strp cards.

Base station features:

- Inductive authentication of transponders
- Can receive and validate KEELOQ® code hopping transmissions
- Can learn up to 4 KEELOQ encoders
- Can be used to program HCS410 devices inductively or through the PWM / S2 lines

The base station has a number of push button inputs and LED outputs on it. These can be described as follows:

The **RESET push button** resets the base station

The **POLL push button** allows the user to force the base station to poll continuously for 2 seconds before switching off.

The **LEARN push button** places the base station in learn mode

The **LEARN LED** gives the user information about the status of a learn and general functioning of the base station. The Learn LED will flicker on briefly each time a transponder's serial number is read as the transponder is brought into the field. This indicates that the base station has detected a transponder in the field. If the transponder has been learned the base station will attempt to validate the transponder.

The **VALID TOKEN LED** is lit up for 500ms each time the base station successfully validates a learned transponder inductively.

The **S0, S1, S2, S3 and PROX_RF LEDs** are used to indicate that a valid RF transmission has been received from a transmitter and the LEDs are lit for 500ms depending on which buttons were pressed on the transmitter

The **FIELD LED** indicates when the base station is polling for a transponder and the field is on.

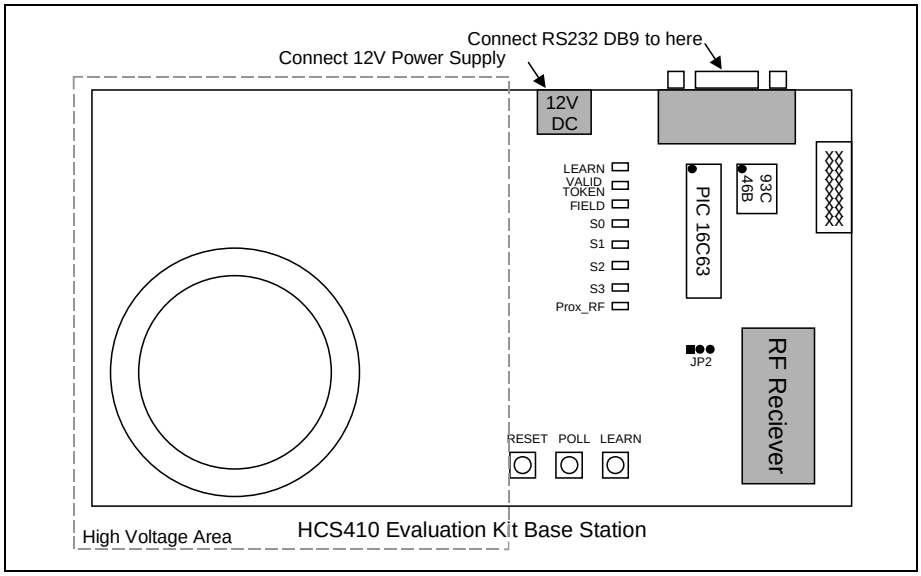

Figure 2.1: Base Station

Base Station Outputs

The base station has a number of LEDs which display the results of authentication attempts.

The S0, S1, S2, S3 and PROX_RF LEDs are switched on for 500ms whenever the base station receives a valid code hopping transmission from a learned transmitter. The PROX_RF will be illuminated if the HCS410 is activated by a magnetic field.

The VALID TOKEN LED is switched on for 500ms whenever the base station authenticates a learned transponder.

The LEARN LED flickers every time a RF transmission is received or if the serial number is read from a transponder. This is done before the base station attempts check if the transmitter has been learned. This output is useful to a programmer giving feedback as to whether the base station detects a transponder or transmitter.

Table 2.1: Base Station Jumpers

Jumper	Name	Description
JP1	B2T	This is the line between the PIC and the circuitry controlling the base station coil. The jumper should be in place unless the user wants to disable the base station coil.
JP2	T2B	This connects the base station to the inductive analog reception circuitry (pins 1 and 2) or to the 8x2 header (pins 2 and 3).
JP3	RF_OUT	This is the output of the RF receiver. This jumper should be removed to disconnect the RF reciever from the PIC.
J2		The pins on the 8x2 header are mapped as follows: Pin 1 - Ground Pin 2 - Not used Pin 3 - PWM used during programming Pin 4 - Not used Pin 5 - 12 V directly from the power supply Pin 6 - Not used Pin 7 - LC0 Pin 8 - Not used Pin 9 - LC1 / S3 Pin 10 - Not used Pin 11 - S2 Pin 12 - Not used Pin 13 - S1 Pin 14 - 5V Pin 15 - S0 Pin 16 - Not used

Inductive Communication

The inductive communication between the base station and the HCS410 takes place via the resonant capacitor / coil combination and analog reception circuitry on the base station. The capacitor / coil are resonated at 125 kHz.

RF Communication

RF reception on the base station is done using the Telecontrolli receiver module on the base station. The transmitter transmits at 433 MHz.

High Voltage - Danger

Please note that base station capacitor / coil has a peak to peak voltage of over 400V and a peak current of over 1A.

Please **don't touch** any of the areas that are labeled as HIGH VOLTAGE. You will get shocked.

Stand Alone Mode

The base station in stand alone mode acts as a stand alone decoder. The base station can learn up to 4 transponders in stand alone mode.

When in stand alone mode the user can look at IFF activity on the base station by connecting the base station to the PC and selecting the Monitor IFF dialog box.

Stand alone mode is the default state of the base station and the base station returns to Stand Alone mode whenever a command from the PC is completed.

The base station does not need to be connected to the PC when in stand alone mode.

Base Station Programming

To program the base station the user should connect the base station to the appropriate COM port on the PC using the RS232 cable given in the evaluation kit. After this the user should enter the appropriate key generation options and transport code in the Options|Key Generation dialog box. Following this the user should bring up the Program dialog box by selecting the HCS410|Program from the main menu.

The user should then select the HCS410's baud rate, the LC encoding and the Anti-collision / XPRF option to be used by the system's transponders. The user should then hit the Prgm Base button after which the base will be programmed.

Please consult the Fault Finding section for communication problems.

Learning a Transponder

To learn a transponder onto a system inductively the user should go through the following steps:

1. Check that the base station is powered up and connected to the PC.
2. Program the base station and transponder with the appropriate setup.
3. Hit the Learn Button - the LEARN LED will light up.
4. Bring the transponder into the field.
5. If the transponder is successfully learned the LEARN LED will flash on and off about 10 times.

6. The base station can learn up to 4 transponders, after which the first transmitter learned will be over written.
7. If the learn operation fails the learn LED will turn off and then on for a second before returning to normal stand alone mode.

It is also possible to learn an HCS410 onto the base station using RF:

1. Check that the base station is powered up and connected to the PC.
2. Program the base station and transponder with the appropriate setup.
3. Hit the Learn Button - the LEARN LED will light up.
4. Press one of the buttons on the transmitter - the LEARN LED will switch off.
5. Press a button on the transmitter a second time. Note that when using secure learn the second transmission should be a SEED transmission.
6. If the transponder is successfully learned the LEARN LED will flash on and off about 10 times.
7. If the learn operation fails the learn LED will turn off and then on for a second before returning to normal stand alone mode.

If the learn operation fails the user should check that both the transponder and base station have been programmed correctly.

Erasing Transponders

It is possible to erase all the transponders learned by the base station.

1. Press and hold the LEARN push button. The LEARN LED will switch on.
2. After about 8 seconds the LEARN LED will switch off indicating that all the transponders have been erased.

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Chapter 3. HCS410

Programming an HCS410

The program dialog box can be reached via HCS410|Program in the main menu. The Program dialog box allows the user to select the HCS410 options to be programmed into the HCS410. After programming the HCS410 the base station should be programmed so that it will be able to learn the HCS410. For a more detailed description of all the features please consult the latest data sheet.

- **Serial Number** - 32-bit serial number
- **Transport Code** - 32-bit transport code
- **User EEPROM** - 64-bit user EEPROM
- **Low Voltage Trip Point** - Can be set to low (3V lithium battery) or high (6V battery).
- **RF Baud Rate** - Selects the communication speed used in code hopping mode.
- **IFF Baud Rate** - Selects the communication speed used in inductive communication.
- **Overflow** - Extends the range of the synchronization counter.
- **Anti Collision / XPRF** - Sets anti-collision and RF transmission options in transponder mode.
- **Code Word Blanking** - Blanks out alternate code words enabling more power to be transmitted in each transmission (FCC).
- **Additional Damping** - Used in circuits with a high Q to enable faster data communication rates.
- **Min 3 Tx** - At least 3 complete RF transmissions are sent each time the transponder is activated using the S0, S1 or S2 inputs.
- **LED Output** - S2 can double as a LED output if this option is enabled.
- **Delayed Increment** - Increments the synchronization counter by 12, 20 seconds after the last button press. This can be used by the decoder to defeat the latest attack on code hopping systems.
- **Extended Serial Number** - The full 32-bit serial number is transmitted in a code hopping transmission when the extended serial number is enabled. If not enabled the S0:S1:S2 status replaces the most significant nibble of the serial number in a transmission.
- The **Ind Prgm** button programs the HCS410 with the data selected inductively

- The **Wire Prgm** button programs the HCS410 with the data selected using the S2 and PWM lines. This can be done when the transmitter is connected to the base station at J2.

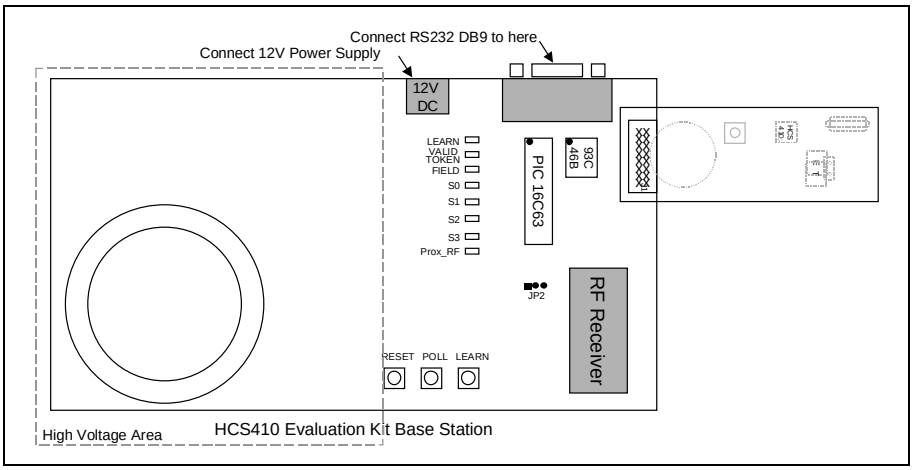

Figure 3.2: Wire Programming a Transmitter/Transponder

- The **OK** button accepts the settings selected but does not program the HCS410 or base station.
- The **Cancel** button discards the changes made and closes the dialog box.
- The **Prgm Base** button programs the base with the appropriate manufacturer's code, key generation source and algorithm, transmission format and speed so that it is able to communicate with an HCS410 programmed with the settings as given.

The key and SEED options are set when the user selects the key generation method to be used when the device is programmed.

Please consult the Fault Finding section for communication problems.

Serial Number

The HCS410 has a 32-bit (8 hex digit) serial number the user can select. The auto increment option will increment the serial number if the HCS410 is successfully programmed when checked.

Transport Code

To program the HCS410, change the serial number or the configuration word inductively the base station needs to send a 32-bit transport code after the appropriate op-code has been sent. After the transport code has been presented the base station can send the data to be programmed into the device. If the transport code presented to the HCS410 does not match the transport code in the HCS410 the op-code will be ignored.

This feature was added to prevent accidentally reprogramming the HCS410 inductively. The transport code is the 32 most significant bits of the SEED / Key2.

During wire programming the transport code that is being programmed into the HCS410 is set in the Key Generation dialog box and does not need to match the transport code currently in the HCS410. If the user wants to inductively program the HCS410 or change the serial number the user should enter a transport code in the appropriate dialog box.

User EEPROM

The HCS410 has 64 bits of user EEPROM. A 64-bit number can be entered (16 hex digits) when programming the device. If a user were to enter 0123456789ABCDEF the data would be mapped such that CDEF was programmed into USR0 and 0123 programmed into USR3.

Low Voltage Trip Point

The HCS410 can be used with either a 3V or a 6V battery. The low voltage trip point selects between the initial battery voltages. If the supply voltage drops below approximately 4V (6V battery) and 2V (3V battery) the HCS410 will set the VLOW bit in a code hopping transmission. This gives the base station the ability to warn the user if the bit is used. In addition to the VLOW bit being set the LED output is disabled when a low voltage condition occurs warning the user to replace the battery.

RF Baud Rate

The HCS410 can communicate at 4 speeds in RF mode. The baud rate bits select the nominal communication rate. These run from 00 being the slowest (T_E = 400µs) to 11 being the fastest (T_E = 100µs) communication rate.

IFF Baud Rate

The HCS410 can communicate at 2 speeds inductively. The slow baud rate has a nominal elemental period of 200µs and a fast baud rate of 100µs.

Overflow

There are two overflow bits available in the HCS410. An overflow bit is cleared every time the 16-bit synchronization counter wraps from FFFF to 0000 (hex). This extends the counter range from 64k transmissions to 192k transmissions. The overflow bits cannot be reset unless the device is re-programmed.

Anti Collision / XP RF

These two bits in the HCS410 are used to enable or disable anti-collision mode and enable or disable RF transmissions when in Transponder mode.

- **None** - Both Anti-collision and inductively activated RF transmissions disabled and the HCS410 works as a pure transponder in IFF mode.

- **Proximity Activated** - When this is selected the HCS410 will send out ACK pulses when it is placed in a magnetic field. If no response is received from the base station within 50ms the HCS410 will transmit a code hopping transmission for 2 seconds before returning to transponder mode.
- **Anti-Collision** - When in this mode anti-collision mode is entered. This allows multiple transponders to be brought into the same field.
- **RF Echo** - All of the HCS410 transponder responses are echoed on the PWM output when this is selected.

Synchronization Counter

The synchronization counter is incremented and transmitted each time the HCS410 transmits a code hopping transmission. The synchronization counter is automatically set to 0000 in software when the HCS410 is first programmed.

Other Options

A number of options are automatically selected by the software. These are:

- The code hopping transmission modulation format is always set to PWM.
- The oscillator tuning bits are set by the base station.
- The key / SEED options are set in the Key generation dialog box selected from the Options|Key Generation in the main menu.

User EEPROM Dialog Box

The 64-bit user EEPROM and 32-bit serial number on the HCS410 can be read and modified in IFF mode. The User EEPROM dialog box allows the user to read or write to the user EEPROM on the HCS410. The User EEPROM dialog box can be opened through the HCS410|EEPROM in the main menu.

To read the user EEPROM the user should hit the Read button. This will read all the user information if there is a transponder in the field.

The user EEPROM can then be modified as needed and written by hitting the Write button. To write to the HCS410's serial number the base station needs to have the transport code that was originally programmed into the HCS410.

The transport code should be entered to allow the user to change the serial number. If the transport code entered does not match the transport code in the HCS410 the serial number will not be modified.

The command status line lets the user know whether the read / write passed or failed.

Please consult the Fault Finding section for communication problems.

IFF Dialog Box

The IFF dialog box can be opened by selecting HCS410|IFF from the main menu. The user can use this option to manually do a challenge / response with a transponder in the field. To do this the user should select the key and algorithm to be used for the IFF and enter a 32-bit challenge.

It is important to note that unless the 2 Key IFF mode is selected in the Key Generation dialog box the user will not be able to use key 2 for an IFF.

After selecting an algorithm, selecting a key and entering the 32-bit challenge the user should hit the IFF button. The base station will attempt to do an IFF with a transponder in the field.

The IFF result text box gives information about the result of the IFF.

Please consult the Fault Finding section for communication problems.

Monitor IFF Dialog Box

When the base station is in Stand Alone mode the base station will dump the serial number, challenge sent, the HCS410's response and the decrypted response to the serial port whenever a successful IFF is performed.

Valid RF transmissions received by the base station in stand alone mode are also dumped to the serial port and can be seen in the Monitor IFF dialog box, with the challenge set to 00000000.

This can be monitored by the user in the Monitor IFF dialog box (HCS410|Monitor IFF).

Code Hopping Transmissions

The HCS410 can be used as an RF transmitter. To force a KEELOQ code hopping transmission the user can activate any of the S inputs, S0, S1, S2 or a combination the S inputs (Note: certain button combinations cause a SEED transmission if enabled). A code hopping transmission has two portions - a fixed portion and a code hopping portion.

The fixed portion contains the 2 QUE bits, 2 CRC bits, a VLOW bit, 4/0 button status bits and 28/32-bit serial number. The encrypted information contains 4 button status bits, 12 discrimination bits and a 16-bit synchronization counter.

SEED Transmissions

If SEED transmissions are enabled in the Key Generation dialog box the user can force the HCS410 to transmit a SEED transmission in place of a code hopping transmission. A SEED transmission takes 60 least significant bits of the SEED from EEPROM and transmits the, followed by the 4 bit button status information, VLOW bit, 2 CRC bits and the 2 QUE bits.

SEED transmissions are activated by pulling S0, S1 and S2 high at the same time. A delayed SEED transmission can be activated by pulling S0 and S1 high at the same time. A delayed SEED transmission transmits a normal code hopping transmission for 2 seconds and then switches over to SEED transmissions.

Chapter 4. Configuration File

Configuration File Overview

The KEELOQ production programmer (PG306001) uses a configuration file to save user selectable settings. The evaluation kit also uses the configuration file to save the user selectable settings. This makes the migration from the evaluation kit to the production programmer easier than would otherwise be the case.

Load Setup

To load a previously saved configuration file select File|Load Setup from the main menu.

Save Setup

To save the current configuration select File|Save Setup from the main menu.

Save Setup As

To save the current configuration file under a different name and directory select File|Save Setup from the main menu.

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Chapter 5. Key Generation

Key Generation Overview

Key generation is used to generate keys for HCS410 encoders. The HCS410 uses it's key to generate responses to IFF challenges and to encrypt the code hopping portion of a transmission when used as a transmitter. The HCS410 has 2 keys available. The first of the keys is used to encrypt the code hopping portion of the key and to do any of the IFF functions when an IFF is performed using Key 1.

Key 2 can be used either as a second IFF key or as a SEED in a SEED transmission. The key is generated when the HCS410 is programmed. Key generation in KEELOQ systems has 3 parts, the key generation source, the key generation algorithm and the manufacturer's code.

The key generation source is either the HCS410's serial number or the HCS410's SEED. Normal key generation uses the encoder's serial number as the source. Secure learn uses the HCS410's SEED as a source.

The key generation algorithm can be selected as either the KEELOQ decryption algorithm or as the XOR algorithm.

The manufacturer's code is a 64-bit value used to create a unique relationship between key generation source and the encoder key.

The key generation method used when programming the base station or an HCS410 is selected in the Key Generation dialog box (Options|Key Generation). Note that in order to use secure learn the second key is used as a SEED and the user only has a single key. This also implies that if a user were to use two keys for IFF, key generation must be either simple or normal key generation because enabling 2 key mode in the HCS410 disables SEED transmissions.

Manufacturer's Code

The 64-bit manufacturer's code is used in key generation for one or both of the HCS410's keys. The manufacturer's code creates a unique relationship between key generation source and the encoder key. If two manufacturers use the same source (say serial number of 1111) and algorithm (say decryption) the key generation process will produce two completely different encoder keys for the two manufacturer's.

Encoders for the two different manufacturers will not be interchangeable. This prevents cloning of transmitters. If two manufacturers decide to work together they will have to share a manufacturer's code. The manufacturer's code is central to system security and should be kept a closely guarded secret.

The manufacturer's code is entered in the Key Generation dialog box (Options|Key Generation).

Key Generation Algorithm

There are two key generation algorithms currently supported by Microchip. The first of these is the decryption algorithm. The second is the XOR algorithm. Both algorithms use the manufacturer's code to create a unique link between the key generation source and the encoder key.

Key Generation Source

The source used in key generation is either the serial number of the HCS410 or the SEED of the HCS410. When using the SEED as the source the user will need to transmit a SEED transmission during the learn process.

SEED/IFF2

The HCS410 has a 64-bit space that can be used as either a SEED during a SEED transmission or as a second IFF key. The selection can be made in the Key Generation dialog box (Options|Key Generation).

This space is also used as the transport code which is used to protect the HCS410 from being accidently being programmed in IFF mode. The Seed/Key2 is used as the transport code regardless of the setting of SEED/IFF2.

- **No SEED - 1 Key** - This option disables the use of the area completely disabling both SEED transmissions and the areas use as a second key.
- **Limited SEED** - The SEED transmissions will be disabled when the synchronization counter goes over 256 when limited SEED transmissions are enabled - only 1 key is available for IFF authentication.
- **SEED** - SEED transmissions are always enabled in this mode - only 1 key is available for IFF authentication.
- **Key IFF** - SEED transmissions are disabled and the transponder has 2 keys for IFF authentication available.

Simple Learn

Simple learn uses a single key for all the encoders in a system. This key is the manufacturer's code. This method of key generation is less secure than either normal learn or secure learn because once the encryption key for one encoder in the system is known, the encryption key for all encoders in the system is known. In a system where convenience is a priority and security is a low priority this may not be a problem.

Normal Learn

Normal learn uses the serial number of the HCS410 during key generation to generate the key. When learning the HCS410 onto a receiver / base station the receiver needs to either read the serial number (IFF mode) or receive a valid transmission (RF mode). Thereafter a key can be generated using the decryption algorithm and the manufacturer's code.

Secure Learn

Secure learn uses a SEED transmission from the HCS410 to generate a key. When secure learn is used as the key generation method the user will only have a single IFF key, the location of the second IFF key being used to store the SEED.

The user can select between either the decryption algorithm or the XOR algorithm to generate the encoder key.

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Chapter 6. Communication

Serial Port Selection

The user can select which of the PC's serial ports to use in the Select Serial Port dialog box. The user can select from COM1 through COM4 if available on the PC. The user can test the communication between the base station and the PC by hitting the 'Test Coms' button.

OK accepts the selection and Cancel leaves the dialog box discarding changes.

Please consult the Fault Finding section for communication problems.

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Chapter 7. Fault Finding

Fault Finding

If the user gives a PC command (program, IFF, Read, Write etc.) and the command fails the user should check for the following:

1. Check that the base station is powered up.
2. Check that the serial cable is connected to the base station and PC securely.
3. Check that the correct serial port has been selected.
4. Check that the base station has been programmed with the current setup (Communication speed and protocol).
5. Check that the transponder is in the field.
6. Check that the jumpers at JP1, JP2 (across pins 1 & 2) and JP3 are inserted.

If the user programs a transponder and the transponder doesn't want to learn the transponder:

1. Check that the power is on.
2. Check that the base station has been programmed - hit the 'Prgm Base' button in the HCS410|Program dialog after programming the HCS410.
3. Check that the transponder was programmed correctly.

Failed to program a long range transmitter/transponder when plugged into the board:

1. Check that jumper at JP2 is placed across pins 2 & 3.

Fails to receive RF transmissions:

1. Check that JP3 is inserted.
2. Check that the transmitter is programmed with an RF transmission rate of' '00' or '01'.

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Appendix A. Schematic Diagrams

Figure A.1: HCS410 Base Station (BASE_V3.0)

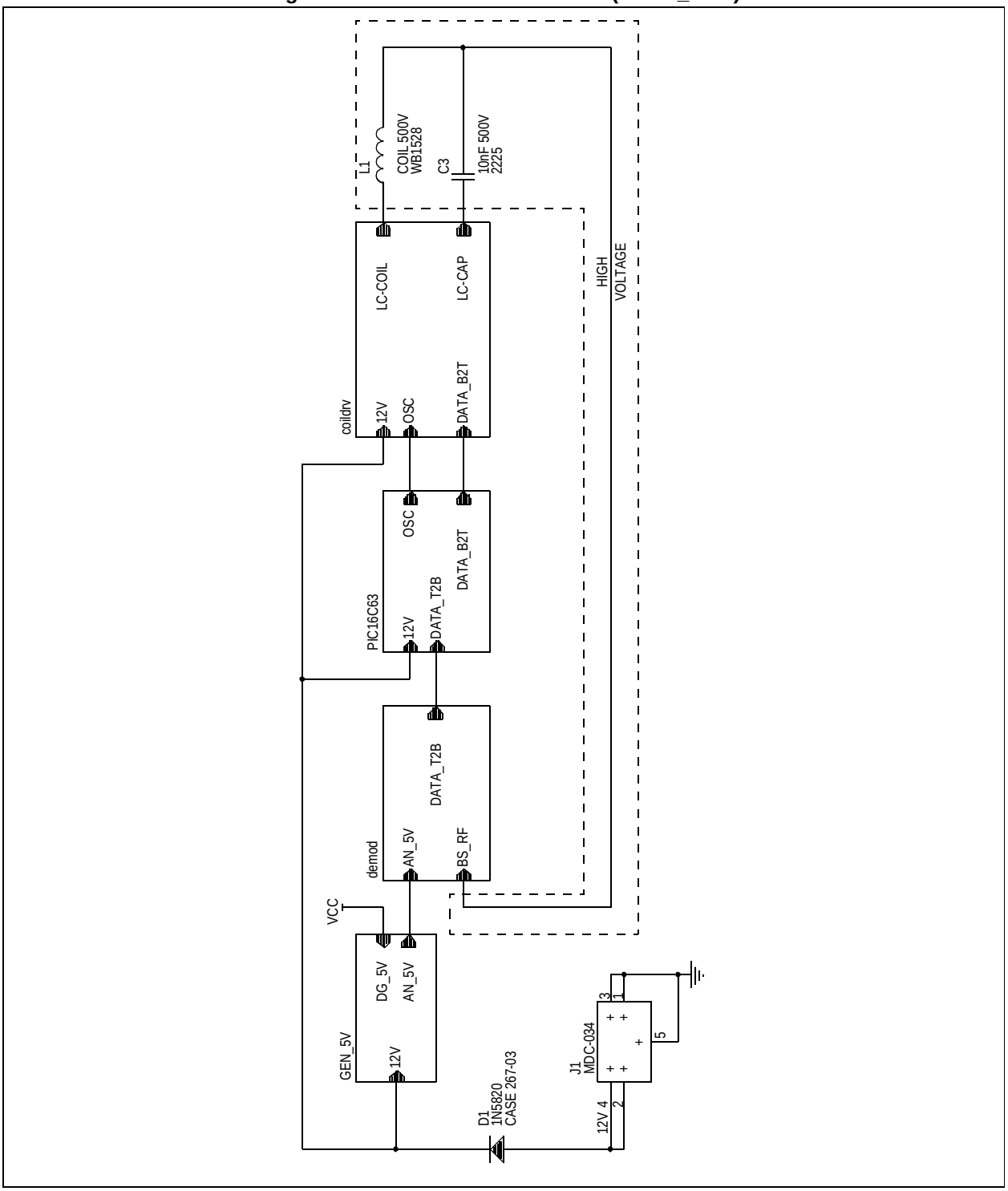


Figure A.2: HCS410 Base Station (GEN_5V)

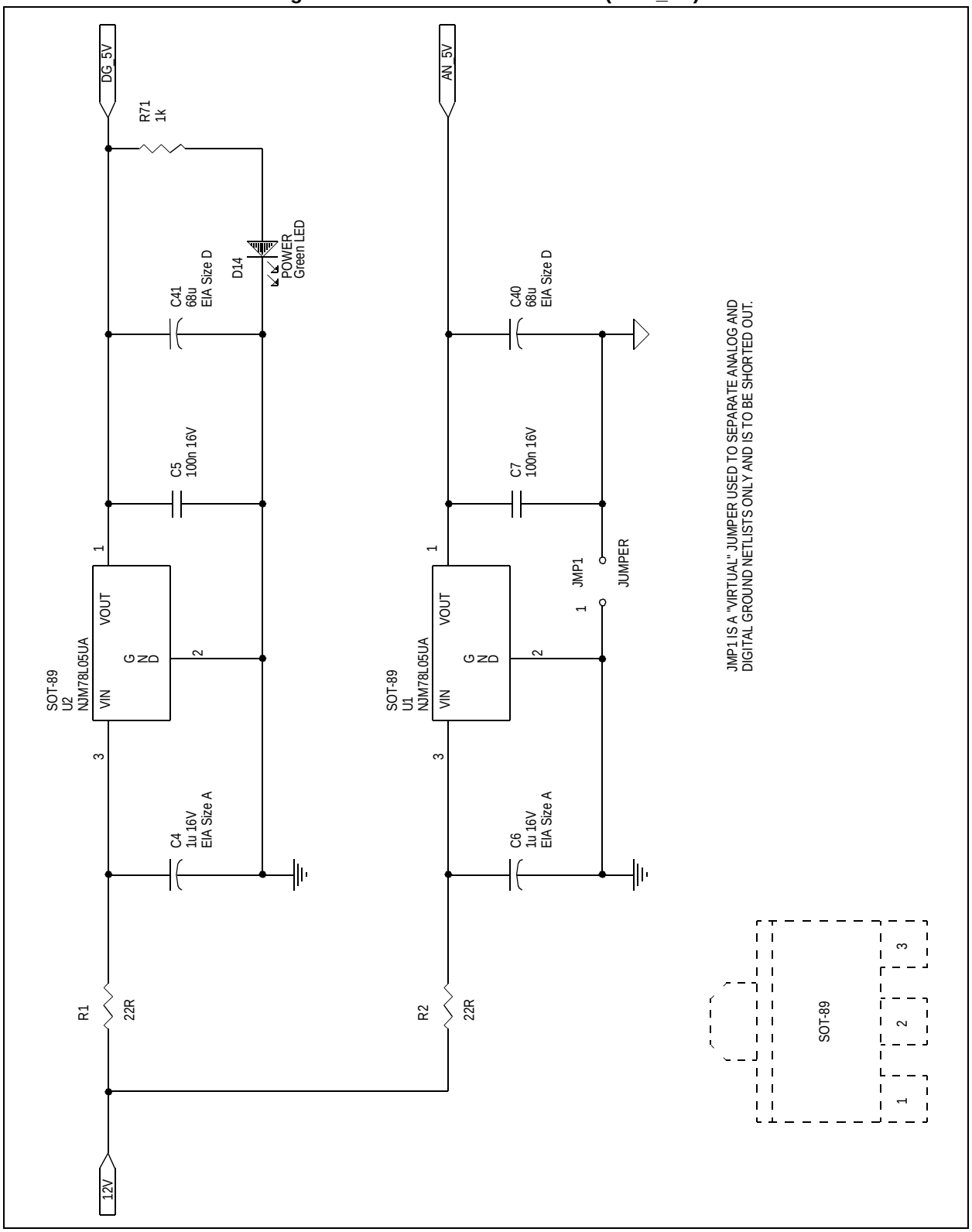


Figure A.3:HCS410 Base Station (demod)

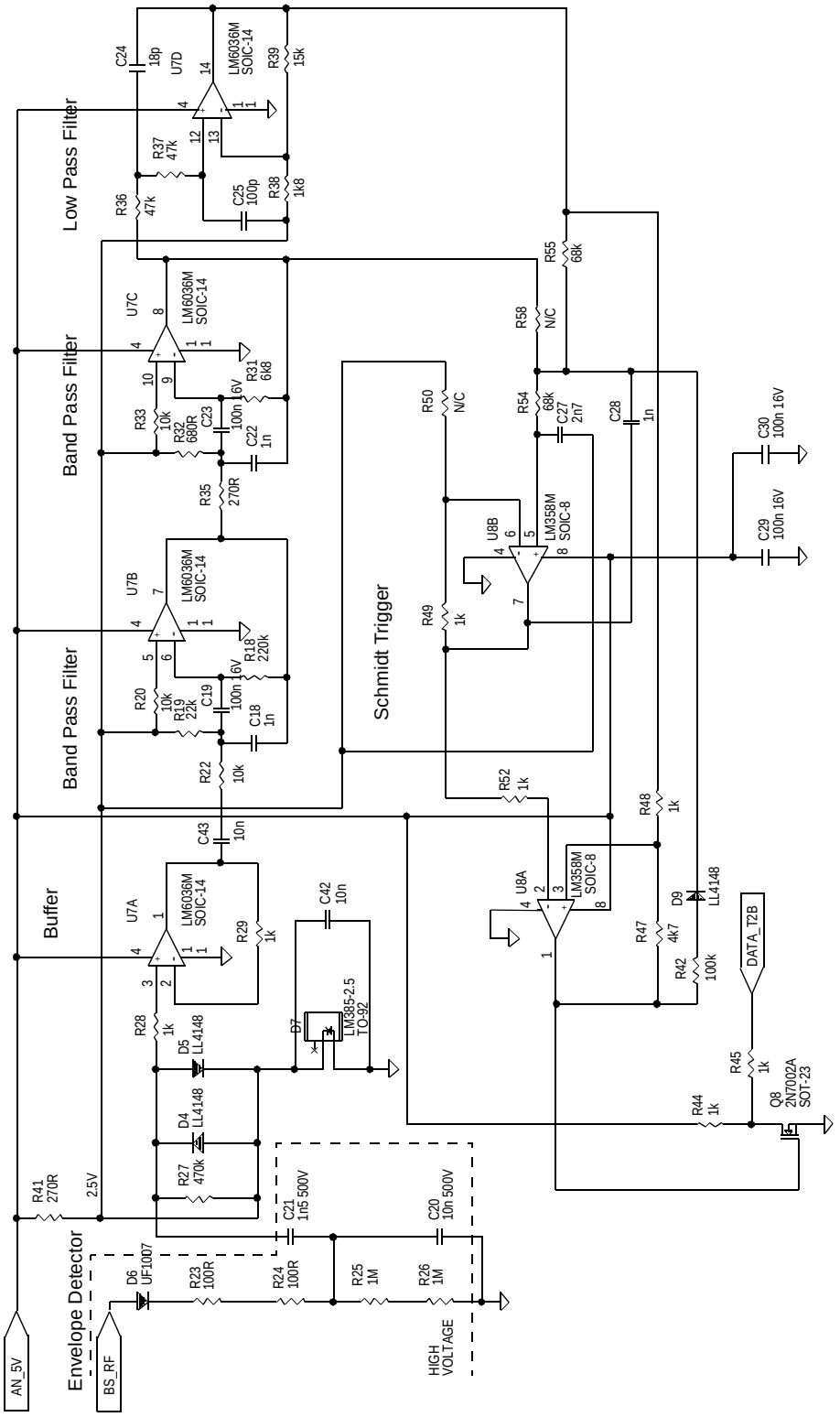


Figure A.4: HCS410 Base Station (PIC16C63)

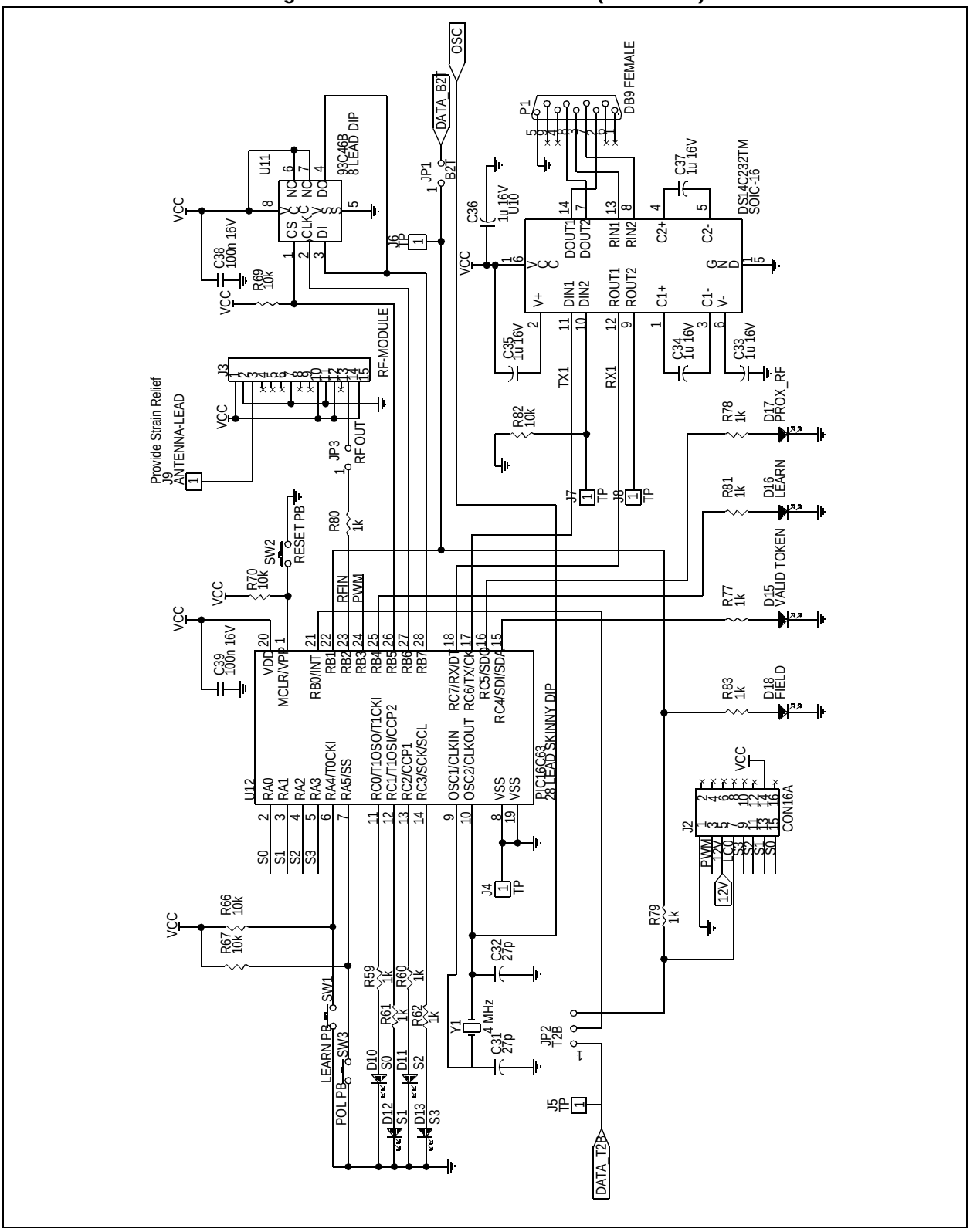


Figure A.5: HCS410 Base Station (coildrv)

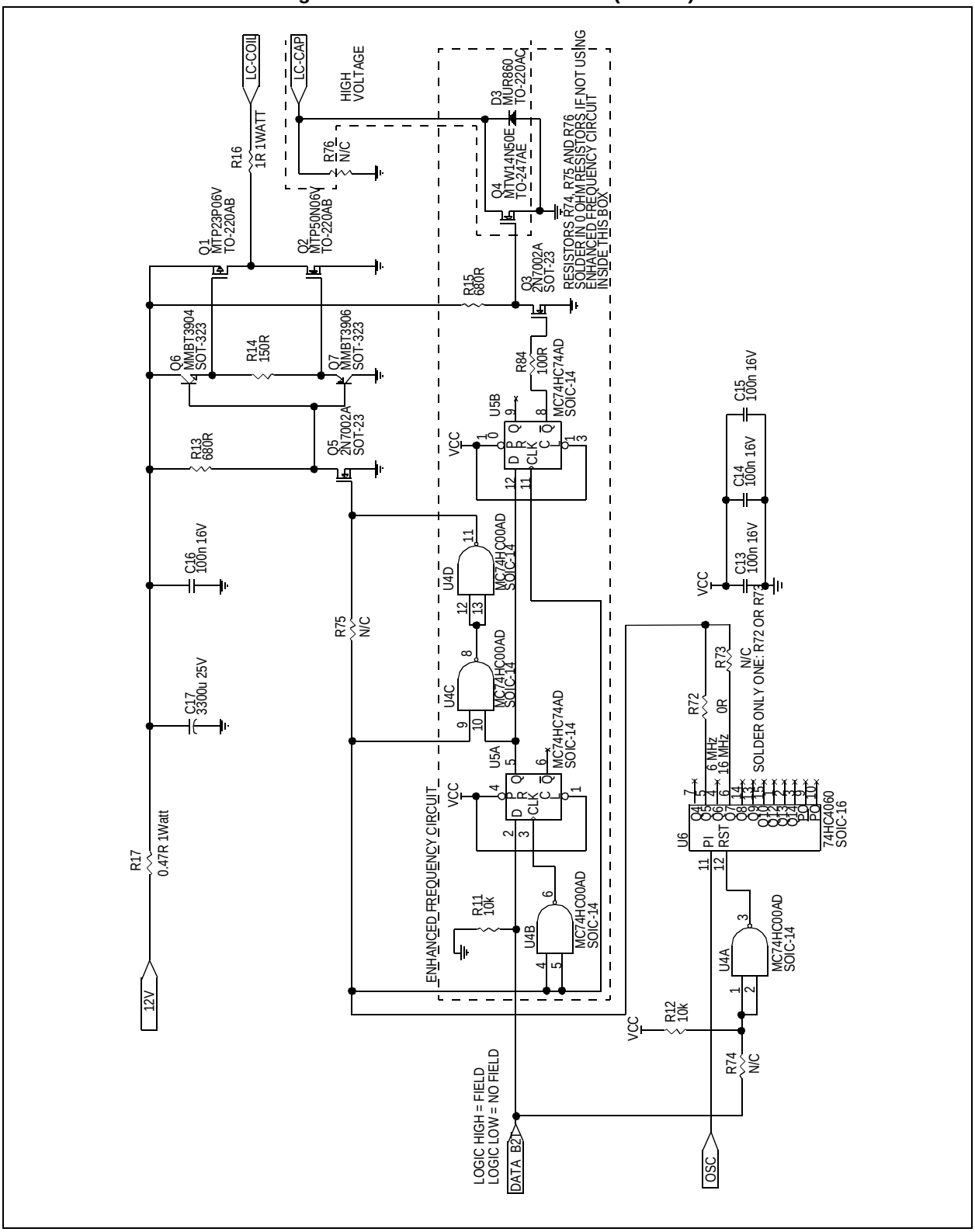


Figure A.6: HCS410 DIP Socket Long Range RF Transponder

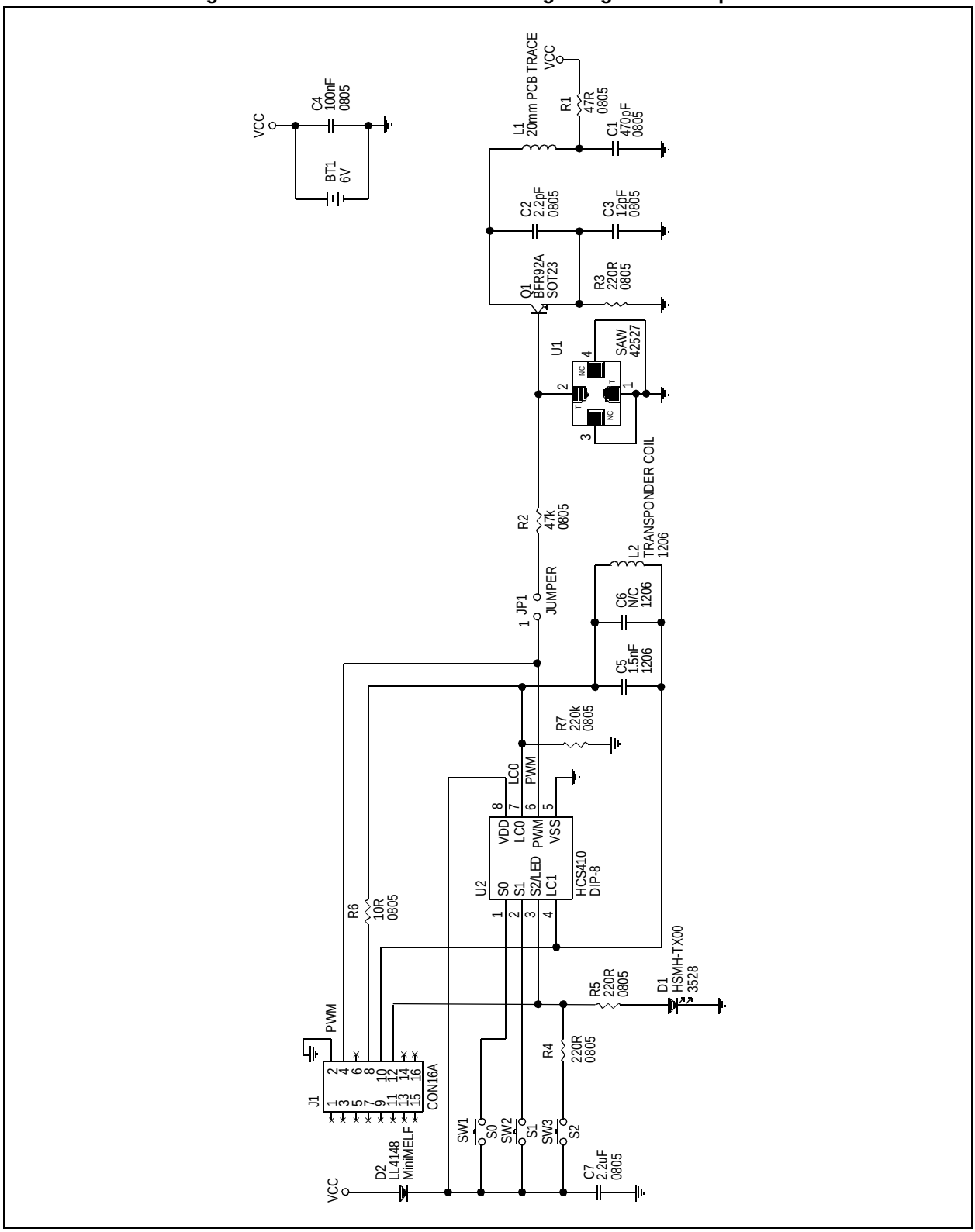
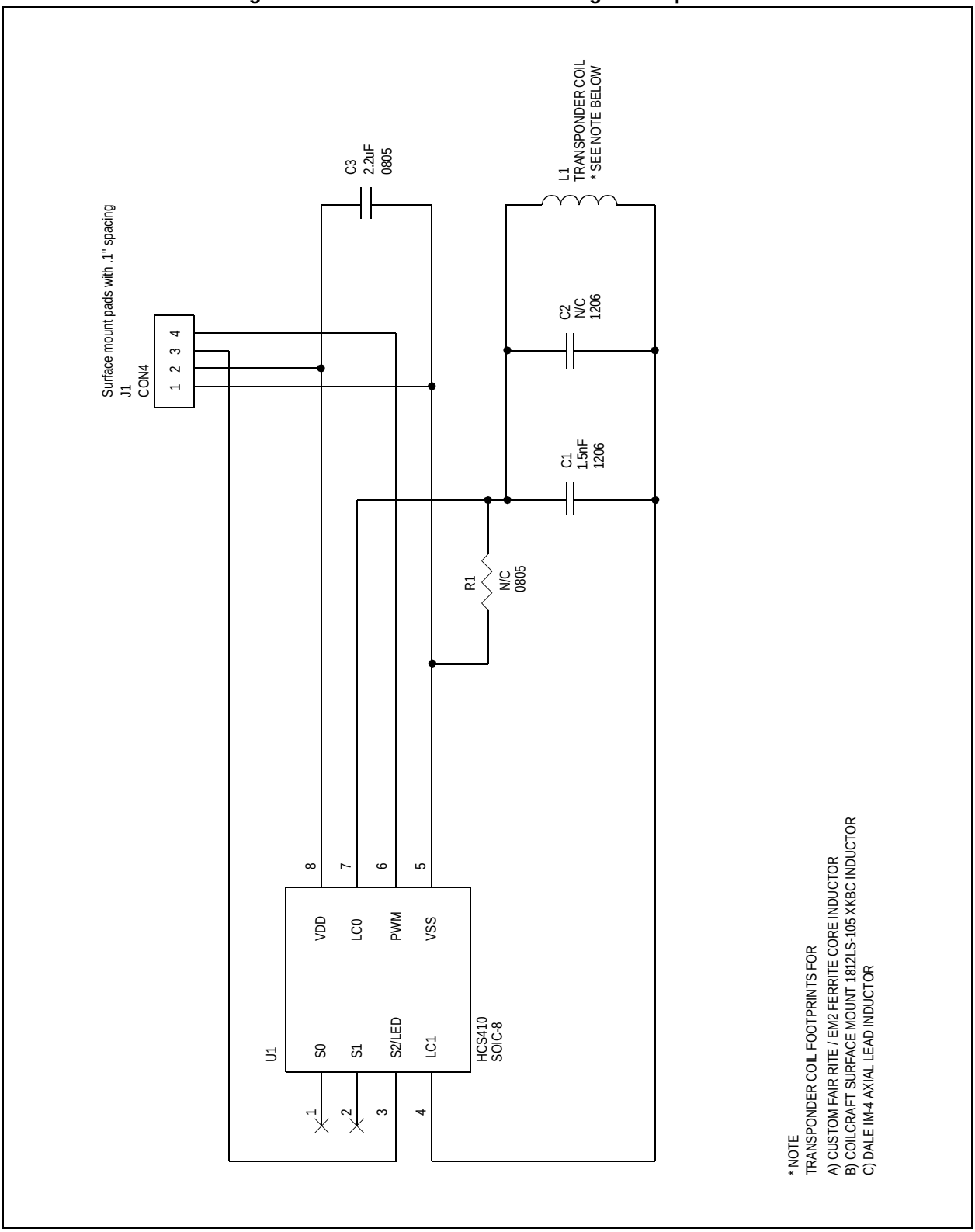


Figure A.7: HCS410 SOIC Short Range Transponder



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