Rocket-Switch-Interface
DESIGN RATIONALE V1.0

Makers Making Change
A Neil Squire Program

Introduction

The goal is to create a low-cost switch interface that can be alternative to commercial options. The device needs be able to perform the main functions that is offered in alternative devices.

Research

Commercial alternatives

Device	Company	Inputs	Information	Cost ($US)
Swifty	Origin Instruments	• 2 - Stereo Jack (Requires splitter)	• Splitter is sold separately : $10 • USB Extension : $10 •	$99
Tapio	Origin Instruments	• 2 - Stereo Jack (Requires splitter)	• iPad and iPhone Switch Interface	$120
Tecla Shield	Tecla	• 2 mono jacks + 4 way Joystick d-pad	• Discontinued? • 9-pin DB connection for joysticks	
Hitch 2	Ablenet	• 4	• Ability to program one to four keystrokes of your choice • 9-pin DB connection for joysticks	$120
JoyCable	Thinksmartbox	• 2	• Up to 2 switches	£99.00 or $118
Crick USB Switch Box	Crick Software Inc.	• 4	• Works on Windows and Mac computers • **Crick Software application**	$160

DIY Alternatives

Device	Creator	Inputs	Information	Cost ($US)
Enabled Controller Mini	Milador	• 4 input jacks and 2-axis analog input	• Morse code mode • Morse mouse mode • Gaming firmware	$40
ATMakers KeySwitch	ATMakers	• 5	• Low memory issue with the selected MCU • Gaming firmware	$40
FAIO Multiplexer	Milador	• 4	• Morse code mode • Morse mouse mode • Gaming firmware	$55

Requirements

Goals

ID	Description
G01	Cost Effective (Low cost comparing to alternative options)
G02	Easy to use
G03	Easy to assemble
G04	Minimal size

Functional Requirements

ID	Description
F01	The device shall have one or more input channels.
F02	The device shall send output data via USB HID to the host device.
F03	The device shall be compatible with switch control software.
F04	The device switch shall incorporate minimal input protection.
F05	The device latency shall not exceed 50 milliseconds.
F06	The device shall support visual feedback for user interactions.
F07	The device shall not consume more than 20 mA of current from the USB port.

F08	The device shall be able to perform Mouse button, joystick button and keyboard emulation.
F09	The device shall weigh less than 25 grams.
F10	The device shall be smaller than 50mm x 40mm x 20mm.

Non-functional Requirement

ID	Description
NF01	Shall look professional with tight tolerance on case size.
NF02	Input ports should be legibly labelled for easy identification

Constraints

ID	Description
C01	Shall be able to be built as a single unit for ≤ $40 CAD
C02	Shall be easily manufacturable by a moderately skilled maker

Ideation

The initial idea was to add a custom PCB to an existing, small-sized commercially available microcontroller board.

There are a few other ways this could be accomplished:

- Using components with a proto board and breadboard-friendly 3.5 mm jacks
- Using components in a 3D printed jig / 3d printed PCB
- Using panel mount switch jacks mounted in a 3d printed enclosure

Conceptual Design

Components

Dev Board/MCU

The TRINKEY board is a great low-cost option to design the switch interface based of it, as it offers the basic requirement for creation of a switch interface. Trinkey offer one to three GPIO's and a built-in RGB LED in a small footprint (USB Flash Stick size).

The Trinkey is offered in following versions:

1. Adafruit NeoKey Trinkey

- Digikey Link: https://www.digikey.ca/en/products/detail/adafruit-industries-llc/5020/14307382
- Cost: $10 CAD
- Pros:
  - USB NeoPixel Mechanical Key Switch
  - LED Visible from top and bottom
  - One Touch pad
  - Factory code is compatible with Switch control on Android
- Cons:
  - One GPIO
  - No exposed ground pad (Needs to use pull down)

2. Adafruit Rotary Trinkey
   - DigiKey Link: https://www.digikey.ca/en/products/detail/adafruit-industries-llc/4964/14307384
   - Cost: $10
   - Pros:
     - 2 Analog pins and 1 digital pin exposed which can be used as three GPIO's
     - One Touch pad
     - Power and ground pads exposed
   - Cons:
     - Factory code is not compatible with switch control software
     - LED Visible from bottom side

3. Adafruit Proximity Trinkey
   - Digikey Link: https://www.digikey.ca/en/products/detail/adafruit-industries-llc/5022/15222465
   - Cost: $14 CAD
   - Pros:
     - Two Touch pads
     - Two RGB LEDs on top side
   - Cons:
     - Factory code is not compatible with switch control software
     - No Exposed GPIO's
     - No exposed power and ground pad

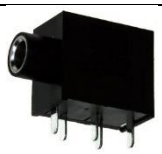
This is not a suitable option because there are no solder pads readily accessible to connect a switch easily.

Both the Adafruit NeoKey Trinkey and the Adafruit Rotary Trinkey could be used to create a switch interface. The Adafruit Rotary Trinkey was selected for the following reasons:

1. Ability to use 2 switches
2. Ground pad is exposed.
3. The rotary switch has thru hole connections that make it easier to connect the switch jacks.

3.5 mm Input Jack Options

3.5 mm Jack	SJ1-3533NG	SJ1-3535NG	MJ-3536N	SJ-43514	STX-3120-3B
Type	Stereo (3 Conductor, TRS)	Stereo (3 Conductor, TRS)	Mono	Stereo (4 Conductor, TRRS)	Stereo (3 Conductor, TRS)
Cost (CAD$)	1.9 to 1.92	1.93 to 1.96	1.37 to 1.39	1.45 to 1.47	1.15 to 1.16
Availability	689,251 from Digikey, 21,251 from Mouser	109,033 from Digikey, 5,468 from Mouser	22,746 from Digikey, 8,534 from Mouser	28,000 from Digikey, 27,750 from Mouser	4,467 from Digikey, 5,220 from Mouser
Manufacturer	CUI Devices	CUI Devices	CUI Devices	CUI Devices	Kycon, Inc.
Dimensions	14(+4) mm x 8.2mm x 12.3mm	14(+4) mm x 8.2mm x 12.3mm	15.8(+3) mm x 10mm x 10mm	11(+3) mm x 4.9mm x 5mm	10.5(+3.5) mm x 12mm x 10mm
Number of Sets	1	1	1	1	1
Number of Positions	3 Conductors, 3 Contacts	3 Conductors, 5 Contacts	2 Conductors, 3 Contacts	4 Conductors, 4 Contacts	3 Conductors, 3 Contacts
Voltage - Rated	12VDC	16VDC	12VDC	12VDC	N/A

Current Rating	1A	1A	1A	1A	N/A
Internal Switch	None	2 Switches	Single Switch	None	None
ProtoBoard Friendly	None	None	None	None	Yes
					

Trinkey doesn't provide enough pins to support jack internal switch (touch pad may not be a reliable method to provide additional input)

SJ-43514 is a reliable and low-cost option.

Hardware pullup

Hardware pullup can be added as an optional feature

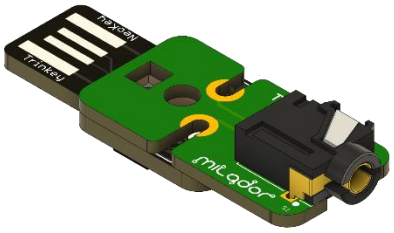
Mounting Hole

A single M3 mounting hole to provide additional support for the enclosure.

Concepts

Concept 1 : Mono

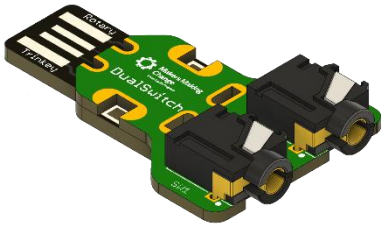
- Adafruit NeoKey Trinkey
- One switch input through pull-down resistor
- Factory code can be used
- Total cost without PCB: $11.36
    - Adafruit NeoKey Trinkey x 1: $9.73
    - SJ-43514 3.5mm Jack Stereo x 1: $1.48
    - 4.7 kΩ 1/4W Through Hole Resistor x 1: $0.15



Concept 2: Dual version 1

- Adafruit Rotary Trinkey
- Two switch inputs through software/hardware pull-up resistor
- Low-cost option
- Total cost without PCB: $12.99

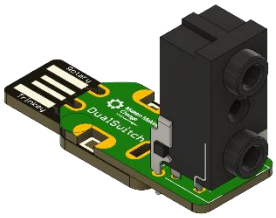
1) Adafruit Rotary Trinkey x 1: $9.73
2) SJ-43514 3.5mm Jack Stereo x 2: $1.48
3) 4.7 kΩ 1/4W Through Hole Resistor x 2: $0.15



Concept 3: Dual Version 2

- Adafruit Rotary Trinkey
- Two vertical switch inputs (Jack with 2 sets) through software pull-down resistor
- Total cost without PCB: $14.47

4) Adafruit Rotary Trinkey x 1: $9.73
5) SJ-43514 3.5mm Jack Stereo x 1: $4.44
6) 4.7 kΩ 1/4W Through Hole Resistor x 2: $0.15

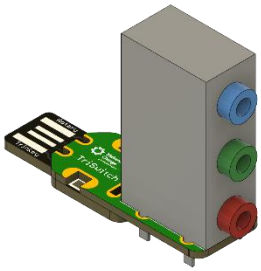


Concept 4: Dual Version 3

- Adafruit NeoKey Trinkey
- Two switch inputs through software/hardware pull-up resistor
- Total cost without PCB: $12.99
    1) Adafruit NeoKey Trinkey x 1: $9.73
    2) SJ-43514 3.5mm Jack Stereo x 2: $1.48
    3) 4.7 kΩ 1/4W Through Hole Resistor x 2: $0.15

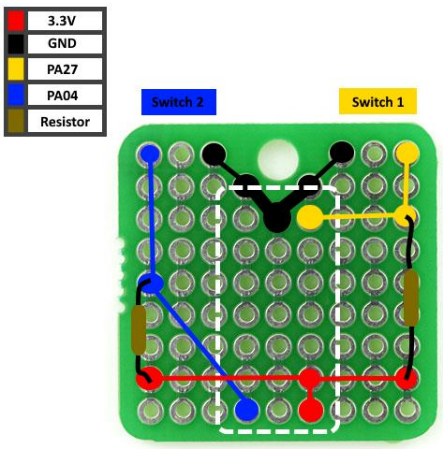
Concept 5: Triple

- Adafruit Rotary Trinkey
- Three vertical switch inputs (Jack with 3 sets) through software pull-up resistor
- Total cost without PCB: $14.85
    4) Adafruit NeoKey Trinkey x 1: $9.73
    5) SJ-43514 3.5mm Jack Stereo x 1: $4.67
    6) 4.7 kΩs 1/4W Through Hole Resistor x 3: $0.15



Concept 6: Breadboard

- Adafruit Rotary Trinkey
- SparkFun ProtoBoard
- Two breadboard friendly 3.5mm switch inputs through software pull-up resistor
- Total cost: $16.13
    1) Adafruit NeoKey Trinkey x 1: $9.73
    2) STX-3120-3B 3.5mm Jack Stereo x 2: $1.16
    3) 4.7 kΩs 1/4W Through Hole Resistor x 2: $0.15
    4) SparkFun ProtoBoard - Square 1" Single Sided x 1: $2.73
    5) Hook-Up Wire x 1: $1.05



Protoboard / Breadboard

Item	Dimension	Availability	Cost $CAD	Link
Sparkfun - Square 1" Single Sided	2.54mm x 2.54mm (9 by 9 0.1 standard spacing)	2000 units available from Digikey and 388 from Mouser	$2.42 to $3.99	Digikey Mouser Sparkfun elmwoodelectronics
ELEGOO Double Sided PCB Board	20mm x 80mm to 90mm x 150mm	Amazon and AliExpress 70mm x 100mm version on Mouser	$1.97 to $3.45 Or $0.56 per unit for 32 units	Amazon.ca Aliexpress
Chip Quik Solder-in breadboard	44.5mm x 17.8mm	86 units available from Digikey and 48 from Mouser	$1.5 to $1.62	Digikey Mouser

STX-3120-3B 3.5mm jack would be idea for this concept due to it's breadboard friendly characteristic.

Concept 7: 3D Printed version

Circuit Board

1. PCB (Dual Concept 1)

Units	1	5	10
Minimum order Unit	5	5	5
PCB Cost $US	$2 ($2.6 CAD)	$2 ($2.6 CAD)	$2 ($2.6 CAD)
Shipping Cost $US	~$18 ($23.5 CAD)	~$18 ($23.5 CAD)	~$18 ($23.5 CAD)
Component Cost $US	$9.94 ($12.99 CAD)	$49.7 ($64.95 CAD)	$99.4 ($129.9 CAD)
Unit Cost $(US)	$29.91 ($39.09 CAD)	$13.93 ($18.21 CAD)	$11.94 ($15.6 CAD)

2. ProtoBoard
   - Unit cost: $12.34 ($16.13 CAD)

Concept Selection

- Low cost ($10 less than Enabled controller Mini)
- Easy to assemble
- Small footprint
- Individual jacks instead of stereo jack that requires cable adapter.

Concept	Microcontroller	Inputs	Single Unit Cost	Qty 5 Unit Cost	Qty 10 Unit Cost	Size
Mono	Neokey Trinkey	1	$37.46	$16.58	$13.97	32mm x 16.5mm x 11mm (Total: 44.7 x 16.5mm x 11mm)
Dual1	Rotary Trinkey	2	$39.09	$18.21	$15.6	33.3mm x 29mm x 11mm (Total: 44.6 x 29mm x 11mm)
Dual2	Rotary Trinkey	2	$40.57	$19.69	$17.08	33.8mm x 16.5mm x 31.7mm (Total: 45.1 x 16.5mm x 31.7mm)
Dual3	Neokey Trinkey	2	$39.09	$18.21	$15.6	31.8mm x 29mm x 11mm (Total: 44.4 x 29mm x 11mm)
~~Triple~~	~~Rotary Trinkey~~	~~3~~	~~$40.95~~	~~$20.07~~	$17,46	41mm x 16.5mm x 42.5mm (Total: 52.3 x 16.5mm x 42.5mm)
Breadboard	Rotary Trinkey	2	$16.13	$16.13	$16.13	10mm x 10mm x 11mm (Total: 21.3 x 10mm x 11mm)
3D Printed	Rotary Trinkey	2				

The concept selected is to look at offering both the Breadboard and Dual-Version 1 options, so that a maker can utilize the breadboard version for the least expensive option and use a custom PCB when producing quantities of 5 or more.

Prototyping

- Mono version was fabricated and assembled using PCB.
- The Concept 2: Dual version 1 was fabricated and assembled using PCB.

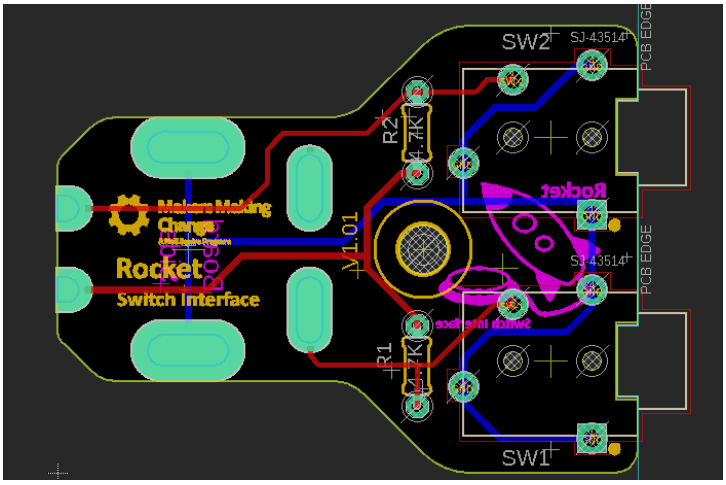
Testing

- Mono and dual versions were successfully tested with Universal Switch accessibility feature of an Android smartphone.

Detailed Design

Concept 2: Dual version 1 was selected as the final concept due to the following reasons:

- It offers all the required features including exposed GPIO pads and ground pads
- It's a more cost effective option compared to other PCB base concepts
- This concept has a smaller footprint compared to other concepts
- The selected Trinkey board for this concept has additional solder pads which can help with the assembly process of the device.



Opportunities for Improvement

- Create the breadboard version for smaller builds of 5 or less
- Improve the software settings and use GUI based settings
- Minimize the dimensions of the case to allow easier connection for USB ports beside