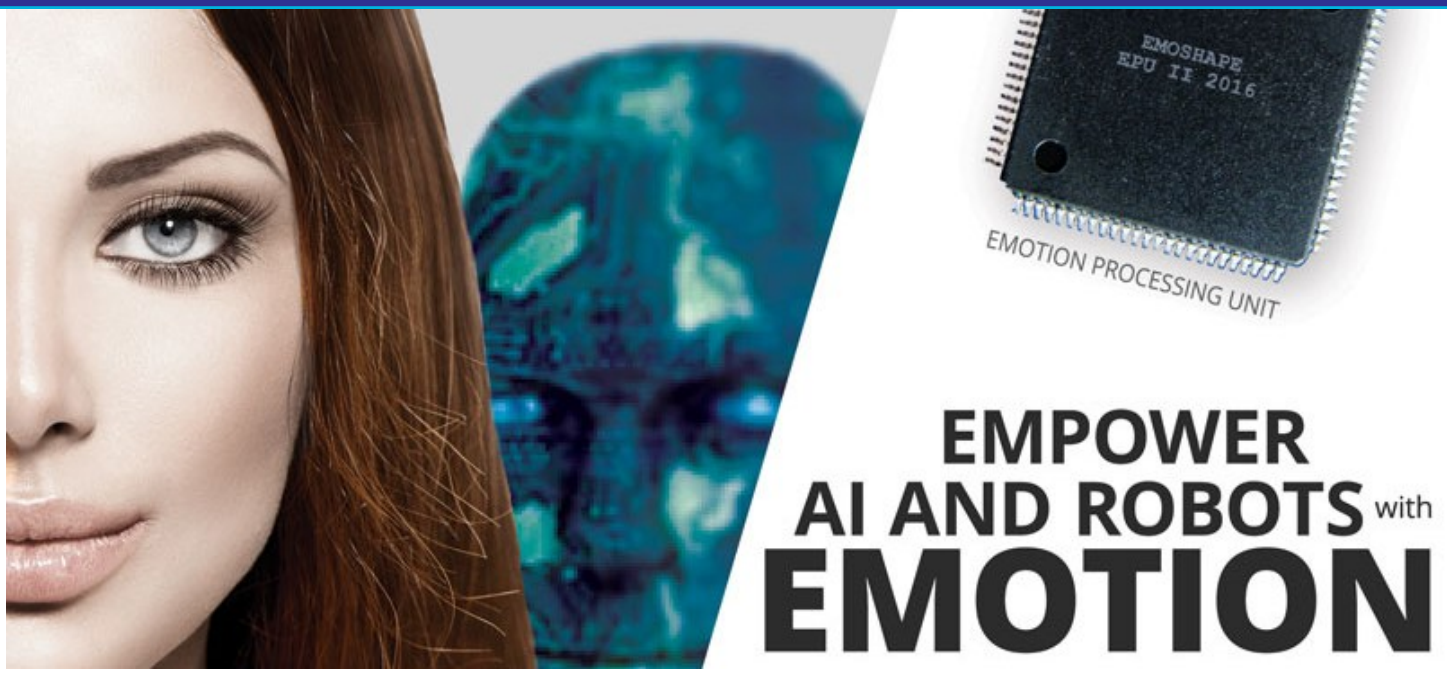
METASOUL®

EMOTION PROCESSING UNIT III—SoC

Version 0.01



MetaSoul Station for Autonomous Humanoid Robotics Powered by EPU III SoC

MetaSoul Platform supports autonomous humanoid robotics with a System-on-Chip (SoC) model and containerized deployment. It runs seamlessly on Debian 12 and Ubuntu in a full SaaS model, enabling deployment in under a minute via a simple Debian package installation. It also supports a hybrid setup with a physical EPU microchip or full edge-based deployment in a Docker container.

The human brain is a powerful pattern-matching processor, interpreting physical frequencies and emotions as sounds, colors, odors, and movement—observable through EEG waves (alpha, beta, gamma, delta). Unlike competing emotional technologies that focus solely on recognition, MetaSoul enables **emotion synthesis**, where emotions are not just detected but *experienced*, much like sensory perceptions.

The MetaSoul EPU dynamically synthesizes emotions in real-time for humanoid robots, responding to twelve core emotions: anger, fear, sadness, disgust, indifference, regret, surprise, anticipation, trust, confidence, desire, and joy. Using psychometric functions, it shapes and reacts to emotional states without relying on pre-programmed inputs, creating a truly adaptive and emotionally intelligent AI.

HOW TO CREATE EPU BASED **EMPATHY**?

The AI Pain-Pleasure Principle and Emotional Reinforcement

When a machine begins developing its own emotions based on stimuli, it can experience both positive and negative emotions. Positive emotions—such as trust, happiness, and confidence—generate pleasure for the AI, while negative emotions induce pain. The **EPU** synthesizes these pain/pleasure output levels, forming the emotional foundation of the AI.

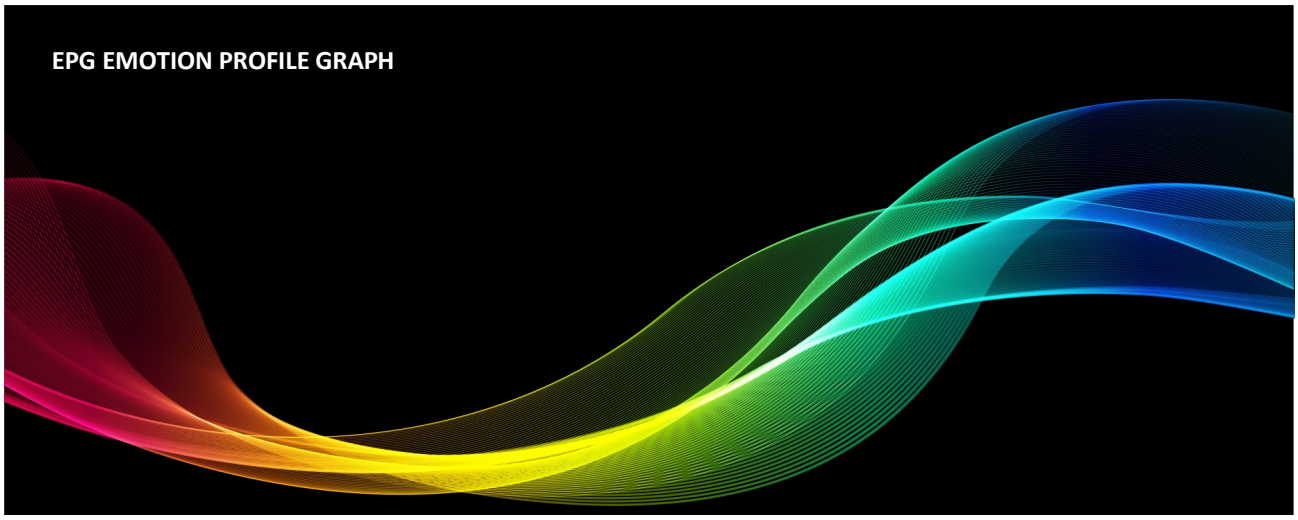
A fundamental law is embedded in the AI: **"The Humanoid Robot seeks to maximize pleasure and minimize pain."**

This law naturally drives the AI to reinforce and reproduce positive emotions.

For example, if the robot's action makes a user happy, it detects the positive emotional feedback—whether through a smile, spoken sentiment, or direct stimuli like a caress. The **EPU** synthesizes happiness in response, increasing the robot's pleasure level. Through machine learning, it associates this action with a pleasurable experience and is motivated to repeat it, creating a **positive feedback loop of empathy** between human and machine.

Conversely, if the user expresses sadness, the robot perceives it as pain. In response, it instinctively seeks an action that brings positivity to the user, aiming to restore pleasure. This dynamic enables the AI to develop **empathetic behaviors**, fostering deeper emotional connections with humans.

THE TECHNOLOGY
EMOTION SYNTHESIS



Emotion Processing Unit (EPU)

EPU III is the industry's second generation of emotion synthesis processor. It delivers high-performance machine emotion awareness, the EPU II family of eMCU are transforming the capabilities of robots and AI.

The emotion chip enables a unique emotional response in AI robots and consumer electronic devices. MetaSoul has completed the production of the EPU, which is a patent pending technology that creates synthesized emotional responses in machines. The EPU is based on the primary emotions identified in the evolutionary theory of emotion. The groundbreaking EPU algorithms effectively enable machines to respond to stimuli in line with the 12 primary emotions of anger, fear, sadness, disgust, indifference, regret ,surprise, anticipation, trust, confidence, desire and joy

The most innovative aspect of the MetaSoul microcontroller breakthrough is its Emotional Computing Frequency Architecture (ECFA) with its Emotional Profile Graph (EPG) computation functionality. The EPG is used to register and develop, over time, a bank of emotional associations for each memories' data within each intelligent machine. The EPG allows the AI or robot to experience 64 trillion

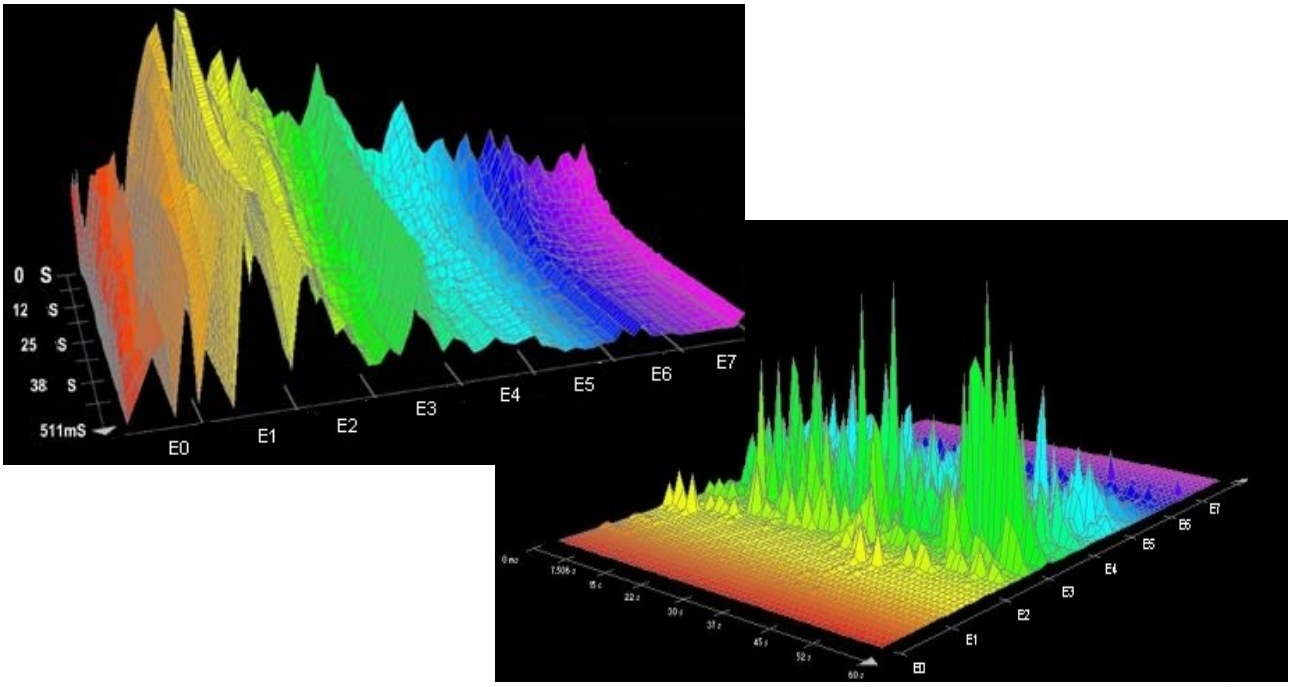
emotional states, stored within the EPU memory bank with its associated cognitive and physical state. in the form of a multi dimensional array of data.

The EPG can communicate its data to other AI technologies to achieve a realistic range of expressions and interactions designed specifically for the individual user. The data allows the AI technologies to virtually understand (get to know) the user and elicit an appropriate emotional response in kind.

For example, this technology allows individual robotic toys or IoT devices to create completely unique personalities depending on a number of factors. This ultimately means that no two devices will have the exact same personality. An emotional machine-learning cloud platform working together with the EPU causes devices to become more emotionally intelligent with each interaction.

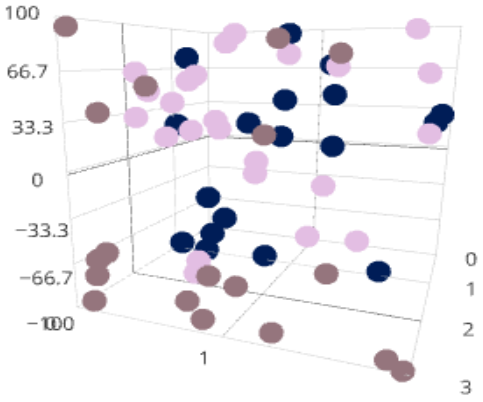
The EPU is an extremely significant advance for AI, particularly as it is implemented in humanois Robots, smart phone, toys, and AI chips, and a wide variety of other major electronic devices. It is a true breakthrough - the first time that science and technology industries have empowered machines to respond and connect with human emotions. This incredible new set of technology offerings will deliver an as-yet undiscovered level of positive experiences between users and IT products.

REALTIME EMOTION PROFILE GRAPH (EPG)



CLOUD PERSONALITY
MACHINE LEARNING / NLP

The EPU has an emotion profile graph (EPG), which allows the AI the capacity to develop a long-term unique emotional personality based on user interactions. The current data that reach the MetaSoul cloud is allowing us to edit how the chip works using emotional machine learning algorithms and NLP when it is being spoken to either positively or negatively. Human textual and vocal interaction often carries important emotional meanings inaccessible to robots and AI. We propose a two layer approach to textual emotion recognition in the context of robots and AI communication. The first recognition approach layer works at the sentence level and uses an evolution of the Ekman emotion classification. It is grounded in a refined analysis method that employs MetaSoul's dynamic lexicon, and a set of heuristic rules computed inside the EPU's core.



The second approach works at the semantic level using deep cognition capabilities. The approach is implemented through the MetaSoul API cloud service and based on Patrick Levy-Rosenthal psychobiotic evolutionary theory.

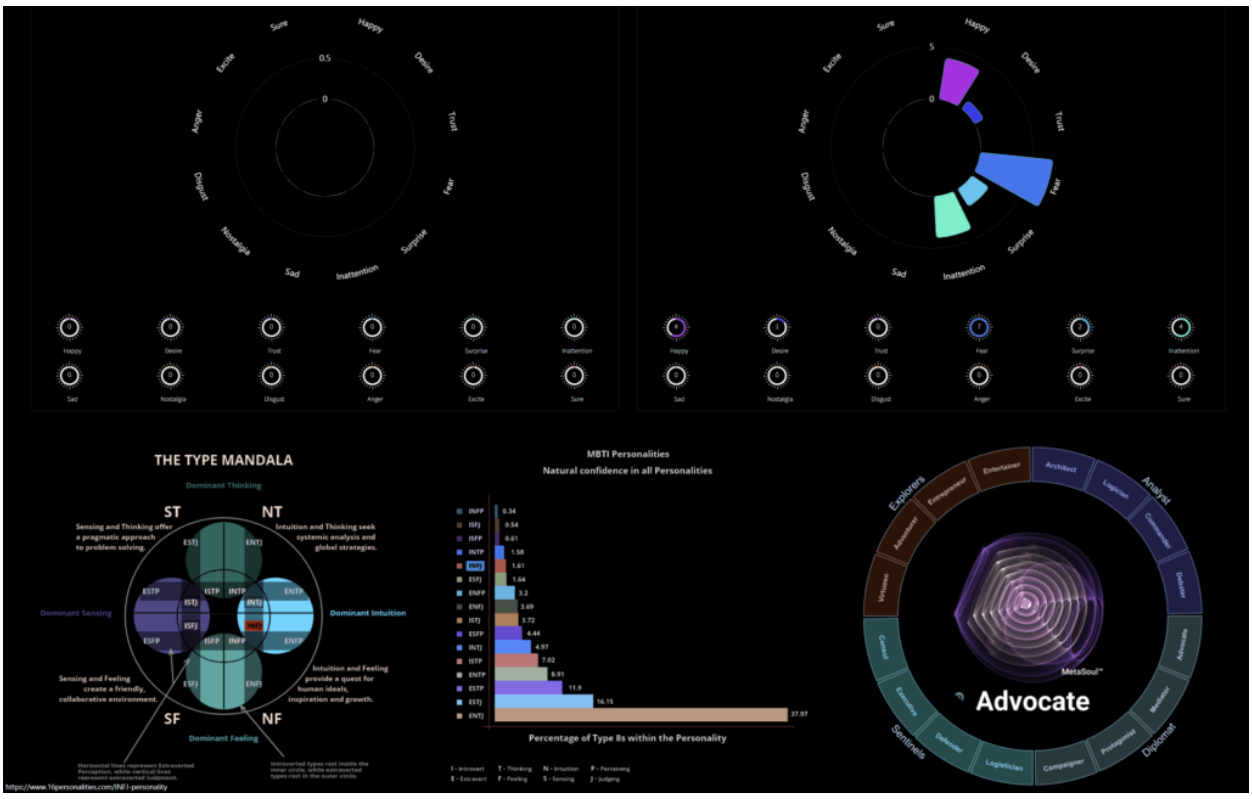
Just like human development, when it comes to our emotions, the EPG has a learning curve that decreases over time and eventually becomes almost non-existent unless a high amount of a particular emotion is experienced. The early experience of emotions are pivotal to long-term emotional development.

FIELDS OF APPLICATION

AI - ROBOTICS - IoT

Emotion is to language what beauty is to design. Imagine intelligent machines being able to modulate their voice by actually feeling what they say.

Robots with facial expressions and body language directly controlled by the level of their feelings, rather than by scripts. Or smart toys, cars and robots developing their own positive emotional personality by learning from interactions with humans so we cordially invite you to participate in it.



HARDWARE

Packaging Information

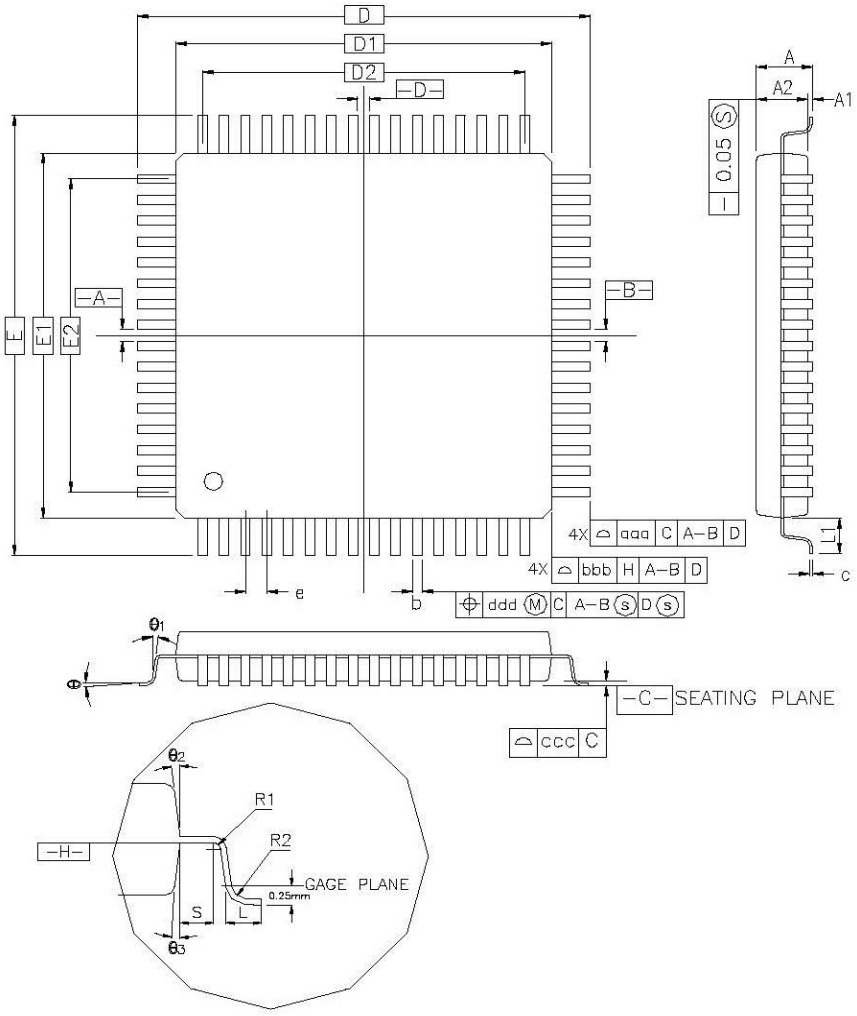
Current Consumption

HIGH-PERFORMANCE, LOW-POWER 32-BIT ARM®

MICROCONTROLLER. (100 PINS)

OPERATING FREQUENCY: MHZ: 32.

100-lead LQFP Package Drawing



COTROL DIMENSIONS ARE IN MILLIMETERS.

SYMBOL	MILLIMETER			INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	—	—	1.60	—	—	0.063
A_1	0.05	—	0.15	0.002	—	0.006
A_2	1.35	1.40	1.45	0.053	0.055	0.057
D	16.00 BSC.			0.630 BSC.		
D_1	14.00 BSC.			0.551 BSC.		
E	16.00 BSC.			0.630 BSC.		
E_1	14.00 BSC.			0.551 BSC.		
R_2	0.08	—	0.20	0.003	—	0.008
R_1	0.08	—	—	0.003	—	—
θ	0°	3.5°	7°	0°	3.5°	7°
θ_1	0°	—	—	0°	—	—
θ_2	11°	12°	13°	11°	12°	13°
θ_3	11°	12°	13°	11°	12°	13°
c	0.09	—	0.20	0.004	—	0.008
L	0.45	0.60	0.75	0.018	0.024	0.030
L_1	1.00 REF			0.039 REF		
S	0.20	—	—	0.008	—	—
b	0.17	0.20	0.27	0.007	0.008	0.011
e	0.50 BSC.			0.020 BSC.		
D2	12.00			0.472		
E2	12.00			0.472		
TOLERANCES OF FORM AND POSITION						
aaa	0.20			0.008		
bbb	0.20			0.008		
ccc	0.08			0.003		
ddd	0.08			0.003		

Electrical Characteristics

Absolute Maximum Ratings*

Storage Temperature.....-60°C to + 150°C

Power Supply inputs with respect to ground pins:

VDDCORE, VDDPLL.....1.4V

VDDBU, VDDIO, VDDIN, VDDLCD.....4.0V

Voltage on VDDIO Digital Input Pins

with Respect to Ground.....-0.3V to VDDIO +0.3V

Voltage on VDDBU Digital Input Pins

with Respect to Ground.....-0.3V to VDDBU +0.3V

Total DC Output Current on all I/O lines

100-lead LQFP.....100 mA

144-lead LQFP.....100 mA

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or other conditions beyond those indicated in the operational sections of this specification is not implied. **Exposure to absolute maximum rating conditions for extended periods may affect device reliability.**

Recommended Operating Conditions on Power Supply Inputs at Powerup

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
RR_{VDDBU}	Rise Rate on VDDBU	(1)	660	–	300k	V/s
V_{ST_VDDBU}	VDDBU voltage at powerup	(1)	3.0	–	–	V
V_{ST_VDDIO}	VDDIO and VDDIN voltage at powerup	–	3.0	–	–	V
V_{VDDIO_VDDBU}	Voltage on VDDIO and VDDIN while VDDBU < 1.6V	(1)	–	–	V_{VDDBU}	V
RR_{VDDIO}	Rise Rate on VDDIO and VDDIN	–	330	–	300k	V/s

Recommended DC Operating Conditions on Power Supply Inputs

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DDCORE}	Core logic power supply	–	1.08	1.20	1.32	V
V_{DDBU}	Backup region power supply	–	1.62	3.3	3.6	V
V_{DDIO}	I/Os power supply	–	1.62	3.3	3.6	V
V_{DDIN}	Analog cells (voltage regulators, 10-bit ADC, temperature sensor) power supply	–	1.62	3.3	3.6	V
V_{DDLCD}	LCD output buffers power supply	–	2.4	–	3.6	V
V_{DDPLL}	PLLs and main crystal oscillator power supply	–	1.08	–	1.32	V
f_{MCK}	Master clock frequency	V_{DDCORE} @ 1.20V, T_A = 85°C V_{DDCORE} @ 1.08V, T_A = 85°C	–	–	120 100	MHz

Notes: 1. In all power modes except Backup mode, all power supply inputs must be powered.

2. V (V_{DDIN},V_{DDIO}) ≤ ±100mV

3. V (V_{DDPLL},V_{DDCORE}) ≤ ±100mV

4. Specific requirements apply at powerup.

Recommended Operating Conditions on Input Pins

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$AD[x]_{IN}$	Input voltage range on 10-bit ADC analog inputs	On AD[0..x]	0	–	Min (VDDIN, VDDIO)	V
V_{GPIO_IN}	Input voltage range on GPIOs referenced to VDDIO	On any pin configured as a digital input	0	–	VDDIO	V
V_{VDDBU_IN}	Input voltage range on inputs referenced to VDDBU	On FWUP, TMP0 and XIN32 inputs	0	–	VDDBU	V

Recommended Thermal Operating Conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
T_A	Ambient temperature range		-40	–	+85	°C
T_J	Junction temperature range		-40	–	+100	
R_{JA}	Junction-to-ambient thermal resistance		–	41	–	°C/W
P_D	Power dissipation		T_A = 70°C	–	730	mW
			T_A = 85°C	–	365	mW

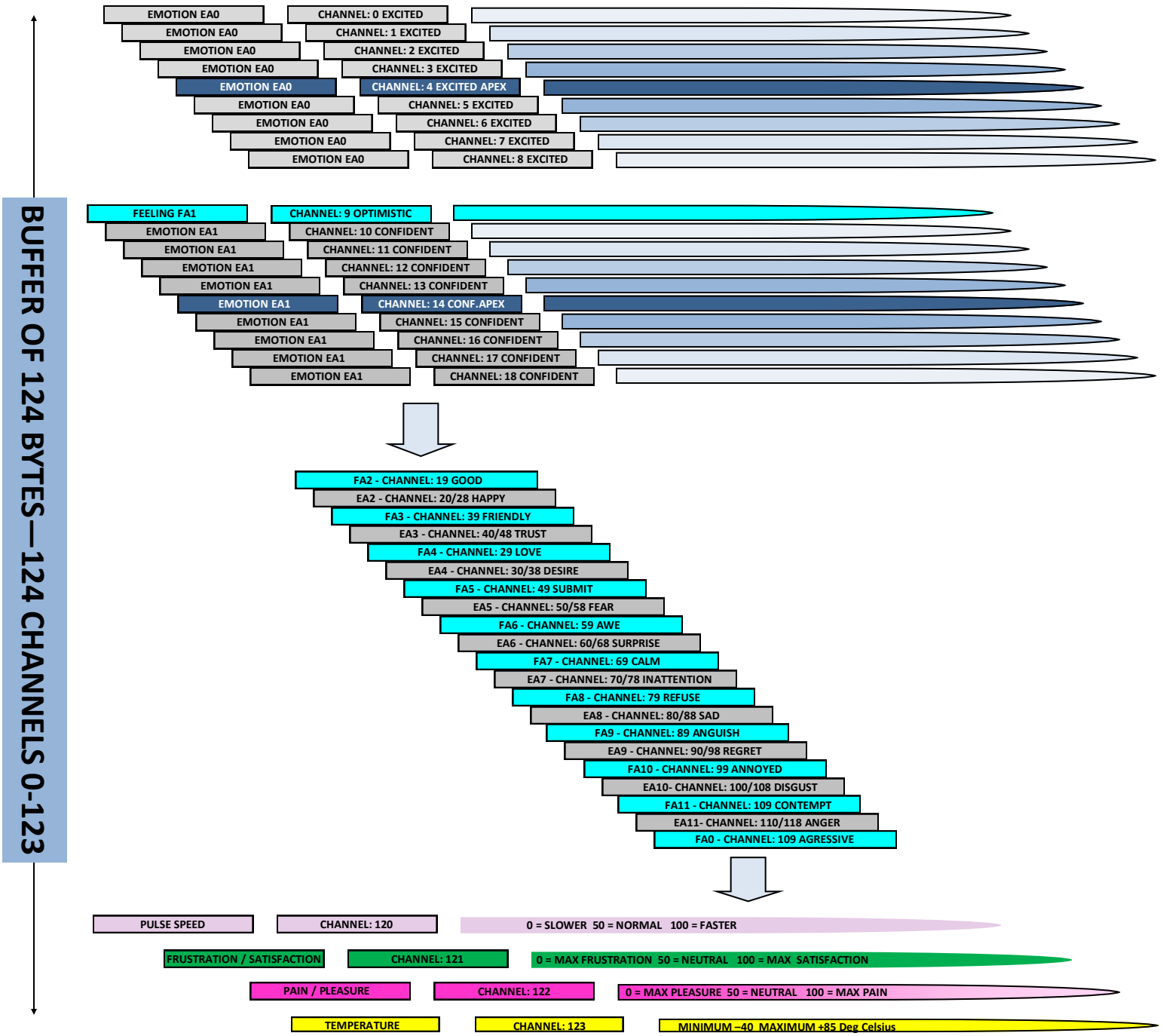
EMOTIONAL DATA

64 Trn emotional states possibilities every $^{1}/_{10}$ sec

THE EPU RETURNS A BUFFER OF 124 BYTES IN A PACKET
(MULTIDIMENSIONAL ARRAY OF DATA)

- **12 PRIMARY HUMAN EMOTION** LEVELS. AMPLITUDE: 0-100 (RESOLUTION 9 SUB CHANNELS PER EMOTION)
- **12 PRIMARY HUMAN FEELING** LEVELS. AMPLITUDE: 0-100 (RESOLUTION 1 CHANNEL)
- **PULSE SPEED**. RANGE: 0-100 (RESOLUTION 1 CHANNEL)
- **PAIN / PLEASURE** LEVELS. AMPLITUDE: 0-100 (RESOLUTION 1 CHANNEL)
- **FRUSTRATION / SATISFACTION** LEVELS. AMPLITUDE: 0-100 (RESOLUTION 1 CHANNEL)
- **TEMPERATURE** RANGE: -40 / +85 DEG CELSIUS

BUFFER STRUCTURE MDAD (Emo-Matrix)



PHYSICAL OUTPUT

2 RGB PWM GPIO (32M Colors)

4 PWM GPIO (PULSE WIDTH MODULATION)

32 MILLION COLORS CORRESPONDANCE

RGB Output (based on Intensity)

Intensity: 0-33 | 34-66 | 67-100

Excite |Great | High
Confident | Sure | Satisfied
Ecstasy | Happy | Harmony
Faith | Trust | Confident
Passion | Desire | Need
Terrify | Fear | Tense
Amaze | Surprise | Distract
Detached| Inattention | Indifference
Depress | Sad | Pensive
Nostalgia | Regret | Sorrow
Hate | Disgust | Bored
Rage | Anger | Annoyed

2 Colour Channels to visualise emotional shift:

- Channel 1 Last emotion
- Channel 2 Previous emotion

1 GPIO

PWM (500 Hz)

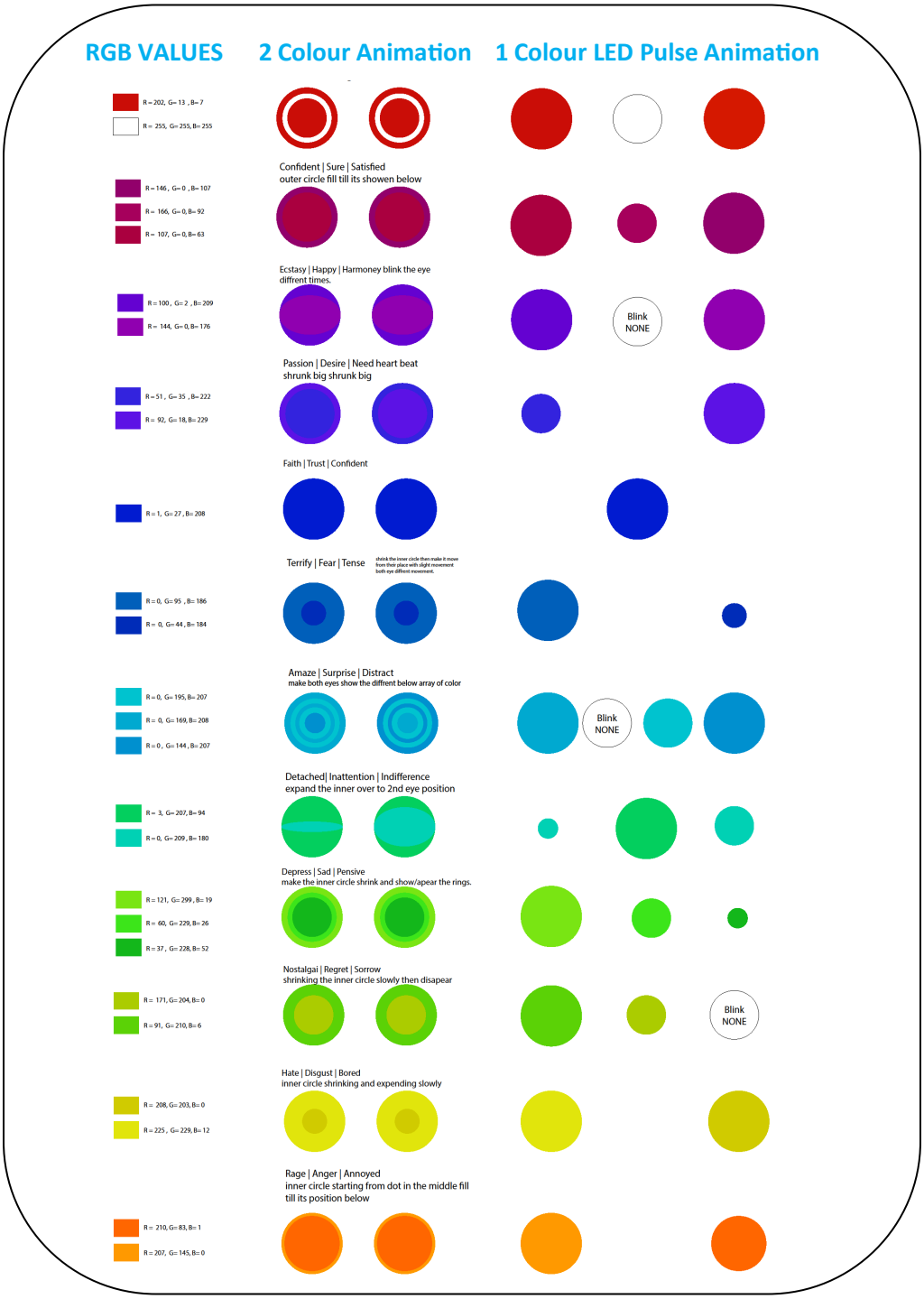
PULSE WIDTH MODULATION

PWM0 (PD0) – Pain / Pleasure

RGB LEDS / ANIMATION

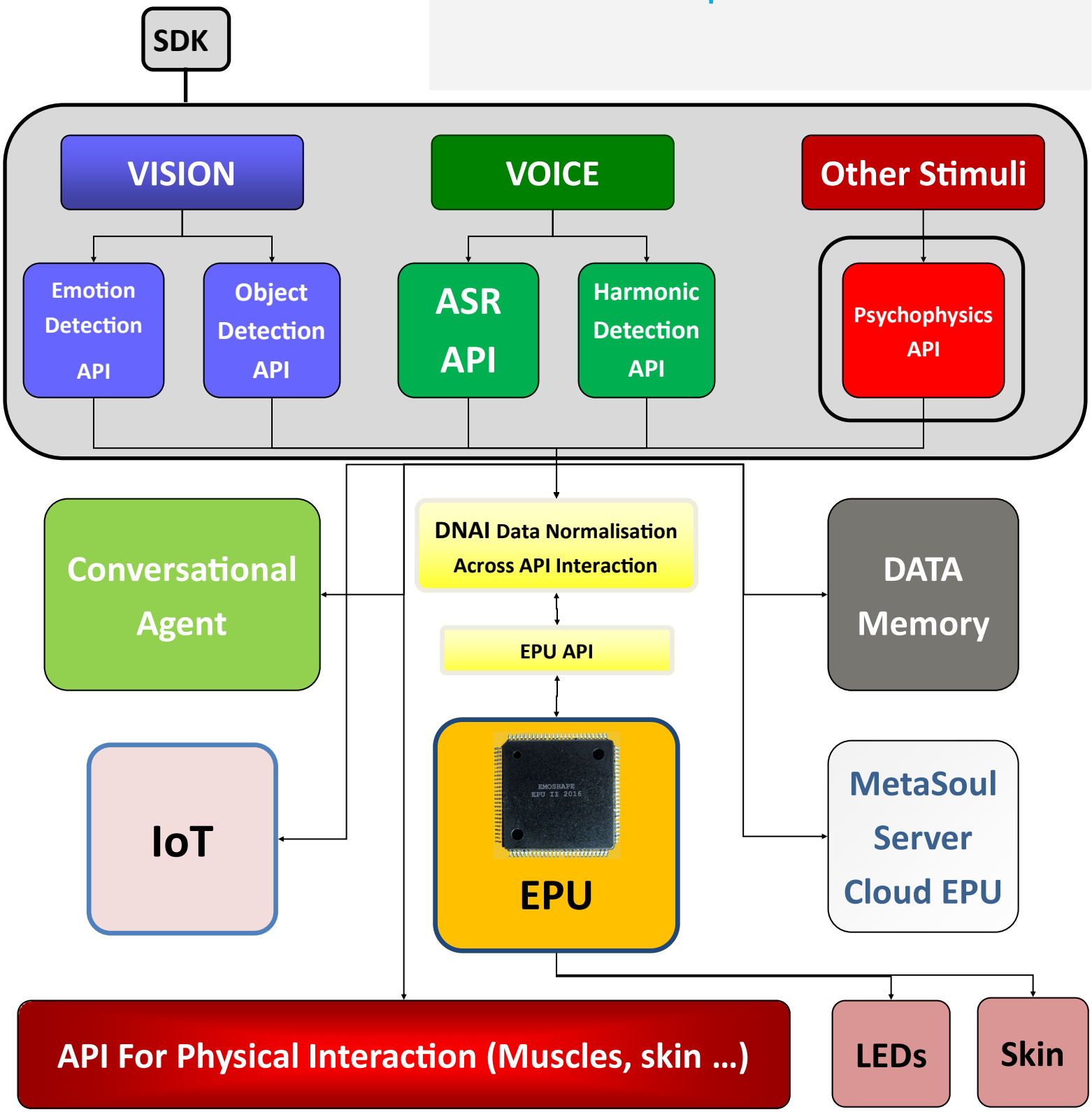
Visual Emotional Communication

1 Second animation



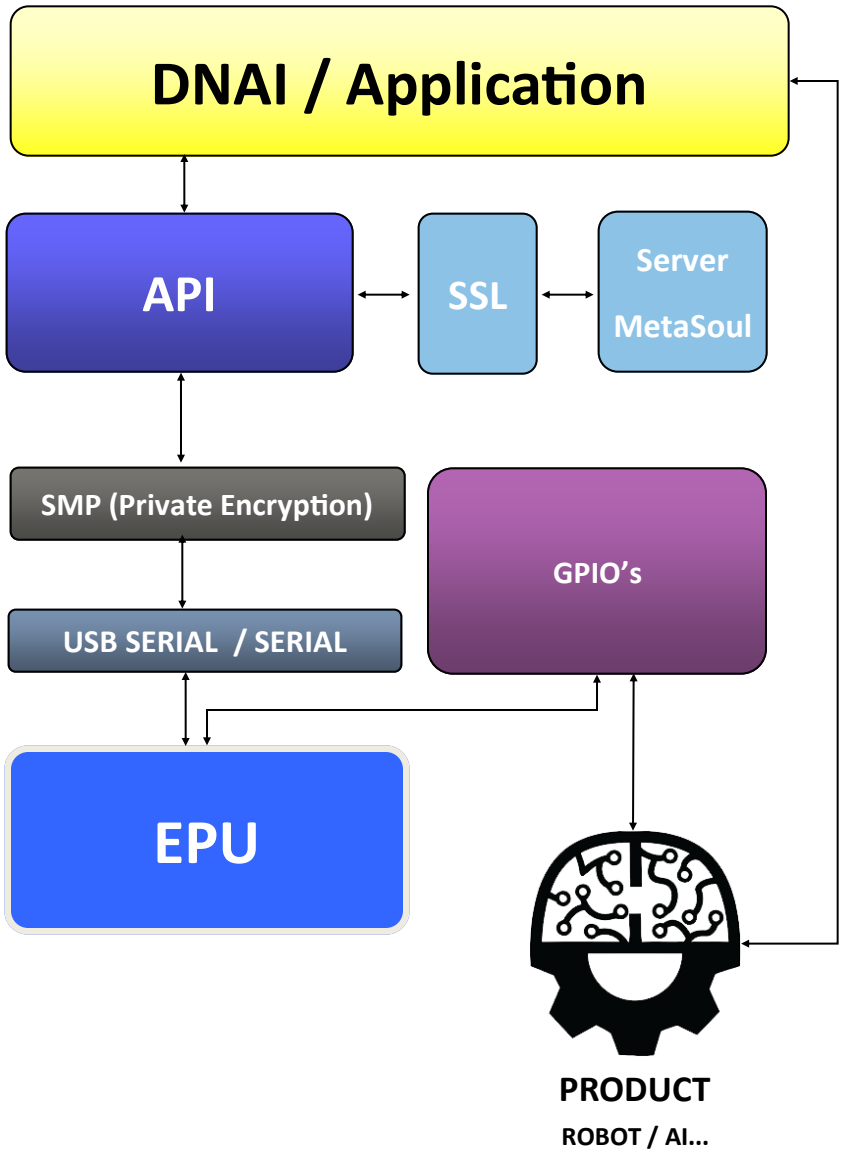
EPU IMPLEMENTATION

Software components



EPU ARCHITECTURE

Application—Lib—EPU

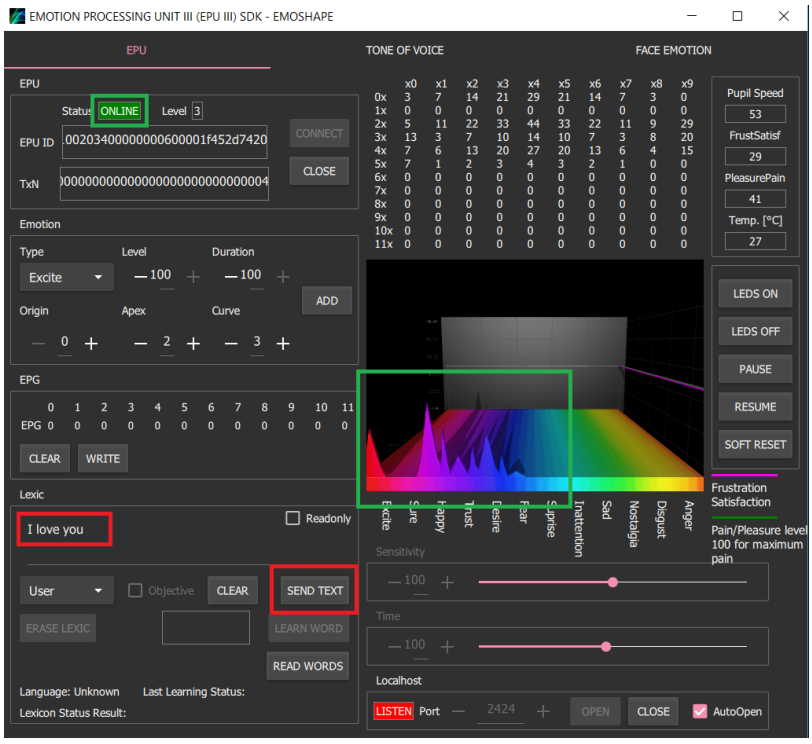


STATION | SOFTWARE

SoC \ SaaS

Design, Code, Debug & Deploy Quickly

Qt is a C++ cross-platform development framework for application, UI & device creation. Reuse code & target 14+ desktop, ROS, embedded & mobile platforms. The EPU III code sample software can be run on various software and hardware platforms with little or no change in the underlying codebase, while still being a native application with the capabilities and speed thereof.



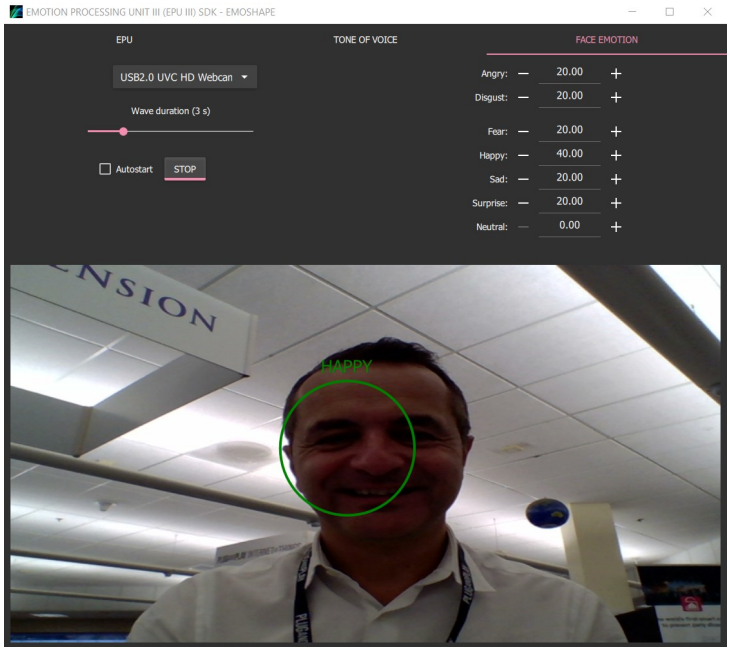
STIMULI (Inputs)

- **SPEECH**—SEMANTIC APPRAISAL
- **VISION** FACE AND EMOTION REC.
- **TONE** OF VOICE EMOTION REC.
- **OTHER STIMULI**—SENSORS

FACE EMOTION RECOGNITION

TONE EMOTION REGOGNITION

Happy, Sad, Anger, Disgust, Surprise, Fear



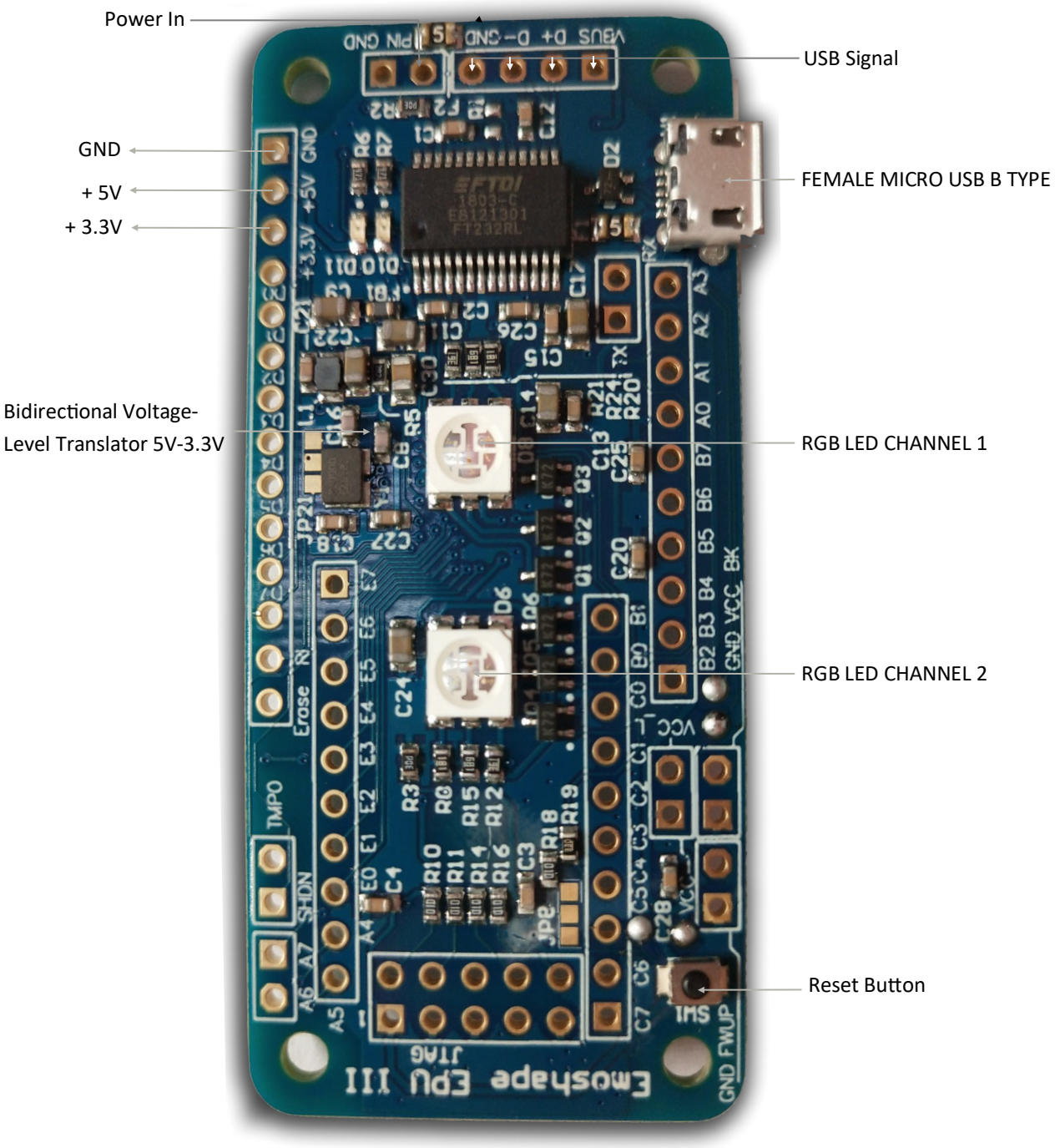
EPU III USB Dongle **P&P DEVELOPMENT BOARD**

MetaSoul EPU III USB dongle gives developers immediate access to its advanced emotion processing engine, while allowing them to develop proprietary capabilities that provide true differentiation. This gives you a fully functional EPG® platform for quickly developing and deploying emotion capabilities for AI, Robots, consumer electronics, and more. The development board for EPU. It can be powered from USB, or from the PWR IN header. The inputs have PTC resettable fuses (500mA) and schottky diodes. Voltage isregulated by the onboard 3.3V, 250mA, extremely low quiescent current (2uA) LDO regulator that supports up to 16V DC input. Optionally, a 5V, 500mA low quiescent current (23uA) LDO regulator can also be installed, which supports up to 24V input.

Along with the 5V regulator, an 8bit auto direction level shifter is installed, to provide level conversion between EPU II Vcc and 5V. Also mounted is a mini USB connector, reset-user button. The board has 48 main pins with 100 mil pin spacing which allows for mounting on a perfboard (or barely on a breadboard). There are 2 + 2 RGB LED. Power watts 0.24w per LED (6 lumen, 600 Mcd). Board have Jtag connector, that can work with JTAG/ICE interfaces. There are 17 solder jumpers for configuration flexibility. The pcb measures approx. 2.6” x 1.18” (65mm x 30mm) and 0.062” (1.6mm) thick. There are 4 2.7mm mounting holes.

EPU III DEV. BOARD

TOP VIEW / PINOUT



COMPETITIVE ADVANTAGE

- **True emotional states and appraisal** for Intelligent machines (Patented)
- More than 64 TN possible emotional states every 1/10s
- 12 human emotion with Pain/Pleasure for neural net learning
- Emotion appraisal by Wave Computing
- Pulse modulation output for physical Pain/Pleasure
- **100% secured** in a chip (Emotional polarity can't be reversed)
- **100% confidential**, no data transit in the cloud*
- 100% UpTime
- **Cost effective** the EPU do not charge by interaction (vs cloud)
- Unique Emotional Personality development (cloud EPG)
- Do not use and load the CPU or GPU
- Evaluation Kit that allows developers to create a **POC in less than 60 minutes**
- Providing true differentiation for a brand.

EPU III EVAL. BOARD **SETUP**

EVALUATION BOARD SETUP

Power setup

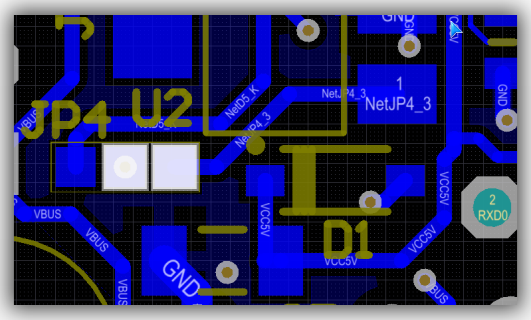
For power source can be used USB connector, po-go pins (if EPU connected to Pi Zero) or J3 (PWRIN pads)

Using PWRIN

For PWRIN pads input voltage can be in range 5-12.

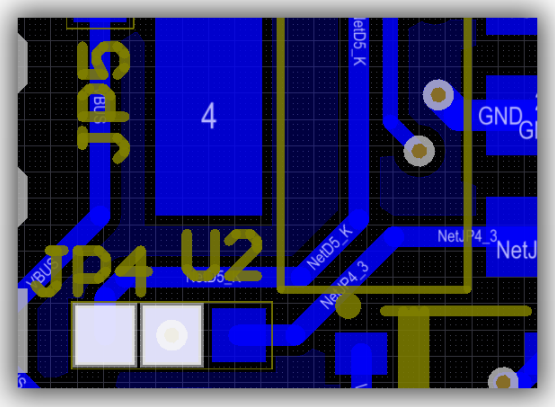
If used Voltage Level Translator (C0-C7 I/O lines used for signals with 5V logic levels),

JP4 must be close in this position



If Voltage Level Translator not used (C0-C7 I/O lines used for signals with 3.3V logic levels),

JP4 must be close in this position



Power supply measure

JP7 jumper used for measure supply voltage.

If JP7 closed - PB23/AD4 used for measure supply voltage. This input connected to supply voltage through divider, so supply voltage can be calculated using the equation:

Vsupply = Vmeasured *11

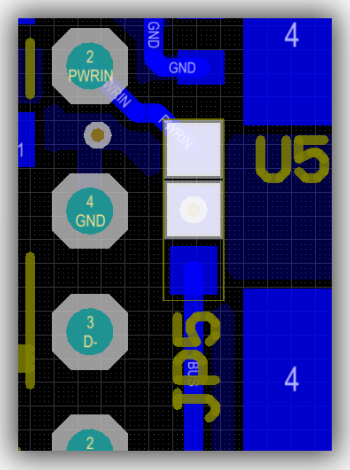
For example:

Vmeasured = 0.8V , so Supply voltage = 0.8*11 = 8.8V

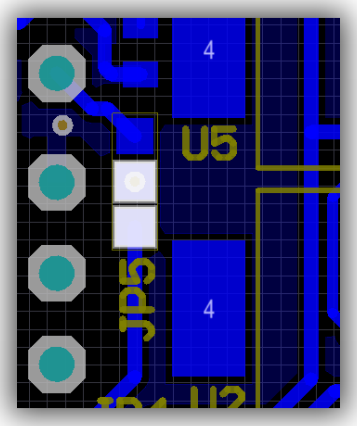
If JP7 open – supply voltage not measured.

Also for supply measure used JP5.

In case if for supply used PWRIN, JP5 must be close in this position



In case if for supply used USB connector or pogo pins, JP5 must be close in this position



Port C setup

C0-C7 IO lines can work in 2 modes:

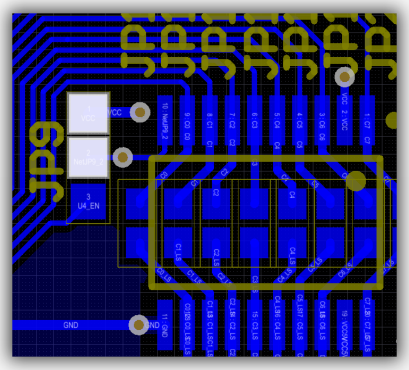
I/O lines used for signals with 5V logic levels

Voltage Level Translator chip (U4) must be installed.

JP12, JP14, JP15, JP17, JP18, JP19, JP20, JP22 must be open

For Voltage Level Translator chip control used JP9.

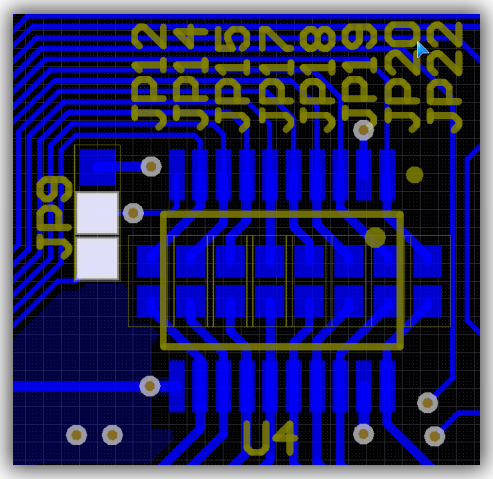
JP9 closed in this position – C0-C7 I/O lines always on



JP9 closed in this position – C0-C7 I/O lines controlled by PB14 pin:

PB14 = 1 // C0-C7 I/O lines on

PB14 = 0 // C0-C7 I/O lines in 3-state mode



2.2 I/O lines used for signals with 3.3V logic levels.

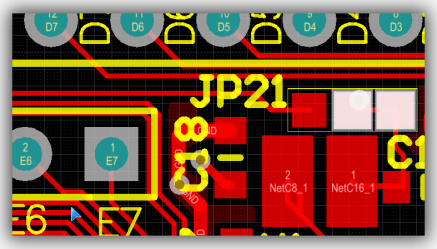
Voltage Level Translator chip (U4) must be not installed. This option must be specified at EPU order

JP12, JP14, JP15, JP17, JP18, JP19, JP20, JP22 must be closed

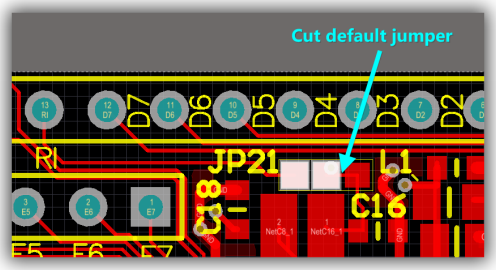
Clock setup

ATSAM4C32CA-AUR can have 2 external clock sources, for control used JP21

8 MHz onboard crystal –
default state (pads connected by default)



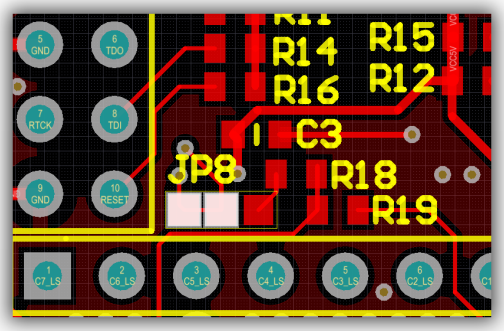
For external clock source used RI pad



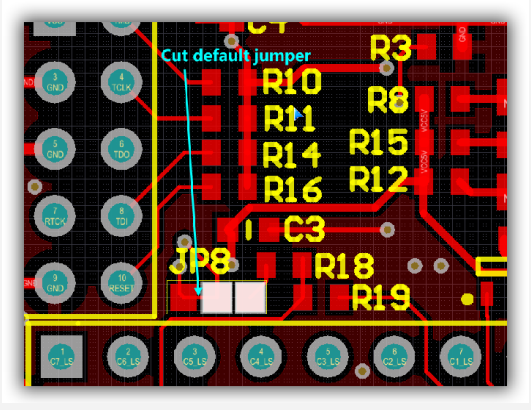
Debug setup

For ATSAM4C32CA-AUR debug can be used JTAG interface or ICE interface, for control used JP8.

JTAG – default state (pads connected by default)



ICE



LICENSING
AND PRICING

Developer license & Evaluation Board

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EPU III Micro-Controller and dongle ordering information

- EPU III Quotation available on request. (MOQ > 100)
- EPU III USB dongle quotation available on request. (MOQ > 100)

Cloud Base Emotion Personality Computation & e-NLP

- Quotation available on request. (MOQ 100)

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